

THE
PROCEEDINGS
OF THE
LINNEAN SOCIETY
OF
NEW SOUTH WALES

FOR THE YEAR

1927

VOL. LII.

WITH FIFTY PLATES
and 372 Text-figures.

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CORRIGENDA.

- Page 194, line 19, for *sanguisorba*, read *sanguisorbæ*.
 Page 562, line 15, for *coerulescens*, read *caerulescens*.



THE
PROCEEDINGS
OF THE
LINNEAN SOCIETY
OF
NEW SOUTH WALES

WEDNESDAY, 30TH MARCH, 1927.

The Fifty-second Annual General Meeting, together with the Ordinary Monthly Meeting, was held at Macleay House, 16 College Street, Sydney, on Wednesday evening, 30th March, 1927.

ANNUAL GENERAL MEETING.

Mr. A. G. Hamilton, Vice-President, in the Chair.

The Minutes of the preceding Annual General Meeting (31st March, 1926) were read and confirmed.

A letter of apology from the President (Dr. E. W. Ferguson) for his unavoidable absence through illness was read.

A letter of greeting to the meeting, dated Cambridge, England, 22nd February, 1927, was read from the Secretary, Dr. A. B. Walkom.

PRESIDENTIAL ADDRESS.

The past year has been one of more than usual activity in scientific affairs in Australia: The Australasian Association for the Advancement of Science and Australian National Research Council held their meetings in Perth in August last; quite a number of Australians have attended the third Pan-Pacific Science Congress in Tokio, and that important body "the Council for Scientific and Industrial Research" has been constituted. The activity of members of the Society in conducting their own lines of research is emphasized by the fact that the volume of proceedings was larger than usual and, in addition, there were eleven papers in hand for 1927 before the close of 1926.

The Australasian Association for the Advancement of Science held its 18th meeting in Perth during August, 1926. This was the first occasion on which the Association had ventured to hold its meeting at Perth, some doubt having been felt as to the possibility of holding a successful meeting in a centre which has been considered so remote. The unparalleled success of the 18th meeting in every

respect, shows that such doubt need no longer prevent Perth taking its place among the regular centres at which meetings are held.

It was with very great regret that we learnt of the death a few months ago of the President of the Association, Edward Henry Rennie, M.A., D.Sc., Professor of Chemistry in the University of Adelaide, who was a native of Sydney, a graduate of the University of Sydney, where he obtained his M.A. in the same year (1876) as the late J. J. Fletcher. Professor Rennie also received the B.Sc., from the University of London in the same year (1879) as the late J. J. Fletcher.

The Third Pan-Pacific Congress was held in Tokio, Japan, in November, 1926, under the auspices of the National Research Council of Japan and was attended by upward of 130 delegates from overseas. The countries represented were those bordering or having interest in the Pacific and included the United States of America, Australia, Canada, France, Great Britain, Hawaii, Japan, Netherlands, Netherlands East Indies, New Zealand, Philippine Islands, and for the first time, China and Russia.

The subjects discussed at the Congress included all branches of physical and biological Sciences and a very full programme was carried out.

At this meeting a Pacific Science Association was formed and a constitution adopted under which future Pacific Science Congresses will be held at intervals of not less than two years nor more than five years. The next meeting is to be held in Java in 1929.

Amongst the delegates who attended were the following members of this Society: Mr. R. H. Cambage, C.B.E., President of the Australian National Research Council, Messrs. E. C. Andrews and G. H. Halligan and Professors L. A. Cotton, T. Griffith Taylor and W. N. Benson (New Zealand).

The Great Barrier Reef Committee have completed their boring operations at Michaelmas Reef, Oyster Cay, near Cairns. The boring party landed during April, 1926, and operations ceased about the end of August. The boring results have yielded a rich harvest of information and have shown that the total thickness of the coral at Oyster Cay is about 427 feet. The material on which the coral rests is quartz sand, coloured green by the presence of glauconite and containing fragments of shells of molluscs and of foraminifera. The nature of the underlying quartz sand suggests that it was formed in shallow water conditions. This quartz sand was penetrated to a depth of 600 feet and practically all coralline material above it was loosely coherent, necessitating the use of casing right through. During the year several pieces of physiographical and geographical work had been completed and a report on the Barrier Reef Plankton Collections had been prepared. The Committee has decided to assist the expedition which will be sent out during the coming year by the University of Cambridge under the leadership of Mr. F. A. Potts, M.A. This expedition proposes to study the marine zoology and botany of a portion of the Reef.

A highly successful appeal for funds to institute Cancer Research at the University of Sydney has brought the large sum of over £127,000.

As members already know, the Council decided to perpetuate the memory of the late J. J. Fletcher by the institution of an annual "J. J. Fletcher Memorial Lecture". The lecture, which is to be limited to some branch of natural history, is to be delivered at the invitation of the Council, and for the first lecture, in 1928, I am sure all will agree that no more fitting choice could have been made than Sir Baldwin Spencer, one of Mr. Fletcher's oldest and closest friends in Australia, who has kindly consented to deliver the lecture early in 1928. In

addition, it is intended to erect a small tablet in memory of Mr. Fletcher as soon as the opportunity offers.

The concluding part of Volume LI of the Society's proceedings has been issued. The complete volume (657 plus xciv pages, 48 plates and 227 text-figures) contains thirty-five papers from twenty-nine authors, including several representing first contributions by some of the younger members of the Society. The Society's research staff contributed four papers.

Exchange relations with scientific societies and institutions were normal, the receipt for the session numbering 1,821, as compared with 1,409, 1,457 and 1,450 for previous sessions. The year has been marked by the large number of applications received from Societies and Institutions in other parts of the world to be placed on our exchange list. As many as possible of these have been acceded to, and the following names have been added to the exchange list during the year: Biologische Wolga-Station, Saratow, Russia; Botanic Gardens, Rio de Janeiro; Botanical Laboratory of the University of Montreal; College of Agriculture, Los Banos, Philippine Islands; Dominion Museum, Wellington, New Zealand; Institut des recherches biologiques à l'Université de Perm, Russia; Marine Biological Laboratory, Woods Hole, U.S.A.; Siberian Institute of Agriculture and Forestry, Omsk; and Instituto Botanico, Universidade de Coimbra, Portugal.

The vacancies on the Council caused by the resignations of Mr. J. H. Campbell and Professor H. G. Chapman, and the death of Mr. J. J. Fletcher were filled by the election of Mr. A. H. S. Lucas, Professor A. N. Burkitt and Dr. C. Anderson respectively.

As a result of representations made by Professor Sir Edgeworth David and Professor A. C. Seward of The University of Cambridge, the International Education Board (founded by John D. Rockefeller, Jr. in 1923) awarded to Dr. A. B. Walkom a Fellowship in Science to enable him to pursue his studies in palaeobotany under Professor Seward during 1927. The Council has granted Dr. Walkom twelve months' leave of absence to allow him to take advantage of this award; and has appointed Dr. G. A. Waterhouse as Acting-Secretary during Dr. Walkom's absence.

I have much pleasure in offering the Society's heartiest congratulations to:

Dr. P. D. F. Murray on attaining his Doctorate in Science in the University of Sydney.

Mr. A. F. Basset Hull on his election as a Corresponding Member of the Academy of Natural Sciences of Philadelphia.

Dr. A. B. Walkom on his election as General Secretary of the Australasian Association for the Advancement of Science in succession to Mr. E. C. Andrews.

Mr. E. C. Andrews on the invitation extended to him to deliver the Silliman Lectures at Yale University in 1927.

Mr. R. H. Cambage on his election as President of the Australian National Research Council and as President-elect of the Australasian Association for the Advancement of Science.

Dr. Margaret O'Dwyer on attaining the degree of Doctor of Philosophy of the University of London.

During the past year the names of twelve members have been added to the roll, and two names have been removed from it, five members have resigned and we have lost five members by death. The number of ordinary members on the roll is now 163. Death has continued to take heavy toll among members, the

losses for the past year including Miss E. E. Chase and Messrs. H. E. Finckh, J. J. Fletcher, Charles Hedley and Sir Hugh Dixon.

Eleanor Emily Chase, who died at Roseville on 17th May, 1926, was born in Victoria and was educated at St. Catherine's Church of England Girls' School, Waverley and the University of Sydney. She entered the University in 1914 and obtained the degree of Bachelor of Science, with honours in Zoology and Physiology, in 1917, gaining at the same time Professor Haswell's prize in Zoology. She was appointed demonstrator in Zoology on graduation, and in 1923 was appointed lecturer. During the five years that she was a member of the University staff she won the warm regard of her colleagues and of a large number of students by her conscientious devotion to her duties as well as by her charming personality. Her opportunities for carrying out research were limited, but she contributed one paper on "A new avian trematode" to our proceedings in 1920. She accompanied two important collecting expeditions during recent years, one to Barrington Tops, N.S.W., and the other to the Capricorn Group, Q. She had been a member of this Society since 1921 and was also a member of the Royal Zoological Society of New South Wales. In addition she was a Vice-President of the Sydney University Science Society, a member of the board of directors of the Women's Union at the University, and secretary to the committee of the National Council of Women on sex education.

The sudden death, at such an early stage in her scientific career, of one who had done promising zoological work and had endeared herself to those with whom her work brought her into contact, is a distinct loss to biological science.

Hugh Dixon, who died at Colombo on 11th May, 1926, was born in George Street, Sydney, on 29th January, 1841. He was educated at Timothy Cape's Academy at Paddington, and while still a youth he joined his father, who was a tobacco manufacturer, the business later becoming probably the greatest of its kind in Australia. He was deeply interested in church affairs and was a generous benefactor to the Baptist Church in New South Wales, having, with his wife Dame Emma Dixon, originated almost every existing trust fund connected with the Baptist Union, including the Aged and Infirm Ministers' Fund, to which he gave £10,000. For some time he was president of the Young Men's Christian Association and was a liberal supporter of the Boy Scouts. He was knighted in 1921. His general interest in science was manifested in his continuous membership of scientific societies; he had been a member of our Society since 1887 and of the Australasian Association for the Advancement of Science since 1898. He was particularly well known for his interest in amateur gardening, his pet hobby in this respect being the growing of orchids.

Herman Edward Finckh, who died at Mosman on 31st May, 1926, was born at Moore Park, Sydney, on 26th May, 1864. His earliest recollections were walks on Sunday mornings, across what is now the Golf Links, where he used to watch the aborigines cooking over their camp fires. When ten years of age, he and his younger brothers and sister were taken to Heilbron, Germany, to be educated; he remained there for eight years, after which he toured Europe and America for two years. On his return to Sydney he went into partnership with his father, who carried on business as a jeweller in George Street, eventually taking over the business himself. He retired about fifteen years ago and devoted himself to natural history work. His earliest interest was horticulture and later on the breeding of birds and small animals, in which he was very successful. In 1904 he decided to take up marine work—an interest that grew from a desire of

his daughter (now Mrs. C. A. Messimer) to have a salt water aquarium. He began with one small tank, but later on when Mr. E. R. Waite resigned from the Australian Museum, Finckh bought his tanks. From that time onwards his tanks increased in number and he spent considerable time in studying the life histories of the Australian fishes and also many exotic species that he imported from time to time. His aquaria were well known to the naturalists of this State and he was always ready to show them to anyone who was interested. He was a recognized authority on the care and management of aquaria and during the past two years was engaged upon a book dealing with these matters and also on the life histories of some fish. It is hoped that this book will be published shortly. At the time of his death his fish numbered about 5,000 mature specimens.

Finckh joined this Society in 1908; he had also been on the Council of the Royal Zoological Society of New South Wales, of which he was a Vice-President for many years; he did very efficient work as Hon. Treasurer of the Naturalists' Society of New South Wales for many years; he was also a member of the Aquarium Society, of the Wild Life Preservation Society and of the Gould League of Bird Lovers. His keen interest in and love for nature made him a very enjoyable companion and he never spared himself in his performance of his duties in connection with Natural History in New South Wales.

Joseph James Fletcher was the eldest son of the late Rev. Joseph Horner Fletcher. He was born in Auckland, N.Z. in 1850 and came to Queensland in 1860. He was educated at Ipswich Grammar School, at Newington College (of which his father was then Principal) and at the University of Sydney, gaining his B.A. degree in 1870 and his M.A. degree in 1876. In 1870 he joined the senior staff of Wesley College, Melbourne, and in 1876 went to England to study Biology at the University of London, where he obtained the B.Sc. degree in 1879, being one of the first two Australians to take a science degree from that University. Before returning to Sydney he spent some time in study at the University of Cambridge and there wrote his first paper in collaboration with J. J. Lister. This paper was published in the Proceedings of the Zoological Society of London for 1881. On his return to Sydney in 1881 he joined the staff of Newington College, where he had as a colleague R. T. Baker, until lately Curator of the Technological Museum, Sydney. He joined this Society in 1881 and was elected to the Council on 31st January, 1883. He soon attracted the notice of its founder, Sir William Macleay, who invited him to become its director and librarian. He entered upon his duties on the first day of January, 1886, and from that time devoted all his energies to the work of the Linnean Society of New South Wales. How he carried out his life work can be judged by the prominent position this Society takes in the scientific world. For 33 years he guided its affairs, edited its proceedings and when, in March, 1919, he retired from the position of Secretary, he was chosen as President, an office he worthily filled for two years. He remained on the Council until his death at Hunter's Hill on the 15th May, 1926. His membership of the Society, with one exception, had been longer than that of any other member of the Society.

The high degree of excellence reached in the performance of his duties is known to all workers in natural science in Australia. The PROCEEDINGS since 1886 and up to the time of his retirement may justly be said to be a monument to his capacity, his zeal and his devotion to duty. Authors of papers well know that he was ever ready to advise them and if necessary to make suggestions, which would tend towards the improvement of a paper in some detail and having set

a standard his watchful eye saw to it that such standard was maintained throughout the series. In all his doings he not only commanded our respect, but our affection as well and he served as an inspiration to many a student. Many of the leading members of the Society at the present time owe a deep gratitude to him for the valuable advice and instruction that he was always ready to give. Fletcher had a profound reverence for the founder of this Society, Sir William Macleay, and at all times instilled into our members the great debt we owe to him. On the 14th June, 1920, to commemorate the one hundredth anniversary of the birth of Sir William Macleay, he delivered an important address entitled "The Society's Heritage from the Macleays". In this he dealt with Alexander Macleay and his two sons, William Sharp and George, and it furnishes a most valuable record of what members of that family did in the cause of natural science. He had almost completed the remaining portion dealing with Sir William Macleay. Fletcher, no doubt, felt the removal of the office of the Society from Elizabeth Bay to 16 College Street, but he did nothing to oppose this step, for he foresaw that the new home nearer the centre of Sydney would increase the usefulness of the Society.

His published papers include 36 in These PROCEEDINGS together with one in collaboration with A. G. Hamilton and another with C. T. Musson, who has also presented for publication an important paper on *Grevillea* hybrids, based on the careful notes made by Fletcher over a period of several years. This paper will appear in 1927.

In January, 1900, Fletcher presided over the Biology Section at the Melbourne Meeting of the Australasian Association for the Advancement of Science. In 1921 he was awarded the Clarke Memorial Medal by the Royal Society of New South Wales. He was a trustee of the Australian Museum and a member of the Royal Zoological Society of New South Wales.

After his death Mrs. Fletcher felt that the desk, presented to her husband on his retirement from the position of Secretary in 1919, should find a place in the Society's rooms, so she graciously presented it to the members. It is now in the office and will be used by the future secretaries of the Society.

An appreciation of Mr. Fletcher by one of his oldest friends, Sir W. Baldwin Spencer, appears at the conclusion of this part.

Charles Hedley, who died at his home, "Nukulailai", Muston Street, Mosman, on the morning of the 14th September, 1926, was born at Masham Vicarage, Yorkshire, on the 27th February, 1862. On account of his health his school life was limited to two years at Eastbourne College, but he was an extensive reader and received instruction from his distinguished father, Rev. Canon T. Hedley, a Fellow of Trinity College, Cambridge. To avoid the English winters he was sent each year either to the south of France or to Italy, and at these places he began to find his first enjoyment of nature. At Mentone he purchased a book by A. Moquin-Tandon on Conchology. This book on land shells adopted what was then a modern view, that in the Mollusca the animal should be studied as well as the shell it formed. He has often spoken of this book as the one that gave him a stimulus which he carried throughout his zoological career. Here, when out collecting, he met George French Angas, a former Secretary of the Australian Museum, who was engaged in a similar occupation. Angas later gave him a letter of introduction to Dr. G. Bennett of Sydney.

He left England for New Zealand in 1881, intending to learn sheep farming there, but very soon found that the wet climate of New Zealand did not suit his

health. The conditions under which he worked were far from satisfactory, so he came to Sydney in September, 1882. Shortly after his arrival he met Dr. G. Bennett, to whom he was immensely drawn. He wrote to his father, "I have again been to dinner with Dr. Bennett. Fancy speaking to a man who has talked with Cuvier, who is an intimate friend of Owen, who knew or knows Darwin, Hooker, Huxley, Lyell, Wallace, Thomson, Rolleston, Balfour, Gunther, all the distinguished men of science who have lived in the last half-century!" A trip to Hay to find if the dry inland air would relieve his asthma, was not successful, so he went to Queensland. He lived first at Nerang and afterwards took up an oyster lease at Stradbroke Is., Moreton Bay. Here, as in after years, he found he always had better health when living close to the sea. Though he was able to visit the Queensland Museum on many occasions he felt himself isolated from congenial companionship. In 1884 he was fruit growing at Boyne Island, Port Curtis, where he gathered information from the aboriginals for his first paper, "Uses of some Queensland Plants" (Proc. Roy. Soc. Queensland, 1888). Here when driving in a sulky he met with an accident, smashing his left elbow, and when he recovered he found he could no longer do any laborious work and so he left Boyne Is. in 1888 and for about two years lived in Brisbane. He occupied himself in collecting and doing voluntary work at the Queensland Museum. He found his first new species, a slug at Burleigh Heads and described it as *Limax queenslandicus* with figures and was pleased that his drawings caused such favourable comment. He also published a list of the Land Shells recorded from Queensland.

On the 1st January, 1889, he was appointed a supernumerary officer of the Queensland Museum and on 2nd May, 1889, he became a Fellow of the Linnean Society of London, and in July, Hon. Secretary of the Royal Society of Queensland. In 1890 at the invitation of the Administrator, Sir William Macgregor, he visited British New Guinea, and reached some hitherto unexplored regions. He spent some time at the St. Joseph's River, Milne Bay, and made important collections. Fever forced him to return to Brisbane though he wished to remain. He came to Sydney towards the end of 1890 and resided there until his death. On the 1st April, 1891, he commenced duty at the Australian Museum as assistant in charge of Landshells. On 1st January, 1896 he became conchologist and on 20th December, 1908, Assistant Curator. On the death of Robert Etheridge, Junr., in January, 1920, he was appointed Acting Director until his appointment on 14th February as Principal Keeper of Collections. He resigned on 30th March, 1924, to become Scientific Director to the Great Barrier Reef Committee.

Hedley's connection with our Society began on the 25th June, 1890, when he was elected a corresponding member. On 29th April, 1891, he became an ordinary member; he served on the Council from 1897 to 1924 and was President, 1909-1911. He contributed to this Society forty-four papers—the first in 1890—and five others of which he was a joint author. These papers dealt chiefly with Mollusca, of which he described numerous new species. His papers on Zoogeography, a subject in which he was keenly interested, are very important and he has made noteworthy contributions to the study of the distribution of plants and animals in the South Pacific. He also wrote a few papers on Ethnology. In all, he wrote nearly two hundred papers which have been published in Australia and abroad. Hedley's papers were remarkable for the clear way he put his facts and for the interest he excited in everything he wrote. His public lectures were always crowded and, speaking in a simple way, with frequent humorous touches, he always carried his audience with him.

He was an original member of the Australasian Association for the Advancement of Science, was President of Section D at the Brisbane Meeting in 1909 and had attended most of the meetings since its inception and had assisted the Association in many ways. He had been President of the Royal Society of New South Wales (1914), the Royal Zoological Society of New South Wales and the New South Wales Naturalists' Club. He was a member (1893) and Vice President since 1923 of the Malacological Society of London, a corresponding member of the Zoological Society of London (1922), a corresponding member of the Academy of Natural Sciences of Philadelphia (1893), Honorary Member of the New Zealand Institute (1924), Honorary Fellow of the Royal Society of South Australia and corresponding member of the Royal Societies of Queensland and of Western Australia. In 1916 he was awarded the David Syme Prize and in 1925 the Royal Society of New South Wales presented him with the Clarke Memorial Medal in recognition of his services to Australian Zoology.

In addition to his writings Hedley was a keen explorer. He was always ready to join any expedition or trip to a place he had never visited before. He had explored most of Eastern Australia. He had visited the Gulf of Carpentaria with Dr. W. E. Roth, had led two trips to the Torres Strait Islands besides many smaller ones in Queensland and New South Wales. He was deeply interested in deep sea dredging and organized expeditions to explore the depths of the ocean. In 1905 and 1906 he was successful in obtaining a large collection of fish and invertebrates from a depth of a mile from the ocean bed off Sydney Heads—a feat never before attempted in Australian waters except from a man-of-war. With W. L. May he was the first to explore the 100 fathom zone off the Tasmanian coast and in company with Dr. J. C. Verco he lifted off Cape Borda the first deep sea bottom of South Australia. He was one of the few scientists to put on a diving dress and descend to a depth of 40 feet below the surface of Sydney Harbour. Of later years his chief interest was the study of the Great Barrier Reef, and his knowledge of it surpassed that of any other scientist. He had travelled over most of it and in his many trips he had landed at a number of the islands of the Reef area. He was the first civilian to make a trip by aeroplane over a portion of the Reef. His presence on the Pan-Pacific Excursion to the Reef in 1923 added greatly to the enjoyment and profit of those who were privileged to travel in the S. S. "Relief" from Mackay.

Hedley did not confine his trips to Australia alone. He visited and collected in New Guinea, Ellice Group, New Caledonia and from all of these places he obtained valuable material. In 1896 he joined the expedition sent out by the Royal Society of London under Professor Sollas to bore the atoll of Funafuti, Ellice Group. He remained on the island for about 10 weeks and succeeded in amassing an interesting collection, particularly of invertebrate and ethnological objects, together with much valuable scientific information. An account of this work was given in "The Atoll of Funafuti" (Australian Museum Memoirs, iii, 1896-1900), to which Hedley contributed the general account and the sections of ethnology and mollusca. Of later years he desired to go further afield to see other parts of the world, so in 1922 we find that he was in Western Canada and Alaska and in 1925 he visited Africa to see the Great Rift Valley. In the last few years the two men whose names will always be remembered in connection with Australian Zoology have passed away—the late Professor W. A. Haswell and the late Charles Hedley. Both in their own way have done more than any other two men to advance Zoology in Australia. Haswell will always be remembered for his accuracy and

care of detail and he has amongst zoologists a world-wide reputation for his Text Book of Zoology. Hedley was known for his hospitality, being always the first to welcome any visiting biologist, to make them feel at home in Australia, and to place himself and his knowledge entirely at their disposal this all in addition to the reputation he had for his scientific writings.

Hedley was held in the highest esteem by those who were his contemporaries and he was an ideal companion during a walk through the bush or along the seashore. He was of the utmost help to those younger than himself and many of the members of this Society will remember with gratitude the advice that he was ready to give them. He was always willing to listen to any biological or geological problem that presented itself and never grudged the time spent in helping others in their work. By nature he was kindly and courteous and he was the best of friends. Zoological Science in Australia has lost a great man, who could ill be spared, but he has left behind him a monument of hard and patient work and others will arise to carry on the work he has so ably begun.

The assistance he gave to young naturalists and to institutions has been great. During his lifetime he gave many books to this Society and to the Australian Museum and by the wish of Mrs. Hedley, her husband's books are being divided between these two institutions, so our library will be increased by the addition of many important books.

During the end of April until August, 1926, he had been supervising the sinking of the bore on Michaelmas Reef, Oyster Cay, near Cairns, and returned to Sydney about the middle of August to make preparations to visit Japan in connection with the Third Pan-Pacific Science Congress. He had to cancel his arrangements as he did not feel too well, though no serious consequences were expected and it was thought that a few weeks' rest would restore him to health. His sudden death on the morning of the 14th September, 1926, was a great shock to all his friends. His remains were cremated and the ashes taken by Mr. E. C. Andrews and in the presence of the other Australian delegates to the Third Pan-Pacific Science Congress, distributed on the waters near the Great Barrier Reef, which he loved and knew so well.

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

Dr. R. Greig-Smith, Macleay Bacteriologist to the Society, has continued his investigations into the activity of the mineral colloids such as fuller's earth, kaolin, silica, aluminium hydrate upon fermentation. The possible assistance given to the alcoholic fermentation by their aiding the diffusion of carbon dioxide has been reported upon when it was shown that the colloids have an action of their own quite unconnected with the physical elimination of carbon dioxide. It has been shown that agar-fibre acts like the mineral colloids in accelerating the fermentation of solutions of sugar by yeast provided that a sufficient amount is present. The possible stimulation of enfeebled yeast cells by the mineral colloids led to the determination that when yeast cells are heated to just short of the lethal temperature they have a different action upon saccharose than normal unheated yeast. In presence of a mineral colloid the normal yeast inverts less saccharose and generally consumes less sugar while the heated yeast inverts the same amount of saccharose and consumes more sugar. It would seem that heating the yeast partly diminishes its invertase-secreting function. During the gum fermentation of saccharose by *Bac. vulgatus* it was noted that the non-reducing sugars decreased to a minimum then increased and again diminished. This led to the discovery of a substance intermediate between gum-levan and

levulose. Its presence can be shown but it has not been possible to prepare it in the pure state or in pure solution; it is always accompanied by levulose. Work is being prosecuted in the direction of the reason for the activity of the mineral colloids in accelerating fermentation.

Miss May M. Williams, Linnean Macleay Fellow of the Society in Botany, has continued her investigations into the Cytology and Phylogeny of the Siphonaceous Algae, part 2 of which, dealing with Oogenesis and Spermatogenesis in *Vaucheria geminata* was published in part 2 of the proceedings for 1926. She has, further, been studying gametogenesis in *Bryopsis plumosa* with encouraging results. The establishment of a marine aquarium in the laboratory has enabled her to observe many interesting phases of gametogenesis. With the exception of the formation of gametes by vacuolization instead of by cleavage, the details of gametogenesis in *Bryopsis plumosa* are very similar to those in *Codium tomentosum*. She is investigating the problem as to whether reduction in the number of chromosomes in the nucleus occurs during gametogenesis, as in *Codium tomentosum*, or at the first division of the zygospore following on fertilization. As opportunity offers she is also continuing her search, as yet unsuccessful, for the reproductive organs of *Caulerpa*.

In continuation of her work on the anatomy of certain ferns, Miss Williams has completed ready for publication a paper on "The anatomy of *Cheilanthes vellea*", showing that this species exhibits, both in external morphology and internal anatomy, well marked adaptations to its xerophilous habitat.

During the coming year she proposes to continue her investigations into gametogenesis in *Bryopsis plumosa* and to undertake a critical examination of the gametangia of *Ectocarpus*.

Dr. I. M. Mackerras, Linnean Macleay Fellow of the Society in Zoology, has continued his investigations on the Diptera, having during the past year devoted most of his attention to the Culicidae. The results of his work are to be submitted in a series of papers under the title "Notes on Australian Mosquitoes", parts i and ii being ready for presentation. Part i, "The Anophelini of the Mainland", includes keys and figures which should make the recognition of the males, females and larvae of all species occurring on the mainland relatively easy. New life histories are described and notes are given on the status, habits and distribution of the species. Part ii deals in a similar way with the mainland and Tasmanian species of *Ochlerotatus*.

In addition to completing his work on the mosquitoes Dr. Mackerras proposes to resume his studies of the comparative morphology and distribution of the genera of the Tabanoidea and to proceed with the study of other families of Diptera Brachycera.

Seven applications for Linnean Macleay Fellowships, 1927-28, were received in response to the Council's invitation of 29th September, 1926. I have pleasure in reminding you that the Council re-appointed Miss May M. Williams and Dr. I. M. Mackerras to Fellowships in Botany and Zoology respectively and appointed Miss Ida Alison Brown and Miss Hazel Claire Weekes to Fellowships in Geology and Zoology respectively for one year from 1st March, 1927. On behalf of the Society I have pleasure in wishing them a very successful year's research.

Miss Ida Alison Brown graduated in Science at the University of Sydney in March, 1922, with First Class Honours and University Medal in Geology and Second Class Honours in Mathematics, also being awarded the Deas-Thomson Scholarship in Mineralogy and a Government Science Research Scholarship. The

latter scholarship was, however, relinquished by her in order to take up the position of Demonstrator in Geology, which she has held until her present appointment to a Linnean Macleay Fellowship. Since graduation she has carried on research in geology and has published four papers, two in the Journal of the Royal Society of New South Wales and two in our own proceedings. The first of these papers, "Notes on hornblende and bytownite from hypersthene-gabbro, Black Bluff, near Broken Hill", is a petrological study, and the other three are the result of field work in the districts of Milton and Moruya. For her work as a Fellow Miss Brown proposes to continue her work on the geological history of the South Coast district of New South Wales, studying in particular the geological age, conditions of sedimentation, mutual relations and tectonic history of the sedimentary rocks, as well as the relationships, petrogenesis and correlation of the associated igneous intrusions, commencing in the Moruya district and working south to Bodalla, Narooma, Mount Dromedary, Cobargo and Bega. Miss Brown comes to us with the strongest recommendations from Professors David and Cotton and she is the first woman to be appointed as a Fellow to do field work in Geology. Though her proposed researches involve arduous work in the field we may look forward to a satisfactory and successful year's work.

Miss Hazel Claire Weekes, who graduated with First Class Honours in Zoology at the University of Sydney in 1925, is the first woman to have been awarded the University Medal in Zoology at graduation. She was also awarded a Government Science Research Scholarship. In 1925 she commenced research work on reptilian embryology and published, in conjunction with Professor Harrison, a paper "On the occurrence of placentation in the Scincid lizard, *Lygosoma entrecasteauxi*". This paper appeared in our proceedings for 1925. These researches have been continued and a large amount of material has been accumulated, two investigations, into the reproductive phenomena in *Lygosoma quoyi* and the development of *Amphibolurus barbatus* being almost complete. This line of work gives promise of extremely important results on the morphological side of zoology and Miss Weekes proposes to continue her studies on reptilian embryology during her tenure of a Fellowship, and we wish her a most successful year's research.

I wish to bring under your notice, more particularly those of you who are entomologists, an important book written by a member of this Society, Dr. R. J. Tillyard, M.A., F.R.S., and published in Sydney by Messrs. Angus and Robertson, who have presented our Library with a copy. This book is entitled "The Insects of Australia and New Zealand". In this work, Dr. Tillyard opens with the classification of insects and gives a short account by which the 24 orders can be recognized from one another. The derivations of the names of the orders and the higher divisions are a help in understanding the various kinds of insects placed therein. A census of the insects of the world, Australia and New Zealand shows the large number of different species already known. More than one-third of Australian insects belong to the order Coleoptera and in New Zealand slightly more than one-half belong to the same order. Over 470,000 different insects have been described from the world and of these 37,000 (about 8%) are found in Australia and 8,000 (under 2%) in New Zealand. The number is being added to each year and it will not be long before 50,000 insects are known from Australia. The orders Plectoptera, Perlaria and Trichoptera are proportionately better represented in New Zealand than in Australia. Chapter ii deals with a general account of the external morphology, more detailed accounts being given in the chapters dealing with the

various orders. In this chapter Dr. Tillyard explains the modern views on wing venation and gives an instructive account of the latest system of nomenclature and notation for the veins of the insect wing. Chapter iii gives a general outline of the internal morphology of insects, giving a short account of the alimentary, excretory, respiratory, circulatory, nervous and reproductive systems as well as the organs of sense. In Chapter iv a concise account of the complete life cycle of an insect is given under the headings: the egg or embryonic stage, the larva or growing stage, the pupa or resting stage and the imago or sexually adult stage. Chapters v-xxviii deal with the twenty-four orders in more detail, and treat of the suborders, superfamilies, families and in some cases subfamilies mentioning typical genera and species in each group. The whole is well illustrated with details of structures, particularly wing venation and figures, both coloured and black and white, of important species.

The subclass Apterygota contains three orders of insects which are entirely wingless: (1) Thysanura (Bristle-tails, Silver-fish). In their early stages these are very similar to the adult and very little work has been done on this order. Only a few species are represented, but it is pointed out that many new forms will probably be found. (2) Protura. These small insects have not yet been found in Australia or New Zealand, but a short account of them is given so that they may be recognized when found. (3) Collembola (Spring-tails). These small and curious insects like the Thysanura and Protura are wingless, but they have no very near relations amongst the insects. It has even been suggested by some authors that they belong to a separate class distinct from Insecta.

The subclass Pterygota contains all the winged insects, though some few of them do not possess wings. They are divided into two large groups. (A) Ectopterygota in which the wings develop as external buds during the larval stages and there is no true pupa. (4) Plecoptera (May-flies). Delicately formed insects, usually small, always found near water, in which their early stages are passed. The hindwings are often very small. About twenty species are known from Australia and New Zealand. (5) Odonata (Dragonflies, Damselflies). These insects also as far as is known pass their early stages in water. They are carnivorous and both nymphs and adults feed upon mosquitoes in their various stages. Dr. Tillyard deals with this group very fully. (6) Orthoptera (Cockroaches, Mantids, Phasmids, Locusts, Grasshoppers, Crickets). In this order the mouth parts are typically mandibulate, the larval forms closely resemble the adults except for the absence of functional wings. The order includes five very distinct superfamilies, which are considered as distinct suborders or even distinct orders by some writers. The order contains some well known insects as cockroaches and grasshoppers and also some with very strange shapes. (7) Isoptera (Termites, White Ants). These insects are more nearly related to cockroaches than to the true ants. They are abundant in Australia especially in the north, but only four species are found in Tasmania and three in New Zealand. They cause many thousands of pounds loss each year by their attacks on houses, fences, and railway sleepers. (8) Dermaptera (Earwigs). These are not very numerous in Australia and only three species have been recorded from New Zealand where a common species introduced from Europe is becoming a serious pest to fruit-growers and gardeners. (9) Perlaria (Stone-flies). These insects form a small, but well marked order about equally represented in Australia and New Zealand. Their larvae are aquatic and are a valuable food for trout and freshwater fishes. (10) Embiaria (Webspinners). A small order resembling Termites. Only six

species are known from Australia and none from New Zealand. (11) Zoraptera. Only six species of this order have been described, none of which is found in Australia and New Zealand. (12) Copeognatha (Psocids, Book-lice). Chiefly very small insects, some of which are a pest in libraries and museums. (13) Anoplura (Lice). Both biting and sucking lice are included in this order, the Mallophaga (Biting lice, Bird lice) are represented by 88 species parasitic upon birds and marsupials, whilst only four native species of Siphunculata (Sucking lice) are known, though many introduced species occur. (14) Thysanoptera (Thrips). Small elongate insects usually infesting blossoms. This order is well represented in Australia about 14% of the known species occurring there. (15) Hemiptera (Cicadas, Plant Hoppers, Scale Insects, Bugs). The insects of this order are generally harmful, nearly all the Homoptera, and the majority of the Heteroptera being plant feeders causing destruction to vegetable foods. Some few Heteroptera are beneficial, feeding on other insects. Scale Insects, Plant lice and other Hemiptera are responsible for the greater part of the total damage done to our crops and fruit.

The division (B) Endopterygota, to which the remaining orders belong, have larvae in which the wings develop internally and have a true pupa or resting stage. (16) Coleoptera (Beetles). This is the largest order of living insects, comprising over 40% of the known insect fauna. They are an easily recognized group, the forewing being specialized as a hard horny covering for the hindwing. Many species are injurious owing to their attacks upon timber, fruit and grain. A few are useful as scavengers and others are predatory on scale insects and aphids. The order is well represented in both Australia and New Zealand. (17) Strepsiptera, a small order of minute insects parasitic upon the orders Hymenoptera and Hemiptera (Homoptera). No species of the order have so far been found in New Zealand. (18) Hymenoptera (Ants, Bees, and Wasps). This is one of the most distinct of the Orders of Insects, usually with four stiff membranous wings, though in some groups many of the species are wingless especially in the females. In many species the ovipositor of the female is often specialized as a sting. Some few species may be considered injurious insects and some ants and wasps are obnoxious, but generally the order may be looked upon as very beneficial to man. Parasitic Hymenoptera play a great part in the maintenance of the balance of insect life, whereby many injurious species of other insects are prevented from overrunning the world. Ants are useful as scavengers. (19) Neuroptera (Alder-flies, Lacewings). Most of the species of this order are delicate looking insects. Many of the larval forms have prominent jaws. The pretty antlions belong to this order, and also the delicate *Psychodopsis* which are often mistaken for moths. (20) Mecoptera (Scorpion-flies). A small order with only twelve species in Australia and one in New Zealand. The perfect insects are diurnal, mostly inhabiting damp cool places. Some are predaceous, killing many small insects. (21) Diptera (Two-winged flies). In this order, except for those species that are wingless, the forewings are only developed, the hindwings being reduced to a pair of small club-like appendages called halteres or balancers. From New Zealand almost as many species have been described as from Australia, but this is chiefly due to the small amount of attention this group has received in the latter country until very recently. In the last two or three years many new species have been made known from Australia and though the number of flies, given by Dr. Tillyard as 2,120 when he wrote his book, is only about 4% of the world's total of flies, if a census were now taken the percentage would be nearer

six. It is probable that not half the flies have yet been described from Australia. Flies are undoubtedly the most important order of Insects considered in relation to man. They are discussed from their medical aspect in another portion of this Address. Besides their importance as carriers of disease, many species cause great destruction to trees, fruit and vegetables. Some few flies are certainly beneficial; the robber-flies prey on other insects. The larvae of Hover-flies prey on aphids and larvae of other groups are parasitic upon the larvae of other insects. (22) Siphonaptera (Fleas). This order is highly specialized and wingless. They cause irritation by their biting and are carriers of disease. (23) Trichoptera (Caddis-flies). This order is related to the Lepidoptera, in fact they are often mistaken for moths, but their wings are covered with dense hairs and rarely with scales. The early stages are passed entirely in water, the larvae living in portable cases or fixed abodes, often very curiously shaped. The larvae form one of the important articles of diet for freshwater fishes. In New Zealand the order has been more extensively studied than in Australia, from the latter country many more than the sixty species already described will be made known. (24) Lepidoptera (Butterflies and Moths). This is the best known order of insects on account of the striking beauty of many of the adult forms. The perfect insects do little damage, and are useful in the fertilization of flowers, but the larvae cause an immense amount of destruction.

Chapters v to xxviii are all designed on the same plan, and consist of sections dealing with Morphology, Life History, Distribution, Fossil History, Economics and Classification. The illustrations are copious, clear and in most cases original. Each chapter concludes with references to the more important papers to be consulted for further details. Dr. Tillyard gratefully acknowledges the help he has received from various entomologists in the various orders in which they specialized.

The chapter on the fossil record and origin of the Australian and New Zealand Insect Faunas shows us what has been accomplished in the space of a few years. Before Dr. Tillyard began to study fossil insects very few species had been recorded, but his enthusiasm inspired several collectors, with the result that a large number of specimens had been found and described. The number is still increasing and Dr. Tillyard has already received a large number of new specimens to study.

The concluding chapter is devoted to the collection, preservation and study of insects and contains very valuable information. A glossary of technical terms is provided as an appendix.

The chief importance of this valuable book to us is that it deals entirely with the insects of Australia and New Zealand. In the vast amount of original matter it contains it has a world-wide importance. Very few general entomological works are as comprehensive and still fewer as up to date. The modern lines of research are included up to the date of writing. This is the second general entomological work produced by a member of this Society, Mr. W. W. Froggatt's excellent "Australian Insects" having been out of print for several years.

Our congratulations are due to all concerned in the production of this book, to author, to artists, to printer and to publishers.

MEDICAL AND VETERINARY ENTOMOLOGY IN AUSTRALIA.—A REVIEW.

In the address from this chair last year the retiring President, Mr. H. J. Carter, gave a *résumé* of the evolution and development of entomology from early times to the present day. In his address Mr. Carter omitted any consideration of one important economic line of modern development—the relation of insects to the carriage of disease both in man and animals. This branch of entomology was deliberately omitted in order that I might deal with it in fuller detail than would be possible in Mr. Carter's more general address. It would be, of course, manifestly impossible to traverse adequately the whole of this subject in the time at our disposal tonight. It is my purpose to restrict my remarks mainly to advances made by Australians in this particular field and at the same time to give a rapid survey of the special problems that confront Australian workers in the lines of medical and veterinary entomology.

The whole science of medical entomology is of quite recent development and may be said to take its origin from the discovery by the late Sir Patrick Manson in 1878 of the role played by *Culex fatigans* in the transmission of *Filaria bancrofti*. This discovery established the principle of development of a metazoan parasite in an insect host. The existence of a corresponding, in this case sexual, development of a protozoan parasite in an insect host was shown by Ross's discovery in 1898 of the life history of the parasite of malaria. Ross was unable from the lack of material to follow out all the stages in the malarial parasite, but was able to do so in the case of the allied *Proteosoma* of sparrows. Since that time it has been shown that a considerable number of parasites both of man and animals pass portion of their life cycle—generally the sexual cycle—in the bodies of insects.

Another aspect of medical entomology later came into prominence when it was shown that bacterial agents of disease could be conveyed through the medium of insects, particularly of flies and fleas. The transmission in this case is purely a mechanical one and there is no question of the cyclical development of a parasite.

The discoveries made by the protozoologist, pathologist and sanitarian in the mode of transmission of insect-borne diseases naturally led to further study of the insects themselves. Ross's discovery of the vector of malaria and the American Commission's discovery of the transmission of yellow fever by *Aedes (Stegomyia) aegypti* undoubtedly stimulated study of the mosquitoes as a whole and greatly enhanced our knowledge of the group. Similarly, the discovery of the role played by the common house fly—*Musca domestica*—in the transmission of typhoid, dysentery and similar diseases led to more intensive study of the Diptera as a whole, particularly of the house frequenting species. The discovery that trench fever as well as typhus and European relapsing fever was spread by the common body louse considerably increased our knowledge of the habits and bionomics of this insect. In similar fashion the study of fleas followed on the revelation of their spread of *pestis bubonica* and of ticks on the part played by them in the transmission of piroplasmiasis and allied diseases in cattle and other animals, though consideration of ticks and mites and their relation to disease is rather outside the scope of the present address.

Examples could be multiplied, but enough have been quoted to show the necessity for systematic study and classification of the insect vectors both actual and potential. I propose to discuss the advances made in Australia in the systematic study of certain groups of Australian insects which are, or which may

contain, species of economic importance from the medical and veterinary aspect as well as to outline the advances made in the study of the diseases concerned, particularly from the point of view of their relations to their insect hosts. I have excluded from my review all consideration of the Arachnida and diseases borne by this Class, though such consideration is generally regarded as falling within the province of the medical entomologist.

Viewing the Class Insecta as a whole it will be seen that only certain groups of insects are concerned in the transmission of disease, and that these are such as by their habits of life history come into more or less close association with man or animals. Practically all insects of medical or veterinary importance fall into the orders Diptera, Siphonaptera, Hemiptera and Anoplura.

Diptera: Within recent years considerable activity has been shown in the study of Australian Diptera, hitherto one of the more neglected orders of Australian insects. Early describers of Australian flies included Desvoidy, Macquart, Walker, Schiner, Thomson and Bigot. Unfortunately, many of these early descriptions are worthless and the species practically unidentifiable except in cases where the types are still available for comparison.

From 1888 to 1890 F. A. Skuse contributed a series of eight papers with two supplements to These PROCEEDINGS on the Diptera of Australia. His work was, however, confined to the Nematocera, with the exception of two small papers on Acalyptrate flies of economic importance. The only groups of medical interest dealt with are the Culicidae or mosquitoes and a few blood-sucking midges comprised in the families Ceratopogonidae and Simuliidae.

Between 1914 and 1918 Arthur White published a series of papers on Brachycera Orthorrhapha dealing mainly with Tasmanian species, but including also papers on mainland species. His writings included descriptions of new Tasmanian Tabanidae.

Since 1920 numerous papers on Australian Diptera have appeared, mainly from the pens of Hardy, Malloch, Bezzi, Mackerras, Hill, Ferguson, Alexander and Tonnoir.

Culicidae: Skuse (1888) first studied the mosquitoes systematically and described 19 new species. This was in continuation of his work on Australian Diptera and was not undertaken from the medical standpoint.

The greater interest shown in the systematic investigation of mosquitoes following on Ross's discovery of the transmission of malaria, and in which such men as Giles, Blanchard, Theobald, Dyar and Knab, Edwards, Christophers, etc., played a leading part, commenced in the 'nineties and has been continued to the present day. In this general study of the group, Australian species, of course, were included, mainly in the works of Theobald. In this connection full credit must be given to the unremitting efforts of Dr. T. L. Bancroft of Burpengary and later of Eidsvold to secure, either by capture or by breeding, representative collections of mosquitoes from the districts in which he was resident. In 1908 Dr. Bancroft published a census of Queensland mosquitoes in which some 32 species are listed. Though this comprised only about one-third of the species now known the work was the only list available for many years and proved invaluable to Australian workers.

The next advance in the systematic study of Australian Culicidae followed on the establishment of the Australian Institute of Tropical Medicine in Townsville and the appointment of an entomologist to that institution. During the years 1912 to 1920 Mr. F. H. Taylor, the entomologist to the Institution, published a

series of papers in which a large number of new species of mosquitoes are described. These included not only species from Australia, but also from New Guinea.

About this period the scale classification introduced by Theobald broke down by its own weight and was replaced by the more rational structural system first proposed by the Americans and now adopted by Edwards of the British Museum. The resultant changes in generic appellations caused a period of some confusion in the nomenclature of Australian mosquitoes, which was increased by the rather considerable specific synonymy that existed. Through the joint efforts of Mr. F. W. Edwards, of the British Museum, and of Mr. G. F. Hill, then entomologist to the Tropical Institute at Townsville, the confusion was finally cleared up and the issue in 1924 by Edwards of his synonymic list of adult mosquitoes of the Australasian Region has placed in our hands an authentic list for the use of all future workers in this group.

Larval characters: While the adult Australian Culicidae are now fairly well known much yet remains to be done on the identification of the larvae. Descriptions of most of the common species have been published by Cooling, Taylor and Hill, while in some instances the larvae of extra-limital species have been described by workers outside Australia.

The latest worker in this field—Dr. I. M. Mackerras, Linnean Macleay Fellow in Zoology—has already a paper on the Anophelini ready for publication and a second on the Culicini nearly completed.

Fieldwork: Work on Australian Culicidae has not been confined to the systematic description of new species. The work of Dr. T. L. Bancroft in collecting and breeding out species in Southern Queensland has already been mentioned. Similar work was carried out in New South Wales by Dr. J. B. Cleland largely in connection with the animal experimental station on Milson Island, Hawkesbury River. In his numerous journeys about the State Dr. Cleland also carefully collected and recorded the species of mosquitoes encountered and encouraged his officers to do likewise, with the result that it is now possible to map out the distribution of the Culicidae in New South Wales with some degree of accuracy.

In North Australia much of the early work of collecting was carried out by G. F. Hill, particularly during his residence in the Northern Territory and later in Queensland and New Guinea. In Northern Queensland Taylor, Priestley, Breinl and Cooling all carried out extensive collecting. Taylor was responsible for a series of mosquito surveys of Northern Queensland towns and also undertook a survey of the mosquito population of the irrigation areas on the Murray River in Victoria. Recently, series of mosquito surveys have been made of Queensland towns mainly by Dr. Hamlyn Harris. Surveys have been made at various times in and around several of the capital cities, notably Brisbane and Adelaide.

Mosquito eradication work: Only brief reference can be made to campaigns that have been instituted for the eradication of mosquitoes in various parts of Australia. The most complete and the best sustained appear to be the measures instituted by the Health Department in Brisbane, which were initiated by Dr. Elkington in 1912. Other centres in which anti-mosquito measures have been put into operation include Adelaide, Toowoomba, Kyogle and various suburban municipalities around Sydney.

In New South Wales powers are given under Ordinance 41 of the *Local Government Act*, 1906, to enable local authorities to compel householders to

prevent the breeding of mosquitoes in or around their properties. This Ordinance is not in general use, but can be applied to any Municipality or Shire by proclamation. The Ordinance compels householders to keep cisterns, tanks, etc., properly screened or covered, to empty any receptacles that may contain water, to rectify defective water spouting, etc., to oil or stock with fish permanent and ornamental collections of water and generally to take such measures as may be necessary for the prevention of mosquito breeding. The more extensive work of ditching, draining, etc., must, of course, be undertaken by the local authority in each district. The stumbling block to the thorough carrying out of anti-mosquito measures is always the financial one and though in many cases something is done, the result often falls far short of expectations and it is often difficult to ensure that adequate maintenance work is continued.

It is to be pointed out here that, whereas in tropical and sub-tropical Australia the eradication, or at least control, of the mosquito is a question of public health importance, in the more temperate portions of the continent this is not the case and it is merely a question of abating a nuisance.

Mosquito-borne Diseases: Three distinct mosquito-borne diseases occur in Australia—Malaria, Dengue Fever and Filariasis. Malaria was at one time undoubtedly much more prevalent in tropical Australia than it is to-day and while endemic foci probably still exist, many of the outbreaks recorded of recent years have been due to the reintroduction of the disease during the rainy season. In southern Australia only sporadic cases have occurred, some half-dozen or so being on record. (New South Wales 7, Victoria 1, Western Australia 1). While, however, the disease is a relatively rare one even in the tropical belt of Australia, the vector, the Anopheline mosquito, is widespread and has been recorded by various observers (Hill, Taylor, Ferguson, Cleland, etc.) from almost every portion of the continent. Much uncertainty exists as to the exact species of *Anopheles* that is responsible. The common and widespread species, *A. annulipes*, occurs throughout the temperate region, but appears to be, if not replaced by, at least associated with, a closely allied species, *A. amictus*, in northern Australia. Do the comparatively slight morphological differences between these two indicate, as Hill suggests, a possible difference in their readiness to act as vectors for the plasmodium? Or is there any difference in the avidity with which they will attack man? Reference might be made in this connection to the researches of Roubaud and others into the man or cattle attacking races of *A. maculipennis* of southern Europe and their relation to the incidence of malaria. That *A. annulipes* can carry malaria is shown by the sporadic cases in New South Wales. There are, of course, other species in tropical Australia, notably *A. bancrofti* and *A. punctulatus*, which may be responsible for the conveyance of malaria in these regions. It is to be noted that in Australia no species has been actually proved to be a vector by experimental feeding on malarial patients and afterwards finding the developing sporozoites on dissection of the mosquito, though Heydon in 1923 proved by experiment that *A. punctulatus* was an efficient carrier at Rabaul. Clearly the factors governing the incidence of malaria, even in the tropical portions of Australia, are not fully known and require investigation. The fact of Australia's comparative immunity may depend on questions of sparseness of population or, as mentioned above, on relative unsuitability of the insect vector.

Dengue Fever: It is now definitely established that dengue fever is conveyed through the medium of infected mosquitoes; the great part played by Australian workers in the elucidation of the aetiology of the disease was the proof of a

particular mosquito—*Aedes (Stegomyia) aegypti*—as vector. Graham working in Syria first definitely proved that dengue was conveyed by mosquitoes and, though his results appeared to incriminate *Culex fatigans*, it was admitted that his stocks of this species probably contained individuals of *Ae. (Steg.) aegypti*. Experiments by Ashburn and Craig were not more conclusive. In 1906 Dr. T. L. Bancroft of Queensland definitely succeeded in transferring dengue by means of *Ae. (Steg.) aegypti* in two instances. This positive result was overlooked for some years and left some doubt as to whether other methods of infection could be absolutely excluded since Bancroft was working in a dengue district. In 1916 Drs. Cleland, Bradley and McDonald of Sydney, in a series of well planned experiments, definitely proved *Ae. aegypti* to be the vector. These observers brought down *Ae. aegypti* from the northern rivers of New South Wales to Sydney, where this species does not occur, and by feeding them on volunteers succeeded in reproducing the disease in four instances, the diagnosis being confirmed by inoculation experiments in other volunteers. Their results have been confirmed since by workers in other parts of the world, notably in the Philippines. The Philippine Commission found that *Ae. aegypti* did not become infective until eleven days after feeding on an infected patient. This is against the whole evidence of the epidemiology of the disease, which indicates that the mosquito may be infective during the first three days after feeding on a patient. This was shown furthermore to be the case experimentally by Chandler and Rice in Texas. It appears from a study of the Philippine Commission's report that no experiments were carried out with infected mosquitoes under seven days after being infected and it may well be that there are two methods of infection—a mechanical method of transference of infected material within the first three days of infection of the mosquito and a developmental method in which the parasite undergoes some change in the mosquito, which does not become infective for eleven days. Further work is required on these points. The causal organism of dengue itself yet remains to be discovered.

Dengue is endemic in northern Australia and invades southern Queensland and northern New South Wales at irregular periods. When the disease makes its appearance up to 90% of the population of a town may be infected. Possibly the periodicity of the appearance of the disease may be associated with mass immunity of the population from a previous epidemic. The fact that the vector disappears from a locality during the colder months in the more temperate portions of its habitat, passing the winter in the egg stage, accounts for the disappearance of the disease with the onset of cool weather. Until the 1926 epidemic in New South Wales dengue had only been recorded from towns along the north coastal rivers, but in 1926 towns along the north-western slopes and on the north-western plains were heavily infected. Enquiry showed the presence of *Ae. aegypti* wherever dengue was present and revealed the fact that this species of mosquito was much more widely spread inland than had been previously known. Whether the inland spread was a recent one or whether the presence of the mosquito had been merely overlooked could not be determined.

Filariasis: The third great mosquito-borne disease—*filariasis*—is widespread, at any rate in certain of the Queensland coastal districts. The discovery of the parent worm—*Filaria bancrofti*—was made by the late Dr. Joseph Bancroft of Brisbane in 1876. The fact that the mosquito was the vector was discovered by Sir Patrick Manson at Amoy, in China, in 1878, but the full details were not worked out; this was largely done by Dr. T. L. Bancroft in Brisbane in 1899.

Filaria has been proved to be carried by a number of different mosquitoes, the commonest being the night feeding mosquito, *C. fatigans*, and it was with this species that Dr. T. L. Bancroft successfully worked in Queensland. Further work by Miss M. J. Walker in Brisbane in 1923-4 confirmed Dr. Bancroft's results with *C. fatigans*. Both observers obtained partial development in *C. annulirostris*; other species of mosquitoes yielded negative results. In the Pacific Islands the common vector as shown by Dr. Manson Bahr (1912), is *Ae. (Steg.) variegatus*, but this species does not touch Australia; furthermore, the island disease is non-periodic and is associated with numerous cases of Elephantiasis, whereas the Queensland disease is definitely nocturnal in periodicity and Elephantiasis is extremely rare, while lymph varix, chyluria, etc., are not uncommon. A considerable field, therefore, yet awaits the investigator in Queensland into the aetiology of the disease, work in which both the pathologist and the entomologist might be suitably employed.

Tabanidae: This family, familiarly known in Australia as March Flies, are abundantly represented, close on 300 species being known. Many of the better known forms were described by Macquart and Walker in the early part of last century. Ricardo, in a series of papers in the Annals and Magazine of Natural History from 1900 to 1917, reviewed many of the older described species as well as described many others as new. Australian workers were thus able to place correctly many species whose identity would otherwise have been uncertain. F. H. Taylor (1913-1920), of the Australian Institute of Tropical Medicine, Townsville, in a series of six papers, four of which were published in These PROCEEDINGS, added numerous species, mainly from northern Australia.

During the years 1919-20 additional species were added by Ferguson, Ferguson and Henry, and Ferguson and Hill. These authors also discussed the somewhat extensive synonymy that had grown up in the family.

Studies on the life histories of Australian Tabanidae were published by T. H. Johnston and M. J. Bancroft and by G. F. Hill, but the life history of only some half-dozen species is as yet known. In connection with the work on Onchocerciasis extensive collections of Tabanidae have been made in various parts of Australia in response to appeals made by the various committees appointed to investigate this disease. These collections have led to a great increase in our knowledge of the distribution of these insects as well as to the access of new species.

Diseases conveyed by Tabanidae: While no disease has been definitely proved to be conveyed by Tabanidae in Australia, strong suspicion falls on these flies as the probable vectors of *Onchocerca gibsoni*, the causal organism of bovine Onchocerciasis. This nematode disease is widespread in the Northern Territory, Queensland and New South Wales and is responsible for severe economic loss. While the causal organism is known, the mode of transmission is as yet unascertained, though various facts point to the vector being a flying insect. Extensive feeding and other experiments with Tabanidae carried out at Kendall yielded negative results, which could not be regarded as conclusive. Dissection in a few cases showed the presence of larval filariae in the proboscis of Tabanidae. Similar larvae had been found by Johnston and Bancroft in Queensland and named *Agamofilaria tabanicola*. These authors regarded the larvae as probably immature forms of some species parasitic in a native animal or bird. Reference might be made here to certain suggestive experiments recorded by Dr. Cilento of Townsville. In the one observation, Tabanidae were seen to bite two cattle on the brisket; the

spots were marked and later worm nodules found to have developed there. In the second case the crushed up heads of several Tabanids, in which nematodes were seen in the proboscis, were injected into the brisket and were followed by the development of worm nodules. The value of these experiments was to a certain extent impaired by the fact that they were carried out in a district in which the disease is naturally common and other modes of infection could not be excluded.

The whole question of the transmission of Onchocerciasis was further complicated by the discovery that two other species of *Onchocerca*—*O. gutterosa* and *O. lienalis*—occur in Australian cattle and in no case is the vector known.

There is no evidence that Tabanids have ever been associated with the spread of anthrax in Australia, as appears to have been the case in other countries.

Other blood-sucking Diptera: The *Leptidae*, though usually non-blood-sucking flies predaceous on other insects, contain a single Australian genus of blood-sucking species, *Spaniopsis*, which is confined to this country. Some five or six species are known, but they are of academic interest only, as they are not known to be associated with any disease.

Simuliidae or Buffalo gnats are represented in Australia by fourteen described and a number of undescribed species. The family was revised in 1925 by Tonnoir.

Ceratopogonidae: Minute midges belonging to the genera *Culicoides* and *Leptoconops* are widespread in Australia and are commonly termed sandflies. They are vicious "biters", raising irritating papules which are generally more irritant after twenty-four hours or longer. The various species found in Australia have been by no means thoroughly investigated, though some half-dozen have been described.

Psychodidae: A single species of *Phlebotomus* has been described from northern Queensland by G. F. Hill. It is not known whether it is associated with any disease, but short duration fevers analogous to three day or Phlebotomus fever are known to occur in the tropical regions of Australia.

Muscidae: Two blood-sucking species of Muscidae occur in Australia, both introduced. *Stomoxys calcitrans*—the stable fly—is widespread throughout the continent and, though usually confining its attention to cattle and horses, will on occasion attack man. It has been suspected as a possible vector of *Onchocerca gibsoni*, but extensive experiments with calves failed to prove any causal relation. *S. calcitrans* has been accused, at various times, of transmitting infantile paralysis, anthrax and surra, but there is no evidence that this species has ever acted as vector of these diseases in Australia. The stable fly is, however, known to be the intermediate host of *Habronema microstoma*, a nematode parasite of horses in Australia. The life history of this parasite and its allies—*H. muscae* and *H. megastoma*—have been worked out by Hill, Bull, and Johnston and Bancroft. *Haematobia exigua* (*Lyperosia exigua*), a close ally of *Stomoxys calcitrans*, has been introduced into northern Australia and has spread from the Northern Territory into the Kimberley district of Western Australia. The attacks of this insect cause considerable irritation and the formation of intractable sores, leading to marked loss of condition in the cattle attacked. The presence of the fly is thus of serious economic importance and is the subject of special investigation by the Commonwealth Government.

Non-blood-sucking Diptera: The vast number of Diptera are non-blood-sucking and only a few are of interest as actual or potential carriers of disease. Certain flies by habits of breeding or by predilection for certain food are attracted to

human dwellings and come into close contact with man. Species that breed in excreta and that are attracted to food stuffs are especially dangerous. Practically all the important species are contained in the families Muscidae, Calliphoridae and Sarcophagidae.

Muscidae: Musca domestica, the common house fly, is *par excellence* the species responsible for the spread of disease, particularly such diseases as typhoid, infantile diarrhoea and dysentery. Since the discovery of the role of this species in spreading typhoid fever, a discovery that followed on the Commissions of Enquiry into the typhoid of the Spanish-American and South African Wars a vast amount of evidence has accumulated incriminating this species and an extensive literature has been compiled of its habits, bionomics, etc. While we thus have a considerable mass of information on these points most of the evidence has been obtained by study of the species in other regions and mainly in temperate climates. Further information is required as to the bionomics of *M. domestica* under Australian conditions, though in essentials the life history will be found to be the same in all countries. There are, however, questions of possible aestivation in the height of summer—it is a well known fact that flies are less abundant in the summer than in spring or autumn; questions of the relative abundance in different localities and States, to mention only two of the many obscure but important aspects of the bionomics of the house fly under Australian conditions. Such questions may be of paramount importance in the study of disease. Why is infantile diarrhoea more common in a hot, dry summer? Is this related to an increase in the fly prevalence during such seasons? What is the relation of its local incidence to that of house flies? It is freely stated that the seasonal curve of this disease closely follows that of the prevalence of flies. As a matter of fact, there is no adequate data on which the latter curve could be constructed for any part of Australia. To answer these and similar questions fly counts spread over a number of years are necessary. Such fly counts are unfortunately not available, with the exception of a short series made by Dr. J. B. Cleland some years ago in Sydney; their institution and maintenance over a series of years is becoming a matter of urgent importance.

Prevention of Fly Breeding: Though the principles of the prevention of fly breeding are well known, but little has been done to minimize the evil. Adequate powers exist under various by-laws and local government ordinances to regulate the storage and disposal of manure, the disposal of garbage and rubbish, the care of stables, dairies, the construction and care of privies, etc., but though these regulations may be, and generally are, enforced, many exceptions exist. I have personally seen conditions existent in country towns which were a disgrace to the community. The control of these conditions is, of course, a matter for the sanitarian. The entomologist has done his share in pointing out the conditions regulating fly breeding; he cannot do more. Too often, however, the efforts of the municipal sanitary or health inspector are nullified by the apathy or even active opposition of the local council. Better results might be obtained if all health inspectors were directly under the control of the central health authority and not servants of local councils. Conditions are as a rule better in the larger towns and cities and the advent of the motor has helped to diminish the fly prevalence by the decrease in the number of horses and the consequent lessening of the use of stables in the cities. In some degree the fly prevalence in a community may be measured by the typhoid incidence. Certain towns, particularly where water carriage of sewage exists, are always free from the disease. This does not

necessarily mean a lessened fly prevalence, but that the fly has not the opportunity to come in contact with infected material. In other towns typhoid recurs annually. That typhoid fever is diminishing with yearly fluctuations in New South Wales is shown by the figures for the yearly incidence for the last ten years. To obtain a proper indication of the spread of typhoid by flies it would be necessary to deduct cases due to other causes, such as direct contamination of food, milk, etc., at the hands of typhoid carriers.

TABLE I.—TYPHOID FEVER.

| Year. | Population. | Cases. | Deaths. |
|-------|-------------|--------|---------|
| 1917 | 1,886,701 | 1,091 | 103 |
| 1918 | 1,928,174 | 810 | 112 |
| 1919 | 2,000,173 | 857 | 106 |
| 1920 | 2,099,763 | 1,016 | 132 |
| 1921 | 2,128,786 | 949 | 129 |
| 1922 | 2,174,688 | 706 | 99 |
| 1923 | 2,211,106 | 873 | 104 |
| 1924 | 2,256,649 | 768 | 97 |
| 1925 | 2,306,081 | 533 | 80 |
| 1926 | 2,349,000 | 674 | — |

Several other species of Muscidae closely related to the house fly have been described from Australia; the nomenclature of these is by no means settled, since some extend beyond Australian limits. The most important is, however, *Vivaparomusca ventustissima*, the well known bush fly. This species is widely distributed throughout Australia, and though it does not enter houses it will persistently attack man in the open, being especially attracted by moist surfaces, such as the eyes, nostrils, lips, or by open sores. Its prevalence varies greatly in different years and there is reason to believe that the species is associated with the spread of ophthalmic infections, such as conjunctivitis ("Sandy blight") and trachoma. It may also be the transmitting agent in cases of Bung-eye. This species was extraordinarily abundant in the summer of 1923-24 and according to the evidence of the school medical services this season was associated with an unprecedented number of cases of ophthalmia in country schools.

An account of the bionomics of this species in Queensland was published by Johnston and Bancroft.

Calliphoridae and Sarcophagidae: These two families may be briefly considered together since in both cases the habits are similar. They are largely of importance because of their habit of attacking meat and depositing their larvae and eggs thereon, thus rendering it unfit for human consumption. The more severe economic loss occasioned through the blowing of sheep will be considered under myiasis. Both families are strongly represented in Australia. The Sarcophagidae have been studied by Johnston and Tiegs and by Johnston and Hardy and in a series of papers by these authors some 25 species are recorded from Australia. The Calliphoridae have until lately been in a state of some confusion as far as the nomenclature is concerned, despite attempts by Patton and by Hardy to elucidate the family. I have recently received, however, a paper by Malloch on

the family, which will be presented to this Society during the current year and which will place the Australian species on a sound classificatory basis. The question of the correct nomenclature is of importance, as Malloch found that under several of the commonly accepted names two or more species have been included. Differences of chaetotaxy and of male genitalia have been largely neglected in the past, but these may be of great importance in determining specific status.

The bionomics of the Sarcophagidae have been largely studied by Johnston and Tiegs and by Johnston and Hardy, and the latter author has also devoted considerable time to the study of the bionomics of the Calliphoridae in Queensland. Bionomic studies of the Calliphoridae were also made by J. L. Froggatt in his investigations into the sheep-blowfly problem. Reference may here be made to the series of experiments carried out by W. B. Gurney into the range of flight of Australian blowflies. This observer found that marked blowflies could be captured up to ten miles from their point of liberation.

Myiasis: By myiasis is understood the development in man or animals of the larval and pupal stages of dipterous parasites. Such myiasis may be more or less accidental or may be, as in the case of the bot flies, a constant phase in the life history of the particular species of fly. Both the common species of blowfly—*Calliphora stygia* and *C. augur*—may on occasion give rise to accidental myiasis, generally in the nature of the blowing of open wounds. Cases of intestinal myiasis are also known, the fly concerned being *Fannia canicularis*, a common introduced species.

Much more important than these cases of human myiasis is the condition of myiasis in sheep due to infestation mainly of the crutch with one or more of the common blow or blue bottle flies. The condition has become so serious during recent years that considerable economic loss has been occasioned, not only through death of affected animals, but also through deterioration of the wool through constant yarding, etc., for the purpose of jetting and crutching or other remedial measures. In New South Wales a special combined Committee of the Department of Agriculture and the pastoralists has been investigating the condition for several years and experimental stations have been established in various parts of the country, but no certain remedy has been discovered; the best results appear to have been obtained by jetting and crutching under pressure, but this entails constant care and treatment at intervals. Efforts to find a deterrant which would adhere to the sheep for any length of time have met with little success. Attempts have been made to control the fly by means of liberating parasites, notably *Mormoniella brevicornis*, but though success has been claimed in certain districts this has not been the universal experience. More assistance might be obtained by more careful attention to clearing up possible breeding places, particularly of carcasses, refuse around shearing yards, etc. In this connection the flight experiments of Gurney become of importance as showing the extent of country that may be infested by one dead sheep. Some six or more species of fly have been incriminated of attacking sheep, but some are probably merely secondary invaders. The status of *Chrysomyia albiceps*, for instance, as a sheep maggot fly has been disputed, some authorities suggesting that it is predaceous on the larvae of other flies present in the wool. It is probable, however, that this species does actually attack the sheep, though it may also act as a predator.

The *Oestridae* or bot flies are represented in Australia by four introduced and one native species. The habits of the introduced species appear to be identical with their habits in Europe. Further information is, however, required in

respect to the time of the year at which infestation occurs, as, according to information gleaned by Mr. Clunies Ross in Western Australia, this appears to be different in Western Australia from what it is in New South Wales. The one native species, *Tracheomyia macropi*, is an inhabitant of the trachea of kangaroos; only the larval and pupal stages are known; the adult does not appear to have been seen.

Parasitic Flies: The *Hippoboscidae* are represented in Australia by three introduced and a fairly large number of native species, most of which are as yet undescribed. The introduced *Hippobosca equina* and *H. camelina* occur in Western Australia, but are not known to carry any parasitic disease in Australia. Both species are unrecorded from eastern States. The sheep ked, *Melophagus ovinus*, is widely introduced. The native species mostly belong to the genus *Ornithomyia* and are parasitic on birds; there are, however, three or four species of *Ortholfersia* which are parasitic on marsupials (kangaroos and wallabies).

The *Nycteribiidae* or bat flies are represented by a number of species belonging to the genera *Nycteribia* and *Cyclopodia*; the species have recently been monographed by A. Musgrave.

Streblidae are known to occur on Australian bats, but no species have so far been described.

Siphonaptera: Australian fleas have been mainly investigated through the researches of Dr. Karl Jordan and the late N. C. Rothschild. Some 35 species are known, mainly parasitic on native rodents and the smaller marsupials. In many instances the species are not restricted to one host, but may occur on a wide range, including both rodents and marsupials. Bat fleas occur, but have not been thoroughly studied. The *Sarcopsyllidae* are represented by some half-dozen species, including the well known *Echidnophaga gallinacea*, the stick-fast flea which has been the cause of considerable economic loss in poultry in Western Australia. It is generally assumed that this species was introduced into Western Australia, but it was certainly present in that State for several years before it attacked the poultry and it is possible that the species is a native of Western Australia. *E. gallinacea* was originally described from Ceylon, but it was already present as a pest in that country and may well have been introduced from Western Australia. Undoubtedly the home of the genus *Echidnophaga* is in Australia, to judge from the number of species there represented. *E. gallinacea* occurs also in South Australia, but not commonly, whereas in Western Australia almost every animal is affected and even children are attacked.

In addition to the native species of Siphonaptera, several introduced species occur in Australia, of which the most important are the rat fleas, parasitic on the introduced black and grey rats—*R. rattus* and *R. norvegicus*—and in particular the so-called Indian rat flea—*Xenopsylla cheopis*—the vector of plague from rat to rat and from rat to man. The association of this species with the transmission of plague was first suggested by Simond in 1898, but it was Dr. Ashburton Thompson of Sydney who, during the 1900 outbreak, clearly showed on epidemiological grounds that the bubonic plague could be spread only through the medium of such an insect as the rat flea. His conclusions were fully verified experimentally by the Indian Plague Commission, of which Professor C. J. Martin, formerly of Sydney and Melbourne, was a member.

The question of the distribution of *Xenopsylla cheopis* in Australian ports is of some importance. The species is known to occur abundantly on rats in Sydney, Brisbane and other New South Wales and Queensland ports and in Perth, Western

Australia. In Sydney about 45% of the rat fleas belong to this species and it shows a distinct seasonal prevalence, being most abundant during the plague epidemic months, February to May. The species occurs in Adelaide, but I have no knowledge of its relative prevalence; whether it occurs in Melbourne, apart from specimens taken on ship rats, appears uncertain. It seems to be absent from Tasmania. It is noteworthy that Melbourne, Adelaide and Hobart have always escaped infection at times when plague was rampant in other Australian ports. The number of fleas captured from rodents in Sydney is shown on the following table:

TABLE II.—FLEAS FROM RODENTS.
MICROBIOLOGICAL LABORATORY, 1909-1926.

| Name | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 | 1917 | 1918 |
|--|-------|-------|-------|-------|------|------|------|------|------|------|
| <i>Xenopsylla cheopis</i> | 1,191 | 701 | 1,105 | 641 | 213 | 233 | 252 | 300 | 197 | 67 |
| <i>Leptopsylla musculi</i> | 514 | 541 | 1,065 | 442 | 113 | 371 | 156 | 108 | 60 | 63 |
| <i>Ceratophyllus fasciatus</i> .. | 210 | 266 | 375 | 219 | 31 | 94 | 72 | 76 | 57 | 47 |
| <i>Ctenocephalus canis or felis</i> .. | 10 | 8 | 11 | 14 | 3 | 2 | 4 | 8 | 1 | 1 |
| <i>Pulex irritans</i> .. | 1 | 1 | 1 | — | — | — | — | — | — | — |
| <i>Pygiopsylla rainbowi</i> .. | — | — | — | — | — | — | — | — | — | — |
| <i>Echidnophaga myrmecobii</i> .. | — | — | — | — | — | — | — | — | — | — |
| Total | 1,926 | 1,517 | 2,557 | 1,316 | 360 | 700 | 484 | 492 | 315 | 178 |

| Name | 1919 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | Total | % |
|--|------|------|-------|-------|-------|-------|-------|------|--------|---------|
| <i>Xenopsylla cheopis</i> | 64 | 302 | 612 | 1,268 | 895 | 539 | 304 | 331 | 9,215 | 44.55 |
| <i>Leptopsylla musculi</i> | 7 | 202 | 780 | 757 | 672 | 639 | 689 | 362 | 7,541 | 36.48 |
| <i>Ceratophyllus fasciatus</i> .. | 30 | 169 | 503 | 542 | 376 | 284 | 309 | 107 | 3,767 | 18.22 |
| <i>Ctenocephalus canis or felis</i> .. | 1 | 6 | 18 | 29 | 11 | 4 | 2 | 2 | 135 | 0.65 |
| <i>Pulex irritans</i> .. | — | 1 | 2 | 4 | — | 2 | 4 | — | 16 | 0.08 |
| <i>Pygiopsylla rainbowi</i> .. | — | — | — | — | — | 1 | — | — | 1 | 0.005 |
| <i>Echidnophaga myrmecobii</i> .. | — | — | — | 1 | — | — | — | — | 1 | 0.005 |
| Total | 102 | 680 | 1,915 | 2,601 | 1,954 | 1,469 | 1,308 | 802 | 20,676 | 100.000 |

Hemiptera: The great order of the Hemiptera or bugs calls for little mention. The common bed bug—*Cimex lectularius*—is introduced and is now widespread throughout Australia. It is not known to carry any disease in Australia, but its

presence is regarded as evidence of dirty and insanitary conditions. In Australia we are fortunately free from such blood-sucking Hemiptera as *Conorhinus* and its allies, which carry Chagas disease in South America.

Anoptura: The three species of human lice occur in Australia as well as the common lice of domestic animals. The three great louse-borne infections of man—Typhus, Relapsing Fever and Trench Fever—do not now exist in Australia, though it is probable that typhus did occur in the early days of colonization. Reference might be made to the occurrence in recent years of a typhus-like disease in Adelaide. The disease is characterized by many of the features of typhus, though in a milder degree, and the serum of patients gives the typical agglutination reaction with Proteus X19. The disease is probably a member of a group of closely allied diseases which includes typhus. The interesting point from the entomological aspect is that the disease does not appear to be infectious, but is probably conveyed through the medium of some insect, or possibly acarine, parasite; research has, however, failed so far to reveal the mode of transmission. A similar, if not identical, disease has recently been recorded as occurring on farms in the vicinity of Toowoomba, Q., and it is probable that cases elsewhere may have been overlooked or confused with typhoid fever.

Other diseases exist in Australia, of which the aetiology and mode of transmission is still unknown. Some of these may perhaps be insect- or mite-borne. Mention has already been made of short-period coastal fevers in the tropical zone; two other diseases as yet unelucidated might be mentioned—Saronia Fever and Mossman River Fever. The latter at any rate appears to be allied to Japanese River Fever and, like it, is probably carried by some species of mite.

The above review of medical and veterinary entomology in Australia does not pretend to be exhaustive. Ample has, however, been said to show the importance of the subject and something of the problems that still await elucidation.

Hymenoptera: Though not containing any disease-carrying insects, the Hymenoptera (bees, wasps and ants) are of interest to the medical and veterinary entomologist from two points of view—firstly, many of the species will attack human beings, inflicting severe stings; and secondly, several of the smaller Hymenoptera are parasitic on flies of economic importance.

Stings from certain wasps, bees and ants are of common occurrence, but are rarely recorded in medical literature. Cleland, in his paper "On Injuries to Man due to Insects", has collected a number of records. The more common stinging ants belong mainly to the Ponerinae and include bull ants, soldier ants and jumpers. A common stinging species is the greenhead (*Chalcoponera metallica*). Several instances are on record where injured people have been attacked by ants and portions of their faces or limbs eaten away.

The parasitic Hymenoptera of interest to us mostly belong to the Chalcidoidea. *Mormoniella brevicornis* (*Nasonia brevicornis*) has already been mentioned; it is parasitic in the pupae of blowflies and attempts, largely unsuccessful, have been made to control the sheep-blowflies by its use. Other species have been suggested for the same purpose, but have not been tested out on the same scale. Attempts are now being made in Western Australia to establish the English blowfly parasite (*Alysia manducator*). The Australian Hymenoptera have been fairly extensively studied; the wasps by Dodd, Girault, Turner and others; the bees by Cockerell, and the ants by Wheeler. Lately J. Clark, formerly of Western

Australia and now entomologist to the National Museum, Melbourne, has taken up the study of the ants and has published several papers on the Ponerinae.

In conclusion, I desire to express my appreciation of the cordial co-operation accorded me by my colleagues on the council and in particular by the permanent officials—Dr. A. B. Walkom and Dr. G. A. Waterhouse. I also wish to thank Mr. Carter and Dr. Mackerras for their help in revising the manuscript of this address; the latter has been of great assistance in checking all references at a time when I was unable to do so.

The following letter was sent to Their Royal Highnesses the Duke and Duchess of York on the occasion of their visit to Sydney:

“We, on behalf of the Members of the Linnean Society of New South Wales—a Society founded in 1874 to encourage the study of Natural History in Australia—desire to offer to Your Royal Highnesses this brief record of our loyalty to the Throne and of the pleasure evoked by the visit of Your Royal Highnesses as the representatives of our revered Sovereign and Her Majesty the Queen.

May we be permitted to offer our respectful greetings and sincere wishes for an enjoyable visit, and for the welfare of Your Royal Highnesses during your return journey to Great Britain.”

It was with deep regret that we learnt of the death last week of Professor A. A. Lawson, D.Sc., F.R.S., F.R.S.E. Professor Lawson was the first occupant of the Chair of Botany in the University of Sydney, being appointed to that position in 1913, when the Chair of Biology was divided, the late Professor W. A. Haswell remaining as Professor of Zoology. The late Professor Lawson worked hard to bring the School of Botany to its present high state of efficiency and had only recently been elected a Fellow of the Royal Society of London. Professor Lawson was a member of the Council of this Society in the years 1922-1924.

Dr. G. A. Waterhouse, Hon. Treasurer, presented the balance sheets for the year ending 31st December, 1926, duly certified as correct by the Auditor, Mr. F. H. Rayment, F.C.P.A., Incorporated Accountant; 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: Professor L. Harrison, B.A., B.Sc.

Members of Council: C. Anderson, M.A., D.Sc., Professor A. N. St. G. H. Burkitt, M.B., B.Sc., H. J. Carter, B.A., F.E.S., Sir T. W. E. David, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., A. G. Hamilton and A. H. S. Lucas, M.A., B.Sc.

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

The following resolution was carried unanimously: That the members of the Linnean Society of New South Wales assembled at the Fifty-second Annual General Meeting desire to express their warm appreciation of the services rendered to the Society by the retiring President (Dr. E. W. Ferguson) during his year of office and their deep sympathy with him in his long illness and trust that he will make a speedy recovery.

Linnean Society of New South Wales

GENERAL ACCOUNT. Balance Sheet at 31st December, 1926.

| LIABILITIES. | | ASSETS. | |
|---|--------------------|---------------------------------|--------------------|
| £ | s. d. | £ | s. d. |
| Capital: Amount received from Sir Wm. Macleay during his lifetime | 14,000 0 0 | Society's Freehold | 11,000 0 0 |
| Further sum bequeathed by his will | 6,000 0 0 | Investments: Commonwealth Loans | 9,660 0 0 |
| | | Loans on Mortgage .. | 7,188 16 11 |
| Contingencies Reserve | 20,000 0 0 | Cash: Current A/c | 331 3 2 |
| Income A/c at 31st December, 1926 | 8,000 0 0 | Savings Bank | 505 0 0 |
| Fletcher Memorial Fund at 31st December, 1926 | 673 5 1 | In hand | 10 0 0 |
| | 21 15 0 | | 846 3 2 |
| | <u>£28,695 0 1</u> | | <u>£28,695 0 1</u> |

INCOME ACCOUNT. Year Ended 31st December, 1926.

| £ | s. d. | £ | s. d. |
|--|---------------------|--|---------------------|
| To Salaries, Wages and Allowance | 1,008 0 0 | By Balance from 1925 | 170 1 10 |
| " Printing Publications | 657 14 0 | " Subscriptions: 1926 | 158 18 0 |
| " Illustrations | 177 19 2 | Arrears | 17 17 0 |
| | 835 13 2 | In Advance | 2 2 0 |
| " Rates and Insurance | 44 14 10 | Entrance Fees | 178 17 0 |
| " Postage | 7 7 0 | Interest | 10 10 0 |
| " Audit | 30 18 6 | Rents | 1,107 17 5 |
| " Printing and Stationery | 40 9 4 | Sales (including 100 copies of Proceedings purchased by Government of New South Wales) | 591 8 8 |
| " Expenses | 30 1 5 | Fellowships A/c (surplus income transferred) | 181 19 10 |
| " Petty Cash | 1 13 0 | Subscriptions to Fletcher Memorial | 21 15 0 |
| " Repairs | 1 12 2 | | |
| " Bank Expenses | 156 16 3 | | |
| " Legal Expenses | 47 13 9 | | |
| " Typewriter | 20 9 6 | | |
| " Premium on War Loan | 26 17 6 | | |
| " Library and Bookbinding | 98 7 11 | | |
| " Appropriation: Contingencies Reserve | 300 0 0 | | |
| " Balance Fletcher Memorial Fund | 21 15 0 | | |
| " Balance to 1927 | 673 5 1 | | |
| | <u>£3,446 11 11</u> | | <u>£3,446 11 11</u> |

Examined and found correct. Securities produced.
 F. H. RAYMENT, F.C.P.A.,
 Auditor.
 Sydney, 12th February, 1927.

G. A. WATERHOUSE,
 Honorary Treasurer.
 Sydney, 21st January, 1927.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

BALANCE SHEET at 31st December, 1926.

| LIABILITIES. | | ASSETS. | |
|--|--------------------|--------------------------|--------------------|
| | £ s. d. | | £ s. d. |
| Amount bequeathed by Sir Wm. Macleay | 35,000 0 0 | Commonwealth Loans | 8,540 0 0 |
| Surplus Income capitalised | 10,120 0 0 | Loans on Mortgage | 36,580 0 0 |
| | <u>£45,120 0 0</u> | | <u>£45,120 0 0</u> |

INCOME ACCOUNT. Year Ended 31st December, 1926.

| | £ s. d. | | £ s. d. |
|--|-------------------|-------------------|-------------------|
| To Salaries of Linnean Macleay Fellows | 984 8 10 | By Interest | 2,825 6 0 |
| " Fellows' Subsidies | 36 15 0 | | |
| " Capital A/c | 620 0 0 | | |
| " General A/c | 1,184 2 2 | | |
| | <u>£2,825 6 0</u> | | <u>£2,825 6 0</u> |

Examined and found correct. Securities produced.
 F. H. RAYMENT, F.C.P.A.,
 Auditor.
 Sydney, 12th February, 1927.

G. A. WATERHOUSE,
 Honorary Treasurer.
 Sydney, 21st January, 1927.

BACTERIOLOGY ACCOUNT.

BALANCE SHEET at 31st December, 1926.

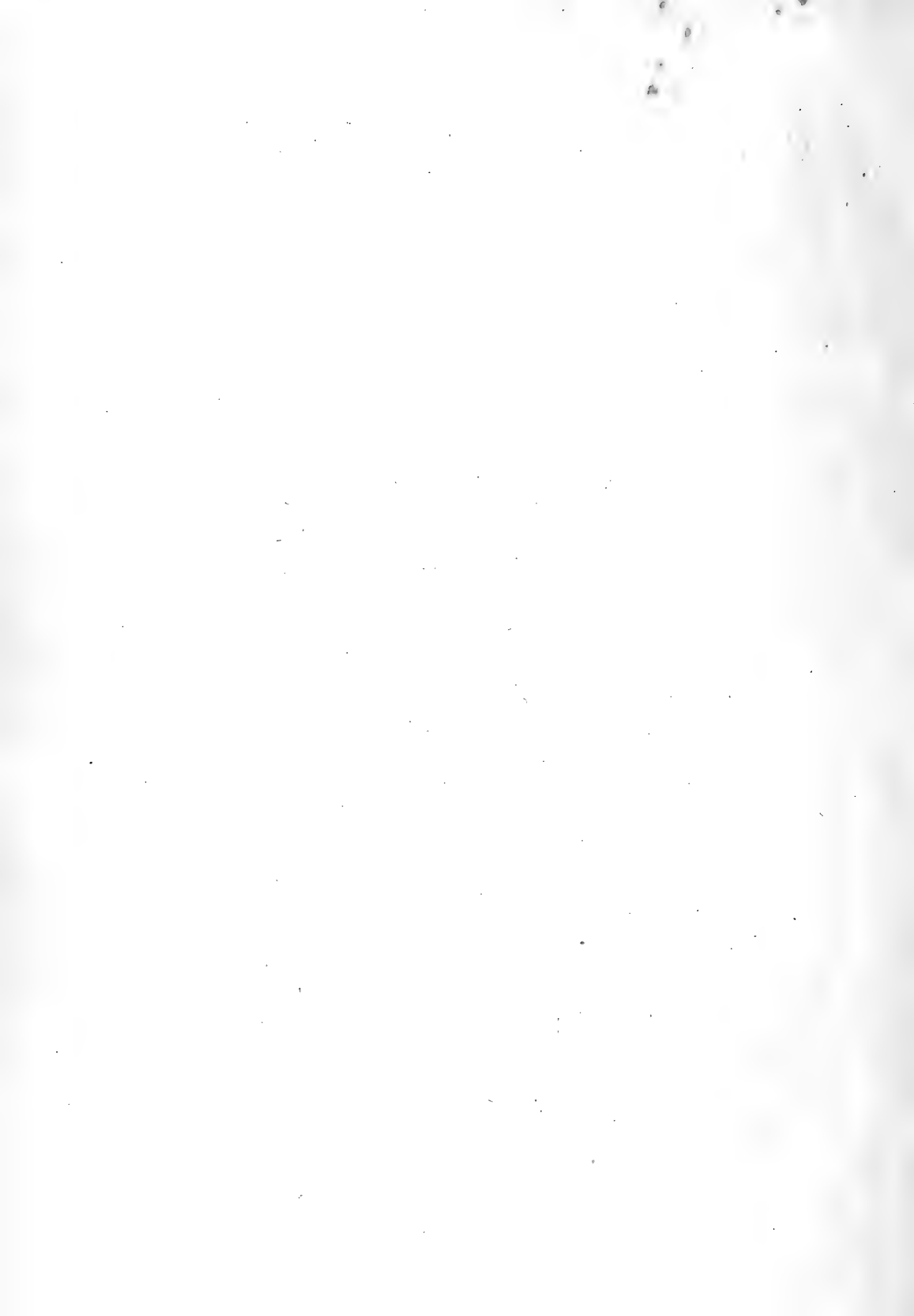
| LIABILITIES. | | ASSETS. | |
|--|---------------------|------------------------------------|---------------------|
| | £ s. d. | | £ s. d. |
| Amount bequeathed by Sir Wm. Macleay | 12,000 0 0 | Commonwealth Loans | 14,800 0 0 |
| Accumulated Income capitalised | 2,000 0 0 | Cash: Commercial Banking Company.. | 109 15 11 |
| Income A/c at 31st December, 1926 | 1,039 12 4 | Government Savings Bank | 123 16 5 |
| | | In hand | 6 0 0 |
| | | | <u>239 12 4</u> |
| | <u>£15,039 12 4</u> | | <u>£15,039 12 4</u> |

INCOME ACCOUNT. Year Ended 31st December, 1926.

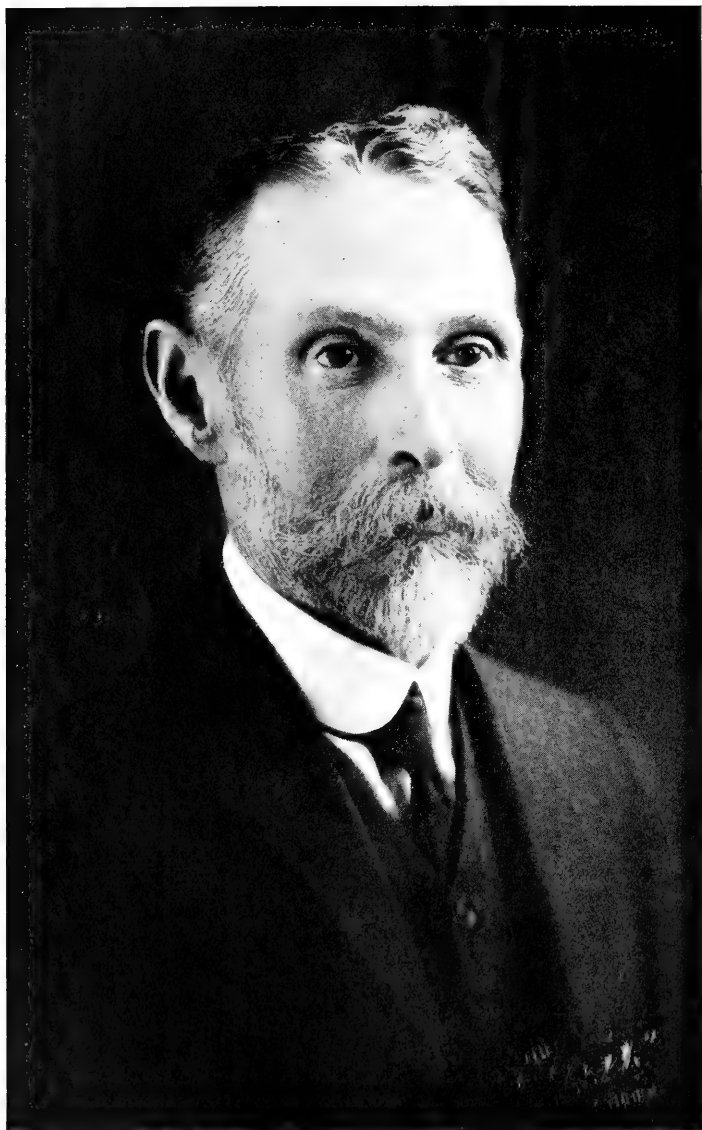
| | £ s. d. | | £ s. d. |
|-----------------------------------|--------------------|------------------------------|--------------------|
| To Salaries and Wages | 604 0 0 | By Balance from 1925 | 926 17 9 |
| " Expenses | 30 3 2 | " Interest | 752 12 1 |
| " Apparatus and Chemicals | 2 7 7 | " Refund Insurance | 1 2 6 |
| " Petty Cash | 9 9 3 | " Tuition Fees | 5 0 0 |
| " Balance to 1927 | 1,039 12 4 | | |
| | <u>£1,685 12 4</u> | | <u>£1,685 12 4</u> |

Examined and found correct. Securities produced.
 F. H. RAYMENT, F.C.P.A.
 Auditor.
 Sydney, 12th February, 1927.

G. A. WATERHOUSE,
 Honorary Treasurer.
 Sydney, 21st January, 1927.







J. J. Fletcher

JOSEPH JAMES FLETCHER.

Joseph James Fletcher was born in Auckland, New Zealand, in 1850. His father, the Rev. J. Horner Fletcher, was then headmaster of what afterwards, under his charge, developed into the "Auckland College". He was both a scholar and a theologian. Later on, for reasons of health, he resigned the headmastership and was appointed to the charge of a church at New Plymouth and, after the outbreak of the Maori War in 1860, was transferred by the Methodist Conference to Australia, first to Brisbane and then to Ipswich, where his son gained a scholarship in the Grammar School. He was then appointed Principal of Newington College Sydney, and there Fletcher passed most of his school days. From school J. J. Fletcher went to the University of Sydney, where he took his B.A. in 1870 and subsequently his M.A. degree in 1876. He does not seem to have distinguished himself especially in the class lists, nor had he the physique necessary for strenuous athletic work, but the following extract from *The Sydney Morning Herald* of January 25, 1868, shows not only that he was a fellow student of men who afterwards held prominent positions in the Commonwealth, but that he must have had qualities that attracted the attention of that fine scholar and experienced Professor, Dr. Badham. It reads as follows: "The Duke of Edinburgh in New South Wales—Dramatic performance at the University. Mr. Cooper's (later Chief Justice of Queensland) impersonation of Phormio was very heartily appreciated and so, too, was the Geta of Mr. (later Sir Edmund) Barton and the Nausistrata of Mr. Fletcher. This gentleman's impersonation of the angry and jealous wife elicited much merriment. Altogether Phormio was a decided success". Writing many years later Fletcher remembers how, "when the play was over and we had been recalled and got our bouquets and as the curtain went down finally, Dr. Badham came up out of the prompter's box and expressed his satisfaction at the way things went off and gave me a word of commendation, having to speak a foreign tongue in a big hall, in a falsetto voice". He adds, "that made up to me for all the grind of rehearsals. I did not get home to Parramatta till after midnight, but I knew that my mother would sit up to hear whether I had got a bouquet and an encore, or had disappointed Dr. Badham". This little episode occurred during his last year at the University. It is perhaps rather difficult to recognize in the ardent naturalist of later years the Nausistrata of "Phormio".

After taking his degree he decided to devote himself to teaching, and accepted a position in Melbourne on the staff of Wesley College, the Headmaster of which was then Professor M. H. Irving, who had resigned the chair of Classics in the University to devote himself to school work. We know little of his work in Melbourne except that, during the time he spent there, he came once more under the influence of the distinguished head of a Public School. It was, however, during this transitional period that he became interested in Natural Science, and, in 1876, he resigned from Wesley College and left for London. This was the time when Huxley was perhaps at his zenith—the year of his famous American addresses. At South Kensington in Huxley's lecture room and laboratory it was possible for a student to listen to the leading exponent and protagonist of the evolution theory, and at the same time gain by practical experience a first

hand knowledge of plant and animal morphology. The latter is now a matter of everyday experience in modern universities, but at that time anything like true biological training was in its infancy. In the South Kensington laboratories Fletcher met and worked with G. B. Howes, who later on succeeded to the Professorship, and Jeffrey Parker, who migrated to New Zealand as Professor of Biology in the Otago University. In those days, when the field of scientific knowledge was comparatively limited, a Chair of Biology included teaching in both Zoology and Botany, mainly from the morphological side. Whilst in England he studied hard and systematically. There was then no such thing as recognition of work done in Australian universities and, in order to gain the B.Sc. of the London University, he had to start again, complete the full three years of work and pass all the examinations necessary for admission to the degree. To start again, however, is perhaps not strictly true because in Sydney, under Dr. Badham, his training, fortunately for himself, had been mainly on the literary and classical side—a training that stood him in good stead in later years. He not only worked in London but came into contact with F. Maitland Balfour, who, at Cambridge, was laying the foundation in England of the science of Embryology. Struck with his keenness and capacity Balfour invited him to visit the University as his guest and there he spent three months amongst a band of students including Milnes Marshall, Haddon, Lister, Adam Sedgwick, McBride, and others who in after years occupied Chairs of Zoology and Biology in many British universities both at home and in the Dominions. It was perhaps the most inspiring and fruitful time in the history of Biological Science. Darwin, Huxley, Hooker and Wallace were all at work, the "Challenger", laden with wonderful material, had returned after its three years' cruise of investigation in southern and tropic seas and in study, field and laboratory scores of eager students, relieved from the dead weight of the special creation theory, were working under the stimulus of an entirely new outlook on the world of life. It is difficult for students of the present day to realize the excitement of those times when everything was new and stimulating and when, further still, it was possible for one man to have a good all round knowledge of, at all events, the salient features of different branches of Science, small departments of which now occupy fully the time of many investigators.

Imbued with the idea that to an Australian the study of problems concerned with the Australian fauna and flora was a duty of paramount importance, he set to work and, before leaving England in 1881, published in conjunction with J. J. Lister who was then a demonstrator in comparative anatomy in the Cambridge University, his first paper entitled "On the conditions of the median portion of the vaginal apparatus in the Macropodidae". The authors based their results upon the scanty material then available in Cambridge and at the Zoological Gardens, London, some of which had already been investigated by workers, such as Owen and Everard Home, with indecisive results. In those days it was almost impossible to devote one's life to scientific work unless endowed with private means, which Fletcher was not. Lack of pence, the attractions of his home country, the hope to be able to do something towards the elucidation of its fauna and flora whilst earning enough by other work to make this possible, drew him back to Australia, where he spent the rest of his life.

Before leaving England, being fully aware of the imperfections of the Australian libraries in regard to scientific literature, he set to work and compiled a "Catalogue of Papers and Works relating to the Mammalian orders, Marsupialia,

and Monotremata". The value of this, in those early days, especially to investigators in Australia, was much enhanced by his inclusion of references to all the new species described since the earlier works of Gould and Waterhouse. This was published in Sydney in 1881. Immediately on arrival in Australia, personally and with the aid of friends up country whom he interested in the work, he collected much more material which served as the basis for further investigations into the structure of the reproductive organs of Marsupials, and for the publication of three additional papers in 1881 and 1883. His first three memoirs embody the results of pioneer investigations into a matter of peculiar interest in regard to the anatomy of Marsupials and are of permanent value. It is much to be regretted that in those days there was no opening in Australia for a young unendowed zoologist. No post was available, either for teaching or for carrying on systematic research under modern laboratory conditions. Fletcher was obliged to return to school work and thus Australia lost the services of one who would have been a brilliant anatomist and an inspiring university teacher had the opportunity presented itself.

He rejoined the staff of Newington College; was acting Headmaster for a short time and then became one of the senior teachers. "As a teacher" says one of his old pupils, Professor Scott Fletcher, now Professor of Philosophy in the Queensland University, he "showed great originality and achieved quite remarkable success. He had his own ideas on the subject of education, and evidently believed that a boy at school should be guided in the development of his moral character as well as taught to acquire knowledge. . . . The roars of laughter that at times rang out from Fletcher's class-room were not only the envy of adjoining "forms" but were ample evidence that the well known austerity of his rule was not unrelieved by a genuinely human touch that stirred both laughter and loyalty . . . his method of imparting knowledge was no less original and effective". This, be it remembered, was forty years ago, before the days of Diplomas in Education, and of attempts to teach teachers how to teach. "He made it a rule", says his old student "never to tell his pupils anything which they could find out for themselves. The spirit of research which he himself had learnt from Huxley he passed on to his successive classes. No matter what the subject was, he set his scholars to work gathering the raw material of fact which his own master-hand was later to round off into systematic knowledge. There is perhaps one word only in which may be summed up both his discipline and his instruction—sincerity. He hated all humbug and shams, but he loved all that is true or beautiful or good in nature, in literature and in human character".

From 1881-1885 Fletcher worked at Newington College, but during these four years two things happened that determined the future course of his life. First, he joined the Linnean Society of New South Wales, and there came into contact with Sir William Macleay, its founder and benefactor, and secondly he married, and in his wife found a companion who, with quiet, ceaseless and unselfish sympathy, devoted herself to him and to his life's work. Those of us who have had the privilege of their private friendship, understand what this meant to him and to us.

These were the early days of the Linnean Society. Macleay was evidently impressed with the enthusiasm and capacity, and probably also, the ideals of Fletcher in regard to Natural History work in Australia, and in 1885 offered him the position of Director and Librarian of the Society. In reply to Fletcher's acceptance of the position, Sir William wrote to him a short but characteristic

note dated April 14, 1885. It runs as follows: "My dear Sir, I was much pleased by your letter of yesterday, accepting my offer re 'Linn. Soc.'. I shall now arrange that the first charge on the £10,000 I leave as an endowment to the Linnean, shall be the salary of the Director, at present I presume my promise will be sufficient security. I hope that the New Year will see our house completed. At all events I should wish your duties to commence then. Yours, William Macleay".

On January 1, 1886, Fletcher entered upon his duties, and henceforth devoted his life to the work of the Society, to the furtherance of the study of Natural History in Australia, and to the carrying out of what he conceived to be the aim and objects of Sir William, and later also of Lady Macleay, with both of whom he always remained on terms of the most friendly mutual trust and confidence, which found expression in their selection of him as executor under both their wills.

From 1886 to 1893 he acted as Director and Librarian; in 1893 the title of his post was changed to that of Secretary in which capacity he acted until his retirement in 1919. He was an ideal Secretary and, if the Society owes the possibility of the present extent of its usefulness to the munificence and public spirit of Macleay it owes almost an equal debt to the loyal and tireless zeal of Fletcher. No task, however great or however small, that he thought touched upon the honour of the Macleays or the welfare of the Society was left undone, no matter what it cost him in time and thought. His width of scientific knowledge, his literary ability, his wonderful acquaintance with work published in regard to Australian Natural History, and the early settlement of the Continent, together with his long practical experience in the field, both as regards Zoology and Botany, were of inestimable value to the Society and its members during the thirty three years in which he held office and, it is not too much to say, largely guided its destinies.

During his term of office he edited thirty-three volumes of proceedings with meticulous care. Every word of every manuscript was carefully read through and even references were verified before it went to the press, often indeed, in the case of younger workers, before it was submitted to the Society, and many of them gladly recognize that they owe him much for hints and suggestions derived from his wide knowledge and experience.

Realizing, so far as he himself was concerned, the urgent need of studying the land and fresh-water fauna before it passed away or became profoundly modified by the opening up of the country and the introduction of alien forms, he decided to work upon such material as he could study during leisure hours without the necessity of recourse to a fully equipped laboratory. He started upon the earthworms, a lowly group about which, in Australia, absolutely nothing was known, though, in Europe, Darwin, in what is now regarded as a classic work, had demonstrated their great practical value to the agriculturalist. From 1886-1894 he published six papers in which he showed the unexpected richness of Australia in this group. He described some seventy new species belonging to nine genera, five of which, as determined by him, were new and confined to Australia. His work was not simply systematic, but included careful field observations in regard to habits and distribution, and the results of anatomical investigation. "On one occasion, when trying to estimate the number of worms in a given area", he says, "when the length of the furrows was 80 yards, I walked behind the plough and counted all the worms I could see, either in the furrows or sticking out of the overturned clods, and I found that for a number of furrows the average number

of worms under these circumstances was about 50 per furrow . . . these would give nearly 10,000 worms to the acre". At the same time he was working, together with Mr. A. G. Hamilton, on the specific identity and distribution of *Peripatus*, and was investigating the Land Planarians, studying them in their living conditions. Of the latter only four species had previously been described, one by Darwin and three by Moseley. Eight new species of *Geoplana* were added and six of *Rhynchodemus*, a genus not before known from Australia.

He then turned his attention to Amphibia, more especially those to be found near Sydney and in the County of Cumberland, where he was able to watch them in their native state. His first paper dealt with their oviposition and habits; the dates and places of spawning; the form of the spawn and the dependence of this, in regard to its developing, upon the nature of the season. He drew attention to the fact that certain species had developed the faculty, some in the adult and others in the larval state, of accommodating themselves to the varying climatic conditions of the dry parts of Australia. To those of us who knew him and his methods of patient inquiry, the following sentences, quoted from one of his papers, explain much. He says: "My most instructive round in one of the suburbs of Sydney included a visit to an old quarry, a brickyard, a deserted tanyard and three waterholes in paddocks used for watering cattle; these five spots were frequented during some period of the year by at least eleven species of frogs". "That our frogs", he says, "aestivate during hot and very dry periods there can be no doubt. During such times one hears no croaking and sees very little or nothing of the frogs, while logs and stones no longer afford sufficient moist shelter. In March, 1885, a very dry month, after just sufficient rain to moisten the ground, hearing croakings emanating from what, under more favourable conditions, is the bed of a pond, I turned up the soil with a stick and soon unearthed half a dozen specimens of *Pseudophryne bibronii* which were in this manner trying to survive the drought. . . . *P. australis* is a lively perky little frog, very partial to damp shelves and cracks in the Hawkesbury Sandstone and breeds earlier. . . . *P. bibronii* on the other hand is much less active, usually makes little or no effort to escape when uncovered in its hiding place, 'shams dead' when placed on its back and falls to the bottom like a stone when thrown into water; I have never found it except on the ground, under stones, logs, etc.; I have found the ova every year for seven successive years, once in April only, thrice in May only, once in June only and twice in both April and June". These records and many others made by Fletcher are reminiscent of the simple observations of a naturalist that, when recorded by White of Selbourne, made him famous. Fletcher learnt to distinguish all the commoner frogs around Sydney by their call. Sitting in the evening on his verandah at Hunter's Hill, enjoying with him the beauty of the fairy like scene of the Parramatta River, framed with the delicate tracery of the trees in his garden, watching the ferry boats gliding to and fro with long reflected lights of white and red and green, he would listen for them, and when, from a pond close by, the shrill piping of the little *Hyla ewingi* was heard, supported later by the slow-timed, dignified croak of its larger relative *Hyla cerulæa* and the calls of two or three other species, he would tell us which note belonged to each. At these times, while we could hear them croaking in the water, he very much enjoyed repeating, by way of warning, a sentence penned and published in an unlucky moment by a well known Professor of Natural Science who had never worked in the field, "In Australia the Hylas inhabit the tops of the lofty gum trees".

He devoted in all seven papers to a careful investigation into the distribution and habits of Australian frogs, and to the descriptions of new genera and species, aided in this and other work by friends such as Messrs. Sidney Olliff, C. T. Musson, W. W. Froggatt, A. M. Lea, A. G. Hamilton, T. G. Sloane and others who recognized in him an ardent naturalist and were themselves as eager as he was to elucidate the Australian fauna. His papers on the Batrachia are not only models of accurate records of distribution but contain valuable original observations, such for example as those on the warning colouration of *Notaden bennettii*, the Catholic frog.

The following, written privately but not published, shows his broad outlook on problems concerned with the origin of the Australian fauna: "I feel satisfied that the Tasmanian frog fauna is the most primitive assemblage of genera and species (i.e. of frogs) we know of and that not only the genera but also the species (with perhaps one or two exceptions) were differentiated in Antarctica. Both in the case of Marsupials (extinct especially) and frogs and other things, I cannot help thinking that there was much more differentiation in Antarctica than we have been disposed to allow. Australia was a residuary legatee but the legacy was of course subsequently increased by endemic differentiation. The chief obstacle in the way seems to be the absence of intermediate forms of so many groups. If the creatures were developed in the centre or on the East Coast (of Australia) from forms which passed through Tasmania and Victoria, where are they now? Or is it that we cannot recognize them when we see them?"

In January, 1900, he presided over the Biology Section at the Melbourne meeting of the Australasian Association for the Advancement of Science, and chose for the subject of his address "The Rise and early Progress of our knowledge of the Australian Fauna". He devoted to its preparation all his spare time during the preceding eighteen months. "I can promise you", he writes, "that there is one President with his coat and weskit off and his pantaloons tied round with string just below his knees—mentally perspiring—I hope to some purpose, if there were not about 1,500 books that I want to see and don't know how to find". The result was the compilation of a record of great value to all students interested in the historic aspect of Natural History in Australia. "I have often", he says, "wondered why no one seems to have attempted an historical sketch of the Fauna such as I contemplated. Idiot that I was and am, I attempted to step into the breach. Already I am wiser and sad and no longer wonder . . . the history of the collections is most lamentably and grievously and sorrowfully depressing. . . . The collectors (in Australia) were full of enthusiasm, but the British zoologists did not come up to the scratch. One is reminded of poor old W. B. Clarke taking home his fossils—hawking them round the United Kingdom, going down on his knees, begging and praying the British Palaeontologists to describe them—getting nothing but kicks and cold shoulders. Determined to get them worked up, he at last carts them off to Belgium, to De Koninck, who helps him out of the difficulty".

In 1893 he edited the Macleay Memorial Volume, containing thirteen papers on zoological, botanical and ethnological subjects, written by Australasian workers, and himself contributed the biographical sketch. Writing in September of that year he says: "We have got to the end of the lane at last, and the volume will be published next week. I cannot say that I am proud of the sketch or that it does justice to the theme. It cost an awful lot of trouble but the absence of journals, letters and documents of that sort and the non-survival of hardly a contemporary

with anything but shadowy recollections left me with but a small basis to work on”.

Times were then very straightened, financially, for the Linnean, as for all other scientific societies in Australia, and he writes: “The situation at present may be summed up in very few words—we hope soon to sell more copies and in the meantime we have got an overdraft”. The latter caused him much anxiety. His whole life was centred in the Society: indeed he was quixotic in a way that sometimes made it difficult for his colleagues on the Council to help him as they were only too anxious and ready to do.

The following years were filled with routine work, and the endeavour to deal with and solve, in a way satisfactory to the Society and in accordance with the intentions of Sir William Macleay, serious legal and financial difficulties that arose in connection with the foundation of the Research Fellowships and the appointment of a Bacteriologist. During all this time, however, he was working whenever opportunity offered, in close contact with friends and colleagues in the Society—J. H. Maiden, A. H. S. Lucas, R. H. Cambage, H. J. Carter, C. T. Musson, Henry Deane and others—each of whom was interested in some special branch but recognized in Fletcher a naturalist of broad outlook and wide sympathies.

As time passed by he found it increasingly difficult, as a private worker with no laboratory or assistance, to indulge in the rather expensive hobby of collecting and maintaining a “spirit” collection that required constant supervision, and therefore he devoted his energies more and more to botanical work, and to the study of certain characteristic features of the Australian flora. Mr. C. T. Musson, his friend and companion on many expeditions, in collaboration with whom he worked for many years, says: “of late his time was chiefly devoted to Botanical matters. He was especially keen about native things, the sandstone plants coming first. He was always emphasizing the fact that this was a dry country and that the plants had to be prepared, even down to the water’s edge for droughty conditions. The amount of detail he got together when studying a subject was remarkable. To give an example, when working at a *Grevillea*, he covered 50 or 60 quarto sheets with detail, hundreds of figures merely dealing with lobing of the leaves. . . . His knowledge of the literature of our Fauna and Flora was profound and his memory extraordinary”. During his work on Australian *Acacia* phyllodes, the results of which were published in his Presidential Address in 1920, he brought together, as every naturalist visitor to his house knew well, a vast amount of material in specimens and notes. These led him eventually to the conclusion that “The so-called phyllodes of the Australian phyllodineous *Acacias* are not simply flattened petioles which have lost their blades . . . on the contrary they are the flattened primary leaf axes or common petioles of bipinnate leaves which have lost their pinnae. . . . I propose to call them *Euphyllodia* or *Euphyllodes* in the sense that they are something more than is implied in the accepted definition of phyllodes”.

Another important piece of work was carried out in conjunction with Mr. Musson on shoot-bearing tumours of *Eucalypts* and *Angophoras*, published in 1918. Mr. Musson writes: “About eighteen years ago during a walk at the Hawkesbury Agricultural College, we met with an extensive crop of seedlings of *Eucalyptus sideroxylon*. On digging some up Fletcher remarked, on observing the remarkable woody growths at the base of the stem, ‘A mallee in miniature’. In their joint memoir the tumour was shown to originate in the axil of the cotyledons, or in a few pairs of leaf axils immediately above them, from proliferating cambium

material. The late Mr. J. H. Maiden first suggested a bacterial origin and in this conclusion the authors concurred, the tumours, according to them, being due to infection by some parasitic soil organism. In some species, spoken of as 'refractory', the growth slows down, a mild attack runs its course without injury to growth. In the mallee gum the concrescence of the nodular growths is complete; they enclose the tap and other roots and intercept water that they contain at the expense of the seedling stem; the so-called 'mallee root' is not a root, but, in its extreme form, a great tumour, from which apparently, though in reality only enclosed by it, stems and roots arise".

A very characteristic sentence in one of his letters shows the way in which he thought about such problems: "When the mallee scrubs have been cleared away what are the soil organisms going to do? Are they going to send in their resignations and die out, or are they going to adapt themselves to attacking the introduced plants that have supplanted them?" After referring to Fletcher's work on *Grevillea* hybrids, for which he had fortunately prepared notes sufficient to allow of its completion by Mr. Musson, the latter says: "He took his last walk with me a fortnight before passing away. We sat in the park near the beautiful Gordon Gully, and discussed various matters, chiefly dealing with Nature he loved so well".

The secretarial work of the Society, made even unnecessarily arduous by his personal supervision of the minutest detail, began to tell upon him. Writing at the close of 1918 he says: "I have not had a holiday since Easter, 1915, and my eyes and brain are very tired, and I am retiring from the Linnean on 31st March, 1919, and have enough proof and indexing to keep me busy, so I enjoyed a week's loaf visiting my *Grevillea* hybrids. . . . I began to realize that thirty-three years was going to be about as much as was good for me. So I decided to give notice of my retirement. . . . I am normal again and looking forward to finishing up properly, to leaving my work up to date and then having a holiday". He then refers appreciatively to the generous treatment accorded to him by the Council; he himself, with characteristic modesty, had asked for a year's retiring allowance.

At the general meeting in March, 1919, the President, Professor H. G. Chapman, expressed the deep appreciation of the Society of the distinguished services that he had rendered to it. "No Society", he said, "has received better service than that given by our Secretary. The welfare of our Society has been the sole care of his industry". Dr. T. Storie Dixon, an old friend and past President who had known Sir William Macleay in the early days, referred to the Secretary's loss as in many ways irreparable, especially by reason of the complete understanding that existed between him and the founder in all matters concerning its policy. Mr. A. H. S. Lucas, another past President, old friend and companion in the field, handed over to the President a portrait to be hung in the Hall; Mr. C. Hedley on behalf of the members presented a desk and chair to him, whilst others bore testimony to the services rendered not only to the Society but to themselves personally in connection with their work. To one of Fletcher's retiring disposition it was a rather trying ordeal but he felt deeply the genuine expressions of appreciation and gratitude. He writes: "My comrades gave me a very cordial and handsome send-off . . . half a dozen speeches and a resolution passed. The warmth and enthusiasm of the proceedings fairly astonished me as I had no knowledge beforehand of this part of the ceremony (referring to the desk

and chair) and they pretty nearly knocked me off my perch, but I managed to hang on and say what it was needful for me to say without being overcome".

He was elected President for the years 1920 and 1921. In his first address he dealt with the two main forms of climatic conditions with which men on the land are concerned. He pointed out that the man in the northern hemisphere has learnt his lesson and can live in harmony with his environment. The winter conditions when he must house and feed his stock are so regular that he can arrange his programme by the almanac. The man in Australia has yet to learn how to adapt himself to Nature's second method for giving the land its needed rest and sweetening by means of what he aptly called a periodic "drought sleep". We have manuals of Faunas and Floras, of fodder grasses and minerals and so on, but how is it, he asked, that we have no manual of drought problems to teach man how, with the aid of knowledge gained from scientific investigation, to insure against damage by drought. In this address he included as a supplement the results of his research, spread over many years of field work, into the so-called *Phyllodes of Acacias*.

At a special general meeting held in June, 1920, to commemorate the centenary of the birth of Sir William Macleay, he delivered an address on "The Society's Heritage from the Macleays". In regard to this he wrote: "I will show my Macleayan things that I am using as the basis for my address for William Macleay's centenary on June 13th next. Some original drawings of Lewin, W.S.M.'s (William Sharp Macleay) original sketches, one of 'an animal caught by Mr. Huxley in the tow net in Torres Straits', portraits, letters, etc. Lady Macleay gave me these when she went to England about 25 years ago. I looked over them, saw they were interesting, locked them up, wondering how I could use them. Now I know what they are and what they mean, and I am up to my neck in it. When I was proposed as President I did not want it. Then I thought of the centenary and how I could use the material for an address—"The Society's Heritage from the Macleays'." The address, which occupied 68 pages of the Proceedings, contains a most valuable record of the lives and work of the three senior members of the family, Alexander, William Sharp, and Sir George Macleay; of the collections they brought together; of their scientific contemporaries; of their 97 years' connection with the parent society in London; of their 51 years' connection with the Australian Museum. It might more correctly be entitled: "Australia's Heritage from the Macleays". It was only his inside knowledge of the family, gained as the result of the complete trust placed in him by Sir William and Lady Macleay, who gave him access to their private journals and papers, that made it possible for him to compile such a valuable historical record of early days not only of the Society but in the Colony. The most pleasing feature to him was the presence of Admiral Dumaresq, of H.M.A.S. "Melbourne", then in Sydney, a grandson on his mother's side of Alexander Macleay. The Admiral was deeply interested in the relics shown, and at his invitation Fletcher spent some interesting hours with him on his Flagship, showing him letters and papers and discussing the early days of the Macleays, within sight of the ancestral home garden at Elizabeth Bay.

In his Presidential Address for 1921 he referred to a subject in regard to which he felt very keenly, that a grave injustice was being done to the memory and generosity of the Macleays, and to the public interested in Natural History. Under the heading of "Is all well with the Macleay Museum at the University?" he certainly showed that it was far from well and that the University was not either in letter or in spirit carrying out its share of the bargain. It was the only time

Fletcher entered into a newspaper controversy, but he felt that "one of Sir William's great enterprises, potentially so fructifying, if properly managed has become bankrupt", and he was quite right. When it was over he wrote, "very busy and very tired and in need of a holiday. At all events what I have done I have done from a sense of duty".

During his thirty years at Elizabeth Bay he had accumulated a very valuable collection consisting especially of marsupial material, amphibia, earthworms, and *Peripatus*. It included all the material upon which his zoological work was based. In 1923 he spent months in overhauling, rearranging and labelling it and finally presented everything to the Australian Museum. It pained him not to be able to present it to the Macleay Museum, but he was not prepared to place it, as he wrote rather scathingly, "in a room, placed under an iron roof, no blinds to the windows, the curator not a zoologist".

After retirement from active work at Elizabeth Bay he spent his spare time in carrying on botanical work on Acacias, Grevilleas, and Loranthaceae, often again in company with Linnean friends of long standing—Messrs. J. H. Maiden, R. H. Cabbage, G. H. Halligan and C. T. Musson. Especially was he fond of exploring botanically the Hawkesbury sandstone and rarely missed a weekly tramp along the upper reaches of Lane Cove, the beauty of which, as seen in later years, from his own verandah, was a never failing source of pleasure by day and night. He writes in 1922, when he was a free man, "Of late the sunsets, sunrises, golden smokes, golden mists and reflections have been particularly beautiful. It is true that more and more houses are going up, and more and more bush is going, but I return thanks daily that though A may own this bit of ground and house, and B that bit, yet none of them, nor all of them own the Lane Cove, or the reflections, or the landscape".

He naturally felt the removal of the Linnean offices to the new premises in College Street, and whilst it was in progress wrote: "Before the Society can vacate Elizabeth Bay and remove the Library, a new one will have to be built. Then, if possible, the Bay property will be offered for sale. You can imagine what a wrench all this is and promises to be to me. It will certainly be more convenient for members and for meetings and is perhaps to be regarded as inevitable, but it is a little sad for the small remnant of the old brigade to cut ourselves adrift from the memories and traditions of the bit of the old historic garden and our associations with Sir William, and the old surroundings".

As the result of an accident four years ago he was forced to abstain from anything like strenuous exertion, though still retaining his association with the Society, and keen interest in his own work and that of his friends, who looked forward to his being able to enjoy some years of well earned rest in surroundings that appealed to him, both because of their scientific interest and of their beauty. But it was not to be, and on Saturday, May 15, 1926, without any warning, he passed away suddenly. It may be truly said that he lived for the Society and the carrying on of the Macleay tradition and, as the resolution of the Council records, "happily lived to see its present high position with an already honoured tradition behind it and an ever increasing activity in scientific research of the highest standard well established and portending a prominent future, with which his name will ever be inseparably associated".

ABSTRACT OF PROCEEDINGS.

SPECIAL GENERAL MEETING.

30th MARCH, 1927.

Mr. A. G. Hamilton, Vice-President, in the Chair.

Pursuant to notice the Honorary Treasurer moved the following addition to Rule vi: The Honorary Treasurer is authorized to accept from any ordinary member, who is not in arrear, the sum of Fifteen Guineas in lieu of further annual subscriptions.

The motion was seconded by Professor Harrison and carried unanimously.

ORDINARY MONTHLY MEETING.

30th MARCH, 1927.

Professor L. Harrison, B.A., B.Sc., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (24th November, 1926) amounting to 61 Vols., 603 Parts or Nos., 24 Bulletins, 12 Reports and 14 Pamphlets, received from 160 Societies and Institutions and 7 private donors were laid upon the table.

PAPERS READ.

1. Notes on Australian Diptera. No. x. By J. R. Malloch. (*Communicated by Dr. E. W. Ferguson.*)
2. The Anatomy of *Cheilanthes vellea*. By May M. Williams, M.Sc., Linnean Macleay Fellow of the Society in Botany.
3. A New *Deltopecten* from the Illawarra District, N.S.W. By John Mitchell.
4. The Fossil Estheriae of Australia. Part i. By John Mitchell.
5. The Geology of the Country between Lamb's Valley and the Paterson River. By G. D. Osborne, B.Sc.
6. Note on a Dicotyledonous Fossil Wood from Ulladulla, N.S.W. By C. Barnard, B.Sc.
7. On a Case of Natural Hybridism in the Genus *Grevillea* (Proteaceae). By C. T. Musson and the late J. J. Fletcher, M.A., B.Sc.

NOTES AND EXHIBITS.

Miss H. Claire Weekes, B.Sc., Linnean Macleay Fellow of the Society in Zoology, contributed a preliminary note on placentation in some lizards. Definite placentation amongst lizards has been described in *Chalcides tridactylus* and *C. ocellatus* by Giacomini (1891) and (1906) respectively; in *Tiliqua scincoides* by Flynn (1923); and in *Lygosoma (Liolepisma) entrecasteauri* by Harrison and Weekes (1925).

The occurrence of omphaloplacentation and allantoplacentation in the Scincid lizards *Lygosoma (Hinulia) quoyi*, *Egernia whitei* and *E. striolata* and of

omphaloplacentation in *T. scincoides* is here recorded for the first time. In *Hinulia quoyi* the allantoaplacentation is highly specialized. In the classic *C. tridactylus*, *T. scincoides* and *L. entrecasteauxi* the foetus obtains its food from the parent by means of the glandular activity of the modified uterine epithelium and the absorbing and phagocytic powers of the enlarged chorionic ectoderm cells. In other words it is the epithelial tissues which play the important part in food transition. In *H. quoyi* the epithelial tissues partly degenerate and there is a concentration of maternal and foetal capillaries in close apposition. Hence it can be stated that the type of allantoaplacentation found in *H. quoyi* more closely resembles that found in the Marsupialia than does any hitherto recorded in a Reptile. In *E. whitei* and *E. striolata* the allantoaplacentation resembles that of *H. quoyi* but offers sufficient variation to be of interest.

Detailed accounts of these phenomena are in course of preparation.

SPECIAL GENERAL MEETING.

27th APRIL, 1927.

Professor L. Harrison, B.A., B.Sc., President, in the Chair.

The minutes of the Special General Meeting of 30th March, 1927, were read and confirmed.

The President pointed out that the addition of Rule vi as carried and confirmed at the Special General Meetings provides for Life Membership of the Society.

ORDINARY MONTHLY MEETING.

27th APRIL, 1927.

Professor L. Harrison, B.A., B.Sc., President, in the Chair.

Mr. W. A. L. Bredero, Orange, Mr. T. G. Campbell, Manly, Mr. W. Dixon, Killara, Miss M. L. Garde, Neutral Bay, and Mr. K. C. Richardson, B.Sc., Sydney, were elected Ordinary Members of the Society.

The President announced that Messrs. A. F. Basset Hull, R. H. Cambage, C.B.E., F.L.S., H. J. Carter, B.A., F.E.S., and Dr. E. W. Ferguson had been elected Vice-Presidents; and Dr. G. A. Waterhouse, Hon. Treasurer for the Session 1927-28.

The President drew attention to the Fourth International Congress of Entomology to be held at Ithaca, New York, in August, 1928.

The Donations and Exchanges received since the previous Monthly Meeting (30th March, 1927) amounting to 7 Vols., 71 Parts or Nos., 7 Bulletins, 2 Reports and 3 Pamphlets, received from 52 Societies and Institutions and 3 private donors were laid upon the table.

PAPERS READ.

1. Two New Species of *Setaria* from Western Australia. By A. S. Hitchcock. (Communicated by Mr. W. M. Carne.)
2. The Influence of certain Colloids upon Fermentation. Parts iv, v and vi. By R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.
3. Notes on Australian Mosquitoes (Diptera, Culicidae). Part i. The Anophelini of the Mainland. By I. M. Mackerras, M.B., Ch.M., B.Sc., Linnean Macleay Fellow of the Society in Zoology.
4. The Physiographic and Climatic Factors controlling the Flooding of the Hawkesbury River at Windsor. By Lesley D. Hall, B.Sc.

NOTES AND EXHIBITS.

Mr. C. T. Musson exhibited specimens of the common introduced snail *Helix aspersa* from Gordon, Sydney, and also for comparison specimens from England. He remarked that he could see little difference in their texture.

Mr. John Mitchell exhibited a very small cylindro-conical stone from an aborigines' camp and workshop on the seashore south of the Bellambi jetty. In general contour it resembles the stones of this character obtained from the western parts of New South Wales, but differs from all of these in its small size (four inches long) and from most of them in being smooth and having a rounded base (*Mem. Geol. Surv. N.S.W., Ethnol. Ser. No. 2*). The stone in question, it is plain, has been made from a thin pebble of some igneous rock, ground into its present shape. It is sub-two-sided; one side is flat, the other convex; each end is rounded. He was not aware of any previous reference having been made to the discovery of a similar stone fashioned by the aborigines of the east coast of Australia.

Mr. J. Mitchell also exhibited a fragment of fossil fish belonging to the genus *Elonichthys*, recently obtained by him from the insect beds near Belmont, N.S.W. Very few fossil fish have been found in the Newcastle Coal Measures. The first was *Urostheneus australis* Dana; the next was not found till 1912, when he secured a few specimens, and now the present specimen. The latter specimens belong to the genus *Elonichthys*, which seems to be the genus best represented in the Newcastle Coal Measures.

ORDINARY MONTHLY MEETING.

25th MAY, 1927.

Professor L. Harrison, B.A., B.Sc., President, in the Chair.

Mr. J. W. F. Armstrong, Bogan River, N.S.W., and Mr. C. G. Oke, St. Kilda, Victoria, were elected Ordinary Members of the Society.

The President announced that a movement had been started to provide a suitable memorial to the late Professor A. A. Lawson, the first Professor of Botany in the University of Sydney.

The President announced that the Society had that day vacated the Hall at Elizabeth Bay which it had occupied since 2nd January, 1886. The Library had been removed to the Macleay Museum, University of Sydney, where it would remain until it could be housed in its new home.

The Donations and Exchanges received since the previous Monthly Meeting (27th April, 1927) amounting to 25 Vols., 370 Parts or Nos., 31 Bulletins, 7 Reports and 19 Pamphlets, received from 73 Societies and Institutions and 2 private donors were laid upon the table.

PAPERS READ.

1. The Interpretation of the Radial Field of the Wing in the Nematocerous Diptera, with Special Reference to the Tipulidae. By C. P. Alexander. (*Communicated by Dr. E. W. Ferguson.*)
2. New Gall-forming Thysanoptera of Australia. By Dudley Moulton. (*Communicated by Mr. W. W. Froggatt, F.L.S.*)
3. Note on Reproductive Phenomena in some Lizards. By Miss H. Claire Weekes, B.Sc., Linnean Macleay Fellow of the Society in Zoology.

4. An Ecological Study of the Flora of Mt. Wilson. Part iv. Habitat Factors and Plant Response. By J. McLuckie, M.A., D.Sc., and A. H. K. Petrie, M.Sc.

NOTES AND EXHIBITS.

Mr. David G. Stead referred to an extraordinary occurrence of large sharks in the following note: Several species of large sharks are known to occur in Port Jackson. Some of these penetrate but a short distance from the sea and only one kind travels far up into the head waters. On the 24th instant a launch party under the charge of Mr. Charles Messenger was fishing along the eastern channel of the harbour entrance when they met with a large school of sharks. Eight of these were captured and were seen by me to-day. They were all of the species *Carcharinus brachyurus* Gunther, the Whaler or Mullet Shark, and ranged in size from about 7 feet 6 inches to 10 feet. Apparently all of those present in this school were of the same species. This appears to be the first record of the occurrence of the Whaler in school formation. Both the Grey Nurse, *Carcharias arenarius* Ogilby (with which the present specimens were confused in the daily press accounts) and the well-known Blue Pointer are known to occur in very large schools on "outside" grounds, but the Whaler is usually more diffused—existing singly or in pairs (♂ and ♀). Mr. Messenger, who is a highly experienced shark catcher, is of the opinion that had several boats been present not less than one hundred sharks might have been taken. The Whaler is the most dangerous of our man-eating sharks, penetrating our estuaries, even up into fresh water. It commonly attains to 10 feet in length and is of great girth. The occurrence of this large school of Whaler sharks is probably an aftermath of the schooling season for Sea Mullet, *Mugil cephalus* Linnaeus.

Dr. C. Anderson communicated the following note:—At a meeting of this Society held on 27th June, 1888 (These PROCEEDINGS, 1888, p. 894), Dr. J. C. Cox exhibited "a Tertiary fossil from Wildhorse Plains, which he believed to be identical with *Thylacodes decussatus* Gm., a living Port Jackson species"; this name is synonymous with *Vermetus decussatus*, a marine mollusc with a vermiform shell. By some unfortunate mistake this note led to the tentative recognition of a new genus of fossil marsupial, ? *Thylacodes* Cox, which is listed in Roger's "Verzeichniss der bisher bekannten fossilen Säugetiere" (*Ber. d. naturw. Verh. f. Schwaben u. Neuburg*, Augsburg, 1896) in the family Phalangistidae, and in Trouessart's "Catalogus mammalium tam viventium quam fossilium" (Vol. II, 1898-9, p. 1156) in the family Phalangeridae, sub-family Thylacoleontinae, along with *Thylacoleo carnifex* Owen, the so-called Marsupial Lion. In the Supplement to this latter work (1904-5, p. 846) this curious mistake is repeated but the sub-family is transferred to the family Dasyuridae.

ORDINARY MONTHLY MEETING.

29th JUNE, 1927.

Mr. R. H. Cambage, C.B.E., F.L.S., Vice-President, in the Chair.

The Chairman offered the congratulations of the Society to Dr. W. G. Woolnough on his appointment as Acting Federal Geologist.

The Chairman announced with pleasure that the Government had recently issued a Proclamation protecting certain of the wild flowers.

The Donations and Exchanges received since the previous Monthly Meeting (25th May, 1927) amounting to 21 Vols., 106 Parts or Nos., 7 Bulletins, 7 Reports

and 2 Pamphlets, received from 69 Societies and Institutions and 2 private donors were laid upon the table.

PAPERS READ.

1. The Gasteromycetes of Australasia. vii. The Genera *Disciseda* and *Abstoma*. By G. H. Cunningham.
2. The Gasteromycetes of Australasia. viii. The Genus *Mycenastrum*. By G. H. Cunningham.
3. Additional Flora of the Comboyne Plateau, 1926. By E. C. Chisholm, M.B., Ch.M.
4. Further Notes on a new Classification of Australian Robberflies (Diptera, Asilidae). By G. H. Hardy.
5. The Phylogeny of some Diptera Brachycera. By G. H. Hardy.

NOTES AND EXHIBITS.

Mr. A. J. Nicholson exhibited from the Macleay Museum Collection a bilateral gynandromorph of the butterfly, *Papilio androgeus* from S. America.

Mr. A. Musgrave exhibited, from the Australian Museum Collection, a remarkable aberration of the female of *Papilio aegeus* from New South Wales. In the specimen the red spots on the hindwing were much enlarged and drawn out to about four times their usual size.

Dr. G. A. Waterhouse exhibited the following butterflies: (1) Mosaic gynandromorphs of (a) *Troides priamus pronomus* from Cape York in which the female markings predominated, (b) *Papilio aegeus ormenus* from Darnley Is. showing about equal proportions of male and female markings; (2) specimens of *Papilio oregon* from Santa Cruz Is. recently caught by Messrs. E. Le G. Troughton and A. A. Livingstone, and suggested that as they resembled *Papilio aegeus* from Eastern Australia so closely, they may have been introduced into the Santa Cruz Group.

Dr. Waterhouse also exhibited fossils from Brookvale, near Manly, consisting of *Esteria coghlani* and a beetle. The latter, the first record of a beetle from the Quarry, was recently found by Mr. W. H. Hatcher.

Mr. David G. Stead exhibited two extraordinary fishing lines: (1) A crocodile line as used by the Malays of the Malay Peninsula, Southern Siam, Sumatra and Borneo, for the capture of the short-snouted crocodile (*Crocodilus porosus*). The line itself is formed of a thin, strong *rotan* (Mal.) cane, to which the unusual hook is fastened—by the middle of the shank—by means of a multi-strand snood of ramie fibre. The strands of the snood are quite separate so as to prevent the crocodile from biting through the line, which becomes entangled in the teeth. After the crocodile swallows the baited hook, the tension of the line on the middle of the hook causes it to lie right athwart the gullet. (2) A baitless and barbless hooked fishing line, known as *rawai* (Mal.) used for the capture of sharks and rays and great eels by Chinese (Hokkien) fishermen. The line is set chiefly at the edge of tidal flats on muddy and sandy bottoms.

Mr. E. Cheel exhibited specimens of *Eremophila longifolia*, infested with the aecidial stage of a rust-fungus (Uredineae) collected at Thackaringa, Broken Hill, by Mr. A. Morris. The cylindrical orange-red coloured pseudoperidia with white tips somewhat agree with those described as *Roestelia polita* by Berkeley which according to McAlpine (Rusts of Australia, p. 98) is an *Uromyces*. The only record so far as he could ascertain of a Myoporaceous plant being found infested with

a "rust-fungus" is that of Cunningham (*Trans. N.Z. Inst.*, 1924, p. 35) on *Myoporum laetum*.

Mr. A. F. Basset Hull exhibited 103 examples of 40 species, 23 genera of abnormal Loricates, showing specimens having 5, 6, 7 and 9 valves; others with damaged and repaired valves, or with one side repaired, and the aperture on the other side closed by enlargement of the adjoining valve. The greater number of these had been obtained since his exhibit before the Society in May, 1925.

Dr. I. M. Mackerras exhibited a series of Diptera Brachycera, showing South American affinities.

Mr. R. H. Cambage recorded a series of flights of the flying squirrel *Petauroides volans*, which in six successive glides covered a distance of 590 yards. A resident at Milton, in the 'seventies, while near his house in the twilight, saw a squirrel leave the top of a *Eucalyptus* tree 100 feet high and glide to the foot of another 70 yards away. This it immediately climbed and from its summit glided to the next at 80 yards. It lost no time in ascending three more trees at distances of 110, 120 and 90 yards apart respectively, and from the top of the last it glided to another 120 yards away, which it climbed and in which it remained, this evidently having been its objective. While climbing the trees it uttered its peculiar squealing call notes as if to give a friendly warning of its approach to any of its kindred that might be in the tree. It is possible the squirrel landed on the ground a few yards short of some of the trees, but its total journey of a third of a mile shows that these nocturnal marsupials may wander a considerable distance from their homes to which they return by the morning.

Archdeacon F. E. Haviland exhibited a device for use in centering and mounting microscopic objects. It consists of a wooden slab recessed, into which fits a brass slab with a central hole and recessed for cover glasses. It is claimed that the object is held in its intended position on the slide and air bubbles are avoided.

Mr. G. P. Whitley exhibited specimens of the Surf Fish, *Iso rhotophilus*, collected by Messrs. F. A. McNeill and A. A. Livingstone at Long Bay baths on 5th May, 1927.

These fishes, which live in the outer breakers of the surf, occurred in thousands in the baths, where they had evidently been stranded after the Easter cyclone. Numerous isopod parasites were clinging to the fishes or swimming freely amongst them, whilst some copepods were netted with the fishes, and had evidently become detached from them. These crustaceans have been identified by Mr. H. M. Hale as: One young female *Irona*, five stages of juvenile Cymothoid isopods, and numerous *Caligus* sp. The collectors noticed some of the fishes in a school turning sideways and sinking to the bottom, where many were eaten by rock-pool fishes.

Subsequent observations made at intervals by Mr. Whitley showed that the turning of apparently sickly fishes was not usually performed by those carrying parasites, and that taken as a whole the fishes fell on their left or right sides, but single specimens turned to right or left consistently. The reason for this action is still unknown. The fishes were plentiful until the end of May, but on 5th June, practically all had disappeared. The majority probably returned to the ocean in the waves which had broken over the baths during the stormy weather meanwhile.

X-ray photographs of three specimens, made by Surgeon Lieut.-Commander W. E. J. Paradise, R.A.N., were also shown. The vertebrae numbered 13 + 29 to 30

(excluding hypural). *Iso flos-maris*, known in Japan as the "Flower of the Wave," has 18 + 25 (Jordan and Starks).

Dr. McLuckie exhibited specimens of Chert obtained from the Rhynie Chert bed, Scotland, discovered in 1913 by Dr. Mackie, containing the petrified remains of very simple early Devonian plants. Fragments of the plant remains, sections and photographs of sections were also exhibited. The fragments had been separated from the main Chert mass by heating and suddenly cooling in cold water. He gave a brief account of the plant remains petrified in this Chert, discussing the extremely simple vascular structure and organization of *Rhynia* and *Hornea* which were leafless and rootless. Absorption from the soil was carried on by the rhizoids which develop from the creeping rhizome. The aerial branches forked, bore stomata (and probably chlorophylliferous tissue) and terminal sporangia, and had a very simple organized central vascular cylinder, consisting of spiral or annular tracheids.

In *Rhynia* and *Hornea* we have the most simply organized vascular plants known. The sporangial structure of *Hornea* with its central sterile tissue and characteristic dome-shaped spore-bearing zone suggests a moss-like character (*e.g.* *Sphagnum*) and a certain analogy is apparent between the Mosses and these simple vascular plants, which show a combination of characters which have been stressed by different botanists to show their Pteridophytic, Thallophytic or Bryophytic affinity. The Rhyniaceae may be a synthetic group related to Pteridophytes and Bryophytes and retaining some characters of their original Algal ancestry.

The discovery of the Rhyniaceae and the excellent elucidation of their structure by Lang and Kidston during recent years has given us a knowledge of the remarkably simple and probably the most primitive of vascular plants. They throw a certain amount of light upon the probable origin of the sporophytic generation of land plants.

ORDINARY MONTHLY MEETING.

27th JULY, 1927.

Mr. H. J. Carter, B.A., F.E.S., Vice-President, in the Chair.

The Chairman referred to the great loss the Society had sustained by the death of Dr. E. W. Ferguson on 18th July and read the following resolution passed by the Council and sent to Mrs. Ferguson on behalf of the Society: "The Society places on record its very deep regret at the death of Dr. E. W. Ferguson. It realizes the debt it owes to the late Dr. Ferguson, who had been a member of the Society since 1908, a member of the Council since 1921, its President during 1926. His death is a loss to the members of the Society and to the naturalists of Australia by whom he was held in the highest esteem and respect. The Society expresses to Mrs. Ferguson and her family their very sincere sympathy with them in their sad bereavement".

Mr. M. F. Albert, Elizabeth Bay; Miss M. V. McHugh, Potts Point; Rev. H. M. R. Rupp, Paterson, N.S.W.; and Mr. W. L. Waterhouse, M.C., B.Sc.Agr., Roseville were elected Ordinary Members of the Society.

The Chairman offered the congratulations of the Society to Mr. A. H. K. Petrie, M.Sc., on his appointment to an 1851 Exhibition Travelling Scholarship.

The Donations and Exchanges received since the previous Monthly Meeting (29th June, 1927) amounting to 3 Vols., 105 Parts or Nos., 3 Bulletins and 20 Reports, received from 53 Societies and Institutions and 2 private donors were laid upon the table.

PAPERS READ.

1. Australian Coleoptera: Notes and New Species. No. v. By H. J. Carter, B.A., F.E.S.
2. The Gasteromycetes of Australasia. ix. Keys to the Genera and Species of the Lycoperdaceae. By G. H. Cunningham.
3. Notes on Australian Diptera. No. xi. By J. R. Malloch. (*Communicated by Dr. I. M. Mackerras.*)
4. Descriptions of New Species of Australian Coleoptera. Part xix. By A. M. Lea, F.E.S.
5. The Vegetation of the Kosciusko Plateau. Part i. The Plant Communities. By J. McLuckie, M.A., D.Sc., and A. H. K. Petrie, M.Sc.

NOTES AND EXHIBITS.

Dr. G. A. Waterhouse exhibited bred specimens of (1) *Ogyris oroetes* from the following new localities: Clermont, Queensland (E. J. Dumigan), Brisbane, Queensland (L. Franzen), and Belltrees, near Scone, N.S.W. (G.A.W.); (2) the three subspecies of *Ogyris amaryllis* from all the States of Australia except Tasmania; (3) specimens of *Ogyris aenone* taken near Cairns by Mr. A. N. Burns.

Mr. W. L. Wearne exhibited a piece of cedar timber in which a portion of a bed-post was embedded. The annual rings showed that this had been in position for about fifty years.

Mr. A. F. Basset Hull drew attention to the recent issue of "A Monograph of the Australian Loricates" and presented a copy to the Society on behalf of the Royal Zoological Society of New South Wales.

ORDINARY MONTHLY MEETING.

31st AUGUST, 1927.

Mr. R. H. Cambage, C.B.E., F.L.S., Vice-President, in the Chair.

The Chairman referred to the death on 6th August of Dr. R. Greig Smith, Macleay Bacteriologist to the Society and read the following resolution passed by the Council: "That the Council places on record its very deep regret at the death of Dr. R. Greig Smith, who was the first Macleay Bacteriologist to the Society, occupying that position for nearly thirty years. During the whole of his residence in New South Wales he had devoted himself assiduously to his research work and had assisted in many ways the advancement of science in Australia. His death is a loss to members of the Society and his presence will be missed from its meetings. The Society expresses to Mrs. Greig Smith its very sincere sympathy in her sad bereavement".

The Chairman also referred to the death of Mr. Thomas Whitelegge, at one time a member of the Society and for several years a member of Council.

Mr. W. D. Francis, Brisbane, Queensland, was elected an Ordinary Member of the Society.

The Chairman announced that Mr. A. G. Hamilton had been elected a Vice-President and Mr. A. J. Nicholson, M.Sc., a member of Council.

The Chairman announced that the Société de Physique et d'Histoire Naturelle de Genève offers a prize for the best unpublished monograph on a genus or family of plants, the closing date being 31st March, 1930.

The Donations and Exchanges received since the previous Monthly Meeting (27th July, 1927) amounting to 31 Vols., 191 Parts or Nos., 20 Bulletins, 3 Reports and 8 Pamphlets, received from 98 Societies and Institutions and 2 private donors were laid upon the table.

PAPERS READ.

1. Notes on Australian Diptera. No. xii. By J. R. Malloch. (*Communicated by Dr. I. M. Mackerras.*)
2. Notes on Australian Mosquitoes (Diptera, Culicidae). Part ii. The Zoogeography of the Subgenus *Ochlerotatus* with Notes on the Species. By I. M. Mackerras, M.B., Ch.M., B.Sc., Linnean Macleay Fellow of the Society in Zoology.
3. The Xerophytic Structure of the Leaf in the Australian Proteaceae. Part i. By A. G. Hamilton.
4. Australian Hesperiidæ. Part i. Notes and Descriptions of New Forms. By G. A. Waterhouse, D.Sc., B.E., F.E.S.

NOTES AND EXHIBITS.

Dr. I. M. Mackerras exhibited a series of Australian Tachinidæ in illustration of Mr. Malloch's paper.

Mr. A. G. Hamilton showed a number of lantern slides to illustrate the xerophytic structure of the leaf of the Australian Proteaceae.

Dr. G. A. Waterhouse exhibited the new subspecies described in his paper and a number of coloured lantern slides of Australian Butterflies.

Mr. David G. Stead exhibited a photograph showing bees collecting bitumen from the coating of wood pipes at Yarrangobilly (N.S.W.).

Mr. Stead invited the attention of the Society to the great destruction of Koalas (Native Bears) which had taken place in Queensland as a result of the short open season of one month (August) declared by the Queensland Government. Already many thousands of skins had actually been exported and thousands more were in store in Sydney and Brisbane. On his motion it was resolved that the Commonwealth Government be requested to refuse all applications for permits to export such skins in the future in accordance with their proclamation of 5th December, 1923.

Mr. G. P. Whitley exhibited a sample of marine growth from off Long Reef, New South Wales. This growth had been reported from Broken Bay, the ocean off Long Reef, and local estuarine waters, where it had occurred as a kind of scum at varying depths. It had proved annoying to fishermen by clinging to their lines, becoming concentrated into lumps as the lines were pulled out of the water. It has been suggested that the presence of this organism might have a deleterious effect on marine animals and that its occurrence in such large quantities might have been due to the lengthy dry weather period just experienced. It was suggested that the organism is a marine alga.

Mr. A. H. S. Lucas exhibited specimens of the English primrose and cowslip and also what was probably a hybrid between them. He pointed out that the hybrid was found growing in a habitat between the two parent forms.

ORDINARY MONTHLY MEETING.

28th SEPTEMBER, 1927.

Mr. A. F. Basset Hull, Vice-President, in the Chair.

The Chairman referred to the death of Mr. Daniel Frederick Cooksey on 16th September, 1927. He had been a member of the Society since 1926.

The Chairman drew attention to the cable from England announcing the death of Professor A. Liversidge, who had been one of the original members of the Society and had served on its Council during 1875 and 1876.

The Chairman announced that the Council is prepared to receive applications for four Linnean Macleay Fellowships tenable for one year from 1st March, 1928,

from qualified candidates. Applications should be lodged with the Acting Secretary, who will afford all necessary information to intending candidates, not later than Wednesday, 2nd November, 1927.

The Donations and Exchanges received since the previous Monthly Meeting (31st August, 1927) amounting to 9 Vols., 87 Parts or Nos., 2 Bulletins and 3 Pamphlets, received from 44 Societies and Institutions and 3 private donors were laid upon the table.

PAPERS READ.

1. Studies in the Goodeniaceae. Part i. The Life History of *Dampiera stricta* R.Br. By P. Brough, M.A., B.Sc., B.Sc.Agr.
2. Notes on Australian Diptera. No. xiii. By J. R. Malloch. (*Communicated by Dr. I. M. Mackerras.*)
3. Notes on Australian Marine Algae. Part iv. The Australian Species of the Genus *Spongoconium*. By A. H. S. Lucas, M.A., B.Sc.

NOTES AND EXHIBITS.

Dr. I. M. Mackerras announced that the late Dr. E. W. Ferguson had bequeathed his fine collection of Amycterids (Coleoptera, Curculionidae) to the Macleay Museum, University of Sydney and that the collection had been transferred to the Museum.

ORDINARY MONTHLY MEETING.

26th OCTOBER, 1927.

Mr. H. J. Carter, B.A., F.E.S., Vice-President, in the Chair.

Rev. E. Norman McKie, Guyra, N.S.W., was elected an Ordinary Member of the Society.

Candidates for Linnean Macleay Fellowships, 1928-29, were reminded that Wednesday, 2nd November, 1927, is the last day for receiving applications.

Mr. D. G. Stead mentioned the movement that had been proceeding for some time for the appointment of a Royal Commission of Inquiry by the Commonwealth Government, to make a close investigation into the general status of the aborigines throughout Australia. Upon his motion, seconded by Mr. I. V. Newman, it was resolved to write to the Prime Minister in support of the proposal.

The Donations and Exchanges received since the previous Monthly Meeting (28th September, 1927) amounting to 12 Vols., 95 Parts or Nos., 13 Bulletins and 2 Reports, received from 56 Societies and Institutions and 1 private donor were laid upon the table.

PAPERS READ.

1. Notes on Australian and Exotic Sarcophagid Flies. By G. H. Hardy.
2. Placentation and other phenomena in the Scincid Lizard, *Lygosoma (Hinulia) quoyi*. By H. Claire Weekes, B.Sc., Linnean Macleay Fellow of the Society in Zoology.

NOTES AND EXHIBITS.

Mr. D. G. Stead drew attention to the feeding habits of the large Black Shag, *Phalacrocorax carbo*, in the lower waters of Sydney Harbour. After many years' observation it was concluded that normally this species lived almost exclusively upon bottom-frequenting fishes, especially the Frog Fish, *Batrachus dubius*, which

was often obtained from a depth of about 26 feet. Catfish, *Cnidoglanis megastoma*, and Flathead, *Platycephalus* spp., were also captured.

Mr. Stead also drew attention to the presence (in waters adjacent to Sydney Heads) of the Wafer Worm, *Leptoplana australis*, a species of dendrocoelous turbellarian worm which was destructive to oysters.

Mr. E. Cheel exhibited specimens of two species of plants of the Selagineae group of the family Scrophulariaceae as follows:—(1) *Hebenstreitia dentata* Linn. This is quite common in the neighbourhood of Newcastle and has evidently been brought from South Africa in ballast. (2) *Selago corymbosa* Linn. Hawkesbury Agricultural College, C. T. Musson. Probably introduced from South Africa in agricultural seeds. It is interesting to note that *Oenothera biennis* (Evening Primrose) is also quite common at Newcastle associated with *Oenothera odorata* and *Hebenstreitia*.

Mr. T. H. Pincombe exhibited *Cleithrolepis granulatus* found (July, 1927) in sewer tunnelling at the head of Tambourine Bay, Sydney, in a similar deposit to that at Brookvale.

Dr. G. A. Waterhouse showed a lantern slide of the pupa of *Liphyra brassolis* and gave some notes on its life history.

ORDINARY MONTHLY MEETING.

30th NOVEMBER, 1927.

Professor L. Harrison, B.A., B.Sc., President, in the Chair.

The President extended a welcome to Dr. A. B. Walkom on his return from England.

Mr. BERT BERTRAM, Greenwich, Mr. F. A. CRAFT, Ashbury, Professor T. G. B. OSBORN, Adelaide, and Miss DORIS A. SELBY, Gordon, were elected Ordinary Members of the Society.

The President announced that the Council had reappointed Miss H. Claire Weekes and Miss Ida A. Brown to Linnean Macleay Fellowships in Zoology and Geology respectively for one year from 1st March, 1928.

The President offered congratulations to Dr. R. J. Tillyard on his appointment as Chief of the Biological Research Station at Canberra; to Mr. C. A. Sussmilch on his appointment as Principal of the East Sydney Technical School and Assistant Superintendent of Technical Education; also to Mr. C. Barnard, B.Sc., on his appointment as Assistant Botanist to the Council of Scientific and Industrial Research.

The President announced the receipt of a formal acknowledgment from the Secretary to the Prime Minister of the resolution carried at the last meeting.

The Donations and Exchanges received since the previous Monthly Meeting (26th October, 1927) amounting to 216 Vols., 298 Parts or Nos., 14 Bulletins and 6 Reports, received from 75 Societies and Institutions and 1 private donor were laid upon the table.

PAPERS READ.

1. Notes on Australian Marine Algae. No. v. By A. H. S. Lucas, M.A., B.Sc.
2. Mosquito Control in the Municipality of Lane Cove, New South Wales. By B. Bertram. (*Communicated by Dr. I. M. Mackerras.*)
3. A new *Dendrobium* for New South Wales and Queensland. By Rev. H. M. R. Rupp.

NOTES AND EXHIBITS.

The President (Professor L. Harrison) exhibited examples of a new species of the primitive Annelid *Stratiodrillus* from the gill cavities of the Madagascar crayfish *Astacoidea madagascariensis*. Through the courtesy and kindness of the Consul-General for France, M. Nettement, and the Governor-General of Madagascar, specimens of this crayfish were forwarded to Miss Lucy M. Wood, B.A., who desired to examine them for Temnocephaloid parasites, and who was successful in obtaining these.

The genus *Stratiodrillus* was established by the late Professor W. A. Haswell, F.R.S., in 1900, for a species obtained from the Tasmanian crayfish *Astacopsis tasmanicus*. In 1913 he described a second species from the Australian crayfish *Astacopsis serratus*. In 1921 a third species was discovered in Uruguay by Dr. E. H. Cordero, which has not so far been described. The present species makes the fourth.

The discovery is of considerable interest, as it sheds some light on the origin of the northern and southern crayfishes, a subject which has formed the basis for classical discussions at the hands of Huxley, Ortmann, Geoffrey Smith, Matthew and others.

It is now established that both *Temnocephala* and *Stratiodrillus* occur in South America, Australia and Madagascar, chiefly as ectoparasites of crayfishes, while neither occurs in the northern hemisphere. *Temnocephala* has no close relations, but the only known relative of *Stratiodrillus*, *Histriobdella homari* occurs upon the Norway lobster, *Nephrops norvegicus*. The suggestion is tentatively made that both northern and southern crayfishes have been derived from *Nephrops*-like marine ancestors, but that the transition from marine to freshwater conditions was, in the northern hemisphere, too sudden for Histriobdellid parasites to survive it; while in the southern hemisphere a more gradual transition has allowed survival. *Temnocephala* would appear to have developed entirely as a freshwater parasite, possibly derived from a Rhabdocoele ancestry.

Mr. A. Musgrave exhibited a coloured drawing of an Argioid spider, *Poecilopachys bispinosa* (Keyserling), made by Miss Joyce Allan of the Australian Museum, from a specimen collected by Mr. B. Bertram at Lane Cove, Sydney. During life the colour of the spider was observed to undergo changes similar to those in the octopus, the colour ebbing and flowing along the fore-border of the abdomen and the abdominal spines, and producing a definite flush. The abdominal spines, too, underwent a change, being quite smooth at times, while at other times they would be papillose. The spider is not uncommon in the vicinity of Sydney. It has been recorded from Gayndah, Queensland, and the Island of Upolu, Samoa.

DONATIONS AND EXCHANGES.

Received during the period 25th November, 1926, to 30th November, 1927.

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

ABERYSTWYTH.

Welsh Plant Breeding Station, University College of Wales.—Advisory Bulletin No. 2 (1927); Bulletin, Series H, Nos. 5-7 (1927); "Self and Cross-fertilisation in *Lolium perenne* L.", by T. J. Jenkin (From *Journ. of Genetics*, xvii, 1, Aug., 1926); "The Welsh Journal of Agriculture", iii (1927).

ACCRA.

Geological Survey of the Gold Coast.—Report for the Period April, 1925-March, 1926 (no date).

ADELAIDE.

Department of Mines: Geological Survey of South Australia.—Annual Report of the Director of Mines and Government Geologist for 1926 (1927); Mining Review for the Half-Years ended June 30th, 1926 (No. 44) (1926); December 31st, 1926 (No. 45); June 30th, 1927 (No. 46) (1927).

Field Naturalists' Section of the Royal Society of South Australia.—"The South Australian Naturalist", vii, 4 (1926); viii, 2-4 (1927).

Public Library, Museum and Art Gallery of South Australia.—Forty-third Annual Report of the Board of Governors for 1926-1927 (1927); "List of Books on Ornithology in the Public Library of South Australia and other Adelaide Libraries" (1926); Records of the South Australian Museum, iii, 3, (1927).

Royal Geographical Society of Australasia, South Australian Branch.—Proceedings, xxvii, Session 1925-26 (1927).

Royal Society of South Australia.—Transactions and Proceedings, 1 (1926).

South Australian Ornithological Association.—"The South Australian Ornithologist", ix, 1-4 (1927).

University of Adelaide.—"The Australian Journal of Experimental Biology and Medical Science", iii, 4 (T.p. & c.) (1926); iv, 1-3 (1927); "The Pink Boll-worm of Queensland", by F. G. Holdaway (From *Bull. Ent. Res.*, xvii, 1, 1926); Commemoration Address, 1925—"Some Aspects of Forestry in South Australia", by Prof. Sir Douglas Mawson (1925); 27 Reprints from *Trans. Proc. Roy. Soc. S. Aust.*, xlix-1 (1925-1926); *Med. Journ. Aust.*, 1925 (1925); *Pap. Proc. Roy. Soc. Tas.*, 1925 (1925); and *Rept. Aust. Assn. Adv. Sci.*, xvii, 1924 (1926).

Woods and Forests Department.—Annual Progress Report for the Year 1925-26 (1926).

ALBANY.

New York State Library, University of the State of New York.—New York State Museum Bulletin, Nos. 269-273 (1926-1927).

ALGER.

Institut Pasteur d'Algerie.—Archives, iv, 1-4 (T.p. & c.) (1926).

Société d'Histoire Naturelle de l'Afrique du Nord.—Bulletin, i, 1909/10—xvi, 1925, 1-7, 9 (1910-1925); xvii, 1926, 7-9 (Index) (1926-1927); xviii, 1927, 1-6 (1927).

AMSTERDAM.

Nederlandsche Entomologische Vereeniging.—Entomologische Berichten, vii, 150-155 (1926-1927); Tijdschrift voor Entomologie, lxi, 3-4, Supplement (T.p. & c.) (1926); lxx, 2 (1927).

ANN ARBOR.

University of Michigan.—Contributions from the Museum of Geology, ii, 7-8 (1926); Miscellaneous Publications of the Museum of Zoology, Nos. 15-17 (1926); Occasional Papers of the Museum of Zoology, Nos. 166-183 (1926-1927); Papers of the Michigan Academy of Science, Arts and Letters, vi-vii, 1926 (1927).

AUCKLAND.

Auckland Institute and Museum.—Annual Report, 1926-27 (1927).

BALTIMORE.

Johns Hopkins University.—University Circulars, N.S., 1926, 2-11 (1926); List of Publications, 1927 (1927).

BANDOENG.

Geological Survey in the Dutch East Indies.—Wetenschappelijke Mededeelingen, Nos. 5-6 (1927).

BARCELONA.

Real Academia de Ciencias y Artes de Barcelona.—Memorias, xix, 15-17 (T.p. & c.) (1926); xx, 1-4 (1926-1927); Nomina del Personal Academico, 1926-1927 (1927).

BASEL.

Naturforschende Gesellschaft.—Verhandlungen, xxxvii-xxxviii, 1925/1926-1926/1927 (1926-1927).

BERGEN.

Bergens Museum.—Aarbok, 1926, 1-2 (T.p. & c.) (1927); Aarsberetning, 1925-1926 (1926).

BERKELEY.

University of California.—Publications: Botany, xi, 3-7; xiii, 11-19; xiv, 1-2 (1926-1927); Entomology, iv, 2-5 (1926-1927); Geology, T.p. & c. for xv (1924-1926); xvi, 5-12 (1926-1927); xvii, 1 (1927); Physiology, T.p. & c. for v (1915-1926); vii, 1-2 (1926-1927); Zoology, T.p. & c. for xxi (1918-1926); and xxiv (1922-1926); xxix, 8-18 (T.p. & c.) (1926-1927); xxx, 6-8 (1926-1927); xxxi, 1-5 (1927).

BERLIN.

- Botanischer Garten und Museum*.—Notizblatt, ix, 89-90 (T.p. & c.) (1926-1927); x, 91 (1927).
- Deutsche Entomologische Gesellschaft, E. V.*—*Deutsche Entomologische Zeitschrift*, 1926, 3-5, Beiheft (T.p. & c.) (1926-1927); 1927, 1-2 (1927).
- Deutsche Entomologische Museum*.—*Entomologische Mitteilungen*, xv, 5-6 (T.p. & c.) (1926); xvi, 1-5 (1927); *Supplementa Entomologica*, Nos. 14-15 (1926-1927).
- Notgemeinschaft der Deutschen Wissenschaft*.—"Flora", Neue Folge, xxi, 2-4 (T.p. & c.) (1926-1927); xxii, 1-2 (1927).

BERN.

- Naturforschende Gesellschaft*.—*Mitteilungen a.d. Jahre 1926* (1927); *Verhandlungen*, 1926 (1926).

BIRMINGHAM.

- Birmingham Natural History and Philosophical Society*.—List of Members, 1927, and Annual Report, 1926; *Proceedings*, xv, 6, Session 1926-27 (1927).

BOMBAY.

- Bombay Natural History Society*.—*Journal*, xxxi, 3-4 (1926-1927); T.p. & c. for xxxi, pts. 1 and 2; xxxii, 1 (1927).
- Haffkine Institute*.—*Reports for the Years 1925, 1926* (1926, 1927).

BONN.

- Naturhistorische Verein der Preussische Rheinlande und Westfalens*.—*Sitzungsberichte*, 1925; *Verhandlungen*, 83, 1926 (1926).

BOSTON.

- American Academy of Arts and Sciences*.—*Proceedings*, lxi, 7-12 (T.p. & c.) (1926); lxii, 1-4 (1927).
- Boston Society of Natural History*.—*Memoirs*, viii, 2 (1916); *Proceedings*, xxxv, 2-3 (1915); xxxviii, 4-7 (1926-1927).

BRISBANE.

- Department of Agriculture and Stock*.—*Queensland Agricultural Journal*, xxvi, 5-6 (T.p. & c.) (1926); xxvii, 1-6 (T.p. & c.) (1927); xxviii, 1-5 (1927).
- Queensland Government Mining Journal (from the Editor)*.—xxvii, Dec., 1926 (T.p. & c.) (1926); xxviii, Jan.-Nov., 1927 (1927).
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Wistar Institute of Anatomy and Biology.—The Journal of Experimental Zoology, xlvi, 2-4 (T.p. & c.) (1926-1927); xlvii, 1-3 (T.p. & c.); xlviii, 1-2 (T.p. & c.) (1927).

University of Pennsylvania.—Contributions from the Zoological Laboratory for the Years 1924-25, xxiv (1925); Two Theses: "The Effect of Sulfur Dioxid upon Plants: Methods of Study", by L. A. Weierbach; "Chromosome Structure and its Relation to the Chromosome Cycle, i", by B. P. Kaufmann (From *Amer. Journ. Bot.*, xiii, 2, 1926).

Zoological Society of Philadelphia.—Fifty-fifth Annual Report of the Board of Directors, 1927; Report of the Laboratory and Museum of Comparative Pathology in conjunction with the Fifty-fifth Annual Report, 1927 (1927).

PITTSBURGH.

Carnegie Museum.—Annals, xvii (bound, complete), 1926-1927 (1927).

PLYMOUTH.

Marine Biological Association of the United Kingdom.—Journal, N.S., xiv, 3-4 (1927).

PORTICI.

Laboratorio di Zoologia Generale e Agraria della R. Scuola Superiore d'Agricoltura.—Bollettino, xix (1926).

PRAGUE.

Botanical Institute of the Charles University.—Mykologia, i, 1-10 (T.p. & c.) (1924); ii, 1-5 (1925).

PRETORIA.

Botanical Survey of South Africa.—"Diseases of Virginian Tobacco in South Africa", by Dr. E. S. Moore (Reprinted from *Journ. Dept. Agric. South Africa*, Sept., 1926; *Memoir*, Nos. 7, 9 (1924, 1926)).

PUSA.

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RENNES.

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RICHMOND, N.S.W.

Hawkesbury Agricultural College.—H.A.C. Journal, xxiii, 8 (Index) (1926); xxiv, 1-7 (1927).

RIO DE JANEIRO.

Instituto Brasileiro de Ciencias.—Boletim, Anno ii, 9-11 (1926-1927).
Instituto Oswaldo Cruz.—Memorias, 1926, xix, 1-2 (T.p. & c.) (1926); 1927, xx, 1 (1927).

RIVERSIDE, Cal.

Graduate School of Tropical Agriculture and Citrus Experiment Station (College of Agriculture, University of California).—Papers Nos. 42, 51, 52, 89, 126-129, 131-140, 144-150, 153-157; T.p. & c. for iii, iv and v (1917-1927).

SAN DIEGO.

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SAN FRANCISCO.

California Academy of Sciences.—Occasional Papers, xii; Proceedings, Fourth Series, T.p. & c. for ii, pts. 1 and 2, 1913-1917, 1918-1926; T.p. & c. for xiv, 1925-1926 (1926); xv, 12-18 (T.p. & c.), 1926-1927 (1926-1927); xvi, 1-18, 1927 (1927).

SAO PAULO.

Museu Paulista.—Revista, xiv-xv (1926-1927).

SARATOW.

Biologische Wolga-Station.—Arbeiten, viii, 4-5; ix, 1-2 (1926); Russische Hydrobiologische Zeitschrift, i, 2-12 (T.p. & c.) (1922); ii-v (1923-1926); vi, 1-7 (1927).

SEATTLE.

Puget Sound Biological Station of the University of Washington.—Publications, v, pp. 109-179 (1926).

SENDAI.

Tohoku Imperial University.—Science Reports, 2nd Series, ix, 2 (1926); x, 2-3 (1926-1927); xi, 1 (1927); 4th Series, ii, 2-4 (T.p. & c.) (1926-1927); iii, 1 (1927).

SHARON.

Cushman Laboratory for Foraminiferal Research.—Contributions, ii, 4; iii, 1-3 (1927).

ST. LOUIS.

Missouri Botanical Garden.—Annals, vi, 4 (T.p. & c.) (1919); xiii, 3-4 (T.p. & c.) (1926); xiv, 1-2 (1927).

STOCKHOLM.

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K. Svenska Vetenskapsakademien.—Arkiv for Botanik, xx, 2-4 (T.p. & c.) (1926); xxi, 1 (1927); Arkiv for Matematik, Astronomi och Fysik, xix, 3-4 (T.p. & c.) (1926-1927); Arkiv for Zoologi, xviii, 2-4 (T.p. & c.) (1926-1927); Arsbok, 1926 (1926); Handlingar, Tredje Serien, ii, 1-8 (T.p. & c.) (1925-1926); iii, 1-2 (T.p. & c.) (1925-1926); Skrifter i Naturskyddsaren den, Nos. 5-6 (1926).

SYDNEY.

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TASHKENT.

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TOKYO.

Imperial Fisheries Institute, Department of Agriculture and Forestry.—Journal, xxii, 2-5 (1926-1927); xxiii, 1 (1927).

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TORONTO.

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TOULOUSE.

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TRING, Herts.

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TRONDHJEM.

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TUNIS.

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UPSALA.

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URBANA.

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VIENNA.

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WARSAW.

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WASHINGTON.

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U.S. Coast and Geodetic Survey, Department of Commerce.—Serial Publication, Nos. 350, 356, 366 (1926); Special Publications, Nos. 121, 123 (1926).

U.S. Department of Agriculture.—Year Books, 1925, 1926 (1926, 1927); Bureau of Entomology, Department Bulletins, Nos. 1380, 1426, 1428, 1429, 1439, 1453, 1469, 1472, 1476, 1482, 1487, 1490 (1926-1927); Department Circulars, 361, 395, 410-411 (1926-1927); Farmers' Bulletins, Nos. 1494, 1495, 1503, 1531 1548 (1926-1927); Leaflet No. 2 (1927); Miscellaneous Circular, Nos. 70, 84, 104 (1926-1927); Technical Bulletin, Nos. 3-4 (1927); Report of the Entomologist, 1925-1926 (1926); Twenty-nine Reprints from *Journal of Agricultural Research*, xxxii, 11-12; xxxiii, 1, 2, 4-5, 7-9, 11-12 (1926); xxxiv, 4-9, 11 (1927).

U.S. Geological Survey.—47th Annual Report of the Director for the Fiscal Year ended June 30, 1926 (1926); Bulletins, Nos. 782, 783 B-E (T.p. & c.), 784, 785 C-D (T.p. & c.), 786 A-B (T.p. & c.), 788 A-D, 789, 790 A-B (T.p. & c.), 791, 792 A-B, 795 A-C (1926-1927); Professional Papers, 137, 139, 142 A-D, 147 A-C (T.p. & c.), 148 (1926-1927); Water Supply Papers, 530, 549-551, 553-555, 557, 559, 564, 565, 568, 575, 580 A-B (T.p. & c.), 583, 584, 592, 596 A-B (1926-1927).

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WELLINGTON.

Department of Mines: New Zealand Geological Survey.—Bulletin, N.S., No. 29; Palaeontological Bulletin, No. 12 (1927).

Department of Scientific and Industrial Research: Geological Survey Branch.—Twenty-first Annual Report (New Series), 1926-1927 (1927).

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Centraal Militair Geneeskundig Laboratorium.—Three Separates: "*Lophoscelomyia annandalei* var. *djajasanensis* nov. var.", by S. L. Brug (*Genees. Tijdschr. voor Nederl.-Indie*, lxvi, 5, 1926); "*Lophoscelomyia annandalei* var. *djajasanensis* nov. var. (Diptera, Culicidae)", by S. L. Brug (From *Bull. Soc. Path. Exotique*, xix, 9, Nov., 1926); "Technische wenken voor het verzamelen van muskieten", by S. L. Brug (From *Genees. Tijdschr. voor Nederl.-Indie*, lxvii, 1, 1927).

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WOODS HOLE.

Marine Biological Laboratory.—*Biological Bulletin*, i-1 (1899-1926); li, 4-6 (T.p. & c.) (1926); lii, 1-6 (T.p. & c.) (1927); liii, 1-4 (1927); *Zoological Bulletin*, i-ii (complete) (1897-1899).

PRIVATE DONORS (and authors, unless otherwise stated).

ANGUS & ROBERTSON, LTD., Sydney (donors).—"The Platypus", by Harry Burrell, C.M.Z.S. (Sydney, 1927).

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CLAPP, F. G., New York City, U.S.A.—Two Reprints: "A Review of the Oil and Gas Prospects of Australia" and "Oil and Gas Prospects in New Zealand" (From *Bull. Amer. Assn. Petroleum Geologists*, xi, 1, Jan., 1927, and x, 12, Dec., 1926).

FERGUSON, DR. E. W., Sydney (donor).—*The British Medical Journal*, Nos. 3419-3473 (July 17th, 1926-July 30th, 1927).

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INSTITUTION OF ENGINEERS, AUSTRALIA, SYDNEY (donor).—"Note upon the Destruction of Wharf Piles by Crustacea and Mollusca in Australian Harbours", by A. C. Mackenzie (Paper No. 5, Vol. viii, 1927); *Quarterly Bulletin of the Institution of Engineers, Australia*, iv, 14-16 (1927).

- JANET, CHARLES, France.—“Constitution Orthobiontique des Êtres Vivants. i. Théorie Orthobiontique” (Beauvais, 1925).
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- MEYRICK, E., B.A., F.R.S., Marlborough, England.—Exotic Microlepidoptera, iii, 5-10 (1925-1926).
- MUSSON, C. T., Sydney (donor).—“Carbon Assimilation by Plants”, by J. C. Bose (From “Scientia”, Sept., 1926); Presidential Address of Fourteenth Indian Science Congress, by J. C. Bose (Lahore, 1927); Maine Agricultural Experiment Station, Orono—Bulletins 313, 317 (1923, 1924); Department of Finance, Imperial Plant Quarantine Service, Japan—Technical Bulletin No. 3 (Yokohama, 1925); Four Reprints by J. C. Bose from *Proceedings of Royal Society of London*, Series B, Vols. 88 (1915); 89 (1916); 90 (1919); 93 (1922).
- SKVORTZOW, B. W., Harbin, China.—“Diatoms from Tientsin, North China” (Reprinted from *Journal of Botany*, April, 1927).
- SMITH, DR. R. GREIG, Sydney (donor).—*Chemical Engineering and Mining Review*, xvii, 201, 1925); County of Northumberland, Education Committee: County Agricultural Experiment Station, Cockle Park—Bulletin, Nos. 37-38 (1925-1926); Dove Marine Laboratory, Cullercoats, Northumberland—Report for Year ending June 30th, 1924 (1924); Royal Society of Tasmania—Papers and Proceedings for Years 1924 and 1925 (1925-1926):
- STEEL, MRS., Sydney (donor).—“Monographie der Turbellarien. ii. *Tricladida terricola* (Landplanarien)”. Text and Atlas. (2 vols.). By Dr. Ludwig von Graff (Leipzig, 1899).
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- WATERS, A. W., F.L.S., F.G.S., Bournemouth, England.—“Ancestrula of Cheilostomatous Bryozoa, Pt. v” (Reprinted from *Ann. Mag. Nat. Hist.*, Ser. 9, xviii, p. 424, 1926).
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LIST OF MEMBERS, 1927.

ORDINARY MEMBERS.

- 1927 *Albert, Michel François, "Boomerang", Elizabeth Bay, Sydney.
 1905 Allen, Edmuad, c/o Chief Engineer for Railways, Brisbane, Q.
 1906 Anderson, Charles, M.A., D.Sc., Australian Museum, College Street, Sydney.
 1922 Anderson, Robert Henry, B.Sc.Agr., Botanic Gardens, Sydney.
 1899 Andrews, Ernest Clayton, B.A., F.G.S., Geological Survey, Department of Mines, Sydney.
 1927 Armstrong, Jack Walter French, "Callubri", Nyngan, N.S.W.
 1912 Auroousseau, Marcel, B.Sc., c/o Mr. G. H. Auroousseau, "Wondah", Bannerman Street, Cremorne.
- 1913 Badham, Charles, M.B., Ch.M., B.Sc., Bureau of Microbiology, 93 Macquarie Street, Sydney.
 1888 Baker, Richard Thomas, The Crescent, Cheltenham.
 1925 Barnard, Colin, B.Sc., Commonwealth Research Station, Merbein, Vic.
 1919 Barnett, Marcus Stanley, c/o Colonial Sugar Refining Co., Ltd., O'Connell Street, Sydney.
 1907 Benson, Professor William Noel, B.A., D.Sc., F.G.S., University of Otago, Dunedin, N.Z.
 1920 Blakely, William Faris, Botanic Gardens, Sydney.
 1923 Bone, Walter Henry, 15 Bond Street, Sydney.
 1926 Branch, Kenneth James Fergus, B.Sc., 99 North Steyne, Manly.
 1912 Breakwell, Ernest, B.A., B.Sc., Agricultural High School, Yanco, N.S.W.
 1927 Bredero, William Adrien Lewis, Box 127, Post Office, Orange, N.S.W.
 1912 Brewster, Miss Agnes, Girls' High School, Sydney.
 1923 Brough, Patrick, M.A., B.Sc., B.Sc.Agr., "Kinross", Billyard Avenue, Wahroonga.
 1921 Brown, Horace William, 871 Hay Street, Perth, W.A.
 1924 Brown, Miss Ida Alison, B.Sc., Geology Department, The University, Sydney.
 1911 Browne, William Rowan, D.Sc., Geology Department, The University, Sydney.
 1920 Burkitt, Professor Arthur Neville St. George Handcock, M.B., B.Sc., Medical School, The University, Sydney.
 1921 Burns, Alexander Noble, "Lucerne", Lower Ferntree Gully, Victoria.
 1910 Burrell, Harry, 19 Doncaster Avenue, Kensington.
 1910 Burrell, Mrs. Harry, 19 Doncaster Avenue, Kensington.
 1926 Buzacott, James Hardie, Meringa (private bag), via Cairns, North Queensland.
- 1912 Cadell, Miss Myall, "Wotonga", Belgium Avenue, Roseville.
 1899 Cambage, Richard Hind, C.B.E., L.S., F.L.S., Park Road, Burwood.
 1901 Campbell, John Honeyford, M.B.E., Royal Mint, Ottawa, Canada.
 1927 Campbell, Thomas Graham, Australian Museum, College Street, Sydney.
 1905 Carne, Walter Mervyn, Government Botanist, Perth, W.A.
 1890 Carson, Duncan, c/o Winchcombe, Carson, Ltd., Bridge Street, Sydney.
 1903 Carter, Herbert James, B.A., F.E.S., "Garrawillah", Kintore Street, Wahroonga.
 1899 Cheel, Edwin, Botanic Gardens, Sydney.
 1924 Chisholm, Edwin Claud, M.B., Ch.M., Comboyne, N.S.W.
 1920 Clarke, Harry Flockton, c/o Colonial Sugar Refining Co., Ltd., Rarawai Mill, Ba River, Fiji.
 1901 Cleland, Professor John Burton, M.D., Ch.M., The University, Adelaide, S.A.
 1920 Cooper, Mrs. A. G. S., B.Sc. (née Henry), Ogilvie Street, Denman, N.S.W.
 1908 Cotton, Professor Leo Arthur, M.A., D.Sc., Geology Department, The University, Sydney.
 1900 Crago, William Henry, M.D., 185 Macquarie Street, Sydney.
 1925 Cunningham, Gordon Herriot, Department of Agriculture, Biology Section, 71 Fairlie Terrace, Kelburn, Wellington, New Zealand.

* Life Member

- 1885 David, Sir Tannatt William Edgeworth, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S.,
Sherbrook Road, Waitara.
- 1925 de Beuzeville, Wilfred Alexander Watt, Tumut, N.S.W.
- 1881 Dixon, Thomas Storie, M.B., Ch.M., 215 Macquarie Street, Sydney.
- 1927 *Dixon, William, "Merridong", Gordon Road, Killara.
- 1921 Dodd, Alan Parkhurst, Prickly Pear Laboratory, Sherwood, Brisbane, Q.
- 1923 Drummond, Miss Heather Rutherford, "Havilah", Glenbrook, N.S.W.
- 1926 Dumigan, Edward Jarrett, Boys' State School, Toowoomba North, Toowoomba,
Queensland.
- 1920 Dwyer, Rt. Rev. Joseph Wilfrid, Bishop of Wagga, Wagga Wagga, N.S.W.
- 1914 Enright, Walter John, B.A., West Maitland, N.S.W.
- 1908 Flynn, Professor Theodore Thomson, D.Sc., University of Tasmania, Hobart,
Tasmania.
- 1927 Francis, William Douglas, Botanic Gardens, Brisbane, Queensland.
- 1920 Friend, Norman Bartlett, 48 Pile Street, Dulwich Hill.
- 1911 Froggatt, John Lewis, B.Sc., Department of Agriculture, Brisbane.
- 1886 Froggatt, Walter Wilson, F.L.S., Young Street, Croydon.
- 1920 Furst, Herbert Charles, 223 Macquarie Street, Sydney.
- 1927 Garde, Miss Mary Lee, "Wavertree", Kurraba Road, Neutral Bay.
- 1912 Goldfinch, Gilbert M., "Lyndhurst", Salisbury Road, Rose Bay.
- 1899 Grant, Robert, 24 Edward Street, Woollahra.
- 1923 Gray, Archibald James, "Glendyne", Augusta Street, Concord.
- 1911 Greenwood, William Frederick Neville, F.L.S., F.E.S., c/o Colonial Sugar Refining
Co., Ltd., Lautoka, Fiji.
- 1910 Griffiths, Edward, B.Sc., Department of Agriculture, 136 Lower George Street,
Sydney.
- 1901 Gurney, William Butler, B.Sc., F.E.S., Department of Agriculture, George Street
North, Sydney.
- 1911 Hacker, Henry, F.E.S., Queensland Museum, Bowen Park, Brisbane, Q.
- 1925 Hale, Herbert Matthew, South Australian Museum, Adelaide, S.A.
- 1909 Hall, Edwin Cuthbert, M.D., Ch.M., George Street, Parramatta.
- 1926 Hall, Miss Lesley Damaris, B.Sc., 8 Nicholson Street, Balmain East.
- 1919 Hall, Leslie Lionel, "Haldor", Drumalbyn Road, Bellevue Hill.
- 1897 Halligan, Gerald H., F.G.S., "Alameda", Challis Avenue, Turramurra.
- 1885 Hamilton, Alexander Greenlaw, "Tanandra", Hercules Street, Chatswood.
- 1899 Hamilton, Arthur Andrew, "The Ferns", 17 Thomas Street, Ashfield.
- 1922 Hardwick, Frederick George, B.D.S., D.D.Sc., Church and Macquarie Streets,
Parramatta.
- 1917 Hardy, G. H. Hurlstone, The University, Brisbane, Q.
- 1905 Harrison, Professor Launcelot, B.A., B.Sc., Zoology Department, The University,
Sydney.
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NOTES ON AUSTRALIAN DIPTERA. No. x.

By J. R. MALLOCH.

(Communicated by Dr. E. W. Ferguson.)

(Twelve Text-figures.)

[Read 30th March, 1927.]

In this paper I present a revised synoptic key to the species of the genus *Drosophila* Fallén, with descriptions of some new species, a synopsis of the species of the genus *Homoneura* van der Wulp, descriptions and records of some species of the genus *Sapromyza* Fallén, and descriptions of some other acalyptrate Diptera, most of which have been received from Dr. E. W. Ferguson.

Family Drosophilidae.

Genus MYCODROSOPHILA Oldenberg.

This genus is distinguished from *Drosophila* by the extremely short anterior pair of postsutural dorsocentral bristles, which, like the basal pair of scutellar bristles, are almost indistinguishable and by the humped up thoracic dorsum. All the known species are very similar in colour, glossy black on dorsum, with yellow abdominal markings and pale yellow on venter and sides of thorax. The flies occur commonly on the undersides of fungi in which the larvae feed.

I have before me a series of specimens belonging to a species which is evidently undescribed and one injured specimen which may possibly belong to another species.

MYCODROSOPHILA ARGENTIFRONS n. sp.

Male and female.—Head black, yellow on centre of frons from ocelli to anterior margin and on lower half of occiput, the face brownish, bases of antennae yellowish; orbits shining, rest of frons dull, when seen from in front densely silvery; proboscis yellow below, fuscous above; palpi fuscous. Thorax glossy black on dorsum, with a variable amount of yellow on anterior margin, sometimes in the form of two rudimentary vittae; scutellum when seen from in front brownish or yellowish dusted apically; pleura pale yellow, black on upper margin; post-notum black. Abdomen pale yellow, with a black fascia across hind margin of each tergite which is carried forward on the median line on tergites 3 to 5 and connects with a similar fascia on anterior margin leaving two yellow spots on each, the lateral margins of tergites wholly black. Legs pale yellow. Wings hyaline, with a deep black mark on costa before apex of first vein and a faint cloud extending from it over cell to second vein. Halteres black.

Head a little broader than thorax; frons at vertex nearly twice as wide as length at centre; all bristles, except the anterior reclinate one on each orbit, long; eyes almost bare; facial carina widened and flattened below; clypeus convex. Thorax quite conspicuously convex, the dorsal surface rather densely fine haired. Third costal division over half as long as second.

Length, 2.3 mm.

Type male, allotype, and 5 paratypes, Coramba, N.S.W., 15.2.25.

Genus *LEUCOPHENGA* Mik.
LEUCOPHENGA MINUTA n. sp.

Male.—Head testaceous, occiput and face, except sides, infuscated, frons slightly darkened above, but all these parts with dense white dusting so that in some positions they appear pale; palpi and antennae testaceous; cephalic bristles, except on vibrissal angles, yellow. Thorax testaceous yellow, densely white dusted, almost silvery when seen from certain angles, with evidences of a rufous vitta along each side of dorsum; a brownish vitta along centre of pleura; scutellum testaceous yellow; postnotum brown. Abdomen brownish, when seen from in front with quite dense silvery dusting on dorsum. Thoracic and abdominal hairs and bristles luteous. Legs testaceous yellow. Wings hyaline, a narrow fuscous cloud extending from apex of posterior basal cell obliquely to apex of first vein. Halteres missing in type.

Frons about twice as long as wide, parallel-sided, all bristles well developed; face slightly carinate on upper half; antennae normal; cheek linear; vibrissae short; palpi slender. Both sternopleurals long. Legs slender, no outstanding setulae on mid tibiae. First posterior cell of wing not narrowed apically; third costal section over half as long as second.

Length, 2 mm.

Type, Cairns District, Queensland (Dodd).

Distinguished from other Australian species known to me by the uniformly silvery white dusted dorsum, markings of the wings, and its small size.

Genus *DROSOPHILA* Fallén.

As I have described a number of species of this genus since I published my key in the first paper of this series (These PROCEEDINGS, 1923, p. 615) I deem it expedient to present now an enlarged synopsis which includes 22 species, all at present known to me as occurring in Australia. I have found it necessary to draw up this key for my own convenience in identifying material and hope that it may prove as useful to other students of the group as it has to me for that purpose. There must be many Australian species of the genus unknown to me. Most of those herein included are similar to the general run of species of the genus throughout its range, but some, and especially *nicholsoni*, are aberrant, though not entitled, in my opinion, to subgeneric segregation. I have not attempted to figure the genitalia of either sex, some of which possess striking specific features, nor have I attempted to determine the structure of the eggs of the species. Some of the eggs are furnished with filaments at one end which vary in form and in number with the species and they may sometimes be as readily distinguished as any of the other stages, and in some closely allied species even more readily than the adults.

Key to the Species.

1. Wings with conspicuous fuscous markings in addition to those over the cross veins or at apex of first costal division 2
 Wings without fuscous markings except sometimes faint clouds over the cross veins or at apex of first costal division 3
2. Wing with a large brownish or fuscous spot at apex of second vein, the dark cloud at tip consisting of a brownish suffusion along the apices of third and fourth veins, more or less coalescent in first posterior cell; mesonotum dark brown, with three linear yellow vittae, the median one not reaching anterior margin; scutellum yellow in centre, dark brown on sides of disc; pleura whitish-yellow, contrasting sharply with the dark brown mesonotum *mycetophaga* Malloch.

- Wing without a dark spot at apex of second vein, the dark cloud at tip consisting of a broad curved brown patch which extends from middle of third section of costa to just over third vein and over disc of wing to beyond fourth vein, but leaves a hyaline spot in apex of first posterior cell; mesonotum brown, with two poorly defined paler vittae which are carried over lateral margins of scutellum, the centre of latter brown; pleura not noticeably paler than mesonotum *polypteri* Malloch.
3. Fore femora with a comb-like series of microscopic setulae on apical third or more of anteroventral surface 4
 Fore femora without a comb-like series of microscopic setulae as above 5
4. Fore femora with short closely placed setulae on more than the apical half of posteroventral surfaces, the longest one, at apex, not longer than the femoral diameter; third section of costa not less than one-third as long as second; facial carina narrow *setifemur* Malloch.
 Fore femora with four or five widely spaced bristles on the entire length of each posteroventral surface, the longest one, at middle, as long as or longer than the femoral diameter; third section of costa about one-fourth as long as second; facial carina much broadened below *immigrans* Sturtevant.
5. Thoracic dorsum with a minute but conspicuous dark brown or fuscous dot at base of each hair and bristle and sometimes with additional brown or fuscous dots on parts causing aggregations which assume the appearance of larger irregular spots, the ground colour of thoracic dorsum never testaceous yellow 6
 Thoracic dorsum with or without dark or pale vittae, not copiously marked with piliferous spots or dots, if faintly marked with piliferous dots then the ground colour of thorax is testaceous yellow 9
6. Third costal division of wing almost as long as second; outer cross vein about one-third as long as apical section of fifth vein *poecilothorax* Malloch.
 Third costal section of wing not over one-third as long as second; outer cross vein much more than one-third as long as apical section of fifth vein 7
7. Facial carina practically absent except between bases of antennae, where it is sharp and linear; eyes almost bare *obsoleta* Malloch.
 Facial carina conspicuous below, where it is rather broad and usually longitudinally sulcate; eyes with dense stiff microscopic hairs 8
8. At least the first three tergites of abdomen with a yellowish spot on each side on the part that is incurved on venter *repleta* Wollaston.
 None of the abdominal tergites with yellowish spots as above *hydei* Sturtevant.
9. All hairs and bristles on insect luteous; thorax not vittate *flavohirta* Malloch.
 All hairs and bristles fuscous or blackish 10
10. Sides of face, frontal orbits, and two narrow submedian vittae on mesonotum which extend over its entire length and on to sides of scutellum, densely white dusted, the whole forming two continuous white lines on a black ground, and very conspicuous; sternopleurals 2 *albostrigata* Malloch.
 Thoracic dorsum with or without dark vittae, not white vittate 11
11. Thoracic dorsum distinctly vittate 12
 Thoracic dorsum entirely without vittae 16
12. Thoracic dorsum with five dark vittae, the intervening spaces pale grey dusted; wing with a deep black spot and two fine bristles on costa before apex of first vein; third costal section almost as long as second *nigrovittata* Malloch.
 Thoracic dorsum with four or six dark vittae, the intervening spaces inconspicuously pale dusted 13
13. Arista with but one long hair above at base, no long hairs below; face without a carina on lower portion; third costal section not over one-fourth as long as second, and shorter than penultimate section of fourth vein; sternopleurals 3 *nicholsoni*, n. sp.
 Arista with at least three long hairs above and one or two below 14
14. Palpi fuscous; face with a vestigial carina only on upper part, not carinate below; pleura with two dark vittae; third costal division over one-third as long as second and distinctly longer than penultimate section of fourth vein; sternopleurals 2 *buscki* Coquillett.
 Palpi testaceous yellow; face with a very conspicuous carina which is continued below middle, its lower portion broadened 15

15. Submedian thoracic vittae narrowed at posterior extremities, but continued to the hind margin of mesonotum, no dark central mark in front of scutellum; the two central series of hairs located on the inner margins of the submedian dark vittae *lativittata* Malloch.
 Submedian vittae not reaching posterior margin of mesonotum; a dark mark on centre of hind margin of latter; the two central series of hairs entirely within the pale central vitta, the next two series on edges of the dark submedian vittae *enigma* n. sp.
16. Facial carina not developed except weakly on upper part between bases of antennae 17
 Facial carina well developed and broadened on lower part of face 18
17. Thorax dull fuscous *fuscithorax* Malloch.
 Thorax testaceous yellow, sometimes with faint dark dots at bases of the bristles and hairs on dorsum *inornata* Malloch.
18. Thorax more or less shining black 19
 Thorax shining testaceous yellow 21
19. Third costal section distinctly more than half as long as second and longer than penultimate section of fourth vein (3:2); frons reddish or yellowish brown except on orbits and triangle, which are shining black, the anterior reclinate orbital bristle laterad of the proclinate one *sydneyensis*, n. sp.
 Third costal section about one-third as long as second and about as long as, or very little longer than, penultimate section of fourth vein 20
20. Frons dark brown, the orbits and triangle dull black; anterior reclinate orbital bristle well above the proclinate one; thorax shining, but not glossy *subnitida* n. sp.
 Frons black, the orbits and triangle shining, anterior reclinate orbital bristle but little above level of the proclinate one; thorax glossy *nitidithorax*, n. sp.
21. Fore metatarsus of male with a comb of short black bristles on apical half, the second segment without a comb *ampelophila* Loew.
 Fore metatarsus and second segment each with a comb of black bristles from base to apex in male *serrata*, n. sp.

[*Drosophila brunneipennis* Malloch described in These PROCEEDINGS, 1923, p. 617, has inadvertently been omitted. In the previous key *loc. cit.* p. 616 it is placed next to *D. melanogaster* Meigen = *D. ampelophila* Loew.—Ed.]

DROSOPHILA NICHOLSONI, n. sp.

Male and female.—Testaceous yellow, shining. Frons opaque brownish, the orbits, sides of triangle, and anterior margin testaceous, not shining; third antennal segment largely fuscous; palpi and proboscis testaceous. Dorsum of thorax slightly brownish and greyish dusted with six brown vittae, the submedian pair of moderate width and complete, the intermediate pair much narrower and connected with the submedian pair behind suture, the sublateral pair broad, rather indistinct and broken at suture; pleura and metanotum largely brown; scutellum brown in centre, narrowly yellow on sides. Abdomen shining, apical tergites slightly darkened. Legs testaceous yellow. Wings greyish hyaline, veins not clouded. Halteres yellow.

Anterior reclinate bristle about one-third as long as posterior one and almost in transverse line with the proclinate one; postvertical bristles long interfrontalia with a few hairs anteriorly; facial carina distinguishable only on upper part; arista with one long hair on upper side at base and some short pubescence beyond, which is only visible under a high magnification; vibrissa single. Thorax with two humerals, about eight series of intradorsocentral setulae, the submedian two series on margins of the pale central vitta, and 3 sternopleurals. Legs normal. Second section of costa about four times as long as third, the latter not longer than penultimate section of fourth vein, ultimate section of fifth vein subequal to penultimate section of fourth and about twice as long as outer cross vein.

Length, 2.5-3 mm.

Type male, allotype, and 2 paratypes, Perth, W.A., 15.11.1924 (Nicholson).

This species is readily distinguished from any other known species in the genus either from Australia or elsewhere by the presence of but one long hair on the upper side of the arista. This character was used as the distinguishing feature of the American genus *Cladochaeta* by Coquillett, but the present species differs from that genus in many characters and is so obviously merely an aberrant *Drosophila* that I retain it in this genus, while noting that it apparently weakens the claim of *Cladochaeta* to generic recognition.

DROSOPHILA NITIDITHORAX, n. sp.

Male.—Deep black, dorsum of thorax and of abdomen almost glossy. Face whitish dusted and, like the cheeks, partly brownish yellow; frons except the orbits and triangle velvety black; antennae black; palpi and proboscis dusky testaceous yellow. Thorax without markings, the pleura not so conspicuously shining as dorsum. Abdomen slightly yellow at base. Legs dusky testaceous yellow, femora almost entirely fuscous. Wings greyish hyaline, veins unclouded. Halteres brownish yellow.

Frontal bristles strong, anterior reclinate orbital half as long as posterior one and slightly but distinctly above level of the proclinate one; interfrontalia with quite dense short black setulose hairs; facial carina nose-like, rounded above on the lower part; rays of arista about 4+2; vibrissae strong. Intradorsocentral setulae in 8-10 series; sternopleurals 3. Legs normal. Third costal section not longer than penultimate section of fourth vein and about one-third as long as second section; outer cross vein at about 1.5 its own length from apex of fifth vein.

Length, 2.5 mm.

Type and paratype, Perth, W.A., 15.11.1924 (Nicholson).

A robust black species which is most closely related to *subnitida* described below.

DROSOPHILA SUBNITIDA, n. sp.

Female.—Distinguished from the preceding species by the brown colour of the frons, the opaque frontal orbits and less shining dorsum of thorax.

There are no outstanding structural distinctions, but the anterior reclinate bristle is larger and farther from the proclinate one, the third section of costa is a little longer and the insect is less robust.

Length, 2 mm.

Type, Sydney, N.S.W., 6.1.25.

This species has somewhat the appearance of *fuscithorax* Malloch, but the latter has no carina on lower part of face and differs in other respects.

DROSOPHILA SYDNEYENSIS, n. sp.

Female.—Black, dorsum of thorax and abdomen almost glossy. Frons brownish red, orbits and triangle shining black; face yellowish on sides, slightly white dusted; cheeks yellowish; antennae yellowish or rufous, third segment fuscous; palpi and proboscis yellowish. Thorax as in *nitidithorax*, but the pleura as conspicuously shining as mesonotum. Abdomen with bases of basal two or three tergites yellowish. Legs as in *nitidithorax*. Wings hyaline. Halteres yellow.

Frons with a few hairs in front; anterior reclinate orbital bristle short, in transverse line with proclinate one; facial carina well developed and nose-like.

Thorax as in *subnitida*. Legs normal. Wing venation differing from that of *nitidithorax* and *subnitida* in having the third costal division well over half as long as second, usually about, or even full, three-fourths as long as it, and twice as long as penultimate section of fourth vein, the latter subequal to ultimate section of fifth, and about twice as long as outer cross vein.

Length, 2 mm.

Type and three paratypes, Sydney, N.S.W., 3 and 5.1.1925, and 2.4.1925.

A less robust species than *nitidithorax*.

DROSOPHILA ENIGMA, n. sp.

Male and female.—Very similar to *lativittata* Malloch in colour and general structure. Differs from it in being paler, the ground colour being testaceous yellow, the dorsum of thorax greyish dusted, and with paler vittae which are narrower, the submedian pair separated by a wider space which covers four instead of two series of the short hairs, and the other characters of the markings as stated in the key. The abdominal markings consist of a dark brown fascia on hind margin of each tergite which is narrowed or interrupted in centre, widened each side of median line and again at the lateral curvature, the fasciae rather indistinct on the lateral incurved portions of the tergites. As in *lativittata* the outer cross vein is faintly clouded and the penultimate section of fourth vein is about half as long as ultimate.

Length, 3 mm.

Type male and allotype, Sydney, N.S.W., 22.7.23, and 23.9.24. Paratypes, two females, Toronto, N.S.W.

DROSOPHILA SERRATA, n. sp. (Text-figure 1.)

Male.—Shining fulvous yellow, very similar to *ampelophila* Loew which it closely resembles in many respects. The type specimen is rather immature, but the thorax is not vittate and the abdomen has a faint dark uninterrupted apical fascia on each tergite. The legs are yellow and the wings yellowish hyaline with unclouded veins. Halteres yellow. Bristles and hairs fuscous.

Anterior reclinate orbital bristle about one-third as long as posterior one and distinctly above the level of proclinate one; eyes quite densely stiff-haired; face distinctly carinate. Thorax with six series of intradorsocentral hairs; prescutellar acrostichals not differentiated; both humerals strong; only two sternopleurals well developed. Two basal segments of fore tarsus with a comb-like series of short stiff



Text-fig. 1. *Drosophila serrata*, two basal segments of fore tarsi of male from in front.

black bristles on anterior side, the comb on basal segment bipartite (Fig. 1). Third section of costa about half as long as second and a little less than twice as long as penultimate section of fourth vein, the latter about one-third as long as ultimate section and subequal to ultimate section of fifth vein; outer cross vein at about twice its own length from apex of fifth vein.

Length, 1.75 mm.

Type, Eidsvold, Queensland, 2.4.24 (Bancroft).

There are several described species of the genus with the two basal segments of fore tarsi armed with comb-like bristles, but none of these have the armature as in this species so far as I am aware. I described one, *biarmipes*, from India, but in it the combs are confined to the apical parts of each segment and do not extend along the whole length of the anterior surfaces as here.

Genus GITONIDES Knab.

The species described below falls most readily into *Gitonides*, but it differs from the genotype in having the frons much narrower anteriorly and the first posterior cell of the wing quite noticeably narrowed apically.

GITONIDES CONVERGENS, n. sp.

Head brownish testaceous; upper half of occiput fuscous, lower half white dusted; upper extremities of frontal orbits, ocellar spot and clypeus, fuscous; face slightly white dusted; palpi brownish, paler at apices. Thorax brownish testaceous, dorsum when seen from in front with a broad brownish central vitta which is faint in front of the suture, where it is sometimes divided centrally and which is divided between suture and hind margin, a broad branch curving to each side and between the two pairs of dorsocentrals, and a narrower central one continuing to hind margin, the disc laterad of the anterior and posterior portions of vitta white dusted, between these pale markings and lateral margins there is a broad brownish vitta; humeral angles testaceous; scutellum when seen from in front with a brown central line which broadens out and covers apex, a fainter brown mark on each basal angle and a less distinct dark mark on disc each side of the dark central line, the latter surrounded by whitish dusting. Abdomen testaceous, all tergites except the basal two largely or entirely black. Legs testaceous, femora browned, tibiae dark at apices, the mid pair most conspicuously so. Wings hyaline. Halteres yellow.

Frons at vertex about one-third of the head width, much narrowed anteriorly, at front margin not half as wide as long in centre; proclinate orbital bristle well above middle of frons, the anterior reclinate bristle quite small and about midway between the others; arista bare; face slightly carinate; antennae normal, inserted at middle of profile. Thorax with two pairs of postsutural dorsocentrals, the anterior pair short, about eight series of intradorsocentral setulae, one humeral and two sternopleurals; scutellum convex. Abdomen broad and short. Legs stout, normal. Inner cross vein at two-fifths from apex of discal cell; outer cross vein at less than its own length from apex of fifth vein; ultimate section of fourth vein over three times as long as penultimate section; first posterior cell quite noticeably narrowed apically.

Length, 3 mm.

Type, Eidsvold, Queensland, 1924 (Bancroft).

Family Agromyzidae.

Subfamily MILICHIINAE.

DESMOMETOPA VARIPALPIS, n. sp.

Female.—Head black, whitish-grey dusted, with the usual opaque black M-shaped frontal marking; cheeks yellowish below; palpi testaceous, with conspicuous irregular black spotting. Thorax black, slightly shining, evenly greyish dusted and without vittae. Abdomen greasy in type, black, and probably less dusted than thorax. Legs black, tarsi yellowish, darker at apices. Wings hyaline. Knobs of halteres yellow.

Each orbit with the two upper bristles directed outward over eyes, the two anterior bristles incurved; arista hair-like, almost bare; palpi large, a little longer than head, lanceolate, broader than cheek, their apices rather pointed, bristles short. Thorax with two pairs of postsutural dorsocentral bristles. Legs normal. Wings as in *m-atrum* Malloch.

Length, 2.5 mm.

Type, Bourke, N.S.W., 6.5.26.

I know no species of this genus which has the palpi coloured and shaped as has this one, these organs being in all others unicolorous or yellow with dark apices.

Family Piophilidae.

PIOPHILA CONECTA Walker.

This species I previously listed as *latipes* Meigen. (These PROCEEDINGS, 1925, p. 316). Dr. O. Duda considers that *conecta* Walker is a distinct species, having two humeral bristles instead of only one, and the second segment of the fore tarsus about 1.5 as long as wide, not about as wide as long.

Besides the specimen already recorded by me I have seen another female specimen from Wahroonga, Sydney, N.S.W., 26.1.26.

I have before me what appears to be an undescribed genus of this family but have only one female specimen so defer describing it meantime.

Family Sapromyzidae.

Genus SAPROMYZA Fallén.

In presenting my synopsis of the species of this genus (These PROCEEDINGS, 1926, p. 33) I stated that undoubtedly there were many species still unknown to me and as evidence of this furnish descriptions of several that have been received since I completed the key. Under the description of each of these I have included notes which will serve to associate them with their most closely related forms in the key, but unfortunately there must yet be many undescribed species which can only be distinguished from those dealt with to date by a careful comparison with the complete descriptions or with the type-specimens.

I erect one new subgenus in the present paper for the reception of a very striking species from Sydney, but the others I retain in *Sapromyza sens. str.*, though several of them are rather aberrant from the genotype.

It will be necessary to publish a full key to the species later, but whether this duty may fall to me or another worker time will decide.

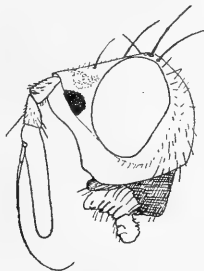
Subgenus HENDELOMYZA, n. subg.

Characters: Face concave in profile; basal segment of antenna as long as, or longer than, second, with some fine hairs below apically; sternopleura with but one bristle; thorax without presutural dorsocentrals. In other respects similar to *Sapromyza*.

SAPROMYZA (HENDELOMYZA) TENUICORNIS, n. sp. (Text-fig. 2.)

Female.—Head fulvous yellow, shining; ocellar spot fuscous, a fuscous line along inner margin of each orbital stripe which curves round anterior margin of latter and becomes wider there, almost connecting with the black spot between each antennal base and eye; some white dusting on sides and upper margin of frons; lower central part of face fuscous; parafacials white-dusted below the black

spot; third antennal segment brown, darker apically; arista black, yellowish at base; proboscis and palpi black. Thorax shining fulvous yellow, with two submedian vittae and one near each lateral margin white-dusted; pleura entirely white-dusted; scutellum paler yellow than mesonotum. Abdomen glossy black, yellowish on disc basally, where it is slightly grey-dusted. Legs yellow, apices of fore femora and tibiae infuscated. Wings honey yellow. Halteres brown.



Text-fig. 2. Head of *Sapromyza* (*Hendelomyza*) *tenuicornis*, from side.

Head in profile as in Figure 2; entire frons shining; anterior orbitals rather far from lateral margins; ocellars rather weak; arista subnude; head wider than high; proboscis stout. Thorax with but two pairs of postsutural dorsocentrals and one pair of prescutellar acrostichals; intradorsocentral setulae in four series in front of suture; scutellum convex, with four bristles; prosternum almost bare; mesopleura and sternopleura each with one bristle. Abdomen stout. Fore femur without preapical anteroventral comb; tibiae with preapical dorsal bristle. Inner cross vein almost below apex of first vein and at middle of discal cell.

Length, 7.5 mm.

Type, Bayview, Sydney, N.S.W., 19.12.25.

A very characteristic species which might eventually be placed in a separate genus, though I prefer to consider it as a subgenus at present.

It must be noted that *magnicornis* Malloch, with which *tenuicornis* has some characters in common, has two sternopleural bristles and the head quite differently shaped. This new species does not fit into any caption of my recently published key, the only other species having the antennae longer than the head being *magnicornis*.

SAPROMYZA RIPARIA, n. sp.

Male and female.—Head dull ochreous yellow; frons brownish in centre, ocellar spot fuscous; orbital stripes densely yellowish-grey dusted; a black or brown spot between each antenna and eye; antennae pale brown or yellowish, third segment and arista black; proboscis yellow; palpi black. Thorax subopaque ochreous yellow, rather densely greyish dusted, with two conspicuous brown submedian vittae which become wider behind, and traces of two sublateral vittae of the same colour behind suture; mesopleura and anterior part of propleura fuscous; scutellum brownish yellow, paler at anterior lateral angles and between apical bristles, and with two black apical spots. Abdomen ochreous, shining, with central part of each tergite darker and the apices paler. Legs testaceous yellow, apices of all femora, tibiae and tarsi, and bases of all tibiae, black. Wings yellowish hyaline. Halteres yellow.

Head almost normal in form, the face slightly receding below; orbital stripes receding from eyes anteriorly; frontal bristles all distinct; third antennal segment about 1.5 as long as wide; arista very short pubescent; proboscis stout. Thorax with three pairs of postsutural dorsocentrals, the anterior pair short and well behind suture; mesopleura with one bristle; sternopleura with two bristles rather close together; prosternum with a few very short hairs. Fore femur without anteroventral comb; mid tibia with two long apical ventral bristles; all tibiae with preapical dorsal bristle. Inner cross vein below apex of first vein and at middle of discal cell.

Length, 7.7-5 mm.

Type male, allotype, and one paratype, Clyde R., Nov., 1925 (H. J. Carter).

This species will run to caption 11 in my key to the species of the genus, but it is distinguished from *magnifica* Malloch by the unspotted wings and grey orbital vittae and from all the others falling under caption 10 by the entirely opaque frons.

SAPROMYZA BREVICORNIS, n. sp.

Male and female.—Head black; frons velvety, the triangle and orbital stripes glossy; parafacials and sometimes the sides of face yellowish, the former white dusted; cheeks yellow below, black above; antennae fuscous, yellowish at bases, arista black; palpi and proboscis black. Thorax shining fulvous yellow, sometimes darkened a little on disc of mesonotum. Abdomen glossy black, yellow at base. Legs black, coxae, trochanters, bases of femora, of tibiae and of tarsi of mid and hind legs, yellow. Wings brownish hyaline. Halteres yellow.

Head of normal form, the face centrally vertically convex; frontal bristles normal, the anterior orbital distant from eye; antennae short, third segment not much longer than wide; arista with very short pubescence. Thorax with three pairs of postsutural dorsocentrals, the anterior short pair well behind suture; scutellum convex; mesopleura with one bristle; sternopleura with two; prosternum with a few hairs. Abdomen robust. Fore femur without an anteroventral comb; mid tibia with an unequal pair of apical ventral bristles; preapical dorsal bristle present on all tibiae. Wing venation as in *riparia*.

Length, 5-6 mm.

Type male, allotype, and two male and one female paratypes, Sydney, N.S.W., Sept.-Oct., 1925.

This species runs to caption 10 in my key, having the head black, with parafacials yellow, but is readily distinguished from *sciomyzina* Schiner by having the frons largely velvety instead of shining, and the third antennal segment not much longer than wide, instead of twice as long as wide.

SAPROMYZA URBANA, n. sp.

Male.—Entirely testaceous yellow, shining, the frons not conspicuously shining, and with undifferentiated orbits. Wings hyaline. Halteres yellow.

Anterior orbital bristle not much in front of middle of frons, shorter than the ocellars; surface of frons with microscopic black hairs; antennae short; arista broken in type so that it is not possible to determine the nature of the hairing if any. Thorax with three pairs of postsutural dorsocentrals, the anterior pair rather weak, but in this character the species is about intermediate between the two groups defined in caption 9 of my key; hairs on thorax much weaker than in *unicolorata* Malloch, the median two series on dorsum most conspicuous. Legs slender, the fore femur with only two or three of the posteroventral bristles on apical half well developed, the anteroventral preapical comb present but weak.

Inner cross vein below apex of first vein; penultimate section of fourth vein not over half as long as ultimate section.

Length, 3.75 mm.

Type, Sydney, N.S.W., 8.10.25.

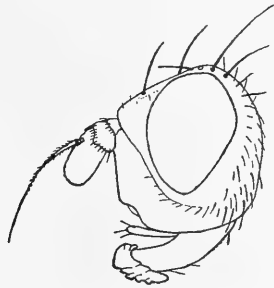
An inconspicuously coloured species with no outstanding external structural characters. It differs from any Australian species except *unicolorata* Malloch in being entirely testaceous yellow, and is a less robust species than it, with weaker hairing, and different venation. The hypopygia are distinct but I have only the type-specimens of each and do not care to dissect these, unless compelled to for lack of other material later.

An error occurs in caption 22, first section, of my key. The inner cross vein is beyond, not proximad of apex of first vein in *unicolorata*. This feature is correctly reported in the description of the species.

SAPROMYZA MARIAE, n. sp. (Text-figure 3.)

Male and female.—Fulvous yellow, distinctly shining. Frons dull, the orbital stripes and triangle shining; ocellar spot black; parafacials white dusted; antennae, palpi, and proboscis, yellow, arista fuscous. Dorsum of abdomen largely black or fuscous. Legs yellow, apices of fore and hind femora and tibiae, fore tarsi from before apex of basal segment, and mid and hind tarsi from before apex of third segment, black. Wings luteous hyaline. Halteres yellow.

Frontal bristles all well developed, anterior orbital distant from eye; third antennal segment fully 1.5 as long as wide, rounded at apex; arista subnude; head



Text-fig. 3. Head of *Sapromyza mariae* from the side.

in profile as in Figure 3. Thorax with three pairs of postsutural dorsocentrals, the anterior pair short; mesopleural hairs stronger than usual, one or two of them quite bristle-like; scutellum normal. Hypopygium stout, the forceps much shorter and stouter than in *flavimana* Malloch. Fore femur without preapical antero-ventral comb; mid tibia with two long apical ventral bristles; preapical dorsal bristle weak on hind tibia. Inner cross vein almost below apex of first vein and close to middle of discal cell.

Length, 6.65 mm.

Type, female, allotype, one male and one female paratype, St. Mary's, N.S.W., 12.8.24.

This species will run to *flavimana* Malloch in my key, but the latter has the frons entirely shining, the face flat and dull, and the fore femora more largely black, etc.

SAPROMYZA OCCIPITALIS Malloch.

Eight specimens, Sydney, N.S.W., October and November, 1925.

SAPROMYZA SCIOMYZINA Schiner.

One specimen, Sydney, N.S.W., 25.10.25.

SAPROMYZA BRUNNEOVITTATA Malloch.

Two specimens, Sydney, N.S.W., 18.10.25.

SAPROMYZA STIGMATICA Malloch.

One specimen, Millgrove, V., Dec., 1925 (F. E. Wilson).

SAPROMYZA MACULITHORAX Malloch.

Four specimens, Sydney, N.S.W., July, August, and November, 1924-25.

SAPROMYZA VARIVENTRIS Malloch.

A male of this species is darker than the type female, the spot at base of antennae on the parafacials being black, and the pale parts of the legs more brownish yellow. The thoracic vittae are also broader, and the abdominal markings are less regular.

Locality, Nevertire, N.S.W., 25.3.26, the same day and month as type, but a year later.

Genus *HOMONEURA* van der Wulp.

In one of my recent papers (These PROCEEDINGS, 1926, p. 551) I stated that I would present in my next paper a synopsis of the Australian species of this genus known to me, and though I am confident that my material contains but a small portion of the native species I feel that I ought to provide a synopsis of those already described in the interests of students of the family. This synopsis contains only 14 species, some of them so closely allied that their separation as distinct species has been based largely upon the structure of the male hypopygia, figures of some of which I present herein. I have previously referred to the importance of the male hypopygia as distinguishing characters of the species in this family and hope that an examination of the figured examples will create an interest on the part of some Australian student that will result in a comprehensive study of the family on this basis. One of the species figured exhibits an asymmetry of the inferior forceps which is unique in my experience in this family, but it appears to be a perfectly normal specimen in other respects.

Key to the species.

1. Wings with quite conspicuous brown or fuscous clouds or spots, the cross veins and the apex of second vein always clouded 2
- Wings clear or yellowish, at most the cross veins slightly clouded, none of the longitudinal veins clouded at apices 7
2. Thorax with only two of the three strong pairs of dorsocentrals behind the suture, the other pair in front of suture; wing with conspicuous fuscous markings, the most prominent consisting of a broad oblique fascia, the outer edge of which is at apex of second vein, extending over fourth vein but not to margin of wing, and enclosing a clear spot in first posterior cell; face largely fuscous, white below; a black spot between each antenna and eye; arista plumose; dorsum of thorax and abdomen largely fuscous; legs bicoloured, testaceous and dark brown *atrogrisea* Malloch.
- Thorax with three strong pairs of postsutural dorsocentrals, or if there are but two such pairs there are no presuturals present 3

3. Frons opaque fuscous; both cross veins of wings and apex of second vein with fuscous clouds; arista short plumose *fumifrons* Malloch.
Frons yellow or brownish yellow; in addition to the wing spots mentioned above there are two other spots present, at or near apices of third and fourth veins 4
4. Spots on apical part of wing at extreme apices of the veins; arista with very short pubescence *apicinebula* Malloch.
Spots on apical part of wing not all at extreme apices of veins; arista plumose ... 5
5. Tips of palpi black; thoracic dorsum with a dark mark along inner side of humeral callosities and two narrow dark vittae along inner margin of lines of dorso-centrals *proximella* Malloch.
Palpi entirely yellow; no dark mark along inner margin of humeral callosities 6
6. Cell between auxiliary and first veins of wing dark at apex; thoracic dorsum with four faint, broad reddish vittae, the central pair extending on to disc of scutellum *preapicalis* Malloch.
Cell between auxiliary and first veins of wing clear; thoracic dorsum not noticeably vittate *barnardi* Bergroth.
7. Halteres black; thorax and abdomen uniformly shining black; arista plumose; legs fuscous, tibiae and tarsi testaceous yellow *signatifrons* Kertész.
Halteres yellow; thorax and abdomen fulvous or testaceous 8
8. Thorax distinctly vittate, with 1 + 3 pairs of strong dorso-centrals *eidsvoldensis* Malloch.
Thoracic dorsum not vittate, with three pairs of postsutural dorso-centrals 9
9. Abdomen with one or more of the tergites of apical part with a pair of round black spots 10
Abdomen without evident paired black spots 11
10. Ocellar bristles short and weak; no dark dorso-central vitta or series of spots on abdomen; superior forceps of hypopygium stout, rounded at apices (Text-fig. 4) *indecisa* Malloch.
Ocellar bristles long and strong; a more or less distinct dorso-central dark vitta or series of spots on apical tergites of abdomen; superior forceps of hypopygium slender apically (Text-fig. 5) *gordoni*, n. sp.
11. Third antennal segment and apices of palpi black; arista pubescent 12
Antennae and palpi entirely yellow; arista long haired *illingworthi*, n. sp.
12. Females 13
Males 14
13. Preapical abdominal sternite glossy black only at apices of processes *armata* Malloch.
Preapical abdominal sternite entirely glossy black and heavily chitinized *perthensis*, n. sp.
14. Superior hypopygial forceps simple, but slightly curved, not recurved (Text-fig. 7) *asymmetrica*, n. sp.
Superior hypopygial forceps pronouncedly recurved 15
15. Apices of superior hypopygial forceps simple, inferior pair long and slender (Text-figs. 8, 9) *perthensis*, n. sp.
Apices of superior hypopygial forceps branched, inferior pair broad and serrated on edges (Text-fig. 10) *armata* Malloch.

HOMONEURA GORDONI, n. sp. (Text-figure 5.)

Male.—Very similar to *indecisa* Malloch, differing in colour in having the apices of some of the abdominal tergites blackened (possibly not invariably so) the apical two or three tergites with a central vitta or series of elongated dark spots, and the outer cross vein of wing slightly clouded.

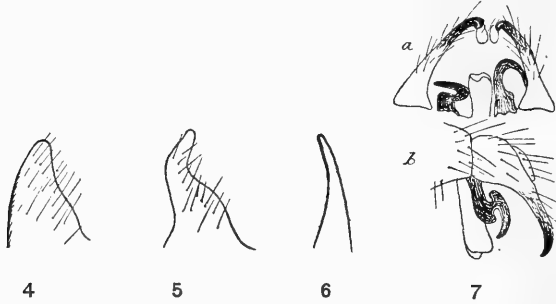
A larger species than *indecisa*, with frontal bristles all strong, the hypopygial forceps less robust, and the penultimate and ultimate sections of fourth wing vein subequal in length. The antennae are missing in type specimen so that it is impossible to determine if they are similar to those of *indecisa*.

Length, 5.5 mm.

Type, Gordonvale, N. Queensland, October (J. F. Illingworth).

HOMONEURA ILLINGWORTHII, n. sp. (Text-figure 6.)

Male.—Similar to *indecisa* in colour, but without any paired black spots on the apical abdominal tergites, each segment brownish or fuscous on hind margin and the apical two or three with a faint dark dorsocentral elongate spot. Antennae and palpi yellow; frons dull, orbits and ocellar region shining. Wings yellowish, outer cross vein slightly clouded.



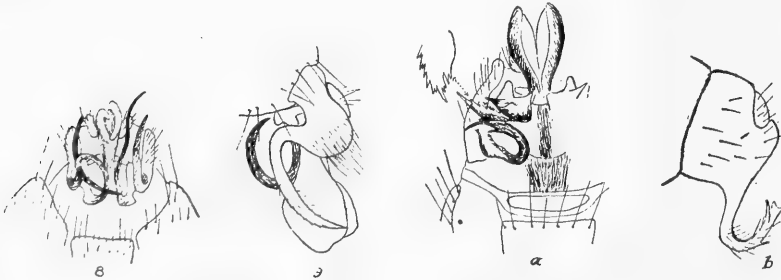
Figs. 4, 5 and 6. Superior hypopygial forceps of *Homoneura indecisa*, *H. gordonii*, and *H. illingworthii* respectively.

Text-fig. 7. Hypopygium of *Homoneura asymmetrica*.
a, from below; b, from the side.

All frontal bristles long and strong; arista plumose; third antennal segment fully 1.5 as long as wide; face slightly convex in centre vertically. Hairs below humeral bristles strong; centre of propleura with a few microscopic black hairs; prosternum also haired; thorax with three strong pairs of postsutural dorso-centrals and 8-10 series of intradorsocentral hairs; mesosternum quite regularly setulose on most of its length. Superior hypopygial forceps long and slender, tapered to a point (Text-fig. 6). Fore femur with an anteroventral comb; mid tibia with three strong apical ventral bristles. Penultimate section of fourth vein about three-fourths as long as ultimate section.

Female.—Similar to male, the abdominal markings more distinct.

I can see no fine hairs on the propleura but the specimen is not in good condition, and the pinning prevents a view of the mesosternum. Apical genital segment unspined.



Text-fig. 8. *Homoneura perthensis*, hypopygium from below.

Text-fig. 9. *Homoneura perthensis*, from the side.

Text-fig. 10. *Homoneura armata*, male hypopygium. a, from below, one side incomplete; b, from the side, superior forceps only.

Length, 5.5-5 mm.

Type, Gordonvale, N. Queensland, October (J. F. Illingworth); allotype, Cairns District, Queensland (Dodd).

Named in honour of Dr. J. F. Illingworth who collected the type specimen.

HOMONEURA PERTHENSIS, n. sp. (Text-figures 8 and 9.)

Male and female.—Very similar to *armata* Malloch in colour, but more shining, and the penultimate ventral abdominal segment in female entirely, or almost entirely, glossy black, instead of black at apex only.

Structurally the two species are very similar and, like *asymmetrica*, both have an isolated outstanding bristle on each side of mesosternum in front of middle instead of regular setulose hairs as in *illingworthi*. The female has the penultimate ventral segment differently shaped from that of *armata*, there being a short blunt process on each side at apex, while in *armata* the apical margin has a deep V-shaped ventral cleft dividing the two tapered apical lateral angles; the apical segment of the female in *armata* has about half a dozen stout black thorns, while there are only fine hairs present in *perthensis*. The male hypopygia of the two species are shown in Text-figures 8, 9 and 10.

Length, 5.5-5 mm.

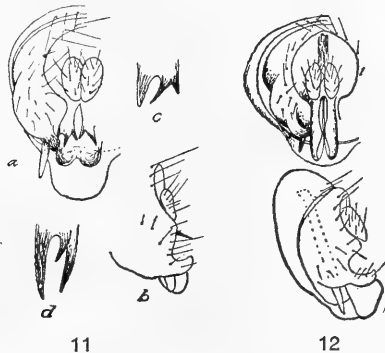
Type male, allotype, and one female paratype, Perth, W.A., 15.11.1925 (Nicholson).

HOMONEURA ASYMMETRICA, n. sp. (Text-figure 7.)

Male.—A smaller and less robust species than *perthensis*, but very similar in most respects. Readily distinguishable by the structure of the male hypopygium

Length, 4 mm.

Type, Perth, W.A. (J. Clark).



Text-fig. 11. *Homoneura preapicalis*, male hypopygium. a, ventral view, one side incomplete; b, side view; c, apex of inferior forceps; d, another form, possibly a distinct species, Sydney.

Text-fig. 12. *Homoneura barnardi*, male hypopygium, ventral and lateral views.

HOMONEURA PREAPICALIS Malloch. (Text-figure 11.)

HOMONEURA BARNARDI Bergroth. (Text-figure 12.)

Sapromyza barnardi Bergroth, Stett. Ent. Zeit, 1894, p. 74.

I present figures of the male hypopygia of the above-named species to facilitate their identification (Text-figs. 11 and 12).

Family Neottiophilidae.**Tapeigaster brunneifrons, n. sp.**

Female.—Head black; frons a rich red-brown, with a spot of white dust on each vertical angle and another at middle against each eye; parafacials, cheeks and face, whitish dusted, the cheeks reddish brown; antennae brown, slightly dusted; proboscis black; palpi reddish brown. Thorax shining brownish-black, with brownish dusting, the dorsum with two submedian vittae and the lateral margins white dusted; pleura white dusted. Abdomen shining black, yellow at base, and centrally on apical two tergites. Legs black, a testaceous yellow ring at base and another at middle of each tibia, tarsi testaceous yellow. Wings yellowish hyaline. Halteres yellow.

No distinct orbitals present, the hairs on anterior margin of frons setulose; arista subnude. Only the prescutellar dorsocentrals and acrostichals present; scutellum short, rounded in outline, convex, haired on disc, the basal pair of bristles much shorter than the apical pair; sternopleura with one bristle. Abdomen short and broad, tapered at apex. Femora of all legs stout, armed with short stout spines on apical halves of anteroventral and posteroventral surfaces; preapical dorsal bristle indistinct on fore and hind tibiae. First posterior cell of wing narrowed apically.

Length, 7 mm.

Type, Newcastle, N.S.W., 7.4.26.

The darkest coloured species of the genus known to me.

THE INFLUENCE OF CERTAIN COLLOIDS UPON FERMENTATION.

By R. GREIG-SMITH, D.Sc., Macleay Bacteriologist to the Society.

(Two Text-figures.)

[Read 27th April, 1927.]

PART IV. AGAR FIBRE IN THE ALCOHOLIC FERMENTATION.

In Part ii of this series it was shown (These PROCEEDINGS, 1925, p. 345) that agar had a somewhat irregular action. It depressed and then accelerated the alcoholic fermentation of dextrose when present to the extent of 0.2%. With 0.1%, it slightly accelerated and with 0.05% the fermentation was depressed. Both in the fluid and in the solid state it markedly accelerated the fermentation of lactose by the high temperature organism, when present to from 0.3% to 0.6% (These PROCEEDINGS, 1924, p. 440). It had a strongly positive action when in the fibrous or the flocculent condition in the ammoniacal fermentation of urea (These PROCEEDINGS, 1925, p. 350) when present to the extent of 0.4%. In the lactic fermentation of dextrose, 0.2% had no action.

The small quantities of agar were used when it was added to the medium prior to sterilizing the fluids. It dissolved during the steaming and separated out in the flocculent state when the fluids cooled. Half of one per cent of agar which was the usual amount of the other colloids taken in the experiments caused the fluids to become very viscous and it did not seem that this condition was advisable for the alcoholic fermentation.

Small amounts were used in the following in which the agar had been treated with acid, washed and finally dried. In all the other experiments, the commercial fibre had been used.

TABLE I.—THE INFLUENCE OF AGAR UPON THE ALCOHOLIC FERMENTATIONS.
Percentage of Invert Sugar Consumed.

| Days | 2 | 3 | 4 | 5 |
|--------------------|------|------|------|------|
| No agar | 17.5 | 40.8 | 63.7 | 79.4 |
| Agar 0.05% | 15.1 | 36.9 | 60.4 | 77.4 |
| Agar 0.1% | 15.1 | 36.9 | 62.9 | 81.8 |
| Agar 0.2% | 15.7 | 35.8 | 64.4 | 84.2 |

This bears out what had already been found with crude fibre, that small quantities (0.05%) depressed while those a little larger at first depressed and then accelerated (These PROCEEDINGS, 1925, p. 345, Table vi).

In all these experiments with agar and yeasts, the agar had been in the flocculent condition; it had been added to the nutritive fluids before sterilization. In the experiment about to be recorded, half of one per cent of agar was used and

in order to avoid a thickening of the media, the agar fibre was put into a dry tube and steamed upon several occasions after which it was dropped into the fluid just before seeding. The experiments with agar in the ammoniacal fermentation of urea showed that fibrous agar was almost as efficient as floccules of agar in accelerating the fermentation.

TABLE ii.—THE INFLUENCE OF AGAR FIBRE UPON THE ALCOHOLIC FERMENTATION.
Percentage of Invert Sugar Consumed.

| Days | 2 | 3 | 4 | 5 |
|---------------------|------|------|------|------|
| Control, no agar .. | 16.6 | 38.6 | 60.1 | 77.6 |
| Agar fibre, 0.5% .. | 17.5 | 41.1 | 65.0 | 82.5 |

In this case the agar has shown a decided accelerating effect all through the fermentation and makes it appear that the previous indeterminate results were caused by the use of an insufficiency of the colloid.

PART V. OLD OR HEATED YEAST CELLS ARE NOT STIMULATED BY FULLER'S EARTH.

It was shown in an earlier paper (These PROCEEDINGS, 1923, pp. 48, 623) that the mineral and similar colloids were able to stimulate the cells of the high temperature organism after they had been weakened by chill. In this paper some tests were made to see how yeast cells that had been weakened by age would respond to the presence of one of the most active of the mineral colloids, namely, fuller's earth.

In the first the cells were twenty hours old, in the second the culture was twenty days old and the third was an old culture that had been kept at laboratory temperature for four and a half months. Films of the last showed long sausage shaped cells woven together into clumps as well as single cells. The clumps were broken up as much as possible by repeated passage through a capillary nozzle, a procedure employed in all cases where a homogeneous suspension is desired. The yeast was a stock Scotch distillery yeast and the three tests are grouped together for convenience, although they were made at intervals of three and of twenty days.

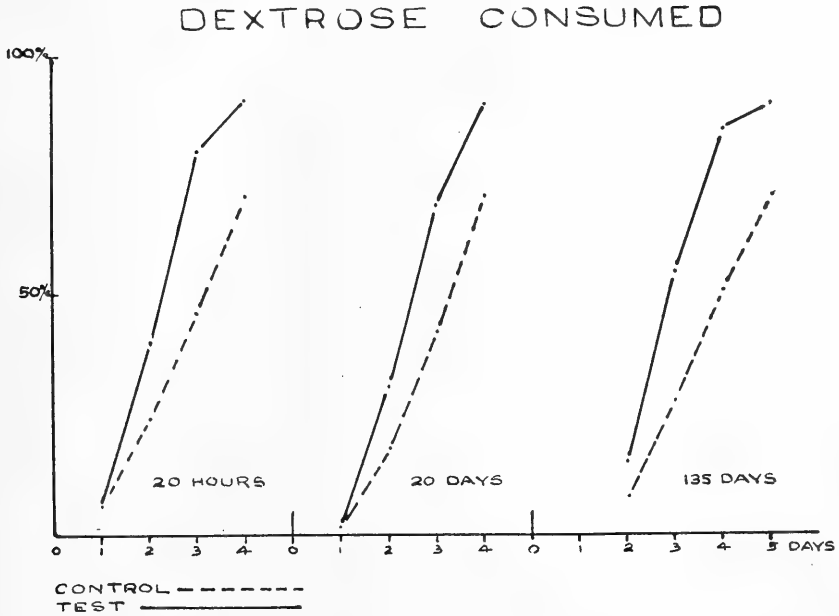
TABLE i.—THE INFLUENCE OF FULLER'S EARTH UPON THE FERMENTATION OF
DEXTROSE BY YEAST CELLS OF DIFFERENT AGES.

Dextrose Consumed Per Cent.

| Age of Cells. | Days | 1 | 2 | 3 | 4 | 5 |
|----------------|-------------------|-----|------|------|------|------|
| 20 hours | Control | 5.9 | 23.7 | 46.0 | 71.3 | — |
| | Fuller's earth .. | 6.7 | 39.9 | 79.9 | 90.6 | — |
| 20 days | Control | 1.9 | 18.4 | 42.1 | 70.7 | — |
| | Fuller's earth .. | 1.7 | 31.3 | 68.7 | 90.0 | — |
| 135 days | Control | — | 7.7 | 28.3 | 51.0 | 71.2 |
| | Fuller's earth .. | — | 15.2 | 55.2 | 84.8 | 90.5 |

The graphs of the three tests show that the younger cells began to ferment quicker but once fermentation had begun there was a similarity in the curves.

The mineral colloid did not show any differentiation between a young and an old culture of cells.



Upon finding that the colloid did not have an effect upon cells weakened by age and by contact with their own byproducts, an attempt was made to see if the application of heat would weaken them sufficiently to enable the colloid to exhibit an effect.

Suspensions of the same yeast were heated for half an hour at 45° and at 50° and sown in a dextrose medium which was incubated at 28° as in the previous cases. The following results were obtained; those for the unheated cells have already been recorded in Table i (20 hours).

TABLE ii.—THE INFLUENCE OF FULLER'S EARTH UPON HEATED YEAST CELLS.
Percentage of Dextrose Consumed.

| Days | 1 | 2 | 3 | 4 |
|----------------------|------|------|------|------|
| Heated at 45° | | | | |
| Control | 5.9 | 24.7 | 48.2 | 70.1 |
| Fuller's earth | 5.6 | 41.3 | 81.1 | 90.5 |
| Heated at 50° | | | | |
| Control | none | 10.0 | 32.7 | 60.7 |
| Fuller's earth | none | 13.2 | 49.7 | 82.9 |

Heating the yeast at 45° had no effect upon it, the dextrose consumed in the presence and absence of the mineral colloid was the same as by the unheated yeast (Table i, 20 hours). At 50°, it was weakened or partly destroyed and was slower to start the fermentation but the colloid did not accelerate the presumably weakened cells, indeed the differences between the control and the colloid determinations are less than with the unheated cells.

Heating the yeast cells therefore does not weaken them so much as to enable the colloid to exhibit a greater differentiation.

Conclusions.—The mineral colloid, fuller's earth, does not accelerate the fermentation of dextrose by yeast cells that have been weakened by age or by heat.

PART VI. THE NON-ADSORPTION OF THE INVERTASE OF HEATED YEAST BY FULLER'S EARTH.

In Part v of this series, it was shown that the heating of yeast cells to 50° did not affect them to an extent to enable the mineral colloid, fuller's earth to show the stimulating effect which had been observed with weakened bacterial cells. Apparently the dextrose-fermenting function had not been affected. While this seems to apply to the alcoholic fermentation it might not apply to the other functions of the cell, for example, the secretion of invertase might be weakened and it might respond to the accelerating influence of a mineral colloid. With this idea in view, a number of experiments were made with yeast cells that had been heated to near the lethal temperature before being grown in solutions of saccharose.

The nutrient solution generally contained peptone 1 g., meat-extract 1 g., monopotassium phosphate 0.7 g., dipotassium phosphate 0.3 g., yeast-water 100 c.c., and magnesium sulphate anhyd. 0.3 g. in 500 c.c. of tap-water. The solution had a pH value of 6.8. To the above an equal volume of 16% saccharose solution was added generally just before seeding with the heated yeast. This solution of sugar had been filtered through porcelain to eliminate the spores of *Bac. levaniformans* which are always in sugar. The test flask or flasks received 0.5% of fuller's earth which had been sometimes ignited, treated with hydrochloric acid washed and dried or sometimes simply heated at 200°.

The first experiment gave a curious result and caused one to think that a novelty had been encountered but the succeeding tests were different and were more or less uniform. Five tests were made with heated yeast and five with normal unheated distillery yeast. All the experiments were made at different times and somewhat alternately, three heated, two normal, two heated and three normal but for convenience the results with the normal cells are tabulated first. In some of the tests the nutrient solutions were contained in small flasks and in these the fermentation proceeded rather briskly on account of the shallow layer of liquid formed by 50 c.c. The whole contents of these small flasks were taken for the determination of the sugars. In the majority of the tests, large flasks were used and portions of the 500 c.c. were daily abstracted for the determination of the reducing sugars before and after inversion at 70° with 10% hydrochloric acid. The reducing sugars were calculated to saccharose and expressed as percentages of the saccharose originally taken. The total inversion is the sum of the inverted saccharose present plus the saccharose lost, it being assumed that the saccharose

must have been first inverted before being fermented to alcohol, carbon dioxide and acids.¹

In heating the yeasts the cells were suspended in a nutrient fluid generally a modified Hansen's fluid contained in Freudenberg flasks. These were immersed in water at 55° for varying times. After treatment, the flasks were incubated and that with the fewest colonies, as in *a*, was taken for seeding the test flasks. In *b*, the cells were suspended in a fluid of pH 6.2 and all flasks showed a good growth even when heated for 105 minutes; the last was distributed in a fluid of pH 5.6 and heated at 56°. This destroyed most of the cells, the 15-minute flasks contained two colonies which were grown, distributed and used. In *c*, the cells, suspended in a fluid of pH value 5.6, had been heated at 55° for 105 minutes. In *d*, the suspension medium had a pH value of 6.4 and the cells were heated for an hour at 54°. The growth that developed consisted of a large flocculent colony and many small ones; the small colonies were picked out, distributed and used. Similar colonies appeared as the result of heating a suspension in pH 5.7 for 50 minutes at 54°. The large flocculent colonies were picked out and used in *e*.

In the normal unheated set, 1 and 2 were made in small flasks and these show a rapid fermentation. The yeast in 5 was the crop from a single cell of the stock yeast which had been used in all the other tests.

The speed of the fermentation varied in the tests. This was partly due to differences in the amount of yeast added in seeding, partly to the amount of fluid in the fermentation flasks and possibly the amount of invert sugar originally in the fluids as the result of steaming the solution of saccharose might have had an influence. The invert sugar present at the start of each experiment was not always determined but in some cases it was. In *d*, there was 13%, *e* had 2%, 1 and 2 had less than 1.5%, 3 had none and 5 had 4%. Each pair of the test and control fluids was made at the same time with the same constituents, sown with the same number of drops of the same suspension of yeast, was contained in flasks of the same shape and capacity and was incubated side by side. One experiment may differ from another but each control can be compared with its test.

During fermentation, the pH values of the fluids fell, that is, the acidity rose from 6.8 to about 4.3 when from 80 to 90% of the sugar had been consumed. The control and the test were usually the same although in a few cases there was a difference of 0.1 or 0.2; the more fermented fluid was the more acid.

An examination of Tables i and ii and better, perhaps, of the graphs, shows that with the normal yeast the total inversion is slowed by the colloid, the consumption is slowed in four cases out of five; with the heated yeast, the total inversion was scarcely influenced by the colloid, the consumption was hastened in all cases.

It seems to be clear that normal yeast, if we may take this distillery yeast as a type, has its activity upon saccharose inhibited by the presence of a mineral colloid such as fuller's earth. This is probably the result of the adsorption of the yeast invertase by the colloid. Upon adsorption, the enzyme is rendered inert as has been shown by other workers and by the author (These PROCEEDINGS, 1925,

¹ In Part ii (1925) of this series the invert sugar as found has been given. It would have been better to have given the total inversion as this appears to be the proper way to express the enzymic activity. When the results of Table ii (of Part ii) are expressed in terms of the total inversion, it is shown that asbestos behaved like the fuller's earth in this paper (test *a*) and the loss of saccharose was much the same in the absence or presence of asbestos.

TABLE i.—THE ACTION OF NORMAL UNHEATED YEAST UPON SACCHAROSE IN PRESENCE OF FULLER'S EARTH.
In Terms of Original Saccharose.

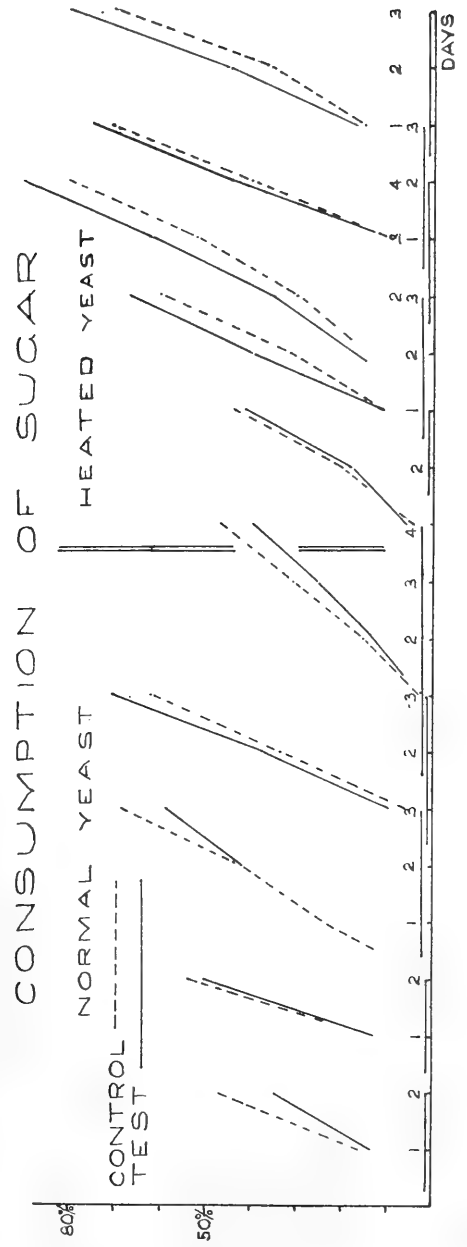
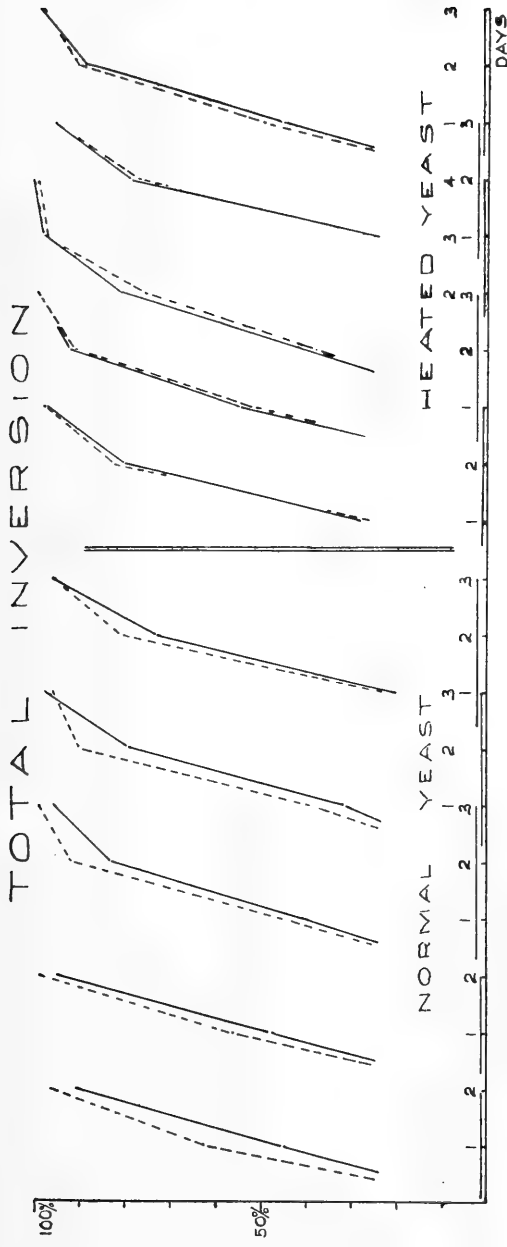
| Test | 1 | | 2 | | 3 | | | 4 | | | 5 | | | |
|------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
| Days | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 4 |
| Control. | | | | | | | | | | | | | | |
| Saccharose inverted .. | 46 | 48 | 44 | 45 | 21 | 50 | 30 | 33 | 56 | 34 | 20 | 66 | 65 | 47 |
| Saccharose consumed .. | 16 | 47 | 13 | 54 | 24 | 42 | 69 | 6 | 34 | 62 | 3 | 15 | 31 | 52 |
| Total inversion | 62 | 95 | 57 | 99 | 45 | 92 | 99 | 39 | 90 | 96 | 23 | 81 | 96 | 99 |
| Fuller's Earth. | | | | | | | | | | | | | | |
| Saccharose inverted .. | 32 | 56 | 36 | 44 | 15 | 42 | 37 | 21 | 42 | 27 | 17 | 60 | 70 | 60 |
| Saccharose consumed .. | 13 | 35 | 12 | 51 | 24 | 41 | 59 | 9 | 37 | 71 | 3 | 13 | 26 | 40 |
| Total inversion | 45 | 91 | 48 | 95 | 39 | 83 | 96 | 30 | 79 | 98 | 20 | 73 | 96 | 100 |

TABLE ii.—THE ACTION OF HEATED YEAST UPON SACCHAROSE IN PRESENCE OF FULLER'S EARTH.
In Terms of Original Saccharose.

| Test | a | | | b | | | c | | | | d | | | e | | |
|------------------------|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|--|
| Days | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | |
| Control. | | | | | | | | | | | | | | | | |
| Saccharose inverted .. | 22 | 62 | 54 | 41 | 59 | 39 | 45 | 45 | 19 | 16 | 37 | 24 | 34 | 54 | 28 | |
| Saccharose consumed .. | 4 | 20 | 44 | 11 | 32 | 60 | 30 | 52 | 80 | 9 | 40 | 72 | 15 | 36 | 70 | |
| Total inversion | 26 | 82 | 98 | 52 | 91 | 99 | 75 | 97 | 99 | 25 | 77 | 96 | 49 | 90 | 98 | |
| Fuller's Earth. | | | | | | | | | | | | | | | | |
| Saccharose inverted .. | 22 | 62 | 55 | 43 | 52 | 32 | 45 | 36 | 10 | 15 | 34 | 21 | 29 | 44 | 19 | |
| Saccharose consumed .. | 6 | 18 | 42 | 11 | 40 | 67 | 36 | 62 | 90 | 9 | 44 | 75 | 17 | 45 | 80 | |
| Total inversion | 28 | 80 | 97 | 54 | 92 | 99 | 81 | 98 | 100 | 24 | 78 | 96 | 46 | 89 | 99 | |

pp. 50, 342). The adsorption can be only partial as the production of reducing sugars is lessened and not prohibited. The slower production of fermentable hexoses has been followed by a slower alcoholic fermentation in four cases out of five, a result which seems to be quite natural. Had there been no slowing in the formation of the reducing sugars the colloid would have hastened the alcoholic fermentation, judged by the consumption of the sugar, as has been shown in Parts ii, iii and v of this series.

These experiments with heated yeast were made to see if heating the yeast to near the lethal temperature would influence the production of invertase and the results are in a positive direction. A change did occur in this particular yeast, grown in the particular medium. The invertase became indifferent to the presence of the mineral colloid, fuller's earth, and as a consequence the alcoholic fermentation of the inverted saccharose was accelerated by the mineral colloid. The practical outcome was that the heated yeast behaved towards saccharose just as an unheated yeast behaves towards dextrose or invert sugar in presence of the colloid.



Conclusions.—Heating the yeast to near the lethal point led to a subsequent inversion of saccharose but the agent causing the inversion, presumably the invertase, was indifferent to the presence of the mineral colloid. The invertase of normal yeast is sensitive to the presence of the colloid, being partly adsorbed and producing a lessened inversion under similar conditions. As a result of the indifference, the alcoholic fermentation of saccharose by heated yeast is accelerated by the mineral colloids just as the fermentation of dextrose by a normal yeast is accelerated.

A NOTE ON REPRODUCTIVE PHENOMENA IN SOME LIZARDS.

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Society in Zoology.

(Three Text-figures.)

[Read 25th May, 1927.]

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 3. Comparison with the Mammalia.
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- II. On the Growth of the Extra-embryonic Mesoderm in *Lygosoma (Hinulia) quoyi*, *Tiliqua scincoides*, *Egernia whitei* and *Egernia striolata*.
- III. On the Occurrence of Corpora Lutea in *Lygosoma (Hinulia) quoyi*, *Tiliqua scincoides*, *Egernia whitei* and *Egernia striolata*.
- IV. The Omphaloplacentation of *Tiliqua scincoides*.

I. THE PLACENTATION OF *Lygosoma (Hinulia) quoyi*.

In a preliminary note communicated to this Society, 30th March, 1927, the author recorded the occurrence of placentation in the Scincid lizards *Lygosoma (Hinulia) quoyi*, *Egernia whitei* and *Egernia striolata* and stressed the importance of the discovery of a type of allantoplacentation in these lizards which more closely resembles that found in the Mammalia than any hitherto recorded in a reptile. It is proposed in the present communication to describe briefly the allantoplacentation of *L. quoyi* and compare it with allantoplacentation as it occurs among the Reptilia, Marsupialia and Eutheria and to follow at a later date with a detailed account of the placentation of *L. quoyi*, *E. whitei* and *E. striolata*.

1. DESCRIPTION OF MATERIAL.

The habitat of *L. quoyi* ranges from sea level to approximately 5,000 feet above sea level. Those lizards which inhabit the highest regions are much smaller in the adult condition than those found at sea level, and during the gestation period, which covers approximately three months, the females of the former type carry from three to five young, while those of the latter carry from five to nine young. The placentae in both are identical.

Given normal climatic conditions, ovulation among the females at sea level (Sydney, N. S. Wales) occurs during the beginning of October, whereas it is two or three weeks later among the females at 5,000 feet above sea level. There is no sign of albumen surrounding the egg, but a thin shell membrane is present during the early stages of development of the embryo. However, by the time the chorio-allantoic membrane is well established, there is comparatively little shell membrane

left between it and the uterus. The developing embryo is dorsal in position with regard to the parent and lies with its head directed mesially whether the embryo be in the right or left oviduct, the embryos in the one female being approximately at the same stage in their development. The uterus surrounds each egg as a thick white envelope which remains as an expanded chamber on the extraction of the egg. These chambers are connected each to each by a short narrow straplike portion of the uterus. Before the formation of the placentae the wall of each of these so called "incubatory chambers" is uniform in structure throughout and consists of an outer covering of peritoneum, a coat of longitudinal and circular muscle and a narrow mucous membrane with flattened glands embedded, bounded by a layer of fairly large columnar epithelial cells. The chorion lies immediately beneath the uterus and consists of an outer layer of small flat ectoderm cells and an inner layer of tapering mesoderm cells. The allantoic stalk carrying the allantoic vessels leaves the ventral surface of the body of the embryo a short distance in front of the hind limbs, passes upwards around the embryo and expands into the allantoic vesicle. The mesoderm bounding the outer surface of the allantois fuses with that of the chorion forming the chorioallantoic membrane in the connective tissue of which ramify the allantoic vessels. The fusion between the allantois and the chorion gradually extends around the under surface of the chorion until the allantois reaches the yolk-sac. As in *Lygosoma (Lirolepisma) entrecasteauxi* (Harrison and Weekes, 1925) the allantois does not extend around the yolk-sac but comes into contact with the upper surface only, the mesoderm of the allantois fusing with that of the yolk-sac.

The omphaloplacenta is insignificant and functions during the early development of the embryo. It is composed of modified uterine epithelium and chorionic ectoderm overlying a richly vascular yolk-sac.

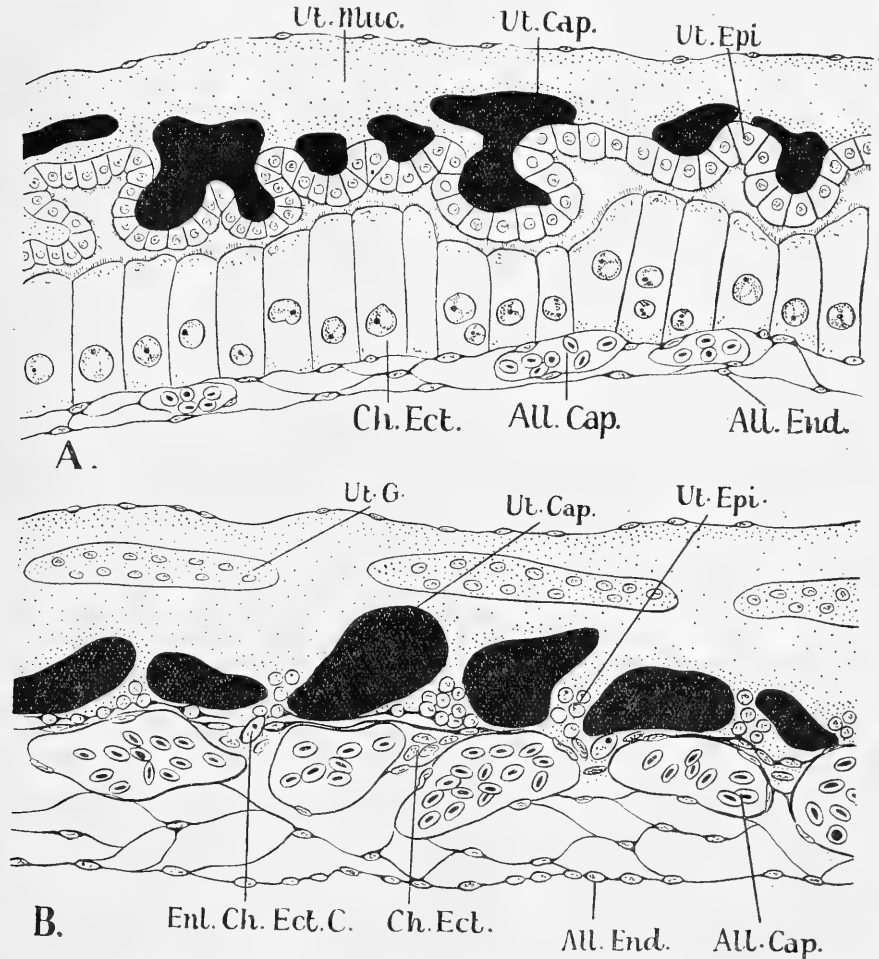
The allantoplacenta is highly specialized, is established approximately two weeks after fertilization, reaches maturity two weeks later and functions until immediately prior to the birth of the foetus. The fixation of the embryo is brought about by the invasion of the uterine epithelium by enlarged chorionic cells scattered throughout the chorionic ectoderm. The development of the placental region is not restricted, placental modifications of maternal and foetal tissues existing for the main part over the entire area embraced by the allantois.

In the modification of the maternal tissues, the uterine epithelium undergoes partial degeneration, the dividing cell walls disappearing and the cell nuclei becoming pushed aside by the multiplication and expansion of the underlying maternal capillaries, so that they come to be roughly grouped in nests between the exposed capillaries (Text-fig. 1, B). The chorionic ectoderm consists of the scattered and enlarged cells which serve to fix the chorioallantoic membrane in position, and for the remainder, of a layer of flattened cells which undergo the same partial degeneration on the expansion of the underlying allantoic capillaries as occurs among the uterine epithelial cells. Neither the uterine epithelial cells nor the chorionic ectoderm cells completely disappear but remain clearly definable throughout the life of the placenta, the former functioning for food secretion and the latter for food absorption (Text-fig. 1, B). But the function of food transition is mainly carried on by the closely apposed maternal and foetal capillaries, which are for the most part only separated by their endothelial walls and a thin layer of maternal and foetal cytoplasm. This type of allantoplacenta is extremely interesting and is so far peculiar to this species of lizard, having no parallel among those reptiles for which placenta has been recorded.

2. COMPARISON WITH *Chalcides tridactylus*, *Lygosoma entrecasteauxi* AND *Tiliqua scincoides*.

Definite placentation amongst lizards has been described in *Chalcides tridactylus*, *Chalcides ocellatus* by Giacomini (1891 and 1906 respectively); in *Tiliqua scincoides* by Flynn (1923); in *Lygosoma entrecasteauxi* by Harrison and Weekes (1925).

In both the classic *C. tridactylus* and *L. entrecasteauxi* the allantoplacental area is restricted and elliptical in shape, and the uterine wall is folded into villous ridges lined by enlarged cubical ciliated epithelial cells and containing a



Text-figure 1.—The two dissimilar types of reptilian allanto-placentation. (A) section through placental region of *L. entrecasteauxi* showing modification and apposition of maternal and foetal epithelium; (B) section through placental region of *L. quoyi* showing partial degeneration of maternal and foetal epithelium. All. Cap., Allantoic Capillary; All. End., Allantoic Endoderm; Ch. Ect., Chorionic Ectoderm; Enl. Ch. Ect. C., Enlarged Chorionic Ectoderm Cell; Ut. Cap., Uterine Capillary; Ut. Epi., Uterine Epithelium; Ut. Muc., Uterine Mucosa.

rich network of maternal capillaries. The chorionic ectoderm cells are columnar, extremely elongated and in *L. entrecasteauxi*, ciliated. There is no interpenetration of chorionic ectoderm into the maternal crypts, the fixation of the embryo being so slight that the least handling in the preparation of material separates the maternal and foetal membranes (Text-fig. 1, A). As Flynn (1923, p. 76) possessed but one stage in the development of the allantoplacenta of *T. scincoides* and further, as his account is extremely brief and without the necessary illustrations, it is impossible to deduce correctly the type of allantoplacental present in that lizard. He says (1923, p. 76) that "the union between chorion and uterine epithelium is very intimate. The uterine epithelium apparently consists of a single layer of very flattened cells, while the chorionic ectoderm has proliferated greatly, is much vacuolated, resembling a typical plasmodium, and is formed in the main of markedly enlarged cells with large nuclei and connected together by amoeboid processes. These processes insinuate themselves into and between the maternal cells. . . ." Hence it can be seen that in each of the three lizards *C. tridactylus*, *L. entrecasteauxi* and *T. scincoides* the foetus obtains its food by the glandular activity of the uterine epithelium and the absorbing and phagocytic powers of the chorionic ectoderm. In other words it is the epithelial tissues which play the important part in food transition (Text-fig. 1, A).

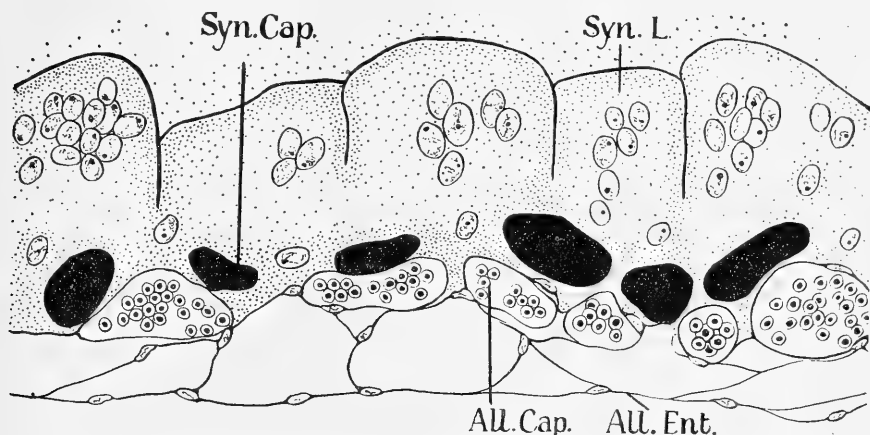
This is a distinct type of allantoplacental and it differs from that existing in *L. quoyi* since in the one, the epithelial tissues are modified to perform the function of food transition, while in the other the epithelial tissues partially degenerate to allow the maternal capillaries to pass maternal materials more or less directly to the foetal capillaries (Text-fig. 1, B). The relationship which exists between these two types of placental is somewhat similar to that which exists between the indecidual and decidual types of mammalian placental, although the difference which occurs between the two reptilian types is not as great as that which occurs between the two mammalian types. The placental of *C. tridactylus*, *L. entrecasteauxi* and *T. scincoides* resembles the indecidual form of mammalian placental in essentials, allowance being made for the comparatively simple structure of the reptilian uterus and the difference in the sizes of the developing embryos. The placental of *L. quoyi* resembles that of the three above mentioned lizards in that there is no invasion of maternal tissue but in other respects it resembles the decidual mammalian type.

3. COMPARISON WITH THE MAMMALIA.

Perameles is the only marsupial for which allantoplacental has been recorded. The placental of *Perameles* was described by Hill (1897), redescribed by Flynn (1923), and these authors hold different opinions as to the nature of the placenta. Hill claims (1897, p. 387) that the uterine mucosa undergoes hypertrophy; that the vessels in the mucosa increase in size and number; that the uterine epithelium changes into a vascular syncytium, the nuclei becoming grouped together in nests situated in lobular projections of the deeper surface of the syncytium; and that the maternal corpuscles pass up between the syncytial lobules and form a network beneath the epithelial protoplasm. He claims further that the embryo becomes attached to the prepared maternal wall by means of enlarged chorionic ectoderm cells, which eventually degenerate over the placental area proper; that the allantioic capillaries now directly reach the vascular surface of the maternal placental syncytium to which they become intimately attached, dipping down into the depressions on its surface and forming in places a regular

interlocking system, and that finally the foetal and maternal blood streams are now only separated by their thin endothelial walls and perhaps a layer of syncytial protoplasm (Text-fig. 2).

Flynn claims (1923, p. 175) that the chorionic ectoderm does not completely degenerate but actively invades the maternal tissues and thus brings the type of placentation found in *Perameles* in line with that found among the eutherian mammals, more especially the Carnivora "where there are the same characteristics of passivity of uterine epithelium and activity of the trophoblast with a division of the latter into a cytotlastic and plasmodial layer".



Text-figure 2.—Section through allanto-placental region of *Perameles* (after Hill). All. Cap., Allantoic Capillary; All. Ent., Allantoic Endoderm; Syn. Cap., Syncytial Capillary; Syn. L., Syncytial Lobule.

However both authors agree that the foetal membranes of *Perameles* are closely apposed to the maternal wall and that a degeneration of epithelial tissues leads to a close proximity of maternal and foetal blood streams, a condition of affairs hitherto only met with among the Eutheria. But it will be recalled that in *L. quoyi* there is the same partial degeneration of epithelial tissues and mutual apposition of maternal and foetal blood streams, and further that this is the only recorded case among reptiles of this type of allanto-placentation. Hence the deduction that the allanto-placentation of *L. quoyi* more closely resembles that of the Mammalia, than any hitherto recorded in a reptile.

4. THEORETICAL CONSIDERATIONS.

As this is a preliminary communication, it is unnecessary to enter upon a lengthy discussion of the significance of the allanto-placentation of *L. quoyi*, yet the type of placentation is so interesting and its bearing upon phylogenetic questions of such importance that a brief discussion of the outstanding features of interest is warranted.

The importance of the nature of the allanto-placentation in *L. quoyi* is indicated when it is demonstrated that in the genus *Lygosoma* two members, namely *L. entrecasteauici* and *L. quoyi*, have each developed distinct types of placentation between which there is almost as much difference as exists between the

indeciduate and deciduate mammalian types (Text-fig. 1 A, and B). The occurrence of these distinct types of placentation in two members of the same genus is, to my mind, conclusive evidence of the independent evolution of the placenta in each. Hence I now claim that besides the three lizards *C. tridactylus*, *T. scincoides* and *L. entrecasteauvi*, a fourth lizard, *L. quoyi*, has independently developed an allantoplacenta, a fact which further strengthens the suggestion in a previous paper on lizard placentation by Harrison and Weekes (1925, p. 484), that "the occurrence of true placentation in two not very closely related Scincid lizards *Lygosoma* and *Chalcides*, in Australia and Europe respectively, indicates that the allantoplacenta is a functional adaptation, which may have arisen independently many times in evolution and upon the mere occurrence of which phylogenetic statements cannot justifiably be based".

In his account of the placentation of *Perameles*, Flynn says (1923, p. 127), that "according to Hill's account the placentation of *Perameles* is without parallel in the whole mammalian group" and he adds that this fact has led even Hubrecht to suggest (1909) that the placenta of *Perameles* on further investigation may after all prove to be more comparable with some one or other of the placentae of the Eutheria. Flynn studied the placentation of *Perameles* with the object of discovering, if possible, some link between it and the eutherian type and he claims that his investigations revealed satisfactory results, the placentation of *Perameles* being comparable to some extent with that found among the Carnivora. But since two essentially dissimilar types of allantoplacentation occur in two members of the reptilian genus *Lygosoma*, and further, since there is a much closer relationship between these two members than exists between the marsupial and eutherian mammals, I suggest that the fact that the placentation of *Perameles* as described by Hill may have "no parallel among the whole mammalian group" need not be as incredible as Hubrecht and Flynn suppose.

It will be recalled that in *L. quoyi* the chorionic ectoderm of the placental region is inactive and partially degenerates after the fixation of the embryonic membranes, allowing for a close proximity of maternal and foetal capillaries. Since such a specialized type of placentation has presumably been independently evolved in this viviparous lizard from oviparous stock as an adaptation to environment, I venture to suggest that the somewhat similar placental condition in *Perameles* (after Hill) may be the result of a similar response to environment and may be independent of any genetic relationship with that of the Eutheria.

5. SUMMARY.

(a) Omphaloplacentation and allantoplacentation are recorded for the viviparous Scincid lizard *Lygosoma (Hinulia) quoyi*, the type of allantoplacentation being compared and contrasted with that of the Reptilia and the Mammalia.

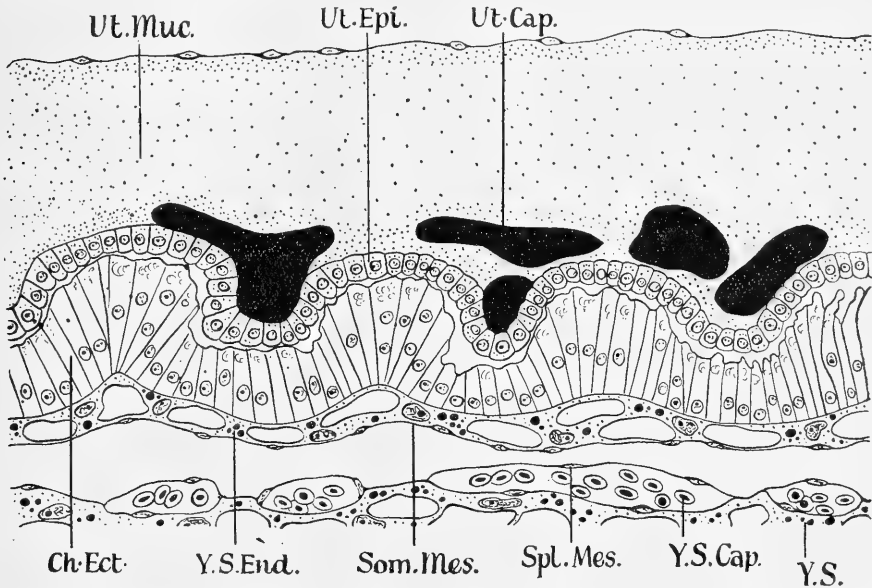
(b) The occurrence of two distinct and dissimilar types of allantoplacentation in two species of one reptilian genus indicates that the allantoplacenta is a functional adaptation evolved independently in each species.

(c) The difference between these two types of allantoplacentation in two closely related lizards emphasizes the fact that a similarity between the marsupial and eutherian types of allantoplacentation need not necessarily be expected.

(d) The similarity between the independently developed allantoplacentation of the specialized reptile *L. quoyi* and that of the specialized marsupial *Perameles* (after Hill) suggests that a similar response to environmental conditions has occurred in these widely separated forms.

II. ON THE PECULIAR GROWTH OF THE EXTRA-EMBRYONIC MESODERM IN
Lygosoma (Hinulia) quoyi, *Tiliqua scincoides*, *Egernia whitei*
AND *Egernia striolata*.

In each of the above mentioned lizards the growth of the extra-embryonic mesoderm is normal until the formation of a temporary sinus terminalis. The mesoderm then dips into the yolk-sac and continues its growth, not over the surface of the latter as is normally the case, but embedded in its substance. As the mesoderm grows into the yolk-sac it splits into two layers as it does in the normal condition when forming the extra-embryonic coelome. Thus an outer layer of endoderm is separated from the bulk of the yolk-sac, a condition not hitherto recorded (Text-fig. 3, Y.S. End.).



Text-figure 3.—Section through omphaloplacental region of *T. scincoides* showing apposition of chorionic ectoderm to maternal villous ridges. Ch. Ect., Chorionic Ectoderm; Som. Mes., Somatic Mesoderm; Spl. Mes., Splanchnic Mesoderm; Ut. Cap., Uterine Capillary; Ut. Epi., Uterine Epithelium; Ut. Muc., Uterine Mucosa; Y.S., Yolk Sac; Y.S. Cap., Yolk Sac Capillary; Y.S. End., Yolk Sac Endoderm.

III. ON THE OCCURRENCE OF CORPORA LUTEA IN *Lygosoma (Hinulia) quoyi*,
Tiliqua scincoides, *Egernia whitei* AND *Egernia striolata*.

After ovulation the ruptured follicles in the ovaries of each of the four above mentioned lizards become yellow in appearance and richly vascular. This is due to the presence of a corpus luteum in each, the growth of which is rapid, each follicle being completely filled with luteal cells in less than a week after ovulation.

IV. THE OMPHALOPLACENTA OF *Tiliqua scincoides*.

Flynn (1923) described the occurrence of an allantoplacenta in *T. scincoides* but made no mention of an omphaloplacenta. The presence of an omphaloplacenta in this lizard is now recorded (Text-fig. 3).

Both immature and mature stages in the development of the omphaloplacenta are available, the placenta apparently functioning throughout the development of

the embryo. The area of placental modification extends over the entire under surface of the yolk-sac where the bounding layer of chorionic ectoderm comes into contact with the surrounding uterine wall.

The uterine wall and the chorionic ectoderm are thrown into a series of folds which interlock, recalling the attempt at the formation of an omphaloplacenta in *C. tridactylus* and *C. ocellatus* (Giacomini, 1891 and 1906 respectively), and the type of omphaloplacenta found in the marsupial *Didelphys* (Selenka, 1886; Osborne, 1888). The folded wall of the uterus is thickened over the placental region and is lined by enlarged epithelial cells containing large, deeply staining nuclei. The chorionic ectoderm consists of extremely narrow elongated cells which fit into the maternal crypts, there being no actual interpenetration of maternal and foetal tissues. The arrangement of the foetal tissues surrounding the yolk-sac is not usual owing to the peculiar growth of the extra-embryonic mesoderm mentioned above. Beneath the chorionic ectoderm there is a thin layer of yolk-sac endoderm containing yolk granules. Between this and the main yolk-sac is the extra-embryonic mesoderm which has differentiated in the normal manner into somatic and splanchnic layers. The somatic mesoderm together with the above mentioned layer of yolk-sac endoderm and chorionic ectoderm is separated from the yolk-sac, and it is this band of tissue which is folded to fit into the maternal crypts (Text-fig. 3). The splanchnic mesoderm lines the yolk-sac and gives rise to a complex network of blood vessels which ramify through the substance of the latter.

Detailed accounts of these phenomena are in course of preparation.

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NOTES ON AUSTRALIAN MOSQUITOES (DIPTERA, CULICIDAE).

Part i. THE ANOPHELENI OF THE MAINLAND.

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of the Society in Zoology.

(Three Text-figures.)

[Read 27th April, 1927.]

The valuable revision of the Australasian Culicidae by Edwards (1924) has placed our knowledge of the family on a sound basis and enabled Australian workers to undertake the study of local problems with some degree of confidence. In this series of papers it is hoped to clear up some of the taxonomic problems which he left obscure, largely because of the inaccessibility of the Macleay types, to discuss the status and relationships of a number of species, and to add such fresh information as is available with regard to distribution, habits and life histories.

Edwards's work was soon followed up by Hill (1925), who made a very full and detailed study of the status and distribution of the *Anopheles* of the *Myzomyia* group with special reference to those occurring in Northern Australia and the adjacent islands. In the present paper his work is extended, special attention being paid to the males and larvae. The status of the various forms of *A. annulipes* Walk. is discussed and the opinion expressed by Hill (1925) and Ferguson (1926) as to the synonymy of *A. mastersi* Sk. with this form is confirmed. Keys are given to the females and larvae of all species occurring on the mainland and figures of, and notes on, the male hypopygia. The life histories of *A. atratipes* Sk. and *A. stigmaticus* Sk. and the larva of *A. amictus* Edw. are described for the first time.

A very great deal of material has been available for study, and I wish particularly to express my indebtedness to Dr. E. W. Ferguson for advice and for the use of material and to Mr. H. Hacker of the Queensland Museum for the opportunity of examining the fine series of northern forms of *A. annulipes* Walk., of *A. amictus* Edw. and of *A. corethroides* Theo. in their collection, without which this paper could not have been nearly as complete as it is.

Key to Adult Females.

1. Conspicuously ornamented species with numerous white markings on wings and legs. (Subgenus *Myzomyia*) 2
More concolorous brown or black species. (Subgenus *Anopheles*) 6
2. Pale apical half of the antepenultimate segment of the palpi divided by a dark ring *punctulatus* Don.
Pale apical half of the palpi continuous and without such ring 3
3. Proboscis pale on at least portion of the apical half *annulipes* Walk. (part)
Proboscis entirely dark 4
4. Abdominal tergites 2-7 devoid of scales *annulipes* Walk. (part)
Abdominal tergites 2-7 with numerous flat pale scales 5

5. Tarsi apically banded only *amictus* Edw.
 Tarsi apically and basally banded *amictus* Edw. Type C, Hill.
6. Small brown species with the basal four-fifths of the hind femora creamy to yellow anteriorly *stigmaticus* Sk.
 Larger black species with the femora not so marked 7
7. Palpi with bushy outstanding scales; wing with a white spot beyond the middle of the costa; hind tarsi with narrow white rings *bancrofti* Giles.
 Palpi normal; costa without such spot; hind tarsi entirely dark *atratiipes* Sk.

Key to Larvae.

1. Inner anterior clypeal hairs widely separated and closer to the outer anterior clypeal hairs than to each other (Subgenus *Myzomyia*) 2
 Inner anterior clypeal hairs very close together (Subgenus *Anopheles*) 4
2. Posterior clypeal hairs closer together than the inner anterior and projecting well beyond the head *amictus* Edw.
 Posterior clypeal hairs wider apart than the inner anterior and not reaching to the anterior margin of the head 3
3. Posterior clypeal and inner occipital hairs multiple *annulipes* Walk.
 Posterior clypeal and inner occipital hairs single *punctulatus* Don.
4. Outer anterior clypeal hair strongly branched *bancrofti* Giles.
 Outer anterior clypeal hair single 5
5. Larger black larvae with the antennal plume large and strongly branched
 *atratiipes* Sk.
 Small brown larvae with the antennal plume very small and finely branched
 *stigmaticus* Sk.

Note.—*A. punctulatus* Don. is included in the keys since it has been recorded from the extreme north of the mainland. The characters available from the descriptions for the separation of its larva are not all that might be desired; a critical reexamination of this species will probably reveal others of greater value. It is to be noted that the above key to adults will *not* apply to males of the *Myzomyia* group; comparison with known females and a critical examination of the palpal and leg markings, of the abdominal scaling, and especially of the hypopygium are the only means of placing specimens of this sex.

ANOPHELES (ANOPHELES) ANNULIPES Walker.

This is the common species on the mainland. Its range is from Cairns to Tasmania and it is found in the dry inland districts and on the mountains to a height of 5,000 feet as well as being common in the coastal area. Records from the islands to the north of Australia require confirmation; most, if not all, undoubtedly refer to other species of the group. In the southern part of its range it is the only member of the subgenus met with, but in South Queensland *A. amictus* Edw. appears in company with it and gradually replaces it further north. *A. annulipes* Walk. bites chiefly in the evening and at night but occasionally also in the middle of the day; its resting attitude is about 45° with the surface. This species is a presumed malaria carrier in Australia. The evidence for its relation to the sporadic cases which have occurred in New South Wales is very strong, particularly so in a recent infection acquired at Narrabeen, near Sydney (Money, 1926). In Queensland, however, the question is more obscure, since *A. annulipes* Walk. and *A. amictus* Edw. have been confused in the past and either or both may be carriers, while *A. bancrofti* Giles must also be considered as a probable vector.

In the female sex three main types may be recognized:

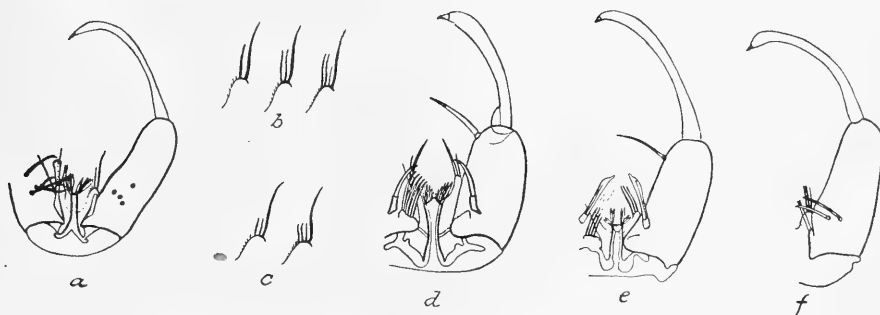
1. Specimens with the proboscis entirely dark and the abdomen devoid of scales on tergites 2-7. This is the typical *annulipes* Walk., and is found in Tasmania, in the coastal districts of the mainland south of Sydney more particularly in the cooler months, and on the mountains. It is relatively rare.

2. Specimens with the proboscis pale on the apical half or less and with few or no scales on tergites 2-7 of the abdomen. This is the *mastersi* Sk. form and is by far the most common type throughout the entire range of the species except possibly in the extreme south and north.
3. Specimens with the proboscis pale on the apical half and with more or less numerous pale scales on tergites 2-7 of the abdomen. These scales are usually narrow, but may be flat and fairly broad though always distinctly narrower than those seen in *A. amictus* Edw. This form is common in the north, but also occurs in New South Wales, where, however, it is distinctly rare.

It is to be noted that all stages linking 1 to 2 and 2 to 3 are present in the very extensive series I have examined, but none linking 1 to 3. It appears that the *mastersi* type is the continuous dominant form and that there is a tendency to differentiate out, at the one end of the range into a type with an entirely dark proboscis, and at the other into a type with scales on the abdominal tergites. In the opinion of the writer this process has certainly not gone sufficiently far to warrant giving varietal or subspecific names to the different forms.

Females of *A. amictus* Edw. are easily separated from any of the above three types by possessing *both* an entirely dark proboscis and numerous pale flat scales on tergites 2-7 of the abdomen.

In the case of the males the proboscis is always entirely dark or almost so; consequently it is only possible to recognize two types, one with scales on the abdominal tergites and one without. There is here also every stage linking the two groups and the hypopygium is constant throughout the entire series. Males with numerous scales on the abdominal tergites are difficult to separate from *A. amictus* Edw., but may be distinguished by the fact that in *A. annulipes* Walk. the scales are markedly narrower and usually less numerous and of course by the hypopygial characters.

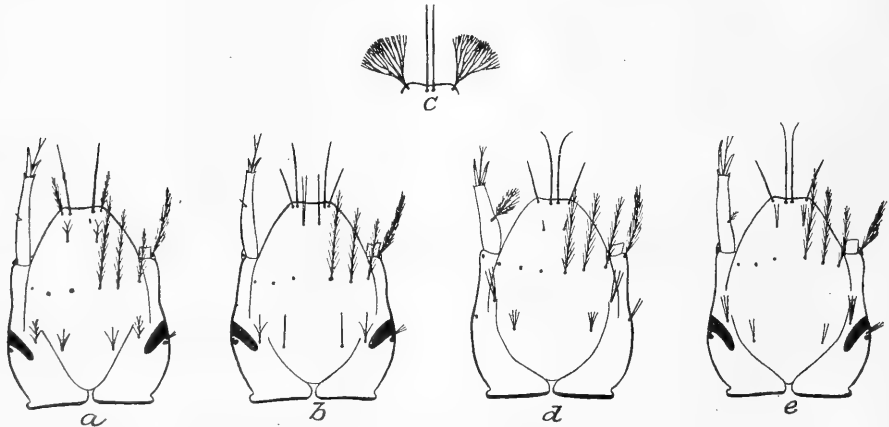


Text-figure 1.—a Hypopygium of *A. annulipes* Walk.; b Claspettes of three specimens of same; c Claspettes of two specimens of *A. amictus* Edw.; d Hypopygium of *A. stigmaticus* Sk.; e Hypopygium of *A. atratipes* Sk.; f Side-piece and its appendages of *A. bancrofti* Giles.

The side-piece of the male hypopygium (Text-fig. 1 a) bears four basal spines usually arranged as in the figure though there is some variation. The leaflets are four or five in number and are rather broad; they are about half the length of the aedeagus. The claspette is rounded and there is some variation in the arrangement of its setae. Edwards (1924) describes this structure as bearing a long apical hair and a single accessory one which is at least half as long as the apical one; this arrangement is frequently met with, but many specimens have two accessory hairs half as long as the apical one, and sometimes also a third which is a little shorter than the others. Variations are met with in the two

sides of the one specimen. *The length of at least one or two of the accessory hairs is constantly as much as half the length of the main hair in all specimens examined, an important point of distinction from A. amictus Edw. in which these accessory hairs are never more than a quarter the length of the main hair (compare Text-fig. 1 b and c).*

The larvae usually live in clear water, preferably in soakage pools and small swamps in which there is some algal growth, but they may also be found (more often in Queensland than in New South Wales) in rock pools, in muddy creeks and waterholes, and even in somewhat polluted water. I have twice taken them in running water, in the Burnett River at Eidsvold, S. Queensland, and in the upper Hunter River, N.S.W. In both instances they were clinging, presumably by means of their caudal grappling hooks, to filamentous algae in shallow water where the flow was not very rapid. At Eidsvold the alga was a species of *Spirogyra* and the association was almost as close as that seen in the case of *C. basicinctus* Edw. and *C. bitaeniorhynchus* Giles, the larvae remaining submerged for long periods attached to the alga, from which apparently they drew their oxygen as well as their food supply. This adaptation is distinctly curious in view of the more usual surface-living habits of the species.



Text-figure 2.—Heads of larvae of a *A. annulipes* Walk.; b *A. amictus* Edw.; c *A. bancrofti* Giles (after Cooling); d *A. atratipes* Sk.; e *A. stigmaticus* Sk.

Cooling's (1924a, 1924b) descriptions of the larva and pupa are rather incomplete and these notes and figures are intended to amplify his. The head is brown and has the pigment arranged in a definite and rather characteristic pattern, not uniformly distributed as in the species of the subgenus *Anopheles* described below. The antenna bears a short sublateral spine about the middle of its length. The cephalic chaetotaxy appears to afford the only reliable characters for the separation of the related species and is shown in Text-fig. 2 a. The inner anterior clypeal hairs are set well apart and much nearer to the outer anterior clypeal hairs than to each other; they sometimes bear two or three very short, fine plumes which are hardly longer than the diameter of the hair. The outer anterior clypeal hairs are about two-thirds the length of the inner and are strongly plumose; in one specimen, probably as an aberration, these hairs were strongly branched. The posterior clypeal hairs are set further apart than the inner anterior, have four branches, are short and do not project as far as the

anterior border of the head. The frontal and subantennal hairs are normal. The inner occipital hair is trifid and the outer one bears a few plumes. The palmate hairs and other characters agree with Cooling's descriptions and figures; they do not appear to offer any assistance in discriminating between the related species. The pecten (in the sense used by Christophers) bears three long teeth as well as the end ones, but is somewhat variable.

The pupal skin is brown and bears no specially pigmented areas, except for the trumpet which is lightly powdered with pigment. The abdominal chaetotaxy is shown in Text-fig. 3 *a* and does not require further description; its characters are most valuable for the recognition of the pupae; the stout lateral spines decrease in size proximally and are very short on the basal segments. The trumpet (Text-fig. 3 *d*) is oblong in shape and is slightly shorter and broader than that of *A. stigmaticus* Sk.

ANOPHELES (MYZOMYIA) AMICTUS Edwards.

A larger, more yellowish species than *A. annulipes* Walk., from which it is to be distinguished in the female by the combination of an entirely dark proboscis with numerous scales on abdominal tergites 2-7, and in the male by the hypopygium. The claspette bears two or three fine short hairs which are always less than one-quarter the length of the main hair (Text-fig. 1 *c* and *b*). The abdominal scales of both sexes are broad, flat, and yellowish in colour. These characters might be considered as very doubtfully of specific value, even though constant, and the statement by Hill (1925) that he obtained typical females of *A. annulipes* Walk. among the progeny of *A. amictus* Edw. females would undoubtedly lead one to sink the latter name as a synonym, were not the question further complicated by the discovery that the larvae are very distinct. In view of this one cannot but let Edwards's name stand until the whole question can be reinvestigated and Hill's breeding experiments repeated and extended with special reference to the males and early stages.

I have only seen females of Hill's type "C." This form is easily recognizable on this sex and an examination of the males and early stages may possibly prove it to be distinct.

The larvae (of the typical form) were found in company with those of *A. annulipes* Walk. and *C. basicinctus* Edw. associated with green algae in running water in the Burnett River at Eidsvold. They were never found in any other situation in this district. They differ from *A. annulipes* Walk. in the following respects (Text-fig. 2 *b*): The sublateral spine of the antenna is definitely beyond the middle; the outer anterior clypeal hairs are single (unplumed) and the posterior clypeal hairs are single, or sometimes bifurcate, and extend well beyond the anterior margin of the head; the inner occipital hair is single and the outer is trifid; the comb differs slightly in the arrangement of the long spines, but is variable; in other respects, including the palmate hairs, there is little or no distinction. Unfortunately the pupae were not preserved.

The biting habits and resting attitude of the adult females are, so far as my experience goes, similar to those of *A. annulipes* Walk.

Distribution.—*A. amictus* Edw. has been recorded from North Queensland and the Northern Territory. I have also taken it at Eidsvold, S. Queensland (April, 1924, bred from larvae, also biting after dusk) and there are specimens in the Queensland Museum from the following localities in Queensland: Charleville, June, 1899, C. J. Wild; Eidsvold, March, 1915, Bancroft; Brisbane, April, 1912,

H. Hacker; Cunnamulla, May, 1899, C. J. Wild. It would appear that in the southern part of its range, which by the way is much more extensive than was formerly thought, it is much less abundant and appears much later in the season than further north.

ANOPHELES (ANOPHELES) BANCROFTI Giles.

There is no fresh information to add concerning this species. Adults and the larvae are readily recognizable by the characters given in the keys. The larva and the pupa have been described by Cooling (1921, 1924b). The latter stage is somewhat difficult to recognize, but is apparently similar to *A. atratipes* Sk. from which it is to be separated by the markedly smaller paddles and probably different chaetotaxy; further material is desirable. The male genitalia have been described by Edwards (1924). Text-fig. 1 f was drawn from a male from the Sepik River, Mandated Territory of New Guinea (R. W. Cilento) which agreed in all respects with typical females from the mainland and with Edwards's description of the hypopygium.

ANOPHELES (ANOPHELES) ATRATIPES Skuse.

A rather uncommon species which was hitherto known only from females. Superficially it resembles *A. bancrofti* Giles, but is easily separable by the palpal clothing and by the wing and leg markings. Its habits, too, are somewhat similar in that it is a sylvan day-biting species which rests at an angle of about 80° with the surface. It is most prevalent in the coastal districts of New South Wales and South Queensland in spring and early summer, apparently disappearing completely later in the season when other Anophelines are most abundant. In the Sydney district it occurs most frequently in the sandstone gullies and in the vicinity of sluggish creeks running through the Pleistocene sand flats. At Dunwich, Stradbroke Is., South Queensland, females were common in September, 1926, along the course of a sluggish creek in which there were moderate numbers of the larvae. A prolonged search was made among the vegetation, on the sheltered sides of logs and tree trunks, and in similar likely situations, but not a single adult male was seen. Neither males nor larvae have been found in any other locality, even where females were not uncommon.

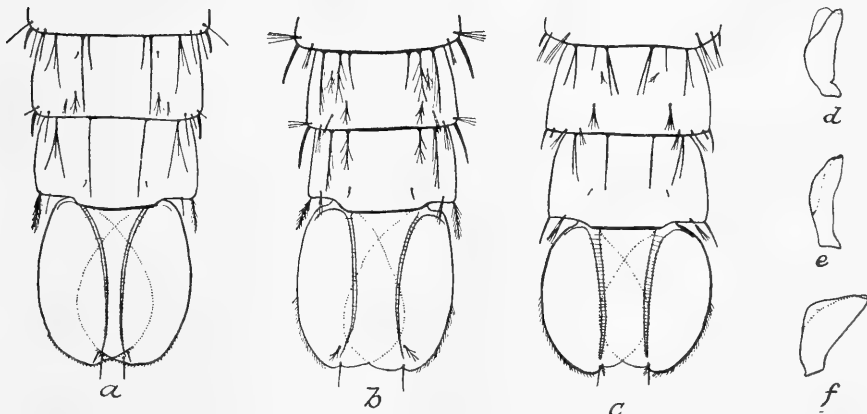
♂. Palpi with the terminal segment swollen and with a patch of long hairs ventrolaterally on the basal half of the terminal segment and extending on to the apical part of the penultimate segment; antennae with long, dense, silky, brown plumes; otherwise resembling the female in all essentials. The hypopygial characters (Text-fig. 1 e) are in some respects intermediate between *A. bancrofti* Giles and *A. stigmaticus* Sk., but show much closer affinities with the latter in the single basal spine of the side-piece, in the pointed rather than lobed claspettes, and in the replacement of the club by a row of four basal spines set on a lobe. It resembles *A. bancrofti* Giles in bearing three subequal spines on the claspette. There are about two pairs each of longer medial and shorter lateral leaflets. The allotype male (Dunwich, Stradbroke Is., South Queensland, bred from larvae, 10th Sept., 1926) is in the Macleay Museum, University of Sydney.

The larvae were taken in a small, sluggish, slightly muddy creek with a fine silt bottom. The pH of a sample of the water was 7.5. (This determination was kindly made for me by Dr. R. Hamlyn-Harris, City Entomologist, Brisbane, who was also good enough to breed through a number of larvae brought back from Dunwich.) Some aquatic vegetation was present, but not a great deal. Other

mosquito larvae were entirely absent, although adults of several species were common along the banks. The local distribution of the species in the Sydney district suggests that it breeds in similar situations and also in pools in sandstone creeks.

The larvae are darker than those of *A. annulipes* Walk., but do not afford any naked eye characters of value for differentiating them. The antennae (Text-fig. 2 *d*) are brown, notably stout and short, and bear apically two spines and a fine trifid hair. The antennal hair is situated slightly basal to the middle, is fully half the length of the antenna and is strongly branched. The head is very heavily and uniformly pigmented and no trace of eyes could be made out in any of the preparations. The anterior clypeal hairs resemble those of *A. stigmaticus* Sk., but the posterior are very short and single. The frontal hairs are strongly plumed and are subequal in length. The subantennal plume is normal. The inner occipital hair is divided into four very fine branches. The outer lies well anterior to the middle and is trifid. The thoracic and abdominal chaetotaxy is not remarkable except for the entire absence or great reduction of the palmate hairs. These structures may be represented by certain short hairs on a few of the abdominal segments, but are certainly not present in the form seen in other Anopheline larvae. The pecten consists in general of long spines alternating with two very short ones. Grappling hooks are developed.

The affinities of the larva are with *A. stigmaticus* Sk., from which it is to be separated by its larger size, much darker colour, much stronger antennal plume, and by the absence of eyes or palmate hairs, a most remarkable and unexpected feature of these larvae.



Text-figure 3.—Terminal segments of pupa of *a* *A. annulipes* Walk.; *b* *A. stigmaticus* Sk.; *c* *A. atratipes* Sk. Lateral view of trumpets of *d* *A. annulipes* Walk.; *e* *A. stigmaticus* Sk.; *f* *A. atratipes* Sk.

The pupa appears to be closest to Cooling's description of *A. bancrofti* Giles. The skin is brown with strong lines of black pigment on the wing sheath along the course of the veins and with transverse dark bars in a row along the antennal sheath. The trumpet (Text-fig. 3 *f*) is very broad, triangular in shape, and is deeply pigmented. This species is apparently separable from *A. bancrofti* Giles

by its larger paddles and probably different abdominal chaetotaxy and from all other Australian species by the broad triangular trumpet, by the pigmentation of the cephalothorax and by the chaetotaxy (Text-fig. 3 c).

It is interesting that this species should resemble *A. bancrofti* Giles fairly closely in the general characters of the adults and in the pupa, but yet show much closer affinities with *A. stigmaticus* Sk. on hypopygial and larval characters which are undoubtedly more reliable.

ANOPHELES (ANOPHELES) STIGMATICUS Skuse.

This is a very rare, small brown species of which I have been fortunate in obtaining a good series of both sexes and of the larvae and pupae at National Park, New South Wales. They were only found in a patch of brush growing on the Narrabeen series near Waterfall. Adults were taken by stirring them out of the grass and bushes and at no time showed any inclination to bite. Their resting attitude is almost horizontal and the palpi are carried closely appressed to the proboscis so that they resemble when alive a small species of *Culex* much more than an Anopheline.

Specimens were compared with the types of *A. stigmaticus* Sk. and found to agree with them in every particular. The most striking features of this species are the pale yellow basal four-fifths of the hind femora and the conspicuous dark patch covering the forking of R and Rs. These characters are not mentioned by Theobald in his description of *A. corethroides* Theo. and the stems of the fork cells are distinctly longer than is indicated in his description. Skuse's description is complete and accurate except for the markings on the mesonotum which are correctly described by Theobald. A male in the Queensland Museum from Burpengary, South Queensland (Bancroft) is from the type locality of *A. corethroides* Theo. and agrees very well with his description. It agrees completely in genitalic characters with typical *A. stigmaticus* Sk., but differs in markings in that the dark patch on the wing is absent and the pale areas on the hind femora are less extensive and creamy white rather than pale yellow. Of the four other specimens from Queensland in the same collection, two are similar to the male from Burpengary, one corresponds to the southern form, and one is intermediate. These were all collected by Dr. Bancroft and are probably from the vicinity of the type locality. The genitalia of both northern and southern forms (Text-fig. 1 d is from a National Park specimen) agree with Edwards's (1924) description of the type of *A. corethroides* Theo. There is no doubt that the synonymy given by Edwards is correct, but the typical *corethroides* form is distinctly less well marked than typical *stigmaticus*.

The distribution is from South Queensland to National Park and the Blue Mountains in New South Wales. The National Park specimens were taken in April, 1925, and January, 1926.

The larvae were found associated with *A. annulipes* Walk. in small pools containing filamentous algae in the bed of a small creek which ran through the brush and had cut down to the Narrabeen sandstone. They are small, brown in colour, and superficially resemble small specimens of *A. annulipes* Walk., naked eye separation of the two being impossible. The antennae are creamy, darker at the tip, and bear apically two spines and a single fine hair which is forked distally; the antennal hair is situated at the junction of the basal and middle thirds of the antennal length and is very short and finely branched. The head is uniformly dark brown in colour and both compound and simple eyes are present. The inner

anterior clypeal hairs are long, bare, and set close together; the outer anterior clypeal hairs are a little more than half the length of the inner and are bare; the posterior clypeal hairs are short and single or divided into two or three very fine terminal branches. The frontal and subantennal hairs are normal. The inner occipital hair is bifid and the outer lies well anterior to it and is trifid. The chaetotaxy of the thorax and abdomen is not unusual. Palmate hairs occur on segments 2-7 of the abdomen, are well developed and conspicuous, and each consists of 20-25 leaflets which are long, slender, pointed, and not serrated. The pecten is composed of regularly alternating long and short teeth. The ventral subdorsal hairs bear the usual grappling hooks.

The pupal skin is a clear pale brown and the trumpet is not pigmented nor are there any zones of pigmentation on the cephalo-thorax. This stage may usually be separated from that of *A. annulipes* Walk. by its smaller size and paler colour. The trumpet (Text-fig. 3 *e*) is longer and not so broad, and the abdominal chaetotaxy (Text-fig. 3 *b*) is strikingly different. From *A. atratipes* Sk. it may be distinguished by its smaller size, absence of pigmentation, much narrower trumpet, and different chaetotaxy. The pupal stage lasted two to four days under the conditions of the experiments.

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THE INTERPRETATION OF THE RADIAL FIELD OF THE WING IN THE
NEMATOCEROUS DIPTERA, WITH SPECIAL REFERENCE
TO THE TIPULIDAE.

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(Communicated by Dr. E. W. Ferguson.)

(Ninety-two text-figures.)

[Read 25th May, 1927.]

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HISTORICAL.

The study of the venation of the Diptera during the past century has brought about many successive and progressive modifications. The early interpretations of Schiner (1862, pl. 2), Loew (1862) and Osten Sacken (1869) were materially improved by Williston (1908, pp. 37-43) and other subsequent workers. The proposal of the Comstock-Needham system of nomenclature and its application to the order (1899) furnished the most important means for a true knowledge and appreciation of the homologies of the veins. Still more recent work by Tillyard (1919) has served to strengthen our interpretation of the medial and cubital fields of the wing.

In the course of his studies on the Tipulidae, the present writer has long felt dissatisfied with the hitherto adopted interpretation of the radial field of the wing in Diptera (Needham, 1908; Comstock, 1918, 1924; Tillyard, 1919; MacGillivray, 1923). At first sight this interpretation would suggest a double dichotomy of the branches of the radial sector, as in the hypothetical type of insects, and this is indeed true in the two most generalized families of living Diptera (Tanyderidae and Psychodidae). In all higher Diptera, however, one or more branches of this dichotomy have been lost and this has been interpreted as having been brought about by a fusion to the margin of either the upper fork (Ptychopteridae;

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Brachycera) or the lower fork (Nematocera) of the primitive dichotomous sector. It has long seemed very strange that in the Diptera we should start with two extremely primitive families (Tanyderidae and Psychodidae) that have no indication of a radial crossvein and then suddenly gain such a vein in the Tipulidae and a few more or less closely allied groups, following which the structure has been completely lost throughout the order. In the present paper, the writer has attempted to demonstrate that the true radial crossvein (r of Comstock (1918, 1924), Needham (1908); ir_1 of Tillyard) has never been developed as a *transverse* element in the Diptera, as shown by all of the above students, and should be omitted as such from any archetype of the order (Tillyard, 1919, fig. 69). The vein lies as a *longitudinal* element in a serial alignment, distinct as a separate unit only in the subfamilies Architipulinae, Tipulinae and Cylindrotominae, and two tribes of the Limoniinae, the Lechriini and some Limoniini. In two earlier papers, the writer had briefly outlined these various interpretations in the subfamily Cylindrotominae (1919, p. 863) and in the Limoniine tribe Pediciini (1918).

Edwards (1926, p. 126) felt inclined to doubt the possibility of two radically different types of radius having been developed within the family Tipulidae. It was for the purpose of attempting to decide this question, which has long been a disputed point in the consideration of the group, that the present writer began a critical comparative survey of the various genera and species, more than 98% of the genera and subgenera, and over 3,000 species of Tipulidae having been available for the purpose. It was soon apparent that two distinct groups were involved, one, represented by the Tipulinae, Cylindrotominae, and the tribes Lechriini and Limoniini, having r present as a *longitudinal* element and forming part of a serial radial vein and with R_4 and R_5 fused to the wing margin; and, secondly, the remaining tribes of the Limoniinae (Pediciini, Hexatomini, Eriopterini, and the aberrant Styringomyini) in which no radial crossvein had been developed, where R_2 had swung cephalad and fused backward from the wing-margin with R_1 , where R_4 had been taken from the primitive dichotomous posterior fork of the sector and become more intimately connected with the anterior branch, R_{2+3} , leaving the posterior branch of the radial field to consist of R_5 alone. This rather involved and somewhat mystifying condition of affairs is discussed in some detail in the present paper. A special effort has been made to choose representatives of Australian genera where these showed the points involved. After this critical review of the known Tipulidae, the writer cannot feel but that the main principles as given at this time are correct.

THE PRIMITIVE CONDITION OF THE RADIAL FIELD IN THE DIPTERA.

The condition of the radial field in the two recent families Tanyderidae and Psychodidae is so like that of the archetype of the Diptera that we must consider them as representing the two most generalized living groups. This contention is beautifully upheld by the recent critical work on the body morphology and phylogeny of the group by Crampton (1924-1926) and Edwards (1926). There can be no doubt but that the two families are closely allied, a view that was apparently first suggested by Lameere (1906). In these two groups there are five branches of radius attaining the wing-margin and no indication of a radial crossvein. It should be noted, however, that in the three families of Diptera most closely allied (Ptychopteridae, Trichoceridae and Tipulidae) the number of branches of the sector has already undergone a reduction and in representatives of all of them the *so-called* radial crossvein (r of previous workers) is found.

In the phylogeny of the Diptera (Crampton, 1924-1926; Edwards, 1926) it is now believed that the Ptychopteridae are closely allied to the Tanyderidae and that they either ended as a blind stem, or, possibly, gave rise to certain groups of the Nematoceros Diptera, and through them, the Brachycera. The Trichoceridae appear to lead directly toward the Anisopodidae, from whence the other groups of the Nematocera seem to have been derived. Since, therefore, the only groups of Diptera that are more primitive than these three are the Tanyderidae and Psychodidae, it follows that whatever interpretation is accepted for the Ptychopteridae, Trichoceridae and Tipulidae must be accepted also for all higher Diptera. It is for this reason that the correctness or incorrectness of the accompanying data and interpretations assumes an importance very much greater than would be the case if merely the single family Tipulidae were involved.

THE TWO TENDENCIES OF SPECIALIZATION IN THE RADIAL FIELD IN THE TIPULIDAE.

As was briefly indicated in the historical introduction of this paper, there appear to have been two very distinct tendencies in the Tipulidae that are so profound that both are shown by the oldest known Tipulidae and related groups (Upper Liassic).

These two lines of specialization are as follows:

A. In the subfamily Limoniinae, the three tribes *Pediciini*, *Hexatomini* and *Eriopterini* (together with the aberrant tribe *Styringomyini*, which apparently must be considered with the *Eriopterini* in any discussion of the groups) have evidently been derived through some primitive *Pediciine* ancestor from a type that was not unlike our recent *Tanyderidae*. The upper branch of the anterior fork of the primitive sector has swung cephalad and become fused backward from the margin with vein R_1 ; in all but a few generalized members of these three tribes the dichotomous nature of the posterior fork of the sector has been lost by the capture of the anterior branch (R_4) by the stem of the upper fork (R_{2+3}), leaving R_5 alone as the posterior branch of the radial field.

B. In the subfamilies *Architipulinae*, *Tipulinae*, *Cylindrotominae*; and the tribes *Lechriini* and *Limoniini* of the *Limoniinae*, a radial crossvein is present, occupying a *longitudinal* or *oblique* position, and in all higher types becoming part of a serial vein composed of $R_1 + r + R_2$. The distal sections of R_1 and R_2 are lost by atrophy except in the more generalized groups. As in the preceding section A, the *apparent* radial crossvein is really the basal section or deflection of R_2 , in the higher groups of the *Limoniini* this deflection being lost by atrophy. The posterior fork of the primitively dichotomous sector is interpreted as being lost by a fusion of the two elements, R_4 and R_5 to the wing-margin. There is no direct evidence to support this interpretation, however, and it must be held as somewhat tentative (see discussion in concluding paragraph of the *Cylindrotominae*).

A. Subfamily *Limoniinae*: Tribes *Pediciini*, *Hexatomini* and *Eriopterini*.

1. The cephalization of vein R_2 .

In the primitive families of Diptera, the *Tanyderidae* and *Psychodidae*, vein R_2 is a full length vein that lies parallel to veins R_1 and R_3 and attains the wing-margin as a separate entity. In all other groups of Diptera, vein R_2 is either connected with R_1 by the longitudinal crossvein r (as discussed in detail under caption B) or has swung cephalad and forms a fusion with R_1 backward from the margin.

As a preliminary to the data that are presented in this paper, the family Tanyderidae should be briefly considered since it is obviously closest to the ancestral type from which the Pediciini and higher Limoniinae have been evolved. The family includes the following genera: *Macrochile* Lw., fossil, Lower Oligocene (Crampton, 1926b); *Protoplasa* O.S., 3 Nearctic, 1 Palaearctic species; *Péringueomyina* Alex. (*barnardi* Alex.), Ethiopian; *Tanyderus* Phil. (*pictus* Phil.), Neotropical; *Radinoderus* Handl., 7 species, chiefly Australian, 1 Neotropical; *Mischoderus* Handl., 4 or 5 valid species, all from New Zealand; *Neoderus* Alex. (*patagonicus* Alex.), Patagonia; and *Nothoderus* Alex. (*australiensis* Alex.) of Tasmania. *Nothoderus australiensis* Alex. was discussed and figured by

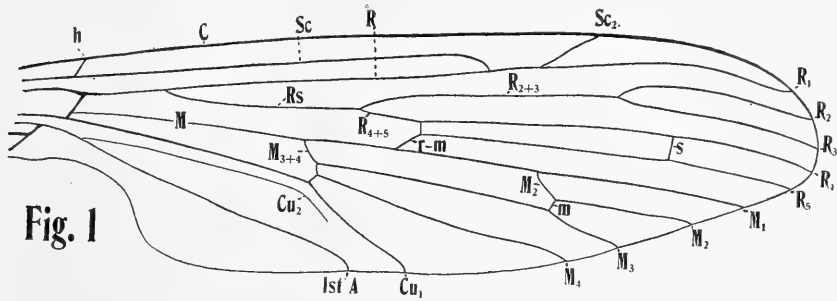


Fig. 1

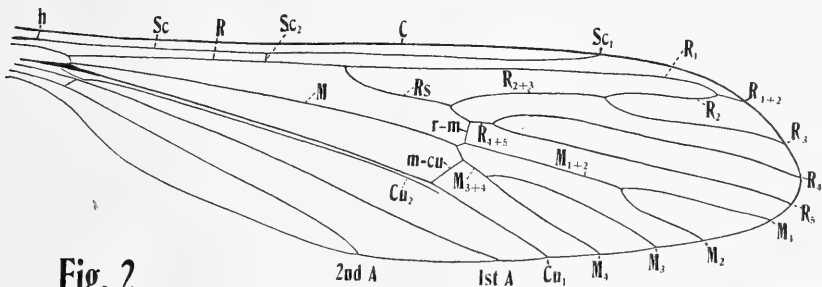


Fig. 2

Text-figure 1. Wing of *Nothoderus australiensis* Alex. (Tanyderidae).

Text-figure 2. Wing of *Tricypfona protea* Alex. (Pediciini).

A = anal veins; C = costa; Cu = cubitus; h = humeral crossvein; M = media; m = medial crossvein; m-cu = medial-cubital crossvein; R = radius; r-m = radial-medial crossvein; Rs = radial sector; Sc = subcosta; s = supernumerary crossvein in cell R₄.

MacGillivray (1923, p. 322, fig. 45) as being "the most generalized dipterous wing that I have seen", despite the fact that the free tip of Sc₂, a remarkable feature of the genus, is omitted from his figure. This primitive fly (Text-fig. 1) shows the arrangement of the branches of radius in the Tanyderidae. The supernumerary crossvein (s) in cell R₄ is a feature that is very characteristic of the members of this family and likewise of the Pediciini.

The first realization of the cephalization of vein R₂ in the lower Diptera came to the writer with the discovery of a remarkable crane-fly, *Tricypfona protea* Alex. (Text-fig. 2) where the venation is very like a Tanyderid except that vein R₂ has swung cephalad and fused with R₁ for a short distance back from the wing-margin.

The study of this fly and a comparison with the then known members of the tribe Pediciini resulted in a short paper by the writer (Alexander, 1918) wherein the radial field in this tribe was interpreted about as is done in the present treatment. This interpretation for the Pediciini was adopted by Edwards (1921) and the writer but no attempt was later made to homologize the venation with that of the other tribes in the Limoniinae and Tipulinae and, from them, the phylogenetically higher families of Diptera. A second species of *Tricyphona* (*formosana* Alex., Text-fig. 3) was later discovered in which the venation of this field is about intermediate between *protea* and the normal condition in the tribe (*T. novae-zelandiae* Alex., Text-fig. 4) where this element (the basal section of R_2) is short

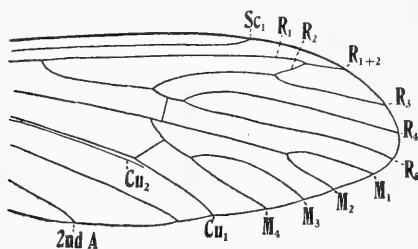


Fig. 3

Text-figure 3. Wing of *Tricyphona formosana* Alex.

Text-figure 4. Wing of *T. novae-zelandiae* Alex.

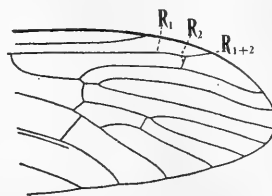


Fig. 4

and transverse in position. It is this basal section or deflection of R_2 that has almost universally been interpreted as being *r* in the groups of Diptera where it has been retained. In a few of his recent papers, the present writer has indicated his opinion that *r* as a transverse element did not exist in the Tipulidae or in the Diptera.

2. The Capture of Vein R_4 by R_{2+3} .

We now come to one of the most curious features in the problem. In the primitive Diptera (Tanyderidae, Text-fig. 1; *Tricyphona protea* Alex., Text-fig. 2), as elsewhere in generalized groups of the higher orders of insects, the radial sector is typically dichotomously twice forked. In the Tipulidae this dichotomous type has been preserved only in a few scattered groups, chiefly in the Pediciini (Text-figs. 8, 9), and in some Eriopterini (*Molophilus*, Text-fig. 39), the upper fork in all of these types being eliminated by the fusion of the upper branch with R_1 , as just outlined. The lower dichotomy in these groups retains its primitive condition of a very deep fork and correspondingly shortened petiole. However, in many members of the tribe under consideration, the Pediciini, as, for example, in the genus *Rhaphidolabis* (Text-figs. 5-6) we find a bewildering condition where the dichotomy is lost by R_4 becoming more intimately attached to the upper fork than to the lower. Similarly in the genera most closely allied to *Molophilus*, as *Erioptera*, we find an entirely comparable condition. This apparently irreconcilable condition is really brought about in a very simple manner by a slight shifting of the relative positions of the veins at the end of the sector. This condition was discussed at some length by Needham in his classic study of the venation of the Tipulidae (1908, pp. 225-226, fig. 14) and has been investigated more superficially by subsequent workers on the family. For the purposes of illustration of the principle,

species of the Pediciine genus *Rhaphidolabis* O.S. in the Nearctic fauna have been selected (Text-figs. 5-9). In species like *R. cayuga* Alex. (Text-fig. 9, 9a) and *R. stigma* Alex. (Text-fig. 8), the primitive condition of the lower fork of the sector is found, cell R_3 being broadly sessile, cell R_4 petiolate. In *R. rubescens* Alex. (Text-fig. 7, 7a) the petiole of cell R_4 has shortened so that both cells R_3 and R_4 appear sessile, vein R_4 being in direct alignment with the sector. From this point on, vein R_4 moves progressively upward on to the stem of the upper fork, R_{2+3} . In *R. major* Alex. (Text-fig. 6, 6a) this migration is very slight so that cell

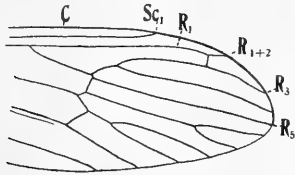


Fig. 5

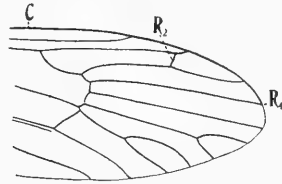


Fig. 8

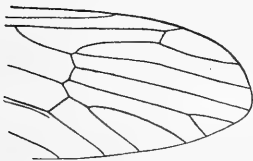


Fig. 6

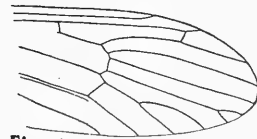


Fig. 9

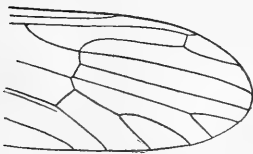
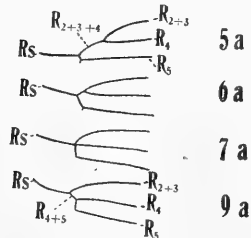


Fig. 7



Text-figure 5. Wing of *Rhaphidolabis polymeroides* Alex.

Text-figure 6. Wing of *R. major* Alex.

Text-figure 7. Wing of *R. rubescens* Alex.

Text-figure 8. Wing of *R. stigma* Alex.

Text-figure 9. Wing of *R. cayuga* Alex. Subfigures, 5a, 6a, 7a and 9a, showing details of the forking of the sector in the above species.

R_3 would be described as being short or very short petiolate, the fused vein R_{2+3+4} being this petiole. In still other species, illustrated by *R. polymeroides* Alex. (Text-fig. 5, 5a), the capture of vein R_4 by R_{2+3} has been more complete and the petiole of cell R_3 is conspicuous. Parallel cases are to be found in *Tricyphona* Zett., *Nipponomyia* Alex. (Text-figs. 14-16) and elsewhere in this generalized tribe. The end result of this shifting is the basal fusion of R_{2+3} with R_4 which becomes very extensive in some groups of the family. As the fusion progresses, cell R_3

becomes more shallow until, in cases discussed under the Hexatomini and Eriopterini, it is entirely lost by the fusion to the wing margin of veins R_3 and R_4 . After the capture of vein R_4 in the manner described, the single remaining vein of the radial field is R_5 .

3. The Apparent Radial Crossvein in the Dicranotae.

A few Pediciini (all species of *Dicranota*, *Amalopina dicranotoides* Alex. and *A. sibiriensis* Alex., *Polyangaeus*) possess a crossvein in cell R_1 , which, in an earlier paper by the writer (1918, p. 205) was interpreted as being the true r . In the light of the evidence now available that r in the Diptera, in the relatively few groups where it occurs (as described under caption B, later) always occupies a longitudinal or oblique position and becomes one of the series of elements making up the serial radial vein, it becomes necessary to examine the case in the

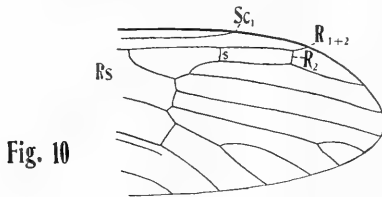


Fig. 10

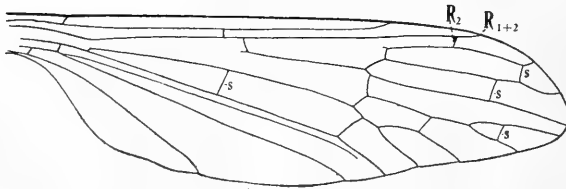


Fig. 11

Text-figure 10. Wing of *Dicranota bimaculata* Schumm.

Text-figure 11. Wing *Heterangaeus gloriosus* Alex.

R = radius; Sc = subcosta; s = supernumerary crossveins.

Dicranotae more critically. It should be noted first that this tribe shows a plasticity in the number and position of crossveins, both supernumerary and adventitious, quite unparalleled elsewhere in the Tipulidae, though virtually duplicated in the Tanyderidae. The genus *Heterangaeus* Alex. (Text-fig. 11) shows how abundant these crossveins may be in a single genus and species and there is no reason to believe but that the crossvein in cell R_1 , in the cases above outlined, is merely another instance of a supernumerary crossvein, in this case occupying a cell where its position and interpretation becomes far more critical than in the other instances. The plasticity of the character is shown by the fact that *Amalopina dicranotoides* and *A. sibiriensis* are the only ones of the genus (of six species) that possess this supernumerary vein. The genotype, *elegantula*

Brun., lacks this vein but has another in cell R_4 . *Dicranota* (Text-fig. 10), in which this character is present, is very closely allied to *Rhaphidolabis* O.S. (Text-figs. 5-9) in which the crossvein is lost, and the presence or absence of this element constitutes the only criterion for the separation of the two groups. Taking into consideration the unusual degree of occurrence of supernumerary and adventitious veins (Johnson, 1901) in members of this tribe, there can be no serious objection to considering the vein in the *Dicranotae* as being merely an additional supernumerary element stranded in cell R_1 .

The writer now wishes to take up the three tribes in this group and discuss the more interesting tendencies.

Pediciini.—As was indicated, the primitive arrangement of the veins at the end of the sector is found in many groups of the tribe. In *Pedicia* Latr., *Ornithodes* Coq., most *Tricyphona* Zett. (Text-figs. 2-4, 12, 13), as well as in *Rhaphidolabis* O.S. (Text-figs. 8-9) the dichotomous arrangement of the veins still obtains. The petiole of the posterior fork (R_{4+5}) is usually short, reaching its maximum length in species

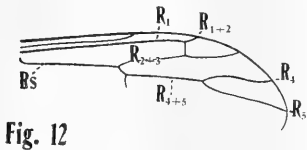


Fig. 12

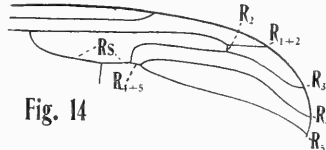


Fig. 14

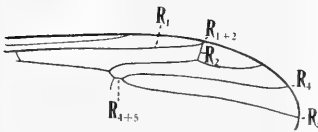


Fig. 13



Fig. 15

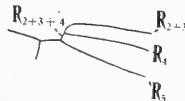


Fig. 16

- Text-figure 12. Wing of *Tricyphona brevifurcata* Alex.
- Text-figure 13. Wing of *T. rainieria* Alex.
- Text-figure 14. Wing of *Nipponomyia kuwanai* Alex.
- Text-figure 15. The same, showing modification of veins at end of sector.
- Text-figure 16. *Nipponomyia symphyletes* Alex.

such as *T. brevifurcata* Alex. (Text-fig. 12). The remarkably primitive condition found in *T. protea* Alex. (Text-fig. 2) has been discussed elsewhere in this paper. No species is definitely known where R_2 ends beyond the level of R_1 and connects directly with costa. In *T. rainieria* Alex. (Text-fig. 13) the deflection of R_2 is at the extreme outer end of vein R_1 , as is also the case in *Polyangaecus maculatus* Doane. Doane even figures his type example of this latter species as having this element connected with costa but no mention is made of this very unusual condition in the text and it is presumably erroneous.

The manner in which the dichotomous posterior fork is lost has been discussed earlier in the case of *Rhaphidolabis* (Text-figs. 5-9). A closely comparable case is found in the species of the genus *Nipponomyia* Alex., where the various modifications are found at times in different individuals of the same species. Thus *N. kuwanai* Alex. may have cell R_4 short-petiolate (Text-fig. 14) or sessile (Text-

fig. 15). *N. symphyletes* Alex. (Text-fig. 16), *N. trispinosa* Alex., *N. novempunctata* S.-W., and *N. sumatrana* de Meij., have R_4 mounted half-way up the perpendicular basal portion of R_{2+3} so that cell R_3 has become petiolate, cell R_4 broadly sessile. In the genus *Tricyphona* we find a great group of species in which the primitive condition is still retained but in still others (as *inconstans* O.S., *constans* Doane, and many of the European species, as *gmundensis* Egg., *littoralis* Meig., *occulta* Meig., *opaca* Egg., *schineri* Kol., *tipulina* Egg., and others) R_4 has been captured by R_{2+3} in the manner previously described. It should be noted here that occasional specimens of *inconstans* are found that show a reversion to the primitive condition of the genus (Osten Sacken, 1869, p. 267; Johnson, 1901, p. 307). Specimens in the related genus *Pedicia* show a similar range in this field of the wing. As was indicated earlier in this paper, supernumerary crossveins are commonly developed in this tribe, occurring in cells R_1 , R_2 , R_4 and M in *Polyangaeus* and in cells R_3 , R_4 , M₁ and M in *Heterangaeus*.

In the subtribe Adelphomyaria, including only the genus *Adelphomyia* Bergr., a connecting element with the following tribe, the Hexatomini, is found. The adult flies are very Hexatomine in structure but the larvae exhibit some curious Pediciine characters. The venation of the radial field is not different from *Limnophila*, discussed later, except that the basal section of R_2 is often weakly developed and tends to be lost by atrophy.

Hexatomini. This tribe is apparently naturally derivable from the Pediciini through the Adelphomyaria on the one hand, and the lowermost subtribe, the Ularia, on the other. Within the tribe there is found a remarkable range of usually large to medium-sized species that are arranged in a variety of subtribes. The number of these latter sub-divisions will probably be increased when certain doubtful genera become better known and new types are discovered. The most specialized groups appear to fall in the Gynoplistiaria, the Limnophilaria, the Hexatomaria and the Elephantomyaria, some of which lead rather gradually toward the Eriopterini. The chief modifications and tendencies in the radial field are discussed below.

Ularia. Includes only the genus *Ula* Haliday. The venation is not different from some species of *Tricyphona*, as *inconstans* O.S.

Epiphragmaria. Includes a number of chiefly Antipodal genera, as *Epiphragma* O.S., *Polymoria* Phil., *Limnophilella* Alex., *Acantholimnophila* Alex., *Rhamphophila* Edw., *Tinemyia* Hutt., *Phyllolabis* O.S., *Horistomyia* Alex., *Heterolimnophila* Alex., *Polymera* Wied., and others. The venation shows no modifications of the radial field over that of *Gynoplistia*, described later.

In *Polymera*, the position of the basal section of R_2 differs greatly in the various species, in some, as *inornata* Alex., the last section of R_1 being equal to R_{1+2} while in other species the section of R_2 is far out toward the tip of R_1 .

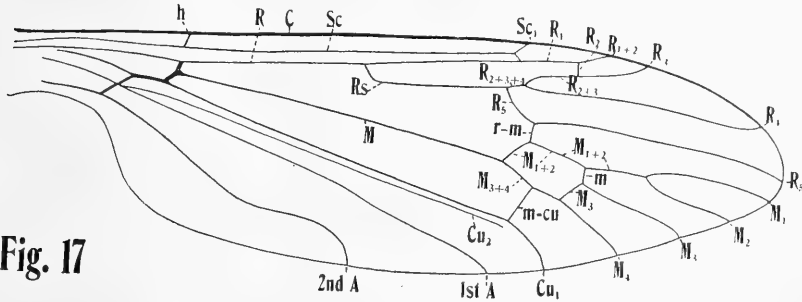
Pseudolimnophilaria. Includes only the genus *Pseudolimnophila* Alex., as known, but other groups will probably be added to the subtribe when better known. The genus included is not different in venation from *Limnophila*.

Dactylolabaria. Includes only the genus *Dactylolabis* O.S., so far as known. As before, the venation is normal for the Hexatomini and requires no comment.

Gynoplistiaria. Includes only the genus *Gynoplistia* Westw., with four subgeneric groups, *Paralimnophila* Alex., *Gynoplistia*, *Cerozodia* Westw., and *Ctedonia* Phil. The group is tremendously developed in Australia and New Zealand. The figure of *G. bella* Walk. (Text-fig. 17) may be taken as typical not only of the subtribe but for the entire tribe Hexatomini. R_{2+3+4} is almost always

very short to entirely obliterated (as in *G. dimidiata* Alex., *G. harrisi* Alex., *G. hiemalis* Alex., *G. nigronitida* Alex.), cell R_3 thus varying from short-petiolate to sessile; R_{2+3} elongate, usually perpendicular or subperpendicular at origin, sometimes with a short spur or weak crossvein at the angle; basal section of R_2 short, the fused R_{1+2} generally short to of moderate length.

Limnophilaria. This subtribe as now constituted includes a considerable range of genera, some of which are discordant and will later be removed. A few of the groups require special comment. *Psaronius* End. shows a venational range



Text-figure 17. Wing of *Gynoplestia bella* Walk.

of the radial field that closely parallels that of the Eriopterine genera *Paragymnastes* and *Gymnastes*. R_s is long and lies close to R_1 in alignment with R_{2+3+4} and its continuation, R_4 ; even in the most generalized species, as *obscurus* Fabr. (Text-fig. 18), R_{2+3} is relatively short and R_2 weak although long and lying parallel to the fused R_{1+2} . In *trianguliferus* Alex. (Text-fig. 19) the tip of R_3 has swung basad and is fused with the tip of R_{1+2} , cell R_2 being elongate-triangular.

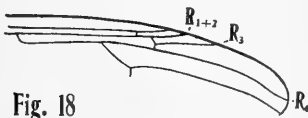


Fig. 18

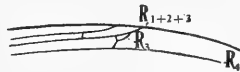


Fig. 20

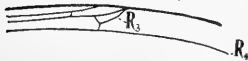


Fig. 19



Fig. 21

Text-figure 18. Wing of *Psaronius obscurus* Fabr.

Text-figure 19. Wing of *P. trianguliferus* Alex.

Text-figure 20. Wing of *P. obliteratus* Alex.

Text-figure 21. Wing of *P. abnormis* Alex.

In *obliteratus* Alex. (Text-fig. 20) the fusion backward from the tip has proceeded so far that cell R_2 is reduced to a tiny triangle. In species such as *abnormis* Alex. (Text-fig. 21), *brevitibia* Alex., and *mancus* Alex., the tendency is carried to its logical conclusion and cell R_2 is entirely obliterated.

The genus *Ischnothrix* Bigot is of importance as indicating the manner in which the aberrant genus *Atarba* O.S. has been derived. In *I. australasiae* Skuse (Text-fig. 22) R_{2+3+4} is very long, the branches R_3 and R_4 short but separate, cell

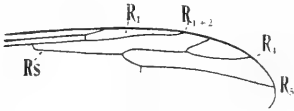


Fig. 22



Fig. 23

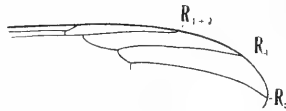


Fig. 24

Text-figure 22. Wing of *Ischnothrix australasiae* Skuse.

Text-figure 23. Wing of *I. connexa* Alex.

Text-figure 24. Wing of *Atarba picticornis* O.S.

R_3 being small. In still other species, as *I. connexa* Alex. (Text-fig. 23) a secondary modification is produced by R_3 having swung basad and fusing backward from the margin with R_{1+2} , presumably for the purpose of strengthening this field of the wing. Similar cases are found in the Eriopterine genus *Gonomyia*, subgenus

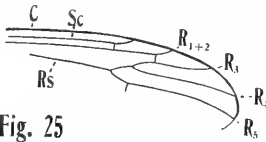


Fig. 25

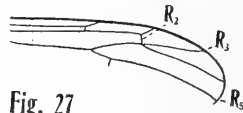


Fig. 27



Fig. 26

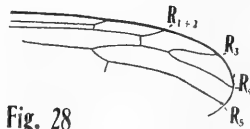


Fig. 28

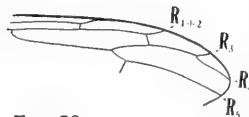


Fig. 29

Text-figure 25. Wing of *Eriocera velveta* Doane.

Text-figure 26. Wing of *E. wilsoni* O.S.

Text-figure 27. Wing of *E. gibbosa* Doane.

Text-figure 28. Wing of *E. fulltonensis* Alex.

Text-figure 29. Wing of *Hexatoma megacera* O.S.

Ptilostena Bergr. In *Atarba* (*picticornis* O.S., Text-fig. 24) veins R_3 and R_4 have fused to the wing-margin or, possibly, one of the branches atrophied shortly before the margin.

Hexatomaria. This very extensive and important subtribe includes four very closely allied genera, *Eriocera* Macq., *Penthoptera* Schin., *Hexatoma* Latr., and *Cladolipes* Lw. Members of this subtribe are chosen to illustrate the manner in which veins R_{2+3} and R_4 fuse to the wing-margin in certain groups of Hexatomini and Eriopterini. The figures show a series of Nearctic species of *Eriocera*, with one species of *Hexatoma*. In *E. velveta* Doane (Text-fig. 25) cell R_3 is still very deep; in *E. wilsoni* O.S. (Text-fig. 26) the cell is a little shorter in proportion to its petiole; *E. gibbosa* Doane (Text-fig. 27) shows the fusion as having progressed to opposite the point of departure of the basal section of R_2 ; *E. fulltonensis* Alex. (Text-fig. 28) shows the fusion of R_3 and R_4 as having continued to some distance beyond R_2 ; *Hexatoma megacera* O.S. (Text-fig. 29) has the veins fused almost to the margin. The condition results in a complete fusion in the European *Cladolipes simplex* Lw. The deepest cell in this subtribe known to the writer is in *E. subrectangularis* Alex., where R_{2+3+4} is about as long as $r-m$.

Elephantomyaria. The very aberrant genus *Elephantomyia* O.S. (*westwoodi* O.S., Text-fig. 30) is placed in the Hexatomini with some question although the reference seems to be correct. The genus as interpreted shows veins R_3 and R_4

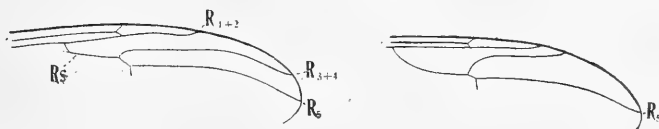


Fig. 30

Fig. 31

Text-figure 30. Wing of *Elephantomyia westwoodi* O.S.
Text-figure 31. Wing of *E. major* Alex.

fused to the wing-margin and the basal section of R_2 entirely atrophied. In the subgenus *Elephantomyodes* Alex., of the Indo-Australian Region (*major* Alex., Text-fig. 31), R_{2+3+4} at origin is perpendicular to subperpendicular, the distal section being closely approximated to R_1 .

In the tribe Hexatomini, the basal section of R_2 is lost by atrophy in many genera, as *Horistomyia leucophaea* Skuse, *Phyllolabis* O.S., some *Zelandomyia* Alex., *Harrisomyia* Alex., *Ischnothrix* Big., *Elephantomyia* O.S., and others. A few groups show a supernumerary crossvein in cell R_3 , as *Ctenolimnophila* Alex. (*decisa* Alex.); the subgenus *Calolimnophila* Alex., of *Pseudolimnophila* Alex.; the subgenus *Dicranophragma* O.S. of *Limnophila* Macq.; *Elephantomyia supernumeraria* Alex., and others. In *Ctenolimnophila bivena* Alex., there is an additional supernumerary crossvein in cell R_4 .

Eriopterini. The great tribe Eriopterini has evidently been derived from the Hexatomini through certain of its subtribes, as the Claduraria and Conosiaria which have retained numerous Hexatomine features and have been referred to as the "Hexatomoid Eriopterini." The most generalized subtribes would thus be those just mentioned, leading, through the Gonomyaria to the so-called "pot-bellied" Eriopterini, the typical Eriopteraria. In this vast assemblage of genera and subgenera several specializations and modifications from the normal type are found that are very puzzling and difficult of explanation. The greatest trouble comes in

three, chiefly Ethiopian, genera, *Ceratolimnobia*, *Xipholimnobia* and *Xenolimnobia*, which, as discussed later, may well pertain to the Lechriini in the following group of subfamilies. More material will be needed to determine finally the exact systematic position of many of the crane-fly genera and a critical study of all the stages and available structures must be made. Very many of the larger and more widely distributed genera are vastly ancient and there has been almost unlimited time during which the various modifications and tendencies have been evolved. It is very certain that more subtribes will be formed when certain groups of exotic Eriopterini become better known. In many of the higher members of the tribe, the basal section of R_2 has atrophied, leaving no hint as to its exact former position. When present, this element shows a great range in position, in some, as *Molophilus* (Text-fig. 39) and *Erioptera* (Text-fig. 40) being retreated far from the tip of R_1 , the fusion of R_1 and R_2 thus being very extensive; in still others the element is far out toward the end of vein R_1 . When the element has atrophied, as in *Gonomyia* and many other groups, all that can be affirmed is that the distal section of R_2 has fused with R_1 and the vein at the margin must be called R_{1+2} .

In the present paper, only a few of the more conspicuous types and certain modifications can be discussed.

Claduraria. This subtribe includes *Cladura* O.S., *Neocladura* Alex., *Crypteria* Bergr., *Pterochionea* Alex., *Neolimnophila* Alex., and *Chionea* Dalm., a group of genera very characteristic of the northern Holarctic Region, most of them appearing as adults in autumn and winter. The venation shows no modifications from the normal type of the Hexatomini and is not further discussed.

Conosiaria. Includes *Conosia* v.d.W. and *Clydonodozus* End., two closely allied Palaeotropical genera in which the maxillary palpi are greatly reduced. The more generalized genus, *Clydonodozus*, has the basal section of R_2 transverse and not greatly different from the condition in the Hexatomini (*angustifasciatus* Alex., Text-fig. 32). The more specialized genus, *Conosia* (*irrorata* Wied., Text-

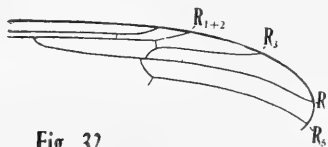


Fig. 32

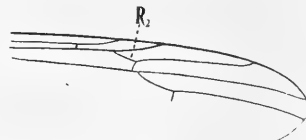


Fig. 33

Text-figure 32. Wing of *Clydonodozus angustifasciatus* Alex.

Text-figure 33. Wing of *Conosia irrorata* Wied.

fig. 33) has the basal section of R_2 reflexed back toward the wing-base so that the proximal end of cell R_2 is acutely pointed. It should be noted that the shifting of veins at the end of R_5 , as already discussed in some detail for the Pediciini, is found in these two genera and even in different specimens of the single genus *Conosia*.

Gonomyaria. An extensive subtribe, interpreted as including, among others, *Gonomyia* Meig., *Gnophomyia* O.S., *Teucholabis* O.S., *Trentepohlia* Big., *Paragymnastes* Alex., *Gymnastes* Brun., *Campbellomyia* Alex., *Dasymallomyia* Brun., *Lipsothrix* Lw., *Aphrophila* Edw., *Astelobia* Edw., *Austrolimnobia* Alex., *Sigmatomera* O.S., *Lecteria* O.S., *Platylimnobia* Alex., and more doubtfully, *Ceratolimnobia* Alex., *Xipholimnobia* Alex. and *Xenolimnobia* Alex.

The following groups should be more critically examined to determine their strict position in subtribes; (1) *Trentepohlia*; (2) *Sigmatomera*, *Astelobia*, *Austrolimnobia*; (3) *Lecteria* (and its exact relationships with the Hexatome genus *Psaronius*); (4) *Paragymnastes* and *Gymnastes*; (5) *Aphrophila*; and (6) *Ceratolimnobia*, *Xipholimnobia* and *Xenolimnobia*. The genera as listed above are grouped chiefly on thoracic characters and, as so united, unquestionably include some discordant elements.

Most of the groups require no special explanation to homologize their venation with the groups previously discussed. In *Trentepohlia* and *Astelobia*, the basal section of R_2 is reflexed strongly basad, as in *Conosia*, just described. The allied genus *Austrolimnobia* has the element transverse and normal in position. In *Paragymnastes* (*fascipennis* Thoms., Text-fig. 34) and *Gymnastes* Brun. (*ornatipennis* de Meij., Text-fig. 35, *shirakii* Alex., Text-fig. 36) we find the loss of the free distal section of R_3 by gradual atrophy and probable fusion back from

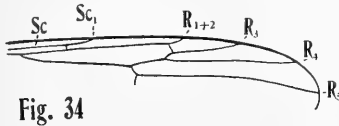


Fig. 34

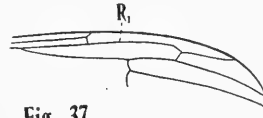


Fig. 37

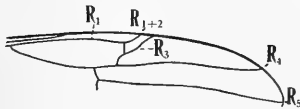


Fig. 35

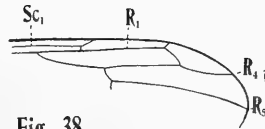


Fig. 38



Fig. 36

- Text-figure 34. Wing of *Paragymnastes fascipennis* Thoms.
- Text-figure 35. Wing of *Gymnastes ornatipennis* de Meij.
- Text-figure 36. Wing of *G. shirakii* Alex.
- Text-figure 37. Wing of *Xipholimnobia terebrina* Alex.
- Text-figure 38. Wing of *Xenolimnobia camerounensis* Alex.

the tip of R_{1+2} , much as previously described under the Hexatome genus *Psaronius*. In *Gonomyia* and *Teucholabis* we find a progressive increase in the degree of fusion of veins R_3 and R_4 , in exactly the same manner as discussed under *Eriocera* (Text-figs. 25-29) in the preceding tribe. This culminates in the subgenera *Lipophleps* Bergr. and *Teucholabis*, respectively, cell R_3 being obliterated, producing a venation that is very similar to that found in the Limoniini in the next section. In *Teucholabis*, $r-m$ is sometimes obliterated by the fusion of vein R_5 on M_{1+2} .

In *Ceratolimnobia* and allied genera, as mentioned above, a much more difficult and serious problem is found. In *Ceratolimnobia* and *Xipholimnobia* (*terebrina* Alex., Text-fig. 37) the appearance is much as in *Trichoneura*, that has been placed in the Lechriini of the following section, except that the critical

distal section of R_1 is not preserved in any material that has been discovered and the apparent homology may be apparent only. In *Xenolimnobia* (*camerounensis* Alex., Text-fig. 38) the condition is reversed, the apparent tip of R_1 being preserved but the entire distal section of R_2 atrophied. It is greatly hoped that additional and possibly annectant forms in this group will be discovered.

Eriopteraria. This subtribe is restricted to the so-called "pot-bellied" Eriopterini (Crampton, 1925, p. 199) and includes among others, the following genera: *Erioptera* Meig., *Empeda* O.S., *Psiloconopa* Zett., *Cryptolabis* O.S., *Dasymolophilus* Goetg., *Tasiocera* Skuse, *Molophilus* Curt., *Ormosia* Rond., *Amphineurus* Skuse, *Trimicra* O.S., *Helobia* St. Farg., *Podoneura* Bergr., *Empedomorpha* Alex., and *Rhabdomastix* Skuse. The species of *Rhabdomastix* bear a noteworthy resemblance to *Gonomyia*, with which genus they were long confused in the European fauna. The genus entirely parallels *Gonomyia* in that some few generalized species have retained the basal section of R_2 while in the majority it is entirely atrophied. In all of the species of the genus yet made known, cell R_3 is present though often very small.

In *Molophilus* (*froggatti* Skuse, Text-fig. 39) we find the same generalized dichotomy of the sector that has been considered under the Pediciini. An intermediate condition is found in *Dasymolophilus* and, especially, in several New Zealand species of *Amphineurus* where cell R_3 ranges from barely sessile through other species where the cell is short-petiolate, to *Erioptera* (*lutea* Meig., Text-fig.

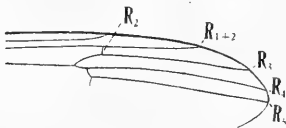


Fig. 39



Fig. 40

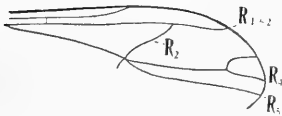


Fig. 41



Fig. 42

- Text-figure 39. Wing of *Molophilus froggatti* Skuse.
 Text-figure 40. Wing of *Erioptera lutea* Meig.
 Text-figure 41. Wing of *Empedomorpha empedoides* Alex., ♂.
 Text-figure 42. Wing of *Styringomyia terrae-reginae* Alex.

40) where the cell is distinctly petiolate. A curious modification of the veins of the radial field in the male of *Empedomorpha* (*empedoides* Alex., Text-fig. 41) is found where the basal section of R_2 is very long, the other elements being reduced and crowded. The female of the same species is a very ordinary fly.

Styringomyiini. The single very isolated genus *Styringomyia* Lw. (*terrae-reginae* Alex., Text-fig. 42) is placed here. The venation of the radial field some-

what suggests *Ceratocheilus*, as discussed under the following section, $R_{2,3}$ being very short and lying obliquely, far distad of R_1 . Any discussion as to how this remarkable venation might have been evolved would be theoretical only.

B. Subfamilies *Architipulinae*, *Tipulinae* and *Cylindrotominae*; Subfamily *Limoniinae*: Tribes *Lechriini* and *Limoniini*.

1. The serial nature of vein R_1 .

The term *serial vein* was proposed by Comstock (1918, p. 69) for a compound vein composed of sections of two or more veins joined end to end with no indication of the point of union. In the subfamilies and tribes considered under this caption, the vein that has hitherto been called R_1 (Needham, 1908; Comstock, 1918) is, in reality, such a serial vein, being composed of three distinct elements, R_1 , r , and the distal section of R_2 . At the margin the vein should be labelled as being R_2 alone (except in the cases noted below), and the cell beneath this distal section of R_2 should be called R_2 instead of cell 2nd R_1 as heretofore. In the *Tipulinae*, *Cylindrotominae*, *Lechriini* and the more generalized *Limoniini*, the three elements constituting the distal end of this serial vein still preserve much of their separate identity by a more or less zig-zag arrangement, and, in many cases, by the preservation of the free tips of veins R_1 and R_2 . The former of these elements is lost in some *Cylindrotominae* and most *Limoniini* but is preserved in virtually all *Tipulinae*, the *Lechriini* and some generalized *Limoniini*. The latter element, R_2 , is lost in many *Tipulinae* (as the *Dolichopezaria*, many *Tipula*) and in the majority of the *Cylindrotominae* but is preserved and forms the true end of this serial vein in many *Limoniini*, but not in the subtribe *Limoniaria*, as discussed later. Veins R_4 and R_5 are interpreted as having fused to the margin, the resulting vein being R_{4+5} .

Architipulinae. The family *Architipulidae*, proposed by Handlirsch (1906-08, pp. 490-491) represents at most a valid subfamily of the *Tipulidae*. Of the genera placed therein by Handlirsch, only *Architipula* Handl. belongs here, the others (*Protipula* Handl., *Eotipula* Handl.) being either *Limoniinae* or *Trichoceridae*. All three genera pertain to the Upper Liassic, of an approximate age of 140,000,000 of years (Lane, 1919). The genera and species referred to the *Eoptychopteridae* in the same reference are more problematical and no attempt is made herein to correlate this material.

Tipulinae. The primitive condition of the radial field in the *Tipulinae* must be assumed as being much as in the *Architipulinae*, that is, with cell R_2 deeper than in recent genera, though approached by some species of *Ctenophoraria* (*Ctenophora* Meig., *Cnemoncosis* End., and *Tanyptera* Latr., *fumipennis* O.S., Text-fig. 43). Other genera of this subtribe show the cell less elongate, as *Prionota* v.d.W., *Pselliophora* O.S., *Dicthenidia* Brullé, and some *Ctenophora* and *Tanyptera*. The generalized condition likewise assumes that the distal sections of veins R_1 , R_2 and R_3 are entire and that the true radial crossvein, r , is present, connecting $R_{2,3}$ at the fork or R_2 shortly beyond the origin. It should again be emphasized that this radial crossvein is never transverse in position but always longitudinal or oblique, forming part of the more or less zig-zag serial vein in this subfamily. The homologies of the radial field are more obvious than in any other group of the *Tipulidae* and there has been little dispute as to the correct terminologies in this field of the wing. Comstock (1918, fig. 377; 1924, fig. 1009) has labelled the basal section of R_2 as being r .

The following, chiefly Australasian genera show a primitive type of radius, in most of them vein R_3 being very long and extended, greatly exceeding R_2 : *Clytocosmus* Skuse (*skusei* Alex., Text-fig. 44); *Platyphasia* Skuse; *Ptilogyna* Westw., *Phacelodocera* End., *Plusiomyia* Skuse (*felix* Alex., Text-fig. 45);

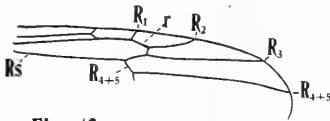


Fig. 43

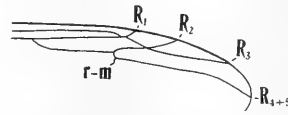


Fig. 44

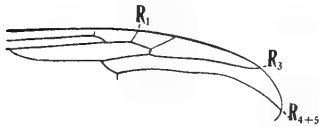


Fig. 45

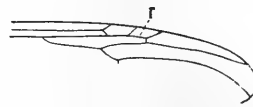


Fig. 46

Text-figure 43. Wing of *Tanyptera fumipennis* O.S.

Text-figure 44. Wing of *Clytocosmus skusei* Alex.

Text-figure 45. Wing of *Plusiomyia felix* Alex.

Text-figure 46. Wing of *Leptotarsus macquarti* Guer.

Ozodicera Westw., *Leptotarsus* Guer. (*macquarti* Guer., Text-fig. 46); *Semnotes* Westw., *Acracantha* Skuse; *Ischnotoma* Skuse; *Habromastix* Skuse; *Phymatopsis* Skuse; *Macromastix* O.S.; *Hudsonia* Edw.; *Zelandotipula* Alex.; *Longurio* Lw. and *Tipulodina* End.

In some species of *Acracantha*, *Ischnotoma*, *Hudsonia*, and the genera of the higher Tipularia (*Prionocera* Lw., *Holorusia* Lw.; *Ctenacroscelis* End.; *Pectinotipula* Alex.; *Tipula* Linn. and *Nephrotoma* Meig.), r is somewhat more

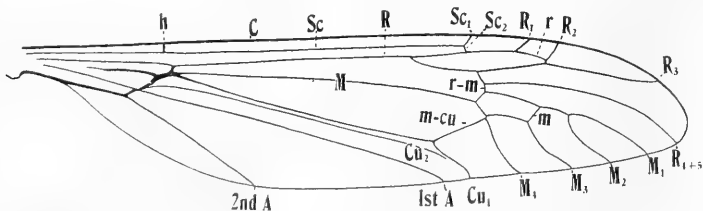


Fig. 47

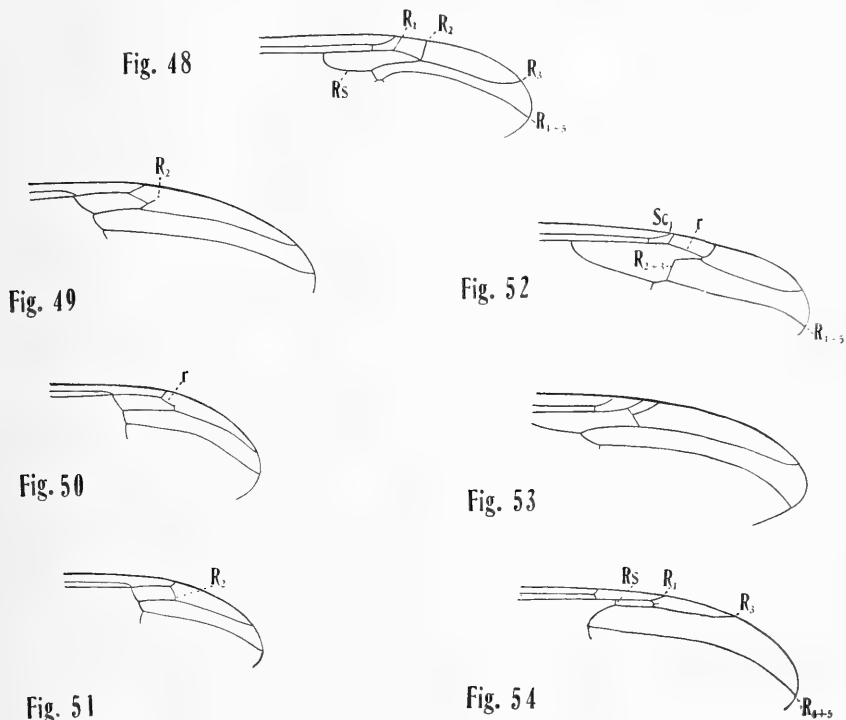
Text-figure 47. Wing of *Macromastix costalis* Swed.

oblique in position and cell R_2 is smaller, vein R_3 being much less extended. *Holorusia*, *Ctenacroscelis* and *Zelandotipula*, moreover, have vein R_3 very strongly arcuated toward vein R_{4+5} , strongly constricting cell R_3 .

In *Brachypremna* O.S. (*candida* Alex., Text-fig. 48), *Tanyppremna* O.S., *Megistocera* Wied. (*longipennis* Macq., Text-fig. 52), some *Macromastix* O.S. (*costalis* Swed., Text-fig. 47) and others, the free tip of R_2 tends to become transverse or nearly so.

Aldrovandia End. (*gesneri* End., Text-fig. 53) has *r* and the very long basal section of *R*₂ in oblique alignment, the distal section of *R*₂ being relatively short and paralleling *R*₁, *R*₃ being very extended.

In most of the genera that have been assigned to the Dolichopezaria (*Dolichopeza* Curt., Text-figs. 49-51; *Oropeza* Ndm.; *Nesopeza* Alex.; *Scamboneura* O.S.; *Megistomastix* Alex.) and other genera in the Tipularia (as *Microtipula* Alex.; *Idiotipula* Alex.;



Text-figure 48. Wing of *Brachypremna candida* Alex.
 Text-figure 49. Wing of *Dolichopeza malagasya* Karsch.
 Text-figure 50. Wing of *D. cinerea* Macq.
 Text-figure 51. Wing of *D. queenslandica* Alex.
 Text-figure 52. Wing of *Megistocera longipennis* Macq.
 Text-figure 53. Wing of *Aldrovandia gesneri* End.
 Text-figure 54. Wing of *Scamboneura plumbea* Alex.

Xenotipula Alex.; *Tipula* (*Acutipula*) *omissinervis* de Meij., and numerous species of the genus *Tipula*, chiefly in the Holarctic Region) the distal section of *R*₂ is entirely or partly atrophied. When the former is the case, as in many *Dolichopeza* (*queenslandica* Alex., Text-fig. 51) and others, the resulting vein that connects *R*₁ and *R*₃ is a serial vein, the cephalic portion being *r*, the usually much shorter posterior portion the basal section of *R*₂. In other cases, as the subgenus *Trichodolichopeza* Alex., the alignment is not so perfect. In *D. malagasya* Karsch (Text-fig. 49), the basal section of *R*₂ forms an acute angle with *r* and the basal portion of the distal section of *R*₂ is preserved as a short stub. A less accentuated case is found in some specimens of *Dolichopeza* (*cinerea* Macq., Text-fig. 50) and many of the species of *Tipula*, above mentioned.

The radial sector, short and transverse in genera such as *Dolichopeza* (Text-figs. 50-51) and *Nephrotoma*, reaches its minimum size in *Scamboneura* O.S. (*plumbea* Alex., Text-fig. 54) where it has apparently migrated distad beyond the level of the other elements of the cord so that it lies at the proximal end of the stigma and appears to be a short supernumerary crossvein; R_{2+3} is then given off, paralleling vein R_1 and forming the caudal margin of the stigma, the tips of veins R_1 , R_2 and R_3 are not especially abnormal but are greatly reduced in size and much crowded. The basal section of R_{4+5} is lengthened and directed strongly basad to form the cephalic portion of the cord. There is a strong spur, sometimes at the angle of R_{4+5} and $r-m$, in other cases on $r-m$ itself, jutting basad into cell R. There is an alternative interpretation to the above that is not as satisfactory since it does not explain the small transverse element above interpreted as being the radial sector. This interpretation would call for an elongated sector that is almost entirely atrophied except for the small spur that juts basad into cell R, as described. It is probable that more conclusive evidence will not be long in coming as material in the genus *Scamboneura* is not especially rare in certain Malayan islands, especially the Philippines.

In *Ptilogyga*, vein R_{4+5} fuses with M_{1+2} , obliterating $r-m$.

Cylindrotominae. The primitive type of the Cylindrotominae may be assumed as having been not unlike the fossil genus *Cyttaromyia* Scudd. (1894, p. 190), with the retention of the distal sections of veins R_1 and R_2 that have been lost in *Cyttaromyia* and many of the living species of the group. When the fauna of the world is considered, several species are found that have retained one or the other of these two branches. An earlier interpretation of the venation of the Cylindrotominae (Needham, 1908) called for a long fusion of the veins back from the wing-margin. The true interpretation of this field was given by Osten Sacken (1869, pp. 290-291) and later amplified by the writer (Alexander, 1914, pp. 604-605; 1919, p. 863). Brunetti (1918, pp. 280-283) has discussed the problem of the venation in the group but has failed to appreciate the true homologies of the veins (as is shown by his still calling the basal section of R_2 in *Phalacrocera replicata* the marginal crossvein, r , and the distal section of R_1 the "costal crossvein"). Brunetti has summed up his beliefs in the following words: "I contend it must be admitted that the 1st vein (R_1) normally and actually ends in the second (base of R_2 or R_{2+3}) because whenever the costal crossvein (distal section of R_1) is absent it most obviously does so end". The venational symbols in parentheses are supplied by the present writer. There can be little question but that the Cylindrotominae have been derived from some Tipuline ancestor in middle or late Mesozoic times.

The following modifications in the various genera may be noted: *Cylindrotoma* Macq. (*nigriventris* Lw., Text-fig. 55) retains the primitive condition of the group except that the distal section of R_2 is entirely atrophied. In a few species (as *splendens* Doane), the distal section of R_1 is only weakly preserved or even atrophied, though present in most individuals. *Phalacrocera* Schin. is of especial importance in that the more generalized species (*replicata* Linn., Text-fig. 56) have retained all three branches of this region of the wing, although R_1 is represented only by a weak spur, r in this case being very long as compared with other species of the genus. In more specialized cases (*tipulina* O.S., Text-fig. 57, *occidentalis* Alex.) the tip of R_2 is entirely atrophied. In *P. formosae* Alex., the tips of both R_1 and R_2 are quite atrophied. *Liogma* O.S. has the genotype, *nodicornis* O.S., with the tips of both R_1 and R_2 atrophied. The other species agree

in this respect but some specimens of *glabrata* Wied. retain R_1 as a weak element. In *Triogma* Schin., R_1 is strongly preserved in *exculpta* O.S., weakly preserved in *trisulcata* Schumm., lacking in *kuwanai* Alex.

In *Stibadocera* End. (*metallica* Alex., Text-fig. 58), R_{2+3} diverges widely from R_{4+5} and is shorter to much shorter than R_3 alone. The distal section of R_1 is preserved but that of R_2 is entirely atrophied. *Stibadocerella* Brun. (= *Agastomyia* de Meij.) shows no trace of the distal sections of either R_1 or R_2 . *Stibadocerodes* Alex. (*tasmaniensis* Alex., Text-fig. 59) shows no vestige of the distal section of R_1 , the extreme base of the distal section of R_2 being more or less preserved as a

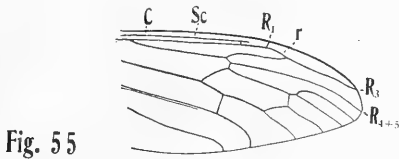


Fig. 55

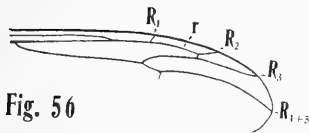


Fig. 56

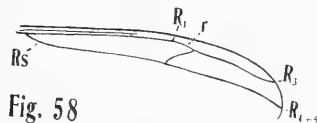


Fig. 58

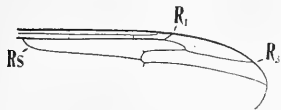


Fig. 57



Fig. 59

- Text-figure 55. Wing of *Cylindrotoma nigriventris* Lw.
- Text-figure 56. Wing of *Phalacrocera replicata* Linn.
- Text-figure 57. Wing of *P. tipulina* O.S.
- Text-figure 58. Wing of *Stibadocera metallica* Alex.
- Text-figure 59. Wing of *Stibadocerodes tasmaniensis* Alex.

short spur, that, when present, is provided with macrotrichiae. The fusion of R_{2+3} is very long, exceeding R_3 alone, and the space between Sc_2 and the basal section of R_2 (the combined penultimate section of R_1 and r) is correspondingly lengthened; $r-m$ unites with Rs before (*australiensis* Alex.) or at the fork.

In a few genera of *Cylindrotominae*, R_{4+5} has swung caudad and fused for a greater or less extent with M_{1+2} , obliterating $r-m$ (some *Liogma*, *Triogma*).

It may be noted in concluding this brief account of the subfamily that the more primitive members of the group (*Cyttaromyia*, *Cylindrotoma*) may provide the explanation of the fate of the posterior fork of the sector in this group of subfamilies. As has already been noted this has been called a fusion of veins R_4 and R_5 to the margin. There is a possibility, however, that the branch interpreted as being M_1 may represent R_5 of the primitive type. In *Cyttaromyia* this is always connected strongly with R by a crossvein or *apparent* crossvein at near

midlength of the cell and in many examples of *Cylindrotoma* this position is still indicated by a strong spur at the angle of M_1 . It is not impossible that in the progressive outward fusion of R_4 and R_5 in this group of subfamilies that the latter vein in the ancestral type was deflected caudad and became fused or intimately connected with M .

Lechriini. This new group includes the genera *Lechria* Skuse and *Trichoneura* Lw. *Lechria* was placed in the tribe Eriopterini by Skuse despite the presence of distinct tibial spurs. Later, the genus was removed to the Hexatomini (de Meijere, Alexander). *Trichoneurā* was described from the Baltic Amber (Lower Oligocene) but has since been found living in the Himalayas.

Lechria (sublaevis Alex., Text-fig. 60) has r long, gently arcuated, connecting with R_2 some distance from the origin of the latter. *L. singularis* Skuse is figured by its describer as having r connecting with R_{2+3} immediately at the fork but a photograph of the wing of the type kindly made for me by Mr. John Shewan shows

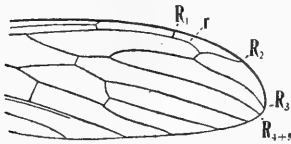


Fig. 60

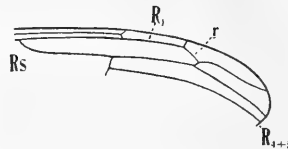


Fig. 61

Text-figure 60. Wing of *Lechria sublaevis* Alex.

Text-figure 61. Wing of *Trichoneura vulgaris* Lw.

that this species, like the above, has r connecting with R_2 shortly beyond the origin, forming a short basal section. The $r-m$ crossvein is on R_5 far before the fork.

Trichoneura (vulgaris Lw., Text-fig. 61) presents a more normal Hexatomine appearance, $r-m$ being connected with R_{4+5} shortly beyond the origin.

Until the present writing both of the above genera have been referred to the Hexatomini. The similarity of the venation to other Hexatomine genera must be explained by convergence. An entirely comparable case is found in the genus *Trichocera* Meig., which until very recently was placed with *Limnophila* in the Hexatomini, the venation of the two groups being entirely comparable. It is now known that *Trichocera* represents an entirely distinct family of Diptera (Alexander, 1926).

As was indicated under the account of the Eriopterini, the genera *Ceratolimnobia*, *Xipholimnobia* and *Xenolimnobia* discussed at that time may correctly pertain to the present group.

Limoniini. In the tribe Limoniini, the elements of the serial vein have become straightened out in perfect alignment or nearly so. In its typical condition, as shown by the subtribe Orimargaria, the venation of the radial field is not difficult to homologize with the entirely similar conditions obtaining in the Tipulinae, Cylindrotominae or the Lechriini, previously considered. In the higher subtribes, especially in the Limoniaria, a very puzzling modification is

brought about in the various species by an outward shifting of the free tip of R_1 , a condition that is discussed in detail under the account of the subtribe.

Some of the more aberrant subtribes that were formerly arranged in the old tribe Antochini before its partition are placed in this tribe rather arbitrarily while awaiting more data to determine their final disposition. Such genera are *Antocha*, *Orimargula*, *Orimarga*, *Diotrepha*, *Thaumastoptera*, *Elliptera*, *Helius*, *Toxorhina* and *Dicranoptycha*. The position of *Toxorhina* in this tribe is most in doubt. Of the other generic groups placed by Osten Sacken in the Antochini (as *Limnobina anomala*), *Teucholabis* has already been discussed under the Eriopterini, and *Atarba* and *Elephantomyia* under the Hexatomiini. Professor Rogers has recently reared *Atarba* and some features of its life-history point strongly to the present tribe but the affinities of the genus with *Ischnothrix* are very marked and the group requires further study. The true status of many of these aberrant subtribes of the Limoniini will probably remain long in dispute and will be solved finally only by a knowledge of all the stages and, perhaps, the discovery of other and annectant types.

Orimargaria. This subtribe includes *Orimarga* O.S. and *Diotrepha* O.S., the two genera being closely allied and showing entirely comparable modifications of

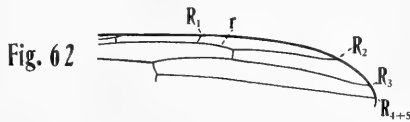


Fig. 62

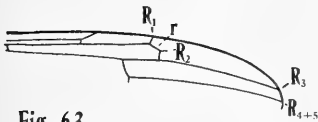


Fig. 63

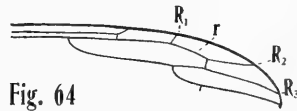


Fig. 64



Fig. 65

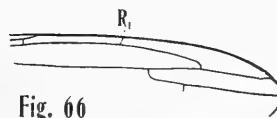


Fig. 66

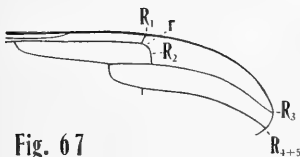


Fig. 67

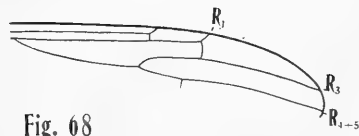


Fig. 68

- Text-figure 62. Wing of *Orimarga excessiva* Alex.
- Text-figure 63. Wing of *O. punctipennis* Alex.
- Text-figure 64. Wing of *Diotrepha fumicosta* Alex.
- Text-figure 65. Wing of *Orimarga joana* Alex.
- Text-figure 66. Wing of *Diotrepha atribasis* Alex.
- Text-figure 67. Wing of *Thaumastoptera calceata* Mik.
- Text-figure 68. Wing of *Tonnoiromyia tasmaniensis* Alex.

the radial field. In many respects the group is more generalized than the *Limoniaria*, despite the great modifications that have taken place in the medial field and the recession of the *m-cu* crossvein. The radial sector is very long, strongly arcuated to feebly angulated at origin, in *O. punctipennis* Alex. (Text-fig. 63) nearly straight, the origin angulated and weakly spurred. The radial field shows a remarkable plasticity of retention and loss of the distal elements. Several species (*O. excessiva* Alex., Text-fig. 62; *O. punctipennis* Alex., Text-fig. 63; *O. andina* Alex.; *D. atribasis* Alex., Text-fig. 66; *D. fumicosta* Alex., Text-fig. 64; *D. flavicosta* Alex.) have retained the distal section of R_1 as a nearly transverse to slightly oblique spur that is sometimes very faint and, when lost, evidently disappears through atrophy. The distal section of R_2 is entirely preserved and very long in *O. excessiva* (Text-fig. 62); *O. pallidibasis* Alex.; *O. alpina* Zett.; *O. dampfi* Alex.; *O. formosicola* Alex.; *D. fumicosta* (Text-fig. 64); still shorter in *O. joana* Alex. (Text-fig. 65); *O. niveitarsis* Alex.; *D. mirabilis* O.S., and others. In some species this tip of R_2 is atrophied but leaves a spur (*O. punctipennis*, Text-fig. 63). In various species of *Diotrepha*, as *atribasis* (Text-fig. 66) the entire distal section of R_2 is atrophied. The *r-m* crossvein is usually not far from the elements that constitute the cord except in the Australian *O. joana* (Text-fig. 65) where it lies far distad, a condition that is perhaps explained correctly in the original characterization of the species. The radial crossvein, *r*, varies greatly in its extent in the various species (Text-figs. 62-66).

Thaumastoptera. The subtribe includes only the genus *Thaumastoptera* Mik, with the genotype, *calceata* Mik (Text-fig. 67) and two extinct species from the Lower Oligocene of Northern Europe. The group is obviously close to the *Orimargaria* but the habits of the immature stages of the two groups are very different and there are certain well-defined correlated structural characters. The radial sector is moderately long, in alignment with R_{2+3} and the long R_3 , these three elements forming a gently sinuous curve to the wing-margin; basal section of R_{4+5} strongly arcuated to weakly angulated; R_1 close to the basal section of R_2 , *r* being very short; distal section of R_2 entirely atrophied.

Tonnoiromyia. The subtribe includes only the genus *Tonnoiromyia* Alex. (*tasmaniensis* Alex., Text-fig. 68). The radial sector is long, nearly straight, diverging gently from R_1 , in approximate alignment with R_{4+5} ; basal section of R_2 lying distad of the level of *r-m*, almost in alignment with R_1 , *r* being very reduced and the distal section of R_2 entirely atrophied.

Limoniaria. The various modifications in the present subtribe, which is one of the largest groups of crane-flies, are very complicated and are discussed in some detail in this paper. The primitive condition of the radial field is found in a considerable range of genera, as *Libnotes* Westw., *Peripheroptera* Schin., *Thrypticomyia* Skuse, and others. The condition in *Dicranomyia* (*Thrypticomyia*) *doddi* Alex. (Text-fig. 78) may be discussed as representing this generalized condition, in many respects not being greatly different from the *Orimargaria*, as described. No member of the subtribe is known to the writer in which the distal section of vein R_2 reaches the wing-margin, as in several *Orimargaria*, but the extreme tip is atrophied, as shown in the various figures (Text-figs. 70-78). The distal section of R_1 is preserved and lies far before the basal section of R_2 , *r* thus being relatively long. The penultimate section of R_1 , *r* and the long distal spur of R_2 are all in longitudinal alignment.

The modifications in the subtribe have been brought about in a manner that is illustrated by actual species and may be discussed by means of the following

eight diagrams (Text-fig. 69, 1-8) arranged to show the apparent evolution of the types of venation found in this subtribe.

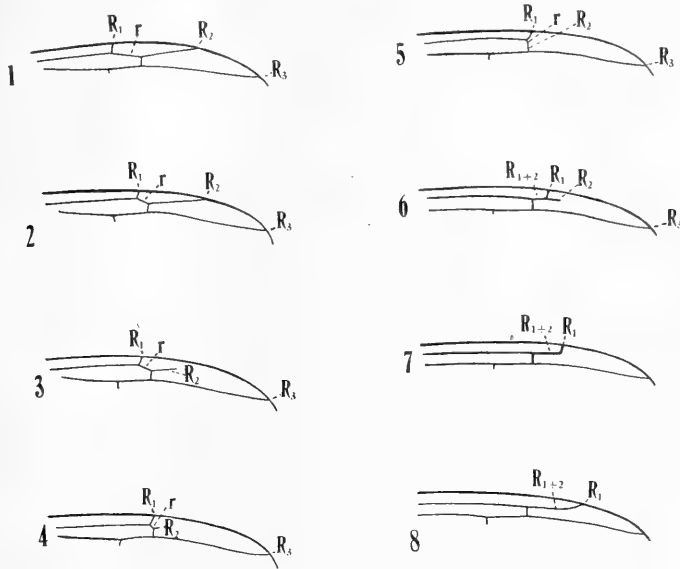


Fig. 69

Text-figure 69. Diagrammatic series to show the evolution of the radial field in the lower Limoniini.

1. The type found in the Orimargaria: R_1 preserved, r elongate, the distal section of R_2 complete, attaining the wing-margin.

2. A further development of Type 1. Note that the free tip of R_1 has moved distad, materially shortening r ; distal section of R_2 still entire.

3. Condition as in Type 2 but the tip of R_2 is atrophied back from the margin. Found in many Orimargaria, Limoniaria.

4. An accentuation of Type 3. Note that the atrophy of R_2 is greater and r even more shortened. The result of this is to tend to bring the free tip of R_1 into approximate transverse alignment with the basal section of $R_2 + r$. Found in numerous Limoniaria.

5. A further development of Type 4, where the atrophy of the distal section of R_2 is complete and the free tip of R_1 is in perfect transverse alignment with the combined basal section of $R_2 + r$. This is the commonest type in the Limoniaria, being found in most *Geranomyia* Hal., *Rhipidia* Meig., *Dicranomyia* Steph., some *Limonia* Meig., and others.

6. A type that reverts back to type 3 with a long spur of the distal section of R_2 persisting; the free tip of R_1 has continued its migration distad beyond the level of r and now lies part way out on this spur. Condition found in *Limonia tristigmata* Alex., *Peripheropectera schineri* O.S., and several *Libnotes*, as *greeni*, Edw., *notatinervis* Brun., *regina* Alex., and others.

7. A further modification of type 6 where the free tip of R_1 has migrated to the end of the spur of R_2 but still forms a rectangular bend or even with a tiny spur on R_2 beyond it. In *Libnotes*, as *undulata* Mats.

8. The culmination of the series, where the free tip of R_1 has migrated to the extreme tip of the spur of R_2 and bends to the costa at a gently oblique angle. It should be noted that in this case of the Limoniaria, as in all others here shown beyond type 2, only the free tip of R_1 reaches the costal margin. Found in *Discobola* O.S., a great section of *Limonia*, and other genera.

A few of the cases in this largest and most widespread group of crane-flies may be further discussed:

Libnotes Westw. In the genotype, *thwaitesiana* Westw., *r* is very long, meeting the basal section of R_2 in a long gentle curve. In several species of the genus, a condition like type 3 of the diagrammatic series is found (as *L. subaequalis* Alex., Text-fig. 70), being further modified in other species to type 4 (*L. obliqua* Alex., Text-fig. 71). Most of the species fall under type 5. Type 6 is found in *L. greeni*, *regina* and other species. Type 7 is found in *L. undulata*. Thus in this single genus, we find an unbroken series illustrating five of the diagrammatic types previously discussed.

Limonia Meig. In this genus we find a considerable range in the types, some of which were very puzzling to the writer until the true solution of the venation in this subtribe was finally ascertained. A great many species fall under type 5, with the tip of R_1 and the basal section of R_2 in transverse alignment (as in *parvistigma* Alex., Text-fig. 72; the European *annulus* Meig.; *bifasciata* Fabr.;

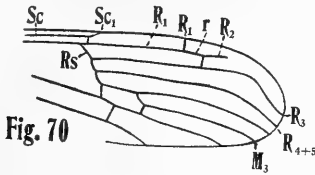


Fig. 70

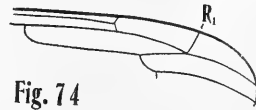


Fig. 74

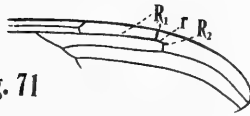


Fig. 71

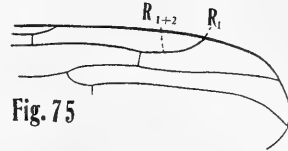


Fig. 75



Fig. 72

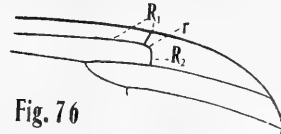


Fig. 76

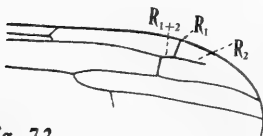


Fig. 73

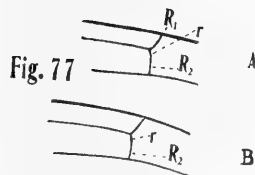


Fig. 77

- Text-figure 70. Wing of *Libnotes subaequalis* Alex.
 Text-figure 71. Wing of *L. obliqua* Alex.
 Text-figure 72. Wing of *Limonia parvistigma* Alex.
 Text-figure 73. Wing of *L. tristigmata* Alex.
 Text-figure 74. Wing of *L. fumosa* Alex.
 Text-figure 75. Wing of *Discobola australis* Skuse.
 Text-figure 76. Wing of *Geranomyia picta* Skuse.
 Text-figure 77. A. Wing section of *G. tonnoiri* Alex.; B. Wing section of *G. victoriae* Alex.

quadrinotata Meig.; the Nearctic *californica* O.S.; *cinctipes* Say; *fallax* Johns.; *immatura* O.S.; *solitaria* O.S.; *triozellata* O.S., and others). The other common type in the genus is No. 8, which, at first sight, looks like a long, free distal section of R_2 , with the free tip of R_1 atrophied (compare diagrams 1 and 8). There are numerous representatives of this type in the Holarctic fauna (as the European *flavipes* Fabr.; *inusta* Meig.; *nubeculosa* Meig.; *tripunctata* Fabr.; *trivittata* Schumm.; the Japanese *amabilis* Alex.; *amatrix* Alex.; *atridorsum* Alex.; *basispina* Alex., *esakii* Alex. and many others; the Nearctic *indigena* O.S.; *maculicosta* Coq.; *parietina* O.S.; *sciophila* O.S.; *tristigma* O.S., and numerous additional species). In two closely allied New Zealand species, *L. sponsa* Alex. falls between types 4 and 5, while *L. tristigmata* Alex. (Text-fig. 73) has progressed to type 6. In two Neotropical species (*L. fumosa* Alex., Text-fig. 74; *L. insularis* Will.), R_1 bends abruptly down to R_{2+3} , a long, subperpendicular branch that is interpreted as being R_1 thence extending to costa.

Discobola O.S. In the numerous Australian and New Zealand species of this genus (*australis* Skuse, Text-fig. 75) type 8 obtains, the distal serial element being very long and gently arcuated, shortest in *D. tessellata* O.S.

Peripheroptera Schin. The more generalized species (*nitens* Schin.; *eudorae* Alex.) fall in type 3, with r long to very long. In other species, r becomes more shortened until in some (as *incommoda* O.S.) type 5 is attained.

Dicranomyia Steph. The great majority of the very abundant species fall in type 5, in a few (as *punctipennis* Skuse, *multispina* Alex.; *tarsalba* Alex., and others) with the distal serial element longer than in type 5 but shorter than 8, gently curved to the costal margin. In the subgenus *Idioglochina* Alex., r tends to be very elongate, arcuated into the short basal section of R_2 . The subgenus

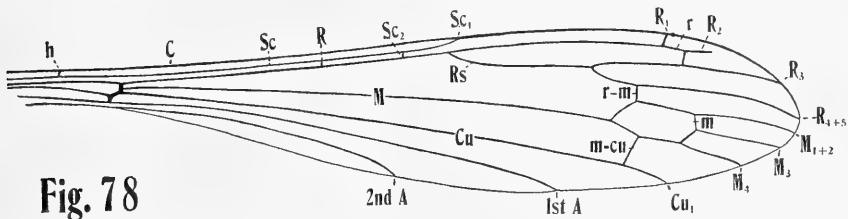


Fig. 78

Text-figure 78. Wing of *Dicranomyia (Thrypticomyia) doddi* Alex.

Thrypticomyia Skuse (*doddi* Alex., Text-fig. 78) has been discussed under the introduction to the subtribe. In *Euglochina* Alex. the entire radial field beyond the cord is crowded into the wing-tip, occupying the distal fifth or less of the wing; type 5 of the series usually obtains.

Rhipidia Meig. In the numerous species of this genus, type 5 is almost universal.

Geranomyia Hal. The Australian species of this very large genus show a progressive modification from a type shortly beyond 4 (with the spur of the distal section of R_2 atrophied but with a distinct angulation, showing the point of union of r and the basal section of R_2 ; *G. picta* Skuse, Text-fig. 76) to other cases that equal type 5. In *G. tonnoiri* Alex. (Text-fig. 77 A) R_1 is virtually in alignment with the base of R_2 but r is still evident as a slight angulated portion near the origin of the distal section of R_1 . In *G. victorae* Alex. (Text-fig. 77 B), r and the basal section of R_2 are in perfect alignment, and likewise about in a

transverse line with the distal end of R_1 . *G. tridens* Brun. is figured by its author as having the distal section of R_1 retained, being intermediate between types 3 and 5.

Supernumerary crossveins are rather frequently found in this field of the wing; in cell R_3 in the subgenus *Neolimnobia* Alexander (of *Dicranomyia*; type, *diva* Schin.); in R_5 in *Dapanoptera* Westw.; in both cells R_3 and R_5 in *Laosa* Edw. and *Libnotes regalis* Edw.

Antocha. This subtribe includes *Antocha* O.S. and *Orimargula* Mik. In both, Sc and R are closely approximated and the outer portion of R_1 lies close to the strongly incrassated costa. R_s is straight to very gently convex, tending to be

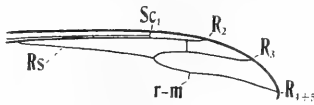


Fig. 79

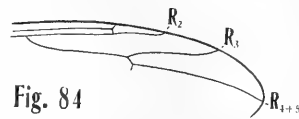


Fig. 84

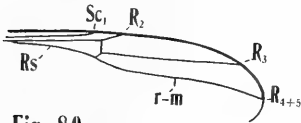


Fig. 80

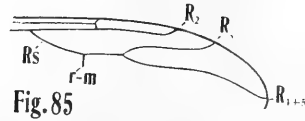


Fig. 85

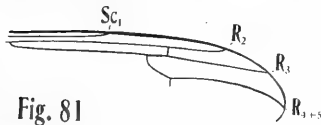


Fig. 81

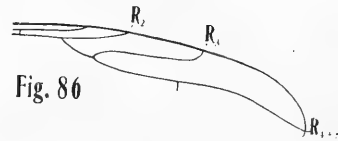


Fig. 86

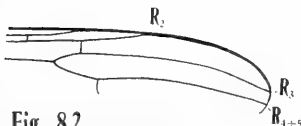


Fig. 82

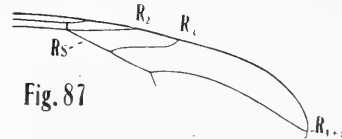


Fig. 87

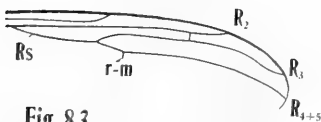


Fig. 83

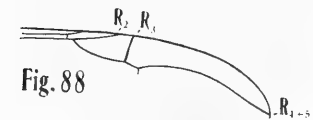


Fig. 88

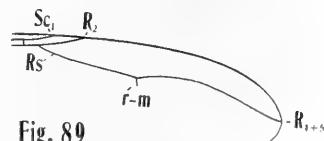


Fig. 89

- Text-figure 79. Wing of *Antocha saxicola* O.S.
 Text-figure 80. Wing of *Orimargula australiensis* Alex.
 Text-figure 81. Wing of *Elliptera tennesa* Alex.
 Text-figure 82. Wing of *Amphilimnobia leucopeza* Alex.
 Text-figure 83. Wing of *Dicranoptycha germana* O.S.
 Text-figure 84. Wing of *Heliu venustus* Skuse.
 Text-figure 85. Wing of *Eurhamphidia nivitarsis* Skuse.
 Text-figure 86. Wing of *Ceratocheilus edwardsi* Alex.
 Text-figure 87. Wing of *C. australasiae* Alex.
 Text-figure 88. Wing of *C. flavirostris* Alex.
 Text-figure 89. Wing of *Toxorhina magna* O.S.

in alignment with R_{4+5} ; basal section of R_2 preserved, the distal section very short. In *Orimargula (australiensis)* Alex., Text-fig. 80), veins Sc_1 and R_2 are more nearly approximated at the wing-margin than in *Antocha (saxicola)* O.S., Text-fig. 79).

Ellipteraria. The subtribe includes only the genus *Elliptera* Schiner. Rs is elongate, lying very close to and paralleling R_1 , in alignment with R_{2+3} ; basal section of R_2 preserved in some species (*tennessa* Alex., Text-fig. 81); *jacoti* Alex.; *zipanguensis* Alex.), placed at or shortly beyond the fork of Rs , the section lost by atrophy in other species (*omissa* Egg.; *clausa* O.S.; *astigmatica* Alex., and others); R_3 elongate, in alignment with R_{2+3} ; basal deflection of R_{4+5} very strongly arcuated to angulated and spurred (*illini* Alex.) or nearly straight and transverse (*jacoti*).

Amphilimnobiaria. The single genus and species, *Amphilimnobia leucopeza* Alex. (Text-fig. 82) is included. Rs is long, angulated and short-spurred at origin; basal section of R_2 preserved, lying just proximad of the level of $r-m$ and opposite the tip of Sc_1 .

Dicranoptycharia. The single genus *Dicranoptycha* O.S. (*germana* O.S., Text-fig. 83) is included. Rs is variable in length, the veins at its fork symmetrical; R_{2+3} very elongate, the basal section of R_2 lying far distad, the distal section of R_2 being very short.

Heliaria. Rs is short and often straight. In *Eurhamphidia* Alex. (*niveitarsis* Skuse, Text-fig. 85), $r-m$ lies far before the fork of Rs . *Rhampholimnobia* Alex. is similar but $r-m$ lies closer to the fork. In *Helius (venustus)* Skuse, Text-fig. 84), $r-m$ is usually on R_{4+5} shortly beyond its origin. In many species of the genus, $r-m$ is obliterated by the fusion of vein R_{4+5} on M_{1+2} . In *H. uniformis* Alex., $r-m$ is opposite the outer end of cell 1st M_2 . In all genera and subgenera of this subtribe, the basal section of R_2 is entirely atrophied.

Toxorhinaria. This subtribe includes the two genera *Ceratocheilus* Wesché and *Toxorhina* Lw. The strict position of the subtribe is still much in doubt and it is placed in the Limoniini with certain misgivings. In the more generalized species of *Ceratocheilus (edwardsi)* Alex., Text-fig. 86; *australasiae* Alex., Text-fig. 87), the basal section of R_2 appears to have been lost as in the preceding subtribe, the long distal section of R_3 reaching the margin in a gently sinuous curve. In still other species of the genus (*flavirostris* Alex., Text-fig. 88) a progressive shortening of the branch R_3 takes place until it has shortened into a small and nearly transverse element. In *Toxorhina (magna)* O.S., Text-fig. 89) this vein R_2 is entirely lost but whether by final fusion of the element with R_2 (as previously discussed for the Hexatomine genus *Psaronius* and the Eriopterine genus *Gymnastes*) or by the atrophy of R_3 when it has become short and weak cannot be stated without more evidence.

PHYLOGENETIC CONSIDERATIONS.

The two principal divisions of the Tipulidae have been distinct since at least the middle of the Mesozoic (Upper Liassic), at which time the Architipuline and Tanyderid types co-existed. From the Architipulinae, the Tipulinae (Text-fig. 90) may be derived in almost a direct line. The Cylindrotominae are quite as obviously an offshoot of the Tipulinae. The two Limoniine tribes, Limoniini and Lechriini, that appear to have been evolved from this same general strain have been isolated from the above and from one another for a longer time and it does not seem possible to derive them directly from the Tipuline stem.

The Pediciini have been derived from some pre-existing type that was not conspicuously unlike the recent Tanyderidae. From the Pediciini, through the subtribes Adelphomyaria and Ularia, the tribe Hexatomini is derivable, leading, in turn, through the Hexatomoid Eriopterini to the higher members of the latter tribe. The exact point of origin of the Styringomyiini must be held in question.

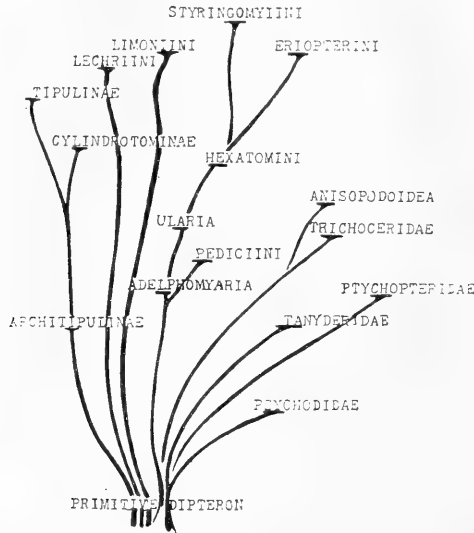


Fig. 90

Text-figure 90. Phylogenetic Tree.

The Ptychopteridae (*Ptychoptera lenis* O.S., Text-fig. 91) have apparently been derived from the Psychodoid stem, but, if so, they have independently had vein R_2 unite with R_1 to form a short fusion back from the margin, much as in the Pediciini. The Trichoceridae (*Trichocera annulata* Meig., Text-fig. 92), in similar manner, must have been derived from some primitive ancestor in this general region yet it too has undergone the cephalization of vein R_2 and the capture of vein R_4 by R_{2+3} , quite as in the higher Tipulidae. It is highly probable that these

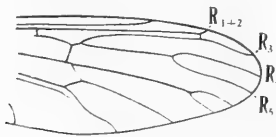


Fig. 91

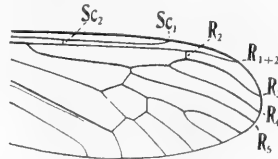


Fig. 92

Text-figure 91. Wing of *Ptychoptera lenis* O.S. (Ptychopteridae).

Text-figure 92. Wing of *Trichocera annulata* Meig. (Trichoceridae).

two families have led more or less directly to the more specialized groups of Nematocera and thence to the Brachycera, and the correct interpretation of the basal section of R_2 becomes of critical importance in any attempt to trace the phylogeny and correct homologies of the higher Diptera.

Of the other families of Nematocera, the Culicidae, Dixidae, Chironomidae, Orphnephilidae, Anisopodidae, Blepharoceridae, Simuliidae and Bibionidae all agree with the interpretation of the wing, as given, except that the basal section of R_2 in all cases has atrophied and in all except the most generalized forms R_3 and R_4 have fused to the wing-margin. The other Nematocerous groups, with a more highly specialized venation, as the Deuterophlebiidae, Scatopsidae, Sciariidae and Cecidomyiidae offer little direct evidence from the few veins that are still retained in the radial field. From other structures, however, the affinities of the groups with the others above listed render it necessary to interpret the venation as is done in the latter case.

The lower groups of the Orthorrhaphous Brachycera in similar manner agree entirely with the above interpretation, veins R_4 and R_5 remaining distinct as in the Ptychopteridae. From these phylogenetically lower families of Brachycera, the higher groups of the Orthorrhapha and the Cyclorrhapha have been derived.

Summary.

The main points of the preceding discussion may be summarized as follows:

1. The so-called *radial crossvein* (r) in all Diptera except a limited group of the Tipulidae (Tipulinae, Cylindrotominae) is, in reality, the basal section of vein R_2 which has swung cephalad across cell R_1 and fused back from the wing-margin with vein R_1 , forming a short or longer fusion, R_{1+2} .

2. There are two distinct lines of specialization in the Tipulidae that have been distinct since at least mid-Mesozoic times. In the *first*, represented by the Limoniine tribes Pediciini, Hexatomini and Eriopterini, the anterior branch of the upper fork of the radial sector (R_2) of the primitive Tanyderoid ancestor has swung cephalad and fused with R_1 , as discussed under 1; by a slight shifting of the veins at the end of the sector, the anterior branch of the lower fork of the sector (R_4) becomes more intimately attached to the stem of the upper fork (R_{2+3}) forming a short to longer fusion of veins R_{2+3+4} ; in higher groups, veins R_3 and R_4 may become fused to the wing margin, obliterating cell R_3 . The basal section of R_2 is present in most cases but in many scattered groups has atrophied, leaving no indication of its previous position. The posterior branch of the sector is thus R_5 alone. In the *second* group, represented by the Architipulinae, Tipulinae, Cylindrotominae, and the Limoniine tribes Lechriini and Limoniini, the true radial crossvein (r) is present but always in a longitudinal or oblique position, forming part of a more or less perfect serial radial vein. In this group, the distal sections of R_1 and R_2 are lost by atrophy. The posterior branch of the sector is interpreted as being a fusion to the margin of veins R_4 and R_5 .

3. In some few Pediciini, of the group Dicranotae, there is a supernumerary crossvein in cell R_1 that simulates a true primary crossvein in this cell.

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THE ANATOMY OF CHEILANTHES VELLEA.

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Linnean Macleay Fellow in Botany.

(Twenty Text-figures.)
[Read 30th March, 1927.]

Introduction.

In a previous paper (Bot. Gaz. lxxviii, No. 4, 1924), the writer described the anatomy of *Cheilanthes tenuifolia*. The interest of this type lies in the fact that the rhizome possesses a true dictyostelic structure, while the petiolar stele consists of a single strand. The xylem elements of the latter contain three protoxylem groups, the median one of which varies in position until it finally becomes exarch in position and then completely detached from the metaxylem elements. Since there is so much variation of stem and petiolar anatomy in the various species of the genus *Cheilanthes*, the investigation of *Ch. vellea* (one of the other two species common in New South Wales) was undertaken for the purpose of comparison with *Ch. tenuifolia* and other foreign types.

Marsh (1914) described four American species namely *Ch. persica*, *Ch. fendleri*, *Ch. gracillima* and *Ch. lanuginosa*. Gwynne-Vaughan (1903) described the stelar anatomy of *Ch. lendigera* and *Ch. microphylla*. All these types show considerable divergence of stelar structure, but, at the same time, form an excellent series for studying the gradual transition from solenostely to dictyostely. Prantl (1882) described the development of the young sporangia of *Cheilanthes* and considered that as the young sporangia develop quicker than the margin, the appearance is almost as though they sprang directly from the marginal cells.

The various species of the genus *Cheilanthes* are mostly small ferns with short horizontal rhizomes. This is the case in *Ch. vellea*: the external morphology shows various adaptations to the xerophytic habitats. The fronds are stiff and pinnately compound: the lower side is often brownish and always covered with a dense growth of hairs. The pinnae are usually opposite, in *Ch. tenuifolia* they are alternate. The sori are continuous and protected by the inrolled margin of the leaf. *Ch. vellea* is common in the dry parts of the interior of New South Wales.

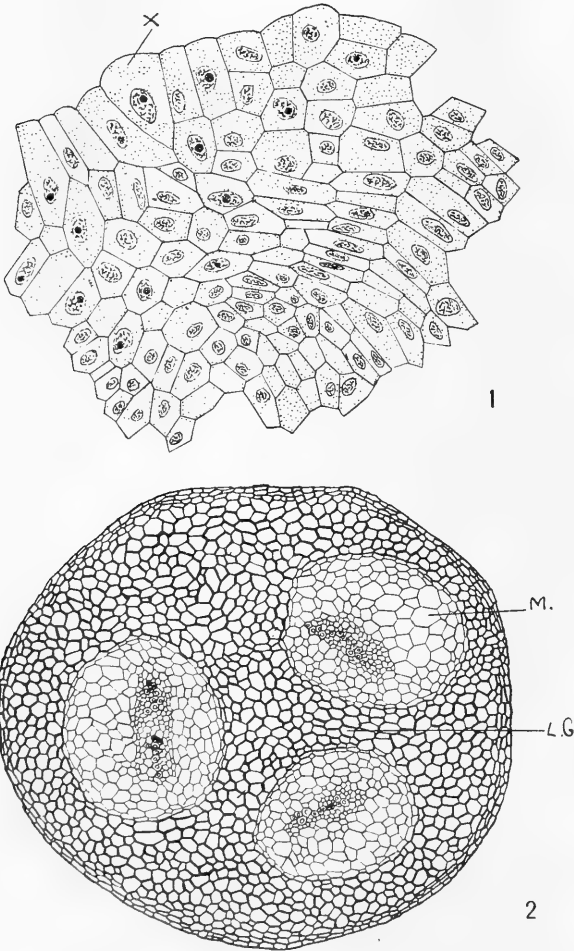
The material for the present investigation was collected at Wiseman's Ferry (1923) and at Pennant Hills (1926). The material was fixed in a 1% chromo-acetic solution, washed, dehydrated and passed in the usual manner into paraffin. Sections were then cut 5 μ to 12 μ in thickness: Flemming's Triple stain, also Safranin and Haematoxylin were the staining processes most extensively employed.

The anatomy of *Ch. vellea* very closely resembles that of *Ch. tenuifolia* with various differences principally in the stelar structure of the petiole.

*Investigation.**A. Rhizome.*

The rhizome is covered by a fairly extensive development of scales, which are very dense around the apex. As indicated in Text-fig. 1, the apex is broad and flat, while the apical cell arises as a small conical emergence. The apical cell is tetrahedral in shape and segmentation is identical with that described in *Ch. tenuifolia* (1924). About 1mm. behind the apex, the whole of the ground tissue becomes sclerized.

In *Ch. vellea* the structure of the stem stele is of that type known as the dictyostele, due to the overlapping of the leaf gaps (Text-fig. 2). Although the



Text-fig. 1. Longitudinal section of the apex of the rhizome. The apical cell (X) is tetrahedral in shape and forms the typical segments. $\times 240$.

Text-fig. 2. Transverse section of the rhizome indicating its dictyostelic structure. Three meristemes (M) are shown and three overlapping leaf gaps (L.G.). $\times 60$.

structure is dictyostelic, it is only a simple type of such a form of anatomy as there were never more than three or four leaf gaps present in any section examined. *Ch. tenuifolia* is a more advanced type in this respect as the vascular cylinder is more frequently broken by leaf gaps than in *Ch. vellea*. The stelar anatomy of these two types at once places them near *Ch. persica* (Marsh, 1914) which is also a distinctly dictyostelic form. The other types which have so far been investigated show considerable variation of stelar structure.

Ch. fendleri (Marsh, 1914) is a true solenostele.

In *Ch. gracillima* (Marsh, 1914), the stele behaves as a true solenostele except at certain points where apparently two leaves are given off together.

In *Ch. lendigera* and *Ch. microphylla* (Gwynne-Vaughan, 1903), each leaf gap in the stele is closed before the next above is formed, so far as the endodermis and pericycle are concerned. The leaf-gap in the xylem, however, remains open until it overlaps with the gap formed in the xylem by the departure of the next leaf-trace above.

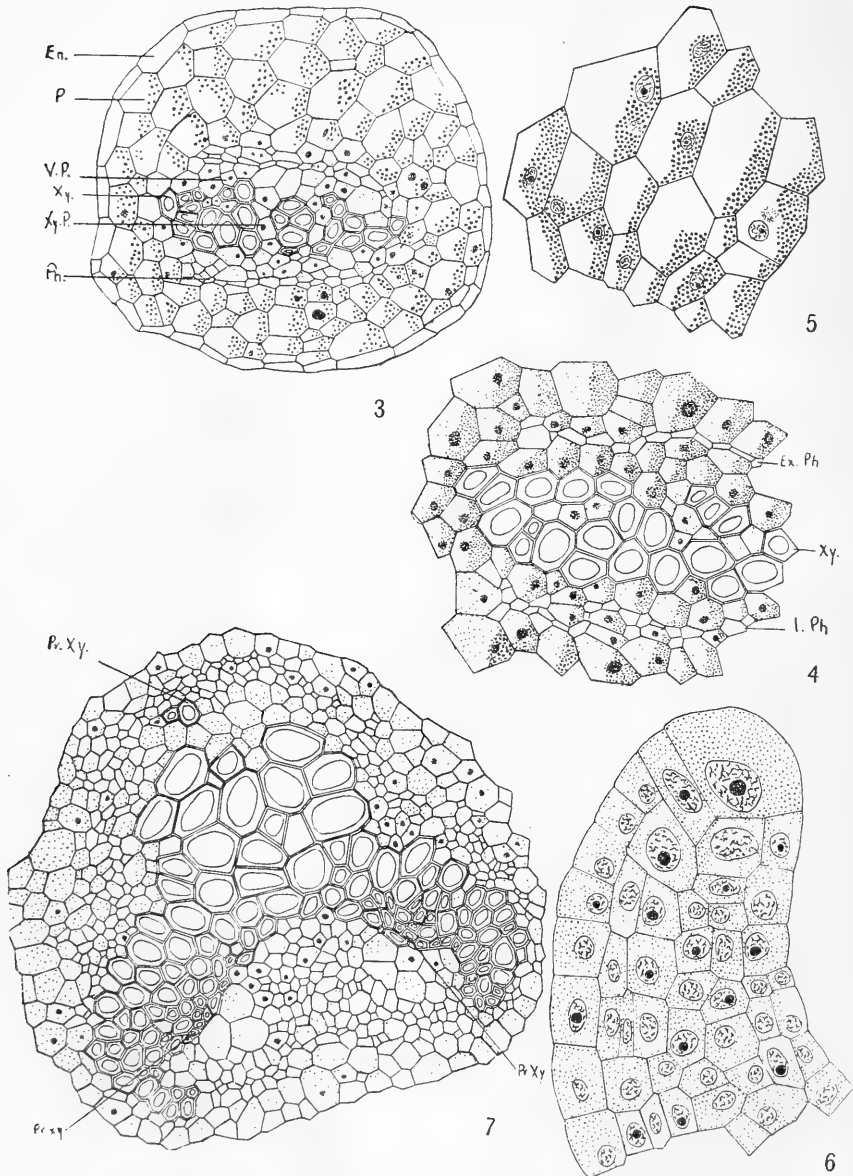
In *Ch. lanuginosa* (Marsh, 1914), the leaf traces are given off singly, in pairs or even in threes, so that at intervals the vascular cylinder may be a complete ring, though more frequently it is broken giving a dictyostelic structure (cf. Marsh, Text-fig. 14).

This series taken in conjunction with *Ch. vellea*, *Ch. persica* and *Ch. tenuifolia* indicate well a gradual transition from solenostely to dictyostely.

In *Ch. vellea*, as in all the other types, the leaf trace comes off from the centre of the meristele; its separation from the stem stele is not effected synchronously on both sides. The root trace passes off in the usual manner.

As indicated in Text-fig. 3, the meristele is composed of a central core of xylem intermingled with which is a little xylem-parenchyma. There is no trace of protoxylem present in the rhizome, even at the apex, all the tracheids of the xylem having scalariform thickening on their walls. The central core of xylem is not as wide as that present in *Ch. tenuifolia*, nor is there so much xylem parenchyma present. This is precisely the condition which follows on Marsh's generalization, since *Ch. tenuifolia* has a more complicated dictyostele than that present in *Ch. vellea*. Marsh (1914) found that there is a close relation between the stelar structure and the amount and arrangement of the wood within the stele. In solenostelic types there is a narrow continuous band of tracheids, not broken up by parenchyma. In dictyostelic types there is a broad band of wood among which a good deal of parenchyma occurs.

The xylem is surrounded by a layer of ordinary parenchyma (Vasal parenchym of Strasburger), followed by a layer of phloem cells. The phloem never consists of more than a single layer of sieve tubes, all of which are of uniform size so that there is no differentiation into protophloem and metaphloem (Text-fig. 4). The phloem does not continue around the leaf gap so that there is no continuity of internal and external phloem; surrounding the phloem are two or three layers of fairly large parenchymatous cells, which as in *Ch. tenuifolia* might be interpreted as representing a multilayered pericycle; surrounding this is the endodermis. The cells of the pericycle are of interest owing to the fact that they contain a great deal of granular matter which is always arranged at one side of the cell, and in the same direction in each cell giving the whole structure a peculiar, but distinctive, appearance. The granules lie on that side of the cell which is the lower side in the position in which the rhizome is lying. The granules are not starch granules but are evidently food granules of various kinds. This



Text-fig. 3. Transverse section of a meristele showing the central core of xylem (Xy.) containing xylem parenchyma (Xy.P.), surrounded by "vasal parenchyma" (V.P.), a single layer of phloem cells (Ph.), a multilayered pericycle (P.) and the endodermis (En.). $\times 150$.

Text-fig. 4. A portion of the above indicating the nature of the xylem (Xy.) and the internal (I. Ph.) and external (Ex. Ph.) phloem. $\times 240$.

Text-fig. 5. A few of the cells of the pericycle indicating the position of the granules. $\times 240$.

Text-fig. 6. Longitudinal section of the apex of the leaf, indicating the two-sided wedge shaped apical cell and its segmentations. $\times 400$.

Text-fig. 7. Transverse section of the vascular strand to the petiole. The three protoxylem groups (Pr. Xy.) are shown. $\times 150$.

condition is not due to fixation as it is to be seen in the living material. The structure is very like that which has been described and figured by Schaefer in various root tips. The condition is evidently a purely physiological one and related to gravity. (Text-fig. 5.)

The rhizome structure at once places *Ch. vellea* as an advanced type of the genus.

B. Leaves.

As indicated in Text-fig. 6, the growth of the leaf is due to a two-sided, wedge shaped apical cell forming two rows of segments, such as is typical for Leptosporangiate Ferns. The outer divisions of the segments become the marginal cells of the pinnae, the other divisions produce the petiole. The young leaf invariably shows circinate vernation.

Petiole.

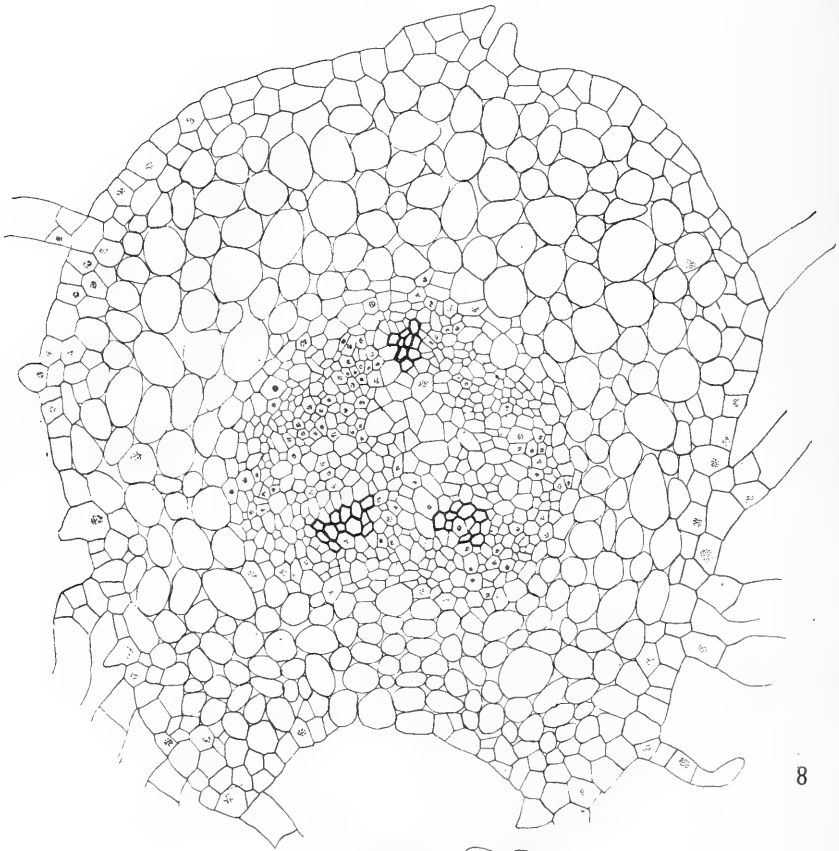
The petiolar stele forms a single strand surrounded by a sclerenchymatous cortex. Text-fig. 7 indicates the vascular strand, the main mass of which is composed of large metaxylem elements in conjunction with which appear three protoxylem groups. The ends of the xylem mass are slightly curved inwards. This is followed by a single layer of parenchymatous cells surrounded by a layer of phloem cells. The phloem is continuous around the strand. This is followed by a few more layers of parenchymatous cells—the pericycle—the whole being enclosed by a typical endodermis. This has usually broken down in the older parts of the petiole. The parenchymatous cells are filled with dense granular contents and contain large nuclei.

The principal interest of the petiolar stele of the genus *Cheilanthes* lies in the various positions occupied by the third median protoxylem group in the different species and at different levels of the petiole of the same species. The vascular strands of the rhizome show no visible protoxylem elements, but as soon as the leaf trace leaves the stem stele, protoxylem groups make their appearance in the trace which had hitherto been without them. As already mentioned, at the very base the condition is that of a simple adaxially curved anarch leaf trace. Text-fig. 8 indicates a section taken from the base of the young petiole. At this level there are two lateral, endarch protoxylem groups, while the third median group is distinctly exarch in position and attached to the as yet un lignified metaxylem elements.

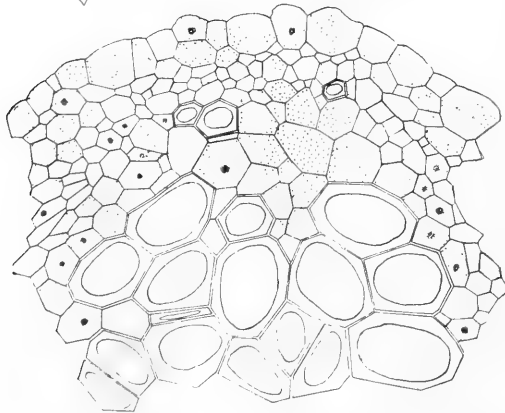
Text-figs. 7 and 9 indicate sections made at higher levels of the petiole. Here the median protoxylem group has become completely detached from the metaxylem and is separated from it by parenchyma. The number of tracheids composing this group is also very much less usually consisting of two or three tracheids often widely separated. At higher levels this group dies out altogether.

The condition here described can easily be brought into line with that which occurs in the species described by Marsh (1914) and that of *Ch. tenuifolia* (Williams, 1924).

Marsh (1914, p. 678) maintains that in all the species which he investigated there was at the base a simple adaxially curved anarch leaf trace, but as the petiolar strand is followed upwards changes occur in the petiolar strand which vary considerably. These changes may be briefly outlined as follows: In *Ch. fendleri* the anarch strand soon develops three protoxylems all of which are endarch. The metaxylem immediately exterior to the median protoxylem group dies out;



8



9

Text-fig. 8. Transverse section of the young petiole near the base. The relative positions of the three protoxylem groups are clear. $\times 150$.

Text-fig. 9. Transverse section of the upper portion of the petiolar stele at a higher level. The median protoxylem group is here detached and broken up. $\times 240$.

the two portions of the stele soon rejoin, but the junction is effected in such a way that the protoxylem is now exarch in position. The protoxylem next becomes completely detached and runs through the major portion of the petiole as a single separate group. Later it becomes broken into three or four smaller groups.

In *Ch. lanuginosa* the three protoxylem groups appear at the base, but at this point the centre of the trace is so narrow that the median protoxylem occupies the whole of the thickness of the stele. The two metaxylem masses rejoin, but the median protoxylem does not persist. It is found for a short distance as a line of thickening among the parenchyma but at higher levels no trace of it can be recognized.

In *Ch. gracillima* the two lateral protoxylems occupying an endarch position are the only ones which can ever be definitely recognized at any level of the petiole.

In *Ch. persica* the petiolar stele has the shape of an obtuse angled isosceles triangle, and has the three protoxylem groups at each angle.

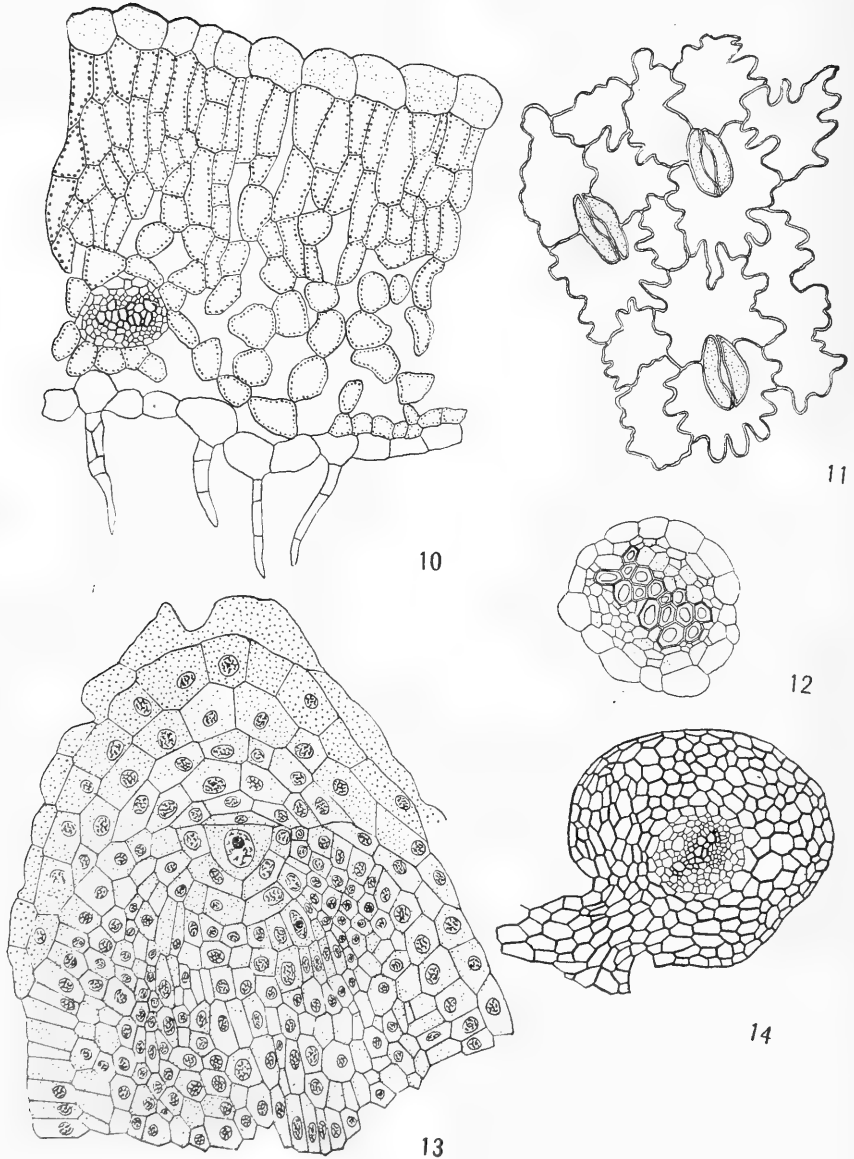
In *Ch. tenuifolia* (Williams, 1924, p. 384-385) the petiolar stele is described as consisting of, at the base, a simple adaxially curved anarch structure. When the protoxylem groups appear, the two lateral components take up the typical endarch position, while the metaxylem immediately exterior to the median protoxylem has died out, leaving the protoxylem as the sole junction between these two masses. These, however, soon rejoin, and median protoxylem becomes exarch. At a higher level it was found to be detached from the metaxylem elements.

It is thus seen that *Ch. tenuifolia* might be interpreted as a form intermediate between *Ch. fendleri* and *Ch. lanuginosa* with regard to the structure of the petiolar stele, since various stages at the base of the petiole in *Ch. fendleri* are not present in *Ch. tenuifolia*, while various phases at the apex in *Ch. lanuginosa* are not represented in *Ch. tenuifolia*. In the same manner *Ch. vellea* might be described as intermediate between *Ch. lanuginosa* and *Ch. gracillima* for the type of petiolar structure.

Marsh (1914, p. 680) maintains that these facts admit of but one explanation, that is, that the base of the leaf preserves primitive characters. He considers that it is difficult to imagine what could actually be the cause of the exarchy and detachment of the median protoxylem: it is simple from a study of leaf base transition to derive *Ch. fendleri* from the normal type and the *Cheilanthes* petioles from *Ch. fendleri*. He also states (p. 681) that in deriving *Ch. lanuginosa* and *Ch. gracillima* from *Ch. fendleri* that the earlier stages may be dropped out at the base of the petiole. This dropping out of the earlier stages is also to be observed in *Ch. vellea* and *Ch. tenuifolia*.

Sinnot (1911) maintains that in the triarch petiolar stele, it is always the median protoxylem group which more readily becomes broken up into two groups. He has also spoken of the "striking constancy" of endarchy in the filicinean petiolar stele. The investigations recorded on the various species of *Cheilanthes* illustrate very well the plasticity of the median group with its gradual movement from an endarch to an exarch position and finally its complete separation and disintegration. While these types mainly agree with Sinnot's generalizations of the filicinean leaf trace, they certainly do seem to have slipped ahead in the general evolutionary scheme.

It is quite generally recognized that the stem and petiolar structure are simply and fundamentally the result of an adaptation to the demands made upon



Text-fig. 10. Transverse section of the pinnule indicating the nature of the upper and lower epidermis, the palisade and lacunar tissue. $\times 150$.
 Text-fig. 11. A surface section of the lower surface of the pinnule, indicating the nature of the stomata. $\times 150$.
 Text-fig. 12. Transverse section of the vascular bundle of the pinnule. $\times 240$.
 Text-fig. 13. Transverse section of the apex of the root showing the apical cell with its typical segmentation. $\times 240$.
 Text-fig. 14. Transverse section of the root showing the sclerized cortex and the central vascular strand. $\times 60$.

these parts by the foliage. Taking this fact into consideration, it might be well to look to the habitat of these Ferns for explanations of any peculiar types of structure present in the stem or petiole. It will be remembered that these ferns are typically xerophytic. Other small ferns found growing under similar xerophytic conditions are *Lindsaya linearis* and *L. microphylla*. The writer has investigated the anatomy of these types (1925) and observed in the petiolar steles the same exarch positions of the median protoxylem groups. In these types, however, there was not to be observed that transition from an endarch to an exarch position.

The tentative explanation offered for this variation in the position of the median group is that it is a response to the unique habitat of these ferns; that is, it is an adaptation to dry conditions.

Pinnule.

The pinnules are lobed; the veins show dichotomous venation, and on the ends of these forked veins the sori are borne. The lower surface of the leaf is protected by a dense mass of hairs.

Text-fig. 10 indicates the minute anatomy of the pinnule. This is very similar to that of *Ch. tenuifolia*. The cells of the upper epidermis are large, are filled with dense granular contents, and are protected by the cuticle. The lower epidermis consists of relatively thin walled cells, and from these grow out the dense mass of hairs which cover the lower surface. The stomata are confined to the lower epidermis and open into large air cavities; they are protected by the inrolled margins of the pinnule plus a covering of hairs. (Text-fig. 11.)

The lacunar tissue is reduced, while the palisade tissue is well developed, often being three cell layers deep. The cells are oblong in shape, and the chloroplasts are arranged, for the most part, along the margins of their walls (Text-fig. 10). The vascular bundles of the pinnae are usually collateral. Each is surrounded by a well defined endodermis, the cells being large, colourless and thin walled. This encloses a layer of parenchymatous cells—the pericycle—which surrounds a central mass of xylem tracheids and a few sieve tubes representing the phloem (Text-fig. 12).

A vascular commissure carries the vascular supplies to the developing sporangia.

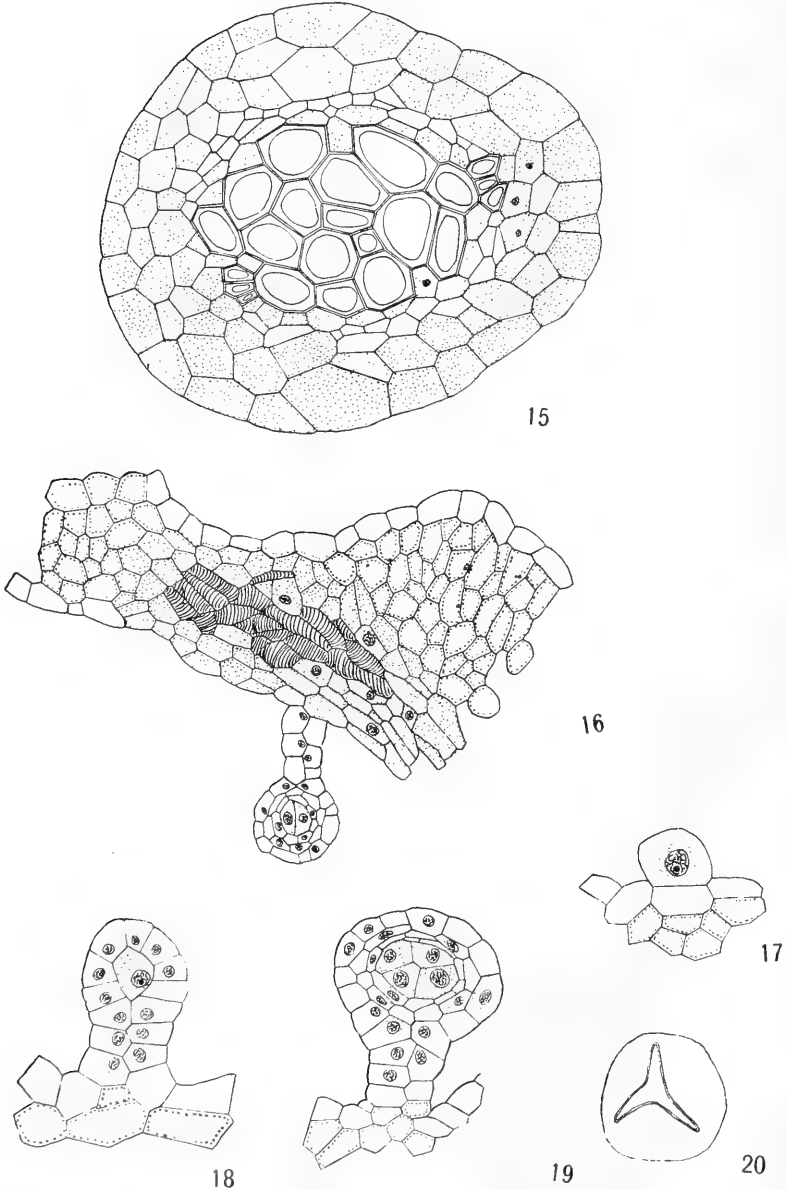
From these remarks, it will be seen that the leaf, both in external morphology and minute anatomy, shows well marked adaptations to its xerophilous habitat.

C. Root.

The roots present no features of particular importance in the present discussion. They arise in connection with the bases of the leaves. The primary roots branch profusely; the secondary roots are produced in two lines corresponding to the protoxylem groups in the vascular bundle of the primary root.

The apex is characterized by the presence of a three sided, pyramidal apical cell, from which segments are cut off in the usual manner (Text-fig. 13).

Text-fig. 14 indicates the minute anatomy of the older root. Here the cortex has become sclerized and surrounds a diarch vascular strand. The latter is composed of a central core of xylem, the metaxylem elements being large and few with the protoxylem groups arranged at the ends. The phloem consists of a single row of sieve tubes which do not continue around the protoxylem groups. The xylem and phloem are separated by one or two layers of parenchyma. Surrounding the phloem and separating it from the endodermis, are three or four



Text-fig. 15. Transverse section of the vascular bundle of the root, indicating its diarch nature. $\times 240$.

Text-fig. 16. This indicates the nature of the soral region of the pinnule. $\times 150$.

Text-fig. 17. This indicates the nature of the first segmentation occurring in the sporangium. $\times 240$.

Text-fig. 18. This indicates that stage in the development of the sporangium when the wall and stalk cells are formed and the central cell which will form the archeosporium proper. $\times 240$.

Text-fig. 19. The typical quadrant stage of development of the sporangium. $\times 240$.

Text-fig. 20. This indicates the nature of the mature spore. $\times 240$.

layers of parenchymatous cells which might be interpreted as representing the pericycle. The parenchymatous cells have dense granular contents and large nuclei (Text-fig. 15).

D. Sorus.

The sori are superficial and continuous on the back of unthickened nerve endings. They are protected by a false indusium which is composed of the inrolled margin of the pinnule. The soral region is represented in Text-fig. 16. It is broad and flat and shows the typical mixed character with regard to the arrangement of the sporangia.

The development of the sporangia is identical with that described in *Ch. tenuifolia* (Williams, 1924), hence for that typical for Leptosporangiate Ferns. The sporangia arise from an epidermal cell which protrudes above the surface and becomes divided by a transverse wall into a base or stalk cell and an upper cell which forms the sporangium proper. Since development is of the general nature typical for Leptosporangiate Ferns, there is no need to describe it here. Various stages in the development are represented in Text-figs. 17, 18, 19.

The annulus is vertical and interrupted by the stalk. The number of spores produced in each sporangium does not exceed 16-20. The nature of the mature spore is shown in Text-fig. 20.

Conclusions.

The convergence of evidence seems to indicate that the genus *Cheilanthes* represents a group of ferns which in the earlier types show anatomically primitive characters, but possessing soral characters which are advanced. In some species, the stem stele becomes more complicated by the insertion of extra leaves and the overlapping of the gaps formed by their departure. These primitive anatomical characters present in the stem might perhaps be interpreted in terms of the habitat of these ferns, combined with the reduction in the foliage.

In all parts of these ferns there are striking adaptations to xerophily. Marsh (1914, p. 677) regards the reduction in the number of sieve tubes constituting the phloem in all parts of the plants as such an adaptation. He states that "the phloem of these forms is remarkable for the absence of differentiation into proto-phloem and metaphloem. . . The whole of the phloem of these forms may fairly be said to correspond with the protophloem of mesophytic species, the slow growth, necessitated by the xerophilous habitat rendering unnecessary those facilities for active translocation which would be given by large metaphloem elements." The writer has also suggested that the structure of the petiole with the peculiar movement of the median protoxylem group is of the nature of a response to the unique environment of these ferns.

Summary.

1. The apex of the stem is occupied by a tetrahedral apical cell cutting off segments parallel to the cutting faces.
2. The stem stele is of that type of anatomy known as the dictyostele; this at once places *Ch. vellea* as one of the more advanced species belonging to the genus.
3. The leaf is formed by segmentation from a two-sided, wedge shaped apical cell.
4. The petiolar stele as it leaves the stem stele is a simple adaxially curved anarch leaf trace.

5. When the protoxylem groups appear, the two lateral components are endarch in position while the median group is exarch.

6. At higher levels in the petiole the median protoxylem group becomes detached from the metaxylem elements; it becomes broken into three or four smaller groups and finally disappears.

7. The pinnae have a reduced lacunar system and a well developed palisade.

8. The stomata are confined to the lower surface of the pinnae and are protected by the inrolled margins of the pinnae together with a covering of hairs.

9. The vascular bundles of the pinnae are collateral.

10. The apex of the root is occupied by a three sided apical cell with typical segmentations.

11. The root is diarch.

12. The sorus is superficial in origin and continuous. It is protected by the inrolled margins of the leaf alone.

13. The development of the sporangia conforms with that typical for Leptosporangiate Ferns.

14. *Cheilanthes vellea* shows, both in external morphology and internal anatomy, well marked adaptations to its xerophilous habitat.

In conclusion, the writer wishes to express her thanks to Professor Lawson, in whose laboratory the investigation was carried out, for advice and guidance.

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THE GEOLOGY OF THE COUNTRY BETWEEN LAMB'S VALLEY AND THE PATERSON RIVER.

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formerly Linnean Macleay Fellow of the Society in Geology.

(Plate i and two Text-figures.)

[Read 30th March, 1927.]

Introductory and Explanatory.

The geological investigation of the country described in this paper began in 1921 when Professor Browne and I made a brief examination of the sections east and north of the Gosforth and Hillsborough district. Following this preliminary work a number of intermittent trips were made to the area, Paterson, Vacy and Rosebrook being used as bases at various times, while on two occasions a stay was made at the house on Portion 42, Parish of Wolfingham, owned by Mr. W. Sherwood of Branxton.

The main portion of the area examined consists of a somewhat dissected plateau, and on account of the almost entire absence of settlement and of good roads into the area, access is somewhat difficult, and much time is consumed in travelling to the region of investigation. For these reasons I have not been able to make the geological examination as detailed as I desired, and it is probable that much more information concerning the detailed geological features can be gained by paying closer attention to the region.

Sufficient work, however, was done to arrive at an understanding of the general features of the structure, stratigraphy, physiography and petrography, and the field-survey was such as to permit the drawing of the map given on Plate i.

In connection with the carrying out of the work I wish to record my indebtedness to Mrs. Hudson and family of "Hillsborough," Mr. and Mrs. Dick Cant, Mr. and Mrs. A. McDonald of Gosforth, and Mr. Peter Campbell and family of Rosebrook for hospitality while visiting the area. I am also grateful to Mr. W. Sherwood for permission to stay on his property during the examination of the Moonabung Plateau, and to my father, Mr. O. L. Osborne, for his company and assistance on one trip. Many of the observations on the geology were made in the company of Professor W. R. Browne, for whose counsel in the field and subsequent helpful discussion I am very grateful.

Salient Features of the Geology of the Country Surrounding the Area Described.

Before describing the geology of the Lamb's Valley-Paterson region, it is necessary to review the geological features of the surrounding country, in order to have the former area placed in its right geological setting.

On the east and north there is the Paterson-Wallarobba district, part of a large area of Carboniferous rocks which has been described fully (These PROCEEDINGS, 1922, pp. 161, 519, and 1925, pp. 67, 112). These rocks comprise both the Burindi and Kuttung Series, and their structure immediately adjacent to the present area is anticlinal, being the western side of the Paterson anticline, so that as one comes west into the area under consideration, higher stratigraphical units are encountered. On the north-west there are Carboniferous rocks again, but not very much is known of their structural features. To the west is the Glendonbrook area and the Stanhope-Tangorin country, both of these being arbitrarily limited on the east by the line of Lamb's Valley. This valley runs along the axis of a northerly-plunging anticline and thus substantially the same section is found on both sides. To the south-west and south lies the Gosforth-Hillsborough district; a detailed description of the general geology of this district has been given by W. R. Browne,¹ who shows that the north-east margin of the area examined by him (the belt bounding the present area on the south-west) consists of portion of the Lochinvar Dome, dipping north-easterly.

In addition to the Carboniferous areas already mentioned there is an area of Permian rocks on the south-east of the area considered here. These Permian rocks have a general basin-like disposition, the lowest member of the Series marking the boundary of the present map in that neighbourhood.

Thus it is seen that the Carboniferous rocks adjacent to the area have such a structural arrangement that they dip towards and surround in a general way the main portion of the area. Thus the chief section of the Paterson-Lamb's Valley area constitutes a basin, and this is excellently shown by the plan of the outcrops on the map. It is proposed to call this the Moonabung Basin, and the plateau which is the present physiographic expression of that basin, the Moonabung Plateau. The name "Moonabung" is applied locally as a general district name for the area. In a former paper (These PROCEEDINGS, 1921, p. 261) this was referred to as Webber's Creek Plateau.

STRATIGRAPHY AND REGIONAL GEOLOGY.

Preliminary.

The Kuttung rocks occurring at Paterson and to the east were classified by division into three stages: a Basal, a Volcanic and a Glacial Stage. In the area considered in this paper, representatives of the last two stages are developed. Investigations at Gosforth by Browne show that the classification just referred to also holds for the rocks on the eastern side of the Lochinvar Dome. In the stratigraphical discussion in this communication most attention will be given to the consideration of the toscanite-dellenite rocks (Paterson type) and of the Main Glacial Beds which form the topmost division of the Glacial Stage.

Volcanic Stage.

Rocks of the Volcanic Stage occupy only a minor portion of the district described. They extend along the right bank of the Paterson River between the localities known as Summer Hill and Lennoxton. Just near the latter place they are displaced by two faults, a small one throwing west and the other, the important Lennoxton fault, throwing here to the south-east. As a result of the

¹ *Proc. Roy. Soc. N.S.W.*, 1926, p. 213.

latter fault the outcrops of the uppermost beds of the Kuttung Series have suffered a lateral displacement of two miles and a half in a direction perpendicular to the strike of the beds.

The topmost horizon of the Volcanic Stage is a green albitic rock of the nature of a pumiceous keratophyre. The upper limit of the stage has been placed here because the keratophyre is followed by conglomerates and tuffs which form the Lower Portion of the Glacial Stage. These clastic rocks possess a lithology which is quite characteristic, and differs from the lithology of the clastic rocks of the Volcanic Stage.

Two sections may be taken to indicate the variety of units in the Volcanic Stage. The more important, which is found near Lennoxton, is as follows, ascending stratigraphically:

| | Thickness in feet. |
|---|-----------------------|
| Purple tuffs with pebbles | 50 |
| Toscanite (Mt. Gilmore type) | 30 |
| Cherts with plant stems | 50 |
| Toscanite, albitized (No. 745) ¹ | 45 |
| Dacite (No. 743) | 80 |
| Acid tuffs (No. 742) | 20 |
| Felspathic tuffs | 100 |
| Potash rhyolite (No. 741) | 30 |
| Breccia (No. 744) | 25 |
| Felsite (No. 739) | 30 |
| Green keratophyre (No. 746) | 30 |
| Total | 490 |

The second section is found at Summer Hill on the right bank of the Paterson River near the boundary between the Cessnock and Bolwarra Shires and ascending stratigraphically, is as follows:

| | Thickness in feet. |
|--|-----------------------|
| Bluish tuff (No. 706) | 50 |
| Coarse banded green tuff (No. 707) | 20 |
| Tuffaceous conglomerate (No. 708) | 10 |
| Breccia | 15 |
| Mauve dacite (No. 713) | 70 |
| Banded green keratophyre (No. 709) | 40 |
| Total | 205 |

Some horizons are common to both localities and these can be traced fairly easily through the intervening country.

The rocks described in the sections just given comprise a series quite comparable with the Volcanic Stage sections to be found further east. There is not a great variety of type, but it should be remembered that in the present case only part of the Volcanic Stage is dealt with. Of the lavas already detailed, only four can be correlated directly with units from the districts to the east. These are those numbered respectively 745, 746, 739 and 741. The particular features of the more important of the horizons in the Volcanic Stage will be considered under the heading of Petrography.

¹ Numbers refer to specimens in the collection of the Dept. of Geology, University of Sydney.

*Glacial Stage.**The Lower Portion.*

On the eastern and northern sides of the area, this division of the Glacial Stage (equivalent of the Mt. Johnstone Beds of Sussmilch), consists entirely of clastic rocks, tuffs predominating. The majority of the tuffs are contaminated with detrital sediment, becoming in places very pebbly. Conglomerates and sandstones are associated with the tuffs, but so far no definitely glacial rocks have been found, although in this portion of the Glacial Stage to the east, one horizon of varve-rock has been recorded, *viz.* from Glenoak, at a position about 200 feet above the base of the Glacial Stage. On the south-western margin of the area now being described, however, there are important glacial and fluvio-glacial deposits. Thus to the north of Hudson's Peak and Drinan's Mt., Browne has shown that the Volcanic Stage is followed by the grey-granite conglomerate and then a series comprising acid tuffs, varve-rock and tillitic conglomerate, culminating in a coarse conglomerate consisting of a tuffaceous matrix and many pink aplite pebbles. This conglomerate is followed by the Paterson toscanite.

The Paterson toscanite divides the Lower Portion of the Glacial Stage from the Main Glacial Beds, but between the Moonabung Plateau and Eelah the toscanite is missing from the sequence, and along this belt it is difficult to draw the line between the two divisions mentioned above. Still it is quite clear from what has been said that there is a distinct difference between the rocks under the Paterson toscanite on the north-east, and their stratigraphical equivalents on the south-west. This matter is of some interest and importance from the standpoint of palaeogeography and will be discussed under that heading.

Paterson Toscanite and Dellenite.

The rocks which come under this heading immediately underlie the Main Glacial Beds in all cases except one. In this instance a very thin flow of toscanite is found sandwiched in with the conglomerate and tuffs which have been described under the last heading. The occurrence of this was first pointed out to me by Dr. W. R. Browne, the unit being found on the bridle track from Hillsborough to Webber's Creek Falls, just a little to the south of Wildman's Gap. This occurrence is of no great importance, stratigraphically, because of its extremely limited extent.

Concerning the main lava-horizon, it is to be noted that this comprises more than one flow in the Moonabung area and also to the west of Paterson. At the base of the main mass on the track to Bell's house there is a small decomposed outcrop of pitchstone, seamed with haematite veins. This is identical with a small flow found in precisely the same stratigraphical position at Westbrook, near Singleton. Whether this is a glassy phase of the Paterson toscanite, or bears to the latter a relationship analogous to that shown by the glassy andesites to their associated lithoidal types is not known.

The maximum thickness of the main mass is about 150 feet, but the variations in the thickness are very marked. One cannot determine exactly the number and extent of the subsidiary flows, but it is quite clear that these exist. Thus near Bell's house the interposition of conglomerate between two flows of toscanite is seen. The conglomerate wedges out to the south and the two flows coalesce. In a number of places a similar state of affairs exists, and in four isolated localities the presence of two flows without any intercalated sediments has been found. To

the west of the *bridle track* not far from the Falls a dense, almost felsitic lava is found resting on the main flow. This is an albitized rock and recalls many of the features of the albitized hornblende andesites of Bridgeman.

To the north of Webber's Creek Falls there are two important flows, which are both toscanitic in character. In the neighbourhood of Paterson on the northern side of Webber's Creek there are a number of interesting varieties of the lavas. One rock, purplish in colour, shows, under the microscope the presence of a pumiceous groundmass indicating that it is definitely a volcanic rock. This unit is associated with two flows of toscanite, which resemble one another.

There are certain features connected with the toscanite in Webber's Creek just a little upstream from the Falls, which puzzle one when endeavouring to interpret their significance. Here there seem to be strings of igneous rock penetrating the glacial sediments. A similar set of features was seen in the bed of Dunn's Creek, east of Paterson and commented upon in 1922. Professor Browne has remarked upon the features in Webber's Ck. and suggested that the toscanite may have been a sub-aqueous flow disturbing the sediments with which it was associated. From an examination of the toscanites over wide areas during the past five years I feel fairly sure that they are essentially extrusive rocks, and that the peculiar features seen in Webber's and Dunn's Creeks are probably best explained by the suggestion of Browne. The hypothesis that the rocks are sill intrusions raises obstacles that are difficult to remove.

The glaciated pavement discovered in 1921 (see These PROCEEDINGS, 1921, p. 259) is upon the surface of the toscanite.

Main Glacial Beds.

Succeeding the Paterson toscanites there is a group of sedimentary rocks which constitutes the Main Glacial Beds, horizons of glacial origin occurring right throughout this series. These rocks are characterized by the fact that the individual units do not persist for any great distance. They outcrop upon the Moonabung Plateau and have been protected from rapid denudation by reason of the existence of the basin structure there. On account of the lack of constancy of the units, it is difficult to find a representative section of any considerable length from which to obtain a fair indication of the stratigraphical succession. In addition to this I have not been able to examine the area as fully as desirable, and hence the stratigraphical detail is not fully known. However, by considering the succession at a number of places and correlating the data, a good idea of the general features of the sequence is obtainable.

The rocks immediately on top of the flows of toscanite, etc., vary somewhat, and comprise varve-rock, tillite, fluvioglacial conglomerate and tuffaceous conglomerate. Careful tracing of the rocks shows that the tuffaceous conglomerates which are developed at the Bald Hill, north of Bell's house, are the lowest, stratigraphically, of the supra-toscanite units. These rocks will be referred to as the Bald Hill Series, and their maximum thickness is about 350 feet. They are present to the north of the Bald Hill, and swing round at the head of Webber's or Moonabung Creek, outcropping in Cabbage Tree Brush. They are also found on the southern slope of Mt. George and above Lennoxton, but they are practically absent along the stretch of low country to the west of Paterson and also to the north-east of the glaciated pavement.

The rocks are fairly coarse, there being an abundance of pebbles of quartz and fine-grained acid rocks like felsites. The pebbles are well-rounded in most

cases and the deposit is reasonably well sorted. Current-bedding is seen in most places, and the matrix, which is definitely tuffaceous, contains a certain amount of relatively fresh feldspar and biotite. Sometimes the tuffaceous conglomerates pass into tuffs. The latter type of deposit is found resting on the toscanite to the east of Mr. M. Boland's farm. Here there is a section leading up to the plateau which, starting at the top of the toscanite and proceeding upward, stratigraphically, is as follows:

| | Thickness in feet. |
|---|-----------------------|
| Acid tuffs with pebbles | 100 |
| Varve-rock | 50 |
| Conglomerate with current bedding | 150 |
| Tuffs with scattered pebbles | 40 |
| Tuffaceous conglomerate | 50 |
| Total | 390 |

The varves here are somewhat coarse in texture, and they show contemporaneous contortions. Further to the east of the point where the above section is found there is a series commencing with conglomerate in which the average size of the pebbles is much less than in the rocks of the Bald Hill Series. This conglomerate contains pebbles of chert, slate, free quartz and felsite. It is followed by varve-rock which shows a peculiar kind of fracture, whereby large flaggy pieces become detached from the underlying rock leaving a surface having a type of confused subconchoidal fracture. This kind of disintegration coupled with the dip of the rocks has had a definite effect upon the development of minor creeks in this region, erosion being facilitated in the direction of dip. Following the varve-shale are some sandy rocks which may be glacial in origin, and these are succeeded by tuffaceous conglomerate in which are some bands of tuff. The pebbles in the conglomerate average about six inches in diameter. The next unit is a mass of tillitic material containing many angular and subangular fragments which have been irregularly accumulated. The tillitic material is succeeded by coarse acid tuff which is ferruginous and varies a little in texture. Then comes a series of purple shaly rocks reminding one of the Lochinvar shales of the Permian system, but probably representing glacial shales, similar to rocks of the same general appearance near the pavement which are definitely glacial. The shales are followed by coarse conglomerate and this is the highest unit examined in the section which is summarized as follows:

| | Thickness in feet. |
|---|-----------------------|
| Conglomerate | 300 |
| Varves | 80 |
| Sandy rocks, possibly glacial | 50 |
| Tuffaceous conglomerate | 300 |
| Tillitic deposit | 200 |
| Coarse acid tuff | 100 |
| Purple shales, possibly glacial | 150 |
| Coarse conglomerate | 100 |
| Total | 1,280 |

If a traverse is taken from the Bald Hill towards the east crossing the basin, we find that the Bald Hill Series is succeeded by a fine cherty tuff carrying excellently preserved remains of *Rhacopteris* and *Calamites*. This is exposed on the right bank of Moonabung Creek at the foot of the long spur leading down from

the Bald Hill. Then comes some very acid tuff, which is immediately followed by a white plant-bearing tuff. In this *Rhacopteris* is again abundant throughout and *Calamites* stems are limited to thin zones. This horizon is only about 25 feet thick, and forms a dip slope to the north and north-west of Sherwood's house, which leads up to a ridge running to the edge of the plateau overlooking Lamb's Valley. The white rock stands out well and forms a useful guide for picking up, from a distance, the general geographical details of the western side of the basin.

Following the second *Rhacopteris*-tuff horizon there are some more conglomerates, and these are followed by rocks which appear to be the Lochinvar Shales. These are overlain by Permian conglomerate. On the east side of the Permian rocks are found which do not fit in with the section on the western side. Thus there are some varves which are limited to the eastern side, and there is only one *Rhacopteris*-bearing horizon. The varves are probably to be placed on the top of the Bald Hill Series. Varves of the same stratigraphical position occur at the head of Webber's Creek in Portion 44, Parish of Wolflingham, resting with associated tillite on the Paterson type of toscanite.

The Carboniferous rocks in the section just described are as follows:

| | Thickness in feet. |
|--|-----------------------|
| Bald Hill conglomerate | 300 |
| Varves and tillite | 80 |
| <i>Rhacopteris</i> tuff, No. 1 | 30 |
| Coarse tuff | 80 |
| <i>Rhacopteris</i> tuff, No. 2 | 25 |
| Conglomerate | 200 |
| Total | 715 |

Considering next the succession in the neighbourhood of the glaciated pavement and Webber's Creek Falls, we find that immediately on top of the toscanite at the pavement there are varves with pebbles and a very minor amount of tillite, while at the Falls the first rocks to succeed the lava are tillites and conglomerates. Following the varves and tillitic conglomerates come some olive-green to brown mudstones with scattered plant stems.

Then comes another series of varves which are almost purple or brown in colour, and relatively free from contemporaneous contortions. These are well exposed in Bell's Creek, which runs just to the north of the pavement and joins Webber's Creek above the Falls. These varves swing round from this locality and then die out as we continue across to the northern side of Moonabung Creek; but they are found on the eastern side of the basin in a number of places. Therefore this second series of varve-shales is well developed, being fairly widespread in the area of the basin.

A little north of Bell's house we see an occurrence of varve-rock which, as regards stratigraphical position, is of interest. The glacial rock is associated with conglomerate which can be followed down the small creek just to the north of Bell's. This conglomerate clearly separates two flows of toscanite and hence the varve-shales are sandwiched in between the lava horizons. From the general field evidence I think it very probable that these varve-shales are lower stratigraphically than those at the glaciated pavement and in Portion 44.

The stratigraphy of the rocks on the Moonabung Plateau, ascending stratigraphically, is summarized as follows:

Carboniferous.

| | Thickness in feet. (Maximum values.) |
|--|---|
| Main toscanite unit | 150 |
| Varve rock and conglomerate at Bell's | 90 |
| Subsidiary flows of toscanite, etc. | 100 |
| Bald Hill Series | 300 |
| Pavement varve-rock and tillitic deposit | 150 |
| Mudstone with plant stems | 90 |
| <i>Rhacopteris</i> tuff No. 1 | 30 |
| Acid, ferruginous tuffs | 80 |
| <i>Rhacopteris</i> tuff No. 2 | 25 |
| Purple varve-rock | 140 |
| Conglomerate | 250 |
| Coarse acid tuff | 100 |
| Purple shales, possibly glacial | 150 |
| Coarse conglomerate | 70 |
| Total | 1,725 |

Permian.

| | |
|---|-----|
| Shales (probably the Lochinvar Shales) | 50 |
| Amygdaloidal basalt | 20 |
| Tuffaceous sandstones and conglomerates | 200 |
| Total | 270 |

This gives a thickness of 1,475 feet for the Main Glacial Beds, which is distinctly less than that obtained at Seaham, but many of the values for thickness given here are only approximate.

It is necessary now to consider the rocks west of Paterson and between Lennoxton and the Permian area on the south. Along the left bank of Webber's Creek for some miles west of Paterson it is possible to gather some information about the succession. Just near the Paterson Park there are two bands of varve-rock with associated sediments, and one can generally find evidence of the existence of the same two horizons as one goes west. Associated strata comprise fine white tuffs, coarse red tuffs and coarse conglomerates with tillitic phases, in one of which an erratic about five feet in diameter was found. The second set of varves thickens considerably to the west and is found well developed towards the Falls, attaining to a maximum of 150 feet.

As one goes up Smith's Creek to the north one finds definite tillite along with the varve rock, and to the south of Lennoxton above the Paterson River the following section in the Main Glacial Beds is found:

| | Thickness in feet. |
|---|-----------------------|
| Conglomerate, probably equivalent of Bald Hill Series | 90 |
| Yellow tuff | 80 |
| Coarse tuffaceous conglomerate | 150 |
| Tillitic deposit | 20 |
| Normal conglomerate, with pink aplite pebbles | 80 |
| Total | 420 |

It will be seen that the varve-rocks have disappeared from this section.

Proceeding from the Falls towards Rosebrook the varves are seen to be strongly developed, the horizon being the equivalent of the purple varves on the Moonabung Plateau. On the eastern fall of the Rosebrook ridge and to the north of Drinan's Mt. there are, of course, at least two horizons of varve-rock.

Associated with the glacial beds just east of the Falls there are some siliceous tuffs which are not seen elsewhere.

Outliers of Permian Age.

Apart from the large area of Permian rocks in the south-east of the area, there are a number of outliers. Most of these are only a few acres in extent, but a larger one is to be found to the east of the Falls (see map). It is probable that there exist other small outliers which are not shown on the map. The rocks constituting these outliers comprise units which are sometimes representatives solely of the Lower Marine Series; as for example the Lochinvar Shales and the amygdaloidal basalt. At other times there are conglomerates which remind one of the Upper Marine conglomerates south of Paterson.

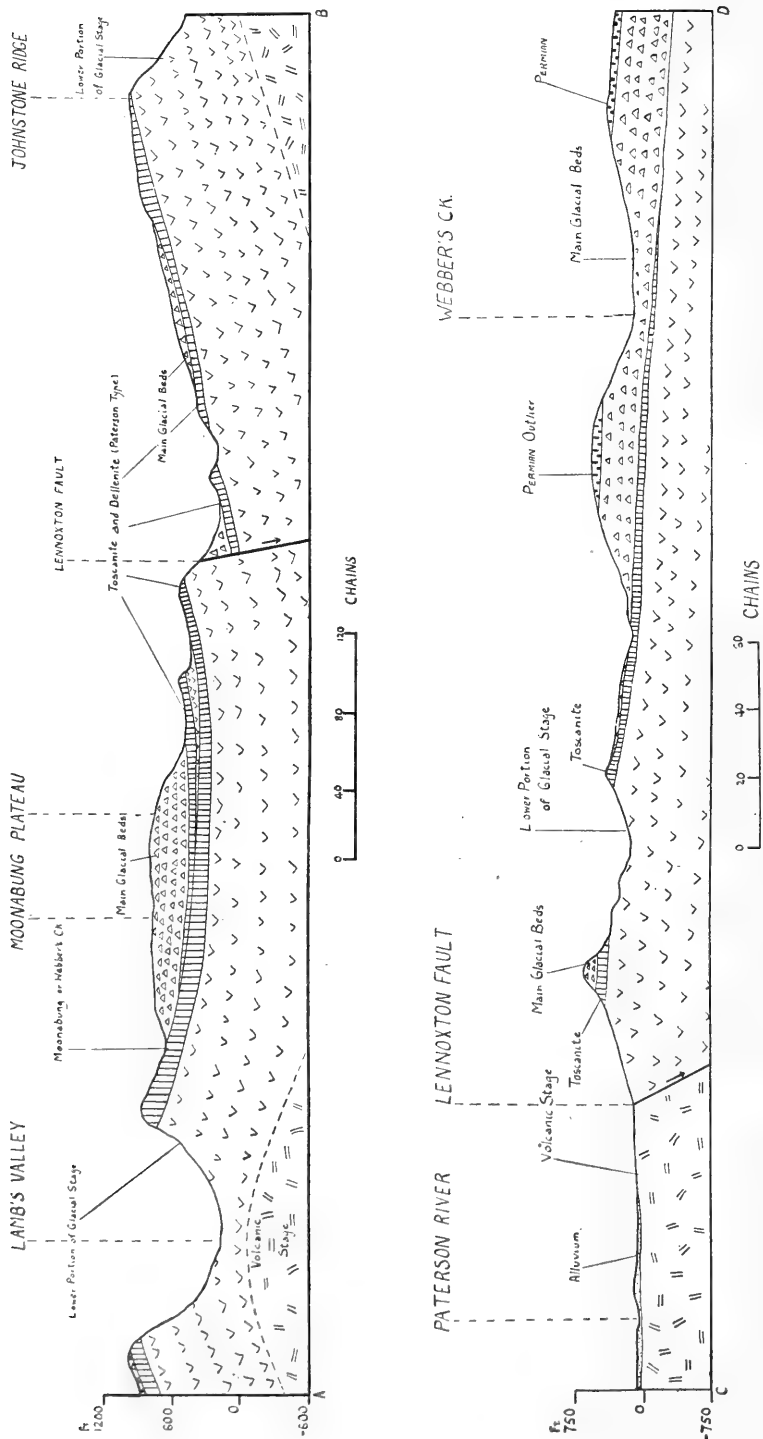
The height above sea-level of the base of the outliers on the Moonabung Plateau is fairly constant, and is in excess of the height of the same horizon on the east side of the Falls by about 340 feet. These data confirm the existence of the Lennoxton fault and to some extent give a measure of the throw in this locality.

STRUCTURAL GEOLOGY.

The greater part of the area consists, structurally, of a basin which has been broken by a large fault on its eastern side. The examination of the dips shows the existence of this basin quite clearly, and physiographically the structure stands out well, as the toscanites, particularly the main one, have on account of being resistant units, dominated the topography. The section given in Text-figure 1 shows the structure of the Moonabung area. The Moonabung basin is of the same general nature as the other basins in the district to the west, viz. the Cranky Corner and Mirannie Basins, and it is separated from the latter by a complementary structural feature. This is a plunging anticline, out of which Lamb's Valley has been carved. The anticline is really the northern end of the Lochinvar Dome, the northerly dip of the beds being the measure of the pitch of this portion of the dome.

Just as the Lochinvar Dome is elongated in a more or less meridional direction, so the Moonabung Basin shows an elongation in that direction, and the plan of the outcrop of the rim of the basin (which consists chiefly of toscanite), is an ellipse, the length of the major axis of which is about five miles, and of the minor axis not more than three miles.

The eastern portion of the area, which is separated from the Moonabung Plateau by the Lennoxton Fault, forms the western side of the Paterson anticline. This structure was described in a former paper in 1922, although much of the detail of this portion of the region was not known then. It will be seen by inspection of the dips to the west of Paterson that the toscanite is dipping in a general southerly direction for some distance, and there is a change in the dip further west, the beds becoming flat near Lennoxton. The structure in the last-named locality is shown by considering Text-figure 2 in conjunction with the map. The gentle dip of some of the beds and the advanced state of the dissection have brought about the existence of both outliers and inliers of certain horizons.



Text-figure 1.—Line A-B on map (Plate 1).

Text-figure 2.—Line C-D on map (Plate 1).

In addition to the Moonabung Basin and the eastern region near Mt. Johnstone, both of which have been already considered, there is a third region which comes up for consideration. This is the area in the south-east which is given over to Permian rocks. The detail of the structure of this area is not yet known and we can only refer to the general structural features. The junction of the Permian and Carboniferous systems from Eelah to the north can be followed fairly readily as has been shown by W. R. Browne, by noting the outcrop of the Lochinvar shales. These appear, however, to cut out as one goes north from the neighbourhood of Rosebrook, except that they are found in the Permian outliers in a number of places. However, they are definitely missing from the sequence near Paterson. A consideration of the strata in the field has led to the position of the junction of the two series being placed as shown on the map.

Now it will be seen that the Permian rocks lie in a plunging syncline, or, to borrow a term used by Prof. Browne, form a "gulf" in the Carboniferous area. This syncline is complementary to the Paterson anticline on the north-east side, and to the eastern margin (now faulted) of the Lochinvar Dome, on the south-western side. But associated with these relationships we have the rather abrupt change in the dip direction of the strata in the neighbourhood of the S.W. end of the Lennoxton fault. Hereabouts one finds on the S.E. side of the postulated position of the fault, the beds turning round to strike in sympathy with the Permian syncline. On the N.W. side of the fault line, however, the beds dip in accordance with the Moonabung Basin. These facts emphasize the irregular nature of the folding.

Faulting.

The most important fault in the area is the Lennoxton fault. This has been followed from a point a little to the south of Wildman's Gap to Vacy on the Paterson-Gresford road. The fault is clearly shown by the outcrops of the various horizons, and it is manifested physiographically also. Above the river at Lennoxton there is a parallel fault associated with the larger one, the former throwing to the west. From a consideration of the structure to the east of Webber's Creek Falls it is clear that the Lennoxton fault is normal in character, throwing in general to the east and south-east. The throw of the fault is difficult to estimate, and it increases as one goes north, but in the neighbourhood of Lennoxton it is between 2,000 and 2,500 feet.

It is rather singular that this dislocation is absent along the track from Hudson's Peak district to the Falls. On the S.W. side of the track at Wildman's Gap there is an interesting fault which has been described by Browne. This and the Lennoxton fault are almost collinear, but careful consideration of the problem and detailed field examination seem to prove clearly that the two are unconnected. The fault in Kilfoyle's creek is not a large one and may easily die out north-eastwards, but the other dislocation seems to be of fair magnitude near the Falls, and one would expect to find it crossing the track to Wildman's Gap. But this it does not do, and it can only be surmised that the fault does not extend any further than is shown on the map. Just at the limit of the map in Portion 9 Parish of Wolfingham there is a number of small outcrops of the Paterson toscanite, and these seem to be the displaced equivalents of the main mass outcropping on the Moonabung Basin. They are of a lower altitude and an examination of their general features of occurrence suggests that they are the remnants of the toscanite

flows, which thin out very definitely as one comes S.E. from the Moonabung Plateau, and that here we have a small displacement along the fracture of the Lennoxton fault, the amount of displacement increasing as one goes north.

Beyond Lennoxton the fault turns to the east, and near Vacy is hidden by thick alluvium, but it looks as if it carries on and becomes the fault described as F₂ and shown on the Clarencetown-Paterson map (see These PROCEEDINGS, 1922, Plate xxvi), since the latter possesses the same features of strike, magnitude, etc.

A very striking effect of the fault is the displacement of the higher lavas of the Volcanic Stage from their alignment at the foot of Mt. Johnstone to the right bank of the Paterson River near Lennoxton.

In addition to the large fault just described, there are a number of smaller ones. One already mentioned throws to the west. Another occurs on the east side of Lamb's Valley above Mr. Boland's farm, where the displacement of the toscanite is clearly seen. Further, in many places on the Moonabung Plateau the beds are standing on edge, indicating faulting, although very few details can be obtained regarding the nature of the movements. Frequently also on the Moonabung Plateau strong jointing is observed, and this feature is no doubt the result of faulting movements.

Finally near Paterson along the Webber's Creek road there are small faults displacing the junction line between the Permian and Carboniferous Series.

All the faults are normal and belong to a general group which includes those described from the Paterson-Seaham region and the series of normal faults mapped in the Singleton district. All these normal faults are probably of late-Palaeozoic age for reasons given in two earlier papers (These PROCEEDINGS, 1922, p. 525, and 1926, p. 401).

PHYSIOGRAPHY.

The area being considered is part of the northern margin of the valley of the Lower Hunter River. Dissection has proceeded to a fairly advanced degree, and the aspect of the topography on the whole is that of late-maturity, although there are exceptions where some of the smaller creeks are concerned, and also sometimes the same creek will show both youthful and mature aspects in different parts of its extent. Thus in the case of Webber's Creek we find an interesting assemblage of varying physiographic features as we pass upstream.

The physiography of the area is intimately bound up with the geological structure, and thus it is convenient to maintain the division used in the chapter on the structural geology, taking the Moonabung Plateau as one part and that constituting the remainder of the region as the other.

The faulting which has occurred does not manifest itself in the presence of initial fault scarps, because the fault-scarp-formation antedated the peneplanation and subsequent uplift, which were in turn antecedent to the present cycle of erosion.

However, the manner in which the strata were arranged by the Lennoxton fault coupled with the arrangement due to folding has had a marked influence upon the topographic evolution.

The peneplain surface in the area of the map was probably not so regular as was the case in some parts of the adjacent country, as for example from Mt. Johnstone towards Mt. Gilmore. What are probably remnants of some of the original shallow valleys and rounded hills are to be seen in certain parts of the Moonabung Plateau, it being fairly clear that Mt. Johnstone and Mt. George and

the Bald Hill as seen now have not suffered much lowering of height due to the erosion which followed the uplift. The respective heights of these, *viz.* 1,130, 1,466 and 1,050 feet give some idea of the height of the plateau in this region at the completion of the Kosciusko uplift.

In two or three places one can see examples of valley-in-valley structure, generally on a small scale, the original broad valleys developed in late Tertiary time, being cut into by small streams, which in these cases are the rejuvenated representatives of the older streams.

The adjacent area of the Paterson-Clarencetown district and the area under consideration belong to the same physiographic unit (part of an uplifted peneplain), and there is as one goes from the west towards the south-east from the present area, a decrease in the general height of the plateau, this probably being due, as mentioned by Browne in the paper on the Gosforth district, to an original slope in the surface of the plateau when uplifted.

There are a number of outliers on the surface of the Moonabung Plateau. These are remnants of the Permian rocks which at one time covered much of the area now forming the surface of the plateau. These rocks were at one time continuous with the Permian rocks south and west of the Hunter River at Gosforth. The denudation of much of the capping of Permian rocks was accomplished in pre-Kosciusko times, and thus the uplifted peneplain was characterized by the existence of relatively isolated patches of Permian rocks scattered about on the Carboniferous basement, these being subsequently somewhat reduced in size by Pleistocene erosion.

As the physiography is affected by the nature of the rocks it is interesting to note the varying resistance offered by the different units to erosion. The most resistant rocks are the toscanite and dellenite (Paterson type). These are responsible for many striking dip slope-escarpment elements which are wholly or partly made of these rocks. The toscanites of the Moonabung Plateau produce the ring-like outcrop which bounds the plateau along almost the whole of its extent. The precipitous cliffs on both sides of Lamb's Valley, which are inaccessible in places, are made of the toscanite.

The conglomerates in the Lower Portion of the Glacial Stage stand out much more strongly than the tuffs and varve-rocks. A good illustration of this is to be seen on the bridle-track to the Falls. Here one crosses two bands of coarse conglomerate separated by tuff, and the former produce steep "pinches" on the track while the tuff has been eroded rather rapidly from off the surface of the lower conglomerate thereby allowing for the presence of a gently sloping section of track along to the base of the upper mass of conglomerate.

The Main Glacial Beds as a whole offer only a medium degree of resistance to denudation, the Bald Hill Series being the exception. The rocks of this series are fairly well cemented conglomerates and tuffs and they are generally found standing out forming fairly rugged features as at the Bald Hill. The varves and mudstones break up rather easily and the tillitic conglomerates, on the whole, disintegrate readily.

In the area of the Volcanic Stage rocks it will be noticed that a broad valley has been eroded by the Paterson River, but while this is a reflection of the advanced state of the denudation, it also emphasizes the fact that the lavas of that stage, on account of their lack of any great thickness in all cases, have not resisted erosion and along with the easily disintegrated conglomerates have been rapidly removed.

The most important stream in the area is the Paterson River, but we are only concerned with the extreme margin of its valley in this area. The physiography of the Lower Paterson has already been described by the writer in another paper, but it is interesting to record the presence near Lennoxton and Summer Hill of terracing along the Paterson. The exact cause of the production of these is not known, and while they may indicate the occurrence of small uplifts late in the history of the river, they may be due to uninterrupted erosional activity.

Dismissing, then, the Paterson River, we see that the next most important stream in the area is Webber's or Moonabung Creek,¹ generally called by the latter name in its upper portion. This stream joins the Paterson River some two and a half miles south of Paterson and its valley for some distance upstream is heavily alluviated. From the point of confluence to the west for a distance of about four miles, the creek is flowing in a direction more or less parallel to the strike of the rocks, and because of this it has been able to erode a fairly wide valley along this belt. The northern limit of the valley just west of Paterson is the outcrop of the Paterson toscanite, and to the south the boundary is, in part, made by the sandstones and conglomerates of the Upper and Lower Marine Series. Thus the Main Glacial Beds and the Lower Marine cherts, etc., have been extensively removed.

Further along the valley, one finds that the trend of the creek and the direction of strike of the rocks are no longer more or less parallel. Eventually, one reaches the barrier of toscanite at Webber's Creek Falls, where, due to the irregular folding and the Lennoxton fault, we find the creek flowing directly across the strike. The falls are about 90 feet in vertical range and form an imposing sight in winter time immediately after rain. They are carved out of toscanite almost entirely.

Above the Falls, Webber's Creek presents a valley, different altogether from that seen on the lowland to the east of the Falls. Now we find that the stream and its tributaries are not able to erode quite so rapidly and on account of the centroclinal nature of the dips on the plateau there is not any striking widening of the small valleys in any particular direction. The presence of the barrier of toscanite at the Falls has brought about the deposition of alluvium over a relatively wide area upstream, and this has been contributed to by the direction of the dip of the strata just above the Falls being directly opposed to the direction of flow of the creek. The alluvium so accumulated produces swamp-like areas in the wet seasons and the aggradation has prevented, in some measure, the deepening of the channel of Webber's Creek to the north-west of the Falls.

The tributaries on the north side of Webber's Creek in the region to the east of the Falls have developed much more extensively than those on the south, and this is due, partly, to the southerly-directed dip of the rocks in the major portion of the northern area. Thus Smith's Creek, and the two to the east of it, have fairly broad valleys, and the extensive erosion has brought about the existence of both inliers and outliers of certain units.

Professor Browne, in discussing the physiography of the Gosforth district, has suggested that in the evolution of the present Hunter River which began with the epeirogenic movements at the close of the Tertiary, there were two main stages of

¹ It should be noted that there is another Webber's Creek, *viz.* in the Glendonbrook district.

erosion consequent upon two uplifts. The former stage consisted of denudation of Permian sediments and the production of certain river and creek systems, which were superimposed upon the underlying Carboniferous terrane when the second uplift took place.

With regard to the physiography of the Moonabung area, as a whole there is nothing to show whether or not there were two main stages in the late Tertiary uplift, but there is evidence of rejuvenation of the ancient streams having occurred.

PALAEOGEOGRAPHY.

The palaeogeography and geological history of the Gosforth district and its environs have been ably dealt with by Dr. Browne, and much of what he has written will apply to the Moonabung area because this is intimately related geologically to the former region. However, there are one or two points connected with the present district which may be considered here: The extent of the Paterson lavas and the nature of the sediments in the Lower Portion of the Glacial Stage and their probable former extent in the region being discussed.

It is quite clear that the toscanite and dellénite flows were very widespread when one remembers that they have been found from Raymond Terrace to at least as far as Mt. Dyrning, north of Singleton. On the north their limitation is not yet known, but while they are found close to the base of the Permian along from Seaham towards Moonabung, they are definitely missing from the sections east of Rosebrook and near Eelah, and probably they do not occur in the Gosforth region, although there are some toscanite flows in the glacial beds recorded by Browne for the west of the Hillsborough district.

The remnants of the thin margins of the toscanites are to be seen between Drinan's Mt. and Wildman's Gap and the flows on the Plateau above the Gap thin out east and south. That the thinning is rather abrupt is suggested by the fact that at the Falls the lavas are about 90 feet thick while a little to the east on the other side of the Lennoxton fault there is no sign of the igneous rock in the succession. Thus in short at a time just prior to the accumulation of the Main Glacial Beds there developed the interesting group of toscanites and dellénites, the flows spreading over a vast area covering the underlying sediments to a depth of about three hundred feet at Paterson where we find the greatest development of the rocks. The area occupied by the igneous rocks was bounded on the south (in this particular region) by a line running from near Wildman's Gap towards the east.

With regard to the rocks constituting the Lower Portion of the Glacial Stage one notices the constancy of the basal conglomerate, but for the bulk of the remainder there is a distinct difference in facies between the rocks which are found right throughout the Clarencetown-Seaham district and to the north of Moonabung on to Mt. Dyrning, and their stratigraphical equivalents in the region extending from just north of Drinan's Mt. to Eelah, and also in the Gosforth district. The rocks of the former areas consist of tuffs with subordinate conglomerates which occur in bands. The conglomerates are not coarse-grained, as a rule, and are always well cemented. The tuffs possess a brown, sometimes chocolate, colour and have a lithology which is characteristic. The rocks of the second group are characterized by the prevalence of pink-granite conglomerates and the general lithology is just as typical as, and quite distinct from, that of the other series. One can see the intermingling of the two types of sediment as one

goes from north of Drinan's Mt. along the base of the Plateau. The pink-granite type of conglomerate is seen on the track to Bell's, but it loses its individuality as we proceed to the north, and at the head of Lamb's Valley and on the northern slope of Mt. George we have the tuffs and more finely-textured conglomerates of the group which is so well developed in the Paterson region. Further, at Gosforth, the rocks of the Main Glacial Beds comprise pink-granite conglomerates, but such sediments are practically absent from the Moonabung Plateau, although immediately following the Paterson toscanite there are conglomerates (the Bald Hill Series) which display the general facies of the Paterson-Singleton group.

Browne has pointed out the probability that the area, which provided the granitic pebbles, which are so prevalent in the conglomerates right through the Kuttung Series in the Gosforth district, was situated to the south, and with this I am in accord, but from a consideration of the data to hand regarding the distribution of the two types of sediment, which are found in the Lower Portion of the Glacial Stage through the areas to the north of Gosforth, I would suggest that the following course of events characterized the development of the Lower Portion of the Glacial Stage. While the conglomerates and other sediments of the present Gosforth district were accumulating in post-Volcanic Stage time in the southern portion of the large Upper Kuttung lake, volcanic activity was manifesting itself by ejecting fragmental material which was widely spread. The material falling in the Gosforth district, was, *taken as a whole*, distinctly coarser, and less contaminated with detrital sediment, than that which accumulated throughout the large area from west of Singleton to Clarencetown. Over this latter region there was being piled up a series of tuffaceous sandstones and occasional conglomerate, the latter indicating grand flood periods in the cycle of erosion. The nature of the sediments in this region and the presence of current bedding suggest that these were developed in a large delta. It is probable that this delta in the great Kuttung freshwater lake, flanked the north-western shore, the areas providing the detritus for the delta formation being composed of a terrane, different from that of the area to the south, where granitic rocks abounded. A line which would effect a broad division between the two types of sediments in the Lower Portion of the Glacial Stage could be drawn on the map, and the actual physical boundary would pass under the Moonabung Plateau.

PETROGRAPHY.

The petrography does not need to be fully discussed here, because the general petrological features of the rocks correspond very closely with those of the rocks of the Clarencetown-Paterson region, which have been described in an earlier paper (These PROCEEDINGS, 1925, pp. 112-138). There it is pointed out that, in the region mentioned, there is a great variety of lavas ranging from intermediate to acid types, and embracing andesites, dacites, keratophyres, toscanites, dellenites, rhyolites and felsites. Some of these are vitrophyric, and some, particularly the more acid, are tuffaceous. Associated with the lavas are some acid albitic tuffs and flow breccias.

In connection with these rocks it is also shown that on account of albitization having affected them it is difficult to make out the magmatic relationships and to work out problems of petrogenesis. On the other hand, it is possible to recognize only a broad sequence of flows throughout the area. Amongst the salient petrological features shown by these rocks, when considered as a whole, are the

following: evidence of the operation of late magmatic processes effecting albitization and kaolinization; autobrecciation; devitrification; spherulitic structure.

Coming now to the rocks of the Moonabung-Paterson region we note that many of the rocks correspond in general features to rocks from the more eastern district. The sequence which is found in the upper part of the Volcanic Stage near Lennoxton is as follows: Toscanite, albitized toscanite, dacite, potash rhyolite and keratophyre.

Specimen 745 is a toscanite from Lennoxton, which in hand specimen shows a general brown colour with lighter streaks due to the presence of elongated inclusions. Free quartz is very abundant and a certain amount of felspar is visible. Microscopically, one sees much phenocrystic quartz and some andesine which has suffered albitization, together with a little orthoclase and some biotite. These are set in a crypto-crystalline groundmass which exhibits flow structure rather well.

Specimen 743 from Lennoxton is a dacite which consists of phenocrysts of quartz, which are often well crystallized, and andesine, set in a rough-feeling groundmass which is a devitrified pumice.

The next flow after 743 is a potash rhyolite of which 741 is a specimen. This is always of a red colour due to the presence of haematite which has developed by devitrification of a glassy rock. The haematite occurs in patches and the structure of the pumiceous groundmass is well displayed by the outline of the iron oxide patches. The felspars are clear and not albitized, and in addition to fairly abundant orthoclase there is some oligoclase.

Specimen 740 is from the felsite at Lennoxton which is near the top of the Volcanic Stage. The rock is light in colour, and has the rough feel characteristic of trachytes. In thin section it is seen to be almost entirely a devitrified pumice, in which are set phenocrysts of corroded quartz, albite (which is probably of deuteritic origin), and subordinate biotite.

Specimens 710 and 713 are from near the Paterson River at Summer Hill, being just at the top of the Volcanic Stage. These are phases of the same lava, the general nature of the rocks being dacitic. Some of the felspar is completely albitized but remnants of original andesine can be made out. The horizon from which these examples were taken is characterized by the variation which is found along the strike.

The green keratophyre which, as shown in the stratigraphy section, is generally at the top of the Volcanic Stage, possesses fairly constant petrographic characters, although there is a great variation in the colour of the rocks from place to place. In hand specimen the white felspar phenocrysts stand out well, and these are seen under the microscope to be albite. The groundmass is strongly pumiceous, and at times there are examples of autobrecciation. These rocks may be called tuffaceous soda rhyolites or keratophyres.

As examples of the tuffs of the Volcanic Stage we may take *Specimens 706 and 742*. The former is from near Summer Hill on the Paterson River, and is a dark-blue rock which is really a flow-breccia, consisting of fragments of felspar and quartz, and also of dacitic rocks included in a pumiceous groundmass or matrix which in places shows flow structure.

No. 742 is a quartz tuff which consists of quartz, albite orthoclase and biotite cemented by haematite and kaolin. In addition to the mineral fragments there are occasionally angular pieces of cherty rocks.

While considering the tuffs of the Volcanic Stage, brief mention can be made of the tuffs which make up such a large proportion of the Lower Portion of the Glacial Stage. *Specimens 705 and 712* are typical of these tuffs, both being from the Summer Hill locality. These are similar in general features, although differing in detail, the former, for example, containing much more in the way of rock fragments. Both rocks consist essentially of pieces of quartz, and plagioclase (often showing albitization), and fragments of glassy and cryptocrystalline rocks.

Paterson toscanite and associated lavas.

As was the case in the other areas, it is convenient to treat the rocks embraced under the above heading as a separate group. In addition to the toscanite, and the closely allied dellenite, we find in association, especially where there is more than one flow, soda rhyolites and certain slightly tuffaceous rocks. Probably the most important feature of this group for the present area, in comparison with the same group in the Paterson area, is the occurrence below the main mass of toscanite of a pitchstone, which shows a certain amount of devitrification. *Specimen 730* of this unit is of a reddish colour and possesses an irregular fracture. Phenocrysts of felspar and biotite can be seen quite clearly in hand specimen. Under the microscope the phenocrysts comprise quartz, andesine, biotite and magnetite. The first of these is somewhat angular in places, but generally corroded. The andesine varies in grain size but maintains a tabular habit. It is fairly fresh and any alteration seems to be the result of ordinary weathering. The mica is notably altered, being bleached and strongly resorbed at times, and the majority of sections show a pleochroism from golden yellow to deep brown. The groundmass is strongly haematitic due to devitrification, but the greater part is still glassy, and exhibits flow structure. The absence of pyroxene and amphibole phenocrysts is of interest and suggests that the rock is distinct from the pitchstones in the lower part of the Volcanic Stage. The rock also differs from many of the rhyolitic pitchstones which are found near Glenoak, and which contain no visible biotite. A chemical analysis is needed to discuss the relationship of this rock to the associated toscanites, but it is probable that a fair amount of orthoclase exists in the base.

Specimens 259 and 260 are from a spot about three miles west of Paterson where there seem to be at least two flows in association. The former is a toscanite, possessing a fawn colour, while the latter is a dellenite and possesses a dark blue colour. *No. 259*, when examined microscopically, shows individuals of quartz, orthoclase and strongly albitized plagioclase with occasional biotite, set in a groundmass which appears to have been devitrified. *No. 260* differs a good deal from the former and shows the presence of much biotite with quartz and the two feldspars, in a groundmass which exhibits excellent examples of fluidal fabric, and which possesses some pumiceous patches and a little tuffaceous material. There is no doubt of these rocks being of extrusive origin, and hence the importance of this evidence in relation to the problem of the mode of occurrence of the Paterson toscanite suite.

Near Bell's and elsewhere there are definite cases of the existence of two flows. *Specimen 737* is from the upper flow just north-east of Bell's house. It differs from the main mass in that there is more phenocrystic felspar and less quartz. The general features of the groundmass are similar in both cases.

Amongst the sedimentary rocks (excluding primary tuffs) there are many tuffaceous sandstones. No sections of these have been made, but macroscopic

examination gives some information about their constitution. Generally there are grains of quartz and felspar and tiny chips of fine-grained rocks cemented by argillaceous material, with a minor amount of haematite. Sometimes the haematite is strongly developed and characteristic red rocks result. Then again, in a few isolated instances there are examples of rocks which possess a siliceous cement.

Concerning the conglomerates one has to note that the matrix is often arkosic, and may have been derived entirely from detritus, or more generally may contain a certain amount of fragmental material derived from volcanic centres. In the case of the Bald Hill Series, biotite is quite an important constituent.

The general nature of the pebbles of the conglomerates has been indicated in the discussion of the stratigraphy and palaeogeography.

EXPLANATION OF PLATE I.

Geological Map of the Lamb's Valley-Paterson District.

A NEW *DELTOPECTEN* FROM THE ILLAWARRA DISTRICT, N.S.W.

By JOHN MITCHELL, late Principal of the Technical College
and School of Mines, Newcastle, N.S.W.

(Plate ii.)

[Read 30th March, 1927.]

DELTOPECTEN RIENITSI, n. sp. Plate ii, figs. 1 and 2.

Spec. chars. Equivalvular, very inequilateral, suboblique, outline suboblong. Right valve strongly convex, ears apparently subequal, transversed by numerous radii, lati-transverse folds of the anterior ear strongly arcuate, and distinct finer striae numerous; radials of the body fine, increased by interpolations, and before the ventral margin is reached are grouped into distinct fasciculi, consisting of six to ten radii in each bundle, the transverse striae are fine and echinate the radials where these are crossed by them; the wider growth lines have scalloped or wavy edges. Beak prominent, incurved, pointed and reaching beyond the hinge line. Left valve flattish, radials less numerous and convex and less distinctly fasciculated than those of the right valve; the beak, too, is much less prominent than is that of the right valve; the two valves are distinctly agape along the hinge line, resilium large. The anterior ear protrudes beyond the anterior end of the shell, and is strongly emarginate.

Dimensions: Length 7.2, width (depth) 4.5 cm.

This *Deltopecten* resembles *D. obliquatus* Ethr. and Dun. (*Mem. Geol. Survey, N. S. Wales*. Pal. No. 5, 1906) in several features but it differs from that species in having a large resilium, fasciculated radials, more apparent on the right valve than on the left; and less oblique in shape.

Loc.—Illawarra District.

Horizon.—Upper Marine beds. Permocarboniferous.

Dedicated to Mr. H. G. Rienits, of Mt. Victoria, N.S.W., who allowed me the privilege of describing this fine specimen and who also kindly presented the type to me.

THE FOSSIL ESTHERIAE OF AUSTRALIA. PART I.

By JOHN MITCHELL, late Principal of the Technical College
and School of Mines, Newcastle, N.S.W.

(Plates ii-iv.)

[Read 30th March, 1927.]

Introduction.

The earliest record (Cox, These PROCEEDINGS, 1880, p. 276) of the occurrence of fossil *Estheria* in Australia was made by Dr. J. C. Cox from the Moore Park Diamond Drill bore; and to this first specimen Dr. Cox gave the name *Estheria coghlini*, after Mr. John Coghlan of the Diamond Drill Company, who was directing the work of sinking the bore referred to, but he neither described nor figured the species. The species was subsequently described by the late R. Etheridge, Junr. (*Mem. Geol. Survey, N. S. Wales*, 1888, Pal. No. I, pp. 6-8, Pl. i, figs. 1-10). The next reference to the occurrence of fossil Estheriae in Australian rocks was also made by R. Etheridge Junr., who in 1892 referred some specimens of this genus, obtained from Denmark Hill, near Ipswich, Queensland, to *E. mangaliensis* Jones (Jack and Etheridge, *Geol. and Pal. Queensland and N.G.*, 1892, p. 387). In 1909 I recorded the discovery of Estheriae in the Newcastle coal measures (Notes and Exhibits, These PROCEEDINGS, 1909, p. 411-12).

In 1925 I referred to the presence of Estheriae in the Belmont chert (tuff) beds. (Descriptions of new species of *Leaia*, These PROCEEDINGS, 1925, p. 438.)

During the year 1890 I collected several specimens of Estheriae from the Wianamatta series near Glenlee, but did not record the find at the time.

It will be seen by the above record that the geologic range of *Estheria* has been considerably extended since 1892, which will be obvious from the following list of the series of rocks from which they have been collected to date, viz.:

1. Wianamatta Series, about 700 feet thick (Clarke) (but probably exceed 1,000 feet in the vicinity of Cobbitty).
2. *Estheria* Shales, about 610 feet thick (David).
3. Newcastle Coal Measures, 1,100 or more feet thick (David).

To complete the actual stratigraphical range of these fossils, the intervening series between the Wianamatta and the Newcastle Coal Measure must be included, as follows:

1. Wianamatta series, about 700 feet thick (Clarke).
2. Hawkesbury Sandstone, about 1,000 feet thick (Wilkinson).
3. Narrabeen Shales, about 650 feet thick (David).
4. *Estheria* Shales, about 610 feet thick (David).
5. Newcastle Coal Measures, about 1,100 feet thick (David).

The total thickness of these together exceeds 4,000 feet; but that does not by any means represent the full geologic range of these fossils in New South Wales as far as present knowledge discloses, for there are at least two gaps in the portion

of the geologic record shown above, and these represent a considerable length of time even from a geologic point of view. These gaps occur between the Wianamatta beds on the one hand, and the Hawkesbury Sandstones on the other, and again, between the *Estheria* Shales and the Newcastle Coal Measures.

That the gap between the close of the Hawkesbury Sandstone Series and the commencement of the deposition of the Wianamatta Series thereon represents a considerable length of time is shown by the extensive weathering the former had undergone before conditions arose to admit of the formation of the latter; and that the break between the Newcastle Measures and the subsequent deposition upon them of the Mesozoic measures represents a great length of time, is shown by the great changes in the fossil Flora ushered in with the Mesozoic deposits lying immediately upon the Newcastle measures. The length of this lapse of time is further emphasized when the denudation of the lower measures before the upper series began to be laid upon them is also considered.

The Mode of their Occurrence.

In the lower portion of the *Estheria* Shales and in the Wianamatta Series they occur in thin bands of impure clay ironstone. In the Newcastle Measures at Belmont and at Warner's Bay, they are found in cherts (tuffs). Judging by the fossils associated with them, it would appear that in each case they were dwellers in fresh, or slightly brackish waters. Those from Belmont and Warner's Bay occur as casts only; but those from Merewether Beach, Newcastle, from the *Estheria* Shales and the Wianamatta beds often have tests preserved. Those obtained from the *Estheria* Shales and the Wianamatta Beds are black and lustrous, but those from the Newcastle beds (Merewether Beach) are of a dun colour. It is not uncommon to find specimens with two valves conjoined, but never free from the matrix, so far as I am aware.

The variety of forms of *Estheria* obtained from the Newcastle Coal Measures is remarkable.

From Victoria, South Australia, West Australia and Tasmania, the occurrence of fossil *Estheria*, so far as I am aware, remains to be recorded.

Largely owing to imperfect preservation my attempts to obtain satisfactory microscopic enlargements of the ornamentations of the interspatial areas of the *Estheria* dealt with in the present paper have not been successful; therefore I decided not to make any special reference to these particular features of this interesting genus so well represented in the Upper Permian rocks of the Newcastle Coal measures of New South Wales.

ESTHERIA COGHLANI COX. Plate ii, figs. 3, 4, 5.

PROC. LINN. SOC. N.S.W. 1880, p. 276 (1881); Etheridge, Junr., *Mem. Geol. Surv. N.S.W.*, 1888, Pl. No. 1, Pl. i, figs. 1-10.

To Mr. Etheridge's description of this species nothing remains to be added. He was of the opinion that among the drawings and specimens examined by him there was a second species. On comparing his figures 1, 3, 6 with figures 8 and 9 that opinion seems to have good evidence to support it. After a careful study of a large number of the specimens from the *Estheria* beds, my view on the point in question agrees with that of Mr. Etheridge, but available evidence is not yet quite conclusive.

The range through geologic time of *E. coghlani* was considerable, for at least one specimen of it was obtained by me from the Wianamatta formation at Glenlee, thus affording evidence of its persistence throughout the Triassic formations as far as represented in New South Wales.

ESTHERIA IPSVICIENSIS, n. sp. Plate iii, figs. 1-4.

Estheria mangaliensis Etheridae (nec Jones), Jack and Eth., *Geol. and Pal. of Queensland and N.G.*, 1892, p. 387.

The late R. Etheridge Junr. described this species but did not figure it. He referred it to *E. mangaliensis* Jones. His description of it is as follows: "Valves broadly subovate, hardly convex; dorsal margin straight, about half the length of the valves, terminated at the anterior end by the umbones; anterior, posterior and ventral margins fully and broadly rounded, the anterior shorter than the posterior, rendering the valves narrower at the former of the two ends; umbones depressed; ridges twelve in number, but probably two or three more exist on each umbo, strong and well marked; interspaces wide, depressed, or perhaps very slightly concave, especially towards the ventral portion of the valves; reticulation not preserved. Length about three-sixteenths of an inch."

"Observations: This little fossil, the first *Estheria* found in the secondary rocks of Queensland, appertains to the group represented by such species as *E. mangaliensis*, *E. Forbesi*, etc., and in fact is so very close to the former in its general features, that I am constrained to consider it as identical, notwithstanding the absence of the reticulated surface in our fossil. It is particularly like Professor Jones' Pl. 2, fig. 16."

In the above description and observations there appear to be some inaccuracies which require correction; and to enable me to make these corrections I have through the courtesy of Mr. B. Dunstan, Chief Govt. Geologist, Dept. of Mines, Brisbane, before me the specimens used by Mr. Etheridge when making his description and determination of the *Estheria* under review.

In the first place the valves of the carapaces of this *Estheria* are said to be hardly convex, instead of being strongly so, when not flattened by external pressure. The interspaces are neither wide nor depressed, but narrow and convex, and flat near the ventral margin. Owing to the gradual way in which the dorsal margin merges into the posterior margin it is difficult to give the exact ratio which the dorsal margin of the Ipswich *Estheria* bears to the total length of its valves; but the following measurements taken with care will result in a fairly accurate estimate of the ratio being arrived at:

1. Length of dorsal margin and of valve 4 : 7 (No. 55 in Coll. Mitchell).
2. Length of dorsal margin and of valve 5 : 12 (Type, Geol. Mus., Brisbane).
3. Length of dorsal margin and of valve 4 : 9 (No. 53 Geol. Mus., Brisbane).

It may be noted here that in the case of three specimens of *E. mangaliensis* Jones (*Mon. Fossil Estheriae*, 1862, p. 78, pl. ii, figs. 16, 20 and 21), the ratios of the lengths of the dorsal margins and lengths of valves are 3:5, 1:3 and 7:18 respectively, exhibiting much variation. These proportions between the dorsal margins and the lengths of the respective valves do not support the identity of the Ipswich *Estheria* with the one from Mangali.

The anterior and posterior ends of the Ipswich *Estheria* are protrusively rounded, and in this respect differ from the Mangali species. The umbones are depressed only when distorted by pressure: ridges visible on mature Ipswich forms are twenty-two or more.

I consider this Ipswich *Estheria* to be a new species, and dedicate it to the locality or measures from which it was obtained.

It differs from *E. mangaliensis* (1) in having a more ovoid form, (2) a greater number of growth ridges, (3) in the individual specimens being more uniform in outline, (4) in having more protrusive anterior and posterior margins. From *E. forbesi* it is easily distinguished.

The illustrations of specimens of the species which accompany the present paper, so clearly show the important features of the species that the writer thinks it unnecessary to give further details except as to dimensions, which are as follows.

Plate iii, fig. 3, is from a specimen dealt with by Etheridge, who also examined the specimens shown on plate iii, fig. 4.

1. Length 5.0; width 3.0 mm. (Type, Geol. Mus., Brisbane).
2. Length 5.5; width 4.0 mm. (No. 27 Geol. Mus., Brisbane).
3. Length 6.0; width 5.0 mm. (No. 55 in Coll., Mitchell).

Loc.—Denmark Hill, Ipswich, Queensland.

Horizon.—Upper Triassic (Jack and Etheridge, Dunstan, Walkom and Tillyard).

ESTHERIA GLENLENSIS, n. sp. Plate ii, fig. 6.

Spec. chars.: Carapace transversely oval, dorsal margin mildly sagged, the other margins rounded, the anterior strongly so; beak prominent about five-eighths anterior, concentric striae nine or ten in number distinct, widely spaced; the whole carapace convex.

Dimensions: Length 4.0; width 3.0, mm., approx.

This species is easily distinguishable from *E. coghlani*. In some respects it resembles *E. mangaliensis* Jones (*Mon. Foss. Estheriae*, 1862, pl. ii, fig. 16), but differs from that species in (1) having many less growth ridges, (2) having a more truncate posterior margin, (3) a more protrusively rounded anterior margin, (4) being of smaller size, and in having wider spaces between the growth ridges; also in having a less variable outline.

The horizons in which the Mangali and the Glenlee Estheriae are found do not differ much in point of geologic time, therefore their identity would not have been surprising, if such had been proven.

Loc.—The species was obtained from a cutting on the Great Southern Railway near Glenlee Homestead.

Horizon.—Wianamatta series.

The fossils found associated with this *Estheria* consist of other Estheriae, plants belonging to the genera *Taeniopteris*, *Macrotaeniopteris*, *Thinnfeldia*, *Cladophlebis* and *Phyllothea*, all of which go to show that the Wianamatta Estheriae dwelt in fresh water.

ESTHERIA WIANAMATTENSIS, n. sp. Plate ii, figs. 7, 8.

Spec. chars.: Carapace small convex, transversely subelliptic; beak sub-central; ridges six or seven only visible, interspaces relatively wide; anterior and posterior margins protrusively rounded dorsal margin arcuate, ventral margin mildly rounded.

Dimensions.—Length 3.0; width (depth) 2.0 mm.

This may represent an immature specimen, but even if that be so, its tumid, almost centrally placed beak and transversely elliptic shape, separate it from other Australian species, and also from *E. minuta* Alberti.

Loc. and horizon.—As for *E. glenleensis*.

ESTHERIA NOVOCASTRENSIS, n. sp. Plate iii, figs. 5, 6.

Spec. chars.: Carapace, outline subquadrate, dorsal margin straight, anterior and posterior margins truncate, ventral margin widely and gently rounded; concentric striae about twenty in number, fine, evenly spaced; test appears to have been of delicate texture, and is much crinkled; beak anteriorly situated and prominent.

Dimensions.—Length 8; width 6 mm. Another L = 9 and width 6 mm. (These dimensions are greater than for any other fossil *Estheria* from the Newcastle Series.)

I know of no species with which this can be either compared or contrasted with advantage, though in the number of striae *E. forbesi* Jones, and the present form approximate.

Loc.—Merewether Beach, a short distance S.W. of the outflow of the Newcastle sewerage; between low and high tide levels.

Horizon.—A few feet below the Dirty Seam of coal of Newcastle Coal Measures, associated with various species of *Glossopteris*, and with *Phyllothea australis*. Upper Permian.

ESTHERIA LENTICULARIS, n. sp. Plate iii, fig. 7.

Spec. chars.: Carapace lenticular, small, smooth; beak subanterior, inconspicuous; concentric striae very fine six or seven in number, interspaces increase in width as they approach the ventral margin.

Dimensions.—Length 2; width 1.8 mm.

The smoothness of the carapace and its small size are the two leading features of this *Estheria*; the fineness of its concentric striae is also very noticeable.

The only Australian *Estheria*, which may be compared and contrasted with it, is *E. wianamattensis*. They are both of small size and have few concentric striae on their valves, but the species here dealt with has a more prominent and anteriorly situated beak than the other one has. The fineness of the striae and smoothness of the carapace of the present species strongly contrast with the similar parts of *E. wianamattensis*. It is not improbable that the Wianamatta species descended from the more ancient one from the Newcastle coal measures.

Loc. and horizon the same as for *E. novocastrensis*.

ESTHERIA TRIGONELLARIS, n. sp. Plate iv, fig. 6.

Spec. chars.: Outline subtriangular, convex, dorsal margin slightly sinuate, short; the other margins well rounded; beak about two-thirds anterior, very prominent, elevated; concentric folds distinct, fairly regularly spaced, from the end of the dorsal margin, the upper part of the posterior margin is depressed along its edge. The description above is made from a mould of a left valve.

Dimensions.—Length 7.0; width 5.0 mm.

Loc. and horizon the same as for *E. novocastrensis*.

ESTHERIA OBLIQUA, n. sp. Plate iv, fig. 1.

Spec. chars.: Transversely suboblong, convex, posteriorly obliquely protrusive, dorsal margin long, straight anterior margin short, sharply rounded and gently

sinuate near the beak, posterior margin truncate; beak anterior and prominent; concentric folds, strongly developed, twelve visible; but probably had sixteen or more; they are strongly geniculated where they cross the umbonal fold, and as they near the ventral margin, they are reduced to striae and are closer together. The ornamentation apparently is made up of small globular bodies.

Dimensions.—Length 7·0; width 5·0 mm.

The specimen described has the valves in apposition, the right being under the left as may be observed by an examination of figure which represents the type.

Loc. and horizon the same as for *E. novocastrensis*.

ESTHERIA LATA, n. sp. Plate iii, figs. 8, 9.

Spec. chars.: Obliquely subflabellate, convex, smooth near the umbonal area; dorsal margin straight, half as long as the length of the valves; anterior margin distinctly rounded, posterior margin rounded and obliquely sub-protrusive, ventral margin widely rounded. Concentric striae. Fourteen visible, fine and fairly distinct, and regularly spaced; beak inconspicuous, subanterior.

Dimensions.—Length 7·0; width 6·0 mm.

This is a very distinct species, easily separated from all other Australian forms discovered up to the present time; also it ranks among the largest of the fossil *Estheriae* from Australian palaeozoic rocks. In some respects it resembles some forms of *E. forbesi* Jones (*Mon. Foss. Estheriae*, Palaeontological Soc., 1862, p. 109, Pl. iv, figs. 8-9) in a general way; but specifically it is a distinct type.

Loc. and horizon.—Merewether Beach, near the Newcastle Sewerage outlet; just below the Dirty Coal Seam, Newcastle Coal Measures, Upper Permian.

ESTHERIA BELMONTENSIS, n. sp. Plate iv, fig. 5.

Spec. chars.: The carapace subquadrate, flattish, dorsal margin straight, relatively long. Under the dorsal line there is a flat area which resembles a hinge plate, and which is not usually observed in members of the *Estheria* group; anterior subtruncate, and the posterior one widely and mildly rounded; ventral margin gently rounded, beak anterior, and inconspicuous, concentric striae, nineteen or twenty in number, distinct and fine.

Dimensions.—Length 6·0; width 5·0 mm.

This species in some features bears a strong resemblance to *E. ipsviciensis*, which may be a descendant of the older Permian type.

Loc.—The chert (Tuff) quarries near Belmont, Parish of Kahibah, County Northumberland, New South Wales, associated with several species of *Glossopteris*, *Leaia* and Insects.

Horizon.—Upper Permian.

ESTHERIA GLABRA, n. sp. Plate iv, figs. 2, 3.

Spec. chars.: Left valve testless, transversely subelliptic; convex; test was apparently thin and delicate; dorsal margin very gently curved, anterior and posterior margins rounded, ventral margin mildly rounded; beak, three-fifths anterior, prominent; concentric ridges, only three or four clearly visible, but traces of others can be seen with the aid of a good lens.

Dimensions.—Length 4·0; width 2·0 mm.

Although a large part of the cast of the valve above described has a smooth appearance, there is slight evidence that the concentric striae on the original test

were more numerous than are at present visible. Its much elongated subelliptic shape separates it from other Australian *Estheria*. The sparsity of its visible striae is another distinguishing feature. The type is a unique specimen.

Loc. and horizon the same as for *E. belmontensis*.

ESTHERIA LINGUIFORMIS, n. sp. Plate iv, fig. 4.

Spec. chars.: Carapace obliquely flabellate, and flattened along the borders of the postero-ventral margins. Dorsal margin straight and long, anterior margin short and rounded; posterior one wide and gently rounded; beak anterior, inconspicuous; concentric striae about eighteen in number, obliquely directed towards the postero-ventral margins, fine and compacted near the umbo and towards the postero-ventral margins, intermediate of these two areas they are distinct or ridged.

Dimensions.—Length 5.0; width 4.0 mm.

The above description of the type is made from a mould of a nearly perfect right valve.

This species, like *E. belmontensis*, bears some resemblance to *E. ipsviciensis*, so much so, indeed, as to make the assumption that the former is directly ancestral to the latter, not an unreasonable one.

The distinguishing features of this form are (1) its anterior beak, (2) long straight dorsal margin, (3) narrow anterior margin, and (4) wide posterior margin.

Loc. and horizon the same as for *E. belmontensis*.

ESTHERIA (?) BELLAMBIENSIS, n. sp. Plate iv, figs. 7, 8.

Spec. chars.: carapace sub-oblong, very inequilateral. Dorsal margin very long and straight, anterior and posterior margins gently rounded, or subtruncate; ventral margin subparallel to the dorsal one; beak, anterior, inconspicuous; concentric striae arranged in two sets—a wide apart set, and between each pair of these, finer ones occur, very numerous; the valves are convex.

Dimensions.—Length 10.0 mm.; width 6.0 mm. approximately.

If this fossil is an *Estheria*, it exceeds in size all other Australian species of the genus. In the character of its growth lines it resembles some *Unionella*; but of three specimens known, each has a length of approximately 10.0 mm., and appears to be mature. This length is much less than any mature *Unionella* possesses. The straight hinge line of the present fossil clearly separates it from molluscan of that group. In shape, size and surface ornamentation *E. bellambiensis* resembles the *E. striata* group. The length of the carapace of the species under discussion exceeds that of all other *Estheria*e known to me from palaeozoic rocks.

Locality.—The north side of the railway line connecting the South Bulli (Bellambi) Colliery with the staiths at Bellambi roadstead, associated with various species of *Glossopteris*.

Horizon.—About 150 feet below the seam of coal worked in the South Bulli Mine, and in stratigraphical position near to the Belmont Insect and Phyllopora beds. Upper Permian.

My hearty thanks are extended to Dr. C. Anderson, Director of the Australian Museum, Sydney, for placing at my disposal for examination a number of recent *Estheria*e. To Mr. W. S. Dun, Palaeontologist, Department of Mines, Sydney; and to Mr. Booker, of the same Department, I tender sincere thanks for valuable aid extended to me while preparing the present paper. I am thankful to Mr. H. G.

Gooch, Photographer for the Department of Geology, University of Sydney, for some excellent photos of specimens dealt with in this paper, and lastly I am indebted to my friend T. H. Pincombe, B.A., of New Lambton, for the privileges of examining the Estheriae collected by Mrs. Pincombe and himself.

I wish to point out that in my paper on "Descriptions of New Species of *Levia*" (These PROCEEDINGS, 1925, pp. 438-447) I have made a mistake in orienting the valves of the carapaces. I find that all right valves are designated left and the left valves right.

EXPLANATION OF PLATES II-IV.

Plate ii.

1. *Deltopecten rienitsi*, n. sp. right valve.
2. *Deltopecten rienitsi*, n. sp. left valve.
3. A right valve of *Estheria coghlani* Cox somewhat pressed into the left valve. From Cremorne bore. $\times 8$. Coll. Dept. of Mines, Sydney.
4. *Estheria coghlani* from Dent's Creek bore. $\times 10$. Coll. Mitchell.
5. *Estheria coghlani* from Glenlee (Wianamatta Series). $\times 14$. Coll. Mitchell.
6. *Estheria glenleensis*, n. sp. $\times 12$. Coll. Mitchell.
7. *Estheria wianamattensis*, n. sp. $\times 12$.
8. *Estheria wianamattensis*, n. sp. $\times 14$.

Plate iii.

1. *Estheria ipsviciensis*, n. sp. Left valve. $\times 8$. Coll. Mitchell. Presented by the Dept. of Mines, Brisbane.
2. *Estheria ipsviciensis*, n. sp. Left valve. $\times 10$. A good specimen. Coll. Dept. of Mines, Brisbane, No. 53.
3. *Estheria ipsviciensis*, n. sp. Left valve (depressed). $\times 10$. This valve was one dealt with by R. Etheridge Junr. as *E. mangaliensis*. Coll. Mines Dept., Brisbane.
4. *Estheria ipsviciensis*. The photograph shows two individuals on the same stone. They were examined by R. Etheridge Junr. (*loc. cit.*) $\times 10$. Coll. Dept. of Mines, Brisbane.
5. *Estheria novocastrensis*, n. sp. Left valve. $\times 5$. Coll. Mitchell.
6. *Estheria novocastrensis*, n. sp. Left valve. $\times 5$. Coll. Mitchell.
7. *Estheria lenticularis*, n. sp. $\times 12$. Coll. Mitchell.
8. *Estheria lata*, n. sp. $\times 6$. Coll. Mitchell.
9. *Estheria lata*, n. sp. Left valve. $\times 5$. Coll. Mitchell.

Plate iv.

1. *Estheria obliqua*, n. sp. Left valve. $\times 10$. Coll. Mitchell.
2. *Estheria glabra*, n. sp. Left valve. $\times 12$. Coll. Mitchell.
3. *Estheria glabra*, n. sp. A mould of right valve showing a more ovoid form than Fig. 2. $\times 9$.
4. *Estheria linguiformis*, n. sp. Right valve. Coll. Mitchell.
5. *Estheria belmontensis*, n. sp. $\times 7$. Coll. Mitchell.
6. *Estheria trigonellaris*, n. sp. Left valve. $\times 7$. Photo from a mould. Coll. Mitchell.
7. *Estheria* (?) *bellambiensis*, n. sp. $\times 6$.
8. *Estheria* (?) *bellambiensis*, n. sp. A pair of fragmentary valves joined along the hinge. $\times 6.5$. Coll. Mitchell.

(The photographs by H. G. Gooch, J. A. Booker and J. Mitchell.)

A NOTE ON A DICOTYLEDONOUS FOSSIL WOOD FROM
ULLADULLA, NEW SOUTH WALES.

By C. BARNARD, B.Sc., Demonstrator in Botany, University of Sydney.
(From the Botanical Laboratories, University of Sydney.)

(Plates v and vi, and six Text-figures.)

[Read 30th March, 1927.]

Introduction.

The subject of this communication is a piece of fossil wood of a dicotyledon. It was found by Miss Brown of the Geology Department, University of Sydney, in a silica quarry at Bannister Head, near Ulladulla, New South Wales.

The author published a brief descriptive note of this fossil in connection with Miss Brown's paper on the Tertiary Formations on the South Coast of New South Wales.⁽²⁾¹ It seems desirable that a fuller account of this interesting specimen, supplemented by figures and photographs, should be recorded in order that its systematic position may be ascertained.

Two fossil Angiosperm stems, with structure well preserved, have previously been described from Australia. Sahni⁽⁶⁾ has published a description of two stems from the Tertiary of Queensland. One, *Petaloxylon scalariforme*, from Mt. Meershaum, near Nerang, is peculiar in that the chief conducting elements are large scalariform tracheids. The medullary rays are 1-3 seriate, twenty-five to thirty cells in height and pursue a sinuate radial course. The other, *Petaloxylon porosum*, has essentially the same structure except that true vessels are also present. Nobes⁽⁵⁾ records the discovery of four petrified stems from some Tertiary Brown Coal deposits in South Australia. The preservation of these was so poor that no description was published.

A great number of leaf impressions have been described by Ettinghausen⁽⁸⁾ and Deane.^{(3) (4)} These remains, which have mostly been derived from Tertiary

¹ The silica beds, in which the specimen was found, were formerly believed to be of Permo-Carboniferous age and the silicification was thought to have been effected by the intrusion of volcanic dykes (Harper).^{(8) (9) (10)} Miss Brown⁽²⁾ has lately proved that these strata are of Tertiary age and has shown on reliable geological evidence that silicification has been effected by later Tertiary basalts.

These "silica rocks" occur in patches, associated with clays and sandstones, in the Milton-Ulladulla district on the South Coast of New South Wales, overlying beds of Upper Marine age. At Bannister Head there is a slight angular unconformity between the later sediments and the underlying Permo-Carboniferous strata; and also at Pattimore's Lagoon deposit, as well as at Bannister Head, remnants of the basalt flows are evident in the form of capping sheets.

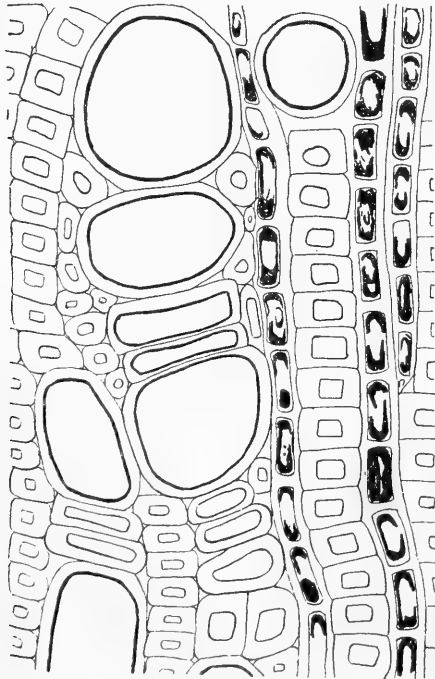
Petrographic studies by Miss Brown of the olivine basalt composing these lavas have established the correlation between the flows in this region and other Tertiary basalts of the State. Though the exact age of these "Tertiary Olivine Basalts" has not been definitely determined, it is generally held (Sussmilch)⁽²⁰⁾ that they belong to the Upper Miocene or Pliocene period. The deposition of the underlying silica beds must then be assigned to the Lower Tertiary Period.

deep leads, come from the same period as the Ulladulla fossil and give an indication of the Angiosperm flora existing at that time.

Ettinghausen has described fruits as well as leaf impressions of *Casuarina*, *Persoonia*, *Grevillea*, *Hakea*, *Lomatia*, *Dryandra*, *Callicoma*, *Ceratopetalum*, *Pomaderris*, *Eucalyptus*, *Santalum*, *Myrica*, *Quercus*, *Alnus*, *Acer*, *Aralia*, *Cinnamomum*, *Fagus* and *Elaeocarpus* from Vegetable Creek, near Emmaville, New South Wales. These, it will be observed, include many endemic genera as well as representatives of the Malayan flora.

The same author has described many types from Dalton, near Gunning, New South Wales. Deane^{(3) (4)} has identified a number of leaf impressions from the clay beds at Mornington, Berwick, and Wonwron, Victoria; R. M. Johnston^{(11) (12)} describes similar impressions from the Lower Tertiary of Tasmania.

These remains have, with few exceptions, all been referred to existing genera. In some cases the resemblance between fossil forms and living species is so close that the affinity has been expressed in the specific name given to the fossil. *Eucalyptus pre-coriacea* from the Lower Tertiary, for example, is almost identical with the existing species "*coriacea*." From this evidence it will be observed that the flora of the Lower Tertiary was very similar to that existing at present.



1

Text-figure 1.—Representation of portion of the transverse section (slightly diagrammatic), showing the seriation of the vessels and fibres; illustrating particularly the thickness of the walls of the vessels and fibres. $\times 280$.

Description.

Material. The specimen consists of a fragment of secondary wood preserved by the agency of silica. It measures roughly 8 cms. by 4 cms. The end, which is cut transversely, shows regular and well developed annual rings. The curvature of these indicate that the piece of wood was about two and a half inches from the centre of the stem and that the stem had a minimum diameter of five inches. The structure of the wood is well preserved. Unfortunately the specimen does not show any pith or bark.

Microscopic Description.

Diagnosis: The wood has a fine texture. Annual rings developed. *Vessels* numerous, circular, in radial series or isolated; bordered or scalariform pitting, mostly porous perforate, tertiary bands present, slightly stratified, average diameter 0.1 to 0.075 mm.; average of 50 per sq. mm. *Wood fibres* form the ground tissue of xylem, thick walled, size variable, arranged in regular radial series. *Wood parenchyma* cells abundant, rectangular, vertical height, 0.04 mm., width 0.25, occurring in vertical series. *Medullary rays* numerous, diffuse, biseriate, rarely uniseriate, 10-15 cells in height, heterogeneous, cell walls thick with simple oval or circular pits.

General: The vessels are of medium size and are evenly distributed throughout the wood. The wood fibres compose the bulk of the wood and are very thick walled. The vessels in the spring have a diameter up to 0.16 mm. These become gradually smaller till at the end of the annual ring in the autumn the average diameter is 0.04 mm. Parenchyma cells are abundant, diffuse and mostly situated at the end of the annual rings, almost forming metatracheal bands. The medullary rays are very uniform in height. The vessels and wood fibres are arranged in regular radial series.

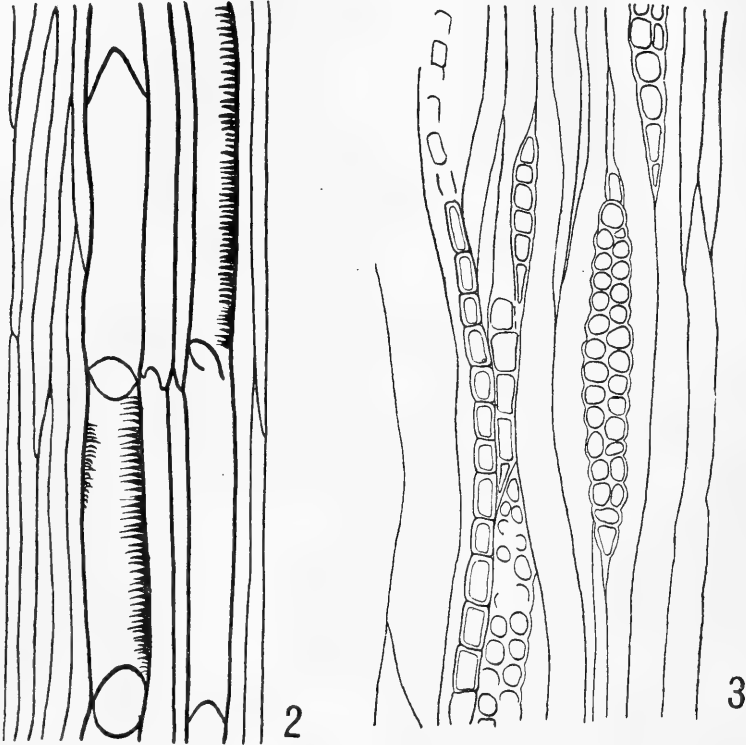
Details of Elements:

In transverse section the *Vessels* show an approximately circular configuration. They occur singly or in pairs or in radial rows up to ten in number. In these latter cases the tangential walls are flattened (Text-fig. 1 and at *b* in Fig. 1, Plate v). The average diameter is 0.075 mm. The average diameter of the spring elements is 0.13 mm. and the autumn average is 0.05 mm. The walls are thick. In longitudinal section the sculpturing on the walls consists of regular series of small oval bordered pits in horizontal rows (Text-fig. 4c and Fig. 2, Plate v). The borders of the pits are narrow.

The large vessel in the centre of Fig. 2 Plate v shows this type of pitting very well. In some cases the coalescing of the pits gives rise to a close scalariform sculpture. This feature is apparent in the large vessels in Fig. 3 Plate vi and appears, in fact, to be the dominant type. The internal spiral bands of thickening, termed tertiary thickenings, are also present in many of the vessels.

The average length of the vessel segments is 0.6 mm. The two segments, illustrated in Fig. 3 Plate vi, are typical and each of these has a length of 0.6 mm. The majority are of the porous end-wall type (Text-figs. 4c and 6 and Fig. 2 Plate v and Fig. 3 Plate vi). The septa in these elements are short and distinct; they are almost at right angles to the longitudinal walls of the vessel. Each is perforated by one large pore. A few vessels exhibit a number of elongated pores on the end-wall. These are examples of the scalariform perforate type. In some

cases the so-called "imperfect perforation" is present. The end-walls in vessels, which show this feature, are very oblique and numbers of bordered pits occur on them together with one or two large perforations (Text-fig. 4 *a* and *b*). Vessels with end-walls of this nature are longer and have a smaller diameter than the neighbouring vessels with the porous type. No tyloses were observed. The vessels appear to be more or less stratified or storied.



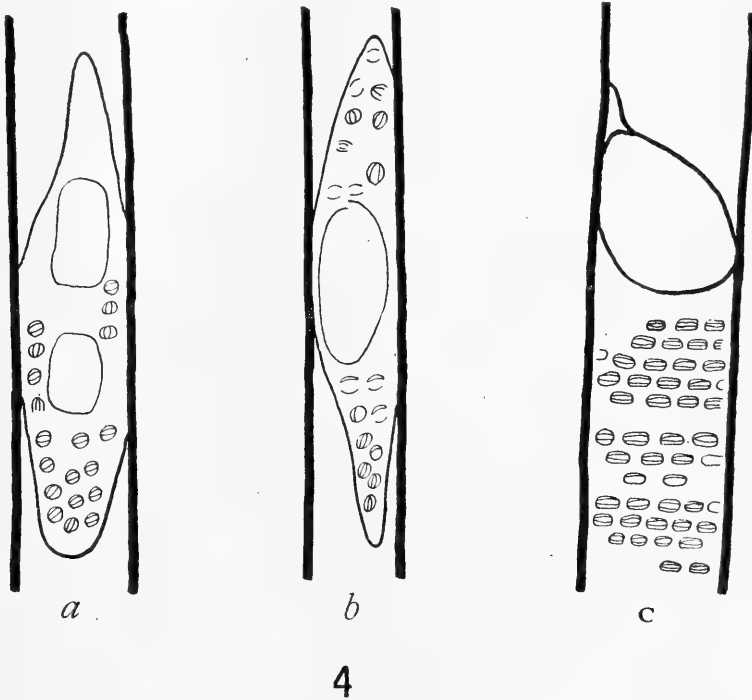
Text-figure 2.—Representation of portion of the radial longitudinal section showing the vessels in detail. An indication of a close scalariform sculpturing is apparent on the lateral walls of several porous end-wall types of vessels. $\times 80$.

Text-figure 3 represents a portion of the tangential longitudinal section showing the medullary rays in detail together with vessels and fibres. On the left there is a series of parenchyma cells with the original thickness of the walls preserved. $\times 165$.

The *wood fibres* vary considerably in diameter and length. The average diameter is 0.02 mm.-0.01 mm. Very often the tangential diameter is greater than the radial. In general the walls seem thin (Text-fig. 2), but this appearance is due to the fact that it is really the junction line between contiguous fibres which represents the wall. In places where the preservation of the structure is more perfect and the true thickness of the wall is shown it presents a very characteristic appearance. The nature of the fibres is seen at *a* in Fig. 1 Plate v. The lumen

represents only one-third or one-fourth of the diameter. No pitting could be observed in the longitudinal aspects of these elements. They are regularly seriated in a radial direction.

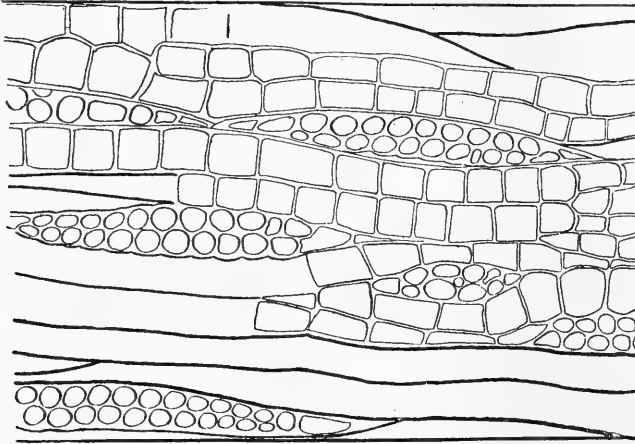
The *wood parenchyma* cells are seen to best advantage in the longitudinal sections (Text-figs. 3, 4 and 5 and Fig. 3 Plate vi). They occur in vertical series and are most abundant in the region of the autumn wood. There are as many as forty cells in one series. The average vertical height of each cell is 0.040 mm. and the average width in tangential and radial aspect is 0.025 mm. The pitting on these cells was not observed. The walls are comparatively thick. In some instances black carbonaceous material is apparent in the cell cavity.



Text-figure 4.—Illustrating the types of end-wall found in the vessels in radial longitudinal section. In *a* and *b* the end wall is of the imperfect perforate type. At *c* is shown a typical porous perforation in a vessel, which shows multiseriate pitting on the vertical wall. $\times 280$.

The *medullary rays* are numerous and diffuse, heterogeneous and without exception uniseriate or biseriate. The vertical height of the ray is also a definitely characteristic feature. They are relatively short. The biseriate type of ray is predominant and in tangential section generally contains 20 to 30 cells (Text-figs. 3 and 5 and Fig. 4 Plate vi). These rays are therefore about 10 and 15 cells in height. The two rows of cells, comprising the width of the ray in tangential view, alternate. The uniformity of the width of the ray is one of the most interesting features of the stem. The individual cells have a vertical height of 0.02 mm. and are approximately 0.07 mm. in radial length (Text-fig. 6). In

tangential view they appear rounded with an average diameter of 0.02 mm. A large amount of black carbonaceous matter is present in the cell cavity (Fig. 4 Plate vi). In places the pits on the walls of these cells may be distinguished in the radial longitudinal section. They are more or less rounded and simple. The walls of the ray cells contiguous to other ray cells are thick and are pitted in the same manner. These pits could be observed in section as well as in surface view (Text-fig. 6).



5

Text-figure 5.—Representation of portion of the tangential longitudinal section of the autumn wood showing an abundance of wood parenchyma series. $\times 165$.

Systematic Position.

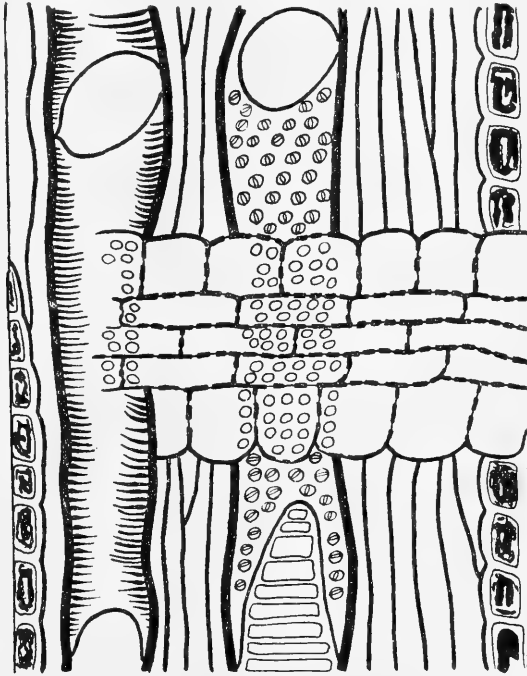
Our knowledge, at present, of the systematic anatomy of the dicotyledonous stem is meagre. On this account the affinities of a fossil stem may be satisfactorily determined, only when very distinctive features are observed.

Fliche,⁽⁷⁾ Lignier,⁽¹⁴⁾ Stopes and Fujii,⁽¹⁸⁾ Stopes,⁽¹⁹⁾ Krausel,⁽⁴³⁾ Bailey,⁽¹⁾ and Edwards,⁽⁶⁾ have described dicotyledonous stems from the Cretaceous and Tertiary in other parts of the world. Each of these authors has named the fossils described, after the woods of the living genera, which they most closely resemble. In this way the affinities of the specimens have been indicated. In the case of the Ulladulla fossil it has been found that the structure indicates an affinity with a certain Natural Order and not with one particular genus. There is a very close resemblance between the woods of the various genera of this Natural Order. On this account it is not possible to select one genus, which has a preeminent affinity with the fossil. The writer therefore has not followed the precedent established by the authors quoted above, but deems it wisest only to indicate the apparent systematic position of the specimen.

The characters of every Order upon which information is available⁽¹⁷⁾ have been carefully considered. Representatives of certain orders show similarities to the fossil but differ in important details. Types of the Schizandreae group of the Magnoliaceae, for example, possess a very similar combination of wood structures,

but differ in the fact that the medullary rays characteristically have a great vertical height. Certain genera of the Natural Orders Bixineae, Euphorbiaceae, Anacardiaceae, and Rutaceae have somewhat similarly constituted woods. These particular genera, however, are not represented in the present-day Australian flora. As a most striking resemblance is evident between the wood of the fossil and the woods of an Order, which is widely distributed in Australia, it seems that the similarities referred to above may be disregarded.

The writer has examined figures, descriptions or actual sections of representative woods of most of the natural orders found in Australia. The Saxifragaceae alone possess the same type of wood structure as that exhibited by the fossil. The combination of wood structures, which are characteristic of this



6

Text-figure 6.—Diagrammatic representation of a radial longitudinal section. All the features depicted may be clearly observed in certain places in the sections. The heterogeneous nature of the medullary ray is shown and the nature of the pitting on the various elements. $\times 280$ approx.

order, seems to be identical with the combination of structures present in the fossil. The regular radial seriation of the vessels, the occurrence of scalariform perforate end-walls in the vessels, as well as the narrow, heterogeneous, and uniform medullary rays are characteristic features of the woody genera of this order. For these reasons the writer tentatively places the Ulladulla specimen in the Natural Order Saxifragaceae.

I am indebted to Mr. Welch, of the Technological Museum, for allowing me to examine photo-micrographs of the woods of certain representatives of this order,

which I could not easily obtain in the living state. *Weinmannia*, *Ackmana*, *Schizomeria*, *Quintinnia*, *Callicoma*, and *Ceratopetalum* show a remarkable resemblance to the fossil. In the case of *Ackmana* the structures were almost identical.

In conclusion, I wish to thank Professor A. A. Lawson for advice in the preparation of the text, and Mr. Welch for the above-mentioned assistance. I am indebted also to Dr. Carl Boesen and Mr. R. Murray, B.Sc., for the photomicrographs reproduced.

Summary.

1. The specimen described was obtained from the "Silica" beds at Bannister Head, near Ulladulla, on the South Coast of New South Wales. These beds are of Lower Tertiary age.

2. The specimen is a piece of silicified secondary wood.

3. The structure of the wood is that of a typical dicotyledon, and shows a very close agreement with that of the Natural Order Saxifragaceae. The author tentatively places the specimen in this Order.

I have endeavoured to represent the nature of the individual elements accurately though a certain latitude has been taken in making the drawings. In Text-fig. 2, for instance, the medullary rays have been omitted in this radial longitudinal representation in order that the vessels may be seen more clearly. Further a uniform state of preservation is not present throughout the specimen; and irregularities in preservation render it impossible to depict the true character of all the elements in a drawing with the camera lucida. The less obvious details of structure in the various elements may not all be observed in one place in the section. For these reasons it was thought advisable to draw together features which could be definitely recognized into two diagrammatic figures (Text-figs. 1 and 6).

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EXPLANATION OF PLATES V and VI.

Plate v.

1. Photo-micrographic representation of portion of the transverse section. The vessels are clearly seen and in places the wood fibres are visible. Fibres are well shown at *a*. The cellular structure of the numerous and narrow medullary rays is not distinguishable. These cells are filled with carbonaceous material. $\times 200$.
2. Photo-micrographic representation of radial longitudinal section. The principal feature is a large vessel showing a large terminal porous perforation and multi-seriate pitting on the lateral wall. The wood fibres may be seen and also indications of the medullary rays, which are poorly preserved in this portion of the stem. $\times 200$.

Plate vi.

3. Photo-micrographic representation of a radial longitudinal aspect showing two large vessels with porous perforations. Medullary rays are seen crossing the vessels. On the lateral walls of the vessels portions of the scalariform type of sculpturing are discernible. $\times 200$.
4. Photo-micrographic representation of the tangential longitudinal section. This shows the medullary rays. At *a* a series of wood parenchyma is evident. $\times 200$.

ON A CASE OF NATURAL HYBRIDISM IN THE GENUS *GREVILLEA*
[N.O. PROTEACEAE].

By C. T. MUSSON and the late J. J. FLETCHER, M.A., B.Sc.¹

(Plate vii.)

[Read 30th March, 1927.]

In the Abstract of Proceedings dated 30th July, 1913, is given a short account of a case of hybridism between two species of Blue Mountain *Grevillea* by the late Mr. J. J. Fletcher. He contended, with many facts, much detail and a large range of specimens, that *G. Gaudichaudii*, R.Br., consists of a series of transitional forms between *G. laurifolia*, Sieb., and *G. acanthifolia*, A.C. That the entire series known as *G. Gaudichaudii* is a series of variable naturally related forms, explainable only as being hybrids between the two other species mentioned. That the two parent-species are markedly contrasted in most of their morphological characters, in their habit of growth, in being members of two different plant associations, consequently in their habitats; cross-pollination being possible, however, by reason of comparative proximity, and because the racemes of both are of the same pattern (elongated, secund and centripetal); moreover, the conditions favouring cross-pollination arise only at or close to the boundary between their respective habitats; consequently they are usually found in company with one or other, or both the parent-forms.

G. Gaudichaudii has no specific characters; being of mixed origin, the characters are inherited, being blends or mixtures of those of the parent-forms. They are the first Australian, Proteaceous, wild hybrids recorded. They are not infertile, but they rarely reproduce themselves, because likely to be overlooked by visiting birds (the natural agents in pollination) or are likely to be pollinated from one of the parent-forms. (C.T.M. and J.J.F.)

Historical.

During the stay of the French corvette *Uranie*, engaged in a scientific voyage round the world, in command of Captain Freycinet, in Port Jackson, in November and December, 1820, Gaudichaud, the botanist of the expedition, made a fruitful excursion to Bathurst. Among the most important botanical additions to his collection was a rare, undescribed *Grevillea*, probably the only plant of its kind seen by him. It was obtained on the Blue Mountains, at "Vallée de Jamison."

¹ This paper is the outcome of an examination of extensive notes on the subject left by the late J. J. Fletcher and has been prepared for publication at the request of Mrs. Fletcher. Having had the opportunity to assist in the field work, knowing Mr. Fletcher's views, having examined the species in the field and worked over the collected specimens, I can endorse fully the detail and conclusions given. Except where indicated, this paper is copied directly from Mr. Fletcher's notes.—C. T. MUSSON.

But Gaudichaud did not go far enough from the Western Road to see the Jamison Valley which, at that time and for long afterwards, was inaccessible from the main road. What he means, we may fairly well conclude, was the little valley and its tiny rill of water visited by C. Darwin.² (It seems quite probable that Gaudichaud when at The Weatherboard on his way to Bathurst took advantage of the short time at his disposal to take the (probably) one walk that presented itself, and which was later taken by C. Darwin. This is an interesting conjecture, and is quite likely correct, for in those early days there were no side roads opened up and any visitor would doubtless be directed, when the coach stopped at The Weatherboard, the old name for Wentworth Falls, to the one track, apparently between what is now known as King's Tableland, and the more westerly spur at the end of which now exists the Wentworth Falls Hotel. The tiny creek runs approximately south from the township and falls over the cliff as described by Darwin. Gaudichaud could not have collected his plant in the Jamison Valley; but on the high ground overlooking it; somewhere along the valley mentioned above.—C.T.M.)

On his return to Paris, Gaudichaud gracefully presented a portion of his specimen to Robert Brown, who subsequently described it in the *Suppl. Prod.* (1830) under the name of *G. Gaudichaudii*, R.Br.

In the meantime the scientific records of the voyage of the *Uranie* had been in preparation and Gaudichaud wished to include a description of his new *Grevillea* in the botanical part of the work, which was eventually published in 1826. This description, the earliest to be published, is usually quoted as if it were R. Brown's.

From a comparison, internal evidence shows it is evidently Gaudichaud's own description that he gives. Brown may or may not have sent him a copy of his proposed description. But as Gaudichaud's specimen was not exactly a duplicate of the one he had parted with, and he wished to figure it, he evidently described his own specimen, adopting R. Brown's name.

Forty years later Bentham redescribed *G. Gaudichaudii* more fully than had his predecessors (*Fl. Aus.*, V, p. 438); but unfortunately for those who came after him, he apparently did not see R. Brown's specimen, nor specimens like them and in drawing up his description he omitted to make provision for any but his own. The consequence is that both the status and the identity of *G. Gaudichaudii* are left in doubt. If we are to take Bentham's description as the standard for determining *G. Gaudichaudii*, then the specimens of R. Brown are not that species, and we are given no clue as to how they are to be disposed of. It seems remarkable that Bentham apparently did not himself realize this anomaly.

Modern Details.

At the meeting of this Society in July, 1910, in response to an invitation issued at a previous meeting asking members who had collected, or who had in their possession specimens of *G. Gaudichaudii*, four members brought specimens, some

²"In the middle of the day (1844) we baited our horses at a little inn called The Weatherboard. The country here is elevated 2,800 feet above the sea. About a mile and a half from this place there is a view exceedingly well worth visiting. Following down a little valley and its tiny rill of water, an immense gulf unexpectedly opens through the trees which border the pathway, at a depth of perhaps 1,500 feet. Walking on a few yards, one stands on the brink of a vast precipice, and below one sees a grand bay or gulf. . . . About 5 miles distant in front, another line of cliffs extends, which thus appears completely to encircle the valley."—Darwin's *Naturalist's Voyage Round the World*, 1845, p. 523.

of them from the Botanic Gardens Collection. The joint collection then exhibited was, almost certainly, the best at the time in Australia. Three collectors had obtained plants which answered to the descriptions of Brown and Gaudichaud; but no plant was produced which corresponded with Bentham's description. Since then I have devoted my brief holidays to the further study of these plants under natural conditions, and have now (1915) a much better collection than that exhibited in 1910; but I have not yet found a single plant to which Bentham's description will apply. Nevertheless I raise no doubt as to the correctness of Bentham's descriptive details, though I think one of his inferences was made under a misapprehension, due to want of knowledge not determinable from the examination of herbarium specimens alone; and that this is open to correction. I believe I am now in a position to offer a solution of the difficulties which arise from the conflicting descriptions.

The Conflicting Descriptions.

The three descriptions mentioned, together with a note by Mr. J. H. Maiden, which was not intended to be descriptive but to put on record some observations of the late Mr. W. Forsyth¹ on living plants, comprise all the literature about *G. Gaudichaudii* available.²

Brown refers to some MS. notes of Allan Cunningham's, at the end of his description in which the species is referred to under the MS. name *G. acanthifolia* var. *quercifoliae*. Unfortunately Cunningham's notes were not published. There is no mention of the species in his "Specimen of the Indigenous Botany of the Mountainous Country between Sydney and Bathurst" (Field, 1825), though *G. acanthifolia* was first described in this paper; or in any other of his published writings as far as I know.

Dr. Woolls and Baron von Mueller, as far as I can ascertain, never found any occasion to refer to it.

In order, therefore, to make clear how some specimens I have now collected come in, in an important way, I preface an account of these with a brief statement of the whole case, based chiefly upon a comparison of the descriptions of *G. Gaudichaudii* by Brown, Gaudichaud and Bentham, supplying necessary comments.

Though not first in chronological order, I begin with R. Brown's description.

One minor correction needs to be made, otherwise the description is satisfactory as far as it goes; having no knowledge of the habit of *G. Gaudichaudii*, he naturally took the spikes to be erect. The plants are prostrate, as pointed out in Mr. Maiden's note, and the spikes are more or less horizontal as in *G. laurifolia*; and, as in that species, frequently rest upon the ground.

From a comparison of the descriptions of *G. Gaudichaudii* and *G. acanthifolia*, it is evident that R. Brown considered *Gaudichaudii* to be distinguishable from *acanthifolia* by the scattered appressed hairs on the underside of the leaves, by their simpler lobing, by the presence of an intra-marginal vein, by the racemes not being so dense and by the perianths having less clothing (sericeous as compared with very villous). The term sericeous, however, in the specimens I have seen applies only to the white silky hairs; but besides these there is some hairiness tinged with the colour, dark crimson, of the perianth as in *G. laurifolia*. If the white silky hairs could be removed the perianth would not be glabrous.

¹ These PROCEEDINGS, 1904, p. 749.

² Written between 1913 and 1918.

From my point of view, the condition in question is the result of a mixture of the corresponding characters of *G. laurifolia* and *G. acanthifolia* when these two species are crossed.

One other point, the lobes of the pinnatifid leaves are described as entire, a character in which R. Brown's specimen differed from that described and figured by Gaudichaud. Portions of plants showing this character may be procured without difficulty, but in all plants of the *Gaudichaudii* group (see ii below) that I have seen, if all the leaves are examined, some of them will be found to offer indication of secondary lobing. Brown's and Gaudichaud's specimens may, therefore, have been different portions of the same plant, and yet offer the differences recorded. Finally R. Brown definitely recognized that the racemes and flowers were not exactly like those of *G. acanthifolia*.

Turning to Gaudichaud's description (he saw both species in the living condition), it is evident he did not copy the descriptions of Brown, but drew up his descriptions independently. He recognized, like Brown, the differences in the indumentum of the leaves, in the lobing of the leaves, in the clothing of the perianth (sericeous in one case, tomentose in the other), but he used the wrong adjective in both cases in describing the pistils; the styles are glabrous in both cases, but the ovaries are villous in both cases.

A very interesting and important omission, however, is that of the presence of the intra-marginal vein. If he had had the opportunity of seeing the leaves of *G. laurifolia* (which he apparently did not collect), its presence might have struck him. From this omission, and the mistake about the pistils, as well as in other small details, it seems clear to me, that R. Brown did not write this description, and that in all probability Gaudichaud did not see a copy of R. Brown's before his own was published. He gives a good figure of a portion of a stem or branch with nine leaves, having 5, 7, 8 and 9 lobes; and two spikes which are evidently not exactly like those of *G. acanthifolia*; whilst the ovary is correctly figured as villous (*Frey. Voy. Bot.*, p. 443, and Plate 46).

Turning now to Bentham's description it appears that the plants to which it applies are not known to local collectors; it may be that they are a second cross between one of the ordinary forms and a hybrid.

Some Indirect Evidence.

In the neighbourhood of Sydney it is easy to find plants of two or more different species of *Grevillea* flowering at the same time and fruiting freely, growing close to each other under conditions apparently quite favourable to cross-pollination by nectar-seeking birds. Nevertheless transitional forms between such species have never been reported. They do not seem to be produced in the cases examined, apparently for reasons given below.

For some years I have had an excellent opportunity of periodically inspecting an extensive crop of thousands of specimens of the two species *G. sericea* and *G. buxifolia*, the former more numerous than the latter, crowded together on a ridge overlooking the Lane Cove River, 200 to 300 yards wide, it terminates abruptly on the east. Half a mile west the Hawkesbury sandstone is overlaid by Wianamatta shale, with a corresponding change in vegetation. This ridge was swept by a destructive bush fire on 2nd January, 1909, a phenomenally oppressive day with hot westerly wind. In due course, after rain had fallen, seedlings came up in great profusion, especially so *Grevilleas*, which grew rapidly, got ahead of the more slowly growing plants and temporarily took charge of the area. So

numerous were they that one could walk down one side of the ridge and up on the other or zig-zag in any direction and yet keep one hand on one or more plants all the time. The two species mentioned were flowering side by side, their branches overlapping, so that the racemes of one were sometimes only a few inches from the other. Seven capsules to a raceme were quite a common occurrence. The plants are so different that they are readily distinguishable at sight at any stage of growth. I was interested in the renascence of the vegetation on this circumscribed spot, having had the Grevilleas continuously under observation from the time they were seedlings, yet I never succeeded in finding a single plant that was not certainly determinable as one or the other. There appeared no evidence whatever of any kind of successful hybridization, nor was there, as far as I have observed, in a fresh crop of seedlings that came up. I am therefore led to conclude that the Honey-eaters cannot cross-pollinate them.

Elsewhere *G. punicea* and *G. buxifolia*, *G. sphacelata* and *G. sericea*; and on the lower part of the Blue Mountains *G. phyllicoides* and *G. parviflora*, may be found growing together under conditions which seem to be favourable for crossing, but apparently without any such result. It may be that the pairs of species enumerated are infertile, *inter se*; that is a matter for experimental investigation.

There is another possible explanation, which may be the correct one. Reference to the *Flora Australiensis* shows that the species of every pair referred to are placed in different sections of Bentham's Table; in other words the racemes are of different patterns or there are structural peculiarities of some sort present in one and not in the other. The result probably being, that a nectar-seeking bird visiting the flowers of one species may carry the pollen away from flowers on one part of the head, their position not matching with that of the receptive stigmatic surface of the other species. The result would be that cross-pollination of other flowers in the same or in other racemes of one type could take place, whilst in other species with raceme types differing it could not be effected.

Experimental investigation into these interesting details is much to be desired. At present we have little or no data for consideration.

(It has been observed that Honey-eaters commonly make a practice of commencing with the lower flowers of a raceme, working upwards. This would favour cross-pollination in the case of *laurifolia* and *acanthifolia*, as in both species the flowers open centripetally. In the case of *sericea* and *buxifolia*, one opens centrifugally, the other centripetally, a fact which would tend to prevent crossing.—C.T.M.)

Some Detail as to the Three Species from Fresh Specimens, 1913.

G. laurifolia (Plate vii, fig. 1.)

G. laurifolia (Plate vii, fig. 1) belongs to the xerophytic plant association which successfully occupies the poor soil of dry situations in the Hawkesbury Sandstone series (approximating to the Bunter Sandstone of the Trias). It certainly occupies some very dry positions on the ridges or on more level areas on the top of the tableland, where the ground must be so sunbaked and hard in droughty summers, that when heavy rain falls comparatively little can be stored as it runs away so rapidly. On the other hand mountain mists, which are not infrequent, may be helpful.

These plants are prostrate in *habit*, with several radiating procumbent stems arising from a thickened base. These stems are often 8-10 feet long, wiry and flexible, and readily made up into a small coil (except when very old); they are

well branched and very leafy, forming carpets lying close to the ground. In very old plants the basal thickening forms a large knob and the stems arising from it may be an inch in diameter or more for some feet from the base.

The *leaves* have a characteristic venation and indumentum, and cannot be mistaken for any other local plant. They are distinctly thicker than those of *G. acanthifolia*. Petiolate, entire, they vary a good deal in shape and size, according as they are well exposed to the light, or shaded by grass, shrubs or trees. They may be ob-lanceolate, long and narrow, short and broad or broadly ovate, even almost circular, and mucronate. Glabrous above when adult, very young leaves and shoots are thickly coated with a mixture of silky white and ferruginous or reddish appressed hairs lying very close together. Those of the upper leaf surfaces are soon lost. Except the midrib the under surface is thickly coated with silky white hairs lying close together and doubtless of use in checking transpiration as well as serving to protect the stomata from dust, or soil washed down by rain. The veins are very conspicuous, nearly parallel on each side of the midrib. They end distally in a characteristic well-marked intra-marginal vein.

The *perianth* tube, viewed from outside, has much more colour than in *G. acanthifolia*, and this is all the more evident because most of the appressed hairs clothing the tube are dark crimson or ferruginous, only a few white hairs being mixed with them. The hairs appear as if plastered down, not merely appressed. *Racemes* of very young unopened buds, with the bracts *in situ*, may have the globular limb, and that part of the limb not hidden by the bracts, ferruginous or rusty; or they may be turning crimson, though with a distinctly ferruginous tint on the globular limbs. The *bracts* are yellowish, coated with yellowish or rusty and white hairs. The *rhachis* is also thickly coated with short crimson, ferruginous or rusty appressed hairs. As the tube dries the colour sometimes becomes almost magenta. In still older buds in which the bowed style has not yet begun to protrude from the flowers, the tubes of the perianths, and the pedicels, are more distinctly crimson, but the globular limbs are still ferruginous, to the naked eye contrasting in colour. The rhachis may have more evident crimson hairs mixed with ferruginous or rusty hairs; while the bracts may be yellowish, or tinged with crimson near the base or over the greater part of their surface. In still older *racemes*, in which the bowed styles of the lowest flowers are protruding, there is still a noticeable contrast between the colour of the tubes, and of the globular limbs; and so much of the inner surface of the limb as is exposed, is seen to be edged with dark crimson, in still older flowers changing to purple. This may be confined to the free edge of the split perianth leaving a yellow gutter between, or the whole of the exposed inner surface may be purple, becoming darker as the flowers mature; eventually fading to some shade of dark red in dried flowers.

In mature flowers the globular limb and tube still show the difference—crimson—ferruginous. The *pedicels* are same colour as the perianth—rusty. In some racemes the flowers remain ferruginous without change, in others one-half longitudinally is crimson, the other ferruginous. Stipes of the ovary is longer than in *G. acanthifolia*. Styles lighter crimson, stigmatic disc green, sometimes crimson. Freshly exposed pollen is bright yellow and floury, contrasting strongly with the crimson. Hairs on the ovary and the stipites not so numerous as in *G. acanthifolia*, usually white mixed with crimson, or they may be nearly all crimson with just a few white. I think the hairs of the tomentum are correctly described as appressed all over (on tube and limb). The perianth and globular limb split on the lower

side (Bentham), the latter nearly to the base to allow the exit of the pollen-carrying disc, while the two laminae of the limb usually cohere on the upper side. When exposed in this way the inner surface is purple or there is a purple stripe on each side with an intervening longitudinal yellowish area along the coherent margin extending for some distance below the revolute limb but not to the base. The purple colour is evanescent, changing to dark crimson.

G. acanthifolia. (Plate vii, fig. 6.)

This species is tolerant to any amount of water applied to the roots; it belongs to a mesophytic assemblage of plants which flourish in wet swampy areas mainly caused by soakage from springs. Such areas are noticeable from a distance because of the absence of trees, and their green appearance. They are often mentioned by early explorers as they offered chances of feed for their horses or bullocks when there was nothing to be had elsewhere. They occur at different levels, frequently on the slopes of shallow valleys or bordering creeks,¹ sometimes they surround small islands of drier ground on which a few trees may occur. They are to be found only in the upper portions of the tributary valleys of the Grose and Cox rivers. Further down the valleys are enclosed between precipitous cliffs, and this, with absence of sun, profoundly alters the conditions for plant life.

In very dry seasons these areas dry up on the surface and are often burnt over. If the Grevilleas are only well scorched, the portions above ground die, but after sufficient rain they again send up shoots from the thickened base.

G. acanthifolia also flourishes on the banks of creeks, close to the water; and it is not unusual to see some of the main roots actually trailing in running water. It occurs also in depressions near and along the course of creeks, supplied from the overflow after heavy rains.

It sometimes occurs in unusual situations. I have seen one flourishing on the side of an apparently dry embankment leading to a bridge crossing a creek, and growing close to a plant of *G. laurifolia*. Possibly when rain falls the embankment is capable of absorbing more moisture than one might expect; perhaps much more than the sun-baked virgin ground which had never been stirred by spade or plough, but in which *laurifolia* can flourish.

Notes on Fresh Specimens, March and November, 1913.

Leaves: Trifid leaves sometimes subtend an inflorescence. Have seen 3-19 lobes; intermediate numbers commonest. There is an intra-marginal vein (or perhaps an epidermal thickening) to the lobes, *but it is not visible on the under-surface*; nevertheless, when held up to the light, it is visible like the ordinary veins (anatomical examination is wanted here). Seedling leaves, and leaves of side shoots, also the lowest leaves near the ground, of adult plants have relatively much more lamina, and are more easily pressed flat, not being so rigid.

Shoots: Young shoots, and unexpanded young leaf-masses, are coated with white silky hairs on both sides but not the upper surface of the young leaves, as in *G. laurifolia*. This is not mentioned in the *Flora Australiensis*.

Spikes: Not truly secund at first, when young there are bracts all up the rhachis (or all round). That is on the *back*, or the inner side not exposed and facing the stem. As the flowers expand, they reach out towards the light; but even then there are bracts on the back.

¹ This is what A. Cunningham means when he says of this species that its habitat is "wet, peaty bogs on the Blue Mountains."

Flowers: In very young spikes, before the styles protrude, the flowers, like the exposed surface of the bracts and the rhachis, are silky white, due to the hairs, and show no colour, or very little. The bracts are greenish or yellowish green on their inner surfaces. The bowed styles are rich pink; before they appear a little colour shows in the perianth, but it is masked by the silky hairs. In older spikes, it is to the massed styles the colour of the spikes is chiefly due, as seen from a distance, a fact not usually recognized. As the flowers mature, the colour of the styles fades to a lighter pink. At any time, viewed from outside, the perianths show but little colour. But when the styles are nearly ready to straighten, and afterwards, the inside of the perianth, viewed from front or above, is a rich purple (sometimes looking almost black), fading to purplish red in dry (herbarium) specimens. It fades considerably and what is left appears as longitudinal streaks (about ten). In herbarium specimens the colour of the inside of the perianth is perhaps more noticeable than in the fresh state; possibly due to disarrangement and flattening of the silky hairs in the process of drying. The perianth limb looks greenish outside, notwithstanding the coating of white silky hairs, this silky indumentum being most conspicuous. The hairs are appressed, projecting and rather tufty on the revolute limb; after the stigmatic disc has been released they appear as a very noticeable tuft on each side of the expanded revolute limb. The tube of the perianth of young flowers in bud, bracts and rhachis all appear of the same colour when fresh. Flower pedicels are greenish (like rhachis and bracts) and coated with white hairs, when fresh. The pollen masses when freshly exposed on the stigmatic surface are pink, those of *G. laurifolia* and the hybrid (*G. Gaudichaudii*) are bright yellow. The stigmatic discs are light green, fading to yellowish green.

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The Hybrids (Plate vii, figs. 2-5). Fresh flowers November, 1913.

With the exception of one plant, I have not seen spikes and flowers of any of the *Gaudichaudii* series, that were not readily distinguishable from those of *acanthifolia*. But I have had the great advantage of examining fresh as well as dried flowers. Plants of Section i have flowers and spikes like *G. laurifolia*, a little lighter in colour in some, but still some shade of crimson, with the same noticeable contrast between the tube and the globular limbs of the perianth (crimson as compared with ferruginous), but with a noticeable increase in the white silky hairs on the tube giving this a sericeous appearance. The inner surface when exposed purple. Plants of Section ii show a good deal of difference in the amount of colour in the perianth, some having very little (not more than in *acanthifolia*) when growing covered up in the shade, except as regards the purple inner surface, when the styles are hardly darker than those of *acanthifolia*. In others there is more diffused colour, lighter than in *laurifolia*, the exposed inner surface purple, when the limb and tube split. The pedicels are green as in *acanthifolia*, but what readily distinguishes them from that species is the admixture of white and crimson hairs on the limb, and white and ferruginous hairs on the globular end. The tomentum as a whole is also more copious and longer on the globular end. Even in dried specimens the contrast is strikingly obvious. The rhachis and bracts are also distinguishable from their rusty appearance due to the admixture of white and rusty or ferruginous hairs. This admixture of the different kinds of hairs on the flowers, rhachides and bracts is perhaps one of the best examples of mixed characters in these hybrids; apparently analogous to the case of hybrid roses between parents having either glandular or non-glandular hairs, mentioned

by Kerner.¹ The tomentum, as a whole, is more copious than in *laurifolia*, but less so than in *acanthifolia*; the hairs are somewhat longer than in *laurifolia*, not quite so long as in *acanthifolia*. The hairs on the ovary are more numerous, and the tuft is denser than in *laurifolia*, being very like *acanthifolia*, but in many cases there are a few crimson hairs mixed with the white.

Classification of Hybrids (G. Gaudichaudii).

The series of hybrids met with, comprises recognizably different types of individual plants. The series, as known to me (J.J.F.) is divisible into two sections according as the plants have entire mixed with pinnatifid leaves, or all leaves are pinnatifid, as in *G. acanthifolia* the number of leaf lobes is not constant. With this difference in leaf character there are correlated certain differences in flower character.

Fresh flowers are only available during the summer months, whereas plants may be seen in leaf through the year, therefore the leaf characters most readily catch the eye. I have had specimens, illustrating a series of stages commencing with *laurifolia* and ending near *acanthifolia*, whilst the reverse could also, necessarily, be illustrated. A short account of various types will show how the characters of the parent species are blended, also indicating something of the variations to be seen, pointing conclusively to their hybrid nature.

Section i: Prostrate plants with procumbent stems. Entire leaves altogether of the *laurifolia* type, mixed with pinnatifid leaves with lobes numbering up to 9, all the lobes entire. Flowers indistinguishable from *laurifolia*, or with more white appressed hairs on the tube of the perianth. Habit like that of *laurifolia*.

- A. Entire leaves most numerous with pinnatifid leaves usually having not more than three lobes (very rarely four). Flowers and inflorescence indistinguishable from those of *laurifolia*.
- B. Entire leaves in a minority, pinnatifid leaves, up to five lobes; venation and indumentum of *laurifolia*; tube of perianth with more white hairs.
- C. Like B, but indumentum reduced to a remnant of scattered appressed hairs occurring singly, so that underside of leaves is almost glabrous, much as in some plants of A.
- D. Entire leaves more reduced in number mixed with pinnatifid leaves, having 2-7 or any intermediate even number of lobes, indumentum well developed in some specimens.

Section ii: Prostrate plants with procumbent stems, stiffer than in *laurifolia*, and not forming such leafy carpets. All leaves pinnatifid, with from 3-15 lobes (maximum and minimum not found on same plant). Some leaves with entire lobes, but in every plant seen, some bilobed. Three and four lobed lobes may occur, occasionally with bilobed on the same leaf. Indumentum very variable, well

¹"The cellular structures produced from the epidermis of the stem and leaves which are differentiated as hairs, bristles, scales, glands *et cetera*, classed together as under the name of indumentum, are very constant characters in most species of plants. Hybrids exhibit the most varied combinations of the indumenta of their parents. In the majority of cases the characteristics of the two stocks in this respect are mixed, but less frequently they are united, and in the latter case the shape, size and number of hairs . . . are intermediate between those of the appendages in the two parent species."—Kerner and Oliver, *Nat. Hist. of Plants*, p. 564.

"Where one parent rose bears only non-glandular and the other only glandular hairs, the hybrid is sure to be clothed with a mixture of the two kinds of hairs."—*Ibid.*, p. 564.

"The colour of the flowers in hybrids is usually the result of a *fusion* of the colours in the parent species; less frequently it is a *mixture* of the original colours."—*Ibid.*, p. 567.

developed and much reduced on the same plant. Intermediate in extent on others, or reduced generally, on the leaves to a functionless remnant of appressed hairs, singly scattered; recognizable but vestigial. No plant seen with under surface of leaves entirely glabrous.

Fresh flowers with more white silky hairs on tube of perianth, hiding the colour and giving dried flowers a greyish appearance. On the revolute limb of the perianth the hairs are tinged with ferruginous or reddish colour. Capsules hardly distinguishable from those of *acanthifolia*.

- E. Leaves with from 3-11 lobes, the maximum of indumentum for this section, but it varies in amount on leaves of the same plant.
- F. (Here is *G. Gaudichaudii* R.Br.). Leaves with from 3-11 or 5-15 lobes, with a maximum of bilobing; indumentum recognizable but vestigial, reduced to a few scattered hairs. Perianth with the tube sericeous, the hairs on the revolute limb tinged with ferruginous or reddish. *This is the type of hybrid most frequently met with.*
- G. Leaves with 7-13 lobes (or any intermediate even number), with most (but not all) leaves having a maximum of secondary lobing; some trilobed, rarely four lobed. No five lobed lobes seen.

Remarks on the Various Types of the Series.

A. If the pinnatifid leaves are removed, it will pass as a specimen of *G. laurifolia*. If it were the only member of the series known, it might be regarded as a sport, perhaps due to bud variation. Fine colonies of *G. laurifolia* carpeting considerable areas of ground may be found too remote from plants of *G. acanthifolia* for birds to pass directly from one to the other, but in such cases the plants show no tendency whatever to produce lobed leaves. Fourteen plants of this type seen; from the conditions under which they were growing, I believe them to be seedlings from ovules of *G. laurifolia* fertilized by pollen of *G. acanthifolia*.

One fine plant was growing in the midst of a carpet of *G. laurifolia*, and, except in one instance, the others were growing quite close to, side by side with and the branches overlapping, or a little lower down a slope than, one or more plants of *G. laurifolia*. In some cases they were the only hybrids to be found in the locality. In one case only was a plant solitary, and this must have been a case either of a seed having been removed further than usual from the parent form, or more probably was a plant whose former associates had been removed by fire or accident.

B. Six plants have been examined. The finest example was growing on a grassy slope, well exposed to the sun, just below, several plants of *G. laurifolia* with plants of *G. acanthifolia* a few yards away at the bottom of the slope. Another was one of a row of four contiguous plants; the two middle ones were examples of type C. The remaining one of the four a fine example of type F. Two others were growing close to plants of *G. acanthifolia* and the sixth quite close to a group of plants of that species.

C. Two plants only seen, the two referred to above. Both old, very dry and quite alike. Dried leaves appear almost glabrous, but the scattered hairs readily seen on fresh leaves. They had a very distinctive appearance. The leaves, even when fresh, were incurved at the edges in an unusual manner. The facies of these two plants suggested the idea that they were suffering from excessive transpiration due to the loss of the indumentum.

D. Three plants seen, all, I believe, seedlings from *G. laurifolia*. One was growing in the midst of a carpet of *G. laurifolia*, another was beside a plant of that species, the branches overlapping. The third was growing in a grassy glade, near some other hybrids, but with plants of both *G. laurifolia* and *G. acanthifolia* close at hand.

E. Two plants seen, both remarkable for the well developed indumentum and for its variable amount. One plant showed great variety of lobing in the leaves. The other was overshadowed by a plant of *G. acanthifolia*, and hampered in symmetrical growth by other plants. A well marked intra-marginal vein present. But for the indumentum, this plant was quite of the F type.

F (= *G. Gaudichaudii*, R.Br.). The commonest type met with, about fifty plants seen. Not only is this the type most frequently produced, but in my opinion it is the reciprocal hybrid. Solitary plants were seen in the midst of carpets of *G. laurifolia*; others were seen growing close to, even overshadowed by, a plant of *G. acanthifolia*. Others were growing on slopes between *G. laurifolia* above and *G. acanthifolia* below. On the whole they are most frequently situated near plants of *G. laurifolia*. Mr. Forsyth noted this close association with *G. laurifolia*, but without realizing its significance. The reason, as one can see, is that when the birds¹ travel up the valleys visiting *G. acanthifolia* in the swampy lower parts first, and come to the last of them, they very naturally visit *G. laurifolia* on the slopes above, if there is a display within sight. On the other hand, after visiting the Banksias, Lambertias, and other plants on the ridges and upper slopes they work down over the *laurifolia* areas until they reach the wetter lower slopes where *acanthifolia* flourishes; they may then pass direct from the former species to the latter.

G. Five plants seen, two of them fine plants, one with stems seven feet long, growing in the midst of a carpet of *G. laurifolia*; another near a plant of type B, close to plants of both parent species. A fourth was growing between plants of the two parents. The fifth, a solitary plant, growing further from the parent forms than usual; but there was evidence of interference with the surface.

Summary.

Grevillea Gaudichaudii, R.Br. is a hybrid. The parents are *G. laurifolia* Sieb. and *G. acanthifolia*, A.C.

The forms described by R. Brown, Gaudichaud and Bentham are representatives of naturally related forms, the result of hybridization; and fill places in a graded series between the parents.

These plants are only found near one or both parents, along the Blue Mountains from Wentworth Falls to Blackheath. (The area west of this has not been searched.)

The characters of *G. Gaudichaudii*, R.Br. are blends or mixtures of those of the parent forms.—C.T.M.

EXPLANATION OF PLATE VII.

1. *Grevillea laurifolia*, Sieb.
- 2-5. Various forms of *Grevillea Gaudichaudii*.
6. *Grevillea acanthifolia*, A.C.

¹ The Spinebill chiefly.

THE PHYSIOGRAPHIC AND CLIMATIC FACTORS CONTROLLING THE
FLOODING OF THE HAWKESBURY RIVER AT WINDSOR.

By LESLEY D. HALL, B.Sc., Science Research Scholar in Geography,
the University of Sydney.

(From the Department of Geography.)

(Plate viii, and nine Text-figures.)

[Read 27th April, 1927.]

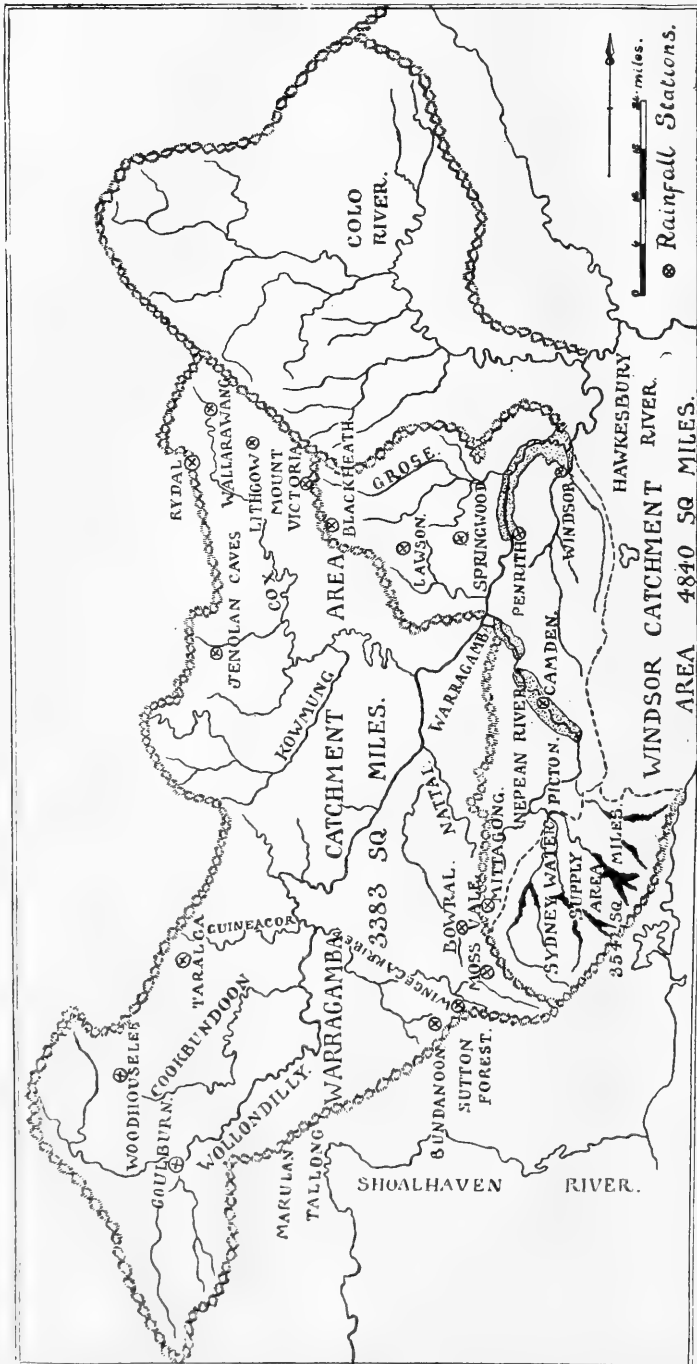
Introduction.

Floods of the Hawkesbury River at Windsor have been part of man's experience ever since the first farmers came and settled the rich alluvial flats along its banks in 1794. Records show that in recent years these floods have decreased considerably both in height and frequency, but the cause of the decrease is not definitely known. It may be due either to dam building on the headwaters of the river, or to an actual diminution in precipitation. In the following paper the effect of the Nepean dams on the floods of May and June, 1925, has been investigated in an effort to find a definite relationship between flood waters, water conservation and climatic conditions over the catchment area of the river. The term "catchment area" is used throughout to denote the entire area drained by the stream irrespective of special regions reserved for water supply.

So far as I am aware no work of this nature has been done for the Windsor district. Josephson, 1885, discusses the history of the floods of the Hawkesbury River, but makes no attempt to give their causes or to enter into the details of rainfall. David and Guthrie (1904), have investigated the nature of the Hawkesbury River silts and their results are mentioned in this work. Information as to the position and capacity of the dams and the amount of water stored during the flood months, were kindly supplied by the Metropolitan Board of Water Supply and Sewerage; while other details concerning rainfall and run-off for the whole Windsor catchment area were contributed by the Water Conservation and Irrigation Commission. Thanks are especially due to Mr. French of this Commission for making these facts available and for his helpful suggestions and kindly assistance. Rainfall figures were given by the Weather Bureau and flood details were obtained from copies of the *Windsor and Richmond Gazette* of various dates, for which my thanks are due to the Editor who gave me access to his files.

GENERAL DESCRIPTION OF THE HAWKESBURY RIVER.

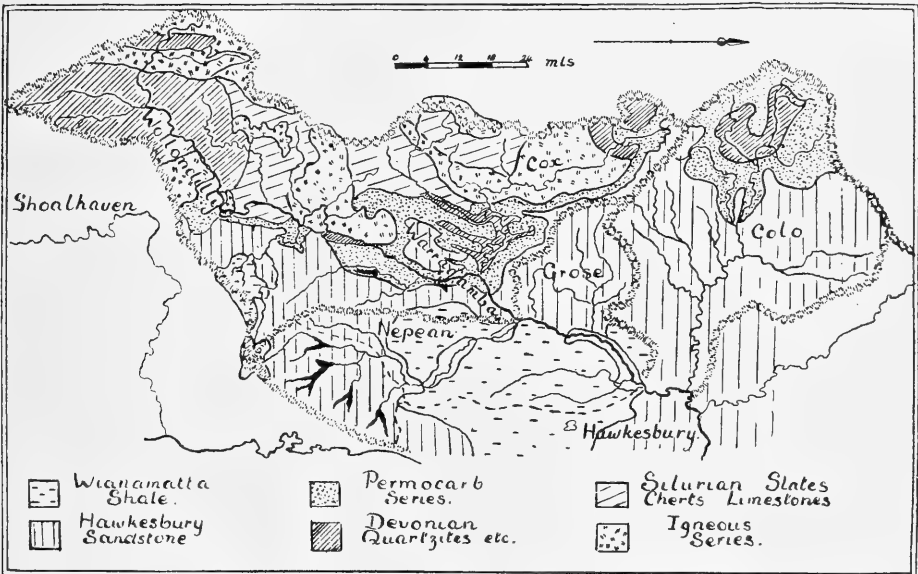
Three hundred and thirty-five miles in length, the river with its several large tributaries, drains all the immediate country to the north, west and south of Sydney, an area of approximately 8,000 square miles. It rises 20 miles from Goulburn, where it is known as the Wollondilly, flows generally northwards, and after receiving water from the Cookbundoon, Wingecarribee and Nattai streams, is joined by Cox River from the western mountain region. From here it is known



Text-figure 1.—A general map showing the catchment area of the Hawkesbury River above Windsor. (From a map obtained from the Water Conservation and Irrigation Commission.)

as the Warragamba and flows through a deep gorge till joined by the Nepean near Mulgoa. The main river is now known as the Nepean and continuing northwards, is joined by the Grose a little above Richmond and by South Creek at Windsor. After the Grose junction it is called the Hawkesbury and is joined by two large streams, the Colo and the Macdonald, before reaching Wiseman's elbow, where it turns eastward and finally enters the sea at the beautiful drowned estuary of Broken Bay. A consideration of the map, Fig. 1, will show that the headwaters of the river above Windsor may be divided into three systems, namely, the Wollondilly-Cox, the Nepean and the Grose, each of which has its own definite catchment area.

The Wollondilly-Cox has a catchment area of 3,383 square miles including all the country drained by the Wollondilly, Cookbundoon, Wingecarribee, Nattai, Cox and Warragamba rivers. Part of the western warp, it is all highland, but varies



Text-figure 2.—Sketch map showing the approximate geology of the catchment area of the Hawkesbury River above Windsor.

somewhat geologically. The upper Wollondilly flows through a series of Palaeozoic rocks, so that its gorges are less striking than the huge canyons which have been cut in the Hawkesbury sandstone by the Cox. The lower Wollondilly, Nattai and Warragamba have also cut deep gorges in the sandstone. Thus the northern part of the catchment area is of a very rugged character making communication difficult. Within the area there is a comparatively small population and only a few large towns. Settlement has collected in three regions. On the Upper Wollondilly, beyond the limits of the sandstone, there is good agricultural land which supports a farming population. Goulburn, population 11,950, is an important inland town on the Great Southern Railway. Taralga is another large town in this district where grazing, dairy-farming and fruit growing are the chief industries. Good workable soil and a less rugged topography, have led to settlement in this area.

In the Bundanoon-Mittagong district is a series of small towns along the Southern Railway, well within the sandstone area and important only from the tourist and residential aspect. Among these are Bowral (2,640), Moss Vale (2,030), and Mittagong (1,440). Round Sutton Forest is some good grazing land due to the presence of basalt and the intrusive rock of the Gib at Bowral is important commercially. On the headwaters of the Cox are several towns the most important of which is Lithgow (12,940). Here river erosion has caused the sandstone to be worn away and the coal measure series to be exposed. Coal is mined at Lithgow and is the cause of the industrial prosperity of that centre. Other towns on the Cox catchment area are Mount Victoria, Katoomba and Wentworth Falls, all of which are tourist resorts. Except for these regions, juvenile dissection and barren sandstone soils have prohibited settlement on the Warragamba catchment area.

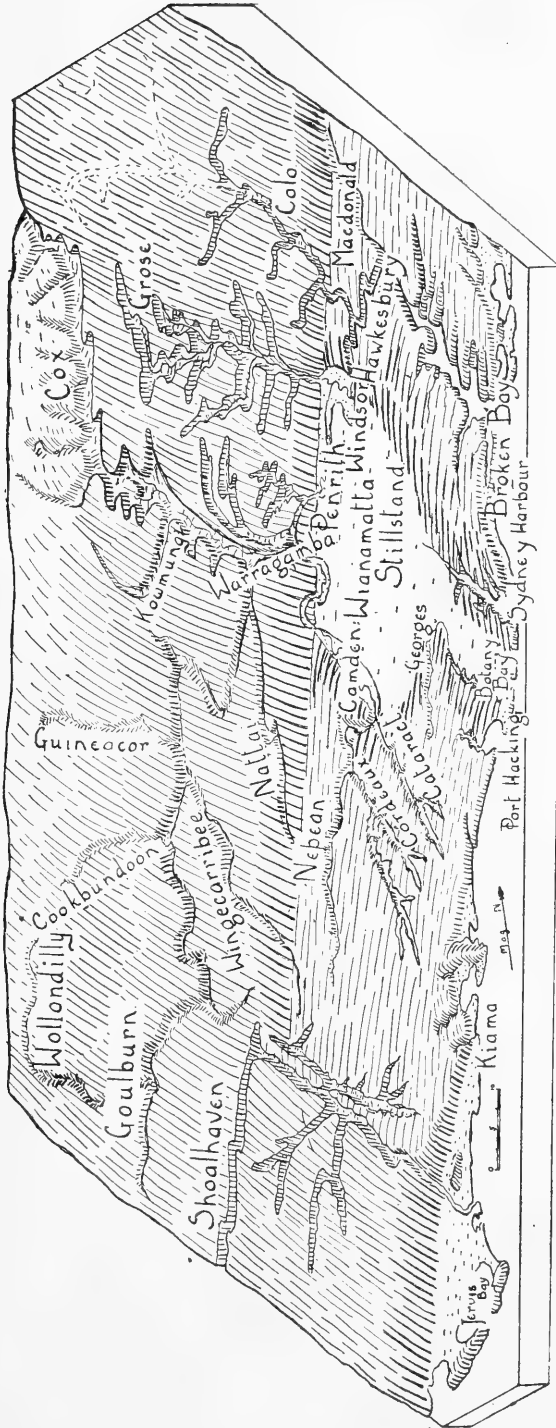
The Nepean.—On the headwaters of this stream 354 square miles of uninhabited country have been reserved for Sydney water supply. The catchment area is practically all Hawkesbury sandstone drained by the Nepean, Avon, Cordeaux and Cataract rivers. The maximum elevation is only 2,000 feet, so the river gorges are by no means as rugged as those of the western warp. Still the district does not invite close settlement and the small towns are mostly confined to the southern railway line. The presence of juvenile gorges at the headwaters of the streams and the absence of any close settlement were two factors in determining the choice of this site for the location of the water supply dams.

The Grose has a catchment area of 250 square miles; a sandstone region of juvenile dissection and part of the western warp. Its deep canyons, wide gullies and barren hill tops prohibit all settlement except for towns such as Springwood, Lawson and Blackheath along the western railway, which are important tourist resorts.

The waters from these three highland areas are discharged into a comparatively flat region of Wianamatta Shale and lake silts; undulating grassy country with hills not more than 200 feet above sea-level, which contrasts strongly with the sandstone highlands surrounding it on three sides (Taylor, 1923*a*). The Nepean leaves the southern warp at Menangle and meanders through the "fossil lakes" of Camden and Wallacia before again entering the uplifted region where it joins the Warragamba. The Camden district, therefore, is only liable to be flooded by Nepean water, which comes from a smaller drainage area than that which affects Windsor. The combined Warragamba and Nepean water is discharged on to the flats again at Penrith, causing floods here before it is joined by the waters of the Grose. The floods on the lowlands of Richmond and Windsor are caused by waters draining a total catchment area of approximately 4,840 square miles. At Cattai the river enters the northern warp and the flood waters are once more contained within the river valley.

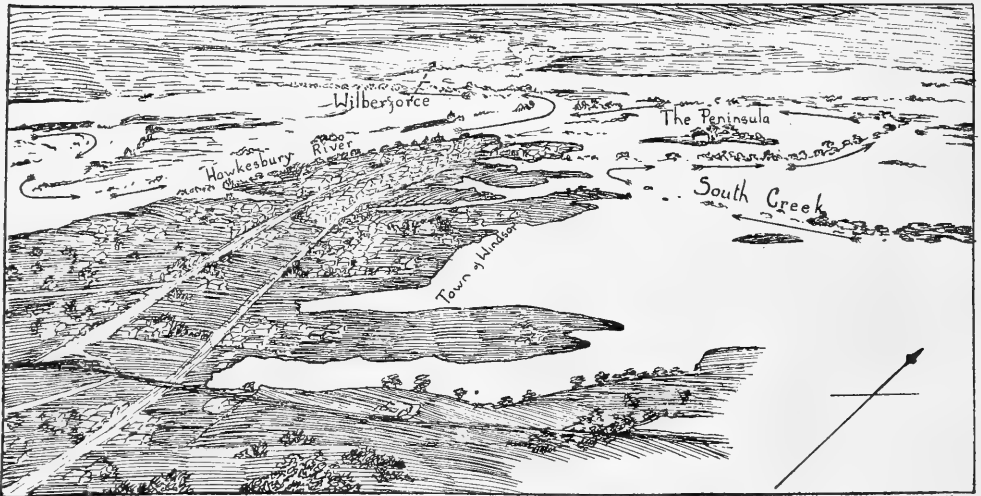
HISTORY OF FLOODS AT WINDSOR.

The Hawkesbury River is recorded to have flooded for the first time in 1799, doing much damage and causing great distress among the people of the young settlement. This flood ushered in a series from 1799 to 1801 and then the river was normal till 1805 when another series of floods commenced. The records of these early floods are not accurate and no attempt was made to ascertain to what height the river rose above normal. In 1808 there was another flood and the frequency and destructive power of these floods was the cause of much anxiety



Text-figure 3.—A block diagram showing the nature of the country drained by the Hawkesbury River (based on Taylor, 1923a).

to the infant colony. Thus we find that the town of Windsor owes its origin directly to the necessity of constructing large granaries at higher levels in order to protect the produce from inundation. During 1811 a severe drought was experienced and was followed directly by another flood. Situated under the shadow of the great warp, the Windsor district does not receive a very high rainfall and droughts are fairly frequent, while the rain falling on the mountains will often cause floods of the river. These unsuitable conditions and the growth of the settlement made it imperative that the mountains should be crossed and more extensive pasture lands discovered. Between 1816 and 1819 three large floods occurred, then we have record of a series of smaller floods occurring at intervals until 1857 which marks the beginning of a wetter cycle. Three floods are recorded for 1860 followed by a small one in 1863 and a very large one in 1864. Three years



Text-figure 4.—Windsor Peninsula surrounded by flood waters, June, 1925.
(Sketch from a *Daily Guardian* photograph.)

later came the largest flood known to white men when the water rose 63 feet above summer level of the river, entered the town and left only two parts of it exposed as islands.

The people had hardly recovered from this disaster when, in 1870 the river rose 15 times and flooded the flats five times. This was a record wet year at Windsor and the climax of the rainfall which had been increasing since 1857. From 1870 to 1879 floods occurred of smaller magnitude than the preceding ones, after which a drought period set in so that the river did not flood again till 1889. For the next few years a good rainfall was recorded, but at the close of 1893 a drought began which lasted about fourteen years, although there were floods at Windsor almost every year between 1893 and 1900. Since that time the rainfall has been steadily decreasing and though some floods have occurred their height has been much less. In 1904 the river rose over 40 feet, a record which has not been equalled since. Dry years followed in which the rainfall for the year was below the average until 1910, when it started to increase and a small flood of 21 feet occurred. 1911, 1912 and 1913 had small floods without much rain in

the Windsor district, then in 1915 heavy rainfall throughout the Hawkesbury watershed caused a rise in the river of 25 feet. October, 1916, witnessed a high flood of 35 feet 6 inches, followed by five years of drought which were broken by heavy rains in 1921, when the river rose 20 feet. From this time onwards the rainfall has been better, the flood of 1922 being a fairly high one. There is no doubt, however, that floods of the Hawkesbury have decreased considerably during the last twenty-five years.

In May, 1925, the water rose 25 feet, that is, about 2 feet over the Windsor Bridge, and a great many of the low-lying places were covered. The water only broke over the banks of the river in very low spots and, running up the gullies, inundated a good deal of land. In the flood of June the water was 15 feet above Windsor Bridge, or 37 feet 3 inches above summer level of the river, which is the biggest flood experienced since 1904. Many people on the lowlands were driven from their homes and it is estimated that damage amounting to between £40,000 and £50,000 was done in the Windsor district and approximately £30,000 round Richmond. All the country round Cornwallis, Freeman's Reach, Pitt Town Bottoms, Wilberforce lowland, the Peninsula and the flats along South Creek were one vast sheet of water dotted here and there with the tops of houses and trees. Windsor was a complete island as the water backed up over the roads at the southern end of the town. The following is a list of the floods which occurred between 1795 and 1925 compiled from various sources:

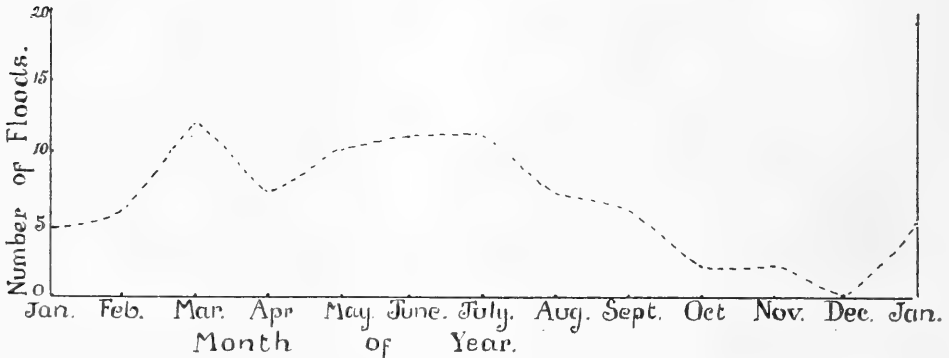
| Year. | Month. | Height above summer level, feet. | Year. | Month. | Height above summer level, feet. | Year. | Month. | Height above summer level, feet. |
|-------|--------|----------------------------------|-------|--------|----------------------------------|-------|--------|----------------------------------|
| 1795 | Jan. | — | 1857 | Aug. | 37½ | 1889 | May | 38½ |
| 1795 | Aug. | — | 1860 | Feb. | 26¾ | 1890 | Mar. | 38¾ |
| 1799 | Mar. | 50 | 1860 | Apr. | 36¾ | 1890 | Mar. | 34½ |
| 1800 | Mar. | — | 1860 | July | 34½ | 1890 | June | 22½ |
| 1801 | Mar. | — | 1860 | Nov. | 36 | 1891 | June | 35½ |
| 1805 | Feb. | — | 1861 | Apr. | 27½ | 1892 | Sept. | 26½ |
| 1805 | Mar. | — | 1863 | — | — | 1893 | Mar. | 28½ |
| 1806 | Mar. | 48 | 1864 | June | 48 | 1894 | Mar. | 31¾ |
| 1806 | Oct. | 30 | 1864 | June | 32½ | 1895 | Jan. | 30½ |
| 1808 | Nov. | 20 | 1864 | July | 36 | 1897 | July | 22½ |
| 1809 | May | 48 | 1866 | June | 26 | 1898 | Feb. | 31½ |
| 1809 | Aug. | 47½ | 1866 | July | 27½ | 1899 | Aug. | 22 |
| 1810 | July | — | 1867 | Apr. | 21 | 1899 | Aug. | 26½ |
| 1811 | Mar. | — | 1867 | June | 63 | 1900 | July | 46 |
| 1812 | Mar. | — | 1869 | May | 36¾ | 1904 | July | 40 |
| 1816 | June | 45½ | 1870 | Apr. | 45 | 1908 | Aug. | 15 |
| 1817 | Feb. | — | 1870 | May | 35½ | 1910 | July. | 21 |
| 1819 | June | 46 | 1871 | May | 36¾ | 1911 | Jan. | 25¾ |
| 1820 | June | — | 1872 | — | — | 1912 | July | 22 |
| 1821 | Sept. | — | 1873 | Feb. | 41½ | 1912 | Aug. | 24 |
| 1826 | Jan. | — | 1875 | June | 38¾ | 1913 | May | 26½ |
| 1826 | Sept. | — | 1876 | Sept. | — | 1913 | May | 20 |
| 1830 | Apr. | — | 1877 | May | 30 | 1915 | Jan. | 25 |
| 1831 | Apr. | — | 1877 | May | 20 | 1916 | Oct. | 35½ |
| 1832 | Mar. | — | 1878 | Feb. | 26½ | 1921 | — | — |
| 1833 | Apr. | — | 1879 | Sept. | 43½ | 1922 | July | 31 |
| 1857 | July | 32½ | 1879 | Sept. | 34½ | 1925 | May | 25 |
| | | | | | | 1925 | June | 37½ |

This list of floods records all those mentioned in the following references:

- (1) 1799-1819: Articles in the *Nepean Times* for June, 1925, entitled "126 Years Ago."
- (2) Tebbutt: Catalogue of the floods and freshes of the Hawkesbury River and South Creek at the Peninsula, Windsor, New South Wales. 1855-1903.
- (3) "Results of Meteorological Observations at Mr. Tebbutt's Observatory. 1898-1915."
- (4) Results of Rain and River Observations. 1903-1908.
- (5) *Windsor and Richmond Gazette*. 1905-1925.
- (6) Josephson, J. P., 1885: "History of Floods in the Hawkesbury River." *Proc. Roy. Soc. N.S.W.*, page 97.

RELATION OF FLOOD HEIGHTS TO YEARLY RAINFALL.

Floods in the Windsor district come at all seasons and have been known to occur in almost every month although the winter months, May, June and July, are the most common (see graph, Text-fig. 5). No flood has been recorded for



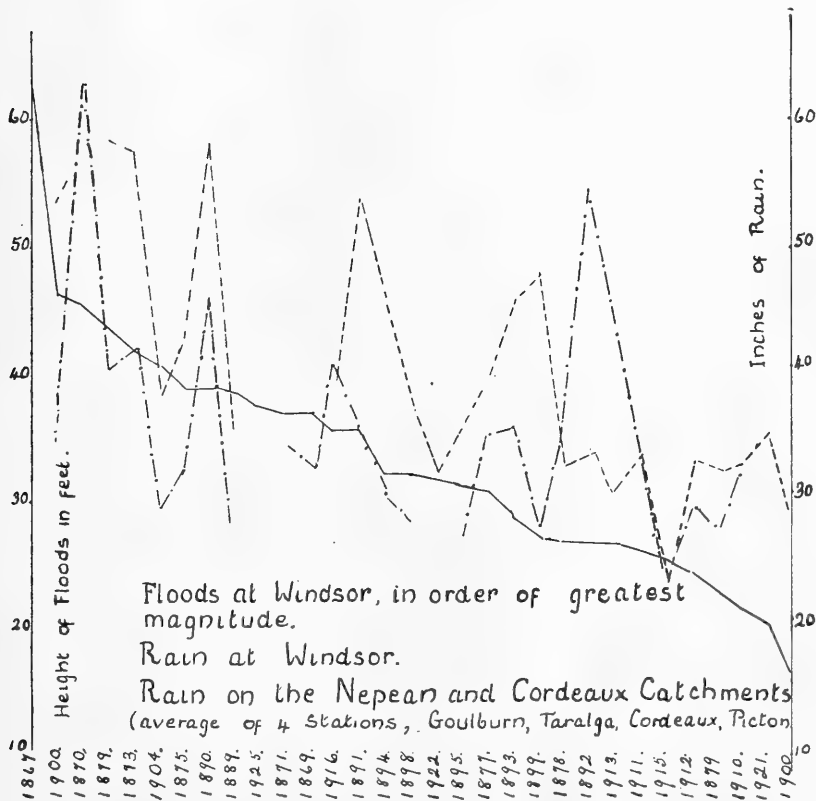
Text-figure 5.—A graph showing the number of floods occurring in each month of the year from 1795 to 1925.

December and very few in October or November. Floods are caused by heavy rain falling on the watershed of the river and are not affected by precipitation at Windsor. A fall of rain on the southern drainage area sufficient to cause floods is usually due to a cyclonic disturbance whose influence is felt all along the coast; thus it often has rained or is raining at Windsor during the rise of the flood waters. Cases have been known, however, when the river rose without any rain having fallen in the immediate district. The graph, Text-figure 6, shows the floods at Windsor in order of decreasing magnitude, with rainfall at Windsor for the corresponding years superimposed. It is obvious that the two lines bear no relation to each other. The third line shows the rainfall over the Nepean and Warragamba catchment areas, calculated as an average from the four stations, Goulburn, Taralga, Cordeaux and Picton. In this the relationship is more apparent as the rainfall curve is composed of a series of maxima and minima, with a general decrease in the height of the maxima, which corresponds to the decrease in height of the floods. The minima mark those years when the heavy rainfall was more coastal and all the flood waters came from the Nepean. The association between the rainfall and the flood line is not very close, for a flood does not depend on

the amount of annual rainfall, but on a very heavy fall over a short period. Constant precipitation may give a high annual total with not enough at any one time to cause a flood, while flood rains followed by droughty conditions will result in a low yearly average. If heavy rain falls at a time when evaporation and percolation factors are high the run-off may not be sufficient to cause a flood.

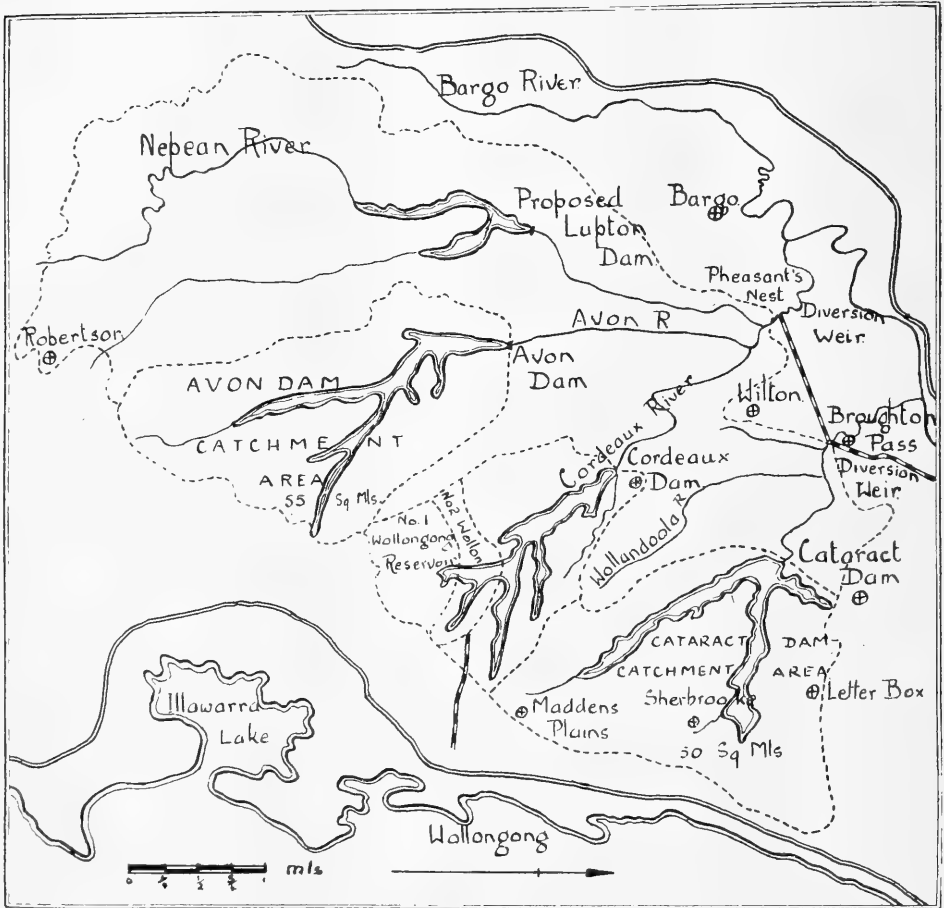
WATER CONSERVATION ON THE NEPEAN.

The great flood of 1867 occurred during a time when floods were much more frequent than they are at present and when the waters over the whole catchment area were uncontrolled. Since that time schemes for the conservation of water have been carried out on the Upper Nepean. The locality was chosen as being the place nearest to Sydney which was high enough and comparatively uninhabited; not from any direct rainfall considerations. The first project was the building of a tunnel from Pheasant's Nest to Broughton's Pass, which diverted water from the Nepean and Cordeaux rivers to the Cataract. The water of both streams was carried along, partly by tunnel and partly in an open canal to



Text-figure 6.—A graph showing the relation of flood heights at Windsor to the yearly rainfall. In this figure the continuous graph represents the floods at Windsor, the dot and dash graph the rain at Windsor and the broken line the rain on the Nepean and Cordeaux Catchments.

Prospect and so to Sydney. Then the Cataract dam was built and stored water first in 1906. It was filled for the first time in 1911. In time of flood or fresh only a fraction of the flow of the Nepean River can be diverted to Sydney and the same might have been said of the Cataract River before the completion of the dam. In dry weather, however, practically the whole flow of the Cordeaux



Text-figure 7.—Sketch map of the catchment area of the Nepean River showing the position of the water conservation dams.

above Pheasant's Nest and the Cataract above Broughton's Pass is diverted, to the great disadvantage of settlers on the Nepean, who are thus deprived of water which would have otherwise reached their land. To assist them compensation weirs have been built along the Nepean, and are replenished from time to time by water released at Pheasant's Nest and Broughton's Pass.

The catchment area of the Cataract Dam is 50 square miles and, when full, it backs up the water to a depth of 150 feet and stores 20,743 million gallons. Construction of dams on the Cordeaux and Avon rivers is now almost complete and during the flood rains of May and June, 1925, they stored a great deal of

water. As soon as these dams are finished one is to be constructed at Lupton on the Nepean proper, and with the four dams in working order a continuous flow of 108 to 110 million gallons of water per day will be able to be maintained to Sydney as well as the coastal supply to Mt. Kembla and Wollongong. In 1871 there were only two rainfall observing stations in the catchment area but at various times since then others have been established. The following is a list of these recording stations:

| Catchment Area. | Rain Gauge Stations. | No. of Years. | Yearly Average. |
|-----------------|------------------------|---------------|-----------------|
| Cataract. | Sherbrooke | 32 | 59.16 |
| | Madden's Plains | 17 | 58.47 |
| | Letterbox | 16 | 49.43 |
| | Mount Pleasant | 17½ | 57.13 |
| | Cataract Dam | 20 | 34.82 |
| | Broughton's Pass | 36 | 33.16 |
| Nepean. | Cordeaux | 53 | 61.01 |
| | Cordeaux Gauge Weir .. | 15 | 42.04 |
| | Robertson | 34 | 57.69 |
| | Mittagong | 28 | 33.61 |
| | Bargo | 22 | 30.22 |
| | Wilton | 28 | 27.23 |

The average rainfall on the Cataract catchment area of 50 square miles is 48.69 inches. On the Nepean catchment area, which includes 35 square miles of Cordeaux drainage and 55 square miles of the Avon, the rainfall is less, the average being only 41.98 inches. Therefore, though the Cataract Dam has a smaller catchment area than the Avon it receives a greater amount of water. One inch of rain falling over one square mile of country is equivalent to 14.52 million gallons of water. A great deal of this water is lost by percolation and evaporation so that only a small percentage runs over the surface and into the river. Measurements of the amount of rain falling on the catchment area of a river will give the actual number of gallons which fell, while from measurements of the velocity of the stream the number of gallons discharged can be obtained. From these two sets of figures the actual amount of water lost by percolation and evaporation can be found and the run-off expressed as a percentage of the rainfall. Between 1887 and 1906 on the Warragamba catchment area the average rainfall was 32.45 inches and the mean estimated run-off was 16%. The run-off is found to be a variable factor depending on climatic conditions and whether the rain falls after a wet or a dry season. On the Cataract catchment area for the 25 years since 1900, the average rainfall per annum was 50.56 inches and the average discharge was 13,358 million gallons or 33.64%. An inch of rain over the 50 square miles of the Cataract catchment area is equivalent to $50 \times 14.52 \times 10^6$ or 726 million gallons of water. Of this about one-third or 242 million gallons is available to be stored in the dam. The average fall of 50 inches of rain over the whole area will only produce 12,100 million gallons of water to be stored and, as this is only about half the capacity of the dam it seems evident that its catchment area is not

large enough. Yet the Avon Dam with about equal available water is twice as big as Cataract with a total capacity of 47,159 million gallons. The heavy rains of May and June, 1925, were not sufficient to fill the Avon and Cordeaux dams which would seem to be too large for their catchment areas. In this connection it is necessary to remember the purity of the water which flows into the Avon Dam, an important factor in a country where settlements are to be found on most of the rivers.

THE ACTION OF THE DAMS DURING THE 1925 FLOODS.

Heavy rains were experienced on the Nepean catchment area during May and June, 1925, the total precipitation over the whole area for the two months, as calculated from four rainfall stations on the Cataract catchment and three on the Avon and Cordeaux, being 37.08 inches. Of this 22.84 inches fell during May as compared with the 14.24 inches which fell in June. At the time of the May fall, however, the ground was dry and a great deal of the water was lost by percolation and evaporation. For this month the average run-off over the whole area was 63.6% of the rainfall, while during June when the ground was still moist the average run-off was 76.9%. On the Cataract catchment area the mean precipitation for the month of May was 25.24 inches and the run-off was 66% of the rainfall. There were 5,470 million gallons of water stored at the beginning of the rain and the increase was 6,263 million gallons. The dam did not overflow during the May flood and the water continued to rise during the rest of the month owing to run-off from the hills which continues for a good while after rain has fallen. At the beginning of the heavy June rains there were 17,954 million gallons in storage and the dam was filled within three days. The overflow at the time of the June flood is estimated at 4,421,324,500 gallons. The rainfall for that month was 13.95 inches and the run-off was 74.7%. The total amount of water stored in the Cataract dam in May and June was 15,273,000,000 gallons.

On the Cordeaux catchment area records from three stations only are known and their readings give a mean rainfall of 23.19 inches for May. The increase in storage of the dam was 6,848,000,000 gallons and the run-off was 58.4% of the rainfall. The June rains averaged 15.29 inches but the run-off was higher, 70.3%, and increased the storage by 5,439,000,000 gallons, making a total increase of 12,287,000,000 gallons in the Cordeaux storage for May and June. The dam did not reach its full capacity. Records from the Avon catchment area are also very approximate, being based on observations from three stations only. For May a mean precipitation of 20.1 inches is recorded, 25% less than that of Cataract, while the run-off was 66% and gave an increase in the storage of 10,625 million gallons. In June the rainfall of 13.47 inches with a high run-off of 85.8% gave an increase in storage of 9,193,000,000 gallons. The total increase in the Avon storage was 19,816,000,000 gallons, but as the dam was almost empty at the beginning of the rains it did not then reach its full capacity. Storage was commenced on the Avon River at the end of May, 1924, and by the end of June, 1925, 22,308 million gallons had been impounded; practically the whole yield at the catchment, as only a trifling amount was sent to Sydney. Another 71 inches were then required to fill the storage. It is calculated that the mean precipitation over the whole catchment area of 354 square miles for May and June was 18.54 inches, giving a run-off of 105,372 million gallons, of which 48,233,000,000 gallons, or nearly 50% was caught and held in the Cataract, Avon and Cordeaux reservoirs. Some of the excess water not held by the dams was probably discharged down

the canal to Prospect, but in quantity so small as not to affect the calculations, since at the height of the flood the gates are closed to prevent the blocking of the canal by debris.

Details as to the rainfall and discharge from the Warragamba and Grose catchment areas are supplied by the following letter from the Water Conservation and Irrigation Commission: "The most notable falls on the Warragamba River catchment area during the months of May and June were:

| | | | |
|----------------|---------|-------|--------|
| Robertson | | 44.27 | inches |
| Goulburn | | 16.38 | „ |
| Katoomba | | 24.78 | „ |
| Mount Victoria | | 15.59 | „ |
| Bowral | | 22.49 | „ |
| Taralga | | 15.26 | „ |

The rainfall stations are not evenly distributed over the catchment area; on the sparsely settled districts the records are scanty, but by giving each station its proper 'zone of influence' the mean depth of precipitation over the catchment area is estimated at 17 inches. The amount of water discharged by the Warragamba at a point a little up stream from its junction with the Nepean, during May and June is estimated at 297,715,000,000 gallons or enough to supply Sydney for 14 years at the present annual consumption rate. About 35.5% of the rainfall was discharged by the Warragamba, the rest being lost by percolation and evaporation. There are no reliable measurements of the amount of water contributed by the Grose River to the floods of May and June. The catchment area of the stream at its affluence with the Hawkesbury above Richmond is 250 square miles. A conservative estimate of the discharge, basing it on the relation of its area to that of the Warragamba, would be 22,000 million gallons of water, which is little more than the capacity of Cataract Dam. Rainfall stations on the Grose catchment area are Springwood, Lawson and Blackheath."

From a combination of the figures for the three catchment areas the following table is derived:

| Catchment. | Area in square miles. | Run-off, million gallons. | Storage, million gallons. | Storage %. |
|----------------------|-----------------------|---------------------------|---------------------------|-------------|
| Warragamba | 3,383 | 297,715 | — | — |
| Nepean | 354 | 105,372 | 48,233 | 45.7 |
| Grose | 250 | 22,000 | — | — |
| TOTAL | 3,987 | 425,087 | 48,233 | 11.3 |

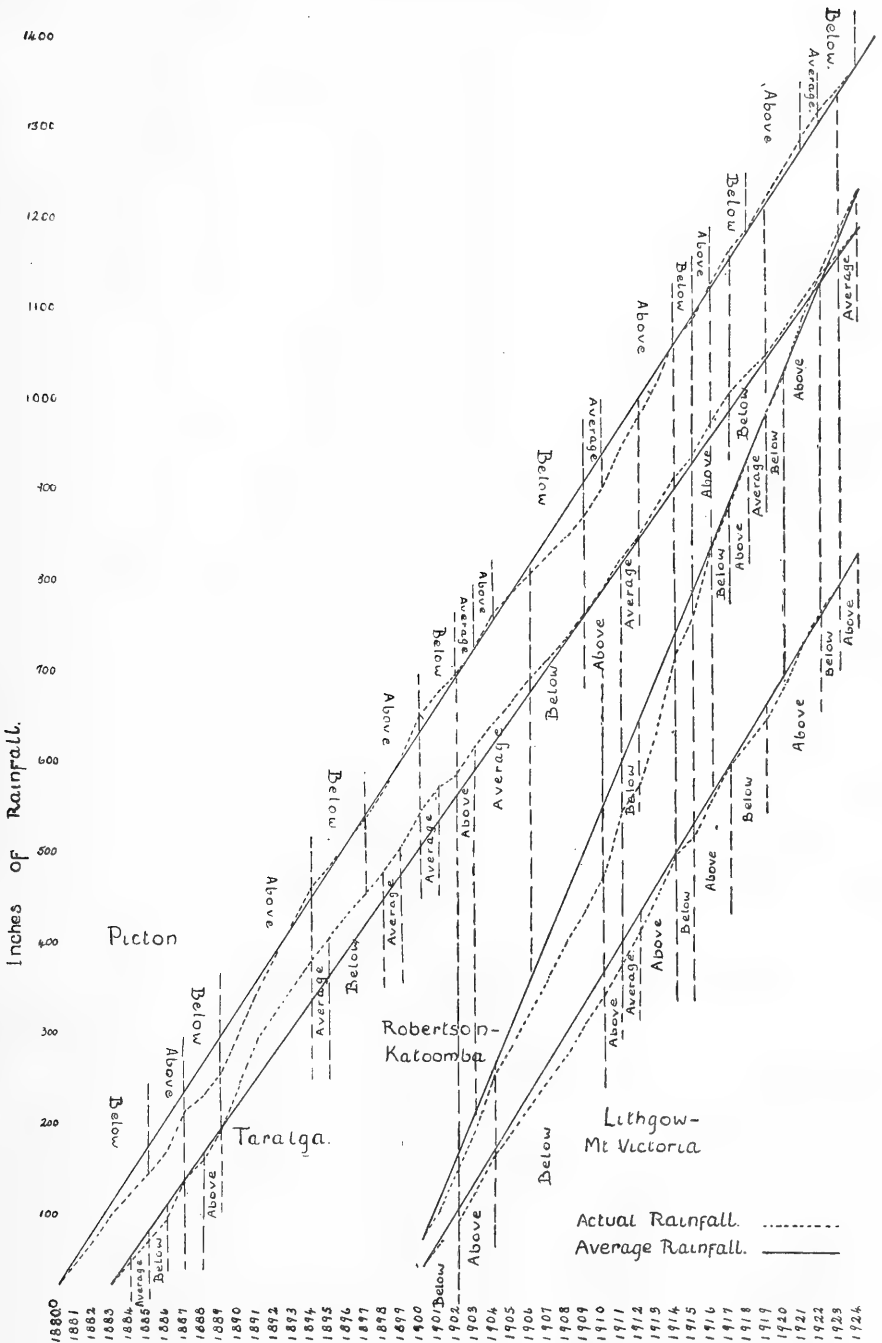
This gives approximately the total run-off from a catchment area of 3,987 square miles, figures for the other 853 square miles of the Windsor catchment area not being recorded. Yet considering that the dams caught and held almost half the

water discharged from the Nepean catchment area and practically 10% of the total water discharged at Windsor, it is obvious that if these dams had not been in existence the magnitude of the floods at Penrith and Windsor would have been greatly increased. The dams on the Nepean cannot prevent floods at Windsor, nor decrease the number experienced there, but their existence is felt in a tendency towards modification during a flood period, although their effect is a variable factor depending on a number of conditions. The Nepean drainage is only about 10% of the Warragamba, but its area is nearer the coast and consequently receives more rainfall, so that in the June, 1925 flood its run-off was equal to 35% of the Warragamba run-off. It is possible for coastal rains to cause floods of the Nepean without additional water from the Warragamba and in such cases there is no doubt that the effect of the dams is very great. The actual amount of water which is held back by the dams depends on the number of gallons already stored at the beginning of the rains. The heavy rains of May were preceded by a dry period and the water in Cataract Dam was low. Also dams at Cordeaux and Avon were only on the verge of completion and almost empty, so that a considerable quantity of water was capable of being stored.

A flood of any magnitude at Windsor is due to a cyclonic disturbance, which causes sudden heavy rain of only short duration over the whole catchment area. As a result a great deal of excess water is discharged in a few days, causing an abrupt rise and fall in the river level. The dams, therefore, by holding back water at the time of general discharge decrease the height to which the flood would have risen and the consequent damage which would have been done. Even if the dams are full and cannot hold back the water from the flood they decrease its peak discharge, because the whole surface of still water must be raised above the level of the dam before the overflow takes place and the drainage from such a surface is necessarily slower. It is not the actual amount of water but the rate of discharge which causes the river to rise and flood the lowlands and an arrangement whereby the water is delayed and caused to pass more slowly down the river does much to lessen its evil effects.

DECREASE IN RAINFALL.

The decrease in the number of floods experienced at Windsor of late years seems rather to be a factor of the decreasing rainfall than to be due to dam building on the Nepean. At Grove Farm the river rose to 67 feet 10 inches on the present gauge in 1867 and only 35 feet 4 inches in 1925. This difference could not be accounted for by the building of the dams. It must be associated with a diminution in rainfall, a factor not due to deforestation as this area, being rugged inhospitable country, is still uncleared to a large extent. The difficulty in this connection is the absence of long time rainfall records by which a decline in precipitation might be verified. Goulburn is the oldest established rainfall station on the Warragamba catchment area. The records commenced in 1858 and the average for 67 years was 25.41 inches, while for the last 30 years the average has been 22.83 inches, a falling off of about 10%. Rainfall records at Cordeaux gauging weir were started in 1872, the average rainfall for 53 years being 53.58 inches, while the average since 1900 shows a decrease of about 20% and is only 44.45 inches. The following table shows how the ten yearly averages compare with the total averages since the formation of the station at various places on the catchment area (figures obtained from Hunt, 1916, and from the Weather Bureau).



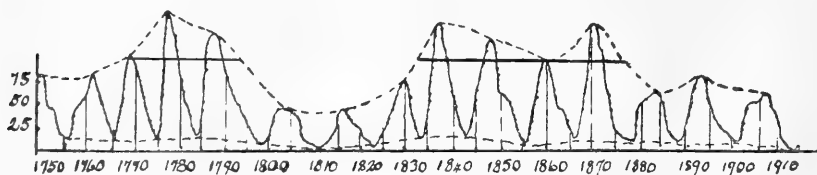
Text-figure 8.—Summation hydrographs showing the variation in the rainfall above and below the average for a number of years, of six stations on the Windsor catchment area.

The summation hydrograph is made by adding together the averages of the rainfall at a certain place over a number of years and then plotting the result as a rising graph. The final point on the graph is joined to the first point by a straight line which is the general average rainfall over the total number of years. When the graph line is parallel to the average line the years were ones of normal rainfall. Where it inclines away from the average the rainfall during those years was above normal and where it inclines in to the average the rainfall was less than normal.

| Place. | Average Rainfall. | | | | | | Total Average. |
|----------------|-------------------|------------|------------|------------|------------|------------|----------------|
| | 1871-1880. | 1881-1890. | 1891-1900. | 1901-1910. | 1911-1920. | 1921-1924. | |
| Cordeaux | 60.0 | 57.42 | 69.66 | 46.34 | 47.91 | 39.58 | 53.48 |
| Picton | — | 27.45 | 35.26 | 24.74 | 34.94 | 28.38 | 30.15 |
| Taralga | — | 30.87 | 30.35 | 24.49 | 28.69 | 27.05 | 28.28 |
| Goulburn | 28.51 | 22.53 | 27.21 | 20.39 | 23.58 | 26.03 | 27.06 |

1871-1880 are years of good rainfall, 1881-1890 are not so good. From 1891-1900 the stations all record rainfall above the average, then from 1901-1910 the rainfall is uniformly low. 1911-1920 shows an increase with two stations above and two below, but 1921 to 1924 are years of low rainfall again. The rainfall at these stations is also depicted on the graph (Text-figure 8), where summation hydrographs show the variation above and below the average from year to year. These graphs show that since 1900 the yearly rainfall has mostly been below the average with a marked decrease in the number of inches precipitated. For six years, 1904-1910, there was a low water condition in the upper Sydney water supply canal from the Nepean, unparalleled in 80 years, and though the average rainfall discharge has increased since then, it is still lower than it was before the dry period.

The graph (Text-figure 9) shows the 11 year cycle of maximum and minimum sun spots with a decrease in the maximum number from 1870 onwards. 1870 was a year of good rainfall everywhere and a time when the greatest number of sun



Text-figure 9.—Major and minor sun spot cycles (Huntington, 1915).

spots have been recorded. From 1881 to 1890 the rainfall was not so good, but at that time the sun spot maximum was not nearly so large as the one preceding. Between 1891 and 1900 the maximum was greater and the rainfall recorded is better, but from that time onwards there has been a steady decline both in sun spots and precipitation. Thus rainfall does seem to vary, not only with the eleven years' cycle but possibly also in accordance with a superimposed major cycle as shown by Huntington, 1915. If this is the case the recent floods of 1925 might be taken to indicate the beginning of a new cycle in which the seasons would gradually improve. Such conclusions are necessarily very tentative as it is difficult to arrive at any definite principle.

FLOOD SILTS OF THE HAWKESBURY RIVER.

The silts brought down by the Hawkesbury when in flood are of two varieties, the rich black mud and the useless sand. The Warragamba, Grose and Nepean flow through sandstone country which is easily weathered, supplying these rivers with large quantities of sandy sediment of no fertilizing value. The mud which is so important to the farmer is derived by the Cox and Wollondilly from the older palaeozoic rocks through which they flow before entering the sandstone region. By the time the waters reach Windsor the sand and the muds have been mixed together giving a light sandy loam which is very fertile. Pure mud is also deposited, enriching the land, but sometimes the flood currents leave behind them patches of sand which ruin the area on which they are placed. The Grose River carries only sandy sediments yet after the flood of June, 1925, black mud inches deep was deposited along the banks of this stream for seven miles above its junction with the Nepean, thus showing the distance to which the flood water must have backed up the Grose against the normal flow of the river. The depth of silt left behind by the flood is a variable factor depending largely on the topography of the district, but also on the height of the waters and their velocity. As the river spreads over the flats it meets resistance and the velocity is checked causing a great deal of the silt load to be immediately dropped. In this way levees or mounds of silt are formed along the banks of the river which prevent the overflow water from draining away from the flats again. In the Windsor district, therefore, large areas of still water result, the silts of which are deposited in a fine layer over the entire surface. Farther down the river where the flats are smaller and more isolated the silt deposit is greater and was from 4 to 6 inches in the June flood. As seen in the river bank at Windsor the flood silts form a series of fine laminations of varying colour according to the proportion of mud and sand (Plate viii, fig. 1). As the surface layer dries it hardens and contracts, breaking into small pieces by a number of small and irregular cracks (Plate viii, fig. 2). When dry it is very soft and friable and soon becomes worn down into the soil. David and Guthrie (1904) give an analysis of flood silt from the Hawkesbury water during the flood of 1904 which shows that the lime, potash, phosphoric acid and nitrogen content of the soil is renewed by flood waters. This is undoubtedly very good, especially in a place such as the Hawkesbury flats where constant tilling is wearing out the good of the soil and artificial manures must be used.

Provided the flood comes at the right season it is more beneficial than otherwise in the more northerly reaches of the river where it is only the orchard flats which are covered by the waters. Here the houses are built on the higher sandstone terraces and so escape damage. The fruit trees are grown in the long flat gullies at the base of the sandstone hills where the flood forms quiet backwaters in which silt is deposited inches deep over the farms. However, floods are very uncertain in their coming and on the low flats between Wilberforce and Windsor often large areas of growing crops are destroyed in addition to other extensive damage which tends to outweigh any good effect. After the flood of June, 1925, the water remained on the surface for days which, although impeding the work of reconstruction, enabled the subsoil to become thoroughly wet. As a result it was possible for the farmer to grow valuable areas of lucerne, a crop which cannot be grown there under ordinary rainfall conditions as rain does not penetrate deeply enough into the soil. Moreover, throughout the dry summer which followed the crops flourished on water stored beneath the surface of the ground. Therefore, although the general opinion is one of censure against the floods, there is always

some benefit to be derived from them. In the Windsor district another difficulty at flood times is the shifting of the land as the river increases the scope of its meanders. The velocity of the flood waters gives them great erosive power and as they swing round a meander the river bank is washed away on one side while sand and debris are deposited on the other. During the June flood a land slide occurred in which 200 yards of the road along the bank was completely washed away. With every flood the channel of the river is altered, the meanders becoming more and more curved and unless they are prevented by artificial means the meanders will become cut off with resulting ox-bow lake formation. This action of the river is a source of great difficulty in a region where the land is divided into private farms whose owners lose large blocks of land with every flood.

FLOOD PREDICTION AND CONTROL.

As floods in the Windsor district are due to irregular cyclonic disturbances on the coast, to forecast their occurrence would be a matter of some difficulty. At one time the people were caught by the water when quite unprepared, but they are now warned by telephone communication which gives them about 24 hours in which to evacuate. The warnings, however, are never very accurate and the people do not know how high the water may be expected to come, nor will they leave their homes till they are quite sure that it will be necessary. The best way of controlling flood waters is to build levees along the river banks high enough to prevent the water from coming over. In the Windsor district this would be an enormous task owing to the great extent of flat land through which the river flows in that locality. Moreover the expense of such an undertaking would not be justified by the value of the land. It is doubtful whether any farmer round Windsor would be willing to go to the expense of erecting a bank to protect his property against the ravages of the river even if it did not do good as well as harm. The risk of life does not even cause them to take precautions, for many still live in houses well within the danger zone and do not even keep a boat when their only means of escape at flood times is by water. The rescue work is carried on by special boats which have to be sent to the afflicted areas from Sydney.

To control floods in the Windsor district it has been suggested to build a dam in the Warragamba gorge to collect all the run-off from the Wollondilly watershed and permit of it being released in more or less regulated volumes. A wall 300 feet high in this gorge would impound the water for 25 miles up the Wollondilly and 20 miles up the Cox. Such a dam might not actually prevent floods for the Burrenjack Dam, which captures nearly all the headwaters of the Murrumbidgee, was unable to prevent flooding of that river in 1925. However, besides lessening the discharge by an amount proportional to the number of gallons already in the dam at the beginning of the rains, it would offer a very large surface of still water over which the excess would have to pass and would thus make the floods less intense and therefore lower in height. If the overflow water were to be discharged down the river more slowly it might possibly be contained within the river banks. The dam would give a continual flow of 200 million gallons per day to Sydney. It is calculated by water supply experts that up to 1967 Sydney, with the 80 million gallons from the Nepean, will only require 160 million gallons from the Warragamba, and if the surplus is not used it will bank up and overflow. This will decrease its usefulness in the prevention of floods and in order to use the excess water schemes for the generation of electric power and for the irrigation of the lowlands have been suggested. The water from the dam on the

Murrumbidgee is used to irrigate land which is naturally fertile and only requires water to make it good for agriculture. It is well drained with uniform surface levels which make redistribution easy, while the low rainfall insures a constant demand for water. Conditions are different in the county of Cumberland. Here there are 26,390 acres of good river land, 14,300 acres of second class river land and the rest is Wianamatta shale, poor soil almost worthless for cultivation with unequal levels which would make the application of water a costly process. The area supports 778 persons per square mile, including the city of Sydney and only 98 per square mile if that town is excluded. Also the rainfall is a very variable factor and the demand for irrigation water would fluctuate. Yet on the river flats the dam would greatly decrease the possibility of floods and irrigation, though costly, would increase the productivity of the land which is the closest agricultural region to the city of Sydney. Nevertheless the proposal to dam the Warragamba is not much favoured by people of the Windsor district, who depend on the river for their water supply. The towns of Richmond and Windsor both obtain water from the river by electric pumps and anything which would check or interfere with the flow of the river or any of its tributaries upstream must seriously jeopardize the supply from the Hawkesbury, especially in dry seasons when the salt water works its way towards Windsor rendering the river water unfit for use.

SUMMARY AND CONCLUSIONS.

Floods in the Windsor district are due to the presence of a river with wide-spread upland drainage, discharging its waters from the mountains on to the flat lands of this locality. They are caused mainly by heavy coastal storms of short duration and result from the sudden and simultaneous discharge of excess water from the large number of tributary streams. This gives a typical high peaked flood wave which passes very quickly so that the rise and fall of the waters is only a matter of days. A high flood is very destructive covering the crops and often entering the homes of the farmers, who are forced to seek shelter on higher ground. The black mud left behind by the waters is fertile and the ground is improved by the moisture yet the damage of the flood outweighs its good effects. Prevention, however, is a difficult matter. The flats are far too extensive and not rich enough to pay for the building of levees. Also floods are not nearly so numerous or so high as they used to be. The best method of controlling floods is by water storage. There are at present three dams on the Nepean which hold back some of the water at time of flood and, by thus knocking off the peak of the flood wave, do much good by making the rise of the waters less abrupt. The river is the one nearest to Sydney and therefore its natural source of water supply, while the inhospitable character of the rugged mountainous area through which it flows prevents settlement and keeps the water fairly pure. It is suggested to build a large dam on the Warragamba River which will assure an ample supply of water to Sydney and at a time of heavy rain will help to smooth down the flood wave so considerably that the water may possibly be contained within the river banks. Dams, however, cannot actually prevent floods and those built on the Nepean have not been the cause of the decrease in the number of floods experienced at Windsor of late years. This decrease is rather a factor of declining rainfall for precipitation on the catchment area has been steadily less ever since the heavy rainfall of 1870.

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DESCRIPTION OF PLATE VIII.

Figure 1.—Flood silts on a grassy bank at Windsor showing the laminated character of the deposits.

Figure 2.—Irregular cracks due to drying in the flood silts at Windsor.



NEW GALL-FORMING THYSANOPTERA OF AUSTRALIA.

By DUDLEY MOULTON.

(Communicated by W. W. Froggatt.)

(Plate ix and fourteen Text-figures.)

[Read 25th May, 1927.]

The gall-making thrips of Australia include some of the most interesting forms of all the Thysanoptera, and I am greatly indebted to Mr. W. W. Froggatt who has supplied me with abundant material of many species, several of which are new. I am offering this brief paper as a preliminary one and hope it will help to stimulate other entomologists to collect and study these thrips whenever they are observed. I wish here to express my appreciation to Dr. H. Priesner for examining many of these specimens.

KLADOTHRIPS AUGONSAXXOS, n. sp. (Plate ix, No. 1347.)

This species of *Kladothrips* can be distinguished from *K. rugosus*, the one other known species of this genus, also found by Mr. Froggatt, by the following characters:

K. rugosus Froggatt.

All antennal segments except the first, more or less uniformly light yellow to yellowish brown.

Pterothorax and first two or three abdominal segments yellow, or yellowish orange. Middle and hind legs uniformly dark brown.

K. augonsaxxos n. sp.

Third antennal segment, also sometimes tip of two, yellow, all others dark brown.

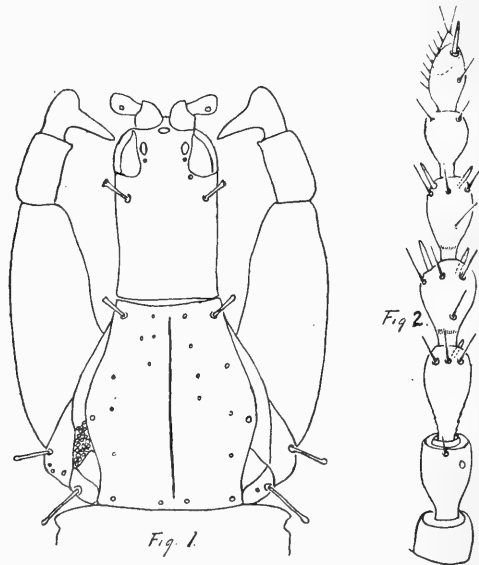
Pterothorax and abdominal segments quite uniformly dark brown. Tips of middle and hind tibia and tarsi often yellowish.

The most striking difference is the enlargement of the egg sac in the abdomen of *K. augonsaxxos* which I have never before observed among the Thysanoptera. The abdomen is normal in one specimen before me, apparently before the development of the egg sac. Its sides are almost parallel, being reduced gradually from the sixth to ninth segments and there is no apparent distention of the connecting tissue between the segments. In other specimens the egg sac is variously enlarged, although the chitinous walls of the segments do not appear to lose their original shape. In one specimen which is typical, the connecting tissue between segments three and four is distended and forms a small, transparent ring extending entirely around the body. The connecting tissue between segments four and five is distended into a larger transparent ring which could possibly contain a single row of eggs, placed end to end. The great spherical egg sac formed between segments five and six is three or four times the width of the body in diameter, tough and strong, whitish, almost transparent in colour, and is seen to contain a great mass of eggs. Segments six to nine and the tube appear to retain their normal shape and size.

Female holotype.—Measurements: Total body length in normal condition about 2.60 mm., with distended egg sac about 2.75 mm. Head length 0.33 mm., width 0.165 mm.; prothorax length 0.33 mm., width 0.36 mm., including prominent fore coxae, 0.45 mm.; width of pterothorax 0.45 mm.; tube length 0.20 mm., width at base 0.08 mm. Antennae, length (width) segment i, 30 microns (39 microns); ii, 60 (38); iii, 75 (33); iv, 69 (36); v, 63 (32); vi, 48 (30); vii and viii, 72 (27); total 435 microns. Length (width) of femora, fore femora 416 μ (133 μ), middle femora 135 μ (63 μ); hind femora 225 μ (90 μ).

Colour dark brown. Extreme tips of fore femora, fore tibia and tarsi including tarsal claws, also third segment of antenna and extreme tip of two orange yellow. Fore coxae, pterothorax except outer borders, extreme bases and tips of middle and hind tibia, and middle and hind tarsi light brown. Connecting tissue between abdominal segments light brownish yellow, especially conspicuous after the egg sac begins to form.

Head about as long as prothorax and half as wide, with straight, almost parallel sides (Text-fig. 1). Postocular spines short and stumpy with dilated tips,



Kladothrips augonsaxos, n. sp.
Fig. 1. ♀ Head and prothorax, dorsal view.
Fig. 2. ♀ Right antenna, dorsal view.

situated well back from the eyes. Eyes comparatively small, neither prominent nor protruding, with small facets, not pilose. Anterior ocellus on apex of head, posterior ocelli contiguous with inner margins of eyes. Mouth cone short, triangular, reaching hardly one-third the length of the prosternum, with bluntly rounded tip. Antenna apparently 7-segmented. The terminal segment has a distinct transverse, oblique suture indicating clearly that it is formed by the fusion of the two terminal segments. (This is also true of the antennae of *K. rugosus* Froggatt, specimens of which are before me.) Antennae about one and one-third times as long as head; segment three club-shaped, segments four,

five and six abruptly constricted, each at about one-fourth its length from the base, these narrowed portions cylindrical, the rest of the segments subglobose. Segment three with one simple sense cone near tip on ventral side, segments four and five each with two, and segment seven with one. All sense cones short and transparent (Text-fig. 2).

Prothorax, not including prominent coxae, somewhat wider than long, shield-shaped, with a distinct median longitudinal thickening. Prominent spines on anterior and posterior angles, also on prominent coxae. All spines stout and transparent, with blunt tips, those on posterior angles 75 microns long. Pterothorax as wide as prothorax and fore coxae combined, sides almost parallel with a small angular indentation in the middle on either side. Anterior legs much enlarged, fore femora about one-fourth longer than head and three-fourths as wide as width of head. Armature of fore tibia reduced to blunt inconspicuous knobs at end on inner side. Claws of fore tarsi are long, straight and pointed, as long or longer than length of tarsi, and project at right angles. Middle legs much reduced, the median femora smaller than the fore tibia; posterior legs somewhat larger. Wings well developed, entirely clear, not narrowed in the middle, with ten double fringe hairs along posterior margin near tip.

Abdomen of normal shape before the formation of egg sac. Tube almost two-thirds as long as head.

This thrips is a true gall maker and produces a spherical gall from one-half to three-quarters of an inch in diameter, hollow, with an outer shell wall of about one-sixteenth of an inch in thickness. The gall is a deformity growing out of the leaf. One female inhabits each gall; she scatters her eggs, hundreds of them, on the inner surface where the larvae hatch, and apparently feed as I have found larvae within the parent gall in all stages.

No males have been observed.

Female holotype in author's collection; paratypes in the Froggatt Collection, Canberra, Australia.

Hostplant: Gallmaker on *Acacia doratoxylon*.

Habitat: Gilgandra, New South Wales.

CHOLEOTHRIPS, new genus (No. 518).

(Sub-family Kladothripinae.)

Head one and one-third times as long as wide and slightly shorter than prothorax, broadest across at the eyes, constricted uniformly toward the base. Cheeks with several thorn-like bristles, a single pair about one-third the length of the head from posterior margin, long and conspicuous and almost one-half as long as prominent postoculars. Eyes large. Ocelli present. Mouth cone short, reaching about two-fifths the length of the prosternum, bluntly rounded, labrum blunt.

Prothorax shield-shaped. Fore coxae enlarged, prominent, and together with the prothorax wider than the pterothorax. Fore femora greatly thickened. Fore tibia stout and armed at the end within with a strong tooth. Each fore tarsus with two teeth. Wings not constricted sole-shaped, but still a little smaller in the middle. Tube almost as long as head. Type: *Choleothrips geijerae* n. sp.

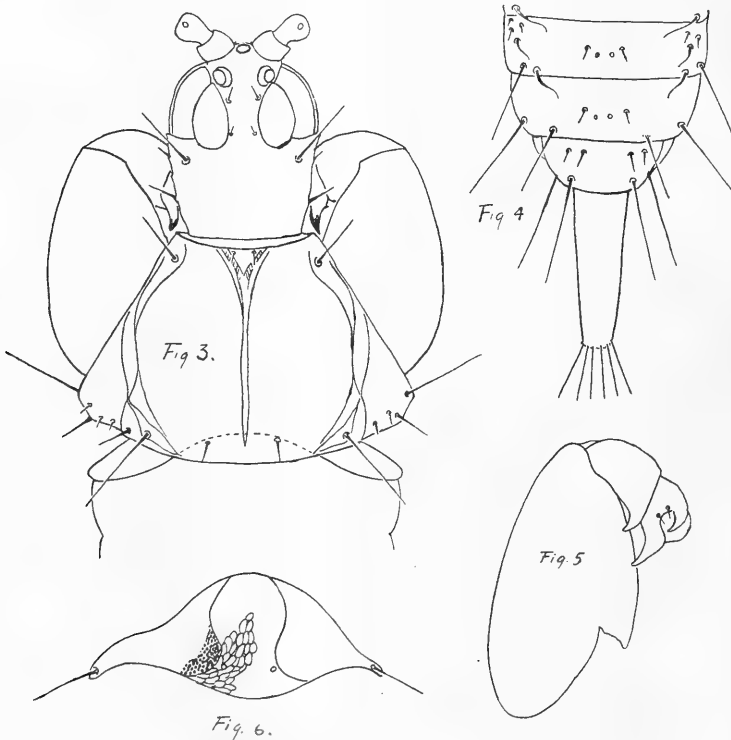
CHOLEOTHRIPS GEIJERAE, n. sp. (Plate ix, No. 518).

Female holotype.—Measurements: Total body length 2.42 mm. Head length 0.33 mm., width 0.25 mm.; prothorax length 0.36 mm.; width 0.416 mm.; including

coxae 0.55 mm.; mesothorax width 0.52 mm.; abdomen width 0.416 mm. Antennae: Segment i 27 microns, segment ii 54 microns, other segments broken off. Legs, fore femora length 0.41 mm., width 0.20 mm.; middle femora length 0.23 mm., width 0.10 mm.; hind femora length 0.33 mm., width 0.12 mm. Tube length 0.315 mm., width near base 0.09 mm.

Colour: Prothorax and fore legs quite uniformly yellowish brown; head, first antennal segments, pterothorax, abdomen, middle and hind legs dark brown, with joints and tarsi of middle and hind legs lighter. Wings uniformly smoky coloured. All prominent spines yellow. (Two paratype specimens have the prothorax and fore legs dark brown like the rest of the body.)

Head one-third longer than greatest width across at the eyes, constricted posteriorly (Text-fig. 3). Postocular spines pointed, 90 μ long. Longest cheek



Choleothrips geijerae, n. sp.

Fig. 3. ♀ Head and prothorax, dorsal view. Fig. 4. ♀ Tip of abdomen, dorsal view. Fig. 5. ♀ Right fore leg, ventral view. Fig. 6. ♀ First segment of abdomen, dorsal view.

spines 39 μ long. Eyes large, occupying four-fifths the width and about four-ninths the length of the head. Facets very small, not pilose. Ocelli present, placed well forward on head, anterior one on apex, posterior ocelli contiguous with anterior inner margins of eyes; mouth cone short, rounded, labrum blunt. There are two distinct swellings ventrally, one on either side of the head, just anterior to the base of the mouth cone. Antennae 8-segmented. Unfortunately the antennal segments beyond the second joint have been broken from all of the specimens before me.

Prothorax distinctly shield-shaped, one-eighth wider than long but about one-third wider than long when the fore coxae are included. A prominent spine on each fore angle, 90 μ long and one on each posterior angle 180 μ . Long spines on angle of fore coxae 135 μ . All spines pointed. The median dorsal suture terminates in front in a triangular enlargement with distinct sculpturing. Mesothorax widest, excluding protruding fore coxae of prothorax, with sides almost parallel. Metathorax with sides tapering gradually to meet the more slender abdomen. Fore femora greatly enlarged, about four-fifths as wide as head and nearly one-third longer (Text-fig. 5). Fore tibia enlarged and armed with a strong curved tooth at the end on the inner margin. Fore tarsi each armed with two teeth, the larger inner one almost as long as the width of the tarsus and with a curved tip, the outer smaller one on the ventral or outer side. The middle and hind legs are much smaller with clearly enlarged femora but small in comparison with the fore pair. Wings fully developed, reaching nearly to tip of abdomen with sides almost parallel; twenty-eight accessory hairs on posterior margin of fore pair.

Abdominal segments three to seven inclusive, are almost equal in length and width, and have parallel sides. Segment two is subequal in width but longer. The tergum of segment one is broad in the centre but compressed to curved points on either side, each bearing a long spine 0.93 mm., with distinct sculpturing (Text-fig. 6). The tube is almost as long as the head with straight sides tapering only slightly toward the tip. The long spines of the ninth segment reach approximately four-fifths the length of the tube, spines on the end of the tube are somewhat shorter (Text-fig. 4).

Described from twelve females, including holotype, with prothorax and fore legs distinctly yellowish, and two paratypes with prothorax and fore legs concolorous with the rest of the body. Holotype in author's collection. Several paratypes in Froggatt Collection, Canberra, Australia.

Hostplant: *Geijera parviflora* (Wilga), forming rolled leaf galls.

Habitat: Gunnedah, New South Wales (W. W. Froggatt).

DOLEROTHRIPS (?) GEIJERAE, n. sp. (Plate ix, No. 518.)

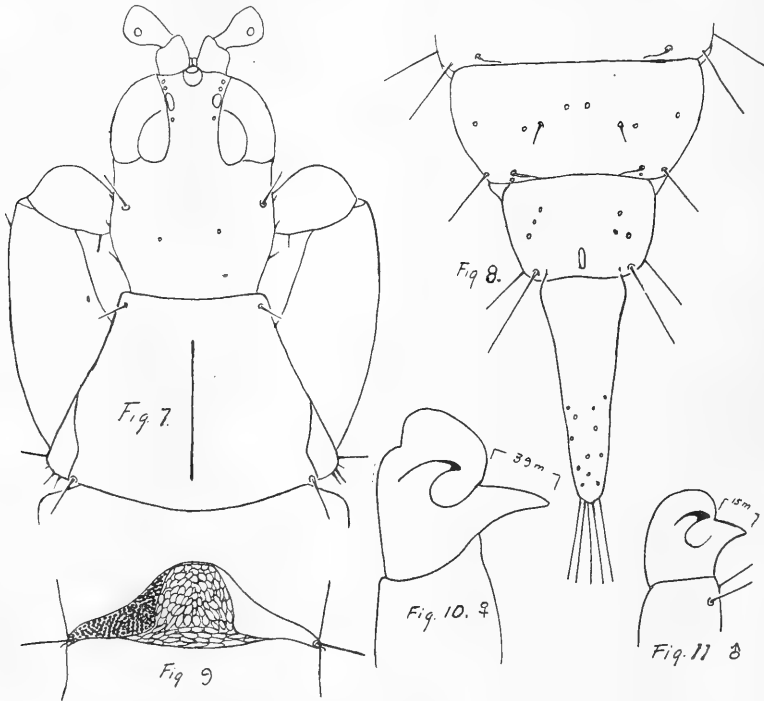
Female holotype.—Measurements: Total body length 2.48 mm. Head length 0.30 mm., width 0.20 mm.; prothorax length 0.30 mm., width 0.30 mm., and 0.36 mm., including fore coxae; mesothorax width 0.55 mm. Antennae: Segment i, 36 microns, segment ii 54 microns, other segments broken off. Legs, fore femora length 0.31 mm., greatest width 0.12 mm.; middle femora length 0.21 mm.; greatest width 0.09 mm.; hind femora length 0.25 mm., greatest width 0.12 mm. Tube length 0.33 mm., width 0.10 mm. across swollen part near base and 0.06 mm. just before tip.

Colour quite uniformly deep brown, wings transparent to slightly smoky.

Head almost one-half longer than width across at eyes. Cheeks swollen in the middle and clearly constricted toward the base, with several short sharp spines. Postocular spines not conspicuous, set back from eyes about one-third the distance between posterior margin of eyes and posterior margin of head. Eyes large occupying two-thirds the width and one-third the length of the head. Outer border of eyes clear light yellow, facets very small; not pilose. Ocelli present, placed well forward on head, anterior one on apex but not protruding over basal segments of antennae, posterior ocelli contiguous with inner anterior margins of

eyes (Text-fig. 7). Mouth cone short, rounded labrum blunt. Antennae 8-segmented.

Prothorax shield-shaped, as wide as long but about one-fifth wider with the prominent fore coxa included. Spines on fore angles weak, spines on posterior angles pointed, 60 m. long, several short stout spines on angles of fore coxa, longest 40 m. Median dorsal thickening fades in front a short distance before the anterior margin but extends almost to the posterior margin of the prothorax. Mesothorax with rounded anterior angles, sides of both meso- and meta-thorax constricted gradually toward the posterior margins. Fore femora enlarged, as long as head. Fore tibia unarmed; fore tarsi each with two



Dolerothrips (?) *geijerae*, n. sp.

Fig. 7. ♀ Head and prothorax, dorsal view. Fig. 8. ♀ Tip of abdomen, dorsal view. Fig. 9. ♀ First segment of abdomen, dorsal view. Fig. 10. ♀ Tip of right fore tibia and tarsus, ventral view. Fig. 11. ♂ Tip of right fore tibia and tarsus, ventral view.

teeth, the larger more conspicuous one extends outward at right angles and is nearly straight, the terminal smaller ventral one is distinctly curved (Text-fig. 10). The middle and hind legs are strong, with femora enlarged, but small in comparison with the fore femora. Wings fully developed, reaching to middle of seventh segment, sides almost parallel, 21 double fringe hairs on posterior margin of fore wing.

Abdomen elongate, first segment broad in the centre and narrowed to a point on either side, it displays distinct sculpturing and bears a single long yellow spine at each outer angle (Text-fig. 9); segments two to six increase in width gradually, and seventh, eighth and ninth with sides rounded and clearly

narrowed posteriorly; tergites of segments two to nine more or less distinctly reticulated; tube slightly longer than head, swollen at the base, narrowed gradually to a rounded tip (Text-fig. 8).

Male: The male is somewhat smaller, about 1.88 mm. in length, similar in colour and shape. The fore tarsus is smaller and tarsal tooth is about one-half as large as in female (Text-fig. 11).

Described from nine females and three males.

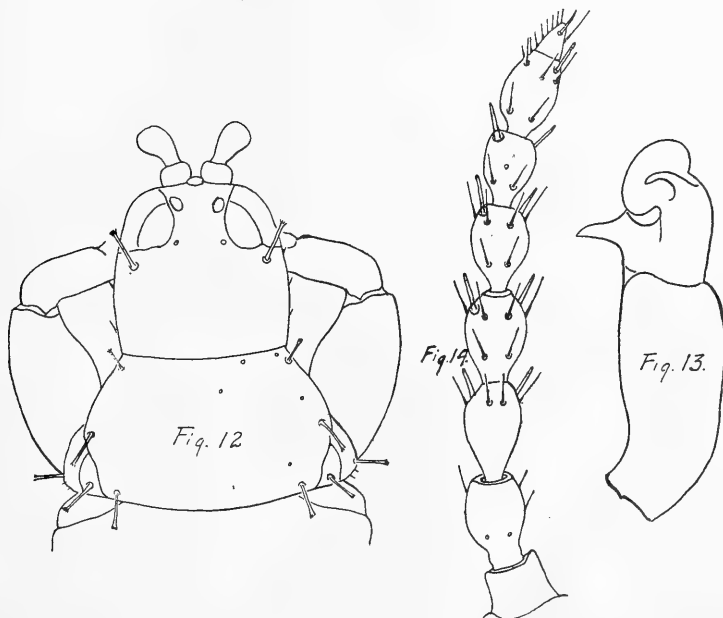
Holotype in author's collection. Paratypes in the Froggatt Collection, Canberra, Australia.

Hostplant: *Geijera parviflora* (Wilga), found in company with *Choleothrips geijerae* forming rolled leaf galls.

Habitat: Gunnedah, New South Wales.

EOTHRIPI BURSARIAE, n. sp. (No. 516.)

Female holotype.—Measurements: Total body length 1.66 mm. Head length 0.21 mm., width 0.20 mm.; prothorax length 0.166 mm., width 0.33 mm.; mesothorax width 0.38 mm. Tube length 0.183 mm., width 0.08 mm. Antenna length (width) segment i, 30 microns (33 microns); ii, 48 (36); iii, 54 (36); iv, 48 (39); v, 48 (36); vi, 42 (33); vii, 48 (27); viii, 24 (18); total length 345 microns.



Eothrips bursariae, n. sp.

Fig. 12. ♀ Head and prothorax, dorsal view. Fig. 13. ♀ Left fore tibia and tarsus, ventral view. Fig. 14. ♀ Right antenna, dorsal view.

Colour brown to dark brown with tips of fore tibia, all tarsi and segments three to five and sometimes six lighter. Wings uniformly light smoky grey. Prominent spines yellow to yellowish brown. Body with numerous orange pigment spots or blotches visible in light coloured specimens.

Head broadly rounded with cheeks slightly arched, broadest across middle line, dorsum with numerous confluent cross striations; postocular spines rather short, stump with dilated tips; cheeks with several short spines. Eyes occupying three-eighths the length of the head, with small facets, indistinctly pilose. Ocelli placed far forward, posterior ocelli contiguous with anterior inner margins of eyes, with dark orange red crescents (Text-fig. 12). Mouth cone reaching posterior third of prosternum, bluntly rounded labium but with pointed labrum. Antennae 8-segmented, approximately one and two-thirds times longer than head, all segments comparatively stout, fourth segment almost five-sixths as wide as long. Two sense cones on segments three, four, five and six, one on segment seven, all are short, blunt and transparent (Text-fig. 14).

Prothorax almost as long as head but noticeably wider, with sides diverging posteriorly. Spines on anterior angles short, mid-laterals a little longer, those on posterior angles longest, all, however, are short, stocky and with dilated tips; each prominent angle of fore coxa also has a similar blunt tipped spine and two or three short pointed ones. Pterothorax broadest, sides almost parallel, converging only slightly near posterior line. Legs rather short, fore femora thickened, fore tibia unarmed, fore tarsi armed each with a spur-like tooth on inner margin and a smaller horn-shaped tooth near tip on ventral side (Text-fig. 13). Wings fully developed, broad, with parallel sides, not constricted in the middle, with ten or twelve double fringe hairs.

Abdomen almost as wide as pterothorax, first seven segments of equal width, eight and nine conspicuously narrowed. Tube slightly shorter than head. Two prominent spines on each posterior angle of segments two to nine, the outer shorter ones (33 microns on segment two) gradually become longer until they reach a maximum length of 111 microns on segment nine; the inner ones, 60 microns on segment two, increase to a maximum length of 135 microns on segment nine, both pairs have blunt or dilated tips. Segments two to seven also have two additional pairs of curved spines on either side, the posterior pair on each segment much stronger than the anterior pair. The longest spines on the end of the tube are two-thirds as long as the tube, 135 microns.

The male is very similar to the female, although somewhat smaller, the abdomen decreases in width gradually from the fourth segment to the tube.

Described from numerous females and males taken from galls on leaves of *Bursaria spinosa* (Native blackthorn) at Warrah and Sydney, New South Wales, Australia, by W. W. Froggatt.

Holotype in author's collection. Paratypes in the Froggatt Collection, Canberra, Australia.

EXPLANATION OF PLATE IX.

No. 518. Rolled leaf galls on *Geijera parviflora* (Wilga) made by *Choleothrips geijerae* and *Dolerothrips geijerae*. Natural size.

No. 1347. Galls on *Acacia doratoxylon* made by *Kladothrips augoussaxos* Moulton. Slightly enlarged.

AN ECOLOGICAL STUDY OF THE FLORA OF MOUNT WILSON.

PART IV. HABITAT FACTORS AND PLANT RESPONSE.

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(Twenty Text-figures.)

[Read 25th May, 1927.]

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1. Introduction.
2. The Habitat Factors.
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3. Plant Response.
 - Leaf Structure of the Chief Constituents of the *Ceratopetalum-Doryphora* Association.
 - Leaf Structure of the Chief Components of the *Eucalyptus piperita-E. haemastoma* Association.
 - Root-systems.
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5. Summary.

1. *Introduction.*

The previous studies (Part i, 1924, Brough, McLuckie and Petrie; part ii, 1925, Petrie; Part iii, 1926, McLuckie and Petrie) of the vegetation of Mount Wilson have brought to light many interesting problems, the solution of which demands intensive study. The most outstanding feature of the vegetation of this region is the great contrast between different associations occurring in close juxtaposition: sclerophyllous *Eucalyptus* Forest alternating with Sub-tropical Rain Forest frequently and sharply in a comparatively small area. This condition has led us to make a more detailed enquiry into the habitat factors which are probably responsible for these remarkable distributional features, and the results of the investigation form the subject of the present communication.

Owing to the absence of a properly equipped permanent field laboratory, the scope of quantitative investigations was somewhat limited. From what has been done, however, it is possible to deduce, in a general manner, what are the basic factors controlling the distribution of the plant communities in this region, and to give an explanation of some of the remarkable features which were recorded in the previous papers. A number of more detailed observations are also recorded upon the ecological structure of the vegetation and upon the nature of its responses to the environment.

We have to record our indebtedness to Mr. D. J. Mares, Commonwealth Divisional Meteorologist, for rainfall and temperature data which have been utilized in this paper.

2. THE HABITAT FACTORS.

It is evident that in a small region like that under consideration, certain factors, *e.g.* climate, will be practically uniform throughout, and, although stamping their impress on the nature of the vegetation, are not directly the cause of the diversity of habitats within the region. Neither rainfall nor the general regional features of climate and season are variable to any marked extent at Mount Wilson, although it must not be thought that they are without their effect on the vegetation; but it is in other directions that one has to seek for the explanation of xerophytic and mesophytic associations existing side by side, and for the occurrence of Rain-Forest in a region with a rainfall rather below that of the typical habitat of that association-type. From what has already been written it will be clear that the *edaphic factors*, rather than the *climatic*, are of fundamental importance in producing the great differences in habitat which result in the presence of these two types; and it appears that we have here an example of compensating factors; in a region in which the climax association-type is sclerophyllous Forest, a local high edaphic favourableness apparently produces the same resultant as would a much higher rainfall with a poorer type of soil; so that a "post-climax", to use Clements's term (Clements, 1916), is here possible in the form of mesophytic Forest. It has also been made evident, however, that it is only in places where exposure is favourable that this effect is produced, so that exposure becomes a second factor of outstanding importance. It is therefore the edaphic factors, and the atmospheric humidity, which depends largely on exposure, that have claimed the greatest consideration in the present enquiry.

Among the general problems of distribution which it was hoped to elucidate are the following:

- (1) The comparatively small amount of invasion of the basalt by types from the *Eucalyptus* Forests of the sandstone.
- (2) The reason why the Rain-Forest grows equally well in the sandstone gullies and on the basalt caps.
- (3) The absence from the basalt of certain Rain-Forest components in the sandstone gullies, such as *Callicoma*, *Todea*, *Blechnum capense* and *Histiopteris incisa* (see Part iii).

CLIMATE OF THE REGION.

Temperature.

No regular records have been taken at Mount Wilson, but the accompanying averages (Table i) of an eight years' record at Mount Victoria, which is only a few miles distant and is of approximately the same altitude, will give a sufficiently accurate conception of the nature of this factor in the region under study.

From these figures it is seen that the extremes are moderate; and although the summer months are fairly hot, the comparatively low minimum values in winter, and the occasional occurrence of snow, are undoubtedly of great significance in controlling the development of the Rain-Forest. We have described it as a luxuriant forest; yet it has not the tropical luxuriance of the more northern Rain-Forests. The floristic composition is comparatively limited, and there are only two dominants; whereas a tropical forest is characterized by great floristic variation. The structure is not excessively complex. The common features of a

TABLE I.
Monthly Temperature Averages at Mount Victoria.

| Month. | Mean Maximum. Degrees Fahrenheit. | Mean Minimum. Degrees Fahrenheit. |
|---------------------------|--------------------------------------|--------------------------------------|
| January | 74.7 | 53.6 |
| February | 73.3 | 54.3 |
| March | 68.6 | 51.0 |
| April | 61.7 | 46.3 |
| May | 53.8 | 41.6 |
| June | 48.4 | 37.3 |
| July | 41.6 | 35.2 |
| August | 51.6 | 37.0 |
| September | 58.8 | 39.6 |
| October | 65.4 | 44.3 |
| November | 71.5 | 48.0 |
| December | 74.9 | 50.6 |
| Average for year | 62.4 | 44.9 |

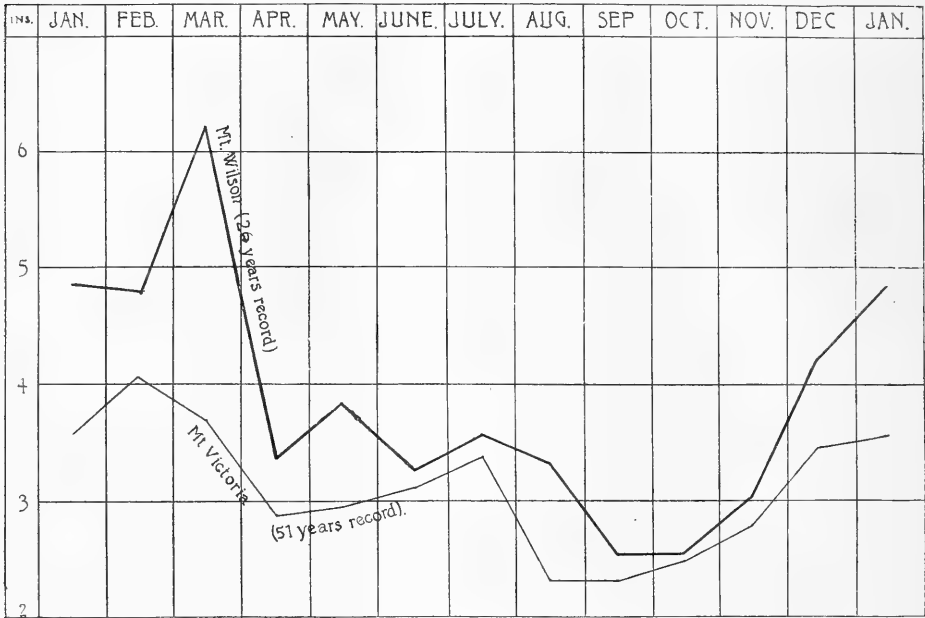
tropical Rain-Forest, *e.g.* very large leaves, plank buttresses, cauliflory, or epiphytly, such as are found even in the coastal forests of the same latitude in New South Wales, are practically absent. While epiphytic mosses and lichens are abundant, epiphytes of Pteridophytic and Angiospermic affinity are not profuse. Indeed, we are driven to realize that the luxuriant physiognomy of the Rain-Forest at Mount Wilson is imparted not by tropical structure and adaptation, but by its wealth of Pteridophytes and by its closeness of structure arising from high edaphic favourableness. Features such as these are in accordance with what one would expect in a montane sub-tropical or temperate Rain-Forest; and although the moderate rainfall is an important factor in causing them, there is no doubt that low temperatures in winter are also effective to a considerable degree.

Rainfall.

While the Blue Mountains as a whole have an average annual rainfall of 30 to 40 inches, Mount Wilson is exceptional in having the higher value of 46 inches. In Text-fig. 1 is given the monthly variation at Mount Wilson and also that at Mount Victoria, a more typical Blue Mountain area. It will be seen that not only is the rainfall at Mount Wilson higher than that at Mount Victoria throughout the whole year, but during the summer it is much higher: the maximum precipitation takes place during the hottest months, December to March.

This state of affairs is of considerable importance in connection with the occurrence of the Rain-Forest at Mount Wilson. While the basalt soil is the main factor leading to the development of this community on the plateau, there is no doubt that were it not for the high summer precipitation it would be a much less favourable habitat for the Malayan Rain-Forest types which at present characterize it. During the winter when desiccation is less, the smaller rainfall is not deleterious.

At Mount Victoria, although the maximum rainfall is also in the summer, it is not by any means so high; and this fact probably explains in part the



Text-figure 1. Annual rainfall graphs for Mount Wilson and Mount Victoria.

occurrence of Rain-Forest in shallow sandstone gullies at Mount Wilson which at Mount Victoria would probably be occupied merely by sclerophyllous *Eucalyptus* Forest.

The basaltic soil and the comparatively high summer rainfall then, are responsible for the maintenance of the luxuriant vegetation of the Mount Wilson area.

HUMIDITY AND EVAPORATIVE POWER OF THE AIR.

Methods.

At the beginning of September, 1924, measurements were made of the evaporative power of the air in different habitats in order to obtain some knowledge of the requirements of the vegetation with regard to this factor.

As standard Livingston atmometer cups were unobtainable at the time, evaporimeters were made from Chamberland filter-candles attached to burettes by a piece of rubber-tubing, the whole being carefully filled with water so as to avoid the inclusion of air-bubbles. As it was desired to compare daily with nightly readings in the Rain-Forest to ascertain whether conditions bordering on saturation obtained there, burettes were used in place of the jars more commonly associated with the Livingston atmometer. This apparatus gave a rapid and accurate record of the water evaporated; it was found, however, during preliminary tests in the laboratory, that in a very humid atmosphere the presence of a column of water in the burette above the level of the filter candle resulted in a tendency towards exudation of water through the pores of the porcelain. To avoid this in all the evaporimeters used, the filter was raised above the level of the water in the burette by the insertion of a vertical piece of glass tubing between the filter and the burette. After this was done, and so long as the water in the burette was not above the level of the filter, trials in the laboratory showed that in an atmos-

phere of constant humidity the rate of evaporation was constant, and was not measurably affected by the level of water in the burette.

Shreve (1914, p. 43) has pointed out that atmometer readings taken in very dry and very moist climates are not strictly comparable, owing to a difference in the character of the evaporating water-film; and this objection would probably apply to our comparisons of readings taken in the *Eucalyptus* Forests with those in the Rain-Forests. The error, however, is not likely to be large enough to influence the general conclusions to be drawn from the results obtained.

The evaporimeters, although having approximately the same rate of evaporation, were standardized in the laboratory by comparison with the evaporation from an open water surface, whereby a factor was obtained for each evaporimeter. By this means the readings were standardized to the evaporation in cubic centimetres from an open water surface one square metre in area in which form they are expressed in the results given in Text-fig. 2.

Readings were taken early in the morning and at sundown for five successive days, the total evaporation for the twelve hours representing day or night being calculated therefrom. The total daily and nightly evaporation for the whole period is given for each station in Text-fig. 2.

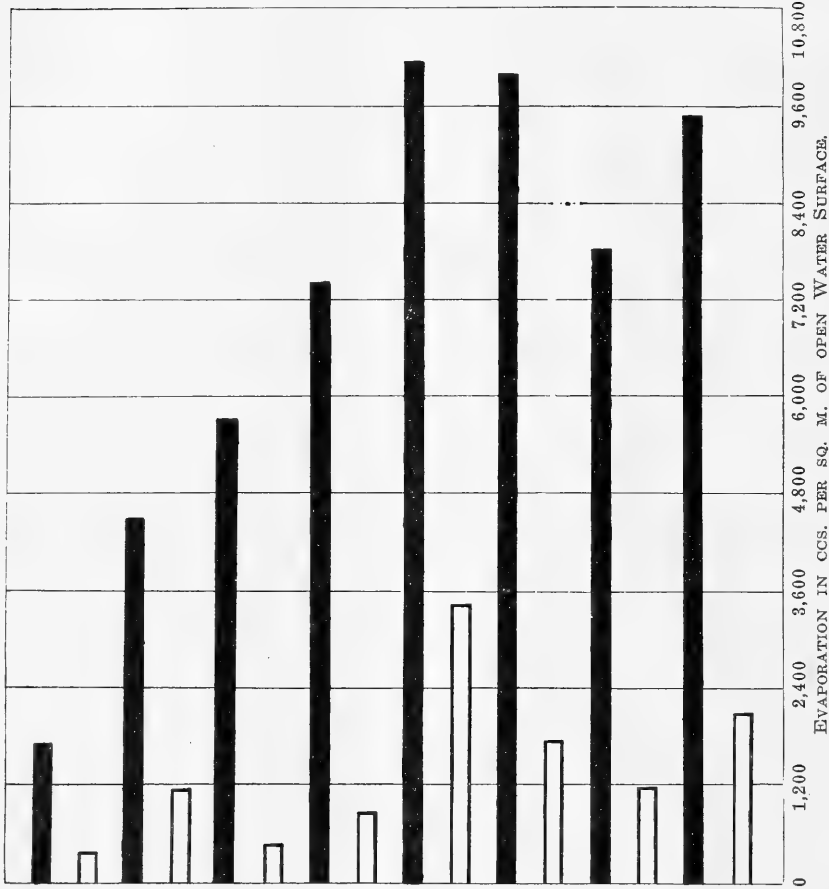
Discussion of Results.

This comparative study of the evaporative power of the air in different habitats gives an interesting confirmation of our observations upon the effect of the exposure on the distribution of the various communities.

The Rain-Forest, as we have previously stressed, is limited to the most sheltered habitats; and it is seen that the evaporative power of the air within it is very much less than in any other habitat. Water vapour appears to arise in considerable amount from the damp soil, forming a humid layer among the ferns on the floor of the forest. Owing to the deep shade and the extreme absence of wind in the forest, the moisture-content at the ground-level is high, and must border on, and no doubt at times attain saturation during the night. The greatly increased insolation at high levels in the Forest lowers the relative humidity and causes a striking difference between the values for the two strata expressed in the diagram. No such dissimilarity is noticeable in the more open communities, where there is little difference in the insolation of the various strata.

The *Alsophila* society of the *Eucalyptus goniocalyx*-*E. Blaxlandi* association has been described as much more tolerant of exposure, avoiding only the full brunt of the westerly winds on the open summits of the basalt caps, which are occupied by the *Pteridium* society in the *E. Blaxlandi* consociation (Part ii, p. 149). The results from stations 4, 5, and 6 show that the *Alsophila* society can withstand very high atmospheric dryness. The values in stations 5 and 6 are even higher than that in station 8 in the *E. piperita* Forest; and, although it is to be expected that more exposed westerly regions in the latter community would give higher values still, it is nevertheless evident that the series of increasingly mesophilous communities is not distributed in a series of habitats characterized by a correspondingly increasing atmospheric humidity. We are therefore led to suppose that the distribution of the *Alsophila* society is governed mainly by soil-moisture, and that it is very largely indifferent to exposure, except perhaps where it reaches an extreme on the open summits of the basalt caps.

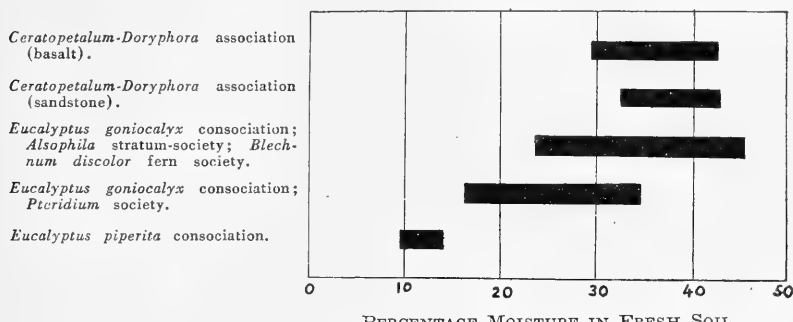
The low values of the evaporation during the night periods are significant since the westerly wind prevalent during the day ceases in the evening.



Text-figure 2. Diagrammatic representation of results of estimation of the evaporative power of the air in various habitats. The black lines represent the evaporation for the day period, those with the white interiors for the night.

THE MOISTURE-CONTENT OF THE SOIL.

A large number of samples of soil were collected at various times at Mount Wilson, in each case after a moderate spell of dry weather. These samples were passed through a 3 mm. sieve and the moisture content was then estimated by drying at 100° C.



PERCENTAGE MOISTURE IN FRESH SOIL.
Text-figure 3. Graphical representation of the soil-moisture ranges of the main associations.

The ranges for the values obtained for the soil-moisture of each association are given in Text-fig. 3. It must be understood that these ranges might possibly be found to be somewhat greater if samples were taken continuously throughout the year; they are nevertheless indicative of the striking features of difference between the habitats of the various communities.

From an examination of Text-fig. 3 it is seen how the range of soil moisture-content for the Rain-Forests, whether on sandstone or basalt soil, does not vary beyond 13%. Thus, although a lower minimum may perhaps sometimes be reached, comparison with the ranges of the other communities at once suggests that the distribution of the *Ceratopetalum-Doryphora* association is determined by water-content of the soil: the association as a whole is apparently independent of soil-type, so long as it finds the necessary high moisture-content. This view is supported by the occurrence of the Rain-Forest on other soils, e.g. shales, in other parts of the State.

The *Alsophila* society of the *Eucalyptus goniocalyx* consociation is not limited to the same extent by moisture-content, the values ranging from 45.2% near the Rain-Forest to 23.5% at the outer boundary; it is probable, however, that there is a minimum value for the lower extremity of the range (in the neighbourhood of 20%) for the habitat of this community, beyond which it is replaced by the *Pteridium* society. It may be asked why the high value of 45.2% is attained in this open community: the answer appears to be that the dense fern stratum may protect the soil from evaporation just as much as the Rain-Forest tree canopy. If then the soil is capable of holding this high percentage of moisture it would be expected that the *Ceratopetalum-Doryphora* Forest would be occupying the habitat; but, as we have seen, the exposure and the prevailing atmospheric humidity are not suited to the requirements of the Rain-Forest here, and in a strong westerly wind this high moisture-content no doubt decreases rapidly.

The *Pteridium* society appears to be one step further in the succession of the mesophilous to xerophilous communities; it is also noticeable that the *Eucalyptus goniocalyx* consociation is evidently confined to soils of a minimum soil-moisture

range, which, although low, is much higher than that of the *E. piperita* consociation.

The *E. piperita* Forest has the lowest values, and there is no doubt, moreover, that after periods of drought the minimum value would be even lower than that given. It is thus clear that the sandstone plateau is a highly xerophytic habitat. It is probable nevertheless that, since water drains rapidly downwards to the lower levels in sandstone soil, it does not have time to dry out between falls of rain, more especially as we have seen that the rainfall is fairly evenly distributed throughout the year.

The comparison of the soil-moisture values of this series of communities indicates clearly how the zonation of vegetation tends to coincide with a zonation of soil-moisture. There is no doubt that the falling gradient is increased by the progressive decrease in the capacity of the vegetation to conserve soil-moisture by shade and humus production. It appears then that the *Ceratopetalum-Doryphora*, *Eucalyptus goniocalyx-E. Blaxlandi*, and *E. piperita-E. haemastoma* var. *micrantha* associations are adapted to habitats of decreasing soil-moisture content: each will occupy the habitat where it finds its range, provided the other controlling factor of exposure permits; if this does not, one of the following associations in the series will occupy the habitat. The more xerophytic communities are no doubt excluded from the more mesophytic habitats by competition.

THE PHYSICAL STRUCTURE OF THE SOIL.

Samples of soil were taken at a depth of six inches from a number of typical habitats, and on arrival at the laboratory they were passed through a 3 mm. sieve. Two portions were then removed, the one being dried at 100° C. and ignited for the estimation of humus, the other being analysed mechanically by the method adopted by the British Agricultural Education Association (see appendix to Russell, 1921). The smaller separations, such as coarse and fine sand, were not made, as only the salient features of difference between the various soils were required. The results of these determinations are given in Table ii.

Discussion of Results.

Obviously the great difference in the physical structure between the basalt and sandstone soils will be a key to a number of other factors, since it will affect the aeration, moisture-retaining capacity, colloidal properties, etc., and will also be likely to have a marked influence on the root-systems. Aeration is one of the chief concomitants of the physical structure of a soil; and it is well known that sandstone, open and porous in nature, is abundantly ventilated and well drained, while clays, on account of the smallness of the component particles are poorly aerated and poorly drained, and tend to be infertile through lack of calcium carbonate. *A priori* it might be expected that the basalt, being a clay soil, although not deficient in calcium carbonate, might have an unfavourable influence on plant life on account of lack of aeration. Humus in amounts of 10% to 30%, however, as is present in the upper layers of the basalt soil (samples 1 to 8) counteracts the baneful effects of clay so far as low aeration goes, and renders the texture more open, without depreciating its moisture-retaining properties (Russell, 1921). This consideration probably explains the presence of the same association on the basalt slopes and in the sandstone gullies throughout this area—a distributional phenomenon which might lead one to deny the influence of edaphism on the distribution of vegetation. From this aspect of the humus-

TABLE II.
Results of Mechanical Analysis of Soil Samples.

| No. of Sample. | Community. | Habitat. | Fine Gravel. | Sand. | Silt. | Clay. | Humus. |
|----------------|--|--|--------------|-------|-------|-------|--------|
| | | | % | % | % | % | % |
| 1 | } <i>Ceratopetalum-Doryphora</i> association. | } Basalt. Do. 1 ft. deep. Do. 5 ft. deep. | 3.51 | 21.06 | 2.34 | 60.32 | 13.77 |
| 2 | | | — | — | — | — | 19.04 |
| 3 | | | — | — | — | — | 26.45 |
| 4 | | | — | — | — | — | 19.04 |
| 5 | | | — | — | — | — | 10.40 |
| 6 | | | — | — | — | — | 12.11 |
| 7 | <i>Eucalyptus goniocalyx</i> consociation; <i>Alsophila</i> society. | Basalt. | — | — | — | — | 30.25 |
| 8 | Do. Tree-fern boundary. | Edge of basalt. | — | — | — | — | 16.48 |
| 9 | } Do. <i>Pteridium</i> society. | Ridges of N.E. slope below basalt. | 8.67 | 68.15 | 9.97 | 2.97 | 10.24 |
| 10 | | } Sandstone; centre of plateau. | — | — | — | — | 10.04 |
| 11 | | | 10.39 | 59.32 | 8.45 | 2.74 | 19.10 |
| 12 | | | 5.28 | 64.90 | 2.45 | 7.75 | 19.63 |
| 13 | <i>E. piperita</i> consociation. <i>Pteridium</i> society. | Sandstone. | 6.80 | 75.19 | 6.33 | 0.00 | 12.84 |
| 14 | } <i>E. piperita</i> consociation. | Westerly slope recorded in Part iii, p. 108, where <i>Telopea</i> appears. | 13.54 | 73.40 | 3.27 | 1.24 | 8.55 |
| 15 | | Same slope; sandstone below basalt; floristic composition, Part iii, p. 108. | 8.12 | 77.73 | 6.11 | 2.77 | 5.27 |
| 16 | } <i>Ceratopetalum-Doryphora</i> association. | } Centre of sandstone plateau. | 4.22 | 73.01 | 8.82 | 5.50 | 8.48 |
| 17 | | | — | — | — | — | 7.01 |
| 18 | | | 13.73 | 60.65 | 6.26 | 0.00 | 19.88 |
| 19 | | | Sandstone. | 1.80 | 70.58 | 2.66 | 9.32 |
| 20 | | Sandstone a little below basalt. | 9.78 | 54.35 | 5.75 | 2.73 | 27.39 |

Except where otherwise stated, samples were taken from a depth of six inches.

Diameter of Particles in various Fractions.

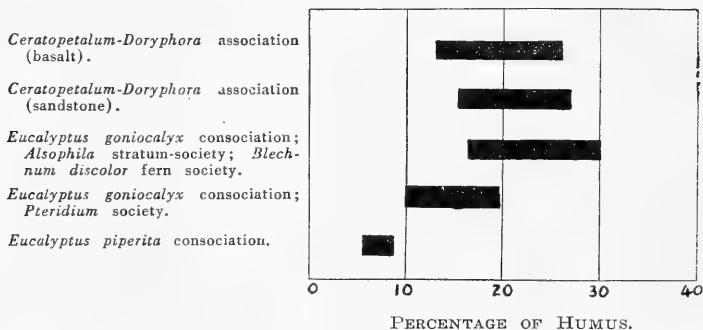
Fine gravel = above 1 mm.
Sand = 1-0.037 mm.
Silt = 0.037-0.002 mm.
Clay = below 0.002 mm.



content, which appears to counteract the effect of other components, the soils are perhaps not so fundamentally different in their influence on vegetation. Consequently it is not surprising that the actual number of plants with soil preferences were found to be very few (Part iii). Such preferences as appear to exist are probably in most cases the results of differences in properties of the soil solution.

Although the humus will have this striking effect near the surface, at depths of some feet its content in soils decreases rapidly, as is indicated in the present instance in samples 5 and 6, and eventually becomes quite low. At the same time the basalt soil is deep, since the rainfall is such as to cause rapid and penetrative weathering, and water and organic acids from the humus percolate through the soil and decompose the underlying rock. It is clear then that at greater depths the soil will not receive the beneficial effects of a high humus content; so that the vegetation would be expected to root in the upper regions if it is a type adapted to a well aerated soil. This point will arise again for discussion in a later portion of the paper.

The large percentage of clay and humus in sample 1 is plainly the key to the high moisture-retaining capacity, and consequent mesophilous vegetation, of the basalt soil. Probably, however, in the surface layers the humus is more important in this respect than the clay; for, as is usually the case, the moisture-content closely follows the humus-content. Text-fig. 4 shows that the ranges of



Text-figure 4. Graphical representation of the humus-content-ranges of the soils of the main associations.

these two properties correspond in a striking manner. It is thus the water-retaining capacity of the humus which makes it possible for the soil-moisture of the sandstone habitats clothed by Rain-Forest to be as high as those of the basalt, despite the absence of clay from the sandstone soil. It must be added, however, that the stations in the sandstone Rain-Forest from which samples were taken for moisture estimations were more particularly in the erosion channels occupied by *Dicksonia* and *Todea*, no samples unfortunately being taken from the apparently drier slopes devoid of tree-ferns; and, moreover, the Rain-Forest on the sandstone occurs only in valleys, where water is continually draining down from the highlands. In this connection it is interesting to note that, as was mentioned previously, the Rain-Forest at Mount Wilson occurs in gullies which on the other parts of the Blue Mountains would probably be occupied by a much more xerophytic community, since the water supply would not be sufficiently constant. In such habitats the gravitational water drains away rapidly and during a dry period disappears from the heights and so causes the gullies to become dried

up. Hence the suggestion is offered that the water supply for the gullies at Mount Wilson is to some extent kept uniform and continuous by slow drainage from the basalt caps; owing to the low capillary power of such heavy clay soils the water would be conserved after rain and would be allowed to drain away slowly and uniformly, thus maintaining a constant supply for the gullies below.

This does not depreciate the previous statement that the humus is the main factor controlling the moisture-content of the soil, since these two factors are reciprocal: the formation of a water-retaining humus depends on the nature of the aspect and the vegetation allowing an accumulation of moisture in the soil: and were it not for this humus the water would probably dry out from the sandstone soil. The relationship between moisture-content and humus is probably responsible also for differences in the properties of the organic portion of the various soils. The moist volcanic soil and the moist and well-aerated and well-drained soil of the sandstone gullies must favour the production of a "mild humus", as in such habitats earthworms, fungi, and bacteria flourish; in particular the effect of earthworms is important since large species are abundant on the basalt and prove an important factor in ventilating the soil. On the other hand the dry sandstone soil forms a very different medium for the existence of these organisms, so that little humification goes on; in this case, therefore, although 7% to 8% of organic matter was found it is improbable that it would have the same moisture-retaining capacity as that of the more humid habitats, and therefore is contributing to the xerophytic nature of the sandstone soil. This absence of humification in the habitat of the *Eucalyptus piperita*-*E. haemastoma* var. *micrantha* association adds point to its facies, as the bare patches between the individual plants are usually occupied by fallen leaves, twigs and branches, which in a more humid forest would soon rot away, but which here dry and accumulate until they provide material for the next forest fire.

A consideration of the analytical results shows that apart from the basalt there is no fundamental difference in the physical structure of the other soils. There is no evidence of mixing of the two main types except in the case of the basalt which contains a fairly high extraneous sand fraction, probably blown in by winds. The clay and silt fractions of the sandstone soils are largely composed of ferric oxide, a common mineral in the Hawkesbury sandstone, and which comes down with these fractions in the analysis. Samples such as 9 and 20 show that even on steep slopes there is no evidence of basalt soil being carried down very far and mixed with the sandstone, although there is no doubt that a mixture occurs in the ecotone region of the Rain-Forest referred to in Part iii (p. 98); the main erosion of the basalt, however, takes place in definite drainage channels, and has been described already (Part iii, p. 105).

In Part iii (p. 103) a description was given of the extension of the *Eucalyptus piperita* consociation to the basalt on a westerly slope. This spread is apparently only a small one, since the analysis of sample 14 shows that the *Lomatia* society is actually on the sandstone side of the junction, although from field observations we concluded that the soil was basalt.

The salient feature of this part of the investigation is the striking correspondence between the ranges of the moisture- and humus-contents of the soil. The clay fraction of the basalt soil holds sufficient moisture to provide a suitable substratum for the development of a rich humus, and is aided by shade and humidity in the Rain-Forest. This explains the mesophytic structure of the vegetation of the basalt soil, a vegetation which extends on to the sandstone only

on slopes or in valley floors which are damp through drainage. The predominant effect of the basalt soil on the distribution of the various associations depends almost solely upon its capacity for retaining water.

Up to this stage then we seem to have found two outstanding factors controlling the distribution of the plant associations. The first of these is *aspect*, which has both a direct effect on the vegetation through the atmospheric humidity, and also an indirect effect by influencing the evaporation of water from the soil. The second factor is the *moisture-content of the soil*, dependent on the humus, which in turn is dependent on the clay fraction of the basalt soil, upon drainage and upon shade.

THE HYDROGEN-ION CONCENTRATION OF THE SOIL SOLUTION.

On account of the high base-content of basalt soils, and the continuous filtering of water through it, it was thought probable that leaching would have an influence on the soil acidity; in any case the latter was likely to be a factor of interest in a region so marked as Mount Wilson in edaphic variation.

Clark and Lubbs' indicators were used for the estimations of the hydrogen-ion concentration of the soil. The procedure was based on Wherry's field-method (Wherry, 1920), with certain modifications: thus it was found necessary in the case of soils which remained turbid for a long period to filter them through ashless filter-papers, having carefully leached these until the washings gave a neutral reaction with brom-thymol blue; it was also found advisable to use the same quantity of water for each extract in order to obtain comparative results, a conclusion arrived at also by other workers (Wherry, 1924).

In Table iii are given the P_H values for samples taken at a depth of 6 inches from the various habitats. Each represents the results of a number of determinations from different parts of the community. The acidity was found to be practically uniform in these habitats at depths from 2 to 8 inches.

TABLE iii.

Hydrogen-Ion Concentration of the Soil Solution from the Habitats of the Main Communities.

| | P_H . |
|--|---------|
| <i>Ceratopetalum-Doryphora</i> association; basalt | 6.5-7.0 |
| <i>Eucalyptus Blaxlandi</i> consociation; summit of basalt cap | 6.5 |
| <i>E. goniocalyx</i> consociation; <i>Alsophila</i> society | 6.5 |
| <i>E. goniocalyx</i> consociation; <i>Pteridium</i> society | 6.5 |
| <i>E. piperita</i> consociation | 7.0 |
| <i>Ceratopetalum-Doryphora</i> association; sandstone | 6.5 |

The lack of variation in these results is a prominent feature. Despite the high content of bases, such as calcium, characteristic of basalt soil, the buffer action apparently prevents any fluctuation in the hydrogen-ion concentration of the soil solution. In all the soils except the dry sandstone the high content of colloidal material in the form of humus and also of clay in the case of the basalt, readily explains this buffer action; in the case of the sandstone it is to be presumed that the absence of an appreciable quantity of basic material on the one hand, and the absence of much humification or abundance of respiring root-systems on the other, mitigate any tendencies towards departure from neutrality in the soil-moisture.

From this it is clear that the hydrogen-ion concentration of the soil solution is not a factor of significance in the study of the distribution of the vegetation at Mount Wilson.

3. PLANT RESPONSE.

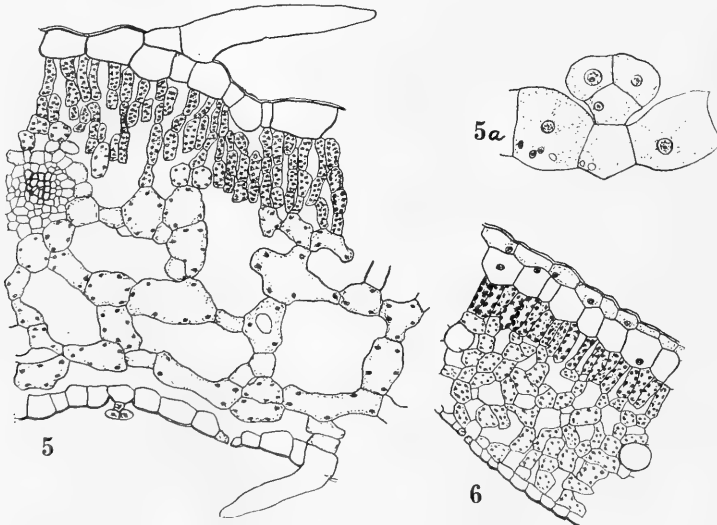
In preceding communications on the ecology of the Mount Wilson area, we have described the main features of the physiognomy and distribution of the flora and have endeavoured to interpret these as responses to certain factors or factor complexes of the environment. In the present paper we have endeavoured to analyse the environmental factors and to deduce the relative significance to the flora of each of the more important. We have indicated the outstanding differences in the various plant associations which occur throughout this area, and now furnish an account of the chief anatomical characters of the most important types of these associations. As Cannon (1924, p. 103) points out, two different and important groups of factors must be considered in the attempt to interpret the anatomical peculiarities of plants from the physiological point of view, namely *heredity* and *immediate environment*. The fact that different genera of the same family and even different species of the same genus attain to harmony with the environment by the most varied anatomical characters, seems to us to indicate that another set of influences of an hereditary nature is acting simultaneously with the present environment, and that the structure of the living types is, generally speaking, the result of the impress of two different categories of forces. On the other hand the physiologist knows on experimental grounds that certain characters are definitely plastic and modifiable by changing environment; hairiness may be replaced by glabrousness by cultivation in a more humid atmosphere; sclerophylly may be replaced by more mesophytic characters under similar conditions; nanism may give way to a taller habit; in short most of the characters of a highly xerophytic plant are changeable under a changed environment, provided it acts for a sufficiently long period during the development of the individual. The different "adaptations" of plants to the more xerophytic or mesophytic conditions appear to us to support the view that the present structure is the resultant of factors now operating but modified in certain respects by the cumulative influence of hereditary forces. This is all the more reasonable when we consider that members of the same family growing under precisely the same conditions in the same locality, show, amidst a general similarity of response certain individual differences. Speaking generally the types from the *Ceratopetalum-Doryphora* Rain-Forest (as the following descriptions will show) have thin unwettable cuticles, little or no sclerenchyma, stomata flush with the epidermis and without the outer vestibule characteristic of xerophytic types, poorly developed palisade and a great development of spongy mesophyll with large air spaces. The types from the *Eucalyptus piperita-E. haemastoma* association on the dry exposed sandstone habitat have stomata sunken in grooves or pits, hairiness, considerable sclerenchyma as hypoderma or as girders associated with the veins, strongly developed palisade and proportionately poorly developed spongy mesophyll, tannin deposits, enormously thick cuticles and outer epidermal walls, and frequently oil sacs.

In these xerophytic types the outer epidermal wall is generally heavily thickened owing to the deposition of anhydrides under the influence of the desiccating conditions. Strong cuticularization is a prevailing feature as the deposition of cutin is intimately associated with the transpiratory activity of the leaf. In the species of *Banksia* mentioned the stomata occur in pits, the cuticle of which is poorly developed. The stomata are usually sunk below the general surface of the leaf, and the cuticle forms, in many types, a prominent ridge overarching the guard cells, thus constricting the approach to them.

Between these two extreme groups of structures are those displayed by components of the *Eucalyptus goniocalyx*-*E. Blaxlandi* association which develops on a much less xerophytic habitat than the *E. piperita*-*E. haemastoma* association. The anatomical characters common to these components of the associations at Mount Wilson may be seen more readily from the following descriptions and figures.

LEAF STRUCTURE OF THE CHIEF CONSTITUENTS OF THE *Ceratopetalum-Doryphora* ASSOCIATION.

Fieldia australis. The chief characteristics are (a) the very thin cuticle for facilitating cuticular transpiration, (b) the poor development of palisade tissue owing to growth in a shaded environment, (c) the extensive intercellular space system of the leaf facilitating aeration and transpiration (the air channels being internal evaporating surfaces), (d) the poorly developed vascular tissue, (e) the numerous short hydathodes for secretion of excess water, and (f) the numerous stomata on the lower surface for aeration and passage of water vapour. These are structural features which characterize a type growing in a shaded moist environment, where aeration and transpiration require to be stimulated as far as possible by anatomical deviations from the normal type (Text-fig. 5, 5a). It has been shown earlier in the paper that in the lower strata of the Rain-Forest, which form the habitat of *Fieldia*, the atmospheric humidity is often in the neighbourhood of saturation.



Text-figure 5. Section of leaf of *Fieldia australis*. $\times 115$.

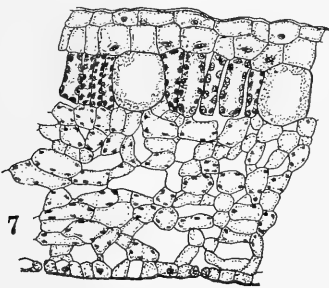
Text-figure 5a. Hydathode of *Fieldia australis*. $\times 300$.

Text-figure 6. Section of leaf of *Atherosperma moschatum*. $\times 115$.

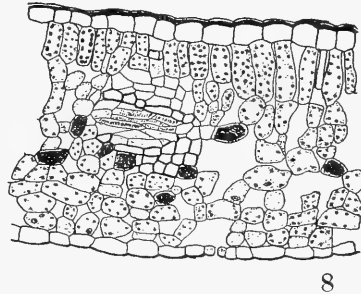
Atherosperma moschatum. In this type the cuticle and outer epidermal cells are thin; the stomata are numerous and on the lower surface only. A hypodermal layer of relatively large clear cells is present on the upper surface, suggesting an aqueous tissue in structure; a narrow palisade layer is developed, while a loose spongy mesophyll occupies more than half the cross section of the leaf.

The palisade layer contains relatively more chromatophores than the cells of the spongy mesophyll (Text-fig. 6).

Doryphora sassafras also has a hypodermal layer of clear thin-walled cells devoid of chlorophyll and suggesting an aqueous tissue. This may be correlated with the fact that *Doryphora* frequently grows in more illuminated and drier situations than prevail in true Rain-Forest areas. The palisade layer is narrow with considerable spaces between certain cells, and large lysigenous oil-glands. The spongy mesophyll occupies more than half of the cross section of the leaf as in *Atherosperma*. The stomata are numerous and occur on the lower surface. The cuticle on both surfaces is thin (Text-fig. 7).



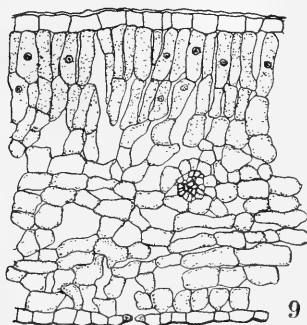
Text-figure 7. Section of leaf of *Doryphora sassafras*. $\times 115$.



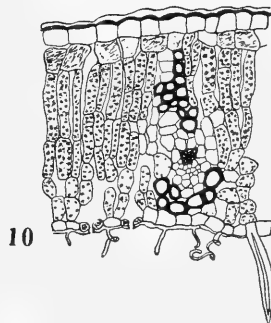
Text-figure 8. Section of leaf of *Ceratopetalum apetalum*. $\times 115$.

Ceratopetalum apetalum. There is no hypodermal layer below the upper epidermis as in *Atherosperma* and *Doryphora*, while the palisade layer is slightly more elongated in comparison with those types. The spongy tissue is extensively developed, while a few isolated tannin cells are distributed through it. A few comparatively thick-walled cells surround the vascular bundles. The cuticle on the upper surface is more strongly developed than in the previous types (Text-fig. 8).

Quintinia Sieberi. This is also a typical mesophyte which frequently starts development from seeds deposited on the trunks of treeferns etc. Compared



Text-figure 9. Section of leaf of *Quintinia Sieberi*. $\times 115$.



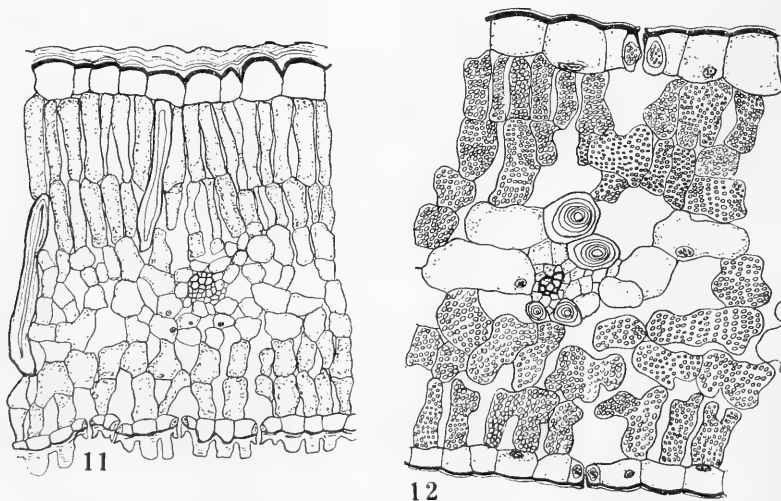
Text-figure 10. Section of leaf of *Callicoma serratifolia*. $\times 115$.

with *Atherosperma*, *Doryphora*, and *Fieldia*, the palisade is more strongly developed, although the proportion of palisade to spongy mesophyll is only very slightly different. Thick walled cells are absent from the smaller veins, while stomata are both numerous and flush with the other epidermal cells (Text-fig. 9).

Callicoma serratifolia occurs in water courses and drainage channels throughout the sandstone and consequently shows an anatomical structure intermediate between the mesophytes of the Rain-Forest and the xerophytes of the *Eucalyptus piperita* forest. The upper cuticle is much thicker than in *Ceratopetalum*. The hypodermal layer contains a tannin-like deposit, the palisade layer is better developed and occupies more than half of the cross section of the leaf. Air channels are extensive, stomata are numerous, and hairs are developed from the lower epidermis. Numerous thick-walled cells occur on the adaxial and abaxial surfaces of the vascular bundles. These are characteristics which stamp *Callicoma* as a form somewhat intermediate between the Rain-Forest Flora and the highly xerophytic individuals of the exposed sandstone habitat. (Text-fig. 10).

LEAF STRUCTURE OF THE CHIEF COMPONENTS OF THE *Eucalyptus piperita*-
E. haemastoma ASSOCIATION.

Telopea speciosissima. The upper cuticle is very thick and laminated, the outer epidermal wall is also thick, and the palisade tissue is composed of elongated cells occupying about half the cross section of the leaf; stereids occur



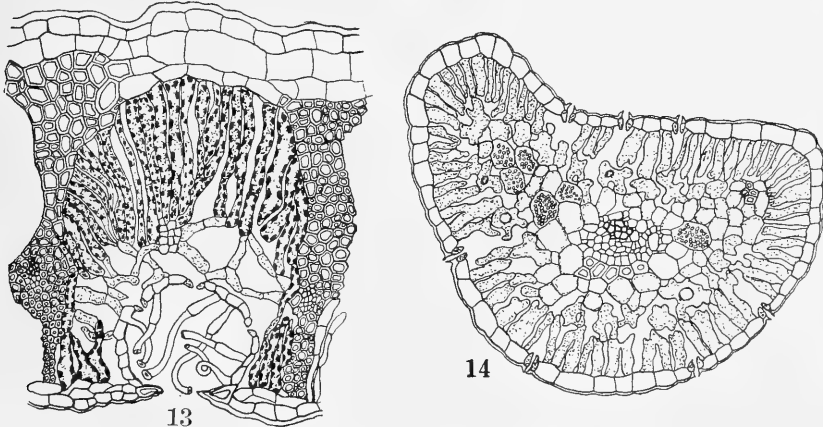
Text-figure 11. Section of leaf of *Telopea speciosissima*. $\times 115$.

Text-figure 12. Section of leaf of *Persoonia salicina*. $\times 115$.

as strengthening cells both in the palisade and spongy mesophyll. The latter is composed of small cells in the centre and more elongated cells within the lower epidermis somewhat suggesting a palisade layer. The cuticle of the lower epidermis is very papillate and forms a cuticular ridge over the stomata which are sunk slightly beneath the other epidermal cells. A small outer and large inner vestibule occur in association with the guard cells—a character to be expected in a xerophytic sandstone type (Text-fig. 11).

Persoonia salicina is an isobilateral type in which palisade tissue is developed on both surfaces, with larger air channels than might be expected in a xerophytic type. The leaf is thick and slightly succulent, and intensely green owing to the enormous chlorophyll content of the cells. The centre of the leaf is occupied by large colourless cells with mucilaginous sap, and cells with thick stratified mucilaginous walls. Isolated stone cells also occur. The guard cells are not so sunk as in *Teloepa*, possibly owing to the vertical position assumed by the lamina through the twisting of the petiole through an angle of 90° . The cuticle is not nearly so thick as in *Teloepa*, and forms a smooth layer on the surface (Text-fig. 12).

Banksia serrata is one of the most extreme xerophytic types in this association. The upper epidermis is covered by a very thick smooth cuticle; a hypodermis of two or three layers of clear cells probably represents an aqueous tissue. The palisade tissue is developed in relation to the cavities on the lower surface, and is composed of long narrow cells with large air spaces between them. The cavities occur at frequent intervals and are lined by epidermal cells, interrupted by *raised* stomata, and producing twisted hairs. Directly beneath the cavities there is developed a very loose network of mesophyll cells containing few chloroplasts compared with the palisade cells. The vascular bundles are strengthened by means of sclerenchyma extending as girders from one epidermis to another. The lower epidermis, excepting that of the cavities, is strongly cuticularized while a hypodermal layer of colourless cells is situated beneath the epidermis (Text-fig. 13) (compare Hamilton, A. G., *Aust. Ass. Adv. Sci.*, 1907, Adelaide, p. 484, 1908).

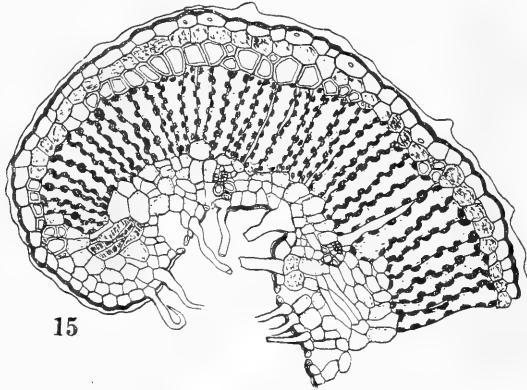


Text-figure 13. Section of leaf of *Banksia serrata*. $\times 115$.

Text-figure 14. Section of leaf of *Persoonia acerosa*. $\times 115$.

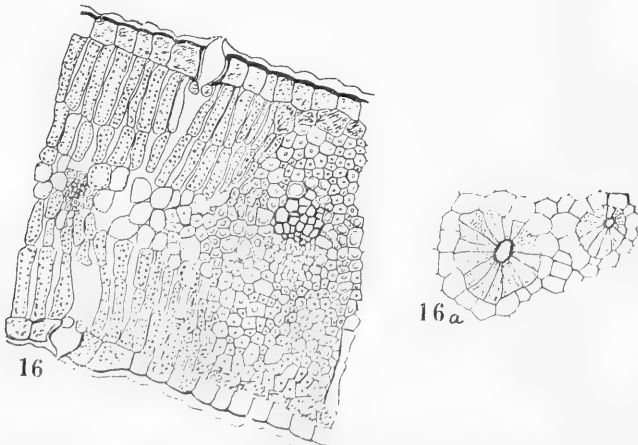
Persoonia acerosa. The cuticle of this pinoid type is fairly thick, and the guard cells are depressed at the base of the outer vestibule formed by the cuticular ridges. The palisade tissue is arranged concentrically within the epidermis. The centre of the leaf is occupied by the vascular bundle and by colourless cells, some of which contain starch, and others probably represent aqueous tissue. Isolated groups of sclerenchyma cells occur in the mesophyll, and in relation to the vascular bundles. The air space system is more elaborate than might be expected in a xerophytic type (Text-fig. 14).

Banksia spinulosa. In this type the leaf margin is recurved, and numerous slightly raised stomata occur in the cavity so formed. Hairs arise from the epidermal cells in the vicinity of the guard cells, which open into fairly large sub-epidermal chambers or cavities. Very little tissue of a spongy nature is developed, while about three-fourths of the cross section of the leaf is composed of elongated palisade cells with very narrow intercellular spaces. The cuticle is strongly developed on both surfaces, while the outer epidermal wall is thickened; the hypodermis is composed of deeply staining tannin cells and sclerenchyma. All the anatomical characters of this type confirm the xerophytic structure of the leaf to be expected from the habitat of the plant (Text-fig. 15).



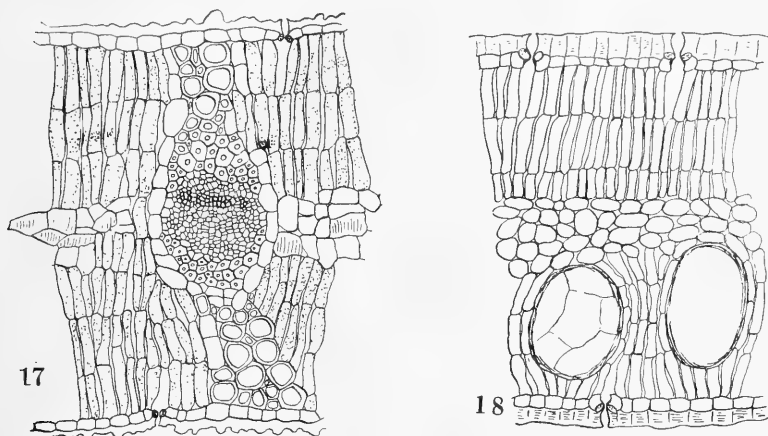
Text-figure 15. Section of leaf of *Banksia spinulosa*.

Hakea dactyloides is an isobilateral type with strongly developed palisade on both surfaces. The main bundles are surrounded by sclerenchyma developed as girders connecting the surfaces of the leaf. The centre of the leaf is occupied by colourless loosely arranged cells, while the stomata are deeply depressed and the ridges of the thick cuticle form comparatively large cavities above the guard cells. Many of the epidermal cells contain a deeply staining substance like tannin (Text-figs. 16, 16a) (compare Hamilton, A. G., PROC. LINN. SOC. N.S.W., 1914, p. 152).



Text-figure 16. Section of leaf of *Hakea dactyloides*. $\times 115$.
Text-figure 16a. Surface view of cuticular ridges over arching the guard cells. $\times 115$.

Eucalyptus piperita has an isobilateral type of leaf, with compact palisade tissue and narrow air spaces. Stomata are found on both surfaces, while aqueous tissue occupies the centre of the leaf on each side of the main vascular bundles. Sclerenchyma is formed in association with the chief vascular bundles and forms a girder across the leaf. A layer of water-jacket cells is frequently present on each side of the vascular bundles. The cuticle is very thick, but the outer epidermal wall is exceptionally thin (Text-fig. 17).



Text-figure 17. Section of leaf of *Eucalyptus piperita*. $\times 115$.

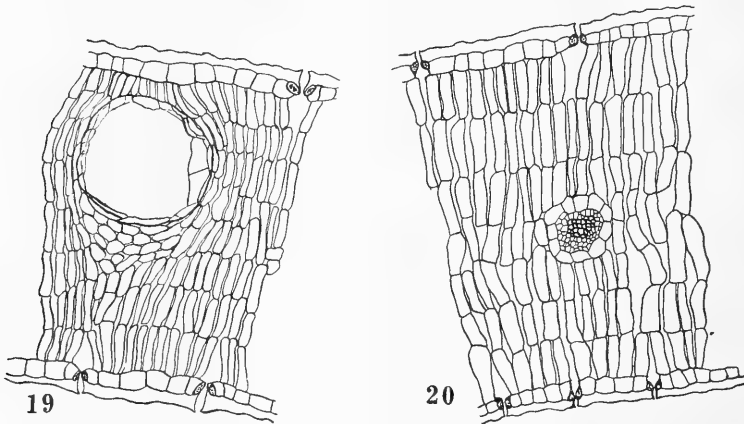
Text-figure 18. Section of leaf of *Eucalyptus haemastoma*. $\times 115$.

Eucalyptus haemastoma resembles *E. piperita* in its isobilateral structure. The chief differences are in the greater development of the cuticle, and the definite central aqueous zone between the palisade of the lower and upper surface. The guard cells of this type like those of *E. Blaxlandi* are distinctly elevated, but protected by a well-developed outer vestibule formed by the enormously thick cuticle. The very narrow intercellular spaces and the consequent compactness of the palisade cells of this species are definite indications of the necessity of rigid control of the transpiring surface, both internal and external. The large proportion of oil glands in these two species may be regarded as an indication of their habitat being more xerophytic than that occupied by the species *E. goniocalyx* and *E. Blaxlandi* in which the glands are less numerous in the leaf (Text-fig. 18).

The components of the *E. piperita*-*E. haemastoma* association have adopted sclerophyllly instead of succulence as their adaptation to the environment. The majority of the species are glabrous and strongly cutinized epidermal cells take the place of trichomes. Several of the species are isobilateral, and develop palisade tissue on both surfaces. The intercellular space system of the mesophyll is exceedingly variable; but generally speaking, types with strongly developed palisade tissue have relatively small and narrow intercellular spaces. In the spongy parenchyma of dorsiventral leaves the spaces are comparatively larger. Perhaps these features of the photosynthetic tissue may be correlated with the aridity of the habitat.

The structure of the foliage of the species of *Eucalyptus* from the various associations characterized generally by differences of environment, indicates some degree of correlation between the anatomical structure and the more important environmental factors, almost amounting to direct cause and effect.

In *E. goniocalyx* the palisade tissue is loosely arranged with numerous intervening spaces for aeration, while central aqueous tissue like that in *E. haemastoma* is generally absent, except in association with the vascular bundles. The cuticle and outer epidermal wall are not so extremely developed



Text-figure 19. Section of leaf of *Eucalyptus goniocalyx*. $\times 115$.

Text-figure 20. Section of leaf of *Eucalyptus Blaxlandi*. $\times 115$.

as in *E. haemastoma*, but nevertheless they indicate a xerophytic type, despite the fact that it grows in a soil with a high water content. Owing to the height attained by the individual and the consequent high rate of transpiration due to exposure and the general evaporating effect of the atmosphere water control is very necessary (Text-fig. 19).

In *Eucalyptus Blaxlandi* the same structural features are revealed. As in *E. goniocalyx*, the guard cells of the stomata are practically flush with the other epidermal cells, or slightly raised and situated at the base of a cavity formed by the overarching cuticle (Text-fig. 20). In these two species of *Eucalyptus* the stomata are much more numerous than in the sandstone species, and taken as a whole the anatomical characters of their foliage stamps them as being types growing under much more favourable conditions of water-supply than *E. piperita* and *E. haemastoma*.

As compared with *E. haemastoma* and *E. piperita* the number of oil glands per unit area is less—a fact which might be interpreted as having some relation with the difference in the aridity of the habitat.

In *E. haemastoma* the colourless aqueous tissue forms a definite zone in the centre of the leaf between the abaxial and adaxial palisade.

Table iv gives the relative number of stomata in some of the chief components of the various associations:

TABLE iv.
Stomata per sq. mm.

| Plant. | <i>Ceratopetalum-Doryphora</i> Association. | | <i>E. goniocalyx-E. Blaxlandi</i> Association. | | <i>E. piperita-E. haemastoma</i> Association. | |
|------------------------------------|---|----------------|--|----------------|---|----------------|
| | Upper Surface. | Lower Surface. | Upper Surface. | Lower Surface. | Upper Surface. | Lower Surface. |
| <i>Eucalyptus goniocalyx</i> | (Isobilateral) | | 33 | 109 | | |
| <i>E. Blaxlandi</i> | (Isobilateral) | | 184 | 188 | | |
| <i>Alsophila australis</i> | | | 0 | 99 | | |
| <i>Acacia melanoxylon</i> | (Isobilateral) | | 236 | 246 | | |
| <i>Lomatia longifolia</i> | | | 0 | 205 | | |
| <i>Drimys dipetala</i> | 0 | 280 | | | | |
| <i>Pittosporum undulatum</i> .. | 0 | 184 | | | | |
| <i>Blechnum discolor</i> | 0 | 60 | | | | |
| <i>Dicksonia antarctica</i> .. . | 0 | 113 | | | | |
| <i>Eucalyptus piperita</i> | (Isobilateral) | | | | 60 | 107 |
| <i>E. haemastoma</i> | (Isobilateral) | | | | 81 | 81 |
| <i>Persoonia salicina</i> | (Isobilateral) | | | | 24 | 28 |
| <i>Telopea speciosissima</i> .. . | | | | | 0 | 184 |
| <i>Hakea dactyloides</i> | (Isobilateral) | | | | 134 | 140 |

THE ROOT-SYSTEMS.

The relation of root-reaction and root-type to species distribution is a most important feature of ecological study, and yet, on account of the difficulty of investigation, it has been too much neglected. In the present instance, although no detailed drawings have been made, we are able to place on record some qualitative observations which have proved of interest.

The Rain-Forest of the basalt soil is characterized by the superficial root-systems of all its components. The root development of the tree-ferns is meagre and shallow; that of the trees, although spreading broadly and considerably branched, is confined to a great extent to the first feet of the soil. This is clearly a reflex of the conditions of aeration as previously described: the lower layers are probably quite unfavourable for root-growth; at all events no types at Mount Wilson appear specially adapted to deep penetration in this soil.

In the sandstone Rain-Forests the root-systems of the trees may be somewhat deeper: upon this point our observations are incomplete. It is worthy of note, however, that *Callicoma serratifolia*, in exception to the other types, has a deeply penetrating root-system. This gives some insight into the absence of this type from the basalt Rain-Forests: if a deep root development is a rigid character, it is obvious that *Callicoma* could not grow on the heavy basalt soil without being suffocated.

Although this suggestion presents itself in the case of *Callicoma*, it has nevertheless, still to be explained why *Todea barbara*, *T. Fraseri*, *Blechnum capense*, and *Histiopteris incisa* occur in the Rain-Forest of the sandstone but not on the basalt; and it must be confessed that no satisfactory interpretation of

this has been found. The following observations, however, are placed on record in the hope that they may be of use in subsequently arriving at the solution.

Todea barbara and *Histiopteris* in the Rain-Forest are mainly confined to rivulets; such rivulets have not been observed in the basalt Rain-Forests; but one specimen of *Todea barbara* was seen in a creek running over basalt soil in a *Eucalyptus-Alsophila* community on the south-eastern side of the plateau. *Todea barbara* will occur in creeks outside the Rain-Forest in highly isolated habitats on the sandstone; it has also been found, however, in deep shade under damp rocks where there was no trace of running water. It may be that the chemical composition of the soil solution has some influence on the distribution of these types, but this is a fact which still awaits intensive study.

The *Eucalyptus piperita-E. haemastoma* var. *micrantha* association of the sandstone is characterized by the extremely deep root-systems of most of the components. It has already been explained that there is probably a higher moisture-content in the lower strata of the sandstone soil, and it is now evident that the plants growing thereon penetrate deeply for the apparent purpose of obtaining this; the open texture of the soil permits them to do so without suffocation. By this means not only are the roots enabled to obtain sufficient moisture, but they escape from what is likely to be a high soil temperature in the upper strata during the summer season. This character is a common feature of sclerophyllous plants, as has been shown by Cannon (1924). The absence of these sandstone plants from the basalt, as in the case of *Callicoma*, is perhaps due to the character of the root-system: it may be that a deep root-system is a rigid character here, which, as Cannon (1915) has suggested, is often the case.

Observations on the components of the *Eucalyptus goniocalyx-E. Blaxlandi* association have not been made, but it has been found that *E. Blaxlandi* growing on basalt soil has a shallow root-system, a fact perhaps correlated with its preclusion from the dry sandstone.

On the whole, then, it appears that the character of the root-system is a significant factor in the distribution of the vegetation of Mount Wilson. In the physiological reaction to their environment the roots of the sclerophyllous sandstone types have had to penetrate deeply and this character seems to have eventually become rigid: the Rain-Forest types have found it better to exploit the superficial strata where they could obtain all the moisture and nutritive substances required. The different plants appear to be confined to those habitats to which their particular type of root-system is adapted.

4. THE ULTIMATE CONCEPTION OF THE VEGETATION OF MOUNT WILSON.

Few montane forest regions offer such a unique field as Mount Wilson for ecological study, provided as it is with two such widely different floras and with two such widely different habitats. The main basis for our study has, indeed, centred round the way in which these two floras have competed for the occupation of these two habitats, and the way in which they have reacted to the environmental conditions.

Superficial survey would suggest that in a region such as this with alternating basalt and sandstone, the geological formation must be the habitat factor of most outstanding significance; yet observations have disclosed the striking fact that distribution of the communities is not to be correlated with this but rather with the *edaphic water supply*. Apart from the role of humus in the determination of soil moisture-content, neither chemical nor physico-chemical properties of the soil

appear to have any fundamental distributional significance, except in the case of several minor subordinate species. Given the climate and the moderately favourable summer rainfall such as they are, wherever the aspect is sheltered, and conditions, whether they be due to drainage or to the physical structure of the soil, permit the establishment of a permanent high edaphic moisture-content, Rain-Forest holds its own; wherever, on the contrary, the true climatic climax habitat conditions establish themselves on the dry and bleak sandstone plateau, the sclerophyllous *Eucalyptus* Forest has unchallenged sway; and wherever conditions are of an intermediate nature, transitional types of community are to be found.

As progression or retrogression appears to be the fundamental feature in the development of plant communities we regard the Rain-Forest as a vestigial remnant of a former vegetation of widespread range in eastern Australia, which, now faced in most parts with xerophytic conditions inimical to its survival, has retreated to such habitats as we have shown still to furnish it with optimum conditions. The xerophytic habitats provided by the elevation of the Blue Mountain Plateau of sandstone, favoured the advance of the xerophilous endemic Flora which now occupies the greater part of this formerly Rain-Forest-clad terrain. Yet, though the old Malayan Flora is securely entrenched in the most favourable mesophytic habitat at Mount Wilson, and though it can even displace the autochthonous element in changing habitats, still wherever the conditions become a little more extreme, *Eucalyptus* secures a footing; and, as through future ages the basalt hills are slowly carried away by the unceasing agents of geological denudation, the area of the Malayan Forest will shrink before the dominance of the autochthonous Flora.

Summary.

1. This paper is a study of the habitat factors, and an attempt to correlate these with the interesting distributional features of the vegetation of Mount Wilson.
2. An explanation of the small amount of invasion of the basalt by types from the *Eucalyptus* forests of the sandstone, and why the Rain-Forest grows as well in many sandstone gullies as on the basalt caps is given in this paper.
3. An analysis of the data of rainfall, temperature, humidity and evaporative powers of the atmosphere in the different habitats, of the hydrogen-ion concentration of the soil solution, of the moisture-content of the soil is made, and the relative significance of these factors upon the distribution and organization of the various plant communities is discussed.
4. The P_H value of the soil solution is proved to be an insignificant factor in the distribution of the vegetation at Mount Wilson.
5. The moisture content of the soil—affected by its humus content, by the component clay fraction, by drainage, exposure etc., is of the greatest significance as a controlling factor of the distribution throughout this area. The significance of aspect and moisture-content of the soil outweigh the effect of all other factors.
6. The response of the more important components to the habitat factors is discussed; the general development of the root system in the various habitats, and the structure of the photosynthetic organs are investigated and correlated with the environment.
7. The distribution of the communities throughout the Mount Wilson area is controlled by the edaphic water supply rather than by the nature of the geological formation.

8. The *Ceratopetalum-Doryphora* association is the dominant community in the most favoured habitats, e.g. on the basalt slopes, and in the sandstone gullies.

The sclerophyllous *Eucalyptus* forests, represented by the *Eucalyptus goniocalyx-E. Blaxlandi* and the *Eucalyptus piperita-Eucalyptus haemastoma* associations, are the climax communities wherever the environmental factors fall below the optimum required for the *Ceratopetalum-Doryphora* association, e.g. on the sandstone slopes and more exposed habitats of the area.

9. The Malayan exotic flora represented by the *Ceratopetalum-Doryphora* association is a mesophytic community which formerly had a very extensive distribution in New South Wales but is now preserved in sheltered valleys and on basalt residuals. Its present area will become smaller as the agents of denudation carry away the basalt caps of the sandstone.

Addendum.

Note on the occurrence of *Eucalyptus amygdalina* var. *nitida*.

Since the publication of the previous parts of this work *Eucalyptus amygdalina* Labill. var. *nitida* Benth. has been observed at Mount Wilson. It was found as an almost pure consociation of the *Eucalyptus goniocalyx-E. Blaxlandi* association on a south-westerly slope. *E. Blaxlandi* was occasional, and the usual stratum-societies of *Alsophila* and *Pteridium* were present.

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TWO NEW SPECIES OF SETARIA FROM WESTERN AUSTRALIA.

By DR. A. S. HITCHCOCK, Systematic Agrostologist of the United States Department of Agriculture.

(Communicated by W. M. Carne.)

[Read 27th April, 1927.]

Recently I received from Mr. W. M. Carne, Botanist and Plant Pathologist of Western Australia, two species of *Setaria* which appear to be undescribed. At the request of Mr. Carne I am submitting technical descriptions. It is unfortunate that there is not more material at hand, but it will aid in the study of this critical genus if these tentative descriptions are placed on record.

SETARIA BUCHANANI, n. sp.

Planta annua; culmis glabris, ad 70 cm. altis; laminis planis, scabris, 15-25 cm. longis, 2-6 mm. latis; panicula densa, spiciformis, basi interrupta, 7-12 cm. longa; axi scabro; ramulis 1-1.5 cm. longis, suberectis; setis antrorsum scabris; spiculis ellipticis, 24 mm. longis; gluma prima spiculam $\frac{1}{2}$ aequante, acuta; gluma secunda longitudine spiculae; lemmate sterile longitudine spiculae; lemmate fertile rugulose.

Annual; culms branching at base, glabrous (scabrous below panicle), about 70 cm. tall; sheaths glabrous; ligule 1 to 1.5 mm. long, membranaceous at base, pilose above; blades flat, scabrous, 15 to 25 cm. long, 2 to 6 mm. wide; panicle dense, spikelike, pale green, interrupted, 7 to 12 cm. long, the axis scabrous, angled, the branches 1 to 1.5 cm. long; bristles solitary below a part of the spikelet, antrorsely scabrous, 2 to 3 times as long as the spikelets; spikelets elliptic, glabrous, about 2.4 mm. long; first glume about half as long as the spikelet, acute; second glume as long as spikelet, 5-nerved; sterile lemma as long as the spikelet, 5-nerved, with an additional pair of nerves above; fertile lemma about as long as the sterile lemma, rather faintly transversely rugulose, pale.

Type specimen: Murchison District, Western Australia, G. Buchanan, H. 201, April, 1925.

This species differs from *Setaria viridis* (L.) Beauv. in the elongate blades, the interrupted panicle, the fewer bristles, and the longer acute first glume.

SETARIA CARNEI, n. sp.

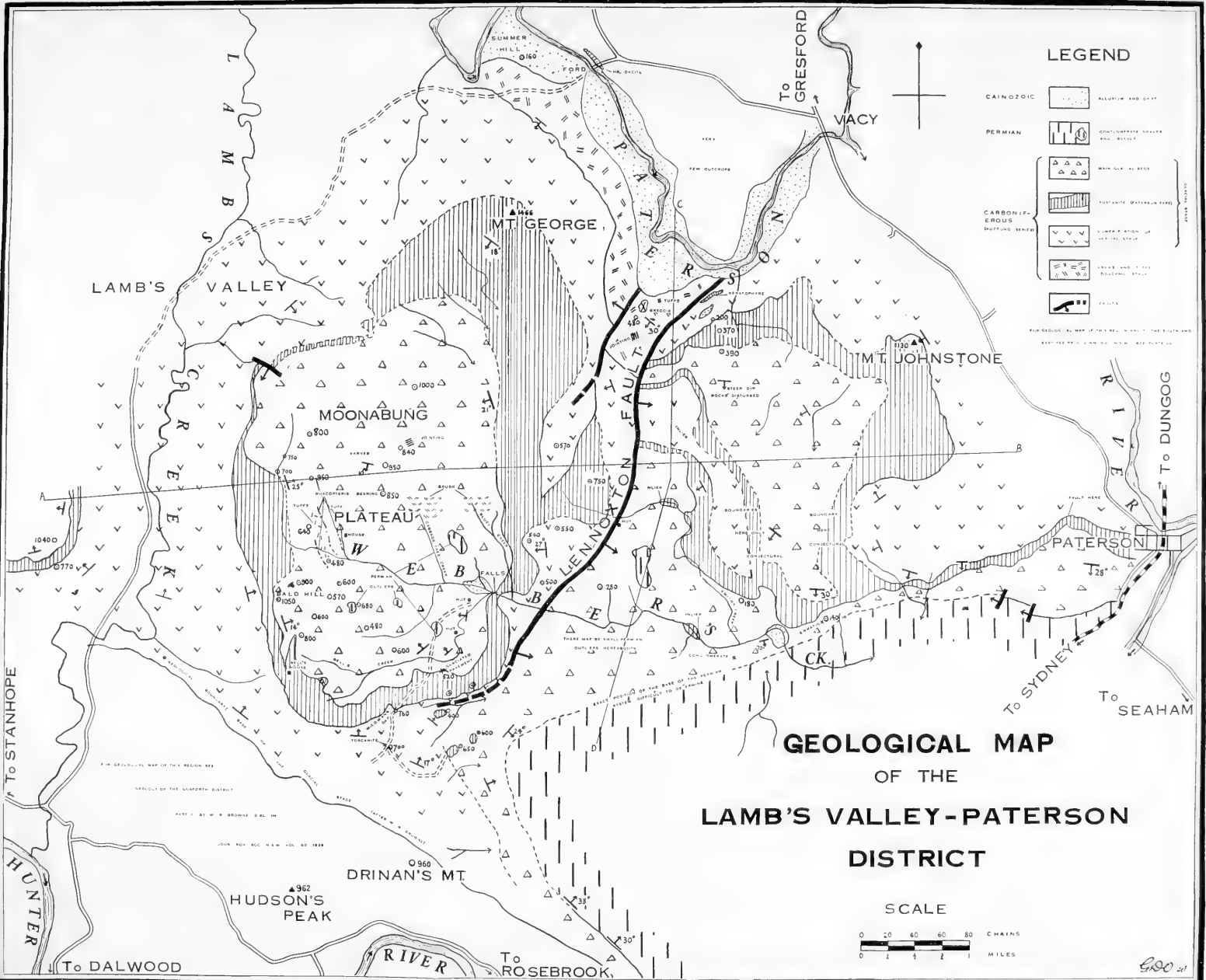
Planta perennis; culmis glabris, 40-50 cm. altis; laminis planis, scabris, 10-20 cm. longis, 2-5 mm. latis; panicula densa, spiciformis, interrupta, 7-12 cm. longa; axi scabro; setis retrorsum scabris; spiculis ellipticis, glabris, 2 mm. latis.

Perennial; culms glabrous (roughish below panicle), 40 to 50 cm. tall; sheaths smooth, compressed; ligule about 1 mm. long, pilose; blades flat, glabrous beneath, scabrous on the upper surface, 10 to 20 cm. long, 2 to 5 mm. wide; panicle dense, spikelike, interrupted, pale, 7 to 12 cm. long, the axis scabrous, angled, the

branches 3 to 5 mm. long; bristles solitary below each spikelet, retrorsely scabrous, 2 to 4 times as long as the spikelet; spikelets elliptic, glabrous, 2 mm. long; first glume about half as long as the spikelet, acutish; second glume as long as the spikelet, distinctly 7-nerved; sterile lemma as long as the spikelet, 5-nerved, with an additional pair of nerves above; fertile lemma rather faintly transversely rugulose, pale.

Type specimen: Broome, Western Australia, collected by the North West Department, H. 197, April, 1925. In the U.S. National Herbarium there is a specimen of this species from West Australia, collected by Drummond.

This species resembles *S. buchanani* in aspect but differs in being apparently perennial, in the retrorsely scabrous bristles, and in the smaller spikelets.



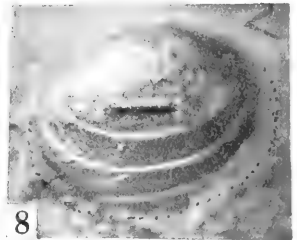
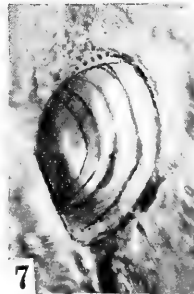
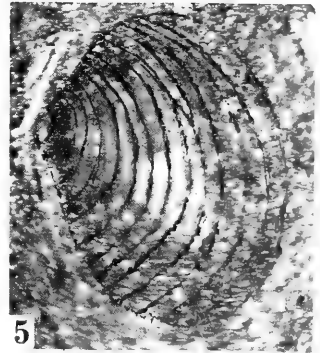
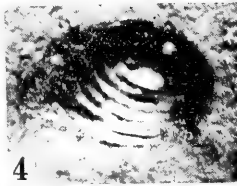
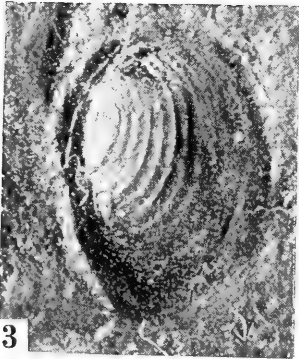
**GEOLOGICAL MAP
OF THE
LAMB'S VALLEY-PATERSON
DISTRICT**

SCALE

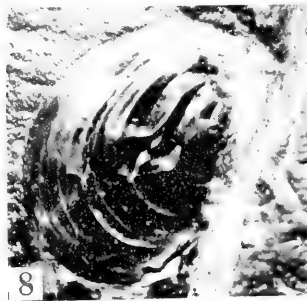
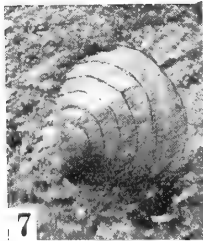
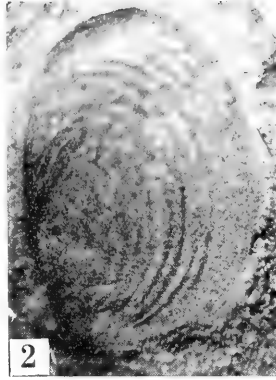
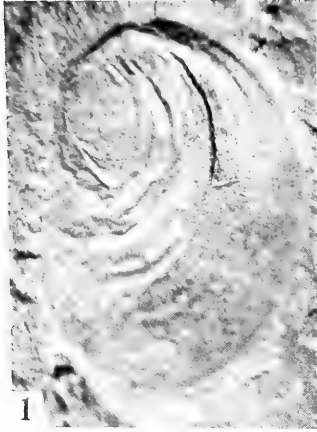


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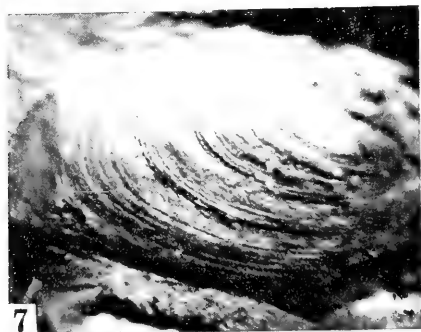
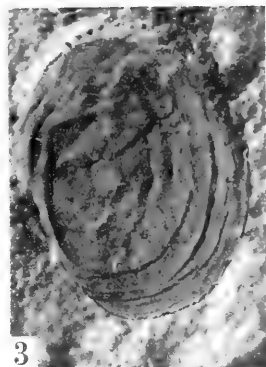
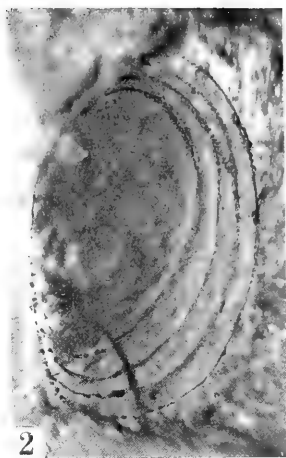




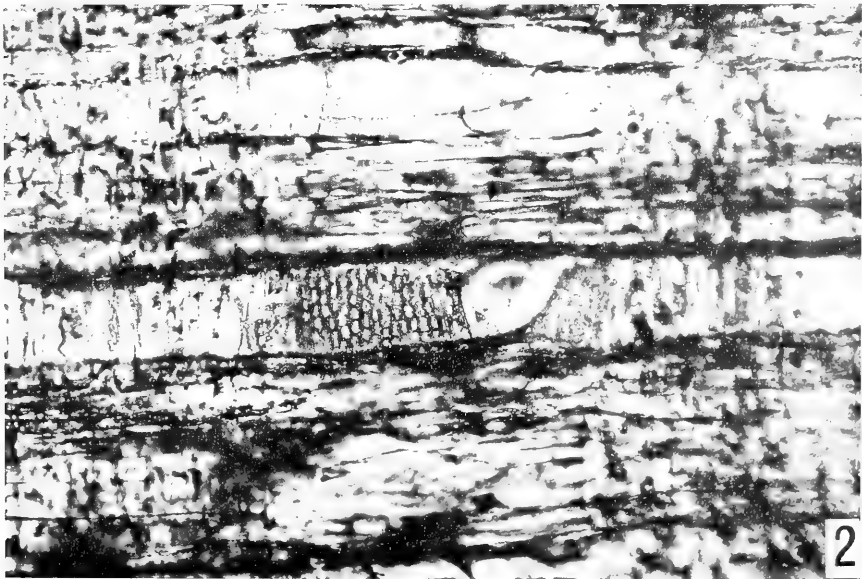
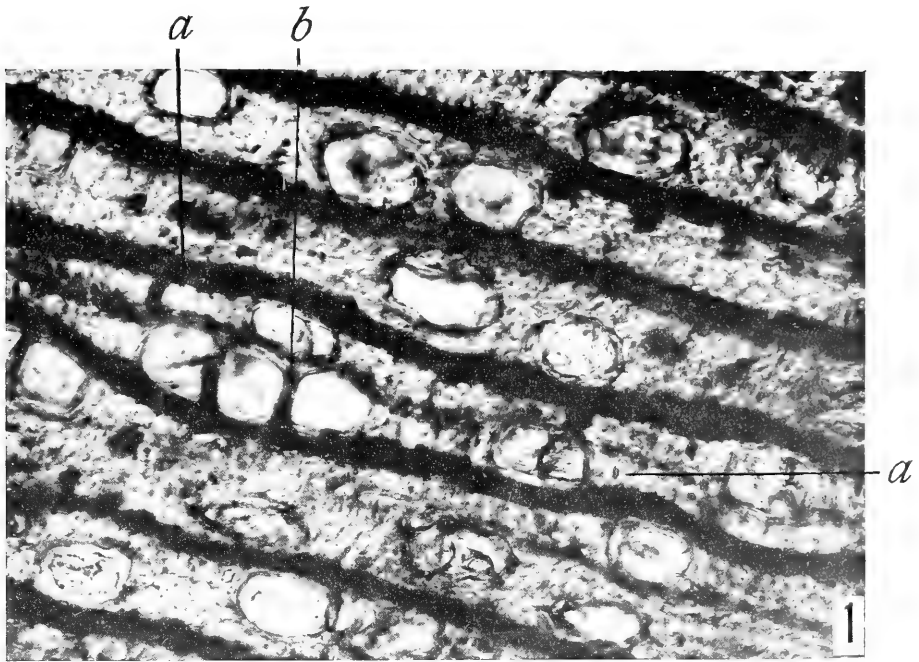
1,2. *Deltopecten rienitsi*, n. sp. 3-5. *Estheria coghlani* Cox.
6. *E. glenleensis*, n. sp. 7, 8. *E. wianamattensis*, n. sp.



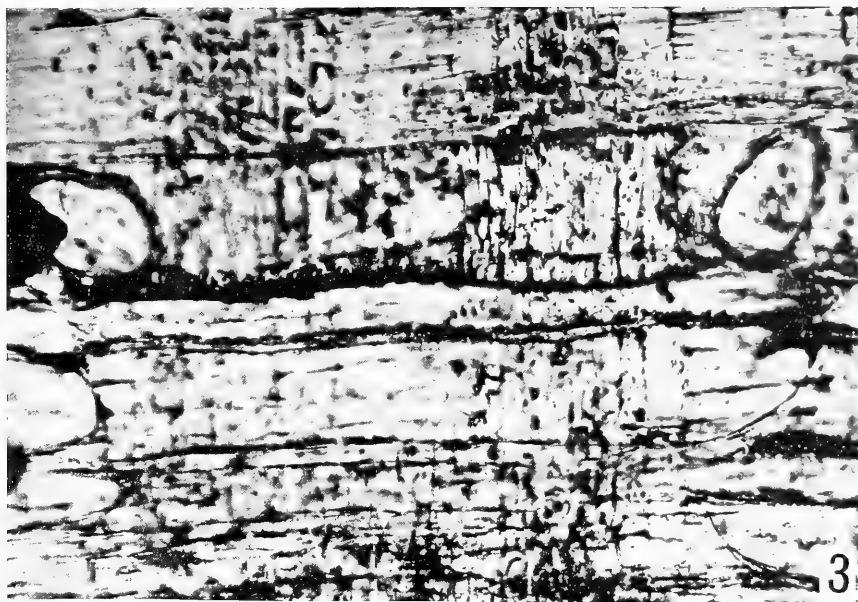
1-4. *Estheria ipsviciensis*, n. sp. 5, 6. *E. novocastrensis*, n. sp.
7. *E. lenticularis*, n. sp. 8, 9. *E. lata*, n. sp.



1. *Estheria obliqua*, n. sp. 2, 3. *E. glabra*, n. sp. 4. *E. linguiformis*, n. sp.
5. *E. belmontensis*, n. sp. 6. *E. trigonellaris*, n. sp.
7, 8. *E. (?) bellambiensis*, n. sp.



Photomicrographs of fossil wood from Ulladulla, N.S.W.



a

Photomicrographs of fossil wood from Ulladulla, N.S.W.



1. *Grevillea laurifolia*. 2-5. Forms of *G. Gaudichaudii*.
6. *G. acanthifolia*.



1. Character of deposits of flood silts.



2. Cracks due to drying in flood silts.

1347.



518.

1347. Galls of *Kladothrips angonsaxros*, n. sp. on *Acacia doratoxylon*.

518. Galls of *Choleothrips geijerae*, n. sp. and *Dolerothrips geijerae*, n. sp. on *Geijera parviflora*.

THE VEGETATION OF THE KOSCIUSKO PLATEAU.

PART I. THE PLANT COMMUNITIES.

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AND

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the University of Melbourne.

(From the Botanical Laboratory, University of Sydney.)

(Plates x-xix and eight Text-figures.)

[Read 27th July, 1927.]

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The *Leptospermum* Shrub Society.

Regeneration of the *Eucalyptus* Forests after Fire.

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The Marsh Vegetation.

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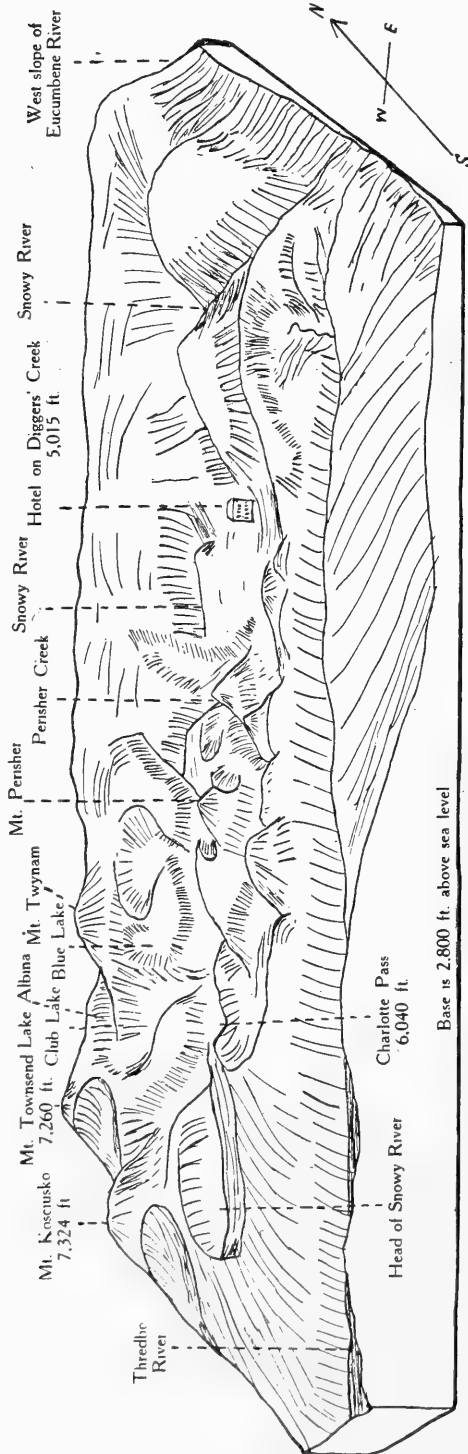
Introduction.

The Kosciusko Plateau, the plant ecology of which forms the subject of this paper, lies in the Snowy Range in the southern portion of New South Wales, and is the highest land surface on the Continent.¹ It is an elevated block about 20 miles long by 6 miles broad, rising gradually from east to west. At the junction of the Thredbo and Snowy Rivers, it is 3,000 feet above the sea. Mount Kosciusko at the other extreme (its westerly limit) is about 7,328 feet high. Only a few isolated points rise above 7,000 feet. A horse shoe-shaped area surrounding the Snowy head-waters exceeds 6,500 feet (contour map Plate x³ and block diagram Text-fig. 1).

¹ The following description of the topography of the Kosciusko Plateau is taken from the paper "The Kosciusko Plateau," by G. Taylor, W. R. Browne and F. Jardine, published in the *Proc. Roy. Soc. N.S.W.*, 1925, pp. 200-205.

² The block, from which this map has been printed, has been kindly lent by the Royal Society of New South Wales, it having appeared in the Proceedings of that Society for 1925 as Plate i.

BLOCK DIAGRAM OF KOSCIUSKO PLATEAU.
 (From the Geographical Laboratory by G. and D. Taylor, Sydney, 1925.)



Text-figure 1. The model is 30 miles from west to east.

"There is a very marked drop in the Plateau east of Perisher Creek, for practically all the high land (over 6,000 feet) lies to the west". . . . "The 5,000 feet contour bounds the Plateau uplands around the lower Snowy River, which flows through a gorge which is largely below that level". "The drainage is arranged according to a very interesting plan. The main stream of the district is really the broad Eucumbene Valley in the extreme east. This is longer and 'older' than the Snowy Valley. The latter has cut back as a gorge into the uplifted plateau—probably along fault planes—as far back as Charlotte's Pass. Above this the valley is fairly wide and approaches maturity. Further west, the head-waters, above the road-ford, flow and meander through a flat senile valley. The Crackenback-Thredbo Valley is a profound gorge for most of its extent. . . . Besides these two parallel gorges of the Snowy and Crackenback, there is a third more or less continuous valley running between them. . . . It consists of a series of shallow basins linked by cols or gaps. . . . Each of these basins drains to the north by a creek leading into the Snowy River: This 'Road Valley' is about 1,000 feet above the two parallel river valleys. Its topography is probably in part due to bygone glacial erosion".

This region is the coldest portion of Australia, and for six months in the year the higher elevations are covered in snow. It thus offers features of special interest so far as the vegetation of Australia is concerned. The Plateau is an elevated land surface composed of gneissic granite, which ascends abruptly from the surrounding plains at about 3,000 feet above sea-level, to an altitude of 5,000 to 6,000 feet, from which level it rises more gradually until it culminates in various peaks ranging up to 7,328 feet. The lower slopes are steep and well drained, and are dissected by various defiles formed by erosion; the higher portion of the Plateau, however, above 5,000 feet, is traversed by long shallow valleys, whose flat bottoms form marshes by the slow draining away of the water from the melting snow of the higher peaks.

A consideration of the plant communities has led us to recognize three unit-areas in the region under discussion:

- (1) The montane zone, from 3,000 to approximately 5,000 feet, comprising the lower slopes of the Plateau.
- (2) The sub-alpine zone, from approximately 5,000 feet to the tree-line at 6,000 to 6,500 feet.
- (3) The alpine zone, from the tree-line to the highest elevations.

The montane zone is entirely clad with sclerophyllous *Eucalyptus* forest, as is characteristically the case with the mountain regions of Eastern Australia. *Eucalyptus* forest also clothes the ridges and slopes in the sub-alpine zone; the boundary between the montane and sub-alpine zones, however, is also the position of the junction of the two main associations of the forest. The lower portions of the slopes of the sub-alpine region, below the forest, are occupied by low-tussock grassland, which, admixed with mat herbage, is also the main formation of the alpine zone. A marsh vegetation occupies the shallow valley-bottoms throughout the sub-alpine and alpine regions. These three types of vegetation will be discussed in detail in the subsequent portion of the paper.

The lists of plants from this area, published by Maiden (1898-99) and Helms (1896-97) proved of great value to the writers in their identification work, but did not furnish an analysis of the communities of the plateau, which is attempted in this paper.

Meteorological Data.

The following information dealing with the distribution of snow falls throughout the season, the mean monthly humidity and the absolute maximum and minimum temperatures, has been kindly supplied to us by Mr. D. J. Mares, Divisional Meteorologist of the Commonwealth of Australia.

The greatest mean monthly humidity occurs during the winter months from about May to September, during which period considerable snow or rain falls, and heavy frosts are frequent.

The absolute maximum temperature so far recorded is 88° on the 9th November, 1919. The mean monthly humidity is lowest during the summer months.

The lowest absolute minimum temperature for any month occurred on the 15th August, 1920, and other very low temperatures during 1919 in the months July to September of the same and the following years, that is just subsequent to the devastating fires which swept over the plateau and destroyed great areas of the *Poa-Celmisia* and *Eucalyptus coriacea-E. Gunnii* associations, and the *E. stellulata* consociation. Perhaps the severity of the climate during such periods has been responsible for the tardy renaissance of the *Eucalyptus* forests and for the killing of areas near the highest portion of the tree-line.

Low temperatures and severe frosts during certain winters if followed by droughty conditions during the summers, retard the development of buds, and flowering and fruiting, and may temporarily destroy the more exposed parts of the *Poa* and *Eucalyptus* associations.

Commonwealth Meteorology.

MT. KOSCIUSKO.—TABLE I.

Mean Monthly Humidity 9 a.m. (14 years).

| Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|------|------|------|-------|-----|------|------|------|-------|------|------|------|
| 56% | 60% | 62% | 65% | 69% | 79% | 84% | 79% | 70% | 60% | 55% | 58% |

Absolute Maximum Temperature, 1911-24 (Fahrenheit).

| Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|----------------------|----------------------|---------------------|---------------------|---------------------|------------------------------------|----------------------|----------------------|----------------------|--------------------------------------|---------------------|--|
| 84.0 30th 1912 | 85.0 15th 1919 | 77.0 5th 1924 | 71.0 4th 1911 | 67.0 2nd 1922 | 56.0 7th 1919 4th 1923 | 52.2 25th 1916 | 57.1 27th 1914 | 78.0 26th 1922 | 78.0 10th 1922 29th 1924 | 88.0 9th 1919 | 78.0 9th 10th 1918 1st 1924 |

Absolute Minimum Temperature, 1911-24.

| Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|----------------------|---------------------|----------------------|------------------------------|----------------------|----------------------|---------------------|---------------------|---------------------|----------------------|---------------------|---------------------|
| 21.0 27th 1919 | 24.9 5th 1917 | 19.8 24th 1917 | 15.0 27th 28th 1911 | 12.0 28th 1913 | 11.0 22nd 1917 | 7.0 16th 1919 | 6.8 15th 1920 | 14.0 8th 1919 | 16.0 22nd 1918 | 13.0 4th 1911 | 20.0 3rd 1924 |

MT. KOSCIUSKO.—TABLE II.
Days of Snow.

| Jan. 1924 | Feb. 1924 | Mar. 1924 | April 1924 | May 1924 | June 1924 | July 1924 | Aug. 1924 | Sept. 1924 | Oct. 1924 | Nov. 1924 | Dec. 1924 |
|-----------|-----------|-----------|------------|----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|
| —* | 1 | — | 2 | 2 | 3† | 4 | 3‡ | 7 | — | — | — |

* Snow still abundant round summit of Mt. Kosciusko.

† Frosts more severe and sustained than for several years.

‡ Rarity remarkable. Frosts severe.

| Jan. 1923 | Feb. 1923 | Mar. 1923 | April 1923 | May 1923 | June 1923 | July 1923 | Aug. 1923 | Sept. 1923 | Oct. 1923 | Nov. 1923 | Dec. 1923 |
|-----------|-----------|-----------|------------|----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|
| 1 | — | — | — | 4 | 5 | 8* | 2 | 5 | 1 | — | — |

* So much snow over such an extended area not seen since 1914.

| Jan. 1922 | Feb. 1922 | Mar. 1922 | April 1922 | May 1922 | June 1922 | July 1922 | Aug. 1922 | Sept. 1922 | Oct. 1922 | Nov. 1922 | Dec. 1922 |
|-----------|-----------|-----------|------------|----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|
| — | — | 1 | 1 | 2 | 11 | 6 | 11 | 6 | 4 | — | — |

| Jan. 1921 | Feb. 1921 | Mar. 1921 | April 1921 | May 1921 | June 1921 | July 1921 | Aug. 1921 | Sept. 1921 | Oct. 1921 | Nov. 1921 | Dec. 1921 |
|-----------|-----------|-----------|------------|----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|
| — | — | — | — | 2 | 3* | 5† | 9 | 1 | 2 | — | — |

* Season mild. Very little snow below 6,000 feet level.

† More rain than snow.

THE EUCALYPTUS FORESTS.

In the region under study there is only one association of *Eucalyptus* forest, namely, the *Eucalyptus coriacea-E. Gunnii* association, which extends from the foot of the Snowy Mountains on the edge of the Monaro Plains up to the tree-line.

It occurs also on the exposed wind-swept Monaro Plains themselves, from which the Snowy Mountains rise.

The following three consociations occur:

1. The *Eucalyptus coriacea* consociation, which is typical of the sub-alpine zone, and is found chiefly from about 4,500 feet to the tree-line between 6,100 and 6,500 feet, although it occurs also at lower altitudes.

2. The *Eucalyptus Gunnii* consociation which is found chiefly between 3,500 and 5,000 feet, and generally prefers the more sheltered slopes characteristic of the montane region.

3. The *Eucalyptus stellulata* consociation which occupies small areas between the altitudes of 4,000 and 5,000 feet.

THE EUCALYPTUS CORIACEA CONSOCIATION.

Habitat.

While the main adaptive feature of *Eucalyptus* forest is xerophily, the *Eucalyptus coriacea* consociation has fitted itself also for existence amid the

severities of a sub-alpine climate, and is the only forest which has ascended above an altitude of 5,000 feet in Australia. The same community occurs on the Monaro Plains, at an altitude of 2,700 to 4,000 feet, where it is exposed to bleak and desiccating winds from the west. *Eucalyptus coriacea* has also been recorded from other mountain tops in New South Wales, where it is found in similar habitats.

So far as the Snowy Mountains are concerned, the *Eucalyptus coriacea* consociation is found chiefly from about 4,500 to 5,000 feet up to 6,500 feet, which is the absolute limit of tree vegetation. It probably occurs, however, at a much lower altitude than 4,500 feet on the western slopes of the mountains owing to exposure to west and north-west winds. Above 5,000 feet the forest is confined to the upper and middle portions of the slopes of the hills, giving place below to grassland (Plate xi, figs. 1 and 2; Plate xii, fig. 3). All flat and gently sloping ground above this altitude is extremely damp, or even water-logged, owing to the drainage from the melting snow on the upper slopes, combined with the impervious nature of the granite substratum. The restricted distribution of the *Eucalyptus* forest which avoids all swampy areas is probably the result of the water-logging and consequent lack of aeration of the lower strata of the soil. Near the tree-line the forest is still further limited on account of the greater amount of snow, and the trees are confined to the drier ridges (Plate xvi, fig. 4).

Structure and Physiognomy.

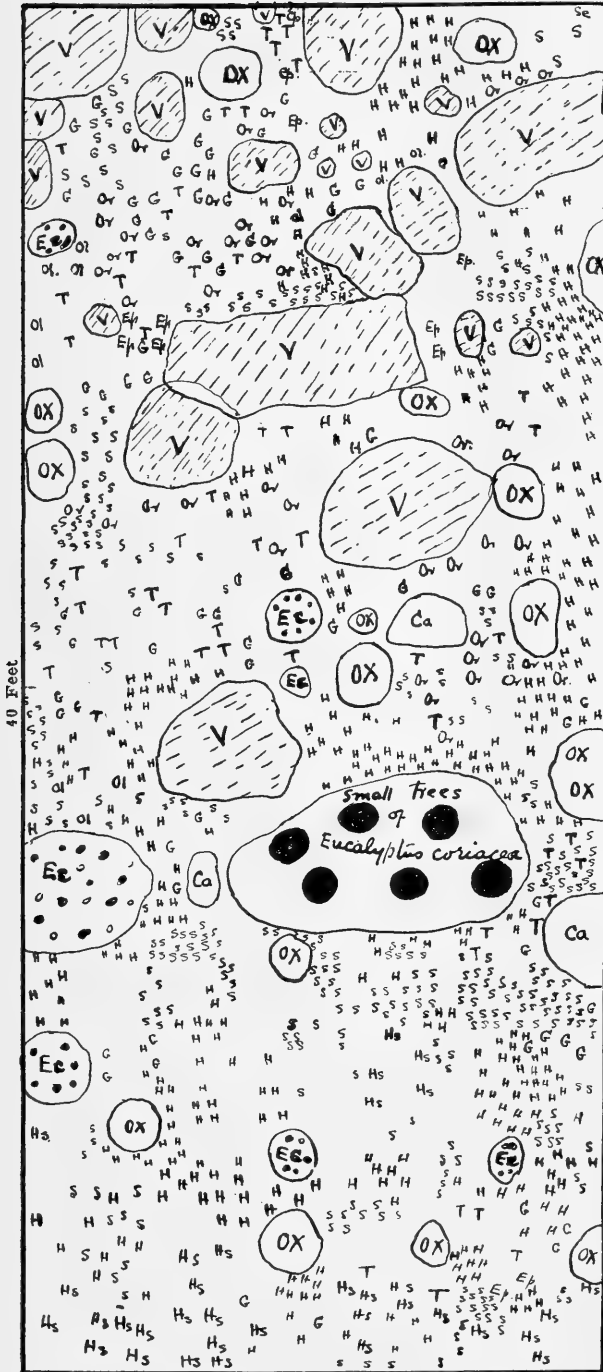
Eucalyptus coriacea is not only dominant, but is the only tree in the consociation at the higher altitudes; it has a distinctive appearance imparted by its smooth white bark, gnarled branches, excessively glaucous twigs, and thick coriaceous leaves. At an altitude of about 5,000 feet, in less exposed areas, *Eucalyptus coriacea* attains a height of about fifty feet and forms an extensive and fairly close forest (Plate xi, fig. 1); at higher altitudes, however, and on the hill-tops above 5,000 feet, the trees become stunted and the forest is more open (Plate xii, fig. 3); while near the tree-line they are rarely taller than twelve to fifteen feet, and often their gnarled branches and trunks are almost prostrate (Plate xvi, fig. 4). This condition is no doubt the result of the heavy snow-falls and frosts during several months of the year and the stimulation of excessive transpiration by strong winds, which are frequent at these altitudes.

While *Eucalyptus coriacea* forms a pure consociation at the higher altitudes, *E. stellulata* becomes frequent at 5,000 feet, as will be described subsequently. *E. Gunnii* is occasional at 5,000 feet, and also becomes abundant in Digger's Creek valley, where an extensive ecotone region exists between the *E. coriacea* and *E. Gunnii* consociations. *E. viminalis* is also occasional in this ecotone region; since, however, the lower strata are highly typical of the *E. Gunnii* consociation, neither this species nor *E. viminalis* can be considered typical of the *E. coriacea* forest.

Shrubs form a conspicuous element in the *Eucalyptus* forests of certain slopes, occurring in dense societies composed chiefly of a dominant species, or else scattered and mixed in composition. In more exposed areas, e.g., on the top of the ridges, shrubs are absent, and the ground is occupied by *Poa caespitosa*, forming low tussocks, and by other grasses and herbaceous types, which also occupy the ground between the shrubs when they are so scattered as to permit of the development of lower strata.

Between 5,000 and 5,500 feet societies of *Oxylobium ellipticum* var. *alpinum* are common, containing as subordinates *Pimelea ligustrina*, *Drimys aromatica* var. *pedunculata*, *Cassinia aculeata*, *Olearia myrsinoides*, *Pimelea axiflora* and *Veronica Derwentia*.

UPPER 17 Feet






Text-figure 2. Chart of an area in an open *Eucalyptus coriacea* forest (5,500 ft.).

This chart illustrates the vegetation on a typical slope. The lower end of this chart is within a few feet of a small creek traversing the hill-side.

As the water is approached certain types such as *Oreomyrrhis andicola* and *Veronica* disappear, while species of *Helichrysum* become more abundant.

Veronica is always abundant on the slopes of the water courses, while *Oxylobium ellipticum* prefers the drier hill-sides more remote from the streams.

-  - *Veronica Derwentia*.
-  - *Oxylobium ellipticum*.
- S - *Stellarium pungens*.
- H - *Helichrysum bracteatum*.
- G - *Geranium dissectum*.
- T - *Taraxacum* sp.
- Or - *Oreomyrrhis andicola*.
- Hs - *Helichrysum scorpioides*.
- Ep - *Epilobium glabellum*.
- Se - *Senecio pectinatus*.
- Ol - *Olearia myrsinoides*.
-  - *Eucalyptus coriacea*, seedlings.
- Ca - *Cassinia aculcata*.

All space between symbols is occupied by *Poa caespitosa* forming a close grassy covering with occasional tussocks and withered patches. An attempt has been made to convey an impression of the relative proportion of the area that is occupied by each component.

Scale: 1 cm. = 2 feet.

The *Oxylobium* society is replaced by one dominated by *Callistemon Sieberi* in the little watercourses which frequently run down the slopes to the creeks and swampy areas invariably occupying the flat bottoms of the shallow valleys. This society is closely related to the *Callistemon Sieberi* consociation of the marsh vegetation, and contains a number of swamp-loving types not found elsewhere in the *Eucalyptus* forests.

Floristic Composition.

| | |
|---|-----|
| Shrub Stratum | |
| <i>Callistemon Sieberi</i> D.C. | d* |
| <i>Cassinia aculeata</i> R.Br. | f |
| <i>Oxylobium ellipticum</i> R.Br., var. <i>alpinum</i> Maiden and Betche | o-f |
| <i>Drimys aromatica</i> F.v.M., var. <i>pedunculata</i> Maiden | o |
| <i>Panax sambucifolius</i> Sieb. | r |
| <i>Leptospermum lanigerum</i> Sm. | lf |
| Ground Stratum | |
| <i>Richea Gunnii</i> For. | f |
| <i>Acaena sanguisorba</i> Vahl. | f |
| <i>Anagallis arvensis</i> Linn. | f |
| <i>Epilobium glabellum</i> Forst. | o |
| <i>Rumex acetosella</i> Linn. | o |
| <i>Taraxacum dens-leonis</i> Desf. | o |
| <i>Stylidium graminifolium</i> Swartz. | o |
| <i>Linum marginale</i> Cunn. | o |
| <i>Blechnum penma-marina</i> (Poir.) Kuhn | o |
| <i>Galium umbrosum</i> Sol. | o |
| <i>Sphagnum</i> societies | o |
| <i>Prostanthera cuneata</i> Benth. | r |
| <i>Epacris paludosa</i> R.Br. | lo |

Veronica Derwentia also forms dense societies (Text-fig. 2), especially in more open areas, with *Olearia megalophylla* (f), *Drimys* (f), and *Oxylobium ellipticum* var. *alpinum* (o) (Plate xiii, fig. 2).

Above 5,500 feet these societies are not so frequent, their place being taken by *Prostanthera cuneata*, which forms abundant societies up to and beyond the tree-line (Plate xvi, fig. 4; Plate xix, fig. 2). *Phebalium ovatifolium* is a frequent subordinate in this society. Elsewhere the shrubs are mixed or absent, *Helichrysum baccharoides* and *H. rosmarinifolium* being conspicuous.

On the tops of the ridges, and between the shrubs where they are less dense, *Poa caespitosa*, with its many herbaceous subordinates, forms a close covering. At the foot of the slopes and at the tree-line this stratum-society passes out unchanged beyond the trees, and assumes the rank of an association, a feature which will be referred to again subsequently (Plate xii, fig. 3).

Floristic Composition.

| | |
|---|--------------------------------------|
| Tree Stratum. | |
| <i>Eucalyptus coriacea</i> Cunn. | d |
| <i>E. stellulata</i> Sieb. | f (up to 5,000 ft.)—o (to 5,500 ft.) |
| <i>E. Gunnii</i> Hook. | o (to 5,000 ft.) |
| Tall-Shrub Stratum. | |
| <i>Helichrysum rosmarinifolium</i> Less. | f-c (above 5,500 ft.) |
| <i>Drimys aromatica</i> F.v.M. var. <i>pedunculata</i> Maiden | f-la |
| <i>Cassinia aculeata</i> R.Br. | f-la |
| <i>Veronica Derwentia</i> Littlej. | f-la |

* In these lists, a = abundant, c = common, d = dominant, f = frequent, l = locally, o = occasional, r = rare, sd = subdominant, vr = very rare.

Tall-Shrub Stratum.

| | |
|--|------------------------------|
| <i>Hovea longifolia</i> R.Br. | f (5,500 ft. upwards) |
| <i>Oxylobium ellipticum</i> R.Br. var. <i>alpinum</i> Maiden and Betche | o-a (5,200-6,000 ft.) |
| <i>Bossiaea foliosa</i> Cunn. | o-la |
| <i>Olearia myrsinoides</i> F.v.M. | o-lc |
| <i>Helichrysum baccharoides</i> F.v.M. | o-lc |
| <i>Olearia megalophylla</i> F.v.M. | o-lf-lc |
| <i>Pimelea ligustrina</i> Labill. var. <i>hypericina</i> Benth. | o-f |
| <i>Phebalium ovatifolium</i> F.v.M. | o-f (above 5,600 ft.) |
| <i>Pimelea axiflora</i> F.v.M. | o |
| <i>Rubus rosifolius</i> Sm. | o |
| <i>Orites lancifolia</i> F.v.M. | o (near tree-line) |
| <i>Grevillea australis</i> R.Br. | o (at tree-line) |
| <i>Hakea Maccreana</i> F.v.M. | r |
| <i>Lissanthe montana</i> R.Br. | r |
| <i>Acacia alpina</i> F.v.M. | r |
| <i>Panax sambucifolius</i> Sieb. | vr (below 5,100 ft.) |
| <i>Prostanthera cuneata</i> Benth. | vr (5,300 ft.)—a (6,000 ft.) |
| <i>Leptospermum lanigerum</i> Sm. | lf |
| <i>Callistemon Sieberi</i> D.C. | lf (5,000 ft.) |

Low-Shrub Stratum.

| | |
|--|---------------------|
| <i>Hibbertia linearis</i> R.Br. var. <i>obtusifolia</i> Benth. | o (below 5,000 ft.) |
|--|---------------------|

Ground Stratum.

| | |
|--|--------------------------|
| <i>Poa caespitosa</i> Forst. | a-lo |
| <i>Taraxacum dens-leonis</i> Desf. | f-a |
| <i>Trifolium</i> sp. | f-a |
| <i>Rumex acetosella</i> Linn. | f-la |
| <i>Helichrysum scorpioides</i> Labill. | f-c |
| <i>Geranium dissectum</i> Linn. | f |
| <i>Ranunculus lappaceus</i> Sm. | f |
| <i>Plantago varia</i> R.Br. | f |
| <i>Senecio lautus</i> Sol. | f |
| <i>Wahlenbergia gracilis</i> D.C. | f |
| <i>Acaena sanguisorbae</i> Vahl. | o-a |
| <i>Stellaria pungens</i> Brongn. | o-a |
| <i>Brachycome scapiformis</i> D.C. | o-a |
| <i>Craspedia Richea</i> Cass. | o-a |
| <i>Podolepis longipedata</i> Cunn. | o-la |
| <i>Stylidium graminifolium</i> Swartz. | o-f |
| <i>Epilobium glabellum</i> Forst. | o |
| <i>Viola betonicifolia</i> Sm. | o |
| <i>Scaevola Hookeri</i> F.v.M. societies. | o |
| <i>Comesperma retusum</i> Labill. | o (5,000 ft.) |
| <i>Brachycome decipiens</i> Hook. | o |
| <i>Poranthera microphylla</i> Brongn. | o |
| <i>Polystichum aculeatum</i> (L.) Schott. | o (under rocks) |
| <i>Kunzea Muelleri</i> Benth. | o |
| <i>Celmisia longifolia</i> Cass. | o-f (above 5,200 ft.) |
| <i>Stellaria flaccida</i> Hook. | o |
| <i>Oreomyrrhis andicola</i> Endl. | o |
| <i>Euphrasia Brownii</i> F.v.M. | o |
| <i>Helichrysum bracteatum</i> Willd. | o |
| <i>Blechnum penna-marina</i> (Poir.) Kuhn. | r |
| <i>Galium umbrosum</i> Sol. | r |
| <i>Linum marginale</i> Cunn. | r |
| <i>Dianella tasmanica</i> Hook. | r |
| <i>Podocarpus alpina</i> R.Br. societies | r (above 5,600 ft.) |
| <i>Asplenium flabellifolium</i> Cav. | vr (5,000 ft. downwards) |
| <i>Chiloglottis Gunnii</i> Lindl. | lc |
| <i>Pterostylis mutica</i> R.Br. | lf |
| <i>Richea Gunnii</i> For. | lo |
| <i>Sphagnum</i> societies | lo |
| <i>Anagallis arvensis</i> Linn. | lo (5,000 ft.) |
| <i>Epacris paludosa</i> R.Br. | lo |

THE EUCALYPTUS GUNNII CONSOCIATION.

Passing into the sheltered gullies just below 5,000 feet, the *Eucalyptus coriacea* consociation gives place to the *E. Gunnii* consociation, very gradually in Digger's Creek valley, comparatively abruptly in other areas. *E. Gunnii* grows taller than *E. coriacea*, the trees averaging about seventy feet in height. For some distance into this consociation a number of shrubs characteristic of the *E. coriacea* forest persist, but a distinct and continuous change is noticeable as one descends the Plateau, new types appearing and former ones disappearing. *Poa caespitosa* tussocks are much less abundant; although they still form a carpet in certain areas where the soil is damper, a considerable amount of the ground is quite bare of grass or only sparsely covered (Plate xvi, fig. 3). In general this forest has a more xerophilous impress since many of the herbaceous types of the *E. coriacea* consociation are absent, the rich carpet of grass is less evident, and the shrubs have a more scraggy, sclerophyllous appearance; indeed the general physiognomy of the community resembles that of the *E. piperita* forest characteristic of the sandstone plateau at Mount Wilson.

The smaller rainfall which characterizes the lower altitudes of the mountains probably contributes to this feature of the *E. Gunnii* consociation, as also does a change in the topography. We are here below the level of the marshy flats and the continual streams of water from the melting snow; the water is concentrated in the deep gorges of the Snowy River and its tributaries, by means of which the gravitational water passes rapidly away, resulting in a general lowering of the soil moisture-content. Moreover this consociation dominates an area from which the snow disappears early on the approach of summer; there is therefore less soil moisture as compared with the higher zones, and the plant life is dependent directly upon the rainfall for its moisture requirements throughout the summer months. The extremely xerophilous structure of the plants inhabiting this zone indicates an approximation to the conditions which have stimulated the development of the highly xerophytic sclerophyllous forest on the Hawkesbury Sandstone habitat around Sydney.

Floristic Composition.

Tree Stratum.

| | |
|--|-----|
| <i>Eucalyptus Gunnii</i> Hook. | d |
| <i>E. viminalis</i> Labill. | o-c |
| <i>E. coriacea</i> Cunn. | o-f |
| <i>E. stellulata</i> Sieb. | o |
| <i>E. amygdalina</i> Labill. var. <i>nitida</i> Benth. | r-o |

Low-Tree Stratum.

| | |
|----------------------------|---|
| <i>Acacia rubida</i> Cunn. | o |
|----------------------------|---|

Shrub Stratum.

| | |
|--|------|
| <i>Oxylobium ellipticum</i> R.Br. var. <i>alpinum</i> Maiden and Betche | f-la |
| <i>Bossiaea foliosa</i> Cunn. | f-la |
| <i>Daviesia ulicina</i> Sm. | f |
| <i>Leptospermum stellatum</i> Cav. | o-c |
| <i>Cassinia aculeata</i> R.Br. | o-f |
| <i>Baeckea Gunniana</i> Schau. | o-f |
| <i>Grevillea lanigera</i> Cunn. | o |
| <i>Lomatia longifolia</i> R.Br. | o |
| <i>Acacia penninervis</i> Sieb. | o |
| <i>Rubus parvifolius</i> Linn. | o |
| <i>Panax sambucifolius</i> Sieb. | o |
| <i>Daviesia corymbosa</i> Sm. | r |

Low-Shrub Stratum.

Discaria australis Hook. o

Grass Stratum.

Poa caespitosa Forst. c-o
Wahlenbergia gracilis D.C. f-c
Stellaria pungens Brongn. f-c
Taraxacum dens-leonis Desf. f-c
Hibbertia linearis R.Br. var. *obtusifolia* Benth. f-c
Helichrysum semipapposum D.C. f-c
Geranium dissectum Linn. f-la
Rumex acetosella Linn. f
Brachycome scapiformis D.C. f
Plantago varia R.Br. f
Epilobium glabellum Forst. f
Trifolium sp. f
Velleia paradoxa R.Br. f
Acaena sanguisorbae Vahl. f
Prunella vulgaris D.C. o-la
Xerotes longifolia R.Br. o-f
Pimelea glauca R.Br. o-f
Arthropodium paniculatum R.Br. o
Persoonia chamaepeuce Lhotsky o
Stylidium graminifolium Swartz. o
Galium umbrosum Sol. o
Lotus australis Andr. o
Lotus corniculatus Linn. o
Helichrysum scorpioides Labill. o
Pterostylis coccinea Fitzg. vr
Bulbine bulbosa Haw. vr
Erythraea australis R.Br. la

THE EUCALYPTUS CORIACEA—E. GUNNII ECOTONE AND THE E. STELLULATA CONSOCIATION.

As has been mentioned earlier, the slopes of Digger's Creek valley (4,000-5,000 feet) are clothed by a forest which represents an ecotone between the *E. coriacea* and *E. Gunnii* consociations. The continuity of this ecotone is interrupted by the occasional presence of a pure consociation of *E. stellulata*. Where Digger's Creek valley joins the main gorge of the Snowy River (at about 4,000 feet) the ecotone gives place gradually to the *E. Gunnii* consociation. One may suppose that in this region the conditions are intermediate between the exposed habitat yet damp soil occupied by the *E. coriacea* forest on the one hand, and the drier, yet more sheltered environment normally occupied by *E. Gunnii*. The valley is sheltered, and the sides are steep; yet the soil in many parts has still much of the dampness characteristic of the higher altitudes.

We have not up to the present been able to discover definitely the factors leading to the interruption of the ecotone by occasional consociations of *E. stellulata*, but it is possible that a slightly greater degree of exposure may be the key to its presence; nor did we observe any difference in the floristic composition of the two communities.

Floristic Composition.

| Tree Stratum. | Ecotone. | <i>E. stellulata</i> . |
|----------------------------------|----------------|------------------------|
| <i>Eucalyptus coriacea</i> Cunn. | d | o |
| <i>E. Gunnii</i> Hook. | a-f | — |
| <i>E. viminalis</i> Labill. | o | — |
| <i>E. stellulata</i> Sieb. | o | d |
| Small-Tree Stratum. | | |
| <i>Acacia nerifolia</i> Cunn. | o in societies | |

Shrub Stratum.

| | | |
|--|-----|-----------------------------|
| <i>Veronica Derwentia</i> Littlej. | f-a | |
| <i>Epacris</i> sp. | f | |
| <i>Pimelea axiflora</i> F.v.M. | f | |
| <i>Oxylobium ellipticum</i> R.Br. var. <i>alpinum</i> Maiden and Betche | f | |
| <i>Bossiaea foliosa</i> Cunn. | f | |
| <i>Hymenantha dentata</i> R.Br. | o-f | |
| <i>Olearia megalophylla</i> F.v.M. | o | |
| <i>Hovea longifolia</i> R.Br. | o | |
| <i>Olearia myrsinoides</i> F.v.M. | o | |
| <i>Drimys aromatica</i> F.v.M. var. <i>pedunculata</i> Maiden | o | |
| <i>Pimelea ligustrina</i> Labill. var. <i>hypericina</i> Benth. | o | |
| <i>Panax sambucifolius</i> Sieb. | o | |
| <i>Daviesia ulicina</i> Sm. | o | |
| <i>Acacia decurrens</i> Willd. | o | |
| <i>Lomatia longifolia</i> R.Br. | o | |
| <i>Acacia penninervis</i> Sieb. | o | |
| <i>Persoonia chamaepeuce</i> Lhotsky | o | |
| <i>Hibbertia linearis</i> R.Br. var. <i>obtusifolia</i> Benth. | o | |
| <i>Acacia siculiformis</i> Cunn. | o | |
| <i>Leptospermum stellatum</i> Cav. | o | } (in drainage channels) |
| <i>Leptospermum lanigerum</i> Sm. | o | |
| <i>Callistemon Sieberi</i> D.C. | o | |
| <i>Hakea Macreana</i> F.v.M. | o | |
| <i>Rubus parvifolius</i> Linn. | r-o | |

Low-Shrub Stratum.

| | |
|--------------------------------------|---|
| <i>Helichrysum semipapposum</i> D.C. | o |
| <i>Cassinia aculeata</i> R.Br. | o |

Ground Stratum.

| | |
|--|---------------------|
| <i>Stellaria pungens</i> Brongn. | a |
| <i>Poa caespitosa</i> Forst. | a |
| <i>Acaena sanguisorbae</i> Vahl. | c |
| <i>Geranium dissectum</i> Linn. | c |
| <i>Trifolium</i> sp. | c |
| <i>Wahlenbergia gracilis</i> D.C. | c |
| <i>Taraxacum dens-leonis</i> Desf. | f-c |
| <i>Galium umbrosum</i> Sol. | f |
| <i>Rumex acetosella</i> Linn. | f |
| <i>Brachycome scapiformis</i> D.C. | f |
| <i>Plantago varia</i> R.Br. | f |
| <i>Viola betonicifolia</i> Sm. | f |
| <i>Vellea paradoxa</i> R.Br. | f |
| <i>Vellea montana</i> Hook. | f |
| <i>Helichrysum bracteatum</i> Willd. | la-o |
| <i>Prunella vulgaris</i> D.C. | o (below 4,650 ft.) |
| <i>Podolepis longipedata</i> Cunn. | o |
| <i>Oreomyrrhis andicola</i> Endl. | o |
| <i>Linum marginale</i> Cunn. | o |
| <i>Craspedia Richea</i> Cass. | o |
| <i>Stylidium graminifolium</i> Swartz. | o |
| <i>Hypericum japonicum</i> Thunb. | o |
| <i>Lotus australis</i> Andr. | o (below 4,400 ft.) |
| <i>Goodenia hederacea</i> Sm. | o (below 4,100 ft.) |
| <i>Poranthura microphylla</i> Brongn. | o |
| <i>Xerotes longifolia</i> R.Br. | o |
| <i>Helichrysum scorpioides</i> Labill. | o |
| <i>Asplenium flabellifolium</i> Cav. | r (under rocks) |
| <i>Exocarpus nana</i> Hook. | r |
| <i>Arthropodium paniculatum</i> R.Br. | r |
| <i>Pterostylis acuminata</i> R.Br. | r |
| <i>Dianella</i> sp. | r |
| <i>Gastrodia sesamoides</i> R.Br. | vr |

Ground Stratum.

| | | |
|--------------------------------------|-------|--------------------|
| <i>Stackhousia monogyna</i> Lindl. ? | If | } (in damp places) |
| <i>Lotus corniculatus</i> Linn. | If-la | |
| <i>Epilobium glabellum</i> Forst. | If-lc | |
| <i>Juncus pallidus</i> R.Br. | lo | |
| <i>Lotus australis</i> Andr. | o | |

THE LEPTOSPERMUM SHRUB SOCIETY.

Along the banks of the rivers occupying the beds of the valleys whose slopes are clad by the *Eucalyptus Gunnii* consociation or by the *E. coriacea-E. Gunnii* ecotone, occurs a society of shrubs about five to seven feet in height. In the upper part of the ecotone at about 4,600 feet *Leptospermum lanigerum* is the dominant, while, as the beginning of the *E. Gunnii* consociation is approached, *Leptospermum stellatum* becomes co-dominant. (Plate xiv, fig. 2).

The majority of the components of this society appear to be species requiring a moderate degree of shelter and soil-moisture. It is interesting to note also that *Kunzea Muelleri* and *Hakea microcarpa* here attain a height of four to five feet, whereas above the 5,000 feet altitude *Kunzea* is only about six inches high, and *Hakea* one foot. In many cases this society is so dense as to be almost impenetrable and, during periods of flooding of the river, is practically submerged.

Floristic Composition.

Shrub Stratum, 4,650 ft.

| | |
|------------------------------------|-----|
| <i>Leptospermum lanigerum</i> Sm. | c-d |
| <i>Callistemon Sieberi</i> D.C. | f |
| <i>Daviesia corymbosa</i> Sm. | f |
| <i>Leptospermum stellatum</i> Cav. | f-d |
| <i>Cassinia aculeata</i> R.Br. | o |
| <i>Hakea Macreana</i> F.v.M. | o |
| <i>Kunzea Muelleri</i> Benth. | o |
| <i>Hakea microcarpa</i> R.Br. | o |
| <i>Correa Lawrenciana</i> Hook. | o |
| <i>Lomatia longifolia</i> R.Br. | r |

Ground Stratum.

| | |
|--|-----|
| <i>Juncus pusillus</i> Buch. | c |
| <i>Hypolaena lateriflora</i> Benth. | f |
| <i>Epilobium glabellum</i> Forst. | o |
| <i>Lotus australis</i> Andr. | o |
| <i>Lotus corniculatus</i> Linn. | o |
| <i>Drosera peltata</i> Sm. | o |
| <i>Oreomyrrhis andicola</i> Endl. | o |
| <i>Styliidium graminifolium</i> Swartz. | o |
| <i>Hypericum Japonicum</i> Thunb. | o |
| <i>Utricularia dichotoma</i> Labill. var. <i>uniflora</i> Benth. | r |
| <i>Juncus pallidus</i> R.Br. | f-a |

Creeper.

| | |
|-----------------------------------|---|
| <i>Glycine clandestina</i> Wendl. | o |
|-----------------------------------|---|

REGENERATION OF THE EUCALYPTUS FORESTS AFTER FIRE.

On account of the high rainfall and general dampness of the ground, bush fires are by no means so prevalent on the Kosciusko Plateau above an altitude of 5,000 feet as in other more arid regions of the State; and at the time of study (1924 and 1925) none had occurred since 1919 in the area under review. The fire which took place in the latter year, however, swept over large areas of the *Eucalyptus coriacea* consociation between 5,000 and 5,500 feet, as well as through a small consociation of *E. stellulata*.

It appears that the *Eucalyptus coriacea* consociation by no means possesses the power of speedy renascence which characterizes *Eucalyptus* forests in other regions. Whereas most *Eucalyptus* forests would have recovered from the fire before the lapse of six years, here we found renascence to be tardy, and sometimes not even to have started. Neither *E. coriacea* nor *E. stellulata* appear readily to produce adventitious shoots from the stem, renascence taking place rather from the root-stock; thus most of the regenerating *E. coriacea* forest showed young shoots rising from the ground surrounding the old dead trunk, and only a few feet high (Plate xviii, fig. 1).

In the more exposed areas no renascence was evident, and it seems that here the severity of the climatic conditions has prevented it. In these areas the dead trees are standing while the normal lower strata of the forest and especially the *Poa* stratum have re-developed. It is likely that regeneration of the forest will be slow, as it will now be chiefly dependent upon migration, followed by a precarious ecesis (Plate xi, fig. 2).

The *Eucalyptus stellulata* consociation regenerates more rapidly, perhaps because of the lower altitude and the consequently greater shelter of its environment; in this case a mass of shrub-like growth surrounded the base of the old trunks, so dense as to cover the ground almost completely.

The regeneration of the lower strata was more advanced, and the burnt areas did not appear to differ appreciably in these strata from those which were unburnt, except that very dense shrub-societies had arisen in places. Where renascence of the trees is slow dense societies of *Veronica Derwentia*, accompanied by *Olearia megalophylla* (f), *Drimys* (f), and *Oxylobium ellipticum* var. *alpinum* (o), are generally characteristic features (Plate xiii, fig. 2). The rapid recovery of these types is no doubt due to their resistant subterranean root-stocks or rhizomes. The *Eucalyptus Gunnii* consociation is subject to more frequent burns and is more akin in its reaction, to the *Eucalyptus piperita* Forest at Mount Wilson.

FACTORS CAUSING OR MODIFYING THE TIMBER-LINE.

In certain more exposed areas on the summits of the hills and on the higher slopes, the tree-trunks in the *Eucalyptus coriacea* consociation appear to have been killed by severe climatic conditions rather than by fire; for although regeneration is taking place as usual from the base of the stem, there is no indication of fire on the trunks, and moreover, these conditions are found only in exposed areas. An analogous phenomenon is seen at altitudes of 6,500 feet, where the stunted *Eucalyptus* forest has migrated during favourable seasons above the normal level of the timber-line, and subsequently, possibly as the result of an unusually severe season, has been entirely destroyed (Plate xvi, fig. 1).

These observations lead us to consider the factors which are effective in controlling the tree-line in this region. Rhydberg (1914) has enumerated some of those which he considered to be important in the case of the Rocky Mountains, and it is of interest to note their significance in the case of the vegetation of the Kosciusko Plateau. The chief of these factors described by Rhydberg are as follows: (1) low temperature during the growing season; (2) shortness of the growing season; (3) late frosts; (4) strong winds; (5) deep snow; (6) form of precipitation; (7) large mountain masses; (8) physiographical barriers.

The timber-line on the Kosciusko Plateau varies from 6,100 feet in exposed habitats to 6,500 feet in sheltered habitats. At these altitudes the forest thins out and the trees are represented by low gnarled and stunted shrubby individuals; the zone, however, between the absolute tree-line (where arboreal species disappear

entirely) and the relative tree-line (where the arboreal species just cease to form forest) is comparatively narrow. Exposure to desiccating westerly and north-westerly winds, very cold in winter and hot in summer, determines the points where the forest suddenly merges into isolated stunted individuals. In other alpine regions of the earth coniferous forests frequently exist above the angiospermic forest, but at Kosciusko the highest arboreal community is that composed of *Eucalyptus coriacea*.

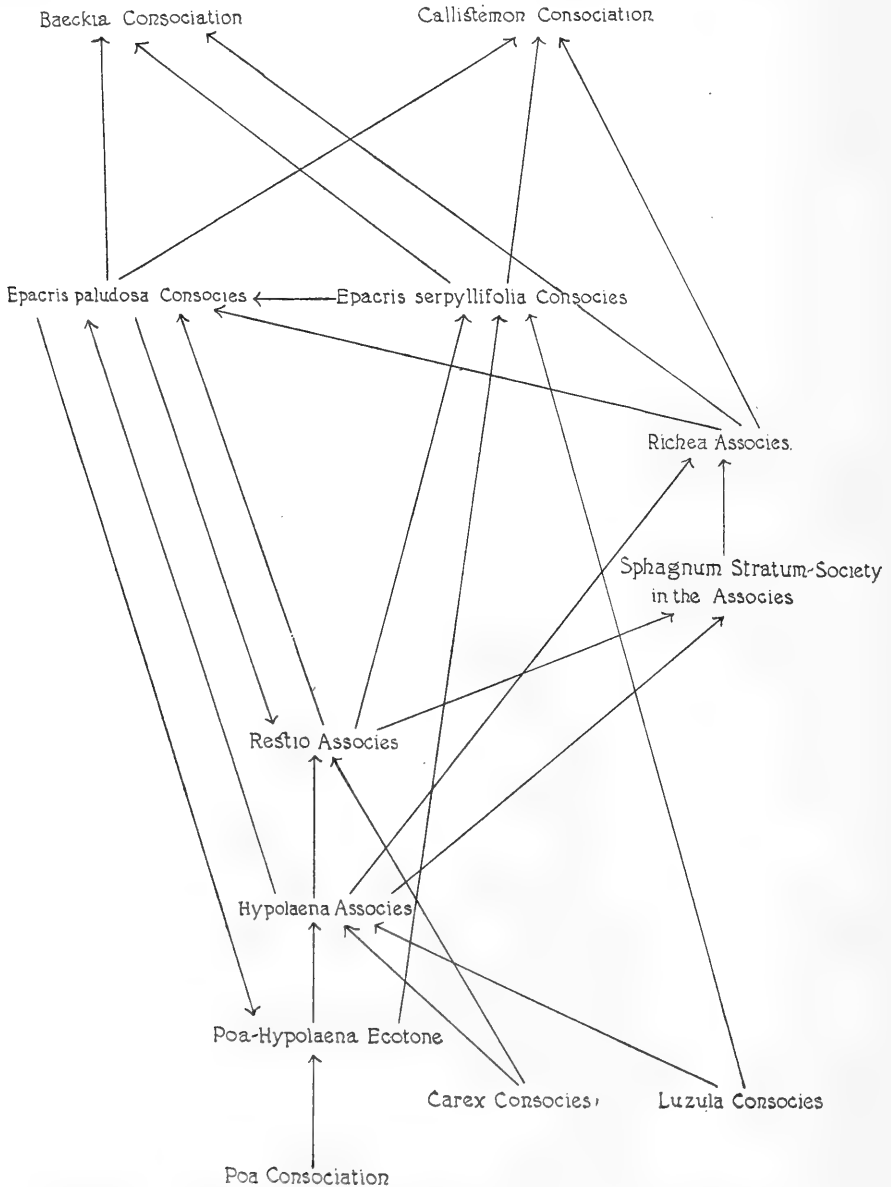
Competition is of considerable importance in connection with the effect of the various climatic factors on the tree-line; the transition zone is undoubtedly a scene of constant struggle between the grassland and the scanty forest. In good seasons seeds of *Eucalyptus coriacea* germinate and develop in the true grassland areas, and if they survive, the grassland community becomes reduced to the status of a subordinate stratum. No doubt this tree after difficult ecesis tends to carry the forest upwards in this manner, but unfavourable seasons, when snow lies late in summer as it occasionally does, and late frosts followed by a dry summer, cause many of the trees to die down, perhaps for good, or perhaps till renascence sets in; the grassland types then for the time resume their dominance, probably to be subordinated again and again during long periods of slow oscillation. Throughout the whole of this district, the higher forest tracts show abundant evidence of the struggle against the grassland types.

The lowering of the temperature during the growing season (from November to March), the first of Rhydberg's factors, has an intermittent effect which probably influences ecesis of the forest trees in their own or the grassland zone. The shortness of the season, however, is more important in the Kosciusko district; but both factors are closely related, for the prevalence of a low temperature during the growing season as the result of late snow-falls or frosts, must inevitably curtail the season for growth. Late snows are common in this area; in some years very heavy falls take place in September, and lie long, water-logging the soil in certain places and delaying the germination and growth not only of herbaceous but also of arboreal types. In such seasons the small alpine and sub-alpine herbs are several weeks later in flowering as compared with other seasons which have no late snow-falls.

Strong wind in winter, especially during frosty periods, appears to be the most important factor affecting the higher forest on the Snowy Mountains. Along the upper limit of the forest, and where it passes into isolated groves or individuals, the trees show the effect of wind by their gnarled, stunted, irregular, often prostrate habit, and their frequently unilateral growth (Plate xix, fig. 2). This peculiar and characteristic growth-form is probably due as much to the desiccating effect of wind, by increasing transpiration from the youngest parts, as to its mechanical action. This wind action prohibits the forest development above 6,100 feet on exposed slopes and peaks, while on the leeward slopes, as has previously been mentioned, the forest ascends to approximately 6,500 feet. The valley-heads and erosion channels on the leeward side, however, are devoid of the forest which occurs on the slopes, as has been described; this is no doubt due to the persistence of the deep snow drifts in such positions, and the smothering of the root-systems while the aerial organs are exposed to strong insolation and high transpiration. This feature has been observed also by Rhydberg in the Rocky Mountains.

The significance of the amount of rainfall during the growing season is by no means certain. On account of the high rainfall and low temperatures generally associated with montane zones—to which the Snowy Mountains are no exception—trees normally occurring in such habitats are usually found to have relatively high

moisture requirements and low temperature requirements (Pearson, 1920); and it is noteworthy that the *Eucalyptus coriacea* forest maintains its optimum development between about 4,500 and 5,600 feet, which is the zone of greatest rainfall. Yet at the same time, although it may be that *E. coriacea* has low temperature requirements, and that this factor causes it to replace the *E. Gunnii* forest at



Text-figure 3. Illustrating the succession in the shallow valleys above 5,000 feet.
Baeckia should be spelt *Baeckea*.

4,500 feet, its occurrence in exposed habitats near Goulburn, near Clarence, and on the Monaro Plains, regions with a rainfall probably often bordering on 20 inches per annum during some months of the year, suggests that it is an extreme xerophyte, more especially as the soil in these regions is dry and generally of low moisture-retaining power. It is improbable that *E. Gunnii* or *E. stellulata* have lower moisture requirements, while our observations on *E. viminalis* in other localities seem to indicate that this has a moisture requirement somewhat higher than most species of *Eucalyptus*. So far as the upper limit of the distribution of *Eucalyptus coriacea* is concerned, however, it may be that the rainfall is of importance, since it is to be expected that in the alpine region the effective rainfall is low during the summer, the precipitation being mainly of the nature of light showers which, while sufficing for the grassland vegetation, do not penetrate deep enough to reach the roots of trees.

THE MARSH VEGETATION.

In the flat, water-logged floors of the shallow valleys above an altitude of 5,000 feet, the *Poa* association, which occupies the lower portions of the slopes, gives place to reed- and bush-swamp. This vegetation is exceedingly complex in structure, comprising a large number of communities, all of which seem to be in successional relation. The causes of this succession appear to be somewhat obscure, and require detailed investigation. We have endeavoured in the present paper, however, to characterize the communities and to indicate, to the extent of our observations, the main lines along which succession seems to take place. No doubt the amount, nature and distribution of the precipitation from year to year and factors which modify the drainage system temporarily or permanently, influence this vegetation materially.

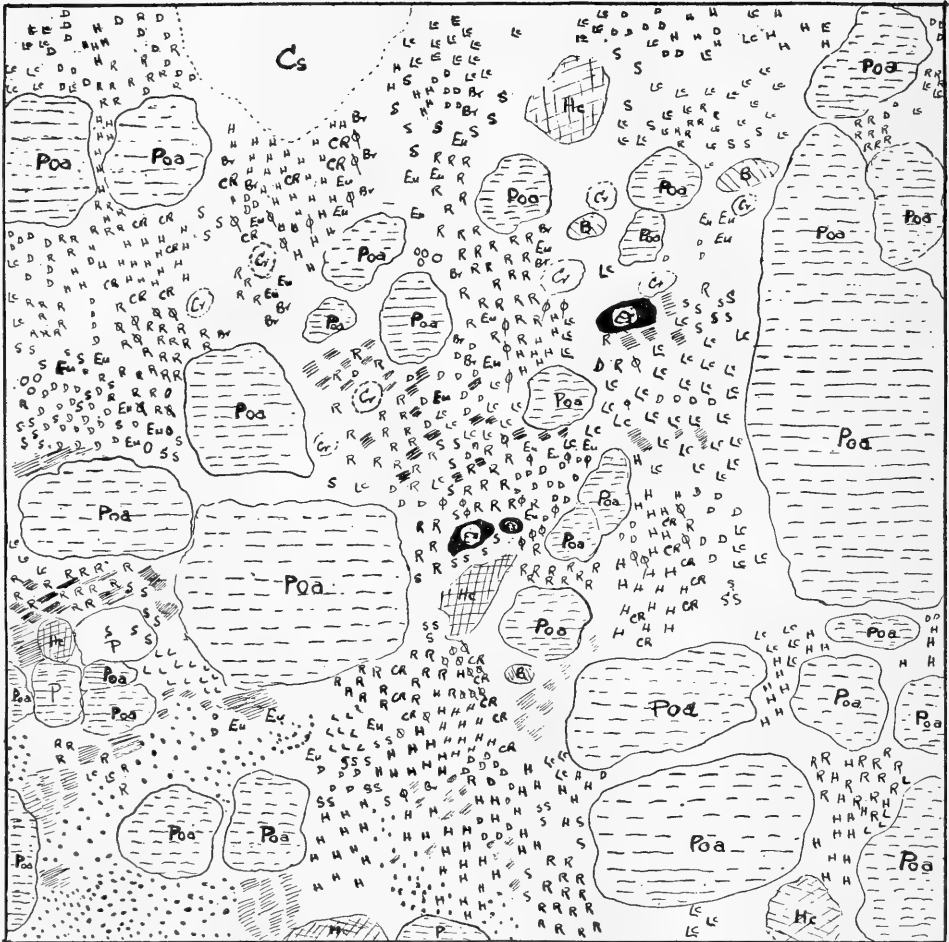
The accompanying diagram (Text-fig. 3) will help to elucidate the remarks which are made upon succession in the following detailed consideration of the communities of this habitat.

Our present investigations indicate that there is little material physiognomic or floristic variation in the communities of the marsh vegetation throughout the extent of their range, from 5,000 to about 6,500 feet, with the exception of the *Richea* and *Restio* associates, which extend in a modified form to 7,000 feet.

THE POA-HYPOLAENA ECOTONE.

Where the *Poa* association of the lower parts of the slopes encroaches upon the damp soil of the valley bottom it forms an ecotone in which it is mixed with *Hypolaena lateriflora*, the dominant of the community which seems to be one of the early stages in the development of the swamp flora. *Hypolaena* is a reed-like plant about six inches in height, and grows densely between the tussocks of *Poa*.

Reference to the accompanying statement of the floristic composition shows that a large number of the subordinates of the *Poa* association are absent from the ecotone; these are apparently more suited to the drier soil, although in the case of *Stellaria pungens*, which favours the damp erosion channels higher up the slopes, it is possible that lack of drainage is an inhibiting factor. It will also be observed that, in the case of a number of the components of the *Poa* association, the frequency decreases on passing into the ecotone, which represents the limit of their range; and in the same manner in this region first appear a number of the subordinates of the *Hypolaena* associates, such as *Oreomyrrhis andicola*. Certain types occurring in the *Poa* association, e.g. *Prasophyllum fuscum*, appear to find a more favourable habitat in the ecotone, and their frequency increases. The

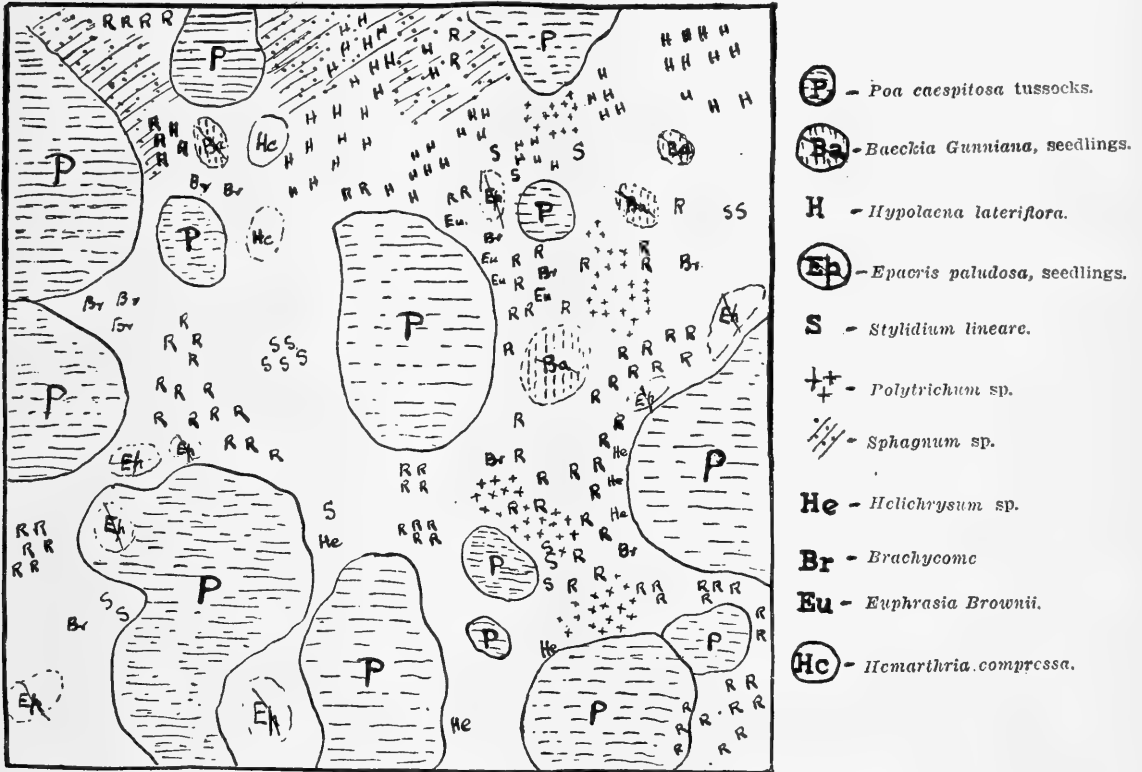


- | | | | |
|-----------|---------------------------------|-----------|--------------------------------|
| | <i>Poa caespitosa</i> tussocks. | | <i>Comesperma retusum</i> . |
| H | <i>Hypolaena lateriflora</i> . | | <i>Epacris serpyllifolia</i> . |
| L | <i>Lotus australis</i> . | CR | <i>Craspedia Richei</i> . |
| Le | <i>Luzula campestris</i> . | O | <i>Olearia</i> sp. |
| R | <i>Richea Gunnii</i> . | | <i>Restio australis</i> . |
| D | <i>Drosera peltata</i> . | Br | <i>Brachycome</i> sp. |
| | <i>Polytrichum</i> sp. | | <i>Baeckia</i> . |
| He | <i>Hemarthria compressa</i> . | S | <i>Styidium lineare</i> . |
| Cs | <i>Callistemon Sieberii</i> . | | <i>Sphagnum</i> sp. |
| Eu | <i>Euphrasia Brownii</i> . | | |

Text-figure 4. Quadrat 4 sq. metres of the *Poa-Hypolaena* ecotone, nearest the marsh communities. The spaces between the tussocks of *Poa caespitosa* are either bare, or occupied by typically moisture-loving types, e.g. *Hypolaena*, *Drosera*, *Polytrichum*, *Richea* and *Luzula*.

Correct spelling should be *Craspedia Richea* and *Baeckea*.

tussocks of *Poa* are less continuous in the ecotone than in the *Poa* consociation, the drainage channels between them which are occupied by *Hypolaena* and the subordinates, being much wider (Text-figs. 4, 5).



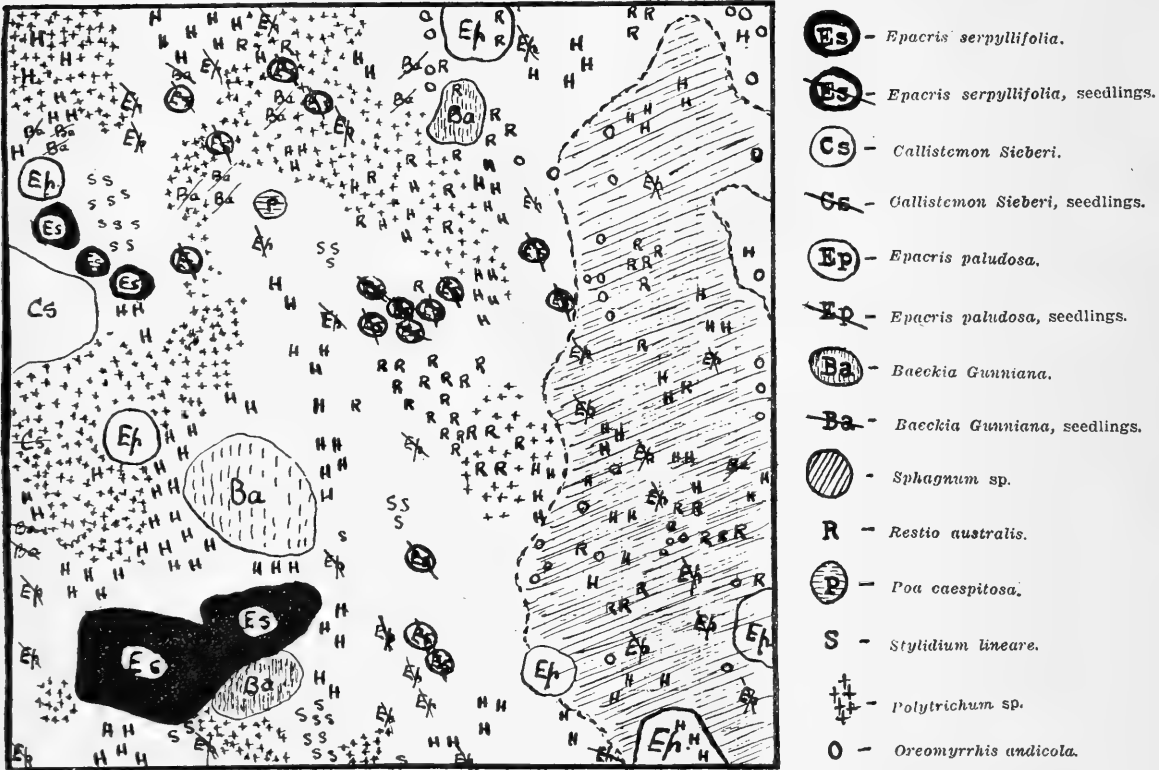
Text-figure 5. Quadrat of the *Poa* ecotone 1 m. square. The spaces between the *Poa* tussocks are drainage channels. The presence of *Restio*, *Hypolaena*, *Epacris* and *Baeckea* suggests the developmental nature of the community, while in addition the mosses represent types not present in the *Poa* consociation. The *Restio* associates (R) is developing somewhat precociously on the right at the bottom.

Generally speaking this ecotone occupies the transitional habitat between that of the *Poa* and that of the *Hypolaena* community. It may arise also, however, as a result of a definite succession; local alterations in the drainage frequently lead to increase in the soil-moisture-content of areas occupied by *Poa*, leading to invasion by *Hypolaena*; as a consequence the same mixed community is found as occurs in the ecotone, although here it possesses rather the character of a *mictium* (Clements, 1916, p. 140).

THE HYPOLAENA ASSOCIES. (Text-fig. 6.)

As the water-table reaches the surface of the soil, on passing from the *Poa-Hypolaena* ecotone towards the centre of the marsh, the *Poa* disappears, yielding the dominance to *Hypolaena*. This species forms a kind of uniform basal

stratum throughout all the communities of the marsh; and where it is not intermingled with taller types it constitutes a distinct community. All stages of abundance of these taller types may be found, especially in the case of *Restio australis*; sometimes their distribution is so open that they rank merely as subordinates in the *Hypolaena* associates although taller than the dominant, from which condition they pass to being dominants themselves when in more close formation.



Text-figure 6. Quadrat 1 m. square of the *Hypolaena* associates, showing development of the *Restio* in the centre. A typical *Sphagnum* patch is seen on the right, while the numerous *Epacris* seedlings indicate that further development is taking place.

Observations seem to indicate that *Restio* appears in flat areas where the content of gravitational water is higher than it is normally in the *Hypolaena* associates, and becomes more prolific with increased water supply. We suggest, therefore, that the accumulation of water in parts, owing to the defective drainage from the great quantities of melting snow on flat ground such as the valley bottoms, causes *Restio* to spring up among the *Hypolaena* and to form a new community.

Isolated societies of *Sphagnum* occur in the *Hypolaena* associates; in these the normal subordinates of the associates, except *Oreomyrrhis andicola*, are often less abundant, and occasionally *Hypolaena* alone remains. In some of the larger

Sphagnum societies numerous seedlings of the epacrid *Richea Gunnii* appear, and, since this type when found mature is usually growing in a dense cushion on old *Sphagnum* beds, it is thought probable that the establishment of *Sphagnum* in the *Hypolaena* associates paves the way for the development of a new community dominated by *Richea*.

In somewhat drier areas than that in which the above succession takes place, the *Hypolaena* associates contains numbers of seedlings, often exceedingly small, of *Epacris serpyllifolia* or of *E. paludosa*. There is no doubt but that this is evidence of another succession taking place from *Hypolaena* to the *Epacris* associates; and it is this evidence in particular, which clearly establishes the seral nature of the *Hypolaena* associates. In the earlier stages of the developing *Epacris* associates, *E. serpyllifolia* seems often more abundant, with only occasional seedlings of *E. paludosa*, although more rarely a pure developing consocieties of the latter is found; in the older stages, however, only the *E. paludosa* consocieties was seen, although there is every reason to believe that the *Hypolaena* associates must be capable of giving rise to both the *Epacris* communities. It must be added at the same time that there is undoubted evidence in places that the *Epacris serpyllifolia* consocieties gives place to the *E. paludosa* consocieties, the dominant of the later community being a larger shrub; and it certainly seems in many cases that a telescoping of this succession takes place in the developing *Epacris* associates, so that the originally abundant seedlings of *E. serpyllifolia* subsequently give place to an invasion of seedlings of *E. paludosa*, which is perhaps a more vigorous type. A more probable explanation is that *E. serpyllifolia* is better adapted to establish itself first in the *Hypolaena* and that *E. paludosa* has to await further changes in the conditions before it can colonize the habitat, after which it readily assumes dominance on account of its larger size.

It thus appears that the *Hypolaena* associates is a synthetic seral community, which, collaterally with habitat changes in different directions, develops along various lines.

THE RESTIO ASSOCIES.

Restio australis, which we have already referred to as dominating a community developing in all probability from the *Hypolaena* associates, is a restiaceous plant from one foot to eighteen inches high, growing densely and often occupying large areas (Plate xii, fig. 2). The subordinates of the *Restio* associates will be seen from the accompanying table to be much the same as in the *Hypolaena* associates, and *Hypolaena* itself forms an almost constantly present lower stratum. *Restio*, however, occurs often with no subordinates as a pure society in little flat water-holes so characteristic of the sub-alpine and montane marshy areas.

Sphagnum societies are occasional, in which communities most subordinates except *Hypolaena* are absent; and judging by analogy with the previously recorded observations in the *Hypolaena* associates, it is possible that these societies may lead to the development of the *Richea* associates.

Seedlings of *Epacris serpyllifolia* and *E. paludosa* are abundant in places, so that there appears reason to believe that when these have attained maturity the *Restio* associates will have developed to a further stage in the sere dominated by *Epacris*.

A large area of the *Restio* associates was observed where dead white gnarled stems of *Epacris* indicated that this plant had previously made fair headway and subsequently died out. Apparently its disappearance was followed by the estab-

ishment of the previous stage of the sere, *viz.*, the *Restio* associates, suggesting that a reversal of the changes in the habitat was the factor leading to the destruction of the *Epacris*.

THE RICHEA ASSOCIES.

Richea Gunnii is a megaphyllous, unbranched or sparsely branched epacid, growing in dense clumps, usually on old *Sphagnum* beds (Plate xiii, fig. 1). The habit of *Sphagnum* of forming mounds is well known, and *Richea* appears to find its most favourable environment on these, sending long shoots upwards through the *Sphagnum*; by this means the clumps of *Richea* reach a height of two or three feet, although the normal height of the plant under ordinary conditions is usually only about one foot.

Richea grows so densely and in such a sodden substratum, that it ordinarily has few subordinates. It seems, however, to consolidate the *Sphagnum* beds, and, as the water in the soil gradually finds drainage channels by which to pass away, other types are able to come in. The first to appear is *Restio*, after which comes *Hypolaena*, suggestive of reversion of the sere owing to reversion of the habitat changes. *Hypolaena* grows up through the *Richea* on long attenuated stalks, in order to reach air and light, so that, although the plant is normally only about six inches high this ecad attains a length of two or three feet. Where the drainage and consolidation has proceeded further, *Baeckea Gunniana* gains entrance, as also less frequently does *Callistemon Sieberi*. This seems to suggest a possibility of *Richea* giving place to the *Baeckea-Callistemon* association, which is the climax stage in the succession taking place in the swamp flora. Probably one may explain in the same way the rather curious local presence among the *Richea* of *Oxylobium ellipticum* var. *alpinum*, a type which usually inhabits much drier places in the *Eucalyptus* forests.

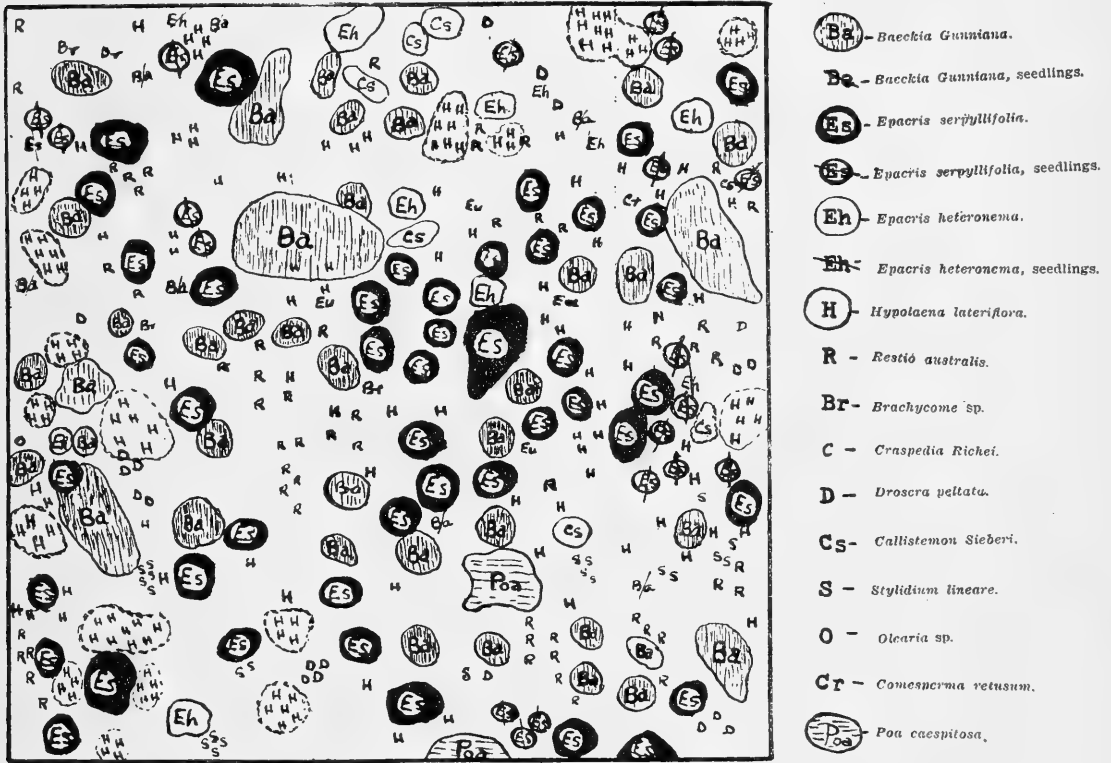
Epacris paludosa also is present in some of the dying clumps of *Richea*, which suggests succession from *Richea* to the *Epacris* associates; this is rendered more probable by the fact that *Epacris* is usually an intermediate stage in the development of the *Baeckea-Callistemon* association.

The distribution of *Richea* between 5,000 and 5,500 feet is much more restricted than that of the communities previously described, nor do the clumps often occupy very extensive areas. From 5,500 to near 7,000 feet (the upward limit of its range), however, the *Richea* associates gradually becomes more frequent and widespread, until it eventually occupies extensive areas of the valley floors where the habitat is sufficiently wet. Its structure in the alpine regions will be referred to again subsequently.

THE EPACRIS ASSOCIES. (Text-fig. 7).

Reference has already been made to the presence of *Epacris* seedlings in the *Poa-Hypolaena* ecotone and in the *Restio*, *Hypolaena* and *Richea* associates, which appear to develop into a community having *Epacris* as dominant. So far, the communities we have been considering have been distributed in zones of increasing content of gravitational water in the soil; *Epacris*, however, occurs in drier soils more akin to that of the habitat of the *Poa-Hypolaena* ecotone and the *Hypolaena* associates. The *Epacris* associates may be a natural development of these two communities in an unchanging habitat; and, indeed, every stage may be observed between these two communities with only a few plants of *Epacris* scattered here and there (Plate xvii, fig. 1), to where it is abundant with only a

subordinate stratum of either *Poa* with a little *Hypolaena* or *Hypolaena* with a little *Poa* (Plate xv, fig. 2; Plate xvi, fig. 2). Consequently the transitional area between the *Poa* consociation and the marsh may be occupied in places by a *Poa-Epacris* ecotone rather than by a *Poa-Hypolaena* ecotone. The *Epacris* associates also appears to follow the *Restio* and *Richea* associates coincident with the drainage of the excess of gravitational water from the soil which takes place eventually as the result of the gradual formation of erosion channels. In this case *Poa* is not present, but later it is possible that *Poa* enters the habitat and becomes as abundant as if the *Epacris* had directly succeeded the *Poa-Hypolaena* ecotone.



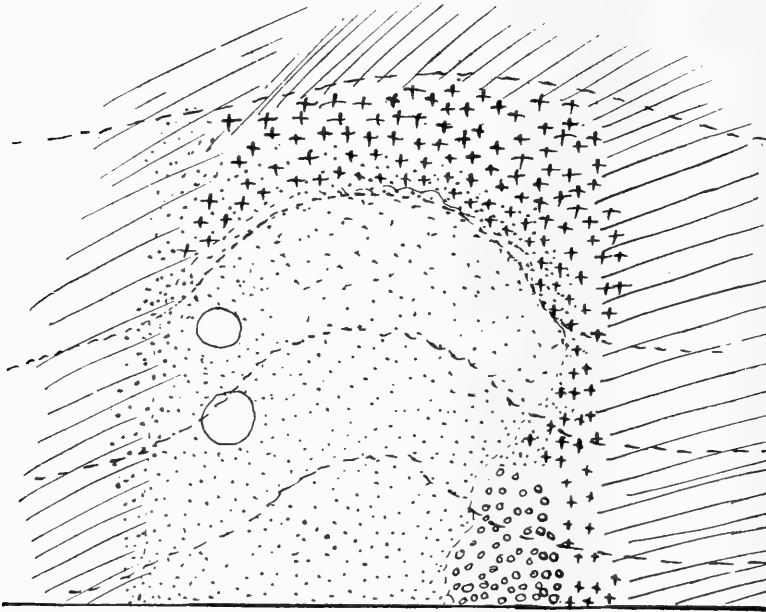
Text-figure 7. Quadrat, 1 m. square of the *Epacris serpyllifolia* consociation in process of developing into the *Baeckea* consociation.

In certain drier parts of the swamp the *Poa* consociation was observed merging into the ecotone, which in parts had apparently developed directly to *Restio* with the omission of the pure *Hypolaena* stage, *Poa* still being present in the *Restio* associates. In places the latter was developing into the *Epacris serpyllifolia* consociation, with scattered plants of the dominant between which *Poa* was abundant. This seems to be a telescoping of the sere owing to drier edaphic conditions.

Destruction of the *Epacris paludosa* consociation and its replacement by the *Poa-Hypolaena* mictium was observed in several places, where the habitat was littered with the dead gnarled and knotted stems (Plate xv, fig. 1). This destruction may

have been caused by snow lying long on the ground and killing out the *Epacris*. The latter would then naturally be replaced by the *Poa-Hypolaena* community which, as has been mentioned above, is akin in its habitat requirements.

As has already been mentioned, two consocieties occur, dominated respectively by *E. serpyllifolia* and *E. paludosa*. The former seems to appear first and often subsequently to give place to the latter, but in large areas *E. paludosa* is absent and the *E. serpyllifolia* consocieties develops directly to the *Baeckea-Callistemon* association, which usually follows the *Epacris* associates as the next and final stage of the sere. Evidence of this interrelationship between these communities is seen in the presence among the *Epacris* of locally abundant seedlings of both *Baeckea* and *Callistemon*. Occasionally in the *Epacris* associates occur single mature plants



†† - *Epacris serpyllifolia* consociation.

||| - *Poa caespitosa* consociation.

/// - *Poa-Hypolaena* ecotone.

••• - *Hypolaena* and *Restio* associates.

○ - *Richea* associates.

○○○ - *Luzula* consociation.

--- - contour line.

Text-figure 8. Diagrammatic Chart (not to scale) of a portion of the marsh vegetation.

of *Callistemon Sieberi* and *Hakea microcarpa*, shrubs about three feet high which stand conspicuously above the dwarf *Epacris* (Plate xvi, fig. 2).

The *Epacris* associes is one of the most widespread communities in the marsh between 5,000 and 5,500 feet, and in many cases, indeed, may possibly be a sub-climax. Above 5,500 feet, however, it gradually gives place to the extensive *Richea* associes which apparently is more suited to the sub-alpine environment. Text-figure 8 shows the interrelationship of the communities described in detail in the preceding pages.

THE BAECKEA-CALLISTEMON ASSOCIATION.

This association appears to be the climax stage in the development of the marsh vegetation, but rather curiously it is very restricted in its distribution, and it is only here and there that conditions appear to permit the existence of the dominants.

The association is present sometimes as a zone round the edge of the marsh in a manner suggesting the occurrence of the *Epacris* associes, but only where the ground has a well-marked slope; at other times it colonizes the margins of channels of water running rapidly through the marsh. These facts of distribution suggest that the association requires a more aerated soil than normally constitutes the marsh; and this conclusion is supported by the similarity between the *Callistemon* consociation of the association under discussion and the *Callistemon* society which inhabits water-courses in the *Eucalyptus* forest higher up the slope (Plate xii, fig. 1).

The dominants occur separately as consociations, the *Baeckea* consociation being the more abundant and containing *Callistemon Sieberi* and *Hakea microcarpa* as subordinates.

The number of species in this association is small, since the closeness of the shrubs prevents the occurrence of lower strata and necessitates the display of all foliage at one level; *Richea*, *Hypolaena* and *Restio* are present in the *Baeckea* consociation growing up on long attenuated stalks through the mass of knotty branches of the *Baeckea*, in the manner described for *Hypolaena* in the *Richea* associes. The light ecad of *Hypolaena* in this community attains a height of three feet, six times the normal height of the plant.

The destruction of *Epacris* by severe conditions with consequent return to the *Poa-Hypolaena* stage of the sere has already been described. A similar case was observed of the destruction of the aerial shoots of *Callistemon* in a consociation of that type, leaving the characteristic white stems standing erect throughout the area. After the ground had been so bared, the *Hypolaena* associes had appeared, and in parts had developed to the *Restio* associes, although not so far as the *Epacris* associes, *E. serpyllifolia* being only occasional. In the meantime a fundamental difference between the epacrid and the myrtaceous type had asserted itself. All our observations indicate that members of the Epacridaceae have generally no means of renascence after destruction of the aerial shoots as is characteristic of the Myrtaceae and many other families represented in *Eucalyptus* forests; therefore, while regeneration of the *Epacris* associes has to await the comparatively slow process of migration and ecesis, *Callistemon*, before even the *Restio* stage had fully asserted itself, had commenced active renascence everywhere by the production of adventitious shoots from the base of the stem, which no doubt would rapidly grow up and restore the original structure of the community, while the *Restio* and *Hypolaena* would be stamped out (Plate xiv, fig. 1). It is interesting to note that *Baeckea* which was apparently occasional in the original

community, had survived destruction, suggesting that *Baeckea* is a more vigorous type; a conclusion supported by its greater abundance at higher altitudes in the *Poa-Celmisia* association.

THE LUZULA-CAREX ASSOCIES.

In flat shallow pools of water occur two closely related consocieties dominated respectively by the sedge-like *Luzula campestris* and *Carex Gaudichaudiana*.

The *Luzula* consociety occurs not only in the marsh vegetation, but also in little flat hollows or natural drains in the *Poa* consociation or in flat areas of the *Callistemon Sieberi* society in the *Eucalyptus coriacea* consociation.

The *Luzula-Carex* association does not appear to form a stage in the complex sere already described, although it passes into it in several ways, as is about to be mentioned. The floristic composition is also considerably different from that of the various stages in that sere, since there are present a number of amphibious or semi-aquatic types such as three species of *Ranunculus*, *Utricularia*, and even the definitely hygrophytic *Chara* or *Nitella*.

In one example of the *Luzula* consociety *Oreomyrrhis andicola* was observed to be equally abundant with *Luzula*. Since the leaves of that rosette-type form a lower stratum than the *Luzula* we have termed it arbitrarily a sub-dominant; at the same time when *Oreomyrrhis* is in flower or fruit, its pedicel is equally as tall as the haulm of *Luzula*, so that during a large period of its existence it is co-dominant. The community in which this observation was made was a less wet habitat than is normally occupied by the *Luzula* consocieties; and it is possible that *Oreomyrrhis* has gained entrance to the community on this account. Increasing drainage of the habitat in one part has resulted in the establishment of numerous seedlings of *Epacris serpyllifolia*, indicating that the community is able to develop into the *E. serpyllifolia* consociety and so link up with the main sere of the marsh vegetation.

Another instance of this is exemplified by the presence of *Restio* in parts of both the *Carex* and *Luzula* consocieties, which of course on account of its larger size soon becomes dominant, forming the typical *Restio* associates. Occasionally *Hypolaena* is also locally abundant in the *Carex* consocieties so that development to the *Hypolaena* associates may possibly take place concomitant with consolidation of the substratum and ablation of the surface water.

These various lines of possible succession are illustrated in Text-fig. 3.

| | | Floristic Composition. | |
|-----------------|--|------------------------|-----|
| | | L. | C. |
| Reed Stratum. | | | |
| | <i>Restio australis</i> R.Br. | lf | lc |
| | <i>Epilobium glabellum</i> Forst. | r | — |
| Grass Stratum. | | | |
| | <i>Luzula campestris</i> D.C. | d | f-c |
| | <i>Carex Gaudichaudiana</i> Kunth. | lf | d |
| | <i>Hypolaena lateriflora</i> Benth. | — | la |
| | <i>Rumex acetosella</i> Linn. | r | — |
| | <i>Poa caespitosa</i> Forst. | lf | — |
| | <i>Plantago varia</i> R.Br. | lf | — |
| | <i>Brachycome</i> sp. | lf | — |
| | <i>Oreomyrrhis andicola</i> Endl. | lsd | — |
| Ground Stratum. | | | |
| | <i>Ranunculus Millani</i> F.v.M. | a | o-a |
| | <i>Utricularia dichotoma</i> Labill. var. <i>uniflora</i> Benth. | — | la |
| | <i>Chara</i> sp. or <i>Nitella</i> sp. | — | la |
| | <i>Velleya montana</i> Hook. | lf | — |
| | <i>Epacris serpyllifolia</i> Labill. (seedlings) | lc | — |
| | Moss societies (chiefly <i>Sphagnum</i> and <i>Polytrichum</i>) | o | — |

FLORISTIC COMPOSITION OF THE MAIN COMMUNITIES OF THE MARSH VEGETATION.

| Species. | Poa consociation. | Poa-Restio ecotone. | Restio associates. | Hypolaena associates. | Richea associates. | Epacris associates. | Callistemon consociation. | Baeckea consociation. |
|--|----------------------|------------------------|-----------------------|--------------------------|-----------------------|------------------------|------------------------------|--------------------------|
| Shrub Stratum. | | | | | | | | |
| <i>Baeckea Gunniana</i> Schau. | — | † | — | † | * | — | f-lc | d |
| <i>Callistemon Sieberi</i> D.C. | o-lc | — | lo | — | — | societies lf | d | o-c |
| <i>Cassinia acutata</i> R.Br. | o | † | † | — | — | societies lf | — | o |
| <i>Lakea microcarpa</i> R.Br. | o | † | — | — | — | — | f | — |
| <i>Helichrysum baccharoides</i> F.v.M. | f | — | — | — | — | — | — | — |
| <i>Phebatium ovatifolium</i> F.v.M. | — | — | — | — | — | — | — | — |
| Dwarf-Shrub Stratum. | | | | | | | | |
| <i>Callistemon Sieberi</i> D.C. young plants | — | — | † | — | — | lf | † | † |
| <i>Baeckea Gunniana</i> Schau. young plants | — | — | — | — | lf | la | † | † |
| <i>Comesperma retusum</i> Labill. | r | o | o | o | lf | o | — | o-f |
| <i>Epacris paludosa</i> R.Br. | — | § | § | § | lf | d-o | r | o-f |
| <i>Epacris serpyllifolia</i> R.Br. | — | — | — | o § | — | o-d | o | — |
| <i>Eucalyptus cortacea</i> Cunn. seedlings | — | — | — | — | — | r | — | — |
| <i>Helichrysum baccharoides</i> F.v.M. young plants | † | † | — | — | — | — | — | — |
| <i>Restio australis</i> R.Br. | r | lf-la | lo-lf | d | — | lf | † | — |
| <i>Linum marginale</i> Cunn. | r | o-c | — | — | o-a | a | c | o-c |
| <i>Oxylobium ellipticum</i> R.Br. var. <i>alpinum</i> Maiden and Betche. | r | — | — | — | la at 5,000 ft. | — | — | — |
| <i>Podolepis longipedata</i> Cunn. | o in societies | † | — | — | — | — | — | — |
| <i>Hypolaena lateriflora</i> Benth. attenuated ecad | — | † | † | † | la | † | a | la |
| <i>Richea Gunnii</i> Hook. | — | — | † | — | d | la over 6,000 ft. | r | lf-la |
| Herb Stratum. | | | | | | | | |
| <i>Actiphylloa glacialis</i> F.v.M. | — | — | r above 5,500 ft. | r above 5,700 ft. | r above 5,700 ft. | — | — | — |
| <i>Baeckea Gunniana</i> Schau. seedlings | — | o | — | lf | * | — | † | † |
| <i>Brachycome decipiens</i> Hook. | f-a | o-f | — | — | — | — | — | — |
| <i>Brachycome scapiformis</i> D.C. | o | o-f | — | — | — | — | — | — |
| <i>Celmisia longifolia</i> D.C. | f above 5,700 ft. | — | — | — | — | — | — | — |
| <i>Craspedia Richea</i> Cass. | f | o-c | o | o | r | o | — | — |
| <i>Diuris pedunculata</i> R.Br. | — | o at 5,500 ft. | — | — | — | — | — | — |
| <i>Epilobium alabellum</i> Forst. | o | o | o-f | o-c | — | — | — | — |
| <i>Euphrasia Brownii</i> F.v.M. | f | r at 5,800 ft. | r | r | — | — | — | — |
| <i>Euphrasia antarctica</i> Benth. | — | — | — | — | — | — | — | — |
| <i>Habea microcarpa</i> R.Br. seedlings | † | r | r | — | — | † | — | † |
| <i>Helichrysum baccharoides</i> F.v.M. seedlings | † | r | — | — | — | * | † | — |
| <i>Helichrysum bracteatum</i> Willd. | o | — | — | — | — | — | — | — |
| <i>Helichrysum rutiloideps</i> D.C. | f | — | — | — | — | — | — | — |
| <i>Helichrysum scorpioides</i> Labill. | f-lc | f | o | — | — | — | — | — |
| <i>Hovea longifolia</i> R.Br. | o | — | — | — | — | — | — | — |

* See dwarf-shrub stratum.
 † See herb stratum.
 § See ground stratum.

FLORISTIC COMPOSITION OF THE MAIN COMMUNITIES OF THE MARSH VEGETATION.—Continued.

| Species. | Poa consociation. | Poa-Restio ecotone. | Restio associates. | Hypolaena associates. | Richea associates. | Epacris associates. | Callistemon consociation. | Epacetes consociation. |
|---|----------------------|------------------------|-----------------------|--------------------------|-----------------------|------------------------|------------------------------|---------------------------|
| Herb Stratum.—Continued. | | | | | | | | |
| <i>Hymenanthera dentata</i> R.Br. | o-f | o at 5,600 ft. | o-lf | — | — | vr | — | — |
| young plants | — | f | vr | — | — | r | — | — |
| <i>Kunzea Muelleri</i> Benth. | c | o | lo-lf | r | — | — | — | — |
| <i>Leptorhynchos squamatus</i> Less. | — | — | lo-lc | — | — | — | — | — |
| <i>Carex Gandchaidana</i> Kunth. | — | — | o | f-c | — | o | — | — |
| <i>Luzula campestris</i> D.C. | — | — | — | — | — | — | — | — |
| <i>Oreomyza andicola</i> Endl. | — | — | — | — | — | — | — | — |
| <i>Oryzobolus ellipticus</i> R.Br. var. alpinum Maiden and Betche | * | o at 5,600 ft. | — | — | * | o | — | — |
| <i>Plantago varia</i> R.Br. | o | f | o-lf | la | — | o | If | — |
| <i>Poa capspitosa</i> Forst. | d | o | — | — | — | o-la | — | — |
| <i>Prasophyllum fuscum</i> R.Br. | o | o-f | — | — | — | — | — | — |
| <i>Prasophyllum fuscum</i> R.Br. var. alpinum Benth. | o | o | — | — | — | — | — | — |
| <i>Prasophyllum patens</i> R.Br. | r | o | — | — | — | — | — | — |
| <i>Pterostylis mutica</i> R.Br. | r-lo | lf | — | — | — | o-f | — | — |
| <i>Pultenaea fusciculata</i> Benth. | o | o | o | — | — | — | — | — |
| <i>Ranunculus lappaceus</i> Sm. | r-f | o | o | — | — | — | — | — |
| <i>Hypolaena lateriflora</i> Benth. | — | sd | d | a | * | a | * | * |
| in <i>Sphagnum</i> societies | — | — | lc | — | — | * | — | * |
| <i>Rumex acetosella</i> Linn. | la | — | — | — | — | — | — | — |
| <i>Senecio lautus</i> Sol. | f | — | — | — | — | — | — | — |
| <i>Stellaria piagens</i> Brongn. | o-a | — | — | — | — | — | — | — |
| <i>Stylidium graminifolium</i> Swartz. | o | o-c | o-f | o | — | f | — | — |
| <i>Taraxacum dens-leontis</i> Desf. | f-a | — | — | — | — | — | — | — |
| <i>Thelymitra venosa</i> R.Br. | — | — | vr | — | — | — | — | — |
| <i>Trifolium</i> sp. | o at 5,000 ft. | o-f | f | f | — | — | — | — |
| <i>Wahlenbergia gracilis</i> D.C. | o-c | — | — | — | — | — | — | — |
| Ground Stratum. | | | | | | | | |
| <i>Acacia sanguisorbae</i> Vahl. | a | — | — | — | — | — | — | — |
| <i>Asperula oligantha</i> F.v.M. | o | — | — | — | — | — | — | — |
| <i>Chiloglottis Gunnii</i> Lindl. | lf | — | — | — | — | — | — | — |
| <i>Drosera peltata</i> Sm. | — | — | r above 5,500 ft. | o | — | o | — | — |
| <i>Drosera Arcturi</i> Hook. | — | — | — | — | — | — | — | — |
| <i>Epacris serpyllifolia</i> Labill. seed- lings | — | lf | f-a | lf-la | — | * | * | * |
| <i>Epacris paludosa</i> R.Br. seed- lings | — | — | f-a | lo-lf | — | * | * | * |
| <i>Galium ambrosium</i> Sol. | o | — | — | — | * | — | — | — |
| <i>Geranium dissectum</i> Linn. | o | — | — | — | — | — | — | — |
| <i>Lycopodium</i> sp. | o | — | — | — | — | — | — | — |
| <i>Lycopodium clavatum</i> R.Br. | o | — | o-f | vr | — | r | — | — |
| <i>Paranthera microphylla</i> Brongn. | o | — | la | la | — | — | — | — |
| <i>Ranunculus</i> sp. | — | — | l | o | — | — | — | — |
| <i>Sphagnum</i> societies | — | — | — | — | — | — | — | — |
| <i>Scaevola Hookeri</i> F.v.M. Labill. var. <i>uniflora</i> Benth. | o | — | la | — | — | — | — | — |
| <i>Utricularia dickotoma</i> Labill. | — | — | — | — | — | — | — | — |
| Moss societies (<i>Sphagnum</i> , <i>Polytrichum</i> , etc.) | — | — | f | f | — | f | — | — |
| <i>Hypericum japonicum</i> Thunb. ... | — | o | la | — | — | — | — | — |

* See dwarf-shrub stratum.

† See herb stratum.

‡ See shrub stratum.

§ See ground stratum.

THE ALPINE VEGETATION.
THE POA-CELMISIA ASSOCIATION.

Above the tree-line in the neighbourhood of 6,000 to 6,500 feet, the open, stunted *Eucalyptus* forest gives place to a vegetation composed mainly of low-tussock grassland and herbs. This vegetation has a characteristically alpine physiognomy, and forms a low dense covering over the treeless peaks which reach an altitude of over 7,000 feet. Two consociations are found, the one being dominated by *Poa caespitosa*, and forming a typical low-tussock grassland community. This is in reality the same community as occurs below the *Eucalyptus* forest on the slopes of the sub-alpine region, and as forms the ground stratum of the forest itself. The composition of the subordinates, however, differs somewhat, as will be seen by comparing the statement of the floristic composition at the end of this section of the paper, with that of the ground stratum of the *Eucalyptus coriacea* consociation and with that of the *Poa* consociation of the sub-alpine region given with that of the marsh vegetation. The other consociation is dominated by a creeping rosette composite, *Celmisia longifolia*, which forms a dense felt-like growth. The *Poa* gives a rich olive-green to the hills in the distance; *Celmisia*, however, with its glaucous leaves, thick white tomentum and numerous inflorescences, appears in the distance as large bluish-white patches scattered over the hillsides; this feature is illustrated in Plate xviii, figs. 2 and 3.

The subordinates of these two communities, as will be seen from the accompanying statement of the floristic composition, are largely composed of the same species, although it appears that the more delicate mesophytic types favour rather the *Celmisia* consociation. The majority of the species conform to characteristic alpine life-forms, as will also be seen from the statement of the floristic composition. Apart from the tussock grass represented by *Poa* and the mat grass represented by *Hemarthria compressa*, the dominant life-form is the rosette herb, intermixed with a smaller proportion of cushion herbs. Shrubs are only occasional and tend to be confined to the shelter of granite boulders; they exhibit a marked degree of nanism, being either prostrate or in the form of low cushions, usually occurring flattened close against the rock surfaces, in order to avoid the effects of the strong winds (Plate xix, fig. 1). Among these shrubs may be mentioned *Grevillea australis*, *Podocarpus alpina*, and the fern *Polystichum aculeatum*.

The extreme shortness of the vegetative season at these high altitudes results in every species flowering at the same period; consequently there is a wealth of floral production unmatched in other regions of the State, more especially as the flowers are mostly large and brightly coloured (Plate xix, fig. 3).

A certain amount of competition and overlapping takes place between the *Poa* and *Celmisia* consociations, and often the two types are co-dominant. In damper parts of the slopes and valley-bottoms in both consociations occurs the dwarfed and prostrate *Epacris petrophila*, which in parts becomes dominant, thus forming a new consociation retaining the typical subordinates of the *Poa* and *Celmisia* communities. The *Richea Gunnii* associes occurs also in the swampy areas, where it is the main community, as has been mentioned earlier; this species is also sometimes locally abundant in the *Celmisia* consociation. The *Epacris* associes of the marsh vegetation, however, does not occur, and it appears that the *Richea* associes forms the climax at these high altitudes. The *Hypolaena* associes is found pure in one or two marshes, and this develops directly into the *Richea* associes, which then contains *Hypolaena* in abundance. The *Epacris*

petrophila consociation occurs associated with the *Richea* consociation in these marshes but does not appear to be developmentally related. In water-courses below the melting snow-drifts a *Ranunculus rivularis* society occurs with a number of semi-aquatic subordinates, including *Caltha introloba* which is confined to altitudes bordering on 7,000 feet.

On many drier areas *Celmisia* and *Poa* occur practically alone, since it appears that the subordinates are the less hardy and more mesophytic types.

During nine months of the year the alpine region is covered in snow which in places frequently lies as drifts throughout the summer. The effect of this on the vegetation is naturally very pronounced. All the herbaceous types die down when the snow comes, but perennate from season to season by subterranean organs of propagation. Thus an area from which the snow has just been melted is seen to be covered with the withered remains of vegetation; and later appear the young shoots of *Poa*, etc. In some areas where snow has remained continuously for several years these withered remains have very largely disappeared, and no doubt the perennating organs are here entirely killed out, so that a new migration will have to take place. These occasional patches are the only areas of granite soil which, in summer-time, are not clothed with a dense carpet of vegetation. Contrary to this feature of the lifehistory of the herbaceous plants, the shrubs are able to withstand the effects of the snow covering, without even losing their leaves, since no periodically deciduous species occur in the New South Wales flora. At the same time the shrubs are often killed during severe seasons, as is evinced by the bleached, gnarled and thick woody stems which are often to be seen.

The *Poa* and *Celmisia* consociations occur also on a large area of slate in the alpine region, where they possess practically the same features. A number of smaller differences in floristic composition appear to exist, as will be seen from the accompanying lists; but we have no definite record of any plant being confined to the consociation on the slate, nor have we definite record of any species not occurring on the slate. It is probable, however, that further work may modify this statement, since our observations on the composition of the slate flora are incomplete.

In the alpine region numerous very typical structural and growth features are exhibited by the herbaceous and shrubby plants. The habit of the shrubs varies with exposure to wind. In the most exposed situations where the desiccating effect of wind is predominant and retards normal elongation of the aerial shoots, nanism, or stunted, dwarfed and distorted growth results. The larger shrubs such as *Phebalium ovatifolium*, *Orites lancifolia*, *Prostanthera cuneata*, *Podocarpus alpina* and *Grevillea australis* assume a close, dense, caespitose habit, which favours reduction of transpiration and natural protection from wind-action. Forms like *Pimelea alpina*, *Lissanthe montana*, and *Kunzea Muelleri* frequently assume a typical espalier habit, prostrate and straggling, and raising their growing tips only a few inches above the level of the soil or protective rock.

Several mat-forming herbs occur in the alpine zone, being generally very dwarfed forms which cling closely to the surface of the soil. The most important of the plants in this category are *Stackhousia pulvinaris*, *Raoulia catipes*, and *Epilobium confertifolium*.

The rosette leaf habit is represented in a number of types, as will be seen from the accompanying statement of the floristic composition. The majority of these plants are characterized by deep tap roots.

Sclerophylly is a characteristic feature of the shrubs, while many types, both shrubby and herbaceous, have extensive and dense coverings of silky or woolly

Floristic Composition.
Poa-Celmisia Association.

| Species. | Life-form. | Granite. | | Slate. | |
|--|---|----------------------|---------------------------|----------------------|---------------------------|
| | | Poa consociation. | Celmisia consociation. | Poa consociation. | Celmisia consociation. |
| <i>Acaena sanguisorbae</i> Vahl. | Creeping mat herb | la | — | la | — |
| <i>Aciphylla glacialis</i> F.v.M. | Rosette herb | f | f | o | o |
| <i>Astelia alpina</i> R.Br. | Rosette herb | — | o | — | — |
| <i>Brachycome cardiocarpa</i> F.v.M. var. <i>alpina</i> | Rosette herb | o | o | o | o-f |
| <i>Brachycome scapiformis</i> D.C. | Rosette herb | f | f | — | — |
| <i>Barbarea vulgaris</i> R.Br. . . | Low erect herb . . . | — | o | — | o |
| <i>Carex breviculmis</i> R.Br. . . | Sedge | o | o | — | — |
| <i>Celmisia longifolia</i> Cass. . . | Creeping rosette herb | lf | d | lf | d |
| <i>Claytonia australasica</i> Hook. | Mat herb | — | o-lc | — | o-a |
| <i>Craspedia Richea</i> Cass. . . . | Rosette herb | f | o | o | o |
| <i>Craspedia Richea</i> Cass. var. <i>alpina</i> Benth. | Rosette herb | o | f | o | o |
| <i>Drapetes Tasmanica</i> Hook. | Prostrate shrub . . . | o | o | — | — |
| <i>Epacris petrophila</i> Hook. . . | Prostrate shrub . . . | la | lo-la | — | — |
| <i>Euphrasia Brownii</i> , F.v.M. | Low erect herb | la | f | o | f |
| <i>Galium umbrosum</i> Sol. | Low herb | o up to 6,700 ft. | — | — | — |
| <i>Grevillea australis</i> R.Br. . . | Caespitose or prostrate shrub | o | — | o | r |
| <i>Helipterum incanum</i> D.C. . . . | Creeping rosette herb | — | o-c | — | o |
| <i>Hemarthria compressa</i> R.Br. | Low grass | c | lf | — | — |
| <i>Hymenanthera dentata</i> R.Br. | Espalier shrub | vr | — | — | — |
| <i>Kunzea Muelleri</i> Benth. . . . | Espalier shrub | vr | — | — | — |
| <i>Lissanthe montana</i> R.Br. . . . | Espalier shrub | o | o | — | — |
| <i>Lycoperdon</i> sp. | Puff-ball | — | o | — | — |
| <i>Lycopodium clavatum</i> R.Br. | Decumbent herb . . . | vr | vr | — | r |
| <i>Myosotis australis</i> R.Br. . . . | Herb | — | r | — | — |
| <i>Olearia floribunda</i> Benth. . . | Espalier shrub | r | — | r | — |
| <i>Oreomyrrhis andicola</i> Endl. | Rosette herb | o | — | — | — |
| <i>Oreomyrrhis pulvinifera</i> F.v.M. | Rosette herb | r | — | — | — |
| <i>Orites lancifolia</i> F.v.M. . . . | Caespitose shrub . . . | vr | — | — | — |
| <i>Pimelea alpina</i> F.v.M. | Espalier shrub | o | o-lc | o | — |
| <i>Pimelea axiflora</i> F.v.M. var. <i>alpina</i> F.v.M. | Espalier shrub | o | o | o | — |
| <i>Phebalium ovatifolium</i> F.v.M. | Caespitose shrub . . . | o-lc | — | — | — |
| <i>Poa caespitosa</i> Forst. | Low-tussock grass | d | o-a | d | o-a |
| <i>Podocarpus alpina</i> R.Br. . . . | Caespitose shrub . . . | o | — | — | — |
| <i>Polystichum aculeatum</i> (L.) Schott. | Fern | r | — | — | — |
| <i>Polytrichum</i> sp. | Moss | — | la | — | — |
| <i>Pentachondra pumila</i> R.Br. | Espalier shrub | o | — | — | — |
| <i>Prostanthera cuneata</i> Benth. | Caespitose shrub . . . | r | — | r | — |
| <i>Ranunculus anemoneus</i> F.v.M. | Rosette herb | — | o | — | — |
| <i>Ranunculus dissectifolius</i> F.v.M. | Rosette herb | — | o-lf | — | — |
| <i>Ranunculus Gunnianus</i> Hook. | Creeping rosette herb | o | o | — | — |
| <i>Ranunculus Muelleri</i> Benth. | Rosette herb | — | o-lf | — | — |
| <i>Azorella dichopetala</i> Benth. | Rosette herb | f | f | — | — |
| <i>Ranunculus</i> sp. | Rosette herb | — | — | la | — |
| <i>Raoulia catipes</i> Hook. | Mat herb | o | f | — | o |
| <i>Richea Gunnii</i> Hook. | Low caespitose shrub | — | la | — | — |
| <i>Senecio pectinatus</i> D.C. . . . | Erect herb | r | — | o | — |
| <i>Stackhousia pulvinaris</i> F.v.M. | Mat herb | lo | lo | — | — |
| <i>Taraxacum dens-leonis</i> Desf. | Rosette herb | o-c | o | c-a | o |
| <i>Viola betonicifolia</i> Sm. . . . | Creeping rosette herb | vr | — | vr | — |
| <i>Danthonia robusta</i> F.v.M. . . | Tufted grass | o-lc | — | — | — |
| <i>Epilobium confertifolium</i> . . | Mat herb | — | o | — | o |
| <i>Coprosma Nertera</i> F.v.M. . . . | Espalier shrub | o | — | — | — |
| <i>Lycopodium Selago</i> , Linn. . . | | r | — | — | — |

hairs on their inflorescences, leaves and young shoots. Examples of this class are *Celmisia longifolia*, *Helipterum incanum*, *Podolepis longipedata*, *Craspedia Richea* var. *alpina*, *Raoulia catipes*, *Oreomyrrhis andicola* and *Ranunculus Muelleri*. The relation of hairiness of alpine and sub-alpine plants to protection against intense insolation, and consequent excessive transpiration and inhibition of growth, is so well known that it needs no discussion here.

| | |
|---|-----|
| <i>Epacris petrophila</i> Consociation. | |
| <i>Epacris petrophila</i> Hook. | d |
| <i>Celmisia longifolia</i> Cass. | f-c |
| <i>Richea Gunnii</i> Hook. | la |
| <i>Craspedia Richea</i> Cass. | o-f |
| <i>Richea</i> Associates. | |
| <i>Richea Gunnii</i> Hook. | d |
| <i>Restio australis</i> R.Br. | la |
| <i>Sphagnum</i> sp. | o |
| <i>Ranunculus rivularis</i> Society. | |
| Herb Stratum. | |
| <i>Ranunculus Gunnianus</i> Hook. | |
| <i>Brachycome cardiocarpa</i> F.v.M. var. <i>alpina</i> | f |
| Ground Stratum. | |
| <i>Ranunculus rivularis</i> Banks and Sol. | d |
| <i>Caltha introloba</i> F.v.M. | a |
| <i>Drosera Arcturi</i> Hook. | o |
| <i>Sphagnum</i> sp. | o |

THE EPACRIS PETROPHILA CONSOCIATION.

The summits of certain of the peaks in the slate region of the Plateau represent an extremely barren habitat: the ground is composed of the upturned edges of the strata of slate, and there is practically no soil. The conditions seem too severe for the grassland which tends to accumulate the raw humus of a moisture retaining soil, and a few of the hardy species form an open community which has the characteristic physiognomy of fell-field or alpine rocky desert (Plate xvii, fig. 2). None of the individuals are more than three or four inches in height, and they are scattered intermittently over the rocky ground. The available moisture is less than elsewhere, hence the plants are mostly xerophytes, especially the dominant, *Epacris petrophila*. It is curious in this connection that this species should have been characteristic of the damper slopes in the *Poa-Celmisia* association.

Although the majority of the components of the community were found in the *Poa-Celmisia* association, the great difference in physiognomy marks it out as a distinct association, distinct even from the consociation of the *Poa-Celmisia* association having the same dominant.

A remarkable feature is the sudden replacement of the *Epacris petrophila* association by the *Poa* consociation on passing to a more sheltered habitat over the brow of the hill, the ecotone region being only a few yards in breadth.

| | |
|---|---|
| <i>Floristic Composition.</i> | |
| <i>Epacris petrophila</i> Hook. | d |
| <i>Colobanthus subulatus</i> Hook. | f |
| <i>Carex breviculmis</i> R.Br. | f |
| <i>Azorella dichopetala</i> Benth. | o |
| <i>Azorella cuneifolia</i> F.v.M. | o |
| <i>Poa caespitosa</i> Forst. | o |
| <i>Brachycome</i> sp. | o |
| <i>Euphrasia Brownii</i> F.v.M. very small form | r |
| Lichens | f |

Summary.

The paper comprises an account of the plant communities of the Kosciusko Plateau.

Three regions are recognized on the plateau, *viz.*, the alpine, sub-alpine and montane zones.

The montane zone and the slopes of the ridges in the sub-alpine zone are occupied by *Eucalyptus* forests, the former mainly by a *Eucalyptus Gunnii* consociation, the latter by a *Eucalyptus coriacea* consociation.

Accounts are given of the structure and adaptations of these forests, including certain features of regeneration, and of the factors controlling the timber-line at the upper limit of the sub-alpine zone.

The flat bottoms of the shallow valleys of the alpine and sub-alpine regions are occupied by a marsh vegetation comprising reed-swamp and dwarf-shrub heath. The interrelationships of a number of seral communities in this habitat are discussed at some length.

The alpine zone, extending from the upper limit of arboreal vegetation to the summit of the plateau, is occupied mainly by a *Poa-Celmisia* association. The *Poa* consociation forms a low-tussock grassland community, and occurs also in the sub-alpine zone between the *Eucalyptus* forest on the slopes and the marsh vegetation in the valley bottoms; the *Celmisia* consociation forms a mat-herb community and is confined to the alpine region.

Acknowledgements.

The authors desire to record their thanks to Professor Griffith Taylor and his associates for the privilege of reproducing their reconnaissance map and the block diagram of the Kosciusko Plateau, and to Mr. E. Cheel of the National Herbarium for kindly identifying a few of the specimens.

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EXPLANATION OF PLATES X-XIX.

Plate x.

Map of Kosciusko Plateau (20 miles by 6 miles), where the elevations are represented by form-lines or approximate contours.

Plate xi.

1. Slope of a shallow valley at about 5,100 feet. The *Eucalyptus coriacea* consociation, with its characteristic shrubs, is seen in the rear. The typical life-form of the dominant is well illustrated in the comparatively large tree on the left. The *Poa* consociation is present on the slopes on the right and left, while the marsh vegetation occupies the level ground where water collects. The low dark heath-like portion is the *Epacris* association, while the *Hypolaena* associates and such communities constitute the remaining portion of the marsh vegetation.

2. A shallow valley at about 5,500 feet, showing destruction of *Eucalyptus coriacea* by severe climatic conditions. The lower stature of the trees at this altitude compared with those of the previous photograph is evident. The replacement of the forest by the *Poa* consociation on the lower parts of the slopes is shown; the marsh vegetation is

sparingly developed, as the drainage is comparatively good in this instance, but darker patches of it are seen in the middle distance. The occurrence of isolated trees on small raised drier hummocks in the *Poa* consociation is a conspicuous feature.

Plate xii.

1. View at 5,200 feet, showing the *Eucalyptus coriacea* consociation in the background, and the *Callistemon* consociation in the foreground.

2. The *Restio* associates in gently undulating country at 5,500 feet. The *Poa* and *Eucalyptus coriacea* consociations are seen on the higher ground in the distance.

3. A shallow valley at 5,600 feet showing the *Eucalyptus coriacea* forest on the ridge and the *Poa* consociation in the foreground. The lower stature of the trees than in Plate xi, fig. 1, is again evident. The tussock-like nature of *Poa caespitosa* is more noticeable at this higher altitude on account of the greater abundance of drainage water. This is particularly seen in the foreground.

Plate xiii.

1. A granite boulder in a marsh at 6,000 feet, showing *Baeckea Gunniana* flattened against it, in order to obtain protection from wind. *Richea Gunnii* is seen in the right foreground.

2. A society of *Veronica Derwentia* in a portion of the *Eucalyptus coriacea* consociation at 5,500 feet, which has been killed by fire. *Poa* is seen to occupy the ground between the plants of *Veronica*.

Plate xiv.

1. A regenerating plant of *Callistemon Sieberi*, whose aerial portion has previously been killed by severe climatic conditions.

2. The Snowy River at 4,000 feet, showing the *Eucalyptus Gunnii* consociation clothing the slope in the background, and the *Leptospermum* society lining the river bank. The difference in the topography from the higher altitude, as well as the denser forest is evident. The bare nature of the forest floor in the *E. Gunnii* consociation is seen on the right.

Plate xv.

1. In the middle distance is seen the *Epacris paludosa* consociation in flower. The foreground was originally occupied by this type, which has, however, died out, as is evident by the dead branches, and has been replaced by the *Poa-Hypolaena mictium*. The *Eucalyptus coriacea* is well developed in the background. Altitude 5,100 feet.

2. Another view of the *Epacris paludosa* consociation in flower, passing through the *Poa-Hypolaena mictium* which reaches as far as the foot of the white tree on the right and then merges into the *Poa* stratum society of the forest.

Plate xvi.

1. A view in the alpine region at 6,700 feet. The white patches on the steep slope on the left are dead trunks of a low forest of *Eucalyptus coriacea*, which has migrated upwards and subsequently been killed by severe seasons. In the foreground is seen the *Celmisia* consociation, the dominant being admixed with *Poa*. The distant ranges are in Victoria.

2. The *Epacris paludosa* consociation, 5,100 feet. A bush of *Hakea microcarpa* is seen in the background.

3. A view in the *Eucalyptus Gunnii* consociation, 4,000 feet, showing the tall trees and the ground almost devoid of vegetation.

4. A shallow valley at 5,800 feet. The *Eucalyptus coriacea* consociation is seen to be here very stunted and confined to the ridges between the erosion-channels running down the slope. Between the patches of forest are dense societies of *Prostanthera cuneata* which extend down over the *Poa* consociation on the lower part of the slope. On the floor of the valley in the creek bed occur the *Restio* and *Hypolaena* associates.

Plate xvii.

1. The *Poa-Hypolaena* ecotone developing into the *Epacris* associates. Plants of *Epacris paludosa* are scattered through the *Poa*. A plant of *Callistemon Sieberi* is seen in the foreground.

2. Summit of a ridge in the slate area at the summit of the Plateau, occupied by the *Epacris petrophila* consociation. The area is seen to have the characteristic physiognomy of fell-field, the plants being scattered openly among the projecting edges of the folded slate strata.

Plate xviii.

1. A portion of the *Eucalyptus coriacea* consociation at 5,200 feet, in which the trunks of the trees have been killed by fire. Regeneration is seen to be taking place from the rootstocks.

2. The *Poa-Celmisia* association above 7,000 feet. The *Celmisia*, in flower, is seen to alternate with the much more sombre-coloured *Poa* consociation. The characteristic patchwork effect of the alternation of these two communities is seen on the distant hills.

3. A view of the alpine region from Mount Kosciusko, 7,328 feet. The patchwork effect of the *Poa* and *Celmisia* consociations is again seen covering the distant hills.

Plate xix.

1. *Podocarpus alpina* in the shelter of a granite boulder, 7,000 feet. Under the rock on the right is the habitat of *Polystichum aculeatum*, the only fern occurring in the alpine region.

2. Scene at 6,000 feet showing a few isolated, gnarled and stunted trees of *Eucalyptus coriacea* in the foreground, surrounded by a dense society of *Prostanthera cuneata* mixed with *Phebalium ovatifolium*. Forest clothes the lower ridges on the left, but the others are practically above the tree-line. Water is seen lying in a marsh on the flat ground to the left.

3. The *Celmisia* consociation at 7,000 feet, with dense societies of *Euphrasia Brownii*, all the plants being in flower.

[The following names on the text-figures, submitted incorrectly, were not noticed until the blocks had been made. Text-fig. 2, *Stellaria*; Text-fig. 3, *Baeckea*; Text-fig. 4, *Baeckea* and *Craspedia Richea*; Text-fig. 5, *Baeckea* and R = *Restio australis*; Text-fig. 6, *Baeckea*; Text-fig. 7, *Baeckea* and *Craspedia Richea*.—Ed.]

AUSTRALIAN COLEOPTERA: NOTES AND NEW SPECIES. No. v.

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

(Six Text-figures.)

[Read 27th July, 1927.]

BUPRESTIDAE.

Mons. Théry has lately published (*Ann. et Bull. Soc. Ent. Belg.*, 1926) a notable contribution to our knowledge of the *Chalcophorini*, that includes the useful, but sometimes provocative, task of research on synonyms. With some diffidence I suggest the following notes on the Australian species of *Cyphogastra* known to me.

According to Théry both *C. venerea* Thoms. and *C. macfarlani* Waterh. are a subspecies of *C. farinosa* F., *macfarlani* being considered as a variety of Thomson's species. I find the limit of the term subspecies difficult to define, but the term is a convenient one as usually applied to a clear geographical race, that the student of evolution believes to show the origin of a distinct species. With this understanding both *venerea* and *macfarlani* seem to me to deserve equal rank, at least as subspecies. *Macfarlani*, besides having the extra lateral pubescent impression (entirely wanting in *venerea*) differs (at least in my specimens) in the outline of the upper surface as viewed sideways; *venerea* being reflexed at apex, while the outline of *macfarlani* appears flat, or even deflexed at apex.

C. vulnerata Théry.—Théry now considers this as a subspecies of *C. pistor* L. and G., but I would claim specific rank for this species, that is, if I correctly identified it from description when I figured it (These PROCEEDINGS, 1921, p. 305) alongside *C. browni* Cart. Thus from *C. pistor* it differs as follows:

A. By markings—lateral sulcus continuous from near shoulder to near apex; two basal marks elongate instead of round; two premedial marks, linear in *vulnerata*, oval in *pistor*. B. Apices of elytra *much* more strongly spinose. C. The outline (as viewed sideways) convex, the highest point at basal third, the outline descending lightly to front, more strongly to apex (in *pistor* horizontal with a slight preapical concavity). D. Form of prothorax—nearly straight in *vulnerata*, more arcuate in *pistor*. Of the above C appears of the greatest value.

C. browni Cart.—I consider this at least of sub-specific value, the several examples captured by Mr. Brown showing the constant differences from *pistor* that were stated in my description. I would reserve the term *variety* for those examples that show more superficial differences, chiefly of colour and size, so well known in the genus *Stigmodera*, and are generally without any zoo-geographical significance.

Cisseis viridipurpurea Cart.—I took a number of this species on the Geraldton wax plants (*Chamaclaucium uncinatum*) at Geraldton in September, 1926, the described type was a ♂, in the ♀ specimens (not described) the head and pronotum are concolorous with the elytra.

CHRYSOBOTHRIS.

In my revision of this genus (These PROCEEDINGS, 1925, p. 227) I quoted Mr. J. Clark as to their habit of frequenting Acacias. Mr. T. G. Sloane has lately supplied me with the following field notes on this subject that are characteristic of this accurate observer, in reference to specimens of *C. mastersi* MacI. taken recently at Moorilla, near Young, N.S.W.

"I took over a dozen during a week in February in blazing hot weather. I got all the specimens in the bright sunshine from 11 a.m. to 2 p.m. on a large fallen limb of *Eucalyptus albens*. The *Chrysobothris* was running on the rough bark of the fallen branch (had nothing to do with the leaves) and I believe lays its eggs in crevices of the bark. The *Anilara* (*A. anthaxoides* Théry) was in the same place on the same limb and with the same habits".

The following notes on what is probably the same *Chrysobothris* were made at Mulwala (Murray River):

(1) December 17, 1880.—"Saw the first 6-spot Buprestis of the season on a fallen bough (*Eucalyptus meliodora*)".

(2) December 26, 1880.—"Captured 4 specimens of the 6-spot Buprestis on a fallen limb of a yellow boxtree (*E. meliodora*). A very hot day, wind from N.W.; thermometer 106° in the verandah".

(3) January 23, 1887.—"A bush fire has been burning since the 19th; at some green trees (*E. meliodora* or *E. hemiphloia*) that were burned down I took 3 dozen specimens of the 6-spot Buprestis; also 5 dozen specimens of *Merimna atrata*. One I watched caught and devoured a small buprest (*Anilara* sp.)".

Mr. Sloane further notes in his letter, "wattles were plentiful at Mulwala and I never saw the local *Chrysobothris* on or about them".

STIGMODERA (THEMOGNATHA) DUCALIS, n. sp. (Text-figure 1.)

♂. Elongate oblong ovate, head and pronotum nitid black (the latter with bluish gleams at sides), elytra orange red, with narrow basal margin, the suture narrowly, a large oval or oblong spot behind scutellum, sometimes with an extension to the scutellum, two oblique linear humeral marks, a wide postmedian fascia extending over about three-quarters of the width, black or blue black, the apex narrowly blue black; underside and legs mostly dark bronze or greenish bronze, the apical segments of abdomen more or less red.

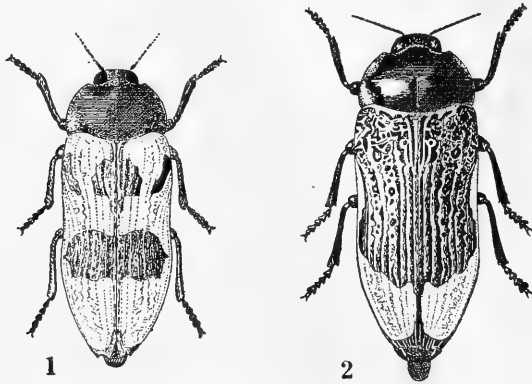
Head closely, regularly, not coarsely, punctate, front lightly channelled between the eyes.

Prothorax (13 × 9.5 mm.), lightly convex, apex and base bisinuate, sides moderately and regularly rounded, with narrow coarsely punctate lateral explanation, all angles acutely produced, disc with fine shallow punctures, becoming coarse and rugose at sides, basal half with a finely cut, shallow, medial sulcus. *Scutellum* transversely oval and convex, nitid and impunctate. *Elytra* of same width as prothorax at base, soon widening behind shoulder, lightly compressed at middle and feebly widening on posterior third, apices each bidentate (the sutural tooth the longer) with a wide truncature between the teeth, elytra slightly dehiscent at apex, striate, each with ten striae besides a short scutellary stria, the fifth interval irregularly rugose-punctate, lateral intervals each with a single row of fine punctures, the medial intervals scarcely, or very sparsely, punctate. *Underside* closely and strongly punctate, the sternal regions rather densely clothed with long silvery hair; abdomen glabrous and less strongly punctate; apical segment arcuately excised.

♀. In the two examples examined, the underside is entirely dark bronze, except for a little red near the lateral edges of the three apical segments, while the abdomen is extended considerably beyond the elytral apex, with a protruding ovipositor. In one example the oblique humeral marks form a narrow lunate fascia, connected with the hind edge of the post-scutellary patch. *Dimensions*: ♂, 27.40 × 10.5-15 mm.; ♀, 44.48 × 15-17 mm.

Habitat.—Western Australia, Zanthus (Transcontinental Railway).

Five examples examined, the first of which was sent for description by Mr. F. E. Wilson. It cannot, I think, be confused with recorded species, and should be placed near *S. spencei* L. and G. in my tabulation. The form, sculpture and nitid surface of the pronotum is somewhat as in *S. oleata* Blkb., but it is less widely rounded, less convex, with a more explanate lateral margin. Holotype ♂ in Coll. Wilson. Allotype ♀ and paratype ♂ in National Museum, Melbourne. Paratypes ♂ and ♀ in Coll. Carter.



Text-figure 1. *Stigmodera ducalis*, n. sp.

Text-figure 2. *Stigmodera miranda*, n. sp.

Drawings by C. Deane.

STIGMODERA (THEMOGNATHA) MIRANDA, n. sp. (Text-figure 2.)

♂. Oblong, lightly attenuated in front and behind, very nitid; head, pronotum and basal three-quarters of elytra dark blue, subapical fourth and margins (widely extending to a humero-basal spot) sanguineous, suture and extreme apex narrowly blue; beneath rather brilliant bronze, sometimes with greenish tinge, flanks of prosternum cyaneous, apical segments of abdomen more or less sanguineous; sternal area (especially prosternum) rather densely clothed with long, upright, silvery hair.

Head, having a light smooth impressed line between eyes, front feebly concave, moderately punctate and rather strongly pubescent. *Prothorax* wide and subexplanate, lightly convex, apex and base bisinuate, anterior angles obtuse, posterior subrectangular, widest behind middle, hinder part of sides parallel, thence arcuately narrowed to apex, disc with finer punctures than with its allies, these interspersed with fine vermiculate smooth spaces; punctures and vermiculations becoming stronger towards lateral margins; a smooth impressed medial line on basal half. *Scutellum* subcircular, nitid and impunctate. *Elytra* as wide as prothorax at base, soon widening and strongly sinuate before middle, rather widely rounded behind, each apex widely truncate between two short teeth,

margins entire; striate, intervals strongly convex, the sixth broken up into irregular ridges and punctures as also the basal parts of the second and fourth; intervals (chiefly the lateral) with a few small punctures. *Underside*: The pro- and meta-sternal punctures largely concealed by hair, but evidently not coarse, abdomen densely covered with moderate sized punctures and a little strigose; apical segment arcuately excised.

♀ differs in its larger size, less amount of red on apical segments (here only showing at sides), apical segment of abdomen elongate and rounded behind (with projecting sternite), more brilliantly nitid and much less hirsute beneath. *Dimensions*: ♂, 40-42 × 15-16 mm.; ♀, 46-50 × 17-19 mm.

Habitat.—Western Australia; Zanthus (National Museum presented by Mr. J. Lambe and Coll. Carter from R. Halse). Five examples before me, 3 ♂♂, 2 ♀♀, of which four are from the National Museum. Holotype ♂ and allotype ♀ in the National Museum, Melbourne. I am indebted to Mr. Cedric Deane, C.E., of Melbourne, for the excellent figures of *S. ducalis* and *S. miranda*. A magnificent species that can be distinguished from its allies by the following table.

Stigmodera (*Themognatha*), colour largely black, or very dark blue, with sanguineous markings.

- | | |
|---|---------------------------|
| 1. Sides of elytra almost straight, margins of pronotum in general (in five out of six examples before me) narrowly red | <i>rectipennis</i> Blkb. |
| Sides of elytra clearly sinuate, pronotum without red margins | 2 |
| 2. Apices simply rounded, intervals regular throughout, colour largely black | <i>princeps</i> Blkb. |
| | |
| Apices not simple, sixth interval (besides others at base of elytra) irregular, colour blue | 3 |
| 3. Pronotum strongly punctate (rugose at sides) with a faint smooth medial line, underside cyaneous | <i>bonvouloiri</i> Saund. |
| Pronotum finely punctate, with impressed medial channel on basal half, underside aeneous, apical segments red | <i>miranda</i> , n. sp. |

* In *bonvouloiri* the pattern of the upper surface is variable, from that portrayed in Saunders's figure to examples in which the elytra are mostly blue with a greenish tinge, the apex only red.

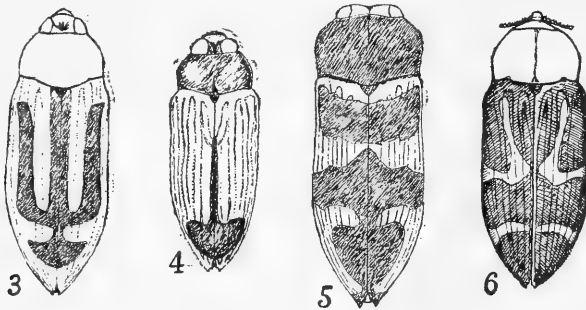
STIGMODERA (CASTLARINA) DEUQUETI, n. sp. (Text-figure 3.)

Oblong, moderately attenuated in front and behind; head, pronotum and scutellum golden bronze, underside golden green, antennae and legs green, tarsi blue, elytra yellow with the following markings bright green, basal border and extreme apex (both narrowly), an elongate, 3-pronged fork-like mark, the outside prongs forming elongate vittae terminating at the humeral callus, the middle prong covering the suture to the base, a sagittate subapical mark connected narrowly at suture with the base of the fork.

Head excavate and canaliculate, moderately punctate. *Prothorax* widest near base, thence subparallel to base and arcuately narrowing to apex, lightly convex, apex feebly, base more strongly bisinuate, anterior angles subacute, posterior subrectangular, disc without defined medial line (except a short, smooth area), a medio-basal and two large latero-basal foveae; surface punctures defined and distant on basal half, closer and finer towards apex, strong and close at sides. *Scutellum* triangular, almost impunctate. *Elytra* of same width as prothorax at base, widening at the humeral swelling, slightly compressed behind this, apices finely bispinose each with a short, oblique lunation, subapical margins entire; striate-punctate, the seriate punctures close, intervals impunctate, the third and fifth roundly convex, the rest flat except at apex. *Underside* very lightly pubescent, finely and evenly punctate. *Dimensions*: 12 × 5 mm.

Habitat.—New South Wales, Armidale (Mr. C. F. Deuquet).

I name this brilliant species after its discoverer, who has generously given a pair to me and the holotype ♂ to the Australian Museum. The elytral pattern is constant (Mr. Deuquet has several other examples), and is near that of the *tricolor* Kirby group, though not quite like any species known to me. The ground colour is that of *confusa* Waterh., in which the pronotum is described as "globose" and the subapical margins serrate, also with a different elytral pattern. This last must be very near that of *S. clancula* Obenb., but in this species the head, prothorax and elytral pattern are blackish ("*schwärzlich*"), the underside is bronze, little shining ("*wenig glänzend*"), the elytra appears to differ in form from *deuqueti*, each with a single tooth at apex, and the habitat is given as Queensland. Holotype ♂ in the Australian Museum.



Text-figure 3. *Stigmodera deuqueti*, n. sp.

Text-figure 4. *Stigmodera fossoria*, n. sp.

Text-figure 5. *Stigmodera dilatata*, n. sp.

Text-figure 6. *Stigmodera flavo-viridis*, n. sp.

STIGMODERA (CASTIARINA) FOSSORIA, n. sp. (Text-figure 4.)

Narrowly oblong; head, pronotum, scutellum, elytral markings, underside and appendages dark green; elytra testaceous, with a wide, sagittate subapical mark, the apical three-fourths of the suture, and the extreme apical margin (very narrowly) dark green, the latero-apical margins slightly tinged with red.

Head deeply channelled and excavate, more brightly metallic than pronotum. *Prothorax* rather strongly convex, apex sub-truncate, base strongly bisinuate, widest at middle, sides well rounded, all angles, seen from above, obtuse; disc uniformly and closely punctate, medial sulcus distinct on basal half (traceable throughout in one example). *Elytra* as wide as prothorax at base, soon widening, the sides nearly straight for the greater part, feebly compressed behind shoulders, striate-punctate, intervals minutely punctate, the short scutellary interval, the third, fifth and seventh more strongly convex, wider and less punctate than the alternate intervals; each apex finely lunate and shortly bispinose, latero-apical margins very minutely serrulate. *Underside* with fine, sparse, recumbent pile; prosternum strongly, metasternum moderately, abdomen minutely, punctate. *Dimensions*: 9-10 × 3.2-3.5 mm.

Habitat: Victoria: Loch (A. H. Westley) in Coll. Wilson.

Two examples (? ♂♂) sent by Mr. F. E. Wilson are, I believe, clearly distinct from any described species. Of the form of *S. titania* Cart., and *S. nanula* Kerr., by its elytral pattern it would be placed near *S. horni* Kerr. (*unimaculata* Cart.) in my tabulation; though this is much larger and different in other characters. It is

narrower and more elongate than *S. balteata* Saund. The name *fossoria* (a digger) is suggested by the spade-like marking of the elytra. Holotype (? ♂) in Coll. Wilson.

STIGMODERA (CASTIARINA) DILATATA, n. sp. (Text-figure 5.)

Subcylindric; head and pronotum blue-black, scutellum violet, underside blue, elytra red with the following markings blue; narrow basal border, wide premedial fascia extended laterally forward but not reaching margins, an irregular post-medial fascia, widened on suture, not connected with the former but connected along suture with large, sagittate, apical mark, the point of the arrow blunted and widened at extreme apex. *Head* deeply excavate and channelled between eyes, strongly and closely punctate. *Prothorax* very convex, widest in front of middle, apex advanced in middle and at sides, base bisinuate, sides widely rounded and strongly dilated anteriorly; front angles obtuse, hind acute; disc with clear, round punctures, fine and close anteriorly, larger and more distant behind, slightly rugose at sides, medial line finely indicated throughout, medio-basal fovea indistinct. *Scutellum* concave and laevigate. *Elytra* as wide as prothorax at base, sides nearly straight, apices with oblique excision not, or scarcely, bispinose, subapical margins entire; striate-punctate, the seriate punctures small and almost hidden in striae, intervals flat (except towards apex) and finely but clearly punctate; underside closely punctate, with sparse, short pubescence. *Dimensions*: 12.12.5 × 4 mm.

Habitat.—Western Australia; Wembley Park (Mr. H. W. Brown).

Another of this keen collector's discoveries, of which he has kindly sent three examples. While allied to *S. trifasciata* Saund., and *S. recta* in form and elytral pattern it differs from all of this group in the unusual form of the prothorax, which is widely dilated in front of the middle, besides showing colour differences from the above-mentioned.

Holotype (? ♀) in Coll. Carter.

STIGMODERA (CASTIARINA) FLAVO-VIRIDIS, n. sp. (Text-figure 6.)

Oblong ovate; head, pronotum, underside, antennae and femora metallic green, elytra chiefly green, with the following markings yellow; a small latero-humeral spot, a narrow, straight vitta outside the third interval, extending from behind the base to the middle, here joining a narrow, straight fascia extending to (and slightly widening at) the sides, and a short narrow, undulate fascia at the apical fourth, this widely interrupted at the suture and sometimes (in four out of eight examples) extending to the sides; tibiae and tarsi blue.

Head channelled and widely excavated, closely but not uniformly punctate. *Prothorax* rather strongly convex, widest at middle, apex sub-truncate, base bisinuate, sides well rounded, arcuately narrowed in front, anterior angles obtuse, scarcely sinuate behind, posterior angles acute; disc densely punctate, the punctures becoming coarser, with rugose surface at sides; a finely cut medial sulcus throughout, terminating in a basal fovea. *Scutellum* subcordate, concave and punctate. *Elytra* sinuate at sides, slightly widest behind middle, their apical region finely serrulate, apex with a defined lunation, each apex finely bispinose, sutural spine very short; striate, both intervals and striae alike closely covered with punctures (of which no defined series is traceable), these becoming coarser, with transverse rugosity, towards the sides; intervals convex, the third interval strongly, the fifth less strongly so, these two wider and more raised than the rest.

Prosternum rather coarsely, the rest of underside more finely punctate; abdomen with thin clothing of recumbent, whitish hair. *Dimensions*: 10-12 × 4-4.5 mm.

Habitat.—New South Wales: Mt. Kosciusko (Professor L. Harrison and the author). Eight examples before me, seven taken by Professor Harrison in February, 1927, on dwarf flowers (*Cassinia*, sp.), one taken by myself in February, 1926. Either all the examples are ♀♀ or there is no sexual dimorphism of the abdominal segments. The only slight colour variation is a tendency for green parts to become blue in three examples (a common form of colour variation in Buprestidae). In one example the elytra show purple patches. The species is structurally allied to the *S. sexplagiata* L. and G. and *S. kershawi* Cart., group, in which one or two elytral intervals are more convex than the rest, though it is more robust and parallel than these two. By colour it stands near *S. wilsoni* Saund., and *S. flavo-picta* Boisd., the yellow markings being much narrower than in typical examples of these species. Some Tasmanian examples of *S. flavo-picta* Boisd., come rather close to it in colour, but are readily differentiated by the more slender and sinuate form and the much finer elytral sculpture. *S. dimidiata* Cart., is without any longitudinal vitta, besides having a less strongly sculptured upper surface. Holotype, sex doubtful, in Coll. Carter.

NEOSPADES NIVEO-SPARSA, n. sp.

♂. Oblong, attenuate behind, head coppery violet, pronotum dark bronze, elytra bronze-brown irregularly marked with small spots of white pubescence, underside metallic with a purple tinge, legs greenish, tarsi red, antennae coppery.

Head strongly, rather closely punctate, forehead with a medial carina, eyes prominent (extending beyond the lateral border of pronotum). *Prothorax*: apex subtruncate, base bisinuate, sides arcuately narrowed from base to apex, lateral carinae diverging towards the front, the upper continuous throughout; two large foveae on each side of middle and a pubescent depression above, and following the line of, the upper lateral carina; disc transversely striolate, rugose punctate at sides. *Scutellum* transversely ovate, with some 8-10 large punctures. *Elytra* subparallel for two-thirds of length, thence obliquely narrowed, apices separately rounded, and fringed with bristly spinules; scalose punctate, the pubescent spots more evident along suture and sides; segments of abdomen with pubescent patches at sides; sternal regions and legs also finely pubescent; external margins of hind tibiae with three elevations each bearing a pencil of spinules near the apex. *Dimensions*: 11 × 4 (+) mm.

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

I am indebted to the above young naturalist for the capture of this distinct species. It should stand near *N. gouldi* Hope in my table (These PROCEEDINGS, 1923, p. 172), from which it is abundantly distinguished by size, form and colour. The outline is somewhat like that of *Cisseis careniceps* as depicted in Fig. 8, p. 169 of my Revision (These PROCEEDINGS, 1923). The tibial elevations are very much as in *N. lateralis* Blkb., except that the third (nearest apex) is continuous between the second and the apex, whereas the first and second are isolated humps. Holotype (sex doubtful) in Coll. Carter.

NEOSPADES CUPRICAUDA, n. sp.

♂. Elongate oblong, head and pronotum golden green or fiery coppery; elytra more or less violaceous or cyaneous, with coppery chiefly at base, sides and apex—the limits of these colours variable and vague—with four pubescent spots towards

apex in an arcuate row, one on each side about half-way, and a few others irregularly dispersed; sternal regions and legs generally greenish, abdomen fiery copper.

Head rather strongly grooved between the eyes, regularly and strongly punctate (less densely than in *N. lateralis* Blkb.). *Prothorax*: apex and base bisinuate, sides nearly parallel on basal half, arcuately narrowed in front, posterior angles subrectangular, the lateral carinae meeting near these angles, parallel for the greater part, slightly diverging at front; disc with moderately light, shallow punctures, with only a slight tendency to transverse strigosity at sides, depressed on each side towards base. *Scutellum* very transverse, with a few large punctures. *Elytra* of same width as prothorax at base, lightly compressed behind shoulders, subapical margins finely serrulate; surface finely scalose punctate; prosternum densely and deeply punctured, metasternum and basal segment of abdomen moderately punctate, the remaining segments finely and much more sparsely so.

♀. Differs in larger size and more obscure colour; the head, pronotum and the whole underside (including legs) being dark copper bronze, elytra largely cyaneous bronze at base and sides, generally coppery at extreme apex. *Dimensions*: 7.9 × 2.5-3 mm.

Habitat.—Northern Territory: King River (Sir Baldwin Spencer).

Mr. J. A. Kershaw has sent twenty-eight (19 ♂♂, 9 ♀♀) of this species from the National Museum for determination. It is in size and colour intermediate between *N. chrysopygia* Germ., and *N. lateralis* Blkb., the colour definition being less regular than in either; but it differs strongly from both in the finer sculpture of both pronotum and elytra—the former having little transverse rugosity, the latter a much less deeply impressed surface. The pronotal structure is also intermediate—less convex than with *lateralis*; more convex with sides less explanate than with *chrysopygia*. The pronounced sexual colouration may be noted as a further distinction.

Holotype ♂ and allotype ♀ in National Museum, Melbourne.

CISSEIS SUB-BIFASCIALIS, n. sp.

Oblong, little attenuate behind; head coppery, pronotum greenish bronze with white pubescence; elytra blue with a preapical fascia and a half-formed post-medial fascia of white pubescence; underside coppery bronze, abdomen with lateral patches of pubescence, appendages coppery.

Head densely punctate, with well defined medial depression, eyes not prominent, head (including eyes) not wider than apex of prothorax. *Prothorax*: apex and base bisinuate, sides nearly straight, feebly widened near base, here both lateral carinae visible from above, these sub-parallel, rather close and continuous to apex; disc largely covered with silvery pubescence, leaving the medial and apical area bare, with fine striolate-punctate surface. *Elytra* oblong, lightly enlarged at shoulders, and compressed at middle, apices widely and separately rounded and minutely spinuled at margins; disc scalose-punctate, sparsely pubescent near base besides on the fasciae, the post-medial fascia represented only near sides, extending thence about one-third of the way across, the preapical fascia uninterrupted; underside finely and closely punctate. *Dimensions*: 6 × 2 mm.

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

Another of Mr. Armstrong's discoveries shows a species that resembles in colour and clothing the well-known *Hypocisseis suturalis* Saund., but differs from

that species in its narrow, sub-parallel form and the structure of the head and prothorax, the head being of the normal *Cisseis* type. It belongs to my Section II, Group B. Holotype (sex ?) in Coll. Carter.

TENEBRIONIDAE.

Pezohelaeus denticollis Cart. Mr. Hacker has lately taken this on Tambourine Mountain, Queensland, and sent it to me for determination. Like the unique type (in the Melbourne Museum) it is a ♂. I now think it possible that this is the male form of *P. hirtus* Macl., of which I only know the female. The two appear identical in form and sculpture, differing markedly in the anterior angles of the prothorax—strongly dentate in *denticollis*—rounded with a slight posterior sinuation in *hirtus*. *Pezohelaeus* should, I think, rank as a subgenus of *Pterohelaeus*, distinguished only by its enlarged tarsi. The sexual character suggested above has its analogy in *Anausis metallescens* Westw. (see These PROCEEDINGS, 1913, p. 71) though absent from the eighty-two known species of *Pterohelaeus*. *P. hirtus* Macl., is rare in eastern New South Wales—Strathfield (H. Cox), Kandos (T. G. Sloane), Gingken (R. B. Carter) being localities recorded by me.

Pterohelaeus guerini Br. = *P. bullatus* Pasc. = *P. ventralis* Blkb. = ? *P. regularis* Blkb. = *P. puer* Blkb.

Having collected long series from New South Wales, Queensland, N.W. Victoria and various parts of Western Australia, I am now convinced of the above synonymy. Champion recorded *P. bullatus* Pasc., from Fremantle, W.A., when describing the Australian collections of Commander J. J. Walker, M.A., R.N. (*Trans. Ent. Soc. London*, 1894, p. 383). I have seen the type of *P. regularis* in the British Museum and a cotype in the South Australian Museum of which my notes say, "very doubtfully distinct from *bullatus*—a common species in the Narrabri district of New South Wales". A cotype of *P. puer* has recently been sent for examination from the South Australian Museum.

LICINOMA.

Since publishing my tabulation of this genus (These PROCEEDINGS, 1920, p. 243) I have added eight new names. I therefore append a revised tabulation.

Licinoma.

| | |
|--|------------------------------|
| 1. Elytra seriate- or striate-punctate | 2 |
| Elytra striate or sulcate only | 22 |
| 2. Elytral intervals of uniform width | 3 |
| Elytral intervals not of uniform width | 19 |
| 3. Elytral intervals flat | 4 |
| Elytral intervals convex | 11 |
| 4. Elytral intervals clearly punctate | 5 |
| Elytral intervals impunctate | 8 |
| 5. Prothorax transverse, sides well rounded | 6 |
| Prothorax as long as wide, sides nearly straight | 7 |
| 6. Pronotum more or less channelled | <i>subcanaliculata</i> Cart. |
| Pronotum not channelled | <i>nitida</i> Pasc. |
| 7. Elytral intervals nodulose | <i>nodulosa</i> Champ. |
| Elytral intervals not nodulose | <i>tasmanica</i> Champ. |
| 8. Elytral intervals nodulose | <i>umbilicata</i> Cart. |
| Elytral intervals not nodulose | 9 |
| 9. Legs dark | 10 |
| Legs testaceous | <i>pallipes</i> Blkb. |

| | | |
|-----|---|----------------------------|
| 10. | Hind angles of pronotum rectangular | <i>nitidissima</i> Lea |
| | Hind angles of pronotum obtuse | <i>planata</i> Cart. |
| 11. | Elytra blue | 12 |
| | Elytra black or bronze | 13 |
| 12. | Pronotum coppery without medial channel | <i>splendens</i> Cart. |
| | Pronotum blue with medial channel | <i>coerulea</i> Cart. |
| 13. | Prothorax transverse | 14 |
| | Prothorax longer than wide | <i>meridiana</i> Cart. |
| 14. | Prothorax widest at middle | 15 |
| | Prothorax widest in front of middle | 17 |
| 15. | Pronotum subcircular and sublaevigate | <i>cyclocollis</i> Cart. |
| | Pronotum not subcircular, clearly punctate | 16 |
| 16. | Elytral intervals narrow and punctate | <i>elata</i> Pasc. |
| | Elytral intervals wide and striolate only | <i>gilesi</i> Cart. |
| 17. | Pronotum with medial channel | <i>truncata</i> Cart. |
| | Pronotum without medial channel | 18 |
| 18. | Head and pronotum strongly punctate | <i>monticola</i> Blkb. |
| | Head and pronotum very finely punctate | <i>apasioides</i> Cart. |
| 19. | Elytral intervals flat | 20 |
| | Elytral intervals convex | <i>aerea</i> Cart. |
| 20. | Head and pronotum coarsely punctate | <i>puncticeps</i> Cart. |
| | Head and pronotum very finely punctate | 21 |
| 21. | Elytral intervals impunctate and non-setose | <i>sylvicola</i> Blkb. |
| | Elytral intervals punctate (third and fifth setose) | <i>commoda</i> Pasc. |
| 22. | Elytral intervals of uniform width | 23 |
| | Elytral intervals not of uniform width | <i>ilidgei</i> Cart. |
| 23. | Colour violet-bronze, pronotum with medial channel | <i>angusticollis</i> Cart. |
| | Colour black, pronotum without medial channel | <i>major</i> Cart. |

ENHYPNON PUNCTATUM, n. sp.

Obovate, very convex, opaque brown, antennae, tibiae and tarsi red, clothed extensively with rough hairy derm, becoming bristles on the legs.

Head less wide in proportion to pronotum than in *E. laticeps* but similar in form; eyes prominent, antennae, first segment very stout, 2 elongate subconic, 3 shorter and narrower than 2, 3-9 subconic, gradually increasing in width, 10-11 clavate, 11th elongate ovate, twice as long as 10. *Prothorax* very convex, base truncate, apex with bilobed process overhanging the head, widely excised between these lobes, sides involute, margins unseen from above, disc with two well raised ridges (forming an extension of the apical lobes), occupying a great part of surface; basal third and sides covered with small tubercles, the ridges with felt-like clothing. *Elytra* of same width as prothorax at base, humeri obtuse, the outline subhexagonally obovate, widening at first obliquely, then angulately subhorizontal, then angulately narrowing towards apex; surface nodulose with two elongate ridges, one on each side of scutellum, extending from the base a short distance, two blunt tubercles behind each of these *en echelon*, four smaller tubercles in a transverse line near middle, a third group of about six tubercles on apical declivity and smaller ones behind these near apex. The area unoccupied by tubercles with regular series of large round punctures, the two sutural rows uninterrupted. *Dimensions*: 5 (vix) × 2 (+) mm.

Habitat.—Tasmania: Mount Wellington (H. H. D. Griffith).

A specimen, labelled as above, has been kindly sent me by Mr. A. H. Elston. It is much larger, with more pronounced excrescences, than *E. laticeps* Cart., the only other member of the genus, and is easily distinguished by the large seriate punctures of the elytra, which are either nonexistent or covered by derm in *laticeps*. It is doubtless one of the moss-dwelling Coleoptera that are so numerous and interesting in the mountain fauna of Tasmania. Holotype in Coll. Carter.

NYCTOZOILUS TAYLORI, n. sp.

Oval, convex, subnitid black, glabrous.

Head densely, finely punctate; antennae with 3 longer than 4-5 combined, 8-10 round, successively diminishing in size, 11 pyriform. *Prothorax*, 5×8.5 , very convex, apex arcuate-emarginate, base nearly straight except for produced angles. Sides widely and evenly rounded, anterior angles subacute (slightly blunted at tips), border with widely rounded reflexed rib, a deep and rather wide convexity between border and disc, hind angles clearly dentate, pointing backwards; disc with indications of medial channel, a foveate depression at middle near base, whole surface with close, fine, shallow punctures. *Scutellum* very transverse. *Elytra* widely ovate, each with three nitid, undulate costae, the first two connected near apex, the intervals irregularly subfoveate with ill-defined reticulations, becoming obsolete at sides and apex. *Prosternum* minutely striolate, abdominal apical segments minutely punctate. *Dimensions*: 19×11 mm.

Habitat.—Queensland: Townsville (Mr. F. H. Taylor).

A single ♀ example kindly sent by Mr. Taylor, entomologist of the Institute of Tropical Medicine. It is nearest to *N. carlovillensis* Cart., but differs in larger size, more nitid surface, more convex pronotum, with wider ribbed border, elytral reticulation less elevated and defined. Holotype in Coll. Carter.

CAMPOLENE CYANEA, n. sp.

Oblong, oval, convex, peacock-blue, nitid, antennae and legs red, underside nitid, black, glabrous.

Head and pronotum coarsely and rather closely punctate, with a subfoveate impression in front of eyes. *Prothorax* convex, sub-gibbous at middle near apex, widest near front, base feebly bisinuate, sides nearly straight, with a narrow horizontal border. *Elytra* of same width as prothorax at base, striate-punctate, the punctures in striae larger than in *C. nitida* Pasc., intervals convex and laevigate. *Underside* even more differentiated from *C. nitida* by the coarse punctures of the prosternum and abdomen, those on the latter somewhat irregular in size and position. *Dimensions*: $7.9 \times 3.3-3.5$ mm.

Habitat.—Queensland: Dalveen (the author and R. Illidge); Stanthorpe (Mr. F. A. Perkins and L. F. Von Wiedt).

Seven specimens examined show a structure very similar to that of the well-known *C. nitida* Pasc., but differing in colour, the more gibbous pronotum, and the much stronger sculpture of the upper and lower surface. I have long had a single specimen under observation and the acquisition of further material from Stanthorpe shows constant distinction from Pascoe's species. Holotype in Coll. Carter.

Cardiothorax consimilis Cart. (1926) = *C. australis* Cart. (1906) var. With further material I do not consider that the distinction of this species from *C. australis* can be maintained. Mr. Hopson informs me that "southern plateau" meant southern highlands of New South Wales—Moruya region—so that my locality (Barrington) should be corrected.

CISTELIDAE.

I took a number of *Hemicistela testacea* Cart., by beating the flowers of *Banksia* sp., at Geraldton, Kojarena and Eradu (W.A.) in September, 1926, in company with *Amphichroum* sp. In this genus there appear to be two lamellae on each of the anterior and only one on each of the four posterior tarsi (or if

two be present on the intermediate tarsi one is so small as not to be evident with a Zeiss binocular); whereas in the majority of Australian Cistelidae the formula for such lamellae would be 2, 2, 1 as stated by me (*Proc. Roy. Soc. Vict.*, 1915, p. 52).

Allecula morio F.—Specimens of this from South France have been sent me by Mr. K. G. Blair. I find two lamellae on each of the four anterior tarsi and one on each posterior tarsus. This is inconsistent with the classification of Solier and Mulsant for this genus "one small lamella on the penultimate joint of each tarsus".

ANAXO CYLINDRICOLLIS, n. sp.

♀. Elongate, oblong, nitid, bronzy black, rather thickly pilose as to upper surface and appendages, more sparsely so below, with suberect white hair; tibiae and basal two-thirds of femora red, its apical third black; antennae opaque, appearing greyish from their white pubescent clothing; tarsi dark.

Head densely punctate, strongly pilose, eyes widely separated, antennal segment 3 longer than 4, 4-10 subequal, each slightly enlarged at apex, 11th very short and oval. *Prothorax* longer than wide, nearly cylindrical, widest near front, lightly narrowed towards base; apex subtruncate, base feebly produced in middle, lateral border and angles unseen from above; disc strongly, not very closely, punctate, a narrow medial channel on basal third and slightly flattened in this region; otherwise with strong transverse convexity; pilose at sides. *Scutellum* semicircular. *Elytra* nearly twice as wide, and two and a half times as long as prothorax, sides parallel, shoulders rather square; striate-punctate, the striae shallow, seriate punctures larger than in *A. cylindricus* Germ., intervals flat and everywhere transversely rugose; clothing subrecumbent near suture, upright at sides. *Underside* finely and sparsely punctate and pilose. *Dimensions*: 10 × 3 (+) mm.

Habitat.—Western Australia: Bridgetown (the author).

♂. Wanting. I took the unique example in August, 1926, when visiting the south-west with the members of the Australasian Association for the Advancement of Science Congress. It is clearly distinct from its nearest ally, *A. dentipes* Cart., in which the elytral intervals are almost smooth and the sternum densely pilose (almost glabrous in *cylindricollis*). *A. cylindricus* Germ., is nitid black, with a wider, less convex, and more finely sculptured prothorax, and convex elytral interstices. Holotype ♀ in Coll. Carter.

HYBRENIA ILLIDGEI, n. sp.

Elongate oblong, nitid black, body and legs sparsely (rather densely on pronotum) clothed with long, upright, black hair.

Head rather coarsely and sparsely punctate, eyes large, prominent, separated by a space of about half the diameter of one eye, antennae with third segment linear, 4-10 subtriangular and subequal, 11th ovate-acuminate. *Prothorax* rather convex, apex slightly advanced in middle, anterior angles depressed and blunt, base gently bisinuate, posterior angles sharply rectangular, sides parallel on basal half, rounded in front, disc with sparse and irregular coarse punctures, each bearing an upright hair, a wide medial depression and a round foveate depression near hind angles. *Scutellum* large, almost smooth, rounded behind. *Elytra* considerably wider than prothorax at base, shoulders prominent but rounded, sides parallel; striate-punctate, the punctures in striae large, square and close;

intervals rather sharply convex, the suture itself subcarinate behind a well-marked post-scutellary depression; each interval with a single line of small setiferous punctures; sterna and epipleurae coarsely punctate, abdomen much more finely so; post tarsi having first segment as long as the rest combined. *Dimensions*: 12-13 × 4-4.5 mm.

Habitat.—Queensland: Brisbane (the author), Queensland National Park (Mr. A. Musgrave). ♂ latet.

Two female examples examined show a rather narrow, parallel species with the general facies of *H. angustata* Macl., but easily distinguished from this and other species having convex elytral intervals by the combination of nitid and strongly pilose surface, sparsely and coarsely punctate pronotum, the elytral seriate punctures of the same average size as in *H. angustata* Macl.* From *H. pilosa* Cart., it is distinguished by its parallel form, black hairs, much more sparsely punctate pronotum and the elytral intervals without wrinkles. Holotype in Coll. Carter.

CERAMBYCIDAE.

Microtragus.—When I wrote my Revision of *Athemistus* and *Microtragus* (These PROCEEDINGS, 1926, p. 492) I was unaware of the paper by Professor Aurivillius (*Arkiv. för Zoologi*, 1917) on the Cerambycidae of the Mjöberg Expedition, a copy of which has lately come into my hands. In this paper three species of the above groups are described as new—(a) *Microtragus cristulatus*, (b) *Athemistus (Hoplathemistus) conifer* and (c) *Athemistus (Hoplathemistus) albofasciatus*—and a new subgenus created. I think *M. cristulatus* is one of the many varieties (var. *sticticus* Pasc.) of *M. arachne* Pasc. almost black, that were amongst those that I examined from the National Museum. The proposed new subgenus *Hoplathemistus* would appear to include my group B of *Microtragus*, if the antennal sockets are approximate. Unfortunately Professor Aurivillius makes no mention of this important character, which together with the presence of the humeral spines I take to be the main distinction of *Microtragus* from *Athemistus*. If this conjecture be correct my *M. echinatus* may be synonymous with *A. (Hoplathemistus) conifer* Auriv. The affinities of *Hoplathemistus* are, I think, with *Microtragus*, of which it is a subgenus, rather than with *Athemistus*.

* In *H. angustata* Macl., the medial striae are almost impunctate, while the lateral striae contain very large punctures: the surface is glabrous.

THE GASTEROMYCETES OF AUSTRALASIA.

vii. THE GENERA DISCISEDA AND ABSTOMA.

By G. H. CUNNINGHAM, Government Mycologist, Department of Agriculture,
Wellington, N.Z.

(Plates xx-xxii.)

[Read 29th June, 1927.]

In 1892 Morgan separated from *Bovista* species possessing a capillitium of free, short, simple fragments of hyphae and placed them in a genus he named *Catastoma*. In the type species of this genus, he noted that the stoma was at the base of the plant, and made this one of the chief characters of the genus. Since the publication of this paper many species have been recognized, and it is now known that the position of the stoma is of no generic value, for it may be apical or basal.

The genus was separated many years previously by Czernaiaiev (1845), who named it *Disciseda*, but his paper was overlooked until Hollos (1902), from a perusal of Morgan's paper was able to recognize the fact that *Catastoma* was the same as *Disciseda*. Lloyd in his publications has taken exception to the use of *Disciseda*, and throughout uses *Catastoma*, a name which is untenable according to the Rules of Nomenclature.

The species are all similar externally, and in consequence difficult of delimitation. This difficulty has been increased because many species have been named and imperfectly described from single specimens.

Lloyd (*Myc. Notes*, 1922, p. 1167) groups the species according to the colour of the gleba, but this is impracticable since in many the colour is not constant, different plants in the same collection, agreeing in all other respects, possessing an olivaceous, umber or purplish gleba (*D. candida*, *D. cervina* and *D. hyalothrix*).

After extended examination of the collections enumerated in this paper, the writer is of the opinion that two groups of characters alone, those of stoma and spores, may be used for the separation of the species.

The stoma may be a simple, plane, poorly defined aperture (*D. pedicellata*, *D. hyalothrix*); or may be conspicuous, mammose and fimbriate (*D. cervina*, *D. hypogaea*); lacerate and toothed (*D. verrucosa*); or definitely tubular and surrounded by a depressed groove (*D. anomala* and *D. australis*). As in old and weathered specimens these characters may be obliterated, the spore characters, which do not change with age, will be found to be more definite and accurate. The genus may in this manner be divided into pedicellate and apedicellate sections; and further separation may be effected according to the nature and to the degree of roughness of the spore-markings (see key).

Abstoma is separated because of the absence of a definite stoma, dehiscence being effected by the irregular rupture of the peridium. One other character of

interest in this genus is the fact that in the two species known, the spores are strongly reticulate.

Members of both genera consist of a peridium enclosing the gleba. The peridium consists of the usual two layers, exoperidium and endoperidium. The exoperidium is in most species in the nature of a membrane composed of hyphae and sand grains or vegetable debris immixed, forming a firm but brittle structure which may attain a thickness of 2-3 mm. or more. As the plant matures this usually fragments and falls away, save for a persistent discoid or cupulate basal portion. In some species the exoperidium is membranous.

The endoperidium is membranous or papyraceous, tough and usually polished, though in one or two species it is furfuraceous. It is perforated with a solitary apical or basal stoma. In one or two species a third delicate gelatinous and reticulate membrane is sometimes present lying between the layers of the peridium. As it may be present or absent on different plants of the same collection, it cannot be considered as being of specific value.

The gleba consists of capillitium and spores. It is usually pulverulent, but is compact in *Abstoma purpureum*. The threads are usually short, 50-100 μ or more, usually coloured, simple or short-branched, straight or more frequently curved, continuous and non-pitted. The spores are continuous, coloured, pedicellate or apedicellate, variously roughened, and usually globose. No sterile base or rooting base is present.

The habit is noteworthy, most species being hypogaeal, growing solitary or in small groups in the ground, and becoming exposed as a rule only at maturity.

All descriptions are original and have been drawn up from specimens examined by the writer.

The writer is again indebted to Dr. J. B. Cleland, University, Adelaide, for the loan of all specimens in his possession.

DISCISEDA Czernaiaiev.

Bull. Soc. Imp. de Moscou, 1845, xviii, p. 153.—*Catastoma Morgan*, *Jour. Cin. Soc. Nat. Hist.*, 1892, xiv, p. 142.

Peridium depressed-globose, of two layers; an exoperidium which may be thick or thin, membranous, or compact when formed of hyphae immixed with sand particles or vegetable debris, fragile, breaking away irregularly, save a small discoid or cupulate basal portion; endoperidium papyraceous or membranous, tough, variously coloured, smooth or furfuraceous, dehiscing by a definite stoma, which may be apical or basal; sterile base absent.

Gleba pulverulent; capillitium of short, simple or short-branched, continuous, non-pitted coloured hyphae. Spores globose, coloured, variously roughened, pedicellate, apiculate or apedicellate.

Habitat:—Solitary or in small groups on or in the ground.

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

A small genus of about twelve species, eight of which occur in Australia and New Zealand.

Key to the species.

Spores long-pedicellate (10 μ or more).

- | | |
|--|----------------------------|
| Spores strongly verrucose, 8-10 μ diam. | 1. <i>D. pedicellata</i> . |
| Spores finely verrucose-areolate, 10-13 μ | 2. <i>D. hyalothrix</i> . |

Spores apedicellate (or apiculate, stumps only of the pedicels persisting).

| | | |
|---|----|-----------------------|
| Spores almost smooth | 3. | <i>D. candida</i> . |
| Spores finely verrucose. | | |
| Stoma fimbriate-mammose | 4. | <i>D. cervina</i> . |
| Stoma tubular, surrounded by a depressed groove. | | |
| Spores finely verrucose-echinulate | 5. | <i>D. anomala</i> . |
| Spores covered with fine round-topped warts | 6. | <i>D. australis</i> . |
| Spores coarsely verrucose. | | |
| Spores covered with flat-topped echinulae | 7. | <i>D. hypogaea</i> . |
| Spores covered with coarse verrucae | 8. | <i>D. verrucosa</i> . |

1. DISCISEDA PEDICELLATA (Morgan) Hollos. Plate xx, figs. 1, 2; Plate xxi, fig. 4.
Term. Feuz., xxv, 1902, p. 103.—*Catastoma pedicellata* Morg., *Jour. Cin. Soc. Nat. Hist.*, 1892, xiv, p. 143.

Peridium up to 3 cm. diam., depressed-globose or lenticular, attached by a small rooting base; exoperidium a thick sand-case, of hyphae and debris immixed, grey or brown, flaking away save a small discoid basal portion; endoperidium tough, membranous, chestnut brown or umber, smooth, shining, dehiscing by a small apical, plane stoma.

Gleba purplish, pulverulent; capillitium pallid chestnut, of the usual type. Spores globose, 8-10 μ diam. (including verrucae), pedicellate, pedicels up to 25 μ long, stout, tinted; episore chestnut brown, coarsely and strongly verrucose or verrucose-echinulate.

Habitat:—Solitary on the ground.

Distribution:—North America; South Africa; Australia.

New South Wales:—*Sussex Island, Clarence River, Sept., 1909; *Narrabri, June, 1919 (Det. Lloyd No. 527 as *Catastoma pedicellata*).

South Australia:—*Yanco Area, Nov., 1919; *Pt. Elliot, Aug., 1918, D. I. Cleland; *Buckland Park, Apl., 1923; *Fullarton, Adelaide, May, 1923; *no locality, F. R. Zeitz.

The species is characterized by the (usually) large size, firm, leathery, umber, polished endoperidium, indefinite plane stoma, and especially by the long-pedicellate, coarsely roughened spores. The spore markings vary somewhat in different collections; in some being strongly verrucose, in others verrucose-echinulate. The length of the spines may vary from 1.5 μ to 0.5 μ . As all conditions may be noted in the same microscopic field, these variations cannot be considered of specific import.

This is one of the most abundant of the Australian species, judging from the collections in Dr. Cleland's possession, and is separated from *D. hyalothrix*, which it resembles in the pedicellate spores and plane stoma, by the smaller, more coarsely warted spores and longer pedicels.

2. DISCISEDA HYALOTHRIX (Cooke and Masee) Hollos. Plate xxi, fig. 5.

Noev. Koezl., 1902, p. 107.—*Bovista hyalothrix* Cke. et Mass., *Grav.*, 1888, xvi, p. 73.—*Catastoma hyalothrix* (Cke. et Mass.) Lloyd, *Lyc. Aus.*, 1905, p. 27.

Peridium up to 2.5 cm. diam., depressed-globose; exoperidium in the nature of a sand-case, flaking away irregularly, save a small attached basal portion; endoperidium umber or purplish, smooth, tough, membranous, dehiscing by an irregular, plane, apical stoma.

* An asterisk denotes that the collection in question is in the herbarium of Dr. J. B. Cleland, Adelaide; and where no collector is given, signifies that the collection was made by Dr. Cleland himself.

Gleba dark olivaceous, becoming dark purple, pulverulent; capillitium threads tinted, of the usual type. Spores globose, 10-13 μ diam., pedicels short, up to 15 μ , stout, tinted; episporium deep chestnut brown, densely and finely covered with tinted or hyaline verrucae, which appear areolate in consequence of their close arrangement.

Habitat:—Solitary on the ground.

Distribution:—Australia.

Victoria:—Lake Allacutya, C. French. Type, in Herb. Kew.

New South Wales:—*Dubbo, June, July, Oct., 1915 (One collection det. by Lloyd No. 137 as *Catastoma hyalothrix*).

South Australia:—*Adelaide, July, 1914.

Characterized by the pedicellate, closely and densely verrucose spores. The verrucae are densely packed, and somewhat irregular in shape and size, consequently in surface view the episporium appears somewhat areolate. The plane stoma is also characteristic. The gleba may be purplish or olivaceous.

3. *DISCISEDIA CANDIDA* (Schweinitz) Lloyd. Plate xx, figs. 3, 4; Plate xxi, fig. 7.

Mycological Notes, 1902, p. 100.—*Bovista candida* Schw., *Syn. Fung. Carol.*, No. 333, 1822.—*B. circumscissa* Berk. et Curt., *Grev.*, 1873, p. 50.—*Catastoma circumscissa* (Berk. et Curt.) Morg., *Jour. Cin. Soc. Nat. Hist.*, 1892, xiv, p. 143.—*Discisedia circumscissa* (Berk. et Curt.) Hollos, *Term. Feuz.*, 1902, xxv, p. 102.

Peridium up to 3 cm. diam., depressed-globose; exoperidium thick, firm, of hyphae and vegetable debris immixed, breaking away circumscissilely from the base; endoperidium ferruginous to umber, tough, covered in part by a reticulate, gelatinous layer; dehiscing by a basal, fimbriate, mammose stoma.

Gleba olivaceous, umber or purplish, pulverulent; capillitium threads pallid chestnut, of the usual type. Spores globose, 3-8.4-5 μ diam., with stumps only of the pedicels remaining; episporium pallid chestnut brown, very finely verruculose, almost smooth when $\times 1,000$.

Habitat:—Solitary or in small groups in pastures; hypogaeal.

Distribution:—Europe; North and South America; Australia; New Zealand.

New South Wales:—*Milson Island, Hawkesbury River, Feb., 1916 (two collections, both det. by Lloyd No. 139 as *Catastoma hyalothrix*).

New Zealand:—Roxburgh, Otago, Aug., 1925, J. C. Neill.

Characterized by the almost smooth spores, absence of a definite pedicel, and fimbriate, mammose stoma. According to Morgan the stoma is situated at the base of the plant.

The gleba is olivaceous when young, deep umber when old; frequently in Australian plants identical in all other respects, it is tinged with purple.

4. *DISCISEDIA CERVINA* (Berkeley), n. comb. Plate xx, fig. 5; Plate xxii, fig. 1.

Bovista cervina Berk., *Ann. Mag. Nat. Hist.*, 1842, ix, p. 447.—*Globaria debreciensis* Hazsl., *Zoo. Bot. Ges.*, 1877, xxvi, p. 226.—*Bovista subterranea* Peck, *Bot. Gaz.*, 1879, iv, p. 216.—*B. argillacea* Pat., *Bull. Soc. Myc. Fr.*, 1888, p. 93.—*B. debreciensis* (Hazsl.) de Toni, in *Sacc. Syll. Fung.*, 1888, vii, p. 476.—*Catastoma subterranea* (Peck) Morg., *Jour. Cin. Soc. Nat. Hist.*, 1892, xiv, p. 143.—*C. debreciense* (Hazsl.) Hollos, *Term. Koezl.*, 1902, lvi, p. 186.—*Discisedia debreciensis* (Hazsl.) Hollos, *Term. Feuz.*, 1902, xxv, p. 102.

Peridium up to 4 cm. diam., depressed-globose; exoperidium thick, brittle, flaking away irregularly save at the base; endoperidium tough, membranous, purplish or tan coloured, furfuraceous, dehiscing by a fimbriate, mammosc stoma.

Gleba olivaceous, umber or purplish; capillitium threads pallid chestnut brown, of the usual type. Spores globose, 5.5-6.5 μ diam., with stumps only of the pedicels remaining; epispore chestnut brown, closely and finely verruculose.

Habitat:—Solitary in the ground; hypogaeal.

Distribution:—Europe; North America; Australia; New Zealand.

New South Wales:—*Forbes, Aug., 1915; *Merebine, Nov., 1918 (Det. Lloyd No. 508 as "near *Catastoma circumscissa*"); *near Barellan, Aug., 1918.

South Australia:—*Grange, July, 1914; *Monarto South, July, 1922 (Det. Lloyd No. 852 as *Catastoma subterranea*); *Ooldea, Aug., 1922.

New Zealand:—Roxburgh, Otago, Aug., 1925, J. C. Neill; Ashburton, Canterbury, Aug., 1925, J. C. Neill.

The species resembles the preceding in many characters, but may be separated by the larger and more definitely verruculose spores. The verrucae differ considerably in different collections, some being fine, approaching those of the former species (when the spore size alone separates them); others being coarse, approaching those of *D. anomala*. In such cases the nature of the stoma aids in separating the two.

Lloyd has examined the type of "*Bovista cervina*" and found it to be the same as "*Catastoma subterranea*". Therefore the specific name *cervina* has priority.

5. DISCISEDIA ANOMALA (Cooke and Massee) n. comb. Plate xx, figs. 6, 7;
Plate xxi, fig. 9.

Bovista anomala Cke. et Mass., *Grev.*, 1889, xviii, p. 6.—*Catastoma anomalum* (Cke. et Mass.) Lloyd, *Lyc. Aus.*, 1905, p. 27.

Peridium up to 2 cm. diam., depressed-globose or pulvinate; exoperidium a thin brown membrane, flaking away save at the base where persisting as a small cupulate structure, externally covered with debris; endoperidium bay brown or umber, firm, membranous, furfuraceous, dehiscing by a raised, tubular, mammosc, circular stoma which is surrounded by a depressed groove.

Gleba olivaceous, becoming umber, pulverulent; capillitium threads pallid chestnut brown, of the usual type. Spores globose, 6-8 μ diam., stumps only of the pedicels remaining; epispore pallid chestnut brown, finely and closely verruculose.

Habitat:—Solitary or in small groups on the ground.

Distribution:—Australia.

New South Wales:—*Milson Island, Hawkesbury River, Jan., 1915 (Det. Lloyd No. 76 as *Catastoma anomalum*); March, 1916; *Dubbo, June, 1915 (Det. Lloyd No. 78 as *Catastoma anomalum*); *Forbes, Aug., 1915 (Det. Lloyd No. 77 as *C. anomalum*).

Victoria:—*Ararat, July, 1918, E. J. Semmens.

South Australia:—*Ooldea, Aug., 1922 (2 collections).

Characterized by the thin and membranous exoperidium, finely verruculose spores and especially by the definite tubular stoma, surrounded by a depressed groove. The stoma is not always tubular, however, for sometimes it may be fimbriate and mammosc, and in old and weathered specimens almost indefinite.

Sometimes a trace of a gelatinous membrane is present lying on the surface of the endoperidium. The gleba is frequently tinged with purple in old specimens.

6. *DISCISEDA AUSTRALIS*, n. sp. Plate xxi, figs. 1, 8.

Peridium up to 3 cm. diam., depressed-globose, attached by a small rooting base; exoperidium thin, umber, fragile, membranous, flaking away irregularly save at the base; endoperidium furfuraceous, dehiscing by a tubular or mammosc stoma, which is surrounded by a depressed groove.

Gleba olivaceous, pulverulent; capillitium threads pallid chestnut brown, of the usual type. Spores globose or subglobose, 5-6.5 μ diam., with stumps only of the pedicels persisting; epispore pallid chestnut brown, closely and finely verruculose, warts round-topped.

Habitat:—Solitary on the ground.

Distribution:—Australia.

Victoria:—*Ararat, May, 1918, E. J. Semmens. Type, in Herb. Cleland.

South Australia:—*Mt. Pleasant, June, 1925.

The characters of the species are the membranous exoperidium, definite stoma of the *D. anomala* type, and the fine, closely grouped, round-topped warts covering the epispore. These, though readily seen when magnified $\times 1,000$, are barely perceptible when $\times 500$.

The plant has a general resemblance to the preceding, especially in the characters of the exoperidium and stoma; but may be separated by the different spores, larger peridium, and darker colour of the endoperidium.

7. *DISCISEDA HYPOGAEA* (Cooke and Masee) n. comb. Plate xxii, fig. 2.

Bovista hypogaea Cke. et Mass., *Grev.*, 1891, xx, p. 35.—*Catastoma hypogaeum* (Cke. et Mass.) Lloyd, *Lyc. Aus.*, 1905, p. 27.

Peridium up to 2 cm. diam., depressed-globose or subglobose; exoperidium membranous, very thin, pallid ochraceous, fragile, falling away irregularly save at the base; endoperidium thin, flaccid, papyraceous, olivaceous, furfuraceous, dehiscing by a minute mammosc apical stoma.

Gleba olivaceous, pulverulent; capillitium of the usual type, tinted. Spores globose, 8-9 μ diam. (including verrucae), stumps only of the pedicels persisting; epispore chestnut brown, closely covered with coarse flat-topped echinulae.

Habitat:—Solitary in the ground; hypogaeal.

Distribution:—Australia.

New South Wales:—*Narrabri, May, 1919.

The coarse, flat-topped spines of the spores characterize the species. These are so well marked as to form a definite halo around the spores when these are viewed in median section; resembling in this particular the spores of certain species of *Geaster*. The thin and flaccid nature of the exoperidium is also characteristic.

Lloyd (1905, p. 27) records the species as being collected in New Zealand by R. Brown; the writer has not seen New Zealand specimens.

8. *DISCISEDA VERRUCOSA* G. H. Cunn. Plate xxi, figs. 2, 6.

Trans. N.Z. Inst., 1926, lvii, p. 205.

Peridium up to 3 cm. diam., depressed-globose; exoperidium brown, tough, of hyphae and vegetable debris immixed, flaking away irregularly save a small persistent basal portion; endoperidium thick, tough, membranous, bay brown or tinged with purple, dehiscing by an irregularly torn, toothed apical stoma.

Gleba purplish, pulverulent; capillitium threads tinted, of the usual type. Spores globose, 6-8 μ diam. (including verrucae), stumps only of the pedicels

persisting; epispore chestnut brown, covered with coarse hyaline verrucae, often in the form of finger-like processes.

Habitat:—Solitary or in small groups on the ground.

Distribution:—Australia; New Zealand.

New Zealand:—Milford Track, Otago, Jan., 1920, E. H. Atkinson, Type, in the herbarium of the writer, No. 887; Waikare, Canterbury, Jan. 1926, G.H.C.

New South Wales:—*Forbes, Aug., 1915.

South Australia:—*Beaumont, May, 1922; *Flinders Range, near Pt. Augusta, Aug., 1922; *Kinchina, Aug., 1922 (2 collections); *Grange, June, 1925, Mr. Tee.

The species is characterized by the nature of the spores, these being covered with coarse, hyaline, finger-like processes. The latter vary in length, however, in some collections being about half the length of those present in others.

Doubtful and Little Known Species.

DISCISEDA MUELLERI (Berkeley) n. comb.

Bovista Muelleri Berk., *Proc. Linn. Soc. Bot.*, 1878, xvi, p. 171.—*Catastoma Muelleri* (Berk.) Lloyd, *Lyc. Aus.*, 1905, p. 27.

Peridium up to 2.5 cm. diam., subglobose, with a short, stout rooting base; exoperidium soon umber with minute, pale subpersistent warts; endoperidium firm, rather thick, brown.

Gleba reddish-brown, capillitium threads flaccid, pale, but little branched. Spores globose, 10-12 μ diam., apedicellate; epispore reddish-umber, coarsely spinulose.

Habitat:—On the ground.

Distribution:—Australia.

Queensland:—Herberts Creek, Darling Range. Type, in Herb. Kew.

The writer has not seen specimens; the description (slightly modified) being that given by Cooke in his *Handbook* (1892). The species is placed in the doubtful section, for the description of the spores is such that it is not possible to compare it with the others. According to Lloyd this has the roughest spores of any species included in the genus. In the description the gleba is said to be reddish-brown, and in fact this is the only character by which it can be said to differ from most others placed in the genus; but as has been shown, glebal colour is not of specific value.

A single broken specimen of some *Disciseda* in the possession of Dr. Cleland has a similar reddish-brown gleba, but the spores are much smaller than the measurements given for *D. Muelleri* and are angular and tuberculate-striate. The specimen is too broken to allow of its being described.

Lloyd (*Myc. Notes*, 1917, p. 631) describes a species under the name of *Catastoma magnum*, stated to have been collected in Canterbury. He considered it differed from *D. anomala* in the larger size, thick, leathery exoperidium and in the apedicellate, strongly roughened spores, but claimed it was but a form of *D. anomala*. From his description it is impossible to say to what species it should be referred. The same "species" has been recorded from South Africa by Verwoerd (1925).

ABSTOMA G. H. Cunn.

Trans. N.Z. Inst., 1926, lvii, p. 206.

Peridium subglobose, of two layers; a thick, fragile exoperidium composed of hyphae immixed with sand particles, breaking away irregularly; and a

papyraceous or membranous, coloured endoperidium which dehisces by irregular rupture, a stoma being absent.

Gleba of spores and capillitium, compact or pulverulent at maturity; capillitium threads short, occasionally branched, smooth, continuous, coloured. Spores apedicellate, globose, reticulate, coloured.

Habitat:—Solitary or in small groups in the ground; hypogaeal.

Distribution:—Australia; New Zealand.

The genus is separated from the preceding because of the absence of a stoma, dehiscence being effected by the irregular breaking away of the peridium; in other characters, as habit, structure, capillitium, etc. it is practically identical. The spores, however, are characteristic in the two species described below in that they are reticulate, a condition not known to occur with any species of *Disciseda*.

1. *ABSTOMA PURPUREUM* (Lloyd) G. H. Cunn. Plate xxi, fig. 3; Plate xxii, fig. 4.

Trans. N.Z. Inst., 1926, lvii, p. 206.—*Catastoma purpurea* Lloyd, *Myc. Notes*. 1922, p. 1120.

Peridium up to 4 cm. diam., subglobose or depressed-globose; exoperidium a sand-case, up to 3 mm. thick, firm, brittle, dull purple, breaking away irregularly and completely; endoperidium thin, papyraceous, fragile, dark purple, almost black, free from the exoperidium save at the base where attached (but not organically); dehiscing by irregular rupture.

Gleba purple, firm and compact; capillitium threads deep chestnut brown, thick walled. Spores globose or shortly elliptical, 8-16.5 μ diam., apedicellate; epispore deep chestnut brown, closely and finely reticulate.

Habitat:—In sand among dunes; hypogaeal.

Distribution:—New Zealand.

Weraroa, Wellington, Nov., 1919, S. A. Cunningham, E. H. Atkinson, G.H.C. Type collections, and type of the genus, in the herbarium of the writer, No. 1783.

The species is characterized by the purple colour of the whole plant, the thick sand-case exoperidium, fragile, non-stomate endoperidium, and deeply coloured, reticulate spores.

The habit is peculiar. The plant grows buried to a depth of several centimetres, 7-10 or more, in sand at Weraroa beach. When wind erosion occurs, as is frequent in this area of shifting dunes, the sand is blown for some distance, large amphitheatres being formed, and the globose plants are carried by the wind often for one kilometre or more from their place of origin. They are rolled along the surface of the dune slopes and finally arrested by debris of the nature of branches of trees and stumps half buried at the tops of the long dune slopes. Here they come to rest and the peridium is gradually removed by friction of the sand particles.

2. *ABSTOMA RETICULATUM*, n. sp. Plate xxii, fig. 3.

Peridium up to 3 cm. diam., depressed-globose; exoperidium of the nature of a fugacious sand-case; endoperidium umber or sepia brown, tough, membranous, smooth, dehiscing by irregular rupture.

Gleba olivaceous, pulverulent; capillitium threads tinted, thin walled. Spores globose, 8-12 μ diam., apedicellate; epispore coarsely and strongly reticulate, chestnut brown.

Habitat:—Solitary on the ground; hypogaeal?

Distribution:—Australia.

New South Wales:—*Forbes, Aug., 1915, J. B. Cleland. Type, in Herb. Cleland.

The olivaceous colour of the gleba, tough and membranous endoperidium, and coarsely reticulate spores separate the species from the preceding. The exoperidium has almost completely disappeared from this collection.

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Index.

Synonyms are in italics.

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|--|---|
| Abstoma G. H. Cunn. | <i>Catastoma</i> Morg. (<i>continued</i>) |
| purpureum (Lloyd) G. H. Cunn. | <i>Muelleri</i> (Berk.) Lloyd |
| reticulatum G. H. Cunn. | <i>pedicellata</i> Morg. |
| <i>Bovista anomala</i> Cke. et Mass. | <i>purpurea</i> Lloyd |
| <i>argillacea</i> Pat. | <i>subterranea</i> (Peck) Morg. |
| <i>candida</i> Schw. | <i>Disciseda</i> Czern. |
| <i>cervina</i> Berk. | Key to species (p. 236) |
| <i>circumscissa</i> Berk. et Curt. | <i>anomala</i> (Cke. et Mass.) G. H. Cunn. |
| <i>debreciensis</i> (Hazsl.) de Toni | <i>australis</i> G. H. Cunn. |
| <i>hyalothrix</i> Cke. et Mass. | <i>candida</i> (Berk.) Lloyd |
| <i>hypogaea</i> Cke. et Mass. | <i>cervina</i> (Berk.) G. H. Cunn. |
| <i>Muelleri</i> Berk. | <i>circumscissa</i> (Berk. et Curt.) Hollos |
| <i>subterranea</i> Peck | <i>debreciensis</i> (Hazsl.) Hollos |
| <i>Catastoma</i> Morg. | <i>hyalothrix</i> (Cke. et Mass.) Hollos |
| <i>anomalum</i> (Cke. et Mass.) Lloyd | <i>hypogaea</i> (Cke. et Mass.) G. H. Cunn. |
| <i>circumscissa</i> (Berk. et Curt.) Morg. | <i>Muelleri</i> (Berk.) G. H. Cunn. |
| <i>debreciense</i> (Hazsl.) Hollos | <i>pedicellata</i> (Morg.) Hollos |
| <i>hyalothrix</i> (Cke. et Mass.) Lloyd | <i>verrucosa</i> G. H. Cunn. |
| <i>hypogaeum</i> (Cke. et Mass.) Lloyd | <i>Globaria debreciensis</i> Hazsl. |
| <i>magnum</i> Lloyd | |

EXPLANATION OF PLATES XX-XXII.

Plate xx.

- Fig. 1. *Disciseda pedicellata*, natural size. The upper plant is reversed to show the persistent basal portion of the exoperidium.
 Fig. 2. *D. pedicellata*, × 2. Showing the plane stoma and the smooth endoperidium.
 Fig. 3. *D. candida*, natural size. Note the large mammose stoma.
 Fig. 4. *D. candida*, × 3. Showing the furfuraceous endoperidium, persistent basal portion of the exoperidium and the fimbriate mammose stoma.
 Fig. 5. *D. cervina*, natural size. Note the mammose stoma and persistent basal portion of the exoperidium.
 Fig. 6. *D. anomala*, natural size.
 Fig. 7. *D. anomala*, × 3-5. Note the tubular mammose stoma surrounded by a depressed ring.

Plate xxi.

- Fig. 1. *D. australis*, natural size.
- Fig. 2. *D. verrucosa*, natural size.
- Fig. 3. *Abstoma purpureum*, natural size.
- Fig. 4. *Disciseda pedicellata*, spores, $\times 1200$.
- Fig. 5. *D. hyalothrix*, spores, $\times 1200$.
- Fig. 6. *D. verrucosa*, spores, $\times 1200$.
- Fig. 7. *D. candida*, spores, $\times 1200$.
- Fig. 8. *D. australis*, spores, $\times 1200$.
- Fig. 9. *D. anomala*, spores, $\times 1200$.

Plate xxii.

- Fig. 1. *Disciseda cervina*, spores, $\times 1200$.
- Fig. 2. *D. hypogaea*, spores, $\times 1200$.
- Fig. 3. *Abstoma reticulatum*, spores, $\times 1200$.
- Fig. 4. *A. purpureum*, spores, $\times 1200$.

All photographs (except Plate xxi, fig. 3, by H. Drake) have been taken by the writer. The spore drawings have been made with the aid of a camera lucida; $\times 1200$.

THE GASTEROMYCETES OF AUSTRALASIA.

viii. THE GENUS MYCENASTRUM.

(Plate xxii, figs. 5-8.)

This genus contains a single species, which has been collected in practically every country in the world, though it is most abundant in sandy regions.

The peridium ranges in size from 2 cm. to 20 cm. or more, and may be globose, obovate or pyriform. It consists of the usual two tissues, exoperidium and endoperidium.

The exoperidium is thin, floccose and usually smooth externally, but forms occur in which the flocci are aggregated into definite scales; at maturity it usually falls away completely, exposing the endoperidium. This latter tissue is unlike that of the other genera of this sub-family in that it is thick, 2-5 mm., and indurated. In young plants it may appear almost cartilaginous, but in mature plants it is hard and coriaceous, or even corky.

The peridium may dehisce in a stellate manner, or by the falling away in irregular flakes from the apical portion.

The gleba consists of spores and capillitium, and is decidedly pulverulent at maturity. The capillitium threads are peculiar and characteristic. Each consists of a short main stem which may be simple or short-branched, and is covered with short, acuminate pointed spines. These threads differ considerably, even in the same plant, in the degree of spininess, shape and size. Mixed with the capillitium threads are usually present numerous long and unbranched septate hyphae of a type similar to those forming the peridium.

MYCENASTRUM Desvaux.

Ann. Sci. Nat., 2, 1842, xvii, p. 143.—*Pachyderma* Schulz., *Verh. Zoo. Bot. Ges. Wien.*, 1875, xxv, p. 79.

Peridium globose, obovate or pyriform, of two layers; a thin, floccose exoperidium; and a thick, indurated, persistent endoperidium; dehiscing in a stellate manner, or by the irregular rupture of the apical portion; sterile base absent.

Gleba olivaceous, becoming umber, pulverulent; capillitium threads very abundant, of numerous short hyphae, continuous, short-branched or simple, branches beset with stout, spinous processes. Spores globose or elliptical, coloured, coarsely echinulate.

Habitat:—Solitary, in small groups or caespitose on the ground; epigaeal.

Distribution:—Europe; North America; Asia; India; Africa; Australia; New Zealand.

The genus is characterized by the nature of the capillitium, the hard and coriaceous endoperidium and the method of dehiscence.

MYCENASTRUM CORIUM (Guersent) Desvaux. Plate xxii, figs. 5-8.

Ann. Sci. Nat., 1842, xvii, p. 147.—*Lycoperdon corium* Guers., in DC. *Fl. Fr.*, suppl. 2, 1815, p. 598. *Bovista suberosa* Fr., *Syst. Myc.*, iii, 1829, p. 26. *Scleroderma*

corium Grev., in Duby *Bot. Gall.*, ii, 1830, p. 892. *Mycenastrum phaeotrichum* Berk. in Hook. *Lond. Jour. Bot.*, ii, 1843, p. 418. *M. chilense* Mont., *Ann. Sci. Nat.*, ser. 2, xx, 1843, p. 375. *Endoneuron suberosum* Czern., *Bull. Soc. Imp. Mosc.*, xviii, 1845, p. 152. *Mycenastrum leptodermeum* Dur., *Fl. Alg.*, 1849, p. 386. *M. radicum* Dur., *l.c.*, p. 387. *M. Beccarii* Pass., *Nuov. Giorn.*, vii, 1875, p. 183. *Pachyderma Strossmayeri* Schulz., *Verh. Zoo. Bot. Ges. Wien*, xxv, 1875, p. 79. *Mycenastrum clausum* Schulz., *Ibid.*, xxvii, 1877, p. 114. *Bovista spinulosa* Peck, *Bot. Gaz.*, iii, 1879, p. 170. *Mycenastrum spinulosum* Peck, *Thirty-Third Rept. for 1879, 1883*, p. 15. *M. olivaceum* Cke. et Mass., *Grev.*, xvi, 1887, p. 33. *Scleroderma phaeotrichum* (Berk.), de Toni, in Sacc. *Syll. Fung.* vii, 1888, p. 139. *S. chilense* (Mont.) de Toni, *l.c.* *S. spinulosum* (Peck) de Toni, *l.c.* *S. radicum* (Dur.) de Toni, *l.c.* *S. leptodermeum* (D. et M.) de Toni, *l.c.* *S. Beccarii* (Pass.) de Toni, *l.c.* *S. olivaceum* (Cke. et Mass.) de Toni, *l.c.*

Peridium globose, subglobose, obovate or pyriform, up to 20 cm. diam.; exoperidium tomentose, fugacious, greyish; endoperidium thick, 2-5 mm., smooth, polished, at first greyish. becoming bay brown, dehiscing in a stellate manner, or by the irregular falling away of the apical portion.

Gleba olivaceous, becoming umber, pulverulent; capillitium threads of the usual type. Spores globose or shortly elliptical, 11-13 μ diam., apedicellate; epispore chestnut brown, densely echinulate, reticulate, wall 2 μ thick.

Habitat:—Solitary, in groups or caespitose on the ground.

Distribution:—Same as that of the genus.

Queensland:—*Barron Falls, Kuranda, Sept., 1917.

South Australia:—*Glen Osmond, Dec., 1920; *Adelaide, Oct., 1922; Feb., 1921;

*Encounter Bay, Jan., 1924; *Pt. Elliot, Aug., 1918, D. I. Cleland.

Western Australia:—*Kalgoorlie, June, 1916.

New South Wales:—*Dungog, Nov., 1916; *Moore Park, Sydney, Dec., 1917;

*Mudgee, Dec., 1917; *Cowra Experimental Farm, Dec., 1917; *Coolamon, May, 1918; *Narrabri, June, 1919.

New Zealand:—Castlepoint, Wairarapa, Jan., 1923, Miss Edwin; Spring Creek, Blenheim, Jan., 1925, W. D. Reid; Levels, Canterbury, Jan., 1927, G.H.C.

The species varies greatly in the size of the peridium, degree of spininess of the capillitium, roughness of the spores, and colour of the gleba. Usually if plants are collected and dried when young the gleba appears olivaceous; if dried when mature it may be umber or even purple.

Caespitose plants are frequent, at least in Australia and New Zealand. Plants break away from the point of attachment at maturity and are then often carried for considerable distances by wind, being rolled along the ground, and in this manner the spores are widely dispersed.

EXPLANATION OF PLATE XXII.

Fig. 5. *Mycenastrum corium*. $\times \frac{2}{3}$. Showing the thick endoperidium and the stellate method of dehiscence. (Photo. H. Drake.)

Fig. 6. *M. corium*. $\times \frac{1}{2}$. Showing the flaking exoperidium. (Photo. by writer.)

Fig. 7. Capillitium. $\times 125$. Showing the spinose nature of the threads; air bubbles in the lumen of the threads show dark in this photo. (Photomicrograph by writer.)

Fig. 8. Spores. $\times 1200$. Drawn from a lactic acid mount with the aid of a camera lucida; New Zealand form. The spines are somewhat exaggerated.

* Collections in the herbarium of Dr. J. B. Cleland, Adelaide University.

THE GASTEROMYCETES OF AUSTRALASIA.

ix. KEYS TO THE GENERA AND SPECIES OF THE LYCOPERDACEAE.

By G. H. CUNNINGHAM, Mycologist, Department of Agriculture,
Wellington, N.Z.

[Read 27th July, 1927.]

The writer would limit the Lycoperdaceae to those genera possessing a non-stipitate, two- or four-layered peridium, copious capillitium, and long-sterigmate, 4- or 8-spored basidia. The limits of the family have been much greater in the past, as the following classifications will show, but as our knowledge of the development and structure of the various genera have broadened, so the limits of the family have been narrowed.

Details of the various classifications which have been proposed are of little other than historical interest today, to the student of this group, but a few are given here to indicate the diversities of opinion held by different authors, as to the position and affinities of the genera included in the Lycoperdaceae.

Commencing with Persoon's *Synopsis Methodica Fungorum*, 1801 (the starting-point of Modern Nomenclature in the Gasteromycetes), we find he divides the Fungi as under (details of the Gasteromycetes only are given):—

¹Class I. ANGIOCARPI: Fungi closed, or bearing very numerous spores internally.

Order 1. Sclerocarpi.

2. Sarcocarpi. Fungi fleshy stuffed. *Sphaerobolus*, *Thelebolus*.

3. Dermatocarpi. Fungi membranous, tough, internally powdery.

†Trichospermi. Seed powder mixed with threads. 13. *Batarrea*.

14. *Gastrum*.² 15. *Bovista*. 16. *Tulostoma*. 17. *Lycoperdon*.

18. *Scleroderma* (Genera 19-27 are now placed in a separate group, the Myxomycetes).

††Gymnospermi. Seed powder without threads.

†††Sarcospermi. Fructifications abundant, fleshy. 38. *Cyathus*.

Class II. GYMNOCARPI: Fungi fleshy. Seeds (few) borne in an open receptacle.

Order 4. Lytothecii. Fertile membrane at length mucilaginous. 39. *Clathrus*.

40. *Phallus*.

5. *Hymenothecii* (Hymenomycetes).

6. *Naematothecii* (Hyphomycetes).

As this and other classifications of that period are not in use today, the many others may be omitted, and attention paid only to those which have been in general use in recent years. Perhaps the best known of these is that followed in Saccardo's *Sylloge Fungorum*, Vol. 7, 1888, where the Lycoperdaceae is arranged as under

¹Thanks are due to Miss Wakefield, Kew Herbarium, for a translation of Persoon's classification. Unfortunately this work is not procurable in New Zealand.

²Genera included by the writer in the Lycoperdaceae are italicized; those excluded by him, or not present in Australasia, are in ordinary type.

(only the arrangement of this family in the various classifications will be considered henceforth):—

Family III. Lycoperdaceae.

Sub-family 1. Podaxineae.

2. Diplodermeae.

Tylostoma, Queletia, Battarrea, Husseyia, Mitremyces, Geaster, Diplocystis, Diploderma, Trichaster, Broomeia, Coilomyces.

3. Lycoperdeae.

Lanopila, Eriosphaeria, Bovista, Calvatia, Lycoperdon.

4. Sclerodermeae.

(*Mycenastrum* is placed here as a synonym of *Scleroderma*).

Ed. Fischer in Engler and Prantl's *Natuerliche Pflanzenfamilien*, I, 1**, 1900, arranged the family as under:—

Order 3. Lycoperdineae.

Family I. Lycoperdaceae.

Lycoperdon, *Globaria*, *Catastoma* (= *Disciseda*), *Bovistella*, *Bovista*, *Mycenastrum*, *Geaster*.

Lloyd's classification (*Genera of the Gasteromycetes*, 1902) is as follows:—

Family 4. Lycoperdaceae.

Tribe 1. Tylostomeae.

2. Podaxineae.

3. Sclerodermeae.

4. Lycoperdeae.

Tribal Alliance i. Geastreae.

Geaster.

ii. Bovisteae.

Bovista, *Mycenastrum*, *Catastoma* (= *Disciseda*).

iii. Lycoperdeae.

Bovistella, *Lycoperdon*, *Calvatia*.

iv. Anomaliae.

Gallacea, Castoreum, Arachnion, Mesophellia, Mitremyces.

Hollos (*Gasteromycetes Ungarns*, 1904), follows the arrangement:—

Family 3. Lycoperdaceae.

Battarrea, *Tylostoma*, *Myriostoma*, *Geaster*, *Astraeus*, *Calvatia*, *Lycoperdon*, *Disciseda*, *Bovista*, *Mycenastrum*.

Carleton Rea (*British Basidiomycetae*, 1922) arranges the family as under:—

Sub-order 3. Lycoperdineae.

Family 1. Lycoperdaceae.

Lycoperdon, *Bovistella*, *Bovista*, *Myriostoma*, *Geaster*.

From a consideration of these classifications we find that Persoon included *Battarrea*, *Tulostoma*, *Scleroderma* and the *Myxomycetes* in the family; that Saccardo placed *Geaster* in a separate sub-family, *Mycenastrum* as a synonym of *Scleroderma*, and included with *Lycoperdon*, etc. such genera as *Lanopila* and *Eriosphaeria*, while *Tulostoma*, *Mitremyces* (= *Calostoma*), etc. are placed in the sub-family *Diplodermeae*; that Fischer placed the genera later considered by the writer all under the *Lycoperdaceae*; that Hollos followed the older school in considering under the *Lycoperdaceae* such genera as *Battarrea*, *Tulostoma*, etc.; and that Rea's arrangement was similar to that of Fischer.

It is out of place to consider in detail the reasons why such genera as *Tulostoma*, *Battarrea*, *Scleroderma*, etc. do not belong to this family; these reasons will be given in subsequent papers dealing with these genera. As has been shown, the writer limits the family to those genera possessing a copious capillitium (which excludes *Scleroderma*); a non-stipitate peridium (which

excludes *Tulostoma* and *Battarrea*); 4- or 8-spored, sterigmate basidia (which excludes such genera as *Diploderma* and its allies).

All the genera considered as belonging to the family (*Abstoma*, *Bovista*, *Bovistella*, *Calvatia*, *Disciseda*, *Geaster*, *Lycoperdon*, *Mycenastrum* (extra-Australasian genera are not considered here) possess a two- or (in *Geaster*) four-layered peridium; the gleba is composed of spores immixed with copious capillitium threads; no stipe is present in any genus; the basidia are all long-sterigmate, and bear apically 4-8 unicellular spores. The development has been worked out for all genera by the writer, and is in most (save *Geaster*) found to be similar to that of *Lycoperdon*, save in minor details, as the formation of the capillitium threads.

STRUCTURAL SIMILARITIES AND DIFFERENCES IN THE GENERA OF THE LYCOPERDACEAE.

Tribe Lycoperdeae.

In the mature plant a two-layered peridium is always present, and the plants are attached to the substratum by a rooting base (*Bovistella* and *Lycoperdon*) which holds them to the place of origin even when old and withered; or they may be attached by a small rooting strand or mycelial cord and at maturity break away and be carried by the wind for some distance (*Abstoma*, *Bovista*, *Disciseda* and *Mycenastrum*).

The outer layer of the peridium is termed the exoperidium, and is usually pseudoparenchymatous, but may be membranous, and is often composed of warts and spines. This structure is often quite thin and flakes away in irregular patches. In *Abstoma* and *Disciseda* this membrane is frequently a thick (1-3 mm.) sand-case, consisting of loosely woven hyphae with which are immixed sand grains or particles of vegetable matter. The whole structure though firm is quite brittle, and falls away in irregular fragments. The exoperidium is one of the most variable tissues, ranging in the genus *Lycoperdon* from a smooth membrane, through furfuraceous to verrucose and even echinulate. The spines or verrucae seldom fall away completely but usually partly persist, especially towards the base. These structures are usually considered valuable aids in diagnosis, but should be used with caution, as in certain species individual plants in the same collection may possess either furfuraceous, verrucose or even echinulate processes to the exoperidium. In those species which are conspicuously spinose, the spines are usually surrounded at their bases with rings of small granules; consequently when the spines fall, the granules persist, giving to the exposed endoperidium a curiously reticulated appearance (*L. compactum*).

The inner tissue, the endoperidium, is in most genera thick and membranous or papyraceous, but in *Mycenastrum* is thick (2-5 mm.), corky, coriaceous and pseudoparenchymatous, and in growing plants often cartilaginous.

The peridium encloses the gleba, which at maturity consists of capillitium threads and spores. The threads serve as most useful generic characters. In many species of the genera *Bovistella* and *Lycoperdon* is present the so-called columella, a cylindrical or elliptical structure of sterile tissue traversing the lower portion of the gleba and attached to the base of the plant. In certain species of the genera *Bovistella*, *Calvatia* and *Lycoperdon* a sterile base is present. This consists of a usually cellular tissue occupying the lower portion of the gleba, and is most frequent in those plants with a well-developed, stem-like base. In two species (*Lycoperdon polymorphum* and *Calvatia candida*) the sterile base is not cellular but compact, and consequently frequently difficult to differentiate from

the gleba. In certain species of *Calvatia* and *Lycoperdon* (*Calvatia lilacina*, *C. caelata*, *Lycoperdon depressum*) the sterile base is separated from the gleba by a definite diaphragm.

The spores are continuous, globose or shortly elliptical, and possess rough or smooth epispires. Their shape, size and degree of roughness are useful specific characters. They may have long and slender sterigmata (often of irregular size on the same basidium) which in turn are borne apically on small cylindrical or clavate basidia. When the sterigmata with the attached spores break away from the basidia the latter are said to be pedicellate; when stumps only of the sterigmata remain attached to the spores the latter are said to be apiculate (though the use of this term is not strictly accurate, it being used generally in the sense of an apical point or apicula, the pedicel being basal); or should the spores become completely detached from the sterigmata they are said to be apedicellate. The basidia in all members of this tribe are regularly tetrasporous.

Most of the genera show a general resemblance, so close in fact that difficulty is sometimes experienced in separating species of *Bovistella* from *Lycoperdon* or *Bovista*. In the writer's experience separation is best effected by means of the capillitium threads, and method of dehiscence. In *Calvatia* and *Lycoperdon* the threads are very long, even throughout their length, sparingly septate or continuous. They are free at one end, and usually attached by the other to the inner wall of the peridium, or to the columella and diaphragm or sterile base should these be present. In *Lycoperdon* three types of capillitium threads are present; hyaline, septate, simple threads; coloured, continuous, simple or sparingly branched threads; and coloured, freely branched threads. These last approach in appearance those of *Bovista* and *Bovistella*.

Calvatia is separated from *Lycoperdon* chiefly by the method of dehiscence. In the former genus the upper portion of the peridium flakes away in pieces, when at maturity the whole may have disappeared, the gleba then being directly exposed. In *Lycoperdon* dehiscence is effected by a definite apical stoma. In two species (*L. depressum* and *L. Wrightii*) dehiscence is first effected by means of the apical stoma, but as the plant ages, irregular flaking away of the whole of the apex of the peridium occurs; consequently difficulty might be experienced in placing plants of these species, according to whether they were collected when mature or immature. In such cases the peculiar hyaline, septate capillitium serves to separate them.

In *Abstoma* and *Disciseda* the capillitium threads are very short, unbranched and usually continuous; and are so characteristic as usually to place any species in these two genera. Immature plants possess capillitium approaching the *Lycoperdon* or *Calvatia* type. In *Disciseda* dehiscence is effected by a stoma which in most species is apical but in one or two species is said to be basal. In *Abstoma* no stoma is present, the spores being liberated by irregular rupture of the endoperidium.

Bovista and *Bovistella* both possess capillitium threads which are peculiar and characteristic. Each thread is free, and has a short, distinct, thick main-stem, with numerous short, dichotomous, acuminate branches. The threads are penetrated to the lumen by peculiar conic pits (absent in *Bovista purpurea*). Dehiscence is effected by means of an apical stoma, as in *Lycoperdon*. The two genera are separated from one another upon habit, *Bovista* being a genus in which plants break away at maturity from the place of growth, *Bovistella* persisting by means of a rooting base as does *Lycoperdon*. Herbarium specimens may usually

be differentiated by the presence or absence of this rooting base. This in turn is usually indicated by the presence of a sterile base, so that by many workers, *Bovistella* has come to be recognized as a *Bovista* with a sterile base. In the opinion of the writer, however, this is not a sufficiently valid distinction upon which to base a genus.

Mycenastrum is characterized both by the capillitium threads and method of dehiscence. The threads are short, free, short-branched and covered with numerous spinous processes. Dehiscence is effected by the stellate splitting of the apex, but in certain forms, even in the same collection, it may be effected by the irregular breaking away of the apical portion.

Tribe Geastreae.

This is represented in Australasia by the single genus *Geaster*.

The structure of species of this genus differs in that no less than four well-defined tissues are present: (1) An outer mycelial layer consisting of a palisade of stout fibres; (2) a central fibrillose layer of interwoven hyphae with long axes predominantly radial; (3) an inner fleshy layer, definitely pseudoparenchymatous in structure (these three tissues comprise the exoperidium); and (4) the endoperidium.

The exoperidium splits into a variable number of rays, which may be expanded, revolute or involute. Dehiscence is effected by the exoperidium splitting from the apex downwards into several stellate lobes, exposing the endoperidium, which in turn dehisces by an apical stoma. The endoperidium is usually membranous or papraceous, and may be carried on a short pedicel, or be sessile. The stoma may be a poorly defined aperture, scarcely discernible from the endoperidium—when it is said to be naked; or it may be enclosed within a definite peristome, when it is said to be peristomate. The peristome may be externally fluted, when it is termed plicate; or silky-fibrillose, when it is said to be fibrillose.

The capillitium threads are continuous, simple (save in *Geaster velutinus* where they are sometimes branched at their apices), thick-walled, acuminate pointed and dark-coloured. The basidia are usually 4-spored, but 8-spored forms are not uncommon. A columella is present in certain species, but is noticeable usually only in immature specimens immediately before dehiscence.

The spores are usually globose, usually some shade of brown, and mostly verrucose or verrucose-echinulate.

In the family Lycoperdaceae there are 57 Australasian species, distributed among the following eight genera: *Abstoma* 2, *Bovista* 2, *Bovistella* 3, *Calvatia* 4, *Disciseda* 8, *Geaster* 23, *Lycoperdon* 14, and *Mycenastrum* 1.

Their distribution is interesting, as the accompanying table shows.

Table of Distribution of the Species.

| Species. | Distribution. |
|---------------------------------------|-------------------------------|
| <i>Abstoma purpureum</i> | New Zealand |
| <i>Abstoma reticulatum</i> | Australia |
| <i>Bovista brunnea</i> | New Zealand, Australia |
| <i>Bovista purpurea</i> | New Zealand |
| <i>Bovistella bovistoides</i> | New Zealand, Australia, India |
| <i>Bovistella pusilla</i> | Australia |
| <i>Bovistella verrucosa</i> | Australia |

| Species. | Distribution. |
|---|--|
| <i>Calvatia caelata</i> | New Zealand, Australia, North America, Europe, Asia, Africa |
| <i>Calvatia candida</i> | Australia, Europe |
| <i>Calvatia gigantea</i> | New Zealand, Australia, North America, Europe |
| <i>Calvatia lilacina</i> | New Zealand, Australia, North America, Europe, Africa |
| <i>Disciseda anomala</i> | Australia |
| <i>Disciseda australis</i> | Australia |
| <i>Disciseda candida</i> | New Zealand, Australia, North America, Europe, South America |
| <i>Disciseda cervina</i> | Australia, North America, Europe |
| <i>Disciseda hyalothrix</i> | Australia |
| <i>Disciseda hypogaea</i> | New Zealand, Australia |
| <i>Disciseda pedicellata</i> | Australia, North America, Africa |
| <i>Disciseda verrucosa</i> | New Zealand, Australia |
| <i>Geaster arenarius</i> | Australia, North America |
| <i>Geaster australis</i> | Australia |
| <i>Geaster Berkeleyi</i> | Australia, Europe |
| <i>Geaster Bryantii</i> | Australia, North America, Europe |
| <i>Geaster campester</i> | Australia, North America, Europe |
| <i>Geaster Clelandii</i> | Australia |
| <i>Geaster Drummondii</i> | Australia |
| <i>Geaster ellipticus</i> | Australia |
| <i>Geaster fenestratus</i> | Australia, North America, Europe, Africa |
| <i>Geaster fimbriatus</i> | Australia, North America, Europe |
| <i>Geaster floriformis</i> | New Zealand, Australia, North America, Europe, Africa |
| <i>Geaster Hariotii</i> | Australia, Europe, Africa, South America |
| <i>Geaster Umbatus</i> | New Zealand, Australia, North America, Europe, Africa |
| <i>Geaster minus</i> | New Zealand, Australia, North America, Europe, Asia |
| <i>Geaster mirabilis</i> | Australia, North America, Asia, South America |
| <i>Geaster pectinatus</i> | New Zealand, Australia, North America, Europe |
| <i>Geaster plicatus</i> | New Zealand, Australia, Africa, India |
| <i>Geaster saccatus</i> | Australia, North America, Europe, South America |
| <i>Geaster simulans</i> | Australia |
| <i>Geaster Smithii</i> | Australia, North America |
| <i>Geaster subiculosus</i> | Australia |
| <i>Geaster triplex</i> | New Zealand, Australia, North America, Europe, South America |
| <i>Geaster velutinus</i> | New Zealand, Australia, North America, Africa, South America |
| <i>Lycoperdon asperum</i> | Australia, Africa, South America |
| <i>Lycoperdon compactum</i> | New Zealand |
| <i>Lycoperdon depressum</i> | New Zealand, Australia, Europe, Africa |
| <i>Lycoperdon glabrescens</i> | New Zealand, Australia |
| <i>Lycoperdon Gunnii</i> | Australia |
| <i>Lycoperdon nitidum</i> | Australia |
| <i>Lycoperdon perlatum</i> | New Zealand, Australia, North America, Europe, Africa, South America, India |
| <i>Lycoperdon piriforme</i> | New Zealand, Australia, North America, Europe, South America, Asia |
| <i>Lycoperdon polymorphum</i> | New Zealand, Australia, North America, Europe, Africa |
| <i>Lycoperdon pusillum</i> | New Zealand, Australia, North America, Europe, Africa, Asia, India |
| <i>Lycoperdon scabrum</i> | New Zealand, Australia |
| <i>Lycoperdon spadiceum</i> | New Zealand, Australia, Europe |
| <i>Lycoperdon stellatum</i> | Australia |
| <i>Lycoperdon subincarnatum</i> | Australia, North America |
| <i>Mycenastrum corium</i> | New Zealand, Australia, North America, Europe, Africa, Asia, India |

This table shows that of these 57 species, 27 occur in New Zealand; 54 in Australia; 24 in Europe; 14 in Africa; 5 in India; 26 in North America; 9 in South America; 6 in Asia; 23 being confined to this biological region.

In the genus *Geaster* (and the related extra-Australian genus *Myriostoma*) are certain structural differences that separate it from the other genera placed in

the family. Consequently the family may conveniently be divided into the two following tribes:—

Tribe Lycoperdeae: Peridium two-layered, dehiscing by an apical stoma or by the gradual falling away of the upper portions of the peridium; capillitium attached or free, simple or freely branched; basidia sterigmate, 4-spored.

Tribe Geastreae: Peridium four-layered, dehiscing by the exoperidium splitting from the apex downwards in a stellate manner exposing the endoperidium, which in turn dehisces by means of an apical stoma; capillitium attached, simple; basidia sterigmate 4-8 spored.

The genera may be arranged as under:—

Key to the Genera.

Tribe Lycoperdeae: Peridium 2-layered; basidia 4-spored.

Capillitium threads attached to the endoperidium and central columella, when present.

Peridium dehiscing by irregular apical rupture 1. *Calvatia*.

Peridium dehiscing by a definite apical stoma 2. *Lycoperdon*.

Capillitium threads free within the endoperidium.

Threads simple, or short-branched.

Threads short, simple, smooth.

Stoma present, apical or basal 5. *Disciseda*.

Stoma absent 6. *Abstoma*.

Threads short, simple, spinose 7. *Mycenastrum*.

Threads freely branched, of a central main stem, and short, dichotomous, acuminate branches.

Plants with a strong rooting base 3. *Bovistella*.

Plants without a definite rooting base 4. *Bovista*.

Tribe Geastreae: Peridium 4-layered; basidia 4-8 spored.

Peridium with a solitary apical stoma 8. *Geaster*.

In order to bring all species of the family together, the following keys to the species of each genus have been given.

1. CALVATIA Fries.

(For emended descriptions, see PROC. LINN. SOC. N.S.W., 1926, li, p. 363.)

Diaphragm present.

Spores smooth *C. caelata* (Bull.) Morg.

Spores verrucose *C. lilacina* (B. et M.) Lloyd

Diaphragm absent.

Plants large, exterior smooth and leathery *C. gigantea* (Pers.) G. H. Cunn.

Plants small, exoperidium furfuraceous *C. candida* (Rostk.) Hollos

2. LYCOPERDON Tourn.

(Descriptions, PROC. LINN. SOC. N.S.W., 1926, li, p. 627.)

Spores without distinct pedicels.

Capillitium hyaline, freely septate.

Diaphragm present *L. depressum* Bon.

Diaphragm absent.

Exoperidium with minute depressions *L. subincarnatum* Peck

Exoperidium reticulate with persistent granules *L. compactum* G. H. Cunn.

Capillitium coloured, usually continuous.

Capillitium continuous or sparingly branched.

Sterile base of large cells, 2 mm. or more.

Exoperidium of minute connivent spines *L. piriforme* Schaeff.

Exoperidium of pointed verrucae *L. perlatum* Pers.

Sterile base of minute cells, 1 mm. or less.

Exoperidium of large cruciate spines *L. stellatum* Cke. et Mass.

Exoperidium furfuraceous *L. nitidum* Lloyd

Capillitium freely branched.

Sterile base cellular *L. spadicum* Pers.

Sterile base compact *L. polymorphum* Vitt.

Sterile base absent *L. pusillum* Pers.

Spores long pedicellate.

Sterile base well developed.

Exoperidium furfuraceous *L. glabrescens* Berk.

Exoperidium of cruciate spines *L. scabrum* (Lloyd) G. H. Cunn.

Sterile base scanty or absent.

Exoperidium of pallid cruciate spines *L. asperum* (Lev.) de Toni.

Exoperidium furfuraceous or tomentose *L. Gunnii* Berk.

3. BOVISTELLA Morg.

(Descriptions, PROC. LINN. SOC. N.S.W., 1925, I, p. 370.)

Spores long pedicellate.

Peridium pallid tan, finely tomentose *B. verrucosa* G. H. Cunn.

Peridium dark brown, areolate *B. bovistoides* (C. et M.) Lloyd

Spores apedicellate *B. pusilla* Lloyd

4. BOVISTA Dill., *ex* Persoon.

(Descriptions, PROC. LINN. SOC. N.S.W., 1925, I, p. 369.)

Capillitium pitted *B. brunnea* Berk.

Capillitium not pitted *B. purpurea* Lloyd

5. DISCISEDA Czern.

(Descriptions, PROC. LINN. SOC. N.S.W., 1927, lii, p. 236.)

Spores long pedicellate.

Spores strongly verrucose *D. pedicellata* (Morg.) Hollos.

Spores verrucose-areolate *D. hyalothrix* (C. et M.) Hollos.

Spores apedicellate (or apiculate, stumps only of pedicels persisting).

Spores almost smooth *D. candida* (Schw.) Lloyd

Spores finely verruculose.

Stoma fimbriate-mammose *D. cervina* (Berk.) G. H. Cunn.

Stoma tubular, surrounded by a depressed groove.

Spores finely verrucose-echinulate .. *D. anomala* (C. et M.) G. H. Cunn.

Spores covered with fine round-topped warts .. *D. australis* G. H. Cunn.

Spores coarsely verrucose.

Spores covered with flat-topped echinulations

..... *D. hypogaea* (C. et M.) G. H. Cunn.

Spores covered with coarse verrucae *D. verrucosa* G. H. Cunn.

6. ABSTOMA G. H. Cunn.

(Descriptions, PROC. LINN. SOC. N.S.W., 1927, lii, p. 241.)

Gleba purple; spores finely reticulate *A. purpureum* (Lloyd) G. H. Cunn.

Gleba olivaceous; spores coarsely reticulate *A. reticulatum* G. H. Cunn.

7. MYCENASTRUM Desv.

(Description, PROC. LINN. SOC. N.S.W., 1927, lii, p. 245) .. *M. corium* (Guers.) Desv.

8. GEASTER Mich.

(Descriptions, PROC. LINN. SOC. N.S.W., 1926, li, p. 76.)

Mouth peristomate.

Peristome sulcate.

Exoperidium not hygroscopic.

Endoperidium pedicellate.

Endoperidium smooth (or farinose, not roughened).

Peristome circular.

Base of the endoperidium smooth or striate

..... *G. pectinatus* (Pers.) Lloyd

Base of the endoperidium plicate *G. plicatus* Berk.

Base of the endoperidium with a collar-like ring

..... *G. Bryantii* Berk.

Peristome elliptical *G. ellipticus* G. H. Cunn.

Endoperidium roughened-verrucose.

Peristome concolorous *G. Hariotii* Lloyd

Peristome surrounded by a silky, differently coloured zone ...

..... *G. Berkeleyi* Mass.

Endoperidium sessile or sub-pedicellate (*G. Hariotii*).

- Exoperidium hygrosopic.
 - Endoperidium pedicellate.
 - Spores 6-8 μ diam. *G. campester* Morg.
 - Spores 4-5.5 μ diam.
 - Endoperidium asperate *G. Clelandii* Lloyd
 - Endoperidium smooth *G. Smithii* Lloyd
 - Endoperidium typically sessile *G. Drummondii* Berk.
- Peristome fibrillose.
 - Exoperidium not hygrosopic.
 - Endoperidium pedicellate.
 - Plants typically minute *G. minus* (Pers.) G. H. Cunn.
 - Plants typically large *G. limbatus* Fries
 - Endoperidium sessile.
 - Exoperidium externally felted-tomentose or tomentose-strigose.
 - Plants large, 3-6 cm. *G. velutinus* Morg.
 - Plants small, 1.5-2 cm. *G. mirabilis* Mont.
 - Exoperidium externally smooth, or almost so.
 - Spores smooth or nearly so *G. subiculosus* Cke. et Mass.
 - Spores verrucose-echinulate or verrucose.
 - Spores 2.5-3.5 μ diam. *G. saccatus* Fries
 - Spores 4-5 μ diam. *G. triplez* Jungh.
 - Spores 7-8 μ diam. *G. australis* Berk.
 - Exoperidium hygrosopic.
 - Endoperidium pedicellate *G. arenarius* Lloyd
 - Endoperidium sessile (*G. mammosus*)
- Mouth naked.
 - Exoperidium not hygrosopic.
 - Endoperidium pedicellate.
 - Exoperidium typically fornicate *G. fenestriatus* (Pers.) G. H. Cunn.
 - Exoperidium revolute (*G. rufescens*)
 - Endoperidium sessile *G. fimbriatus* Fries
 - Exoperidium hygrosopic.
 - Spores 6-7 μ diam. *G. floriformis* Vitt.
 - Spores 4-5 μ diam. *G. simulans* Lloyd

Synonyms Recorded in Australasian Literature.

Bovista

- anomala* Cke. et Mass. = *Disciseda anomala*
- argillacea* Pat. = *Disciseda cervina*
- aspera* Lev. = *Lycoperdon asperum*
- candida* Schw. = *Disciseda candida*
- cervina* Berk. = *Disciseda cervina*
- circumscissa* Berk. et Curt. = *Disciseda candida*
- debreciensis* (Hazsl.) de Toni = *Disciseda cervina*
- gigantea* (Pers.) Nees = *Calvatia gigantea*
- hyalothrix* Cke. et Mass = *Disciseda hyalothrix*
- hypogaea* Cke. et Mass. = *Disciseda hypogaea*
- ilacina* Berk. et Mont. = *Calvatia caelata*
- Muelleri* Berk. = *Disciseda Muelleri*
- olivacea* Cke. et Mass. = *Calvatia candida*
- ovalispora* Cke. et Mass. = *Bovista brunnea*, probably
- pusilla* Pers. = *Lycoperdon pusillum*
- suberosa* Fries = *Mycenastrum corium*
- subterranea* Peck = *Disciseda cervina*
- tomentosa* Vitt. = Misdetermination
- tunicata* Bon. = *Calvatia candida*

Bovistella

- aspera* (Lev.) Lloyd = *Lycoperdon asperum*
- australiana* Lloyd = *Lycoperdon glabrescens*
- cuprica* Lloyd = *Nomen nudum*
- glabrescens* (Berk.) Lloyd = *Lycoperdon glabrescens*
- Gunnii* (Berk.) Lloyd = *Lycoperdon Gunnii*
- nigrica* Lloyd = *Lycoperdon scabrum*
- rosea* Lloyd = *Lycoperdon glabrescens*
- scabra* Lloyd = *Lycoperdon scabrum*

Calvatia

| | |
|---|---|
| <i>aurea</i> Lloyd | = <i>Calvatia candida</i> var. <i>rubro-flava</i> |
| <i>cyathiformis</i> (Bosc.) Morg. | = <i>Calvatia lilacina</i> |
| <i>favosum</i> (Bon.) Lloyd | = <i>Calvatia caelata</i> |
| <i>Fontanesii</i> (Dur. et Mont.) Lloyd | = <i>Calvatia caelata</i> |
| <i>maxima</i> (Schaeff.) Morg. | = <i>Calvatia gigantea</i> |
| <i>occidentalis</i> Lloyd | = <i>Calvatia candida</i> |
| <i>olivacea</i> (Cke. et Mass.) Lloyd | = <i>Calvatia candida</i> |
| <i>primitiva</i> Lloyd | = <i>Calvatia gigantea</i> |
| <i>rubro-flava</i> (Cragin) Lloyd | = <i>Calvatia candida</i> var. <i>rubro-flava</i> |
| <i>Sinclairii</i> (Berk.) Lloyd | = <i>Calvatia caelata</i> |

Cycloderma

| | |
|---------------------------------|----------------------------|
| <i>ohiense</i> Cke. | = <i>Geaster velutinus</i> |
| <i>platyspora</i> Cke. et Mass. | = <i>Geaster velutinus</i> |

Catastoma

| | |
|---------------------------------------|--------------------------------|
| <i>anomalum</i> (Cke. et Mass.) Lloyd | = <i>Disciseda anomala</i> |
| <i>circumscissa</i> (B. et C.) Morg. | = <i>Disciseda candida</i> |
| <i>debreciensis</i> (Hazsl.) Hollos | = <i>Disciseda cervina</i> |
| <i>hyalothrix</i> (C. et M.) Lloyd | = <i>Disciseda hyalothrix</i> |
| <i>hypogaea</i> (C. et M.) Lloyd | = <i>Disciseda hypogaea</i> |
| <i>magnum</i> Lloyd | = <i>Nomen nudum</i> |
| <i>Muelleri</i> (Berk.) Lloyd | = <i>Disciseda Muelleri</i> |
| <i>pedicellata</i> Morg. | = <i>Disciseda pedicellata</i> |
| <i>purpurea</i> Lloyd | = <i>Abstoma purpureum</i> |
| <i>subterranea</i> (Peck) Morg. | = <i>Disciseda cervina</i> |

Disciseda

| | |
|---------------------------------------|----------------------------|
| <i>circumscissa</i> (B. et C.) Hollos | = <i>Disciseda candida</i> |
| <i>debreciensis</i> (Hazsl.) Hollos | = <i>Disciseda cervina</i> |

Geaster

| | |
|-----------------------------------|-------------------------------------|
| <i>affinis</i> Col. | = <i>Geaster triplex</i> , probably |
| <i>Archeri</i> Berk. | = <i>Geaster triplex</i> |
| <i>argenteus</i> Cke. | = Misdetermination |
| <i>asper</i> (Mich.) Lloyd | = <i>Geaster campester</i> |
| <i>biplicatus</i> Berk. et Curt. | = <i>Geaster plicatus</i> |
| <i>caespitosus</i> Lloyd | = <i>Geaster mirabilis</i> |
| <i>calceus</i> Lloyd | = <i>Geaster minus</i> |
| <i>coriaceus</i> Col. | = <i>Geaster triplex</i> |
| <i>coronatus</i> Col. | = <i>Geaster triplex</i> , probably |
| <i>coronatus</i> (Schaeff.) Lloyd | = <i>Geaster minus</i> |
| <i>delicatus</i> Morg. | = <i>Geaster floriformis</i> |
| <i>dubius</i> Berk. | = <i>Geaster velutinus</i> |
| <i>Englerianus</i> Henn. | = <i>Geaster triplex</i> |
| <i>fornicatus</i> (Huds.) Fr. | = <i>Geaster fenestriatus</i> |
| <i>fornicatus</i> Fr. | = <i>Geaster minus</i> |
| <i>granulosus</i> Fcl. | = <i>Geaster minus</i> |
| <i>hungaricus</i> Hollos | = <i>Geaster floriformis</i> |
| <i>hygrometricus</i> (Pers.) Fr. | = Misdetermination |
| <i>involutus</i> Mass. | = <i>Geaster Drummondii</i> |
| <i>lageniformis</i> Vitt. | = <i>Geaster triplex</i> |
| <i>lignicola</i> Berk. | = <i>Geaster mirabilis</i> |
| <i>Lloydii</i> Bres. et Pat. | = <i>Geaster velutinus</i> |
| <i>marginatus</i> Vitt. | = <i>Geaster minus</i> |
| <i>minimus</i> (Schw.) Lloyd | = <i>Geaster minus</i> |
| <i>Morganii</i> Lloyd | = <i>Geaster triplex</i> |
| <i>orientalis</i> Hazsl. | = <i>Geaster Bryantii</i> |
| <i>pseudomamosus</i> Hollos. | = <i>Geaster campester</i> |
| <i>Readeri</i> Cke. et Mass. | = <i>Geaster velutinus</i> |
| <i>Schmidelii</i> Vitt. | = <i>Geaster pectinatus</i> |
| <i>striatus</i> Fr. | = <i>Geaster pectinatus</i> |
| <i>striatulus</i> Kalch et Cke. | = <i>Geaster Drummondii</i> |
| <i>tenuipes</i> Berk. | = <i>Geaster plicatus</i> |

Geaster

- tunicatus* Vitt. = *Geaster fimbriatus*
- umbilicatus* Quel. = *Geaster pectinatus*
- violaceus* Lloyd = *Geaster triplex*

Lycoperdon

- australe* Berk. = *Lycoperdon asperum*
- Bovista* Fr. = *Calvatia gigantea*
- bovistoides* Cke. et Mass. = *Bovistella bovistoides*
- candidum* Pers. = Misdetermination
- candidum* (Rostk.) Bon. = *Calvatia candida*
- cepaeforme* (Bull.) Mass. = *Lycoperdon polymorphum*
- Colensoi* Cke. et Mass. = *Lycoperdon perlatum*
- coloratum* Peck = *Lycoperdon polymorphum*
- Cookei* Mass. = *Lycoperdon spadiceum*
- coprophilum* Mass. = *Bovistella coprophila*
- corium* Guers. = *Mycenastrum corium*
- cruciatum* Rostk. = *Lycoperdon candidum*
- dermoanthum* Vitt. = *Lycoperdon pusillum*
- favosum* Bon. = *Calvatia caelata*
- Fontanesii* Dur. et Mont. = *Calvatia caelata*
- furfuraceum* Schaeff. = *Lycoperdon polymorphum*
- gemmatum* Batsch = *Lycoperdon perlatum*
- giganteum* Batsch = *Calvatia gigantea*
- hiemale* Vitt. = Misdetermination
- hungaricum* Hollos = *Lycoperdon polymorphum*
- lilacinum* (D. et M.) Mass. = *Calvatia lilacina*
- macrogemmatum* Lloyd = *Lycoperdon perlatum*
- microspermum* Berk. = *Lycoperdon pusillum*
- natalense* Cke. et Mass. = *Lycoperdon depressum*
- nigrum* Lloyd = *Lycoperdon polymorphum*
- novae-zelandiae* Lev. = *Calvatia lilacina*
- piriforme* var. *flavum* Lloyd = *Lycoperdon piriforme*
- pseudopusillum* Hollos = *Lycoperdon pusillum*
- pratense* Pers. = Unknown
- purpuraceum* Berk. = Misdetermination
- purpureum* Lloyd = *Lycoperdon purpuraceum*
- reticulatum* Berk. = *Lycoperdon pusillum*, probably
- retis* Lloyd = Doubtful species
- rubro-flavum* Cragin = *Calvatia candida* var. *rubro-flava*
- semi-immersum* Lloyd = *Lycoperdon pusillum*
- Sinclairii* Berk. = *Calvatia caelata*
- substellatum* B. et Curt. = Misdetermination
- tasmanicum* Mass. = *Lycoperdon perlatum*
- tephrum* Berk. = *Lycoperdon subincarnatum*
- violascens* Cke. et Mass. = *Calvatia lilacina*
- Wrightii* Berk. = Misdetermination

Mycenastrum

- bovistoides* Cke. et Mass. = *Bovistella bovistoides*
- chilense* Mont. = *Mycenastrum corium*
- clausum* Schulz. = *Mycenastrum corium*
- leptodermeum* Dur. = *Mycenastrum corium*
- olivaceum* Cke. et Mass. = *Mycenastrum corium*
- phaeotrichum* Berk. = *Mycenastrum corium*
- radicatum* Dur. = *Mycenastrum corium*
- spinulosum* Peck = *Mycenastrum corium*

Scleroderma

- bovistoides* (Cke. et Mass.) de Toni = *Bovistella bovistoides*
- chilense* (Mont.) de Toni = *Mycenastrum corium*
- corium* Grev. = *Mycenastrum corium*
- leptodermeum* (D. et M.) de Toni = *Mycenastrum corium*
- olivaceum* (Cke. et Mass.) de Toni = *Mycenastrum corium*
- phaeotrichum* (Berk.) de Toni = *Mycenastrum corium*
- radicatum* (Dur.) de Toni = *Mycenastrum corium*
- spinulosum* (Peck) de Toni = *Mycenastrum corium*

THE XEROPHYTIC STRUCTURE OF THE LEAF IN THE
AUSTRALIAN PROTEACEAE. PART I.

By A. G. HAMILTON.

(Plates xxiii-xxv and 27 Text-figures.)

[Read 31st August, 1927.]

The endemic Angiosperm flora of Australia is, for the most part, strongly xerophytic, and this characteristic reaches its highest development in the Proteaceae, every species, even those growing in the coastal rain-forests, showing xerophytic adaptations in some degree, the genera *Isopogon*, *Petrophila*, *Grevillea*, *Hakea*, *Banksia* and *Dryandra* being highly specialized in this direction.

Most of the recognized devices for checking transpiration are found in the plants of this family—alteration of the orientation of the leaf, reduction of leaf surface, thickening and cutinization of the epidermis, occurrence of hypoderm, sunken stomates, palisade cells in two rows and closely packed, reduction of intercellular spaces, larger water-carrying vessels than in mesophytes, an enormous development of sclerenchyma and the presence of tannin in considerable quantities. In some species the leaf margin is recurved so as to form, with the midrib, two parallel grooves, which are lined with hairs. The stomates are placed in these grooves, and the hairs not only protect against heat, but check transpiration by surrounding the stomates with a still atmosphere saturated with water vapour. In another group of species the stomates are placed in balloon-shaped cavities on the underside of the leaf; these cavities are lined with hairs, the filiform extremities of which form a plug to the orifice, thus preventing the free interchange of air.

Reduction of leaf-surface is very common, but it is not carried to the extreme of actual leaflessness as it is in many other families. Most species have a coating of two-armed hairs in the juvenile stage of the leaf, but as a rule the arms drop off as the leaf develops, leaving the base embedded in the thickening epidermis. But no species has a dense coating of hair persisting throughout the life of the plant as in the South African *Leucadendron*. *Adenanthos cygnorum* is the only Australian Protead I know which has a permanent coating of hair, and it is much thinner and woollier than *Leucadendron*. Some of the Grevilleas have a dense coat of hair on the underside of the leaf, which is persistent.

Most of the species have several of these adaptations in their leaves. Coatings of bloom, wax, varnish or hygroscopic salts are absent, so far as I know, in the Australian Proteaceae, and ethereal oils do not occur—indeed I am doubtful if the presence of these is a xerophytic adaptation, although many desert plants possess them. Secretory cavities are found in *Franklandia*, and I have recently seen cavities like oil-glands in a species of *Conospermum*.

The conditions causing xerophytism are many—excessive heat, intense light, small rainfall, drying winds, great cold, hot water, as near volcanic springs, light

or poor soils or those containing salt or other substances injurious to plant life (as vegetable acids derived from humus) are all concerned in bringing about these adaptations.

Some xerophytes, when grown in moist conditions, respond by producing foliage of a mesophytic type, probably a reversion to ancestral form, as in the well-known case of *Ulex Europaeus*. But the Proteaceae have their characters so firmly fixed that they do not alter even under the most favourable circumstances. Alterations do certainly occur, but very rarely. For instance I once found a plant of *Hakea pugioniformis* growing on a sand-dune almost at the edge of the sea, which had the leaves greatly thickened and succulent; but this was merely adding another xerophytic character to those already possessed by the plant.

Mr. L. Rodway, Government Botanist of Tasmania, in a letter informs me that the Tasmanian Proteaceae grow in any soil, wet or dry and in any physical or chemical condition. "*Banksia marginata* grows in any soil, wet or dry, and in any chemical or physical condition. *Hakea lissocarpa*, *H. macrocarpa*, and *H. epiglottis* are almost marsh plants. *H. pugioniformis* will struggle along in dry places but prefers plenty of moisture. *Grevillea australis* grows in wet places at a high altitude. In fact, with the exception of *Persoonia juniperina*, which prefers sandy heaths, the Tasmanian Proteaceae flourish in wet places." Yet in the material which Mr. Rodway sent me I can detect no modification or diminution of the xerophytic characters. Probably the soil conditions and the presence of vegetable acids account for the retention of these characters, but I am inclined to think it is due to heredity—the characters have been so long fixed that no alteration in environment will affect them.

I saw a notable instance in *Banksia integrifolia*, growing in the rich basaltic soil of a gully between Mt. Wilson and Mt. Irvine. In the sandy soil near the coast the tree has cuneate leaves not more than six inches in length, the margin usually entire, but sometimes slightly serrate. The upper surface is smooth and dull green. So far as I have seen the trees in this habitat rarely exceed thirty feet in height. But at Mt. Wilson they are at least seventy feet high. In full grown trees the leaves are similar to those of the coast tree, but in young trees from ten to twelve feet in height they are lanceolate, eighteen inches long, very dark green and shining on the upper side, and have a strongly serrated margin. This is the most remarkable instance of alteration brought by environmental change that I have seen but it was an alteration in external form only—sections of the leaves showed the characteristic structure of the coast plant.

In *Hakea trifurcata* and several other species with terete leaves, the plants bear reversionary leaves in their ordinary habitat. The bulk of the leaves are terete, but the plants have large numbers of flat leaves up to three inches in length, and elliptical to spatulate in shape. This is not due to any change of environment, for in their native habitat the flat leaves are just as numerous as they are under cultivation.

Professor J. B. Cleland some years ago showed me a very peculiar example of alteration in a plant of *Hakea vittata* which he had grown from seed in his garden. The plant at first had terete leaves, but after a time flat leaves appeared, which seems to be the opposite of what one would expect. *Hakea orthorrhyncha* also shows a considerable amount of variation, as will be seen later. But the altered leaves in every case are just as xerophytic in structure as the ordinary leaves and show no approach to the structure of a mesophytic leaf.

Notwithstanding their very perfect adaptation it is very noteworthy that the Proteaceae are very sparsely distributed in the arid and semi-arid regions of Australia, both in regard to species and individuals. For instance, in the Broken Hill district only three of the family have been found, and these in small numbers, while the apparently less efficiently protected Eucalypts, Acacias, Eremophilas and Salt-bushes are numerous both as to species and individuals. The same paucity of Proteads is noticeable all over Central Australia. It is also remarkable that these members of the family which are most highly specialized (such as *Banksia* and *Dryandra*) do not occur in these dry regions. The stronghold of the family is the belt of well-watered country bordering the Continent, and possessing a sandy soil. It therefore seems to be the edaphic factor which governs the distribution of the Proteaceae—they require a highly siliceous soil.*

Mr. E. Cheel has recorded⁽³⁾ the presence of what may be possibly mycorrhizae on the roots of some of these plants, and if this is correct it is probable that it accounts for their scarcity in the dry interior—the fungi may not be able to grow under these extreme conditions.

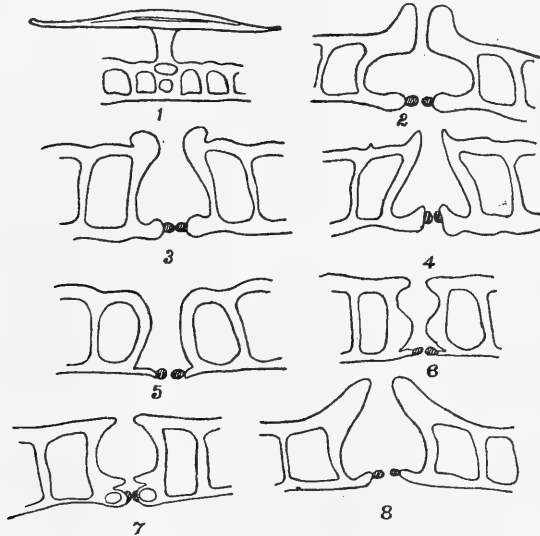
Genus HAKEA.

For the purpose of this paper, the Hakeas may be divided into two groups—those with flat and those with terete leaves. Both groups contain species with entire and with divided leaves. As before noted in some species it is common to find both on the same plant. There are a few species which fall between the two main groups; they are flattened but very narrow. These I shall deal with among the terete species.

The flat-leaved species have a vertical orientation, and are all centric. A few, as *H. cucullata* and *H. auriculata*, are not vertical, but the structure is also centric. The leaves are thick (but in varying degree), flat and leathery. The margin may be entire or toothed, and in the latter case the tooth ends in a prickle formed by the vein running through it. A few, as *H. ceratophylla*, have divided leaves. The surface of the leaf is generally dull, but there is no coating of bloom, wax or varnish, even on the young leaves. There are only a few species with a persistent coating of hairs, and that is very sparse, but all are hairy in the juvenile stage. The hairs are T-shaped (Text-fig. 1), the pedicel being very short. They are thick-walled, with a very narrow lumen, and are silvery or ferruginous in colour. The arms drop off early in the life of the plant, but the pedicel persists and later becomes embedded in the epidermis. In a paper on *H. dactyloides*⁽⁶⁾ I spoke of these as capitate hairs, but further investigation showed their real nature. Solereder⁽⁷⁾ says that these hairs are probably found in every species of *Hakea* and *Grevillea*, and my experience confirms that opinion, as I have found no species of either of these two genera without them. The epidermis is thick, with highly cutinized cuticle, the thickness increasing with age. The thickness of the epidermis varies from 0.02 mm. in *H. undulata* to 0.103 mm. in *H. incrassata*. The cuticle is from 0.003 in *H. undulata* to 0.04 mm. in *H. ceratophylla*. The

* Since this was written, I have read the recent paper by McLuckie and Petrie, "An Ecological Study of the Flora of Mount Wilson, Pt. iv" (These PROCEEDINGS, 1927, pp. 161-184) in which the authors state that the main contributing factor in xerophytism is the low water-retaining capacity of light sandy soil, and on consideration, I think that this is probably the case. It must be remembered, however, that in no locality, so far as my experience goes, are Proteads plentiful on non-sandy soil, wet or dry, while on the other hand, they are found in numbers on sandy soils which are always wet and even swampy.

lateral walls of the cells are thin and the cavities are usually empty, but sometimes contain crystals of calcium oxalate, tannin, or in a few cases, a substance staining faintly with picric-anilin blue. The outer surface of the cuticle is often ridged and there is sometimes a ridge-like thickening in the lateral walls of the cells surrounding the orifice of the air-chamber above the guard cells (Plate xxiii, fig. 1). The cells which lie round this cavity (which I shall call the vestibule) in many species project above the general surface of the leaf; there is thus formed a crater-like opening to the stomata. Hypoderm, in the ordinary sense of the word, does not occur, but in a few species a sheet of sclerenchymatous fibres lies just under the epidermis. The vestibule may be bell, dome, funnel, or hourglass shaped (Text-figs. 2-8). In *H. corymbosa* it is hourglass shaped, and Solereder⁽⁷⁾ says that in *H. cyclocarpa* it is double-funnel shaped (Text-fig. 5), but in my sections it is cylindrical, somewhat constricted in the middle, but not so much as to be hourglass shaped. In *H. cucullata* I observed a few much constricted in the middle (Text-fig. 7), but the majority were the usual type. The guard-cells are at the bottom of the vestibule on a level with the top of the palisade cells.



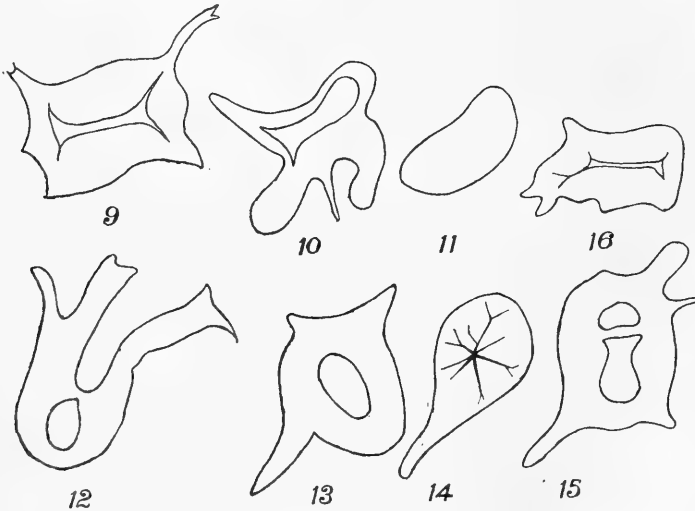
Text-figures 1-8. 1. Two-armed hair. 2-8. Vestibules of stomata. 2, *H. macrocarpa*; 3, *H. Hookeriana*; 4, *H. arborescens*; 5, *H. amplexicaulis*; 6, *H. megalosperma*; 7, *H. cucullata*; 8, *H. linearis* and *H. ruscifolia*. The figures are diagrammatic.

The vascular bundles run through the central region; they are often prominent on the lower or on both sides of the leaf. They vary considerably in number, size, position in the mid-region, and in the amount of sclerenchyma fibres which accompany them. In most species the conducting tissue is in very small proportion to the sclerenchyma fibres which enclose it.

The most characteristic feature of the leaves of the genus is the enormous development of sclerenchyma. It occurs in three forms—fibrous, columnar, and massive. Fibrous sclerenchyma is found in every member of the genus. It usually occurs in connection with the vascular bundles, a strand running along the upper and lower sides of the bundles, and in some cases all round. Sometimes a sheet

of fibres just under the palisade, a feature in which they resemble the *Banksias*. The large amount of sclerenchyma has a very marked stiffening effect on the leaf.

The columnar variety is almost general in the genus, a few exceptions occurring among both flat and terete leaved species, but in some of the flat-leaved forms there are only a very few columns. The columns are cylindrical, spreading out at the top and bottom like the base and pediment of a pillar (Text-fig. 17). In some species the extensions are so wide that they form an almost continuous sheet between the palisade and the epidermis (Text-fig. 19), and sometimes spikes or pegs grow up from this through the lateral walls or even through the cavities of the cells (Text-fig. 19). At the lower end they often send off root-like processes, which penetrate the mid-region and sometimes unite with the outer row of storage cells, thus thickening their walls very considerably. Some of the massive sclereides (when they occur among the palisade cells) appear to be derived from the columns of secondary growth but those in the mid-region are of independent origin. They are of irregular and extraordinary shapes (Text-figs. 9-16). The amount of sclerenchyma in the leaves of the *Hakeas* is very large—some species as much as 50%, and in *H. multilineata* and *H. obtusa* even more.



Text-figures 9-16. Forms of detached sclereides. 9-13 and 16, *H. corymbosa*; 14 and 15, *H. cucullata*.

There are several distinct types of leaf structure although there is a general resemblance all through the flat-leaved *Hakeas*. Solereder⁽⁷⁾ quotes Jönsson's classification of the leaf structure of the Proteaceae from which the following is an extract.

- I. *Hakea*-type. Leaf structure centric; sclerenchyma cells in palisade tissue. Species of *Adenanthos*, *Grevillea*, *Hakea*, *Isopogon*, *Molloya*, *Petrophila*, *Roupala*, and *Stenocarpus*.
- II. *Isopogon*-type. Leaf structure centric; ordinary sclerenchyma cells. Species of *Bellendena*, *Hakea*, *Isopogon*, *Leucadendron*, *Nivenia*, *Sorocephala* and *Xyloneium*.
- V. *Synaphea*-type. Leaf centric; sclerenchyma of the vascular bundles vertically transcurrent. Species of *Hakea* and *Synaphea*.

There are, however, many other differences among the various species of flat-leaved *Hakea*, and I propose to arrange them according to these peculiarities, as follows:

Group I. Species with thick leaves; palisade in two rows; central region with thick-walled cells; columnar and fibrous sclerenchyma both present (Plate xxiv, fig. 1).

H. macrocarpa A. Cunn. The leaf in this species is thick and smooth. Bentham⁽¹⁾ says "Minutely pubescent on both sides", but I have not been able to detect pubescence in the mature leaves in herbarium specimens. In sections, however, the persistent bases of the hairs are seen embedded in the epidermis. The leaf is 0.52 mm. thick, in the thinner places between the veins, and 0.84 mm. at the prominent midrib.

The epidermis is 0.05 mm. and the cuticle 0.03 mm. The lateral walls of the cells are thin and they often contain tannin. There are stomates on both sides, and the epidermal cells surrounding the stomatal opening are slightly raised above the general surface of the leaf. The vestibule is dome shaped (Text-fig. 2) and is 0.06 mm. wide, and the guard cells are at the level of the top of the palisade cells. There are two rows of palisade cells with a total depth of 0.16 mm., and they are closely packed except where they open out in an air-chamber under the guard-cells. The lower row is continuous under the air-chamber. The mid-region is from 0.24 to 0.28 mm. across and is made up of thick-walled cells frequently containing starch and sometimes tannin. Columnar stereides run through the palisade; they are slender and rather sparsely distributed; they spread slightly under the epidermis and send out root-like processes which coalesce with the walls of the outer layer of storage cells beneath, thickening them very much (Text-fig. 17).

Five large veins run through the mid-region, accompanied on both top and bottom by narrow strands of sclerenchyma fibres, the diameter of the whole bundle being 0.4 mm., while the conducting part of the vein is 0.3 mm. On the ventral side the cord of fibres is not so thick as on the dorsal. Besides these five veins there are many smaller ones just beneath the palisade on the ventral side; these have no accompanying strand of sclerenchyma.

H. arborescens R. Br. This has rather a thick leaf, ranging from 0.56 to 0.7 mm. The epidermis is ridged; on the greater part of the leaf it is 0.04 mm. thick, but on the margin it thickens up to 0.07 mm. The cuticle is 0.016 to 0.04 mm. thick, and is highly cutinized. The vestibule is conical (Text-fig. 4) and does not project above the general surface of the leaf; it is 0.03 mm. wide. The palisade is in two rows and has a total depth of 0.16 mm. There is a great development of sclerenchyma. The columnar stereides are 0.02 mm. thick, and spread out slightly at the top; they send out root-like processes at the base but these do not unite with the walls of the storage cells as they do in some other species (Text-fig. 22 and Plate xxiii, fig. 2). The central region is 0.24 to 0.26 mm. wide, and consists of thick-walled cells, many filled with tannin in which starch grains are embedded. The veins are numerous but small, the largest being 0.3 mm. in diameter and the conducting tissue 0.16 mm., but the majority are much smaller than this.

H. cyclocarpa Lindl. Leaf thick, 0.64 mm., epidermis 0.04, and cuticle 0.02 mm. The palisade is in two rows, closely packed and 0.14 mm. deep. The central region is made up of thick-walled cells and is 0.14 mm. across. The veins are small and sub-equal, 0.2 mm. in diameter and the conducting tissue 0.12 mm. There are many columnar sclereides spreading out beneath the epidermis and

above the central region. Throughout the central region there are many bundles of sclerenchyma fibres apart from those capping the veins.

H. Roeii Benth. Leaf thick, 0.74 mm. Epidermis 0.06 mm., and the cuticle 0.04 mm.; vestibule 0.18×0.14 mm., with the edges of the orifice projecting above the surface of the leaf. The palisade is two rows 0.16 mm. deep and the cells 0.018 mm. in diameter. The columnar stereides are very numerous, and spread a little at the top and bottom, the outgrowths uniting with walls of the storage cells of the middle region (Text-fig. 22). This last is 0.42 mm. deep and is composed of thick-walled cells, many filled with starch and a few with tannin scattered irregularly about. The vascular bundles are numerous but small, the midrib being very little larger than the others; it is 0.32 mm. in diameter and the conducting tissue 0.14 mm. They all have caps of sclerenchyma on both ends and these extend laterally so that the bundles are almost entirely enclosed. Just beneath the palisade (but separated from it by a single layer of thick-walled cells) there are many bundles of sclerenchyma fibres.

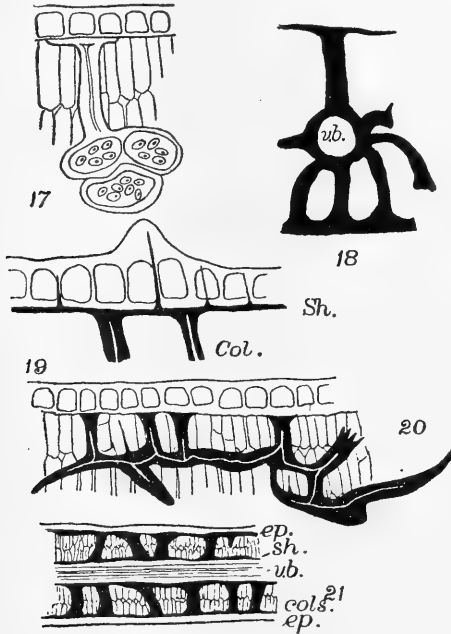
H. Hookeriana Meiss. Leaf thick, 0.72 mm., the epidermis 0.04 mm., and the cuticle 0.02 mm. The vestibule is bell-shaped (Text-fig. 3) and 0.06×0.04 mm. There are two rows of palisade cells with a total depth of 0.24 mm. The columns are numerous and spreading at top and bottom. At the base they form irregular masses, penetrating the mesophyll. This last consists of thick-walled cells, but not so thick as in the preceding species; it is 0.3 mm. across. The veins are few and very small, the largest being only 0.06 mm. in diameter and the conducting tissue 0.04 mm.

H. incrassata R. Br. The leaf is 0.74 mm. thick, with a smooth surface. Epidermis 0.05 mm. and cuticle 0.01 mm. thick. Palisade in two rows, 0.14 mm. deep. The medullary tissue is 0.28 mm. across and made up of thick-walled cells, very many filled with starch or tannin. The columnar stereides are very numerous and closely spaced; they often join at the base. Bundles of fibres lie almost continuously under the palisade, but separated from it by a layer of storage cells. The veins are few, their long diameter is 0.36 mm. and the conducting bundle 0.08 mm.

H. flabellifolia Meiss. The leaf of this species resembles that of *H. Brownii* closely both in external form and in internal structure. The veins are, perhaps, a little less in diameter, and the epidermis a little thicker. The leaf is 1.6 mm. thick; the epidermis 0.08 mm. and the cuticle 0.02 mm. The palisade is in two rows, the cells rather slender with a depth of 0.18 mm. The central region is composed of thick-walled cells, many filled with tannin, it is 0.32 mm. across. The veins are rather small, 0.28 mm. in diameter and the conducting tissue 0.14 mm. There are numerous columns but perhaps not so many as in *H. Brownii*, and they do not spread out so much at the top and bottom as in that species.

H. Brownii Meiss. The leaf is very thick, 0.92 to 1 mm., the epidermis 0.06 and the cuticle 0.02 mm. The vestibule is conical and rather wide (Text-fig. 4). The palisade is in two rows and closely packed. It is 0.2 mm. deep. Thick-walled storage cells occupy the midregion which is 0.4 mm. across; many of these cells are filled with tannin. The veins are 0.5 mm. in diameter and the conducting tissue is 0.2 mm. A very large number of stereides traverse the palisade so that at least 50% of that region is composed of sclerenchyma. The tops and bases of these spread out a good deal so that there is a continuous sheet under the epidermis in places. Here and there small masses of sclerenchyma develop in the cavities of the epidermis (Plate xxiii, fig. 4).

H. Baxteri R. Br. The leaf is 0.74 mm. thick, with a smooth surface but the cells round the orifice of the vestibule project above the surface. The epidermis is 0.07 mm. and the cuticle 0.025 mm. thick. The vestibule is bell-shaped and is 0.06 × 0.08 mm. The air-chamber beneath the guard cells goes the full depth of the two palisade layers, which have a total depth of 0.12 mm. The middle of the leaf is occupied by thick-walled cells; it is 0.32 mm. wide; many of the cells are



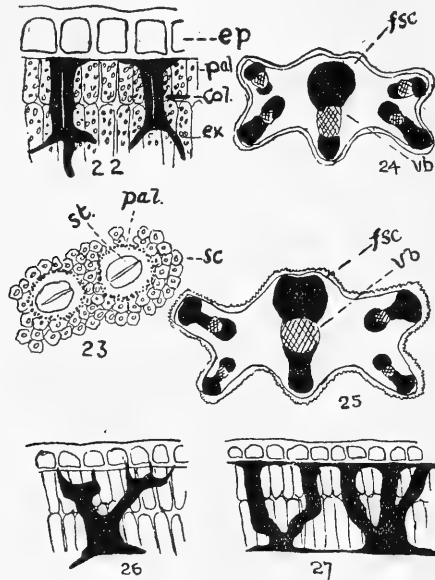
Text-figure 17. Extension of base of column thickening walls of storage cells. 18. Section perpendicular to axis of vein, bases of columns enclosing vascular bundle. 19. Spike-like extensions from sclerenchyma penetrating the epidermis; *H. ruscifolia*. 20. *H. ambigua*, columns sending root-like extensions between the two rows of palisade cells. 21. Section parallel to plane of leaf, *H. amplexicaulis*, column extensions enclosing vascular bundle. The figures are diagrammatic.
 ep. = epidermis, vb. = vascular bundle, col. = columnar sclereides, sh. = sheet of sclerenchyma formed by coalescence of tops or bottoms of columnar sclereides.

full of starch or tannin or both. A few thick veins run through this part, 0.4 mm. in long diameter, the conducting tissue being 0.24 mm. The columnar sclereides are not numerous; they spread out at the top, forming a sheet under the epidermis; at the base they send down extensions into the mid-region and these frequently coalesce with the storage cells of the outer layer, thickening them very much.

H. ceratophylla R.Br. This species is notable for the extreme range of shape in the leaf, which is divided. It is 0.9 mm. thick, with a slightly ridged surface. The epidermis is 0.06 mm. and the cuticle 0.04 mm. in thickness. The vestibule is conical and slightly depressed below the leaf surface; it is 0.02 mm. × 0.04 mm. The palisade is in two rows, the cells rather slender, and it has a total depth of 0.16 mm. The medullary tissue is 0.5 to 0.54 mm. thick, and consists of thick-

walled cells which are filled with starch, those surrounding the veins are full of tannin (Plate xxiii, fig. 3). The stereides are thick—0.04 mm. They expand at the top, forming a sheet under the epidermis and the lower extremities unite with the upper layer of storage cells. The vascular bundles extend from the upper to the lower epidermis, and are heavily capped with sclerenchyma fibres on both sides.

H. Candolleana Meiss. This species has narrow leaves varying from 1 to 4 mm. in width, but the structure is identical in each. The leaf is 0.44 mm. thick, epidermis 0.07 mm. and the cuticle 0.025 mm. The vestibule is narrow and conical.



Text-fig. 22. *H. amplexicaulis*, root-like extensions of columnar stereides. 23. *H. pandanicaarpa*, section parallel to plane of leaf showing arrangement of palisade, and sclerenchyma round the stomates. 24. *H. pycnoneura*, sectional outline of leaf showing arrangement of veins and bundles of sclerenchyma fibres. 25. *H. Morrisonianum*, section of leaf, showing arrangement of veins and bundles of sclerenchyma fibres. 26 and 27. *H. ambigua*, branching columns. (All diagrammatic.)

col. = columnar stereides, ep. = epidermis, ex. = root-like extensions, fsc. = fibrous sclerenchyma, pal. = palisade, sc. = sclerenchyma fibres, st. = stomate, vb. = vascular bundle.

There are two rows of palisade, 0.14 mm. deep. The central region is made up of thick-walled cells containing much starch, and very many tannin filled, it is 0.6 mm. across. The mid-vein is 0.24 mm. in diameter, and the conducting tissue 0.14 mm. Unlike most of the other species the sclerenchyma caps do not encroach on the palisade. The minor and marginal veins are just beneath the palisade, but the mid-rib is midway between the upper and lower layers. The marginal vein has a thick strand of sclerenchyma fibres below, and a little to one side. There are many slender columns which have extended bases but do not spread at all at the top. More than twenty bundles of sclerenchyma are found beneath the palisade tissue.

H. falcata R.Br. The leaf is from 0.6 to 0.65 mm. thick with a ridged epidermis, the latter 0.08 mm., and a rather thin cuticle, 0.02 mm. The vestibule is dome-shaped 0.05 mm. wide; the surrounding epidermal walls do not project above the leaf surface. The palisade is very closely packed and is 0.14 mm. deep. The central region is 0.2 to 0.25 mm. across; some of the cells are pitted. The middle vein is 0.5 mm. and the conducting tissue 0.3 mm. There are not many columns.

H. pycnoneura Meiss. This species and the next resemble *H. florida* and *H. falcata* in the hardness of their leaves but they are also remarkable for their sectional outline (Text-figs. 24 and 25). Their leaves resemble those of some of the Grevilleas, and so far as my experience goes, they stand alone amongst the Hakeas. The leaf of this species is 0.66 mm. thick, and carries a great many two-armed hairs, the arms of which drop off while the bases persist and become embedded in the epidermis. The epidermis is very deeply ridged and the cavities of the cells large; it is 0.06 mm. thick and the cuticle 0.02 mm. The palisade cells are very tightly packed and only 0.1 mm. deep. The central region is 0.32 mm. wide, the cells are very thick-walled, a few contain tannin. There is a large central vein with a heavy capping of sclerenchyma on the dorsal side. This and the next species differ from the majority of Hakeas in having no columnar sclereides.

H. Morrisonianum. The central flat part of the leaf is 0.4 mm. thick, while the dorsal and ventral lobes on each side are 0.48 mm. and 0.44 mm. respectively. The epidermis is 0.08 mm. thick, thinner on the lobes, and thickly covered with T-shaped hairs in the juvenile stage. The vestibule is narrow-conical, 0.02 mm. wide and projects above the surface. The central region is 0.16 to 0.24 mm. wide, and made up of very thick-walled cells. The palisade is not deep—0.1 mm.—and is very closely packed. The veins extend from the floor of the upper epidermis to that of the lower, and are very heavily capped with sclerenchyma fibres, the conducting tissue being barely 0.1 mm. As in the last species, there is a central vein and one in each lobe.

H. florida R.Br. Leaf 0.34 mm., epidermis 0.04 mm., cuticle smooth, 0.016 mm., vestibule not projecting, broadly bell-shaped, 0.04 mm. wide. Palisade in single row 0.1 mm. deep. Cells of central region not as thick as in most other species, 0.1 mm. in diameter. Middle vein 0.5 mm. across and the conducting tissue 0.3 mm.; the marginal and smaller veins being lightly capped with sclerenchyma.

H. pandanicarpa R.Br. This is a very remarkable species, having an arrangement of the palisade and stereides that I have found in only one other species. The leaf is thick—0.92 to 0.96 mm.; the epidermis 0.03 mm. and the cuticle 0.02 mm. The orifice of the narrow bell-shaped vestibule does not project above the leaf surface. The palisade is in two rows, 0.24 mm. deep. The medullary tissue is 0.32 mm. across and consists of thick-walled cells, many containing starch, and a few near the middle filled with tannin (Plate xxv, fig. 3). There are a great many stereides, rather slender, 0.02 mm., spreading a little at the top, and much more at the base, with root-like extensions which often penetrate the mid-region. The storage cells of the outer layer have their walls much thickened by union with these. The veins are few and small, they are capped with bundles of sclerenchyma on both sides.

The remarkable feature of the leaf is the arrangement of the sclereides and palisade in relation to the stomates. Under each stomate there is a cylindrical cavity or air-chamber, surrounded by one row of palisade cells; outside this there

is a circle of columnar stereides two or three rows deep, the tops and bottoms extending so as to touch each other, while the slender shafts leave openings for the free interchange of gases (Text-fig. 23). This is the most elaborate provision against excessive transpiration that I have seen in the Hakeas (Text-fig. 23 and Plate xxiv, fig. 2). It occurs only in this species and in *H. clavata*.

H. clavata, Labill. This species does not fit into any of the groups in which I have arranged the Hakeas, but I have placed it here on account of the arrangement of the stomates, palisade, etc., this being similar to that of *H. pandanicarpa* (Plate xxiv, fig. 2). There is, in the herbarium of the Sydney Botanic Gardens, an undetermined species collected by the late Mr. J. H. Maiden at Esperance, W.A., which has the same structure, but as it has no point of difference except a much shorter leaf, I have no doubt but that it is the same species.

The plant has very thick leaves closely resembling those of *Petrophila linearis*; they are 3.2 mm. thick, epidermis 0.04 mm. and cuticle 0.02 mm., vestibule bell-shaped, 0.06 mm. wide, palisade in two rows 0.32 mm. wide. The central region is 2.48 mm. across and is composed of very thin-walled cells (Plate xxiv, fig. 3). It is difficult to say that there is any chlorophyll in them; only herbarium material was available. At the base of the palisade cells some of the central cells stained a faint blue which might indicate chlorophyll. These thin-walled cells are much larger than the thick-walled cells of this group, ranging from 0.06 to 0.15 mm. in diameter. Bentham describes the leaf as veinless, but there are a few veins, very small and narrow, and with very little xylem. They are distributed just under the palisade, and one is in the centre. There is no sclerenchyma anywhere in the mid-region.

H. obtusa Meiss. Bentham⁽¹⁾ says: "The young shoots silky-tomentose, the adult foliage glabrous". But in the specimens seen by me, the old leaves were slightly hairy. This species might almost be placed in a section by itself, as the mesophyll is composed of very thick-walled cells unlike those of any other species (Plate xxv, fig. 2). This makes it extremely hard, and very difficult to section without breaking up.

The leaf is 0.6 mm. thick, the epidermis 0.06 mm., and the cuticle rather thick—0.04 mm. The palisade is in two rows, 0.14 mm. deep. The thick-walled cells of the mesophyll are rather longer than broad, the long axis being perpendicular to the plane of the leaf; the small cavities being sometimes filled with tannin and sometimes with a substance staining faintly with picric-anilin blue; this region is 0.28 mm. across. The main vein is 0.6 mm. in diameter and the conducting tissue 0.06 mm. The marginal vein is heavily capped with sclerenchyma. There are very few columnar sclereides, and those there are seem to arise from the sclerenchyma of the central region and grow outwards towards the epidermis through the palisade layer.

Group II. Leaves rather thinner than in the previous group; palisade in one row (except in *H. marginata*); cells of mid-region elongated or rounded, and containing chlorophyll (Plate xxv, fig. 4.)

H. megalosperma Meiss. The leaf is rather thick, 0.5 mm., the epidermis 0.05 mm., ridged, cuticle 0.02 mm. The vestibule opens widely and is constricted in the middle (Text-fig. 6). The palisade is in two rows and is 0.12 mm. deep. The veins are small and sub-equal, 0.22 mm. in diameter, with conducting tissue 0.12 mm. There are many columns and they spread widely at the base and apex; where they are over a vein they almost enclose it.

H. amplexicaulis R. Br. Leaf 0.4 mm. thick; epidermis 0.04 mm., smooth, the lateral walls ridged like those shown in Plate xxiii, fig. 1; cuticle 0.02 mm.; vestibule a narrow reversed funnel, and depressed (Text-fig. 5). Palisade in one row 0.1 mm. deep; central region 0.12 mm. across, made up of thin-walled cells containing chlorophyll. There is a midrib 0.68 mm. in diameter, the conducting tissue being 0.5 mm., and a number of smaller veins. The columns are numerous and spreading at the top and much more at the bottom. Over the veins the extensions come into contact with each other and form a sheath to the vein (Text-figs. 18 and 21).

H. glabella R. Br. The leaf is 0.4 to 0.5 mm. thick, the epidermis is 0.04 mm., and the cuticle 0.02 mm.; the vestibule is shallow and cylindrical, and the surrounding cells project above the leaf surface. The palisade is in one row and is 0.1 mm. deep; the central region is 0.12 mm. across. The columns of sclerenchyma are few and spread at the top but not at the base. There is one main vein, 0.56 mm., lightly capped with fibres, and a number of smaller ones, each of which has a bundle sheath, a feature not common in Hakeas.

H. cristata R. Br. The leaf is 0.52 mm., slightly ridged, epidermis 0.06 mm., and cuticle 0.02 mm. The palisade is in one row 0.16 mm. deep; the central region 0.1 mm. across. The stereides spread at both ends and form a partial sheath to the vascular bundles.

H. linearis R. Br. The leaf is rather thin, 0.38 mm., epidermis 0.06 mm., and cuticle 0.02 mm.; the vestibule projects so as to form a cone round the orifice, as also in *H. ruscifolia* (Text-fig. 8). The palisade is in one row and 0.1 mm. deep; the central region is 0.12 mm. across. The columnar stereides spread out at the upper and lower extremities and form a sheath to the vascular bundles as in the last two species. The main vein is 0.32 mm. in diameter and the conducting vessels take up 0.24 mm. of this. The marginal veins are small and have a cap of fibres on the ventral, but none on the dorsal side; a good many tannin cells are near the veins.

H. ferruginea Sweet. Leaf thin, 0.26 mm., epidermis 0.04 mm., and cuticle 0.01 mm.; vestibule conical, 0.04 mm. wide; the palisade is in one row 0.08 mm. deep. The central region 0.1 mm. across. A rather unusual feature is the complete absence of columnar stereides, and there is very little fibrous sclerenchyma.

H. marginata R. Br. The leaf is of medium thickness, 0.42 mm., the epidermis 0.04, and the cuticle 0.01 mm. The vestibule is bell-shaped and does not project above the leaf surface. The palisade cells are in two rows with a total depth of 0.08 mm., and are very closely packed. The central region is 0.2 mm., and consists of thin-walled chlorenchymatous cells closely packed. The main vein is 0.4 mm. in diameter and is completely surrounded by sclerenchymatous fibres, the conducting vessels taking up 0.2 mm. of this. There is a strong marginal vein, also surrounded by sclerenchyma. The other veins are small and heavily capped with fibres on both faces. There are many columns in the palisade, and some irregular massive ones in the central region, some of the arms of which penetrate the palisade and take the form of columns.

Group III. Leaves thick or rather thin; palisade in two rows; medullary region occupied by chlorenchymatous cells arranged in an open network like the spongy tissue in mesophytic leaves (Plate xxiv, fig. 4).

H. auriculata Meiss. The leaf is 0.36 mm. thick (at the midrib it is 0.86 mm.), epidermis 0.04 mm., and cuticle 0.02 mm. Vestibule bell-shaped and depressed, 0.04 mm. wide. Palisade in two rows 0.16 mm. deep; central region 0.1 mm.

across. Midrib 0.68 mm. in diameter, the conducting tissue being 0.34 mm. The small marginal vein has no capping.

H. eriantha R. Br. The leaf is 0.4 mm. thick, epidermis 0.04 mm., cuticle 0.02 mm. Palisade in two rows 0.18 mm. deep. Central region 0.08 mm. across. The main vein is 0.38 mm. in diameter and the conducting tissue 0.16 mm. The columns are numerous and spread at the top and bottom; near the veins the bases enclose them.

The outstanding feature is the narrowness of the mid-region; the palisade and columns of each side almost meet at their bases.

H. lasiantha R. Br. The leaf is 0.44 mm. thick, epidermis 0.03 mm. The cuticle is very thin, 0.005 mm. The palisade is two-rowed, 0.1 mm. deep. The spongy chlorenchyma is 0.1 mm. across. The main vein is 0.54 mm. across, with a conducting tissue 0.3 mm. There are numerous columns, irregular in shape, and spreading both at top and bottom; sometimes the inner extensions entirely enclose a vein, especially the marginal vein.

H. ruscifolia Labill. Leaf 0.4 mm. thick, epidermis 0.04 mm., and cuticle 0.02 mm.; the walls of the vestibule are raised so as to form a conical projection above the surface of the leaf, rather higher on the ventral side than on the dorsal, the cavity being 0.02 mm. wide (Text-fig. 8). Palisade in one row, 0.1 mm. on the ventral side and 0.06 mm. on the dorsal. Medullary tissue a very open network 0.04 mm. wide. The central vein 0.16 mm. in diameter and the conducting vessels 0.08 mm. The smaller veins are narrowly capped as is the marginal vein.

The columnar sclereides are numerous, many of them curved; they all spread out at the apex and base. At the apex they form a continuous sheet under the epidermis, and from this sheet pegs or spikes grow up through the lateral walls of the epidermal cells and sometimes through the cavities (Text-fig. 19). At the base the columns also spread out, and where they are over a vein they coalesce to form a sheath enclosing it completely (Text-figs. 18 and 21).

H. saligna R. Br. Leaf 0.48 mm. thick, epidermis 0.03 mm., cuticle 0.01 mm.; vestibule conical, 0.02 mm. wide, and projecting very slightly above the surface of the leaf; palisade in one row 0.1 mm. deep; central region 0.2 mm. across, and made up of a rather closely packed network of cells, many, especially near the veins, being filled with tannin. Veins sub-equal, 0.36 mm. in diameter, the conducting tissue being 0.16 mm. De Bary, quoted by Solereder, mentions "the occurrence of solitary crystals in the epidermis", but I have never seen any in the sections I have examined, but I find that the occurrence of crystals is often sporadic, one leaf showing numbers while another from the same plant has none.

H. multineata Meiss. Leaf 0.38 to 0.4 mm., epidermis 0.08, and cuticle 0.04 mm. thick; vestibule bell-shaped, 0.03 mm. wide; palisade in one row, varying in depth 0.2 mm. at most. Medullary region 0.16 mm. wide, the cells small and very full of chlorophyll. The veins are sub-equal; the conducting tissue is only 0.2 mm. wide, while the bundles of sclerenchyma run out to the epidermis on each side with a total depth of 0.74 mm. The columns of sclerenchyma are numerous and very massive and irregular. Cannon⁽²⁾ says, "The sclerenchyma appears to be mainly or wholly fibrous", but in all the sections I have examined there are many columnar stereides. At the margin there is a fan-shaped strand of fibres enclosing a small vascular bundle. The characteristic feature of the leaf is the great quantity of mechanical tissue, at least 50% of the leaf substance being sclerenchyma. This makes it extremely difficult to cut sections. Probably the habitat of the plant—the arid regions—accounts for this.

H. laurina R. Br. This species, though growing in the semi-arid parts of Western Australia, is more mesophytic than any other I have seen, the greater part of the leaf being chlorenchyma. It is 0.36 mm. thick, the epidermis 0.04 mm., and the cuticle 0.01 mm. Vestibule, wide bell-shaped, 0.02 mm. wide. The palisade is in one row, 0.1 mm. deep; mid-region 0.1 mm. across, and made up of a rather close network of cells. One central vein 0.44 mm. across and the conducting tissue 0.12 mm.; the fibres of sclerenchyma almost surround the vein but between the edges there are a few thick-walled cells containing starch; the other veins are all small and have very little sclerenchyma, but the marginal bundle is entirely surrounded by sclerenchyma, the vessel bundle being 0.06 mm. in diameter. There are no columnar sclereides.

H. eucalyptoides Meiss. This variety has rather thinner leaves than *H. laurina*, and the midrib projects on both sides of the leaf considerably more. But in other respects it is quite similar.

According to Haberlandt,⁽⁴⁾ Hintz observed water-storage tissue in the leaf margin of various *Acacia*, *Quercus*, *Ilex*, and *Hakea eucalyptoides*. The opinion is expressed that "The margin, which is the region most exposed to damage by excessive loss of water, is provided with a local water tissue composed of a varying number of layers, although water-storage arrangements are altogether absent, or, at any rate, conspicuously less, in the rest of the leaf".

The cells referred to are cells between the sclerenchyma cap of the marginal vein and the epidermis, and they are found at every vein in most species. They are also found under the epidermis wherever the columns spread out to form a sheet at the apex. Haberlandt, however, elsewhere, refers to thick-walled cells as starch-storing tissue. As I have already said, these thick-walled cells may contain starch, tannin, and crystals, and it is quite probable that they may also function as water-storing tissue. But they differ much from the typical water-storing thin-walled cells.

H. corymbosa R. Br. The leaf is 0.32 mm. thick, epidermis 0.04 mm., and cuticle 0.02 mm.; the vestibule is dome-shaped and 0.06 mm. wide. The palisade is in one row, 0.08 mm. deep on the ventral side and 0.06 mm. on the dorsal. Medullary region a very close network, 0.1 mm. across. The middle vein is 0.5 mm. in diameter, and the conducting tissue 0.2 mm.; the caps of fibres extend to the epidermis on each side, but separated from it by a single row of thick-walled cells; the gap between the upper and lower bundles is filled by thick-walled cells containing starch. There are two smaller veins similar in arrangement to the midrib; the marginal vein is capped with fibres on the outside only. The peculiar feature of this species is that there are no columnar stereides, their place being taken by massive sclereides of extraordinary form in both palisade and medullary region (Text-figs. 9-13 and 16).

H. undulata R.Br. Leaf 0.34 mm. thick, epidermis 0.03 mm., cuticle 0.01 mm. Palisade in one row 0.08 mm. deep. Central region a rather loose network 0.16 mm. across. Middle vein 0.44 mm. and conducting tissue 0.16 mm.; there are besides a number of sub-equal veins all lightly capped with fibres; there are no columns but many irregular stereides in the medullary region some of which penetrate the palisade.

H. petiolaris Meiss. Leaf 0.36 mm. thick, epidermis strongly ridged, 0.06 mm., cuticle very thick, 0.04 mm., vestibule bell-shaped, the surrounding cells rising above the leaf surface, 0.06 mm. wide. Palisade in one row, 0.08 mm. on the ventral and 0.06 mm. on the dorsal side. Central region 0.14 mm. across. The

main vein is 0.76 mm. in diameter, and the conducting bundle 0.36 mm., the fibres completely surround the vessels. There are no columns or detached sclereides.

H. neurophylla Meiss. Leaf 0.32 mm. thick; epidermis ridged, 0.04 mm., cuticle 0.015 mm., the surrounding cells projecting above the leaf surface. Palisade one row 0.1 mm. deep. Medullary region 0.12 mm. wide, the cells closely packed. Principal vein 0.46 mm. the conducting vessels being 0.18 mm. There are no columnar or detached sclereides.

H. cucullata R.Br. In this species the leaves are wide, rounded, concave and arranged horizontally on the stem, but the structure is centric. Leaf 0.56 mm. thick, epidermis 0.08 mm. and cuticle 0.04 mm. In specimens from the Melbourne Botanic Gardens the surface is ridged, but in those from the Sydney Gardens it is quite smooth. The vestibule is bell-shaped but in a few instances it is constricted in the middle (Text-figs. 6-7) much as in *Dasytirion filifolius*, figured by Haberlandt.⁽⁴⁾ The palisade is one-rowed and is 0.08 mm. deep. The central region is 0.2 mm., the cells very full of starch. Main vein 0.48 mm., and conducting tissue 0.12 mm. The cap of fibres extends to the epidermis on each side, and is only separated from it by a layer of thick-walled cells; on each side of the conducting bundle and between the ends of the bundles of fibres there are about twenty thick-walled cells full of starch. The specimens from Melbourne Gardens have many irregular columnar sclereides sometimes penetrating deeply into the medullary region, especially where the section passed through an injury to the leaf. The specimens from the Sydney Gardens have no columns, but in the central region there are occasional detached sclereides.

H. conchifolia and *H. Victoriae*. These are generally considered to be varieties of *H. cucullata*; the structure is exactly similar.

H. ambigua Meiss. (Plate xxiii, fig. 2). The leaf is 0.56 mm. thick, epidermis 0.06 mm., ridged, cuticle 0.04 mm., vestibule bell-shaped. Palisade in two rows, 0.14 mm. on the ventral and 0.12 mm. on the dorsal side. Central region 0.12 mm. across, the network rather close. The principal vein is 0.5 mm. across and the conducting tissue 0.14 mm.; the whole bundle, as in *H. petiolaris*, is entirely enclosed by sclerenchyma. The columns are few, they branch in an extraordinary manner, sending out horizontal arms between the two rows of palisade and from these upright processes grow between the cells of the palisade like candelabra (Text-figs. 26 and 27).

H. plurinervia F.v.M. Leaf 0.32 mm., epidermis 0.02 mm. and cuticle 0.01 mm. Palisade in one row 0.06 mm. deep. Central region 0.06 mm. Vein 0.38 mm., the conducting tissue being 0.16 mm. There are no columnar or detached sclereides.

H. dactyloides Cav. I have described this species in These PROCEEDINGS,⁽⁵⁾ and there is nothing to add except to correct the mistake I made in calling the persistent bases of the two-armed hairs capitate hairs. A noteworthy point is the extraordinary massive sclereides, figured in the paper.

H. oleifolia R.Br. Leaf 0.34 mm. thick, epidermis 0.04 mm. and cuticle 0.01 mm., vestibule wide, bell-shaped, 0.06 mm. wide. Palisade one row, 0.06 mm. deep. Central region 1 mm. across. Vein 0.36 mm. in diameter, conducting tissue 0.24 mm. This species is chiefly remarkable for the absence of columns and the very small strands of sclerenchyma. It is, like *H. laurina*, very mesophytic in type.

H. stenocarpa R.Br. Leaf 0.38 mm. thick; epidermis 0.06 mm., cuticle 0.03 mm. Palisade in one row, 0.01 mm. deep; central region 0.1 mm. across. The chief feature is the great development of fibrous sclerenchyma round the midrib. It

is 0.84 mm. vertically and extends 1.3 mm. horizontally, the conducting tissue being 0.28 mm. There are no columnar stereides.

H. varia R.Br. The leaf is 0.54 mm. thick; epidermis 0.06 mm., cuticle 0.02 mm., the vestibule narrow bell-shaped with the cells surrounding the orifice projecting to a height of 0.06 mm. above the surface of the leaf. Palisade in one row, 0.12 mm. deep. Medullary region 0.1 mm. across. Centre vein 0.42 mm. in diameter, the conducting tissue being 0.22 mm. There are many columns which spread out at the apex and base so as to form sheets under the epidermis and above the central region.

The variety *H. intermedia* is identical in structure with *H. varia*.

H. nitida R.Br. Leaf 0.54 mm., epidermis 0.06 mm., cuticle 0.02 mm., vestibule cylindrical but slightly constricted in the middle so as to resemble a dice box, 0.03 mm. wide. Medullary region 0.1 mm. across. The veins are 0.36 mm. in diameter, the conducting tissue being 0.28 mm. The columnar stereides are slender and irregular, the bases extending into the central region.

I have examined an undescribed species in the Sydney National Herbarium, collected by the late J. H. Maiden at Esperance, W.A. It has the ordinary type of structure, the leaf measurements being: Leaf 0.5 mm., epidermis 0.04 mm., cuticle 0.02 mm., palisade one row, 0.18 mm., medullary region 0.12 mm., rather loosely packed, veins 0.35 mm., and conducting tissue 0.14 mm. The columnar stereides are slender and not spreading at the base or apex.

I have not been able to procure specimens of the following species:—*H. stenophylla*, *H. trineura*, *H. stenocarpoides*, *H. cinerea*, *H. loranthifolia*, *H. smilacifolia* and *H. carina*. There are also a few more recently described species which I have not seen.

I am much indebted to the late Professor A. A. Lawson, Professor T. G. B. Osborn, Professor Adamson (who examined all my sections), and Dr. J. McLuckie for valuable advice and assistance; to the late Mr. J. H. Maiden for access to the National Herbarium; to Messrs. L. Rodway, E. Cheel, F. Blakely, C. T. White, J. Audas, C. A. Gardner, O. H. Sargent, J. Steedman and C. G. Hamilton for material; and to Mr. F. Booker for photographing illustrative sections, and assistance in preparing text-figures.

Literature.

Solereeder gives a comprehensive bibliography (although he omits the Australian papers on the subject), but many are theses or dissertations, and no copies could be traced in the Sydney libraries.

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EXPLANATION OF PLATES.

Plate xxiii.

1. Vestibule of stomate showing thickenings in wall of orifice.
2. Root-like extensions of columns in *H. ambigua*.
3. Veins surrounded by cells containing tannin, *H. ceratophylla*.
4. Sclerenchyma spreading into epidermis, *H. Brownii*.

Plate xxiv.

1. Thick-walled cells occupying the mesophyll, *H. Brownii*.
2. Section parallel to plane of leaf showing arrangement of palisade and sclereides round cavity beneath stomate, *H. pandanycarpa*.
3. Thin-walled cells of mesophyll, *H. clavata*.
4. Spongy tissue occupying the mesophyll, *H. undulata*.

Plate xxv.

1. Columnar stereoides spreading at apex and base, *H. Brownii*.
 2. Mesophyll occupied by very thick-walled cells, *H. obtusa*.
 3. Tannin cells running through centre of mesophyll, *H. pandanycarpa*.
 4. Mesophyll occupied by elongated cells containing chlorophyll, *H. amplexicaulis*.
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AUSTRALIAN HESPERIIDAE. PART I.

NOTES AND DESCRIPTIONS OF NEW FORMS.

By G. A. WATERHOUSE, D.Sc., B.E., F.E.S.

(Plate xxvi.)

[Read 31st August, 1927.]

Since "The Butterflies of Australia" was published in 1914, further collecting has resulted in records of many new localities together with several new forms of skippers; the more important of these are given in the present paper.

Subfamily TRAPEZITINAE.

Watson (*P.Z.S.*, 1893, p. 71) places the species I include in the Trapezitinae in Section A of his subfamily Pamphilinae, and remarks (p. 69) that they are somewhat aberrant, and in his key (p. 71) puts the Australian genera in a group distinct from the other genera of his subfamily Pamphilinae. As this group of Australian genera is confined to Australia, New Guinea and the neighbouring islands, a new subfamily was proposed for them. In "The Butterflies of Australia" 51 species of this subfamily were placed in ten genera and it was pointed out (p. 175) that when the life-histories of the species became known, further distinctions would be found. By careful searching I have found some portion of the early stages of 20 species and as the result of a study of these, I have found it necessary to alter the sequence of the genera.

The early stages may be divided into three groups: (a) Larva with head large, hard, rough, some shade of brown without any conspicuous markings; body some shade of brown, often with a pinkish tint and somewhat rough; pupa stout, with the anterior end smooth without any prominent projection. Here are placed the genera *Trapezites*, *Anisynta*, *Signeta*, *Dispar* and *Toxidia*. (b) Larva with head large, hard, black, covered with long white hairs; body white, hairy; pupa without prominent projections at anterior end. Only *Mesodina* comes here. I know the life-histories of *halyzia* and *aeluropis*, both of which pupate head downwards. (c) Larva with head large, hard, pale with a dark brown or black band almost encircling the head in front; body smooth, pale green or yellowish, outer skin very transparent; pupa longer than those of (a), cylindrical, tapering towards posterior end, always with a prominent projection at anterior end, sometimes this projection is long and bifid and varies considerably in the different species. *Hesperilla* and *Oreisplanus* come into this section, which, from their larval characters, are allied to those Australian species of the genera *Taractrocera*, *Padraona* and *Telicota*. The only genus of Trapezitinae omitted is *Neohesperilla* and of the early stages of its species, I know nothing at present.

From the various characters I would now place the genera in the following order: *Trapezites*, *Dispar*, *Signeta*, *Anisynta*, *Toxidia*, *Mesodina*, *Neohesperilla*,

Motasingha, *Oreisplanus* and *Hesperilla*. The larval and pupal characters confirm the slight imaginal characters used in separating *Toxidia* and *Hesperilla*.

It is very difficult to draw up satisfactory descriptions of the species in the Trapezitinae, as though they appear very distinct in the cabinet, the markings above are very similar and similarly placed, so the descriptions of the upper-side are very much the same. The underside of the hindwing always shows the chief distinctions and the apex of the forewing beneath is always coloured in the same manner as the hindwing beneath.

TRAPEZITES ELIENA Hewitson.

Hesperia eliena Hew., *Desc. 100 new Hesp.*, p. 32, 1868 (Moreton Bay); *Trap. eliena* Herr-Schff., *Stett. Ent. Zeit.*, 1869, p. 80, pl. iii, fig. 13 (Brisbane); *Telesto caecilius* Plötz, *Stett. Ent. Zeit.*, 1884, p. 380 (India in error); *Trap. iacchus* Meyr. and Lower (*nec* Fabr.) *Trans. Roy. Soc. S. Aust.*, 1902, p. 87; *Trap. eliena* Waterh. and Lyell, *Butt. Aust.*, p. 176, figs. 604, 605, 1914.

From the large number of specimens available, I can distinguish two good subspecies.

TRAPEZITES ELIENA ELIENA Hewitson.

I possess many specimens from the type locality, Brisbane, and also from Kuranda, Westwood and Gayndah in Queensland, Richmond River, Sydney, and Blue Mountains in New South Wales. In these the general colour of the apex of the forewing and the whole of the hindwing beneath is orange brown in the males and very slightly paler in the females. The spots on the hindwing beneath are sometimes reduced to small black dots without whitish centres, but the discal row are never absent; when reduction takes place the central spot is also reduced in size.

TRAPEZITES ELIENA MONOCYCLA Lower.

Trans. Roy. Soc. S. Aust., 1911, p. 139; *Trap. iacchus* And. and Spry (*nec* Fabr.) *Vict. Butt.*, p. 115, figured, 1893.

I have examined the type from Mt. Gambier, S. Aust., and also the specimens from Victoria in the National Museum, Melbourne and in Mr. Lyell's collection and consider this a southern subspecies, characterized by the apex of the forewing and the hindwing beneath being almost yellow. The central white spot of the hindwing beneath is always large and the discal row of four spots reduced in most cases to mere dots, sometimes absent as in Lower's type. I have 6 ♂ and 4 ♀ from Victoria (Gisborne, Fernshaw and Mordialloc) all of which can be recognized from northern specimens by the underside, though in no case have the discal spots entirely disappeared. I would restrict the name *monocycla* to S. Australia (type) and Victoria. I have not seen a specimen of *eliena* from Tasmania.

TRAPEZITES IACCHOIDES Waterhouse.

This rare species has been taken at Barrington Tops in December by Messrs. Goldfinch and Burns. The specimens differ slightly from Sydney specimens, being much brighter in colour.

TRAPEZITES PHICALIOIDES Waterhouse.

I have taken this species at French's Forest, near Sydney, in October.

SIGNETA TYMBOPHORA Meyr. and Lower.

This very local species was sent to me by Mr. E. J. Dumigan from Bunya Mts., Qld. (Jan., 1926). This is a new record for Queensland, the species hitherto having been found only in the Illawarra District, New South Wales.

ANISYNTE SPHENOSEMA Meyr. and Lower.

I found several larvae in King's Park, Perth, W. Aust., in September and succeeded in rearing a specimen which emerged in Sydney in March. The larvae and pupae are very similar to those of *Trapezites*.

ANISYNTE TILLYARDI Waterhouse and Lyell.

The range of this species has been extended from the type locality (Ebor, N.S.W.) to Bunya Mts., Qld. (E. J. Dumigan, Jan.), Murrurundi (Febr.), and Barrington Tops, N.S.W. (Jan., G.A.W.).

ANISYNTE TASMANICA Miskin.

Additional localities in New South Wales at which I have caught this species are Stanwell Park (near sea level, Mar.), Blackheath (Nov.) and Barrington Tops (Jan. and Febr.).

TOXIDIA MALINDEVA Lower.

Taken at Westwood, Qld. by Mr. A. N. Burns in September and October.

TOXIDIA CRYPSIGRAMMA Meyr. and Lower. (Plate xxvi, fig. 20, ♂, 19, ♀)

Mr. A. N. Burns has taken this species at Westwood, Qld., in February, September and October, including a single specimen of the undescribed female.

♀. ABOVE. Forewing dull brown; two small subapical elongate spots, whitish; discal spots in areas 2 and 3 and a small discal spot above vein 1, whitish; cilia grey-brown. Hindwing grey-brown; cilia greyish.

BENEATH. Forewing pale grey-brown at apex, brown in cell and on disc, greyish near tornus, spots as above, but fainter; cilia greyish, slightly darker at terminations of veins. Hindwing pale grey-brown; cilia as in forewing.

This specimen was taken at Westwood in August, and is in Coll. Burns. This species is easily distinguished from the larger *T. peroni* and *T. malindeva*, both of which have a spot in cell of forewing and have the hindwing marked beneath. It is nearest *T. sexguttata*, which is a narrower winged species and has the hindwing beneath a different shade of brown without markings. Males from Westwood as well as the two from the type locality (Herberton) are larger than those Mr. R. Illidge has sent me from Brisbane.

TOXIDIA SEXGUTTATA Herrich-Schaeffer.

Mr. L. Franzen has given me a female from Palmwoods; S. Queensland (Febr.), which is much darker than the five I have from N. Queensland.

MOTASINGHA MONTICOLA Olliff.

New localities are near Gisborne, Vict. (Lyell, Mar.), and Jenolan Caves, N.S.W. (L. H. Moss-Robinson, Febr.). Though I have visited Mt. Kosciusko each month from December to March, I have never seen this species there, probably as I collected only above 5,000 ft. Prof. L. Harrison has given me two specimens caught at 4,000 ft. in February.

MOTASINGHA DOMINULA Plötz.

The locality given by Plötz is Tasmania, but his measurement is larger than any Tasmanian specimen I have and the unpublished coloured figure by Plötz agrees better with New South Wales specimens than Tasmanian. Should Tasmania be correct for *dominula*, Meyrick's name *drachmophora* must be used for the mainland specimens, which I have taken at Mt. Kosciusko in February and March and Barrington Tops in January and February.

HESPERILLA ANDERSONI Kirby.

A single male was taken by me at Murrurundi in February.

HESPERILLA IDOTHEA Miskin.

I have caught this handsome species at Barrington Tops in January and February.

HESPERILLA DONNYSA Hewitson.

Desc. 100 *new Hesp.*, p. 39, 1868; Hewitson, *Exotic Butterflies*, v, *Cycloptides* and *Hesperilla*, fig. 7, 1874.

"Upperside. *Male*.—Anterior wing rufous-brown, with six transparent yellow spots; one near the middle of the costal margin, two central beyond the middle, and three before the apex; a small yellow spot near the inner margin, and the black line indicative of the male. Posterior wing dark brown, with the centre orange."

"Underside grey. Anterior wing with the basal half dark brown; a ray of yellow from the base to the first transparent spot; the inner margin yellow in the place of the small yellow spot of the upperside. Posterior wing with a spot before the middle, followed by a straight band of small brown spots.

"Female without the small yellow spot of the anterior wing and the central orange of the posterior wing. Exp. $1\frac{5}{20}$ in. Hab. Australia (Moreton Bay). In the collection of W. C. Hewitson".—Hewitson l.c.

In *Exotic Butterflies*, Hewitson modifies this description slightly, giving the orange spot of the hindwing in the male as trifid, and the hindwing beneath "with a minute black spot before the middle, followed by a straight band of several similar spots". The upperside of the male only is figured and a slightly increased size is given.

I have 127 specimens of *H. donnysa* in my collection, but unfortunately do not possess a specimen from the type locality, Brisbane. When this series is examined in the cabinet, certain well marked differences are seen, the orange spot of the hindwing in Tasmanian specimens is always larger and brighter than in specimens from Australia. A small series from Altona Bay, Vict., given me by the late F. P. Spry many years ago, are all very pale and approach another series of specimens bred by me last year from Geraldton, W.A. These three series constitute the three new races I describe. Regarding South Australian specimens, I was inclined to consider them as *H. cyclospila*, Meyr. and Lower, 1902, when I examined the type in the late O. B. Lower's collection in Adelaide last year. Mr. N. B. Tindale has at my request made a further examination of the specimens in the Lower collection under the name *cyclospila* and considers they constitute a species distinct from *donnysa*.

Some confusion has arisen with regard to the name *cyclospila*, as fig. 632 in "The Butterflies of Australia" is certainly not *cyclospila*, though Lower identified

it as such. Meyrick and Lower were quite right in placing *cyclospila* near *donnysa*, and it may possibly be a subspecies of it, whilst the specimen given as fig. 632 is certainly closer to *chrysostricha* M. and L. *H. donnysa* has a more pointed forewing (especially in the male) than *chrysostricha* and its allies.

The four races of *H. donnysa* may be distinguished as follows:—

HESPERILLA DONNYSA DONNYSA Hewitson. (Plate xxvi, figs. 1, 2, 6.)

♂. ABOVE. Forewing dark brown, with six hyaline yellowish spots, one large in cell, three small subapical and two beyond the sexmark, an opaque yellow spot above middle of vein 1; base faintly dusted yellowish. Hindwing dark brown, with a large dull orange spot divided by the veins.

BENEATH. Forewing with apex grey suffused lilacine, cell broadly pale yellow, transparent spots as above, dorsum whitish. Hindwing grey suffused lilacine, a small spot in cell and a discal series of six spots (five almost in a straight line), brown.

♀. ABOVE and BENEATH as in male, but all spots larger.

I would restrict the typical race to Brisbane, New South Wales and Eastern Victoria. In *Exotic Butterflies*, Hewitson gives a coloured figure of the upperside of the male. In "*Butterflies of Australia*", figs. 633 and 634 show this form.

I have 24 ♂, 14 ♀ from N.S.W., and 12 ♂, 13 ♀ from Victoria. In two males there are only two subapical spots and in seven males no opaque spot on the forewing above, in three females there is a second smaller opaque spot above the other. Beneath the general colour varies somewhat. On the hindwing beneath, the six discal spots are not always present, in 4 ♂, 7 ♀ the cell spot is white centred and in three other males and two other females some of the discal spots are white centred, this occurs more frequently in Victorian specimens.

HESPERILLA DONNYSA FLAVESCENS, n. subsp. (Plate xxvi, figs. 17, 18.)

♂. ABOVE. Forewing pale brown, almost wholly covered with yellow scales so that the six hyaline spots are not so transparent as in the type form; two small opaque spots above vein 1. Hindwing pale brown, dorsum covered with yellow scales, central spot yellow orange.

BENEATH. Apex of forewing and hindwing yellowish grey, cell spot and discal spots slightly white centred.

♀. ABOVE as in male with the three subapical spots much longer and a fourth below them; spot above vein 1 large and a smaller one above it. Hindwing with an obscure spot in cell and two beyond the large central yellow spot.

BENEATH as in male, all spots of hindwing white centred.

I have four specimens of each sex and there are others in the National Museum, Melbourne. One male and two females have a fourth subapical spot.

Locality: Altona Bay, Victoria, Mar., Apr. and Nov. (F. P. Spry).

HESPERILLA DONNYSA AURANTIA, n. subsp. (Plate xxvi, figs. 5, 21, 22.)

This form can be recognized by the large bright orange spot of the hindwing above, in most cases the cell spot of the forewing is larger and often in the male and usually in the female there are two opaque spots above vein 1, sometimes as in fig. 21 these two spots coalesce, rarely the subapical spots are connected by two small spots to the discal spots, thus forming a complete band from vein 1 to costa, broken only by the dark veins. Sometimes there are two obscure pale spots beyond the central spot of the hindwing above, in the female.

On the hindwing beneath the spots are larger but not so well defined. In five males and one female the cell spot is white centred and in a further one male and five females, one or more of the discal spots are centred white as well.

I possess 22 ♂, 13 ♀ from Tasmania from the following localities: Eaglehawk Neck, 2 Febr., 1910 (holotype ♂, fig. 22, allotype ♀, fig. 21, and two paratype males); Brunei Is., Dec.; Mt. Wellington, Jan., Febr.; Mt. Magnet, Jan.; Strahan, Febr.; Queenstown.

HESPERILLA DONNYSA GALENA, n. subsp. (Plate xxvi, figs. 9, 10, 13, 14.)

♂. ABOVE. Forewing brown, basal half covered with yellowish scales; spot in cell, large, subapical spots usually four, two discal spots beyond sexmark, all transparent yellow; distad of cell spot a large black streak; sexmark irregular grey; cilia yellowish. Hindwing brown; dorsum covered with yellowish scales; a large central trifid spot, yellow; cilia yellowish.

BENEATH. Forewing with costa and apical third grey; transparent spots as above; a broad yellowish streak in cell; two yellowish spots above middle of vein 1; rest of wing black. Hindwing grey; central spot and discal series of six spots, silvery white, ringed with black.

♀. ABOVE. Forewing as in male, but spots larger; a large opaque spot above middle of vein 1 and a smaller one above it, yellow. Hindwing as in male, central patch, larger and brighter.

BENEATH as in male; spots of hindwing beneath usually larger.

This very distinct subspecies is described from holotype ♂, allotype ♀, and 9 ♂, 7 ♀ paratypes, which I bred from larvae and pupae found at Geraldton, W.A., in September, 1926. All but two males and one female (with three) have four subapical spots on the forewing and two males and one female have still another spot making almost a complete band from vein 1 to costa. Some males have opaque spot or spots above the middle of vein 1 of the forewing and six males and six females have the spots of hindwing beneath, silvery white. The sexmark differs in colour from the other races.

HESPERILLA CHRYSOTRICHIA Meyrick and Lower.

This species is somewhat allied to *H. donnysa*, but the shape of the forewing is different. It is a much stouter-built insect. In all its subspecies the transparent spots of the forewing are paler than in *H. donnysa*. At one time I thought that it represented *H. donnysa* in W. Australia, but the male genitalia are different. I now recognize three subspecies, to one of which I had applied the name *H. cyclospila* in error.

HESPERILLA CHRYSOTRICHIA CHRYSOTRICHIA Meyrick and Lower.

Toxidia chrysotricha Meyr. and Lower, *Trans. Roy. Soc. S. Aust.*, 1902, xxvi, p. 59.

The typical form from W. Australia has the apex of the forewing and the hindwing beneath dull red brown and the spots of hindwing beneath nearly circular and centred silvery white.

HESPERILLA CHRYSOTRICHIA LEUCOSPILA, n. subsp. (Plate xxvi, figs. 25-28.)

♂. ABOVE. Forewing brown, a small spot at end of cell, yellow hyaline; three small transverse subapical dots, pale yellow hyaline; a small discal spot in area 3, pale yellow hyaline; a narrow irregular discal sexmark from before vein 1 to

beyond vein 3; cilia grey brown. Hindwing brown; central patch, deep yellow; cilia grey.

BENEATH. Forewing brown; apex broadly brown; base of cell pale yellow; hyaline spots and dots as above; a large discal spot in area 2 and a divided spot in area 1 whitish; dorsum towards tornus yellowish. Hindwing brown; a spot in cell, dark brown centred silvery white; a series of discal spots, that of area 1, small, brown centred white, those in 2, 3 and 5 elongate, white bordered brown, two dark brown dots in area 4.

♀. **ABOVE.** Forewing brown; cell spot and subapical dots as in male; a large discal spot in area 3, a minute one in area 2, pale yellow hyaline; a discal spot above middle of vein 1 yellow; cilia grey brown. Hindwing as in male.

BENEATH. Forewing as in male; subapical spots larger. Hindwing as in male, white spots much larger; two dots in area 4 better defined.

Locality: Inverloch, Victoria. Holotype ♂, allotype ♀, paratype ♂ in National Museum, Melbourne, paratype ♂ in collection Waterhouse. Besides these four specimens, I have a female from Fernshaw, Victoria, and the South Australian Museum has a defective female labelled Sheringa, Port Lincoln district, 12:10:89.

This subspecies differs from the Western Australian subspecies, in being smaller. The markings above, particularly on the hindwing, are not so bright and the general colour is brown and not red brown. The spots of the hindwing beneath are twice the length of those of the type race. This subspecies must be very rare or very local. The figures are of the upper and undersides of the holotype and allotype.

HESPERILLA CHRYSOTRICHA PLEBEIA, n. subsp. (Plate xxvi, figs. 23, 24.)

H. chrysotricha cyclospila, Waterh. and Lyell (*nec.* Meyr. and Lower), *Butt. Aust.*, p. 188, fig. 632, 1914.

♂. **ABOVE.** Forewing brown; a small spot in end of cell, yellow, hyaline; three transverse subapical dots, pale yellow, hyaline; a discal spot in area 3 and a much smaller discal spot in upper edge of area 2, pale yellow, hyaline; cilia grey brown; a narrow discal sexmark. Hindwing brown; a small central patch, yellow; cilia grey brown.

BENEATH. Forewing brown; apex broadly dull brown; base of cell yellow; hyaline spots and dots as above, with that in area 2 much larger; dorsum towards tornus, whitish. Hindwing brown; a small spot in cell, dark brown centred silvery white; a series of small discal spots, dark brown, those in areas 1, 2, 3, and 5, centred silvery white.

Locality: Bridport, Tasmania, two males in December. Holotype in Coll. Lyell and paratype in Coll. Waterhouse. These two males were identified by Lower as *H. cyclospila*, but I have recently examined his type in Adelaide and find that they do not agree with it. They are smaller than the Victorian race and also paler. The female is unknown.

HESPERILLA CRYPARGYRA Mejr. & G. A. W.

This species is nearest to *Hesp. picta*, but the apex of the forewing is not quite so pointed. The discovery by myself of a fine large and beautifully marked race at Barrington Tops extends its range considerably.

HESPERILLA CRYPARGYRA CRYPARGYRA Meyr. (Plate xxvi, figs. 3, 4, 7, 8.)

Telesto crypsargyra Meyr., *Proc. Linn. Soc. N.S.W.*, 1887, p. 829; Waterh. and Lyell, *Butt. Aust.*, p. 186, figs. 600, 601.

On the forewing of the male of this subspecies there is rarely more than one discal hyaline spot and rarely traces of subterminal streaks above. On the female these spots are always much larger. The type locality is Blackheath, N.S.W. (3,500 ft.), and I have caught it as well at Katoomba, Wentworth Falls, and Woodford (2,000 ft.), all in the Blue Mts.

HESPERILLA CRYPARGYRA HOPSONI, n. subsp. (Plate xxvi, figs. 11, 12, 15, 16.)

This is a much finer and larger race, almost equalling in size *Hesp. picta*. The spots of the upperside in both sexes are always larger and deeper in colour. On the underside of the forewing in both sexes the general colour is brown rather than red brown, the spots are orange rather than yellow and there is a broad orange streak along the upper edge of cell; on the hindwing the silvery markings are much larger and the veins are orange; the costa towards base is broadly orange.

I have named this fine form after my friend, Mr. J. Hopson, who has done so much to help entomologists to collect the treasures of Barrington Tops. Figure 11 is of a male bred in Sydney in October from an egg laid at Barrington Tops in February and placed on my plants of *Gahnia* growing in Sydney. Besides the holotype ♂ and allotype ♀ in my collection, I have a number of paratypes of both sexes caught and bred from the same locality in January and February. The foodplant is a species of *Gahnia* much coarser and paler in colour than the narrow-leaved species on which the typical race feeds in the Blue Mts.

Chief References to Australian Hesperiidæ.

- LOWER, O. B., 1911.—Revision of the Australian Hesperiidæ, *Trans. Roy. Soc. S. Aust.*, xxxv, pp. 112-172.
 MEYRICK and LOWER, 1902.—Revision of the Australian Hesperiidæ, *Trans. Roy. Soc. S. Aust.*, xxvi, pp. 38-129.
 IRSKIN, W. H., 1891.—Synonymical Catalogue of the Butterflies of Australia. *Annals of the Queensland Museum*. No. 1.
 WATERHOUSE and LYEELL.—The Butterflies of Australia, pp. 172-224. All Australian species figured.

EXPLANATION OF PLATE XXVI.

1. *Hesp. donnyisa donnyisa*, ♀, Blue Mts., N.S.W., November.
2. *Hesp. donnyisa donnyisa*, ♂, Blue Mts., N.S.W., November.
3. *Hesp. crypsargyra crypsargyra*, ♂, Blue Mts., November.
4. *Hesp. crypsargyra crypsargyra*, ♀, Blue Mts., November.
5. *Hesp. donnyisa aurantia*, ♂, Mt. Wellington, Tas.
6. *Hesp. donnyisa donnyisa*, ♂, Sydney, N.S.W., October.
7. *Hesp. crypsargyra crypsargyra*, ♂, Blue Mts., November.
8. *Hesp. crypsargyra crypsargyra*, ♀, Blue Mts., November.
9. *Hesp. donnyisa galena*, ♀, Geraldton, W.A., September. Allotype ♀.
10. *Hesp. donnyisa galena*, ♂, Geraldton, W.A., September. Paratype ♂.
11. *Hesp. crypsargyra hopsoni*, ♂, Barrington Tops, N.S.W., October. Holotype ♂.
12. *Hesp. crypsargyra hopsoni*, ♀, Barrington Tops, N.S.W., January. Paratype ♀.
13. *Hesp. donnyisa galena*, ♀, Geraldton, W.A., September. Paratype ♀.
14. *Hesp. donnyisa galena*, ♂, Geraldton, W.A., September. Holotype ♂.
15. *Hesp. crypsargyra hopsoni*, ♂, Barrington Tops, N.S.W., February. Paratype ♂.
16. *Hesp. crypsargyra hopsoni*, ♀, Barrington Tops, N.S.W., February. Allotype ♀.
17. *Hesp. donnyisa flavescens*, ♀, Altona Bay, Vict., April. Allotype ♀.
18. *Hesp. donnyisa flavescens*, ♂, Altona Bay, Vict., November. Holotype ♂.
19. *Toxidia crypsigramma*, ♀, Westwood, Qld., August. Holotype ♀.
20. *Toxidia crypsigramma*, ♂, Westwood, Qld., October.
21. *Hesp. donnyisa aurantia*, ♀, Eaglehawk Neck, Tas., February. Allotype ♀.
22. *Hesp. donnyisa aurantia*, ♂, Eaglehawk Neck, Tas., February. Holotype ♂.
23. *Hesp. chrysotricha plebeia*, ♂, Bridport, Tas., December. Holotype ♂.
24. *Hesp. chrysotricha plebeia*, ♂, Bridport, Tas., December. Paratype ♂.

25. *Hesp. chrysotricha leucospila*, ♀, Inverloch, Vict. Allotype ♀.
26. *Hesp. chrysotricha leucospila*, ♀, Inverloch, Vict. Allotype ♀.
27. *Hesp. chrysotricha leucospila*, ♂, Inverloch, Vict. Holotype ♂.
28. *Hesp. chrysotricha leucospila*, ♂, Inverloch, Vict. Holotype ♂.

All figures from retouched photographs. Fig. 25 is the underside of fig. 26 and fig. 28 the underside of fig. 27. Photographs of figs. 1-24 by Miss A. G. Burns, and figs. 25-28 by Mr. J. Clark.

NOTES ON AUSTRALIAN MOSQUITOES (DIPTERA, CULICIDAE).

PART II. THE ZOOGEOGRAPHY OF THE SUBGENUS *Ochlerotatus*,
WITH NOTES ON THE SPECIES.

By I. M. MACKERRAS, M.B., Ch.M., B.Sc.,
Linnean Macleay Fellow of the Society in Zoology.

(Eight Text-figures.)

[Read 27th July, 1927.]

Edwards in 1924 recognized seventeen valid species of this subgenus of *Aedes* from the mainland and Tasmania, later (1926) raising the number to twenty. In the present paper a further new species is added while two names are reduced to synonymy, bringing the total down to nineteen. The total representation of the subgenus in the Australasian region is twenty-two species.

Two distinct faunal elements are to be recognized (Edwards, 1924):

- A. Females with well developed lower mesepimeral bristles; male hypopygium with well developed apical and reduced basal lobes to the side-piece, appendage of the claspette well developed. Affinities Holarctic. 14 species.
- B. Females without lower mesepimeral bristles; male hypopygium with well developed basal and reduced apical lobes to the side-piece, appendage of the claspette reduced, usually bristle like. Affinities Neotropical. 8 species.

It is with the origins of these two groups and the explanation of the apparent anomalies of their distribution that we are here primarily concerned.

The same author (1922*b*) epitomizes the distribution of the subgenus in the following terms: "This subgenus includes the great majority of the Palaeartic and Nearctic species of *Aedes*, and attains its maximum development in the north temperate parts of these regions; it is almost or quite unrepresented in the Ethiopian and Oriental regions, but appears again with numerous representatives in southern Australia, and one or two in New Zealand. Many species also occur in the Neotropical region, and it is possible, therefore, that Australia was colonized by way of South America, especially as some of the South American, New Zealand and Australian species show rather marked affinities. We may perhaps assume from this that the subgenus is an old-established one".

The Oriental fauna as known at present, and it must be remembered that this region has been well collected, is entirely deficient in *Ochlerotatus*, the only species recorded (Edwards, 1922*a*) being a Palaeartic invader in the Punjab and an Australian invader (*A. vigilax* Sk.) in the south-east. There is no reason whatever to suppose that the subgenus once flourished but has now become extinct. The barrier was probably largely, if not entirely, a climatic one.

There is, then, definite evidence for the belief that Australia was colonized from South America. This evidence is greatly strengthened in the case of Group A by the local distribution in eastern Australia, a line of investigation

which also clearly indicates that the two groups followed different routes and entered this country from different directions.

In Group A, nine species are strictly "Antarctic" in distribution, *i.e.*, dominant in Tasmania, while those occurring also in New South Wales are restricted to the highlands of the Divide with extensions to the coast in spring. This distribution is particularly well exemplified by *A. flavifrons* Sk. and *A. camptorhynchus* Thoms. *A. nivalis* Edw., on the other hand, is a Kosciusko-Barrington Tops species which apparently misses the Blue Mountains and is rare in Tasmania, a somewhat different, but equally typical "Antarctic" distribution. The other five species require brief individual mention. *A. stricklandi* Edw. is southern and western, while *A. burpengaryensis* Theo. is known from South Queensland and is represented in Bass Strait by *A. clelandi* Tayl. and in New South Wales by a form intermediate between these two, which was found at Myall Lakes in spring. These species conform to the same general faunistic localization. *A. sagax* Sk. (including *A. wilsoni* Tayl.) is distributed west of the Divide and is of little value in the present discussion, although its greater prevalence in the more southerly part of its range is what one would expect in a member of the "Antarctic" group. Finally, *A. vittiger* Sk. is a summer species ranging from Townsville, Qld., to Leeton, in southern New South Wales, a distribution which would conform quite well with a northern origin.

It must be remembered, however, that the limitation of different faunal elements to particular environments, though very striking, is not absolute. There is a definite amount of overlapping and similar extensions are met with in individual species of other groups. The important fact is that the local distribution of Group A is precisely that of other Diptera which are believed to have entered Australia from Antarctica.

Group B presents a different problem. Its Neotropical affinities would suggest an antipodal origin, but the local distribution is unequivocally against Antarctic radiation. Of the eight species *A. imprimens* Walk. is found in New Guinea and the adjacent islands, *A. vigilax* Sk. is widespread on the east coast of Australia and extends into the Oriental region as far as Siam, *A. normanensis* Tayl. is not known south of Queensland, while *A. rubrithorax* Macq. and *A. aculeatus* Theo. are both coastal species ranging from South Queensland into New South Wales. All these species point in the clearest manner to an entry from the north. *A. theobaldi* Tayl., like *A. sagax* Sk., is distributed west of the Divide from Queensland to Victoria and is therefore of little value, though its greater prevalence in the more northerly part of its range tends to bring it into line with the other species of its group. Two species, *A. antipodeus* Edw. and *A. albivostris* Macq., are found in New Zealand and are important as indicating an eastward extension of the line of migration which brought them to Australia. I would suggest that this group entered Australia from the north by one of the Gondwanaland arcs of islands which Harrison (1927) indicated as being very successful in explaining other similar distributions.

The more general lines of evidence cannot be entered into here, but the conclusions may be summarized in the following terms. Group A developed in the temperate parts of the Holarctic region and was unable to extend to the southward except along the ridge of cooler elevated country on the western side of the Americas. Keeping to this higher western side, it extended into the temperate southern part of South America and radiated thence through Antarctica into southern Australia, where its climatic limitations are very well shown in the local and seasonal distribution. This migration occurred at a time

when New Zealand was cut off from participation in this element. Group B, on the other hand, originated in the Neotropical region, and almost certainly in the warmer, more low-lying eastern portion. Its line of eastward extension was directly in warm latitudes. Such an extension implies the existence of a Gondwanaland, or of its equivalent in a chain of islands (Harrison, 1927) linking South America to northern Australia and extending eastward to New Zealand. Both these radiations would ante-date the Oriental invasion which is the dominant element in the Australian mosquito fauna. It will be seen that these conclusions imply the acceptance of the Wegener or some similar hypothesis.

The early stages of but two species, *A. vittiger* Sk. and *A. vigilax* Sk., have been described, though a number have been bred. The larvae of all the species are very difficult to find, even in districts where the adults are so numerous as to be a pest. Even when it is possible to find a few pupae, the larvae frequently cannot be discovered. In certain instances, however, they appear to be able to lie hidden in the mud at the bottom of a pool for prolonged periods.

The male hypopygium presents valuable group characters which are, in all the Australian species, sufficiently well marked to afford easy and rapid determination. Such species as *A. theobaldi* Tayl., however, show the undesirability of elevating the two groups to separate subgeneric rank. The presence or absence of lower mesepimeral bristles on the other hand is not quite so constant, since these structures are absent in the male of *A. flavifrons* Sk., though well developed in the female, and they are quite variable in *A. rubrithorax* Macq., but when present in this species are always very weak. In *A. stricklandi* Edw. they are weaker than is usual in Group A, but are markedly longer and stouter than in *A. rubrithorax* Macq. A more convenient though unnatural grouping may be made on the presence or absence of white rings on the tarsal segments. This character also is not completely satisfactory, since two species, *A. stricklandi* Edw. and *A. luteifemur* Edw., which are best included with the unbanded forms, show traces of white rings on one or two segments; they are, however, never likely to be confused with those species possessing true banding, since in the former the rings are only apparent if carefully looked for, while in the latter they are easily visible to the naked eye. In the following key I have included for the convenience of local workers all mainland and Tasmanian species which are inseparable in the female from *Ochlerotatus*. The most easily accessible and constant characters have been used and the arrangement of species is consequently in many instances unnatural.

Key to Australian Species of Ochlerotatus, Banksinella, and Aedimorphus (females).

Species of *Aedes* with the following female characters: ninth sternite small and retracted, cerci long; head with numerous narrow curved scales (except *A. aculeatus* Theo.); claws of at least the fore and mid legs toothed.

- | | |
|---|------------------------------|
| 1. Tarsi of all legs with distinct white basal banding | 2 |
| Tarsi unbanded, or at most with traces of white rings on one or two of the basal segments | 10 |
| 2. Scutum creamy, with striking black vittae | <i>vittiger</i> Sk. |
| Scutum not so adorned | 3 |
| 3. Head and sides of scutum with flat oval yellow scales | <i>aculeatus</i> Theo. |
| Head and sides of scutum with narrow scales | 4 |
| 4. Wings entirely dark scaled | 5 |
| Wings with at least some white scales | 6 |
| 5. Larger, darker species; femora mottled with white anteriorly | <i>camptorhynchus</i> Thoms. |
| Smaller, reddish species; femora not mottled with white anteriorly | <i>rubrithorax</i> Macq. |

6. Lower mesepimeral bristles present; pale scales on wings fairly numerous, scutal integument reddish, wing membrane usually with a dark blotch in middle below costa *flavifrons* Sk.
 Lower mesepimeral bristle absent; scutal integument pitchy, wing membrane without dark blotch 7
7. Wings with numerous large white scales on all veins 8
 Wing scales normal in size and shape, white scales relatively few and mainly along Sc and R₁ 9
8. Pale bands of abdominal tergites nearly straight posteriorly, the dark portions of the tergites usually conspicuously mottled with pale scales, especially posteriorly *theobaldi* Tayl.
 Pale bands of abdominal tergites broad and produced posteriorly into a prominent triangle which forms a broad vitta on segment 6, only a trace of mottling on the dark portions of the tergites form *eidsvoldensis* nov.
9. Medium sized species; the gold scales of the scutum fine and patchy; abdomen with broad white basal bands; last hind tarsal segment with a broad white ring *vigilax* Sk.
 Smaller species; the gold scales of the scutum larger, more numerous and tending to a linear arrangement; abdomen usually with small white basal patches; last hind tarsal segment without, or with very narrow, basal white ring *normanensis* Tayl.
10. Wings extensively mottled with light and dark scales *stricklandi* Edw.
 Pale scales, if present on wing, relatively few and only along anterior border .. 11
11. Scutellum with broad flat white scales *Aedimorphus alboscuteclatus* Theo.
 Scutellum with narrow scales only 12
12. Lower mesepimeral bristle absent; scutum with a broad margin of yellow scales *Banksinella lineatopennis* Ludl.
 At least one strong lower mesepimeral bristle present 13
13. Scutum with a broad margin of pale scales contrasting strongly with the dark field 14
 Scutum not so adorned 15
14. Numerous large flat scales above and in front of the wing root; abdomen unbanded *andersoni* Edw.
 Large scales above the wing root lanceolate and twisted; abdomen conspicuously basally banded *macleayanus*, n. sp.
15. Hind femora mottled anteriorly with pale scales 16
 Hind femora uniformly pale anteriorly at least on the basal two-thirds 17
16. Mesonotum dark brown to pitchy; mesonotal scales bronzy-brown to creamy white *sagax* Sk.
 Mesonotum reddish; mesonotal scales bright pale golden *cunabulanus* Edw.
17. Fore and mid femora with at least some white scales anteriorly 18
 Fore and mid femora entirely dark anteriorly 19
18. Abdomen with white scales at bases of tergites only; wings entirely dark scaled *nivalis* Edw.
 Abdomen unbanded, fourth and subsequent tergites extensively mottled with dull creamy-yellow scales; wings pale scaled on distal part of C and R₁
 *luteifemur* Edw.
19. Venter entirely dark purple scaled *purpureiventris* Edw.
 Venter with numerous pale as well as dark scales 20
20. Abdominal tergites unbanded; scutal integument brownish-black
 *burpengaryensis* Theo.
 Abdominal tergites with basal white bands; scutal integument reddish
 *clelandi* Tayl.

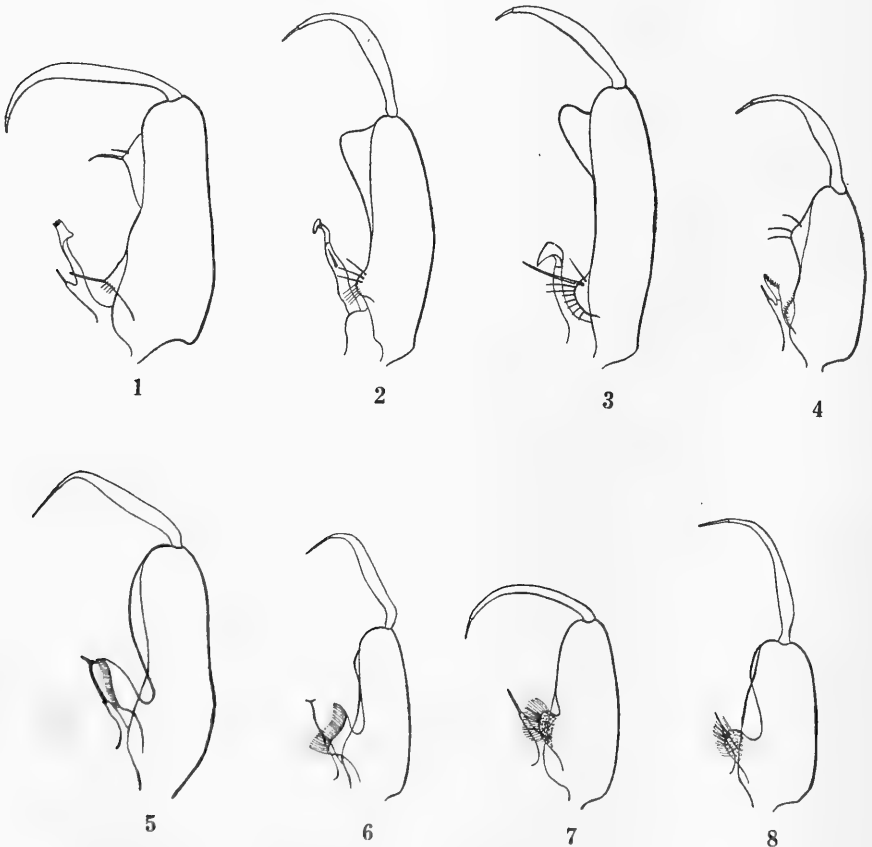
Notes.—This key applies *only* to the females. In the male many characters, which are conspicuous and useful in the female, are ill defined, as is the case with the white scales of the wings, or absent, as may occur with the lower mesepimeral bristles. Except for very distinctive species, a careful comparison with authentic females and an examination of the hypopygium afford the only safe means of identification.

A. nigrithorax Macq. is only to be recognized by hypopygial characters. The female when discovered will probably fall under caption 15.

The following species, not yet known from the mainland or Tasmania, are not dealt with in this paper:—*Aedes* (*Banksinella*) *brugi* Edw., New Guinea; *Aedes* (*Ochlerotatus*) *albirostris* Macq., New Zealand; *Aedes* (*Ochlerotatus*) *antipodeus* Edw., New Zealand; *Aedes* (*Ochlerotatus*) *imprimens* Walk., New Guinea and adjacent islands; *Aedes* (*Aedimorphus*) *vexans* Meig., widely distributed. The last would run down either to *rubrithorax* Macq. or to *vigilax* Sk. in the key; the specimens before me are too abraded to be sure whether there are any white scales on the wings or not. From the former it is readily recognized by its much darker thoracic integument and scales and by its mottled femora, while from the latter it is separable by its shorter proboscis and by the indentation of the abdominal bands, which are straight in *A. vigilax* Sk.

A very distinctive feature of the *nivalis* series is the violet gloss on the abdomen and legs. It is, however, not always present, and when present may occasionally be difficult to detect. It is therefore useless as a key character.

Culex australis Erich. is unrecognizable and must be deleted from the list of Australian *Ochlerotatus*. The name is replaced by *nivalis* Edw.



Text-figures 1-8. Side-piece and appendages of: 1, *A. vittiger* Sk.; 2, *A. flavifrons* Sk.; 3, *A. camptorhynchus* Thoms.; 4, *A. sagax* Sk.; 5, *A. theobaldi* Tayl.; 6, *A. normanensis* Tayl.; 7, *A. vigilax* Sk.; 8, *A. rubrithorax* Macq. All drawn to the same scale.

For the full synonymy and references up to 1924 see Edwards (1924). Subsequent publications on the subgenus and those earlier ones which are directly mentioned are listed at the end of this paper.

GROUP A.—AFFINITIES HOLARCTIC.

The species included here fall into two natural sections on hypopygial characters, those with a sub-basal thumb on the medial aspect of the claspette (*A. vittiger* Sk., *A. sagax* Sk., *A. nigrithorax* Macq., *A. burpengaryensis* Theo.; Text-figs. 1 and 4) and those without such thumb (*A. flavifrons* Sk., *A. camptorhynchus* Thoms., *A. andersoni* Edw., *A. cunabulanus* Edw.; Text-figs. 2 and 3). It will be seen that forms with banded and with entirely dark tarsi occur in both sections. I have, however, used this unnatural but more convenient arrangement, largely because of the difficulty of placing correctly some of the species which are only known from the female.

a. *Tarsi with conspicuous white rings.*

Aedes (Ochlerotatus) *vittiger* (Skuse).

One of the most distinct Australian mosquitoes on account of the scutal adornment. Its hypopygial characters (Text-fig. 1) show its affinities to be with *A. sagax* Sk. and its allies rather than with *A. flavifrons* Sk. and *A. camptorhynchus* Thoms. The claspette is forked and the apical lobe of the side-piece forms a pointed medial projection bearing a strong bristle.

The larva has been described by Cooling (1913) and the larva and pupa figured by Hill (1925 a). The combination of short antennae, long frontal hairs, 3-4 branched subantennal hair, relatively long siphon, the presence of some of the pecten spines beyond the siphonal tuft, and the single row of comb scales will separate this from any other Australian larva.

At Eidsvold *A. vittiger* Sk. breeds in clear or muddy waterholes and is very abundant in midsummer in forest country and in the vicinity of the river. It bites by day and is a source of considerable annoyance owing to the persistence of its attacks. In the Sydney district it is rare and frequents the sheltered sandstone gullies.

Distribution.—Coastal Queensland and New South Wales from Townsville to Sydney; also extends west of the Divide. A summer species, most prevalent in south Queensland. Now recorded for the first time from the mountains and from south of Sydney: Barrington Tops, 5,000 feet, January, 1926; Leeton, December, 1926 (K. McKeown).

Aedes (Ochlerotatus) *flavifrons* (Skuse).

Culicada vandema Strickland.

The types series of *Culex flavifrons* Skuse in the Macleay Museum comprises four specimens, the type male and female which undoubtedly represent one species, another female which is identical with typical *A. vandema* Str., and a third female identical with *A. camptorhynchus* Thoms. With regard to the types, the female differs from typical *A. vandema* Str. in its duller colouration, the rather fewer pale scales on the wing and the markedly fainter blotch on the wing membrane. The two latter characters are somewhat variable in the extensive series of *A. vandema* Str. before me and the colour difference may simply be due to age. A careful comparison revealed no character on which the two could be separated. In the male type the pale scales on the wing are very

few, while the dark blotch has entirely disappeared; lower mesepimeral bristles are absent. A male from Sydney in my collection, which can be allotted without doubt to *A. vandema* Str. also lacks the lower mesepimeral bristle and differs from Skuse's type in its slightly brighter colouration and in the fact that the dark patch on the wing is present though very faint. The hypopygia of the two are identical. I am indebted to Dr. E. W. Ferguson for drawing my attention to the possibility of this synonymy.

A. flavifrons Sk. is easily distinguished in the female by the presence of lower mesepimeral bristles, the numerous pale scales on the wings, the mottled femora, and almost always by the dark patch on the wing membrane. Superficially it bears some resemblance to *A. (F.) occidentalis* Sk. The male (Text-fig. 2) has the apical lobe of the side-piece well developed and projecting distally, while the basal lobe is rounded and bears a row of five fine hairs directed proximo-medially; the claspette has a well developed appendage and bears a single small bristle a little beyond the middle; this appears to be the homologue of the bristle on the medial division in those species in which the claspette is forked.

This species is abundant in Tasmania and appears in considerable numbers in the coastal districts of New South Wales in early spring, where it frequents the sandstone gullies and brush country in company with *A. (F.) alboannulatus* Macq. and *A. (F.) occidentalis* Sk. It is a day biter.

Distribution.—Victoria, Tasmania and King Island (November and December). New South Wales: Blue Mountains (type series); Myall Lakes, Aug. 1, 1922; Woy Woy, Oct. 3, 1925; French's Forest, Sydney, Aug. 17, 1924; Balmoral (Sydney), Nov. 26, 1922; Lane Cove (Sydney), May 31, 1927 (B. Bertram); National Park (Waterfall), Aug. 2, 1925.

ÆDES (OCHLEROTATUS) CAMPTORHYNCHUS (Thomson).

To be separated from *A. flavifrons* Sk. by its darker colour, entirely dark wing scales, and absence of any blotch on the wing membrane. The male, unlike that of the previous species, has well developed lower mesepimeral bristles. The hypopygium (Text-fig. 3) differs in the presence of a stout bristle as well as fine hairs on the basal lobe of the side-piece and in the absence of any bristle on the stem of the claspette, the apex of which is differently shaped. The two species are obviously closely related.

In the Sydney district its habits and season resemble those of *A. flavifrons* Sk. It is, however, less common, and its local environment is rather strikingly different in that it is found in the heath on the more level sandstone ridges rather than in the gullies (Mackerras, 1926). In Victoria it appears to replace *A. vigilax* Sk. as the dominant "bush" mosquito (Hill, 1925b).

Distribution.—New South Wales: French's Forest, Sydney, Aug. 17, 1924; Greenwich, Sydney, Aug. 15, 1925 (B. Bertram); National Park (Gundamaian), Aug. 2, 1925; Sutherland, Aug. 7, 1926. Also Western Australia, South Australia, Victoria (abundant), and Tasmania (abundant from October to March).

b. *Tarsi entirely dark, or with only traces of pale rings.*

ÆDES (OCHLEROTATUS) STRICKLANDI Edwards.

Easily recognized by the numerous broad pale scales scattered over the wing. In the specimen before me, there are traces of white rings at the bases of the first and second hind tarsal segments only; these might easily be overlooked, but are obvious enough under the binocular. There are two fairly strong lower mesepimeral bristles on one side; the other side is obscured by the legs.

Distribution.—Western Australia and Flinders Island, Bass Strait. Additional locality: Mt. Compass, Oct. 27, 1920 (J. B. Cleland).

AEDES (OCHLEROTATUS) ANDERSONI Edwards.

Edwards, 1926, p. 112, new name for *Andersonia tasmaniensis* Strickland.

Another striking species, which is easily separated from all except *A. macleayanus* n. sp. by the scutal ornamentation. The abdomen is unbanded. Edwards (1926) describes the male hypopygium as follows: "Lobes of ninth tergite small, with four to six short bristles. Side-pieces with the basal lobes large, flattened, prominent; a row of long hairs along the margin, and two tergally placed bristly spines, one long with slender curved tip, the other short and straight. Apical lobe well developed but practically bare. Claspers not much swollen, slightly tapering, apical spine long. Claspettes with long stem without basal thumb, appendage flattened but not very broad, without angle at base". This description agrees with the hypopygium of *A. camptorhynchus* Thoms. very closely and shows the uselessness of leg ornamentation in phylogenetic studies.

Distribution.—I have seen a number of females from Victoria (Lower Tarwin, biting by day, G. F. Hill) and from Tasmania, October to December. Also recorded by Edwards for January and February in Tasmania.

AEDES (OCHLEROTATUS) MACLEAYANUS, n. sp.

♀. Head with creamy narrow curved scales in the middle, more ochreous ones laterally, and with ochreous upright forked scales; lateral flat scales mostly white, a few violet brown. Antennae dark brown, torus brownish ochreous. Palpi rather long, deep brown. Proboscis entirely deep brown.

Integument of scutum pithy. There is a broad median area of bronzy-brown fine scales which widens suddenly behind the middle of the thorax; lateral to this is a broad creamy zone of larger twisted scales, which are particularly large above the wing roots; this zone of creamy scales extends medially round the anterior margin of the scutum; further laterally there is a narrow zone of bronzy-brown scales at the lateral edge of the scutum. Scutellum and median prescutellar area with creamy white narrow curved scales. Anterior and posterior pronotal lobes with fine bronzy scales above and larger creamy more outstanding ones below. Pleurae brown, with dense flat white scales forming a band across the upper part; there is also a large white patch on the lower part of the sternopleuron. Three strong lower mesepimeral bristles. Wings entirely dark scaled.

Fore and mid femora mottled anteriorly, the pale scales predominating; hind femora entirely white anteriorly except for a narrow apical dorsal zone. Tibiae and metatarsi mottled anteriorly, largely white behind. Tarsi dark. Ungues of all legs toothed.

Abdomen covered with deep brown scales with a slight violet gloss, the tergites basally banded with ochreous scales. The bands are triangular in shape, with the broad base along the base of the tergite and the apex more or less drawn out, on the sixth segment extending to its apex. There is a large lateral basal patch of creamy ochreous scales on the fourth segment and larger white patches at the sides of the fifth and sixth segments. Seventh with a broad median creamy stripe and white lateral margins. Venter white scaled, except for small apical lateral black patches on a few segments.

Length, 7 mm.

Holotype ♀: Launceston, Tasmania, Oct. 1, 1916 (F. M. Littler), in the South Australian Museum.

This is a rather large species which superficially resembles *A. andersoni* Edw., but differs in the absence of flat scales above the wing roots, the darker thoracic integument, the unmottled hind femora, and the banded abdomen. The scutal ornamentation and the leg characters will separate it from *A. cunabulanus* Edw.

AEDES (OCHLEROTATUS) CUNABULANUS Edwards.

Edwards (1912) first mentions this species as a variation of *A. australis* Theo. (i.e. *nivalis* Edw.), but, when describing it (1924), he stated that it was closer to *A. andersoni* Edw. but much smaller in size. The mottling of the anterior surface of the hind femora will separate it from *A. nivalis* Edw., while the reddish thoracic integument and bronzy gold mesonotal scales distinguish it from *A. sagax* Sk. I have seen a single female from Tasmania which I place here with some hesitation. It is not much smaller than *A. andersoni* Edw. and resembles *A. nivalis* Edw. closely in scutal colouration and scaling, but otherwise fits the description fairly accurately. The relationships of *A. cunabulanus* Edw. have been settled by Edwards's (1926) description of the hypopygium of the male as "practically identical in structure with that of *A. andersoni*, the appendage of the claspette appearing a little broader".

Distribution.—Tasmania, November to February. Additional locality: Mount Arthur, Tasmania, December 28, 1915 (F. M. Littler).

AEDES (OCHLEROTATUS) NIGRITHORAX (Macquart).

Only known from the type male and only identifiable on hypopygial characters. It is possible that future discoveries may show the name to belong to one of the species dealt with below. Edwards's (1924) description of the hypopygium runs as follows: "Side-pieces with the basal lobes well developed, hairy; apical lobes slight, bearing two or three rather stout curved spines. Claspers with the basal two-thirds somewhat swollen, apical third slender, terminal spine long. Claspettes with a sub-basal thumb on the inner side bearing a small terminal bristle, somewhat as figured by Cooling for *A. vittiger*; appendage broad and flat, with a retrorse angle at base. Lobes of ninth tergite each with about six short bristles".

Distribution.—Tasmania.

AEDES (OCHLEROTATUS) SAGAX (Skuse).

Culicada wilsoni Taylor.

Edwards (1924) recognizes these as distinct, but Ferguson (1926) gives this synonymy and I believe it to be correct. I have seen females of both forms and there is little to separate them. In typical *sagax* the scutum is covered with brown scales with small patches of white, and the pleurae are spotted with white, whereas in *wilsoni* the mesonotal scales are all or mostly creamy and the pleurae are more densely scaled. There are, however, intermediate forms. The violet sheen of the abdomen is of no value and may be present or absent in otherwise typical *sagax*. Taylor (1918) gives a photomicrograph of the male hypopygium of *A. wilsoni* Tayl.; it is unfortunately not suitable for detailed study, but does not appear to show any essential difference from that of *A. sagax* Sk.

This species is to be recognized by its dark scutal integument and dull scaling, by the mottled hind femora, and by the banded abdomen.

♂. Palpi entirely brown, a little longer than the proboscis, terminal segments swollen and bearing dense long brown hairs; antennae with long brown plumes; one lower mesepimeral bristle; otherwise similar to the female. Hypopygium (Text-fig. 4) with the apical lobe of the side-piece pointed and bearing one small and two larger bristles, basal lobe very small and covered with fine hairs. Claspette with a sub-basal thumb bearing a short bristle and with the appendage serrated along its apico-lateral edge. The resemblance to *A. vittiger* Sk. and to Edwards's descriptions of *A. nigrithorax* Macq. and *A. burpengaryensis* Theo. is remarkable. Allotype ♂: Eidsvold, South Queensland, Oct. 13, 1926 (Mackerras), in the Macleay Museum, University of Sydney.

Distribution.—Widely distributed in Victoria and New South Wales west of the Divide. Now recorded for the first time from Queensland: Eidsvold, June 6, 1926, biting by day (T. L. Bancroft), and October 7-13, 1926, females biting by day and at dusk, male in tussock near a swamp. Taylor records *A. wilsoni* as a source of great annoyance in the Goulburn Valley district, Victoria.

AEDES (OCHLEROTATUS) LUTEIFEMUR Edwards.

Edwards, 1926, pp. 112-113.

This is rather an inconspicuous species, but is readily recognized by the entirely pale hind femora, especially by the numerous pale scales towards the apex of C and R₁, and by the unbanded abdomen which is uniformly dark anteriorly, extensively mottled with ochreous creamy scales in the middle and entirely pale posteriorly.

Distribution.—Tasmania and Victoria (Edwards).—There are specimens in the South Australian Museum from Georgetown, Tasmania, November to March, and from King Island, Bass Strait, November and December, all coll. F. M. Littler.

AEDES (OCHLEROTATUS) NIVALIS Edwards.

Edwards, 1926, p. 112, new name for *A. australis* Theo. *nec.* Macq.

♀. Proboscis and palpi dark scaled, the former with a few white scales. Scutum and scutellum bright reddish to dark purplish brown; clothed with small bright pale golden scales, sometimes tending to a linear arrangement, but without any special ornamentation. A row of three to six lower mesepimeral bristles, usually the larger number. Legs black, with distinct violet reflections in most specimens; fore and mid femora with some scattered white scales anteriorly, hind femora white on basal four-fifths anteriorly, dark apically with some scattered white scales; no pale scales on tibiae and tarsi. Abdomen deep brown, usually with violet reflections, unmottled; all segments with basal white bands of variable extent, sometimes reduced to a single incomplete row of white scales, but never in my experience entirely absent. Venter white, with large apical lateral and small basal median dark patches on all segments. Size variable, some specimens up to 8 mm., the majority about 5-6 mm. The most characteristic features are the scutal and abdominal ornamentation, the markings of the venter, the adornment of the femora, and the violet reflections when present.

This species is exclusively alpine in New South Wales. It was exceedingly abundant and annoying at Barrington Tops in January and February, biting viciously at dusk and for an hour or two after; occasional individuals could be taken biting at almost any time.

Distribution.—New South Wales: Kosciusko; Barrington Tops, 5,000 feet, January and February, 1925. Victoria: In elevated country. Tasmania: Recorded

by Edwards (1926); there is also a single female in the South Australian Museum labelled "Tasmania" without further data.

AEDES (OCHLEROTATUS) BURPENGARYENSIS (Theobald).

This and the two following are to be separated from all others with dark tarsi by the complete absence of pale scales on the anterior surface of the fore and mid femora. The thoracic integument of *A. burpengaryensis* Theo. is described as deep brownish black and the abdomen as unbanded but with white basal lateral patches to the tergites. The venter has yellowish basal bands to the segments. A specimen before me from Myall Lakes agrees very well with the description, the almost metallic violet reflections of the legs being particularly striking. The tergal markings of the abdomen, however, are different and approach *A. clelandi* Tayl.; the second and third tergites are unbanded, the fourth has a very narrow basal band and there are wider basal bands on the fifth to seventh segments. I have no doubt that this specimen should be placed with *A. burpengaryensis* Theo. rather than *A. clelandi* Tayl., but it certainly forms a link between the two.

Edwards (1924) gives the following note on the male hypopygium: "Chiefly differs (from *A. nigrithorax* Macq.) in having the spines on the apical lobe of the side-piece more slender, and the sub-basal thumb of the claspette rather shorter".

Distribution.—South Queensland: Burpengary (type locality). New South Wales: Myall Lakes, Sept. 3, 1922 (A. J. Nicholson).

AEDES (OCHLEROTATUS) CLELANDI (Taylor).

I have examined a paratype and another authentic female in Dr. Ferguson's collection and cannot find anything to separate it from *A. burpengaryensis* Theo. beyond the bright reddish scutal integument, the conspicuous basal banding of the abdominal tergites and the more extensively pale scaled venter. The violet gloss of the legs is slight in these specimens, but both are rather wasted. These characters are hardly, in my opinion, of specific value. I believe it probable that *A. burpengaryensis* Theo. and *A. clelandi* Tayl. will be found to represent the extremes of a continuous north-south range of variation, but the evidence is as yet insufficient and I have decided to let Taylor's name stand for the present.

Distribution.—Bass Strait: Flinders Island, Nov. 21, 1912 (J. B. Cleland); King Island (A. M. Lea).

AEDES (OCHLEROTATUS) PURPUREIVENTRIS Edwards.

Edwards, 1926, p. 113.

I have not seen this species, which should be easily recognized from *A. burpengaryensis* Theo. by the entirely purple scaled venter.

Distribution.—Tasmania.

GROUP B. AFFINITIES NEOTROPICAL.

Tarsi with white rings.

A. aculeatus Theo. stands out as very distinct, but the other species of this group are all closely similar. The characters given in the key will usually be sufficient for their recognition, but the variability of certain species may render separation difficult in the case of extreme specimens. Indeed, out of the hundred odd females of *A. theobaldi* Tayl. and *A. normanensis* Tayl. before me, there are one or two which might be placed with almost equal propriety in either species. Hypopygial characters, however, establish their specific validity.

Aedes (*Ochlerotatus*) *aculeatus* (Theobald).

A very well defined but rare species with the head and sides of the scutum covered with small oval flat yellowish scales. It is the only Australian member of the subgenus without numerous narrow curved scales on the occiput and its affinities are somewhat doubtful.

Distribution.—South coastal Queensland and north coastal New South Wales.

Aedes (*Ochlerotatus*) *theobaldi* (Taylor).

The most striking feature of this rather ornate species is the presence of numerous broad pale scales on all the main veins of the wing. Though somewhat variable in number and size, these scales are always more numerous and distinctly broader than in any other species of the group. The scutum is covered with small densely arranged golden scales mixed with darker ones. The abdominal tergites are basally banded with creamy scales, usually prominent, but sometimes reduced to a narrow incomplete fascia, never, however, forming a posterior triangular prolongation. The dark posterior portions of the tergites show a variable amount of mottling with pale scales, more marked posteriorly; occasionally the mottling is practically absent and the abdomen is indistinguishable from that of *A. normanensis* Tayl., while in some specimens the whole abdomen is mottled and the basal bands are ill defined. The femora are extensively mottled anteriorly with white scales and the last hind tarsal segment is entirely dark or with a narrow basal white ring.

♂. Differs from the female as follows. Palpi brown, slightly longer than the proboscis, with some creamy mottling beneath which extends round the shaft in the middle to form an indefinite pale ring; penultimate segment with a narrow basal white ring; the apical segments slightly swollen and bearing long brown hairs. Antennae with long silky brown plumes. The abdominal bands are definite and there is little or no mottling. The white scales on the wing are scanty and scattered, but are more numerous and broader than in the males of related species. The side-piece (Text-fig. 5) bears an elongate rather hairy apical lobe and a very large characteristically shaped basal lobe covered with fine hairs which form a definite fringe on its medial border. The appendage of the claspette is better developed than in the other members of the group and forks distally to form a striking fluke-like structure. *A. theobaldi* Tayl. helps in some respects to bridge the gap between the two groups. Taylor's (1918) figure of a hypopygium referred here by Edwards (1924) was actually that of *A. wilsoni* Tayl. Described from twelve specimens, all from Eidsvold.

Allotype ♂: Eidsvold, S. Queensland, Oct. 13, 1926 (Mackerras), in the Macleay Museum, University of Sydney.

This species was abundant at Eidsvold from July to October, 1926, though usually a rarity in that district. It is a day and night biting sylvan species, occasionally also taken in the scrubs. The early stages were not discovered.

Distribution.—"An inland species . . . widely spread from Queensland to Victoria and into South Australia" (Ferguson, 1926). Though in general distributed west of the Divide, it appears in the coastal districts in south Queensland.

Aedes (*Ochlerotatus*) *theobaldi* (Taylor) form *EIDSVOLDENSIS*, new form.

♀. More ornate than the typical form from which it differs in the following respects: the pale scales of the wings, though as numerous, are distinctly narrower;

the thorax is densely covered with small, dull creamy golden scales without darker admixture; abdominal tergites with broad transverse basal creamy bands produced posteriorly to form a prominent median triangle which increases in size on the posterior segments, until on segment six it forms a complete vitta; the mottling of the darker parts of the segments is hardly detectable. This is possibly a distinct species, but I hesitate to treat it as such in view of its closeness to *A. theobaldi* Tayl. and the fact that only one specimen was available for study.

Holotype: The unique female, taken biting by day in forest country at Eidsvold, Oct. 7, 1926 (Mackerras), has been lodged in the Macleay Museum, University of Sydney.

Aedes (Ochlerotatus) normanensis (Taylor).

This obscure and difficult species is very close to *A. theobaldi* Tayl., but is even more likely to be confused with *A. vigilax* Sk. from which it is abundantly different on hypopygial characters. It is distinctly smaller than either and may be separated from both by a *collective* consideration of the following characters:—

1. The pale scales of the wings are narrow and are only numerous along the anterior border. On the rest of the wing they are very scanty or absent, though a few are almost always present along Cu.

2. The scutum bears relatively large pale golden scales without darker admixture; they are not densely packed and show a tendency to a linear arrangement.

3. The basal pale bands of the abdominal tergites are variable in extent, being occasionally conspicuous and straight edged, but more often reduced to a narrow patch. There is no mottling.

4. There is a variable amount of irregular pale scaling on the proboscis beneath. It shows no sharp demarkation from the distal dark part.

5. The mottling of the femora is relatively inconspicuous and the last hind tarsal segment is devoid of, or with only a narrow, pale ring.

The characters of the male are even less definite than those of the female except for the hypopygium. This structure (Text-fig. 6) shows close affinities with that of *A. theobaldi* Tayl., from which it differs in the smaller but more definite apical lobe and the differently shaped basal lobe of the side-piece.

A. normanensis is a day biting forest species which is numerous at Eidsvold in the later half of summer but is rare earlier in the season. I have bred it from mixed pupae taken in a muddy rock pool and in a waterhole in the bed of a sandy creek. The larvae are extraordinarily elusive and could not be found.

Distribution.—South and Central Queensland.

Aedes (Ochlerotatus) vigilax (Skuse).

A re-examination of Skuse's type leaves no doubt as to the identity of this very abundant and annoying insect. It is also clear that it was correctly recognized by Edwards, despite the fact that he states that the wings are entirely dark scaled. The following notes made from the type will serve to separate *A. vigilax* Sk. from any of its allies; wings with scattered pale scales of normal form, fairly numerous along the anterior border, some scattered ones on the other veins, particularly along Cu; scutum with fine scales, mostly dark brown, but interspersed with numerous irregularly arranged bronzy golden ones; pale bands of abdominal tergites white, about one-fourth the width of the segments and straight edged; pale area on ventral side of proboscis conspicuous and with

sharply defined apical limit; femora mottled with numerous pale scales anteriorly; last hind tarsal segment with a broad prominent basal white ring; lower mesepimeral bristle absent. In over 100 females from various localities the range of variation is slight, being practically limited to the amount of pale scaling on the wing; the white scales may be completely limited to the anterior border, or may be so numerous as to approach the condition seen in *A. theobaldi* Tayl. The apical lobe of the side-piece of the male (Text-fig. 7) is not apparent and the basal lobe is large, rounded and covered with numerous hairs, the pigmented bases of which give it a dark appearance; the claspette is small and bears a simple straight apical bristle representing the appendage.

The larvae have been described by Cooling (1924) and Brug (1924) and the larva and pupa figured by Hill (1925a). Their most characteristic features are the short broad siphon, the arrangement of the comb scales in a patch, the short antennae, and the short frontal hairs.

A. vigilax Sk. is the most important of the Australian "bush" mosquitoes. It is exceedingly abundant in the vicinity of estuaries where there are any mud flats or mangrove swamps which appear to be its principal breeding grounds and the dominant factor governing its local prevalence. In such localities as the Hawkesbury River it may settle on one in clouds and make life unbearable. It has, however, a wide range of flight and may be quite numerous several miles from its breeding grounds. It bites both by day and by night. Its habits and the question of its control in the Sydney district have been dealt with elsewhere (Mackerras, 1926); they do not appear to differ materially in other parts of its range.

Distribution.—Widespread round the coast of Australia. Though almost exclusively coastal in distribution, I have taken a few specimens well away from salt water, one at Barrington Tops, N.S.W. (January, 1925) at 5,000 feet elevation and 40 miles from the coast, and several at Eidsvold, S.Q. (December, 1922, April, 1924, and October, 1926). It appears certain that it was breeding in the latter locality if not in both. The season is from October to April, the greatest prevalence being in the middle of summer.

AEDES (OCHLEROTATUS) RUBRITHORAX (Macquart).

A relatively rare species which is easily recognized by the entire absence of pale scales on the anterior aspect of the femora and on the wings, and by the reddish scutum which is covered with fine bright golden scales. The male hypopygium (Text-fig. 8) resembles that of *A. vigilax* Sk., differing only in the broader, more rounded side-piece bearing a more prominent basal lobe which is not darker in colour than the rest of the side-piece.

Edwards (1924) queried *Culex procox* Skuse as a synonym, an opinion which was confirmed by Ferguson (1926) who also pointed out that one or two weak lower mesepimeral bristles may be present. These findings are confirmed by a re-examination of Skuse's type and the study of a fair series of the species commonly known as *A. rubrithorax* Macq. The bristles may be present on one side and absent on the other; when present they are small but quite conspicuous. The fact that *Culex rubrithorax* Macq. was described from Tasmania need not affect the determination, since it is now known that many species described as from Tasmania in Macquart's 4th Supplement actually came from coastal New South Wales. His description fits an abraded specimen reasonably well and it seems preferable to use his name rather than Skuse's, although the latter can be

definitely recognized and the type is in good condition. In the same work Edwards also queries *Culex occidentalis* Skuse as a synonym. The type of this species, is, however, a *Finlaya* and is in my opinion identical with *A. (F.) queenslandis* Strick.

Distribution.—A coastal species extending from South Queensland to Sydney, New South Wales; also recorded, almost certainly erroneously, from Western Australia and Tasmania. Specimens are before me from the following localities: Eidsvold, S.Q. (February and April); Stradbroke Is., S.Q. (September); Myall Lakes, N.S.W. (August); North Harbour, Sydney (October); Balmoral, Sydney (November). Purely a bush species and a day biter.

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NOTES ON AUSTRALIAN DIPTERA.¹ No. xi.

By J. R. MALLOCH.

(Communicated by Dr. I. M. Mackerras.)

(Twenty-three Text-figures.)

[Read 27th July, 1927.]

Family **Calliphoridae.**

As an inducement to the study of this family by Australian workers I offer some preliminary notes on the family characters and groupings within the family, and also present descriptions of some new Australian genera and species derived from material submitted to me for identification by the late Dr. Eustace W. Ferguson. Many of the species are of considerable economic importance, and though most of them are widely distributed and common, definite specific identifications are difficult to arrive at by the use of existing descriptions and the few keys available. Later on, should material become available to me, I may be able to present a fuller revision of the Australian species.

The first difficulty that confronts the systematist in this, as in all other taxonomic work, is the definition of the group or family. To state this may appear superfluous, but the more one widens his acquaintance with taxonomic treatises the more surely he is forced to the conclusion that many, if not most, authors possess merely an intuitive knowledge of the limits of the group they write of, or their concept when reduced to plain English is so broad, ambiguous, or so full of exceptions, that the uninitiated student is largely or completely in the dark as to what really constitutes the group. This is largely true of the status of the work on the family Calliphoridae to-day. Some workers include in it the Sarcophaginae, while others exclude that subfamily, consider it a family, and incline to break the residue up into families or subfamilies according to individual taste or opinion. Personally I prefer to consider all genera that have the second abdominal sternite overlapping sides of the tergite, no well developed convexly formed postscutellum, which possess strong hypopleural bristles in one or more vertical series below the spiracle, and have the first posterior cell of the wing conspicuously narrowed at apex as belonging to the family. This definition would include Calliphorinae, Sarcophaginae, Rhiniinae, Chrysomyiinae, Metopiinae, and some other groups which may be of equivalent or lesser rank such as are represented by *Mesembrinella*, *Bengalia*, etc., but none of which occur in Australia so far as I am aware at this time.

¹ [Mr. Malloch has given the references to Macquart's papers on Exotic Diptera to the original published in "Mémoires de la Société des Sciences, de l'Agriculture et des Arts de Lille". As these Memoirs are not in Sydney, I have added the references to the reprint published in Paris which is in the library of the Society. For a list of dates of publication see *Cat. Library Brit. Mus.* iii, L-O, p. 1215, 1910.—Ed.]

At present I possess Australian representatives of all of the five larger groups listed above, and below I give a key for the recognition of these in the hope that it may prove useful to students of the calytrate flies. It is to be noted, however, that this key is intended to apply to Australian forms only. Some extralimital forms, such as the genus *Compsomyia*, which does not have erect hairs on the small knob below the base of wing, will not run out to their proper places in the key.

Key to Subfamilies of Australian Calliphoridae.

1. Stem-vein of wing (radius) not setulose on posterior upper side of its basal section 2
 Stem-vein of wing with distant setulae or hairs on posterior upper side of its basal section 5
2. Lower calypter with some long fine erect hairs on a part of its disc above
 *Calliphorinae*, pt.
3. Lower calypter without long erect hairs on any part of its disc above 3
 Arista bare or very short pubescent; notopleural bristles two in number
 *Metopiinae*
4. Arista with at least short hairs, the longest distinctly longer than width of arista at base 4
 Notopleurals nearly always two in number; the outer two bristles on area between the presutural dorsocentrals and notopleurals not in a straight line, the anterior one distinctly laterad of the posterior *Calliphorinae*, pt.
5. Notopleurals almost invariably three or four in number; the two outer bristles on the area between presutural dorsocentrals and notopleurals either in longitudinal line, or anterior one mesiad of posterior *Sarcophaginae*
6. The small rounded protuberance below base of wing frequently with erect hairs, lower calypter subtruncate at apex, concave on outer margin, haired on part of upper surface *Chrysomyiinae*
 The small rounded protuberance below base of wing, and upper surface of lower calypter, bare, or without distinct hairs, the calypter rather narrowly rounded at apex, straight, or nearly so, on outer margin *Rhiniinae*

In connection with the above key it appears pertinent to point out that there are some characters in the structure of the male hypopygia which may have a group significance. I do not incline to give much weight to the structure of these organs in distinguishing genera or higher groups as a general rule but in some families the general structure may sometimes be relied upon to identify the males belonging to particular genera. If a comparison is made between the hypopygium of a species of *Calliphora* and one of *Sarcophaga* it is evident at a glance that there is a very decided difference in the two pairs of claspers which are directed downward at apex. In *Sarcophaga* the outer pair are short and very much less conspicuous than the inner pair, being usually referred to as the accessory plates, while in *Calliphora* they are usually as long as the inner pair and quite as heavily chitinized. There are some other distinctions but there is so much variation in the inner portions involved in the penis and its guard in the genus *Sarcophaga* and its allies that little use can be made of these in generalizing.

Undoubtedly competent morphologists could homologize the parts of the hypopygia but the taxonomist is primarily interested in differentiations and not in homologies so occasionally the latter group uses different names for the same part of an organ which course, while probably perfectly justifiable from the point of view of one more especially interested in obtaining identifications than in arriving at homologies, leads to some confusion in terminology.

I have figured the hypopygia of some of the other genera dealt with in this paper and a comparison of these with the figures presented in some of the papers on Australian Sarcophagidae will readily show the distinction to which I refer.

One of the fatal objections to the use of the structure of the male hypopygia as an index to generic and subfamily relationships is that it is very rarely the case that co-ordinated characters can be found in the females and a classification based upon one sex is, not only a hindrance, but practically a bar to the study of any group in which it is so used unless one has authentic males and females of the species, which it is rarely possible to obtain without long and arduous field work.

Subfamily Calliphorinae.

In this subfamily there are in use several generic names which have rather a doubtful status, the basis for the separations being the different number of the so-called sublateral bristles present. These consist of from one to three bristles in front of the thoracic suture in line with the postsutural intra-alar bristles and mesial of the two presutural bristles referred to in the foregoing key to genera, the latter being known as the posthumeral (anterior) and presutural (posterior) bristles respectively. The genus *Cynomyia*, which I have not seen from Australia, has but one of these sublateral bristles, which is almost in line transversely with the hind margin of the humeral callosity, both the weak anterior one and the one just in front of suture being absent. In the genus *Steringomyia*, also unknown to me from Australia, there are two of these bristles present, while in *Onesia* and *Calliphora* all three are usually present.

If we apply these characters to the Australian species included in *Calliphora* by Patton and by Hardy in their recent papers it becomes evident that there are either two or more genera present, or the character is not of generic value. *Cynomyia* I consider is a good genus, but in some Australian species of *Calliphora* the posterior one of the sublateral bristles may be entirely indistinguishable in some specimens, while it is evident though weak in others even of the same species. I am inclined to consider that under these circumstances the Australian species at least cannot be thus generically divided. I find that in *Onesia* there are from one to three sublaterals present, the usual number being three. I do not care to express an opinion here on the validity of *Steringomyia*.

The distinctions between *Onesia* and *Calliphora* are even less marked than are those between the latter and *Steringomyia*. The most recent attempt to separate these is that by Shannon in 1923 in dealing with the North American forms. He cites the straight or slightly curved apical section of fourth vein as against the distinctly curved one, and the short as against the longer third antennal segment as characters in *Onesia* and *Calliphora* respectively, but there is no reason to accept these as generic criteria, the evident intent being merely to perpetuate, and not to discard existing generic concepts. The worst feature of accepting *Onesia* as the same as *Calliphora* is that the former has page priority in the paper in which they both were published and thus would supplant *Calliphora*, with a consequent change of the name of the family to Onesidae.

It is unfortunate that intensive research almost invariably results in more or less radical changes in names of even the most widely known and common insects, and the fault lies not with the modern worker who applies the rule of priority, but with those of past generations who failed to appreciate identities and co-ordinate related forms. Were it possible to accept *Onesia* and *Calliphora* as distinct I would not hesitate to suggest this course, but I can see no good excuse for doing so on any characters distinguishable by me.

En passant it must be remembered that we have been using the name *Calliphora* contrary to the rules of priority, as it has been proven that the name properly

applied to the group is *Musca*, and that the group now known under the generic name *Musca* should be known as *Promusca* Townsend. An attempt has been made to conserve the name *Musca* for the group containing *domestica* and its allies, and in the event that such a course is adopted then the name *Calliphora* will naturally fall as a synonym of *Onesia*. The proper medium for the final disposition of these points would be a monograph on the family so I merely state conditions, and do not make any drastic changes herein, this paper being intended merely to stimulate interest in the family it deals with.

I present below a key for the separation of the few genera of this subfamily I have seen from Australia. There are probably more native genera, but the amount of material available to me now is rather scanty, and possibly with this paper in hand some student of the calyptrate flies may be induced to take an interest in it so that more specimens from a wider range of territory may become available.

Before I attempt to deal with the genera and species of this family it may be well to give space to some remarks upon the status of some of the names in the group apart from the generic names just referred to.

Major Patton has been for some years actively engaged in publishing papers on Calliphoridae and Muscidae, particularly those forms which affect man and domestic animals, and one of his recent papers deals with Australian Calliphoridae. In this paper he cites a number of synonyms and describes several new species. All of the new species are available to me in material sent to me by Dr. Ferguson, so that it is possible to include data upon them in the present paper. It is, however, impossible for me to decide definitely whether his conclusions as to specific identities are or are not correct. I incline to the opinion that some at least of the species he includes as synonyms are perfectly valid species, but without having the same opportunity as he had to examine the type specimens it would be unwise to be dogmatic in giving determinations upon most of these. Mr. Hardy has also recently published a paper dealing with the species of *Calliphora* and though his ideas and mine appear to conform better than do Major Patton's and mine there are so many additional species in my material which he did not have that it is impossible for me to definitely decide what certain of his species are in my lot. However, it may be possible after my paper appears for the data presented to be used in bringing together material for use in a comprehensive study of all the Australian species of the family.

The most recent paper dealing with Calliphoridae is that by Mr. Senior-White. This presents a consideration of the Oriental species, but unfortunately has much the same blemishes present in Patton's work, which is to be expected because there was a close collaboration between these workers. I note here that *Calliphora fulviceps* van der Wulp, an endemic Oriental species, is omitted by Senior-White. This is a very characteristic species, with bright fulvous yellow face and cheeks, the latter furnished with long fulvous hairs, and it has but one pair of presutural acrostichals as a rule, a character which I have not seen elsewhere in the genus. I have not seen this species from other localities than the mountains of Java and Sumatra.

Key to Genera of Calliphorinae.

1. Lower calypter with some conspicuous erect fine hairs on at least part of its upper surface, sometimes very close to base only 2
- Lower calypter without any erect fine hairs on upper surface 4
2. Extreme base of stem-vein of wing on under surface with setulose hairs; upper surface of lower calypter almost entirely haired; presutural area with 3 to 5 bristles 3

- Extreme base of stem-vein of wing without distinct hairs or setulae; apical part of upper surface of lower calypter broadly bare *Calliphora* Robineau-Desvoidy
3. Eyes hairy; no strong forwardly directed orbitals in female; the fourth tergite in this sex with a central longitudinal weak part which gives the segment the appearance of being cleft *Ptilonesia* Bezzi.
Eyes bare; two strong forwardly directed orbitals on each side in female; fourth tergite in this sex entire, the apex transverse and heavily chitinized
. *Xenocalliphora* Malloch
4. Suprasquamal ridge strongly setulose anteriorly and posteriorly
. *Lucilia* Robineau-Desvoidy
Suprasquamal ridge bare at least anteriorly or posteriorly 5
5. Supraspiracular convexity of metathorax with long erect fine hairs
. *Paratricyclea* Villeneuve
Supraspiracular convexity without erect fine hairs 6
6. Propleura haired in centre between the humeral hairs and those on lower margin . . 7
Propleura bare in centre 9
7. Presutural area with 4 or 5 bristles *Melinda* Robineau-Desvoidy, pt. 8
Presutural area with two bristles 8
8. Upper half of parafacials with setulose hairs; supraspiracular ridge bare at posterior extremity *Melinda* Robineau-Desvoidy, pt.
Upper half of parafacials bare; supraspiracular ridge fine haired at posterior extremity *Euphumosia* Malloch
9. Thorax without yellow or golden pile or tomentum besides the usual bristles and hairs *Anthracomysia*, gen. n.
Thorax with yellow or golden pile or tomentum in addition to the usual bristles and hairs *Pollenia* Robineau-Desvoidy

Genus PTILONESIA Bezzi (1927).
Bull. Ent. Res., 1927, xvii, p. 242.

This genus contains one known species, with characters as indicated in the preceding key. It is most closely related to *Xenocalliphora* Malloch, an austral genus known from New Zealand. I prefer to treat this as a genus and not a subgenus as Bezzi has done. Genotype, *Pollenia auronotata* Macquart.

PTILONESIA AURONOTATA (Macquart).

Pollenia auronotata Macq., *Mém. Soc. Sci. Lille*, 1854, p. 135 (1855); *Dipt. Exot.*, Suppl., 5, p. 115, 1855.

Similar in general habitus and colouration to *Calliphora erythrocephala*, but the bright orange coverings of the thoracic spiracles, similarly coloured scales over wing base, and the entirely different armature of the head readily distinguishes the species. The calyptres are fuscous, with white edges.

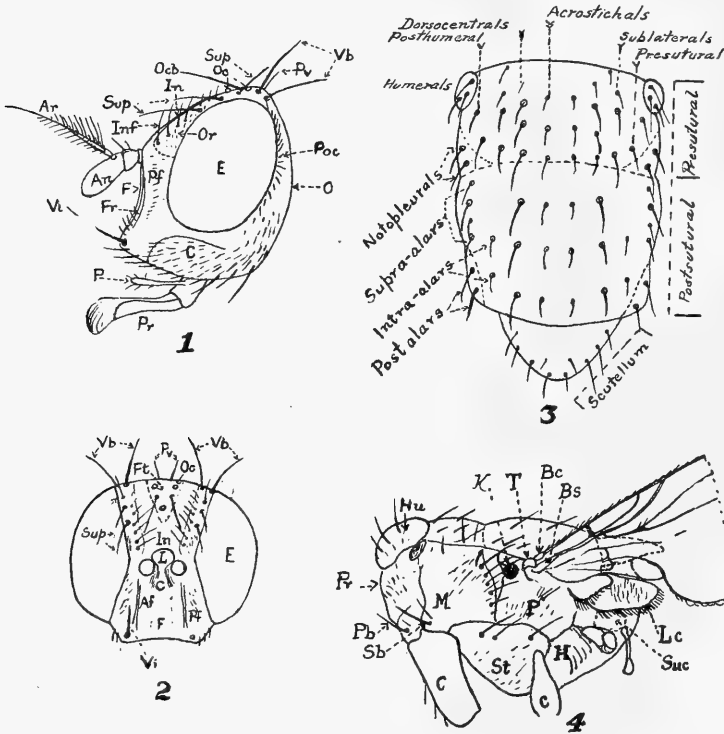
Length, 9-10 mm.

Locality: Sydney, N.S.W., one female.

Genus CALLIPHORA Robineau-Desvoidy (1830).

The Australian members of this genus present a greater diversity of form, colour and vestiture than do those known to me from any other faunal region, and it is not surprising that certain authors have selected some of the species as types of distinct genera. In the case of genera acceptance or rejection is more a matter of individual opinion than is the acceptance or rejection of species. Almost invariably it is possible to demonstrate the existence or absence of differentiating characters in species, but in accepting or rejecting genera one has to decide whether the possession of one or more distinguishing characters in any species or group of species is sufficient grounds for considering them as entitled to generic separation from their most closely allied relatives. Some authors incline to accept a single structural character, such as the presence or

absence of hairs on the eyes, as sufficient to warrant the erection of a genus for the reception of species previously included in a genus the species of which do not possess that character, even when the whole of the species are otherwise similar in features distinguishing them from related genera. The trend of this class of work is towards the erection of a great number of monobasic genera



Text-figure 1. Head from the side, typical. An, antenna; Ar, arista; C, cheek; E, eye; F, face; Fr, facial ridge; In, interfrontalia; Inf, inferior orbital bristles; Oc, ocelli; Ocb, ocellar bristles; Or, orbit; P, palpi; Pf, parafacial; Poc, postocular cilia; Pr, proboscis; Pv, postvertical bristles; Sup, supraorbital bristles; Vb, vertical bristles; Vi, vibrissae.

Text-figure 2. Head from the front, female. Lettering as Text-figure 1, with additions, Af, antennal foveae; Ft, frontal triangle.

Text-figure 3. Dorsum of thorax, bristles lettered.

Text-figure 4. Side of thorax, no definite genus. Bc, basicosta; Bs, basal sclerite of stem vein; C, coxae; H, hypopleura; Hu, humerus; K, knob-like pleural process; Lc, lower calypter; M, mesopleura; P, pteropleura; Pb, propleural bristle; Pr, propleura; Sb, stigmatal bristle; St, sternopleura; Suc, supraspiracular convexity.

without materially assisting the student interested in classification. In other words, monobasic genera tend to obscure relationships, a result that is less desirable than is the retention in one genus of species biologically similar but separable by such a character as that mentioned above. I do not think that the genera *Neopollenia* Brauer, *Neocalliphora* Brauer and Bergenstamm, and

Paracalliphora Townsend, are entitled to full generic rank, and include them, or at least their genotypes, in my synopsis given below.

I have found it impossible to determine definitely whether or not certain forms in my possession are distinct species without a dissection of the male hypopygia and present drawings of these herein to facilitate recognition of the species involved by other students of the group. These organs are not so intricate as those of most species of *Sarcophaga*, but the interior central portions, constituting the penis and its sheath, etc., differ more or less markedly in the different species, providing characters by means of which they may be recognized. It is well known that the male hypopygia are of great value as specific criteria in many groups of insects and in the Diptera such families as Sarcophagidae, Chironomidae, Tipulidae, Dolichopodidae, Asilidae, and others are striking cases in which these organs provide reliable and outstanding means of identification in the male sex. It is not so well known, however, that some families and genera do not present great differences in the structure of the hypopygia of the males, and one need only make a study of the males of the genus *Musca sens. lat.* to discover how trivial are the structural differences between the hypopygia of even the most distinct species of the genus. In fact, Major Patton has expressed the opinion that these organs offer no means for distinguishing the species. This is not strictly correct, but the distinctions are so trivial that only one versed in the differentiation of species can appreciate them. In *Calliphora* the structure of the two apical pairs of claspers or forceps is very much the same in many of the species, but there are minor differences of form and armature, which, coupled with the differences in the structure of the central portions, readily distinguish the species I have examined.

To facilitate the use of this paper I give diagrams showing the portions of the thorax and the position of the various bristles utilized in classification (Text-figs. 1-4).

Key to the Species.

1. Eyes in both sexes with quite dense erect yellow hairs 2
Eyes in neither sex with noticeable hairs 3
2. Thoracic dorsum densely yellowish dusted so that the ground colour is entirely or almost entirely obscured and the thorax appears entirely ochreous
..... *ochracea* Schiner
Thoracic dorsum bluish black, with whitish dusting which does not at all obscure the ground colour *ochracea* form *nigrithorax* nov.
3. At least the tibiae reddish or yellowish, and distinctly paler than femora, or the femora are also yellow 4
Legs entirely black, tibiae rarely very slightly paler than the black femora 8
4. Pleural and abdominal hairs and bristles entirely black; abdomen black, with bright golden yellow pollen which is noticeably checkered; femora, tarsi, and coxae, black, tibiae reddish, darker at bases; posterior sublateral bristle lacking *tibialis* Macquart
Pleural and abdominal hairs in part bright yellow or golden 5
5. Abdomen black or fuscous, with a metallic bronzy tinge and dense yellow dusting which is conspicuously checkered as in *tibialis*, the ventral hairs longer, and, like the lateral hairs and bristles, bright golden yellow; posterior sublateral bristle usually distinct 5A
Abdomen honey yellow on at least the sides and venter, always with a large part of central section of disc metallic blue, or violet coloured 6
- 5A. Eyes of male with facets of upper half conspicuously larger than those of lower half, the frons reduced to a narrow line; thorax almost invariably with three pairs of presutural acrostichals; hypopygium as Text-figure 5
..... *stygia* (Fabricius)

- Eyes of male with facets of upper half but little larger than those of lower half, the frons about as wide as third antennal segment; thorax almost invariably with two pairs of presutural acrostichals; hypopygium as Text-figure 6
 *hilli* Patton
6. Coxae, femora, and bases of tibiae, dark brown or fuscous; thoracic dorsum when seen from behind with a narrow postsutural vitta between the acrostichals, and a spot between these and the dorsocentrals midway between suture and posterior margin, black; scutellum with the pruinosity distinctly checkered, best seen by moving the specimen round in examination; dorsum of abdomen with most of disc of basal three tergites glossy purplish or violet coloured, the dark portion not sharply limited, fourth tergite densely golden dusted, slightly checkered; posterior sublateral bristle lacking *fuscofemorata*, n. sp.
- Coxae, femora, and tibiae, bright honey yellow; dorsum of thorax and scutellum not marked as above 6A
- 6A. Thorax with two pairs of presutural acrostichal bristles, the posterior pair distinctly proximad of a transverse line drawn between the posterior pair of presutural dorsocentrals; posterior sublateral bristle lacking or almost indistinguishable from the surrounding hairs; fourth abdominal tergite densely yellow dusted, with a large underlying metallic greenish basal mark which is obscured by the dusting *augur* (Fabricius)
- Thorax with at least three pairs of presutural acrostichal bristles, the posterior pair just in front of suture, and much behind posterior presutural dorsocentrals; posterior sublateral bristle present, quite distinct from the surrounding hairs 7
7. Humeri bluish black, concolorous with dorsum of thorax; dorsum of abdomen broadly purple on all tergites, the dark colour of fourth conspicuous because of the presence of but thin whitish dusting; sternopleurals 1+1 .. *macleayi*, n. sp.
- Humeri testaceous, very noticeably paler than dorsum of thorax; dorsum of abdomen partly metallic green or blue-green; fourth tergite with more conspicuous dusting; sternopleurals 2+1 *centralis*, n. sp.
8. Posterior sublateral bristle lacking 9
 Posterior sublateral bristle present, sometimes weak and short 10
9. Small species, about 5 mm. in length; abdomen bright metallic blue-green, almost entirely lacking whitish dusting on dorsum; wing veins entirely fuscous; apical section of fourth vein beyond the angle almost or quite straight sp.?
 Larger species, about 10 mm. in length; abdomen brassy green, with rather dense whitish dusting which is distinctly checkered; wing veins yellow at bases, brown beyond; apical section of fourth vein beyond bend distinctly curved
 *dispar* Macquart?
10. The small unarmed scale (basicosta) between tegula and base of costal vein black or fuscous 11
 The small unarmed scale between tegula and base of costal vein whitish or yellowish at least on outer half or more 14
11. Abdomen dark metallic blue, with slight even dusting and a dark central vitta on basal three visible tergites, the fourth with quite dense brassy or yellowish dust, sharply contrasting with the other tergites; calyptres dark brown or fuscous, fringe of lower one yellowish; hairs on occiput except postocular fringe yellow, those on cheeks black *apicalis*, n. sp.
- Abdomen metallic blue-green or black-blue, with or almost without whitish dusting, fourth tergite not at all differentiated from the others 12
12. Robust species, with dull metallic blackish blue abdomen which is quite noticeably white dusted; scutellum with 18-20 bristles; hypopygium as Text-figure 7
 *robusta*, n. sp.
- More slender species, with brilliant metallic blue-green abdomen which is but slightly white dusted; scutellum with 10-12 bristles 13
13. Outer forceps of male hypopygium stout (Text-figure 8); third antennal segment orange, slightly darkened at apex *xanthocera*, n. sp.
- Outer forceps of male hypopygium slender and tapered apically (Text-figure 9); third antennal segment fuscous, narrowly yellowish at base .. *australis*, n. sp.
14. Lower calypter fuscous, with a portion of margin as well as the thickened edge and the fringe, white; cheeks and lower portion of parafacial brownish orange, with black hairs; fourth vein beyond apical curve much bent .. *erythrocephala* Meigen

- Lower calypter brownish, yellowish, or whitish, if the margin is paler than the disc the pale colour is confined to the thickened edge, and does not extend over any part of the disc; cheeks with the raised portion black or fuscous, never orange, if rufous the surface is obscured by grey dust
15. Males 16
 Females 19
16. Facets of upper half of eye larger than usual, the frons reduced above to a very narrow line, which is not wider than anterior ocellus; dusting on entire orbits and parafacials uniformly yellowish grey and dense, when seen from the side without a dark patch opposite base of antennae and another below middle of parafacial; hypopygium as Text-figure 11 *plebeia*, n. sp.
 Facets of upper half of eye not especially enlarged, the frons at narrowest point at least twice as wide as anterior ocellus 17
17. Frontal orbits and parafacials densely and uniformly yellowish grey dusted, not noticeably checkered when seen from the side; apical section of fourth vein almost straight beyond angle; hypopygium as Text-figure 10 *minor*, n. sp.
 Frontal orbits and parafacials variably dusted, with a noticeable white patch on latter just below bases of antennae which is best seen when the head is viewed from the side; if orbits are evenly dusted, the apical section of fourth vein is bent 18
18. Second visible tergite of abdomen with quite strong apical bristles on entire margin; apex of outer forceps of male hypopygium slightly but distinctly dilated or spatulate (Text-figure 13) *accepta*, n. sp.
 Second visible abdominal tergite without well developed bristles on hind margin centrally; apex of outer forceps of male hypopygium acute 18A
- 18A. Inner, or superior, hypopygial forceps of male with a deep notch basad of middle when seen from the side (Text-figure 12) *clarki*, n. sp.
 Inner, or superior, hypopygial forceps of male not notched when seen from the side, straight or slightly curved 18B
- 18B. Both pairs of hypopygial forceps of male almost straight (Text-figure 14)
 *metallica*, n. sp.
 Both pairs of hypopygial forceps of male distinctly curved (Text-figure 15)
 *assimilis*, n. sp.
19. Abdomen bronzy black, with dense brassy or golden dust which is distinctly checkered; wings quite noticeably yellow at bases; prosternal hairs and those on centre of propleura yellow; posterior sublateral bristle strong; fourth vein distinctly curved beyond subapical angle *auriventris*, n. sp.
 Abdomen metallic blue, blue-green, or bronzy, with or without whitish dusting, sometimes checkered, but never with brassy or golden dust 20
20. Fourth vein beyond preapical angle very distinctly curved, not slightly and regularly arched 21
 Fourth vein beyond preapical angle straight or almost so, at most with a very slight and regular arcuation on entire length 22
21. Calyptres slightly browned, centrally at least; abdomen bright metallic greenish blue, with changeable white dusting *metallica*, n. sp.
 Calyptres pure white; abdomen bronzy or greenish black, with quite dense white dusting which is distinctly checkered *plebeia*, n. sp.
22. Parafacials quite densely and evenly yellowish white dusted; abdomen bluish black, with grey dust on tergites, which is rather dense, and distinctly checkered
 *minor*, n. sp.
 Parafacials with checkered or variegated dusting, most conspicuous opposite second antennal segment when seen from the side; abdomen bright metallic blue-green, with rather slight whitish dusting which is most distinct laterally *accepta*, n. sp.

It must be noted that there are probably many species in Australia which are not included in the above key and that the most reliable characters for the recognition of those listed above are those of the hypopygia of the males. The females do not present many outstanding characters and it would be unwise to place too much reliance upon the diagnostic characters used for this sex without having male specimens for checking up. As already stated, the above is

presented merely as a preliminary attempt to distinguish the native species, and must be revised with the accession of more material, and the results checked by rearings in the field.

CALLIPHORA OCHRACEA Schiner.

Reise Novara, Dipt., p. 307, 1868; ? *Ochromyia hyalipennis* Macq., *Mém. Soc. Sci. Lille*, 1850 (*nec* 1834), p. 218; *Dipt. Exot.*, Suppl. 4, p. 245, Pl. xxii, fig. 10, 1850; ? *Adiochosia hyalipennis* Surcouf, *Nouv. Arch. Mus. Hist. Nat. Paris* (5), p. 85, 1920.

This strikingly distinct species was cited as the genotype of *Neocalliphora* by Brauer and von Bergenstamm. I cannot admit its claim to even subgeneric separation from *Calliphora*.

I am inclined to consider this, which is the mainland form, as probably entitled to specific distinction from the one with the dark thoracic dorsum herein listed as a variety, but my material is so scanty that it is impossible for me to arrive at a definite conclusion on the matter. The females before me appear to be a little more robust, with the anterior thoracic width greater, than the Tasmanian form.

Localities: Eungella, 45 miles west of Mackay, Queensland, 1,400-2,000 feet, 13-25 Sept., 1923 (Goldfinch); Sydney, N.S.W., 15 Sept., 1923; Dinner Creek, Ravenshoe, N.Q. (Sherrin).

CALLIPHORA OCHRACEA, form NIGRITHORAX nov.

This is the Tasmanian form, which differs as stated in the key and above paragraph. Whether or not this is *hyalipennis* Macquart is immaterial as the latter name is a homonym, a fact previously pointed out by Hardy.

Length, 10-11 mm.

Type, Mangalore, Tasmania, 15 March, 1914.

CALLIPHORA TIBIALIS Macquart.

Mém. Soc. Sci. Lille, 1844, p. 323 (1846); *Dipt. Exot.*, Suppl. 1, p. 195, 1846.

Apparently one of the commonest and most widely distributed species in eastern Australia. Readily distinguished from any other species in the genus by the reddish tibiae, entirely pollinose abdominal dorsum, and the lack of yellow hairs on abdomen and pleura. In the colour of the pollen on abdomen it resembles *auriventris* described on a subsequent page of this paper. Quite variable in size, ranging from 6 to 11 mm. in length.

Many specimens from New South Wales.

I believe that *Calliphora tessellata*¹ Macquart is the same species as *tibialis*.

CALLIPHORA STYGIA (Fabricius). (Text-figure 5.)

Spec. Ins., ii, p. 438, 1774.

I do not know if Patton made certain when he examined the type of this species whether the eye facets in that specimen are enlarged or not, but accept his assignment of specific names merely as a tentative course, definite decision being dependent upon a careful examination of types. It appears highly probable to me that both species may have been described, as they are widely distributed,

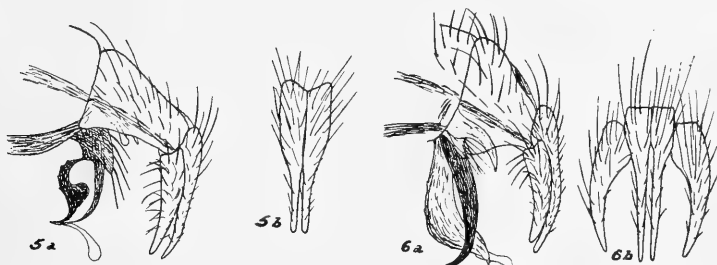
¹ *Mém. Soc. Sci. Lille*, 1842, p. 237 (1843); *Dipt. Exot.*, ii, pt. 3, p. 130, pl. xv, fig. 6, 1843.

and there are several so-called synonyms listed under *stygia*. In the meantime the names accepted herein may be used.

Hardy has expressed the opinion that *hilli* Patton is an aberration of *stygia*, and notes that "both forms are to be bred in Brisbane under conditions that point to the progeny being from the same parent I have not been able to ratify or refute this opinion . . .". In this connection it appears pertinent to indicate that it is unwise to conclude that only one species of this genus is present in lots reared from even a limited amount of food, several species of this and allied genera often occurring in the same pabulum.

Dissection of the males of the two forms points to the fact that they are distinct species. The male hypopygium of *stygia* is figured herein (Text-fig. 5).

Localities: Sydney, Kuringgai, Blue Mts., Kosciusko, N.S.W.; and Ruapehu, New Zealand.



Text-figure 5. Hypopygium of *Calliphora stygia*. a, side view; b, upper forceps from behind.

Text-figure 6. Hypopygium of *Calliphora hilli*. a, side view; b, both forceps from behind.

CALLIPHORA HILLI Patton. (Text-figure 6.)

Phil. Jour. Sci., 1925, xxvii, p. 400.

As indicated under the preceding species this one probably has had some other name given to it before Patton described it. The characters listed in the key readily distinguish it from *stygia* as herein accepted, and the hypopygium is quite distinct from that of its ally (Text-fig. 6). I have before me two females from Eungella, Queensland, which have three pairs of presutural acrostichals, but they have the narrow frons and orbits of *hilli*, and evidently belong here, a conclusion strengthened by the fact that a male of *hilli* was taken along with them. I dissected the male to make certain of its identity.

Localities: Sydney; Barrington Tops, Dec., 1921 (G. Goldfinch), N.S.W.; Eungella, 45 miles west of Mackay, Queensland (Goldfinch).

The records may point to this being a more northern form but I have before me females from New Zealand that are referable here, and Hardy records it from Tasmania.

CALLIPHORA FUSCOFEMORATA, n. sp.

Male.—Head fuscous, lower portion of parafacials, anterior part of cheek beyond the raised area, lower part of face, the palpi, and antennae, brownish yellow, third antennal segment darkened apically; occiput, raised part of cheeks, and the orbits, grey dusted, a paler patch of dust opposite bases of antennae on parafacial; hairs on lower half of occiput and on posterior half of cheeks yellow.

Thorax black, with slight grey dusting, the dorsum faintly vittate, when seen from the side the postsutural area has a narrow central dark vitta, and on each side between the acrostichals and dorsocentrals a small dark spot at middle; many of the pleural hairs yellow, but those on mesopleura anterior to the bristles dark. Abdomen honey yellow, with a broad violet-blue patch on middle of basal three tergites which is not sharply outlined laterally, the fourth tergite densely yellowish grey dusted, with distinct checkering, the dust obscuring the ground colour; most of the ventral hairs and bristles yellow. Coxae and femora fuscous, the latter yellow at bases of hind pair; tibiae honey yellow, hind pair slightly darkened at bases; tarsi black; bristles at bases of ventral surfaces of hind femora yellow, the others black. Wings brownish hyaline. Calyptrae pale brown. Halteres yellow.

Frons at narrowest point about as wide as anterior ocellus; parafacial about as wide as third antennal segment; hairs on facial ridges extending to above middle. Posterior sublateral bristle lacking. Abdomen robust. Legs normal. Apical section of fourth vein beyond angle distinctly curved.

Length, 7 mm.

Type, Kuranda, Queensland (F. P. Dodd).

CALLIPHORA AUGUR (Fabricius).

Ent. Syst., iv, p. 321, 1775; *oecaniae* Rob.-Desv., *Essai Myod.*, p. 438, 1830; *villosa* Rob.-Desv., *id.*, p. 437; *lateralis* Macq., *Mém. Soc. Sci. Lille*, 1842, p. 291 (1843); *Dipt. Exot.*, ii, pt. 3, p. 134, 1843; *rufiventris* Macq., *Mém. Soc. Sci. Lille*, 1846, p. 98 (1847); *Dipt. Exot.*, Suppl. 2, p. 82, Pl. v, fig. 5, 1847.

This species differs from the preceding one in having the head much paler, the lower half of occiput, entire cheeks, lower half of parafacials, and the face being orange yellow. The pleura are quite densely yellowish dusted and appear paler than the dorsum, the humeral angles are yellowish, the dorsum is whitish dusted and on it there is no trace of the spot between the postsutural acrostichals and dorsocentrals. The dorsocentral blue mark on abdomen is quite sharply limited laterally. Coxae, femora, and tibiae orange yellow, tarsi black, ventral bristles on hind femora of male black.

Structurally similar to the preceding species, the posterior sublateral bristle usually lacking; male hypopygia not dissected in either species.

Length, 8-11 mm.

I have before me specimens of both sexes from Sydney, N.S.W.

Two females without more definite locality than Australia differ from those of typical *augur* in having the dorsal blue mark on abdomen much broader, the third tergite being almost entirely blue dorsally, and the fourth is entirely blue with only slight whitish dusting which does not obscure the ground colour. These may belong to a distinct species, but without males of each for dissection I cannot give a definite decision either way so leave them temporarily as *augur*.

Patton lists a number of synonyms of *augur* in his recent paper and it appears probable that further examination of the types of the species so listed may result in the discovery that they do not really all belong to the same species. Meanwhile the only course open to me is to accept his findings. The following two species belong to the same group as the preceding two.

CALLIPHORA MACLEAYI, n. sp.

Male and female.—Head coloured as in *fuscifemorata*, but the cheeks not so much darkened. Thorax shining, with a violet tinge, whitish dusted, and with

mere traces of vittae on dorsum; pleura not shining and much more densely yellowish grey dusted than dorsum, mesopleura yellow haired on lower half. Abdomen honey yellow, broadly violet-blue on centre of dorsum of all tergites, which colour is sharply limited laterally and widened on posterior margin of visible tergites 1 to 3, no dense dust on fourth, the surface, like that of other tergites, distinctly shining; most of ventral hairs and bristles yellow. Coxae, femora, and tibiae honey yellow, tarsi black; femoral hairs and bristles yellow basally. Wings hyaline. Calyptrae and halteres yellow.

Frons in male a little wider than in *fuscofemorata*, the head similar in other respects. Thorax with three pairs of presutural acrostichals, and a distinct posterior sublateral bristle. Otherwise similar to *fuscofemorata*; hypopygium not dissected.

Length, 7-9 mm.

Type male, allotype and one male and one female paratype, Eungella, 45 miles west of Mackay, Queensland, 1,400-2,400 feet, 13-25 Sept., 1923 (Goldfinch).

CALLIPHORA CENTRALIS, n. sp.

Male.—This species has the head coloured as *augur*, the cheeks being entirely yellow, but the third antennal segment is paler than in that species. The thorax is bluish black on dorsum, more metallic posteriorly, with whitish dusting, and more noticeably vittate than the other species, especially anteriorly; the humeri are yellow, and the pleura are quite densely yellow dusted. Abdomen honey yellow, with a narrower blue-green stripe on basal three tergites, and none on fourth, or only a trace in centre of the dark colour. In other respects similar to *macleayi*; hypopygium not dissected.

Length, 9 mm.

Type, Eungella, 45 miles west of Mackay, Queensland, 1,400-2,400 feet, 13-25 Sept., 1923 (Goldfinch).

A female which I take to belong to this species has the thorax more densely whitish dusted on dorsum, and the ground colour of the pleura largely yellow.

Locality: Townsville, Queensland (F. H. Taylor).

A second female agrees more closely with the male in colour of the thorax, but has the fourth tergite overcast with a metallic blue-green tinge.

Locality: Upper Lansdowne, N.S.W., 25 Febr., 1921.

None of the species treated hereinafter have any yellow colour on either the thorax or abdomen, and all of them have entirely black legs, forming a very difficult group to distinguish specifically. Only a careful examination of specimens and more especially an examination of the male genitalia will serve to identify them in the adult stage but corroborative evidence of specific value may be found either in the larval stages or in the habits of the forms involved.

CALLIPHORA sp.

Female.—I have some doubt as to the specific identity of this form. It may be merely an aberrant form of one of the other species dealt with in this paper, but I have no means of checking this up so leave it without a definite name meanwhile.

In colour it closely resembles *clarki* and *accepta*, with the strongest possibility that it belongs to the latter.

Locality: Botany Bay, N.S.W. (H. Petersen).

CALLIPHORA DISPAR Macquart.

Mém. Soc. Sci. Lille, 1844, p. 323 (1846); *Dipt. Exot.*, Suppl. 1, p. 195, 1846; *C. pubescens* Macq., *Mém. Soc. Sci. Lille*, 1850, p. 215 (1851); *Dipt. Exot.*, Suppl. 4, p. 242.

I assign to this species a female specimen which is somewhat similar to the one mentioned above, but it is fully 10 mm. in length, has the thorax more noticeably whitish dusted and less evidently vittate, the abdomen brassy green instead of metallic blue, and quite conspicuously, though not densely, white dusted and slightly checkered; the bases of wings and calyptrae yellowish.

Locality: Uralla, N.S.W.

This is the only species before me that appears to agree with Patton's interpretation of *dispar* Macquart.

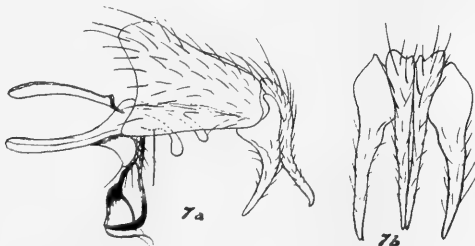
CALLIPHORA APICALIS, n. sp.

Male.—Head fuscous; interfrontalia velvety black, orbits brownish grey dusted, the dusting extending over parafacials to below middle of eye and presenting no conspicuous spot opposite bases of antennae; lower margin of face and the cheek at vibrissal angle rufous, raised part of cheek fuscous, with grey dust; antennae black, apex of second and extreme base of third segment reddish; palpi orange; hairs on centre of occiput and hind margin of cheeks golden yellow, the others black. Thorax black, with a blue cast, dorsum slightly white dusted and very faintly vittate. Abdomen dark metallic blue, with whitish dusting on basal three tergites which is densest laterally and leaves a narrow dark dorsocentral vitta, fourth tergite so densely yellow dusted that the ground colour is hidden, and the segment is conspicuously differentiated from the others. Legs black. Wings greyish hyaline, not yellow at bases, both basal costal scales black. Calyptrae brown, fringes yellowish. Halteres yellow. Coverings of both spiracles brownish yellow.

Head as in *erythrocephala* Meigen; narrowest part of frons about as wide as third antennal segment; eye facets slightly enlarged above; parafacial as wide as third antennal segment. Thorax with the bristling as in *erythrocephala*, the posterior sublateral bristle strong; a fine additional notopleural bristle present in the type. Apical bristles on all except first visible tergite long but fine, the disc of fourth tergite with numerous long fine bristles; hypopygium not dissected, but exposed in type so that the paired forceps are seen to be similar to those of *hilli*. Legs as in *erythrocephala*. Apical section of fourth vein beyond angle distinctly bent.

Length, 9.5 mm.

Type, Kosciusko, N.S.W., 7 Dec., 1922 (Goldfinch).



Text-figure 7. Hypopygium of *Calliphora robusta*. a, side view; b, forceps from behind.

CALLIPHORA ROBUSTA, n. sp. (Text-figure 7.)

Male.—The type specimen of this species is more robust than *apicalis*, with a more rotund abdomen, and is not so brightly coloured, the thorax being almost black, slightly obscured by whitish dusting, and the abdomen is greenish black on all tergites, with slight even whitish dusting which is most conspicuous laterally. The wings are yellowish at bases.

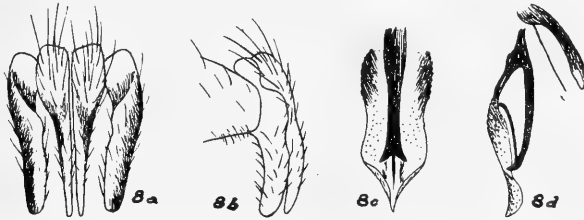
The area between the raised portion of cheek and the vibrissal angle in type has numerous hairs on it while in *apicalis* this portion is bare. Posterior sub-lateral bristle present but weak; only two notopleural bristles present. Hypopygium as Text-fig. 7. In other respects similar to *apicalis* except that the abdominal hairs and bristles are much shorter and weaker.

Length, 10 mm.

Type, Kosciusko, N.S.W., 7 Dec., 1922 (Goldfinch).

CALLIPHORA XANTHOCERA, n. sp. (Text-figure 8.)

Male.—Head black, orbits white dusted, a large white dusted mark on parafacial opposite basal half of antenna, area between vibrissal angle and raised part of the cheek, as well as lower margin of face, rufous; basal two antennal segments fuscous, second segment rufous at apex, third bright orange coloured, extreme apex browned; palpi orange coloured; central part of occiput with yellowish hairs, the other hairs on head black. Thorax as in *erythrocephala*, the fine hairs black. Abdomen quite brilliant metallic blue-green, like that of a *Lucilia*, with slight whitish dusting on the incurved lateral portions of the tergites. Legs black. Wings greyish hyaline, darker at bases; both basal costal scales fuscous. Calyptrae dark brown, the fringes pale. Halteres brownish.



Text-figure 8. Hypopygium of *Calliphora xanthocera*. a, forceps from behind; b, forceps from the side; c, apex of penis from below; d, apex of penis from the side.

Frons as in *erythrocephala*; parafacial about as wide as third antennal segment, the latter shorter and wider than in most related species; arista haired on little more than the basal half. All sublateral bristles of thorax long; an additional bristle between the normal two notopleurals; scutellum with about twelve bristles. Abdomen with the hairs on second visible tergite dense except on middle, those on third much sparser, longer, and stronger, the apical bristles on this tergite long and rather strong, fourth tergite with long setulose hairs on disc which are mostly almost as long as the apical bristles; ventral hairs longest on second and third sternites; hypopygium as Text-fig. 8. Fore tibia with two median posterior bristles; mid tibia with from 3 to 5 anterodorsal and posterodorsal bristles. Apical section of fourth vein distinctly curved beyond the angle.

Length, 7 mm.

Type, Kosciusko, N.S.W., 5 Dec., 1921.

A female before me differs from the above type in having the third antennal segment narrower and much more extensively blackened, the fore tibia with but one median posterior bristle, and the fourth vein straighter on apical section beyond the angle. It may really belong to this species as it has the additional bristle between the two notopleurals, and otherwise closely resembles the male.

Length, 6.5 mm.

Locality: Kosciusko, N.S.W., 7 Dec., 1922 (Goldfinch).

CALLIPHORA AUSTRALICA, n. sp. (Text-figure 9.)

Male and female.—This species closely resembles the preceding one but is larger, has the third antennal segment mostly black, lacks the additional noto-



Text-figure 9. Hypopygium of *Calliphora australica*. a, side view; b, forceps from behind.

pleural bristle, and has the hypopygium as Text-fig. 9. The colour of the abdomen is the same in both species, which distinguishes them from *robusta* and most other species of the genus. Fore tibia with but one median posterior bristle.

Length, 9-11 mm.

Type and allotype, Kosciusko, N.S.W., 7 Dec., 1922, and 14 Mar., 1920, 5,000 feet, respectively; male paratype, Blackheath, N.S.W., 24 Dec., 1921; female paratypes, Fish River, N.S.W., 25 Mar., 1923, and Blue Mts., N.S.W., 28 March, 1923.

CALLIPHORA ERYTHROCEPHALA (Meigen).

Syst. Besch. Eur. Zweifl. Ins., v, p. 62, 1826.

This species, like *Musca domestica* Linné, appears to have an almost cosmopolitan distribution. It is readily distinguished from any other species of the genus in Australia by its red cheeks, which are black haired except behind, and the dark coloured calyptrae with their white margins and fringes.

Locality: Sydney, N.S.W., 30 May, 1921. I record only the material before me.

CALLIPHORA MINOR, n. sp. (Text-figure 10.)

Male and female.—very similar to *accepta* in colour, but the thoracic dorsum is more evidently vittate, and the abdomen is quite distinctly white dusted, especially in the female where there are distinct checkerings, and each hair and bristle is inserted in a minute black dot.

Structurally similar to *accepta*, but the male has the outer hypopygial forceps as Text-fig. 10, the frons is at narrowest part about twice as wide as anterior

ocellus, the posterior sublateral bristle is short, and the size is less.

Length, 3.5-4.5 mm.

Type, male, Townsville, N. Queensland (G. F. Hill); allotype and two female paratypes, Darwin (G. F. Hill); one male and four female paratypes, Cairns, N. Queensland (J. F. Illingworth). The last series in United States National Museum.



Text-figure 10. Hypopygium of *Calliphora minor*, outer forceps from side.

Text-figure 11. Hypopygium of *Calliphora plebeia*. a, side view; b, forceps from behind.

CALLIPHORA PLEBEIA, n. sp. (Text-figure 11.)

Male.—A black species, with the antennae in variable proportion reddish yellow, sometimes entirely so; palpi rufous yellow; orbits, parafacials, and cheeks densely yellowish grey dusted; thoracic dorsum slightly bronzy, with quite evident whitish dust, and rather distinctly vittate; abdomen bronzy or greenish black, with silvery white dusting, which is distinctly checkered. Wings hyaline. Legs black. Calyptrae whitish. Halteres yellow.

The eyes are much closer together than in any other species in this segregate, and the facets are quite noticeably enlarged on upper anterior part. Posterior sublateral bristle present. Bristles on apex of second abdominal segment strong on sides only, those at apex of third stronger than those at apex of fourth, the discal bristles on latter long, but weak and hair-like. Fore tibia with one median posterior bristle. Hypopygium as Text-fig. 11. Apical section of fourth vein bent beyond angle.

Length, 7-10 mm.

Type and four paratypes, Cairns, N. Queensland (J. F. Illingworth). One labelled "flowers", the others "ex corn".

CALLIPHORA AURIVENTRIS, n. sp.

Female.—Very similar to *tibialis* Macquart. Frontal orbits and upper part of parafacials with yellow dust; antennae and palpi testaceous yellow, third segment of former slightly browned; cheeks fuscous on raised part, with yellowish grey dust and black hairs. Thorax black, with whitish dusting on dorsum, and the usual vittae almost indistinguishable; pleura coloured as dorsum, many of the fine hairs yellow, especially on prosternum, centre of propleura, round stigmatal bristle, on pteropleura, and hind and lower portions of sternopleura. Abdomen black, with a bronzy cast, but the dorsum almost totally obscured by dense brassy or golden dusting which is irregularly checkered or variegated, the hairs black. Legs black. Wings quite conspicuously yellow at bases. Calyptrae and halteres orange-yellow.

Head normal. Thoracic dorsum with the surface hairs very fine and short; posterior sublateral bristle quite prominent; acrostichals 2 + 3; both pairs of intra-alar bristles strong. Legs normal. Fourth wing vein quite evenly curved beyond angle.

Length, 11 mm.

Type, Fish River, N.S.W., 25 Mar., 1923.

The colour of the abdomen is very similar to that of *tibialis*, but the legs are entirely black, and the pleural hairs are largely yellow, which is not the case in that species.

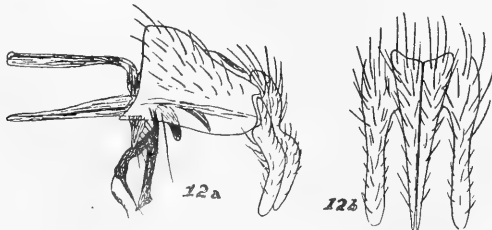
CALLIPHORA CLARKI, n. sp. (Text-figure 12.)

Male.—A species with much the same habitus as some of the European forms at present placed in *Onesia*. Head black, orbits white dusted, when seen from the side the parafacial is black at base of antenna, has a large white dusted spot above middle, and is blackish below; cheeks and occiput yellowish grey dusted; base of third antennal segment broadly rufous; palpi rufous. Thorax bluish black, slightly white dusted, and distinctly vittate, in type with a dark line or vitta connecting the pair in each series of presutural dorsocentrals when seen from the side and behind. Abdomen quite conspicuously metallic green, but with distinct white dusting which is almost evenly distributed on dorsum. Legs black. Wings smoky hyaline, veins dark. Calyptres brownish, margin of lower one yellowish. Halteres brownish yellow.

Narrowest part of frons over twice as wide as anterior ocellus; eye facets slightly enlarged on upper half anteriorly; parafacial distinctly wider than third antennal segment; vibrissal angle produced. All three sublateral bristles distinct. Abdomen broadly ovate; hypopygium as Text-fig. 12. Fore tibia with two posterior median bristles; posterior surface of fore femur longer haired than usual. Apical section of fourth vein distinctly curved beyond angle.

Length, 7 mm.

Type, Perth, Western Australia, 1917 (J. Clark).



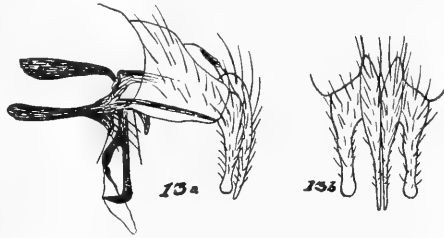
Text-figure 12. Hypopygium of *Calliphora clarki*. a, side view; b, forceps from behind.

CALLIPHORA ACCEPTA, n. sp. (Text-figure 13.)

Male and female.—Similar to *clarki*, differing essentially as noted in the key to species. Hypopygium of male as in Text-fig. 13. The males have usually two posterior bristles near middle of fore tibia, but in the females I have before me there is but one such bristle. The abdomen is but slightly white dusted on dorsum and the species has more the habitus of a *Lucilia* than a *Calliphora*.

Length, 6.7-5 mm.

Type, male, allotype, one male and one female paratype, Botany Bay, N.S.W. (H. Petersen); one male paratype, Como, N.S.W., December, 1923, swept from flowers (H. Petersen); two male and one female paratypes, Blue Mts., N.S.W.; one male paratype, Mooroopna, Victoria, 31 Dec., 1923 (F. E. Wilson); one male paratype, Sydney, N.S.W., 16 Oct., 1921.



Text-figure 13. Hypopygium of *Calliphora accepta*. a, side view; b, forceps from behind.

CALLIPHORA METALLICA, n. sp. (Text-figure 14.)

Male.—A larger and more robust species than the preceding one, with the abdomen more noticeably white dusted, and the second abdominal tergite without the well developed central bristles on hind margin. The hypopygium is as shown in Text-fig. 14, but in other respects the two species are very similar.

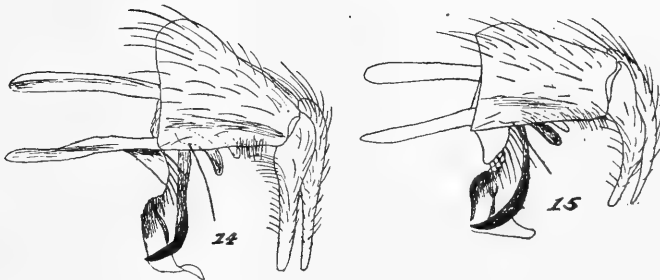
Length, 9-10 mm.

Type, Woolgoolga, N.S.W., 27 Jan., 1923; paratype, Orange, N.S.W., 21 Apr., 1923.

CALLIPHORA ASSIMILIS, n. sp. (Text-figure 15.)

Male and female.—More like *plebeia* in colour and habitus than like the preceding species, but the eyes have the facets but little enlarged on upper half, the frons is wider in male, and the parafacials are not so evenly and densely dusted. The hypopygium of male is as shown in Text-fig. 15.

Length, 8-9 mm.



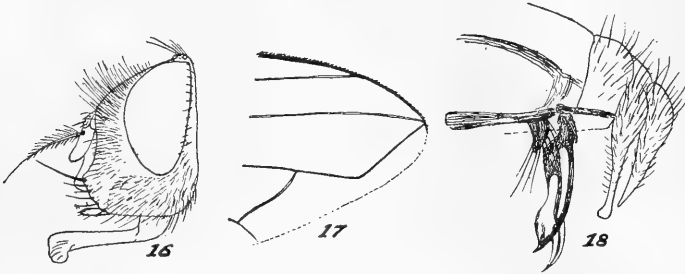
Text-figure 14. Hypopygium of *Calliphora metallica*, side view.

Text-figure 15. Hypopygium of *Calliphora assimilis*, side view.

Type, allotype, and one male paratype, Marwood, near Mackay, Queensland, Jan., 1924 (W. C. Harvey).

It must be remembered that in my opinion there are more species belonging to this last section than are included in the above key and descriptions. Colour

descriptions are almost valueless here and only very careful comparative work and hypopygial examinations will disclose just how many there really are in Australia, facts which are impossible of my ascertaining from the small amount of material now in my hands.



Text-figure 16. Head of *Pollenia hirticeps*, side view.

Text-figure 17. Apex of wing of *Pollenia hirticeps*.

Text-figure 18. Hypopygium of *Pollenia hirticeps*, side view.

Genus POLLENIA Robineau-Desvoidy (1830).

This genus is represented in Australia and New Zealand by species which differ from the genotype, *rudis* Fabricius, in having the extreme basal portion of the stem vein on under side without evident hairs apically. This segregate if entitled to generic rank will bear the name *Sepimentum* Hutton, but I consider it as at best entitled to subgeneric rank.

The head (Text-fig. 16) is quite different from that of typical species of *Calliphora* and the lower calypter is bare. The supraspiracular ridge and centre of propleura are bare, characters which distinguish the Australian species from those of *Lucilia*. In the Australian species of *Pollenia* the prosternum is also bare. The venation of the apex of wing is quite different from that of *Anthracomylia* (Text-fig. 17). There is but one Australian species before me.

POLLENIA (SEPIMENTUM) HIRTICEPS, n. sp. (Text-figures 16, 17 and 18.)

Male and female.—Head black, grey dusted on orbits, raised part of cheeks, and upper parafacials, the anterior part of cheek and lower part of parafacial reddish, and not grey dusted; antennae reddish testaceous, third segment more or less browned apically; arista black; palpi coloured as antennae; hairs on frons, parafacials, and cheeks, black, some of those on lower occiput and a few on hind part of cheek yellow. Thorax black, with a bluish cast, the dorsum thinly whitish dusted and almost entirely without vittae; dorsal hairs all black, the curled or crinkly yellow hairs confined to parts of pleura. Abdomen variable in colour, black with cupreous or blue lustre, or metallic bluish black, with thin regular whitish dusting on dorsum and no markings, the hairs all black. Legs black. Wings slightly smoky, darkest at bases. Calyptrae and halteres brown.

Male.—Head in profile as in Text-fig. 16; frons at narrowest point not wider than third antennal segment, the anterior half forming a large triangle, orbital hairs long and strong, in several series, those on the parafacials also long and curved, the entire vibrissal area sparsely short haired; antennae distinctly separated at base, but no carina on face; longest hairs on arista not longer than width of third antennal segment, the latter rather narrow. Thorax with 2 + 3

dorsocentrals, 2 + 2 acrostichals, two pairs of intra-alars, the prealar long, two bristles on the presutural area, and two sternopleurals. Abdomen narrowly ovate; hypopygium as in Text-fig. 18. Legs as in *Calliphora erythrocephala* Meigen.

Female.—Frons at vertex one-third of the head width, much widened to anterior margin, orbits with a series of quite long, strong, incurved bristles along the inner margin, several series of shorter forwardly directed setulae laterad of these, a quite prominent forwardly and outwardly directed bristle just in front of level of anterior ocellus, and an outwardly directed one between it and the vertical bristles. Abdominal tergal bristles weak.

Length, 6-8 mm.

Type, male, allotype, and one female paratype, Blue Mts., N.S.W.; paratype males, Blackheath, N.S.W., and Mt. Lofty Ranges, S. Aust.

Genus ANTHRACOMYIA, novum.

This genus is rather similar to *Pollenia*, but there are no soft curled or crinkly hairs on thorax, and the venation of the wing is quite different apically (Text-fig. 19). Genotype, *A. atratula*, n. sp.

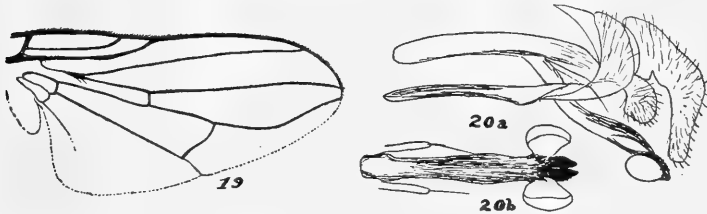
ANTHRACOMYIA ATRATULA, n. sp. (Text-figure 19.)

Male.—Black, shining. Face, parafacials, and raised part of cheeks, whitish dusted; antennae and palpi black; cephalic hairs all black. Thorax slightly whitish dusted on dorsum, without evident vittae. Abdomen glossy black, when seen from behind with slight, even, whitish dusting and a trace of a dark central line basally. Legs black. Calyptrae fuscous. Halteres brownish yellow.

Frons linear above, forming a triangle on anterior half, orbits on widened part of frons gradually widening anteriorly, with a series of long setulose hairs along inner margins and a few fine short hairs laterad of these; parafacial about as wide as third antennal segment, with rather long hairs almost to lower margin of eye; the cheek adjacent to vibrissal angle almost bare; one or two hairs above vibrissae; arista haired almost to apex, the longest hairs about as long as width of third antennal segment; palpi slender. Thorax with 2 + 3 dorsocentrals and apparently the same number of acrostichals, two pairs of long intra-alars, a long prealar, two bristles on presutural area, no upper anterior bristle on mesopleura, and, like the preceding genus, no hairs on the lower anterior half of pteropleura. Abdomen narrowly ovate, the dorsal hairs rather sparse, long and setulose. Legs as in last species, the ventral median bristle present on mid tibia; fore legs in type missing. Wing venation as in Text-fig. 19.

Length, 4 mm.

Type, Allowrie, Killara, N.S.W., 30 Jan., 1921 (Waterhouse).



Text-figure 19. Wing of *Anthracomyia atratula*.

Text-figure 20. Hypopygium of *Chrysomyia megacephala*. a, side view; b, penis from above.

This small species is represented by a male in damaged condition, but it is so clearly distinct from any other species known to me that I have decided to describe it. The character of hairs on the lower anterior half of pteropleura is quite an important one in this group, and may be used to distinguish doubtful specimens of small species of *Calliphora* in which the hairs on the upper surface of lower calypter are not readily distinguishable from this and the preceding genus, the hairs being always present on lower anterior half of pteropleura in *Calliphora*.

Genus LUCILIA Robineau-Desvoidy (1830).

This genus is of considerable economic importance in Australia because of the habits of some of the species which feed in the larval stages in the matted wool of sheep, and penetrate the flesh. There are known to me four well distinguished segregates of the genus, which I accept as subgenera. Three of these I have seen from Australia, and below I append a key for their recognition, the other occurs only in the Oriental region so far as I am at present aware. I have published elsewhere a key to all four subgenera, but this is not readily available to Australian students. It is worth mentioning that in many species of the genus there are sparse microscopic hairs on the face, a character found also in *Phumosia* Robineau-Desvoidy, but in one or two species of the latter the hairs are quite prominent.

Key to Australian Subgenera.

1. The convexity immediately above metathoracic spiracle with conspicuous fine erect hairs *Hemipyrellia* Townsend
- The metathoracic convexity without erect fine hairs 2
2. Sclerite at extreme base of stem vein on under side of wing with short setulose hairs apically *Lucilia* Robineau-Desvoidy
- Sclerite at extreme base of stem vein on under side of wing without evident hairs *Phenicia* Robineau-Desvoidy

Subgenus HEMIPYRELLIA Townsend (1918).

In addition to having erect fine hairs on the metathoracic convexity this subgenus has setulose hairs on the basal sclerite of stem vein below.

I have seen five species of the subgenus, two of which occur in Australia.

LUCILIA (HEMIPYRELLIA) FERGUSONI Patton.

Phil. Jour. Sci., 1925, xxvii, p. 403.

This is the only species of the subgenus known to me in which there is any yellow colour on the abdomen, and in which the legs are not entirely black. It bears a striking superficial resemblance to *Chrysomyia incisuralis* Macquart, but is a true *Hemipyrellia*. Patton's description is reliable as to colour, but the essential characters for the recognition of its subgeneric status are not mentioned by him. The setulose hairs on basal sclerite of first vein below are yellow, which is unique, as is also the yellow colour of the head, pleura, and most of the abdomen.

Localities: Sydney, N.S.W., April, October, and November; Eungella, 45 miles west of Mackay, Queensland, 1,400-2,000 feet, 13-25 Sept., 1923 (Goldfinch).

LUCILIA (HEMIPYRELLIA) CYANEOMARGINATA Macquart.

Mém. Soc. Sci. Lille, 1850, p. 221, (1851); *Dipt. Exot.*, Suppl. 4, p. 248.

I have identified as this species one which occurs commonly in the Philippines, Straits Settlements, and Federated Malay States. I have now before me a male and female from Queensland.

It should be noted that Patton records under *Lucilia nosocomiorum* Doleschall a number of synonyms including *cyaneomarginata* Bigot. Bigot described a *cyaneocincta*, but I can find no *cyaneomarginata* Bigot. I have accepted *nosocomiorum* as the name for a larger species which is apparently the one identified as such by Patton, but it belongs to the subgenus *Lucilia*.

In *cyaneomarginata* the frons of the male is distinctly wider than third antennal segment, the thorax has two pairs of postsutural acrostichals, and the abdomen has conspicuous dark blue apices to the tergites. Length, 7.8-5 mm.

Localities: Cairns, N. Queensland, carrion (J. F. Illingworth).

Subgenus PHENICIA Robineau-Desvoidy (1830).

The members of this subgenus known to me have the eyes of the males more widely separated than is the rule in the other two subgenera occurring in Australia, and the basal sclerite of stem vein is bare.

There are two species known to me, both of which I have seen from Australia.

LUCILIA (PHENICIA) SERICATA Meigen.

Syst. Besch. Eur. Zweifl. Ins., v, p. 53, 1826.

This bright metallic blue-green species has the ventral surface of abdomen in male only moderately setulose, and in both sexes the dorsum of abdomen is without conspicuous white dusting.

I have before me many examples from Australia, some labelled, "Bred from Wool."

LUCILIA (PHENICIA) CUPRINA Wiedemann.

Aussereurop. Zweifl. Ins., ii, p. 654, 1830; *pallifrons* Bigot, *Ann. Soc. Ent. France*, 1877, p. 257.

A coppery or bronzy coloured species with very noticeable whitish dusting on thorax and abdomen. The ventral surface of abdomen in the male is furnished with quite dense long conspicuous bristles.

I identify as this species a female from Kuranda, Queensland (F. P. Dodd).

Subgenus LUCILIA Robineau-Desvoidy.

This subgenus is represented in the material before me by two rather aberrant species. The genotype, *caesar* (Linné) has quite numerous fine hairs on central part of propleura, while the other two have no such hairs or there are but one or two such on anterior margin. The face in some of the species is usually bare, while in others it is invariably furnished with short sparse hairs in middle.

I present below a key for the identification of the two species I have seen from Australia and include *caesar*, which I have seen no Australian specimens of so far.

Key to Species.

1. Face invariably with some microscopic black hairs centrally from lower to upper extremity; abdomen metallic blue, with dark apices to tergites; lower calypter dark brown; centre of propleura bare or with one or two weak hairs on anterior margin *nosocomiorum* Doleschall
- Face bare or with some inconspicuous microscopic hairs near lower margin; abdomen metallic blue-green or blue, without dark apices to tergites 2
2. Antennae black or fuscous, third segment reddish at base; frons in female about as wide as length of antennae; centre of propleura with quite evident pale hairs; calyptres pure white *caesar* (Linné)
- Antennae orange yellow; frons in female much narrower than length of antennae; centre of propleura bare, at most with a fine hair or two on anterior margin; lower calypter brownish yellow *flavicornis*, n. sp.

LUCILIA (LUCILIA) CAESAR Linné.

Fauna Suec., p. 451, 1761.

A brilliant metallic blue-green species which frequently has a golden tinge on abdomen and thorax. There are no traces of dark apices to tergites in either sex.

The species has been recorded from a wide range of localities, but as a matter of fact it is not so commonly found as the records would indicate. I have seen no Australian specimens in either the material sent to me or in the United States National Museum, where there is a good representation of the family from Australia. The characters included in the above key ought to serve to separate it from other Australian species if it does occur.

LUCILIA (LUCILIA) NOSOCOMIURUM Doleschall (1857).

Nat. Tijdschr. Ned-Ind., 1857, xiv, p. 413.

Very similar to *caesar*, but more constantly metallic blue in colour, with dark apices to the abdominal tergites, and usually larger in size and more robust, averaging over 8 mm. in length.

Localities: Kuranda and Townsville, Queensland.

I can detect no outstanding differences in the structure of the Australian specimens and some from Sumatra and the Philippine Islands. The male hypopygia agree, and though the anterodorsal surface of the hind tibia in the Australian males has a regular series of short setulae and there is at least one outstanding bristle in the series on those from the Orient I consider it highly probable that *metilia* Walker, which is the name given to the latter, is the same as *nosocomiurum*, the latter name having priority.

LUCILIA (LUCILIA) FLAVICORNIS, n. sp.

Female.—Frons black, slightly reddish in front, upper orbits and ocellar region slightly shining and faintly bluish; occiput black, grey dusted, cheeks and face orange coloured, white dusted, cheeks slightly darkened posteriorly, face darkened above; antennae entirely orange-yellow, basal two segments slightly darker; palpi orange. Thorax metallic violet-blue, dorsum rather evenly white dusted, the dusting most noticeable when seen from behind, and without outstanding vittae. Abdomen concolorous with thorax, but the dorsum on disc green, white dusted on incurved lateral portions of tergites. Legs dark brown or fuscous, femora with bluish tinge, trochanters and tibiae brownish yellow. Wings greyish hyaline. Lower calypter brownish yellow. Halteres yellow.

Frons at vertex hardly over one-fifth of the head width, and narrower than length of antennae; face bare. Thorax as in *caesar*, but the propleura is bare on centre. In other respects as *caesar*.

Length, 9 mm.

Type, Cairns, N. Queensland, from dung (A. P. Dodd).

I can find no description that appears to fit the above species and though I do not ordinarily undertake to describe species from single females in revising a group it devolves upon one to designate all material by names which will serve to distinguish them until final adjustments have been made.

Genus PARATRICYClea Villeneuve (1913).

This genus is represented in the material before me by one species which belongs to the subgenus *Caiusa* Surcouf. It is possible that it has been described by one or more of the older authors, but it is absolutely impossible to make certain

of most of their species, and even after a number of attempts have been made by recent workers to elucidate their types we are still very much in the dark as to their exact identity, and as to even their generic positions. I consider it much better to describe any species as new which does not agree absolutely with the description of any of those species and do not consider it unscientific to do so even in cases where there is an apparent agreement if the specimens are from different localities within the same faunal region. Only a careful examination of types by some competent specialist will definitely settle specific identities, and prevent the erroneous recording of species from localities in which they do not occur.

Surcouf has recently described the chaetotaxy of *Phumosia analis* Macquart so thoroughly that it is clear the species is not the same as the one described herein.

PARATRICYCLEA (CAIUSA) SURCOUFI Bezzi.

Bull. Ent. Res., 1927, xvii, p. 246.

Male and female.—Shining fulvous testaceous; upper occiput, raised part of cheeks, and frontal orbits grey or fuscous, upper part of frons in female fuscous. Abdomen broadly blackish blue at apex. Legs fulvous yellow. Wings yellowish hyaline. Calyptres and halteres fulvous.

Frons in male reduced to a line, the facets much enlarged on upper half of eye and rather sharply separated from those of lower half; frons in female a little less than one-third of the head width, anterior supraorbital strong, interfrontalia bare; face normally with some microscopic hairs in centre. Thorax with 3 + 4 dorsocentral bristles, the anterior postsutural pairs short, 1 + 2 pairs of short, widely separated, presutural, and one pair of prescutellar acrostichals; sides of scutellum haired, the hairs on ventral surface yellow; pleural hairs yellow, those on upper half of mesopleura black; sternopleurals 1 + 1. Superior hypopygial forceps of male hollowed out behind, slightly curled, and tapered to apices, the inferior as long as superior pair, stouter, and obtuse at apices. In other respects similar to *indica* Surcouf, the hind tibia with two posterodorsal bristles; no hairs at junction of humeral cross vein and subcosta, but one or two below at junction of first and second veins.

Length, 7-8 mm.

Localities: Male, Melville Island, N.T. (G. F. Hill); Darwin, N.T. (G. F. Hill); females, Stapleton, N.T. (G. F. Hill), and Marwood, near Mackay, Queensland (W. C. Harvey); original locality, Queensland (Bezzi).

In the Oriental species before me most, or all, of the hairs are black or fuscous, and the male has the superior hypopygial forceps more slender, not curled, and shorter. Macquart's species *analis* was described from New Holland but I have seen no species which could be considered as possibly this from Australia.

Genus EUPHUMOSIA Malloch (1926).

This genus, like the preceding one, belongs to the arbitrary group "Muscidae Testacea", and the genotype, *papua* Guerin, was included by Surcouf in the genus *Phumosia* Robineau-Desvoidy. I recently erected the genus *Euphumosia* for its reception.

In addition to the characters which may be culled from the key presented on a preceding page of this paper it may be mentioned that the dorsocentrals are 2 + 3, acrostichals 2 + 2, intra-alars 2 pairs, and sternopleurals 1 + 1; in the male

the frons is reduced to a mere line, the facets of the eyes are much enlarged on upper half, and there is a strong submedian ventral bristle on mid tibia in both sexes.

EUPHUMOSIA PAPUA (Guerin-Méneville).

Voy. Coquille, *Zool.*, 1830, Insects, Pl. xxi, fig. 3; *eristoloides* Walker, *Proc. Linn. Soc. Lond.*, 1858, iii, p. 106; *calliphoroides* Walker, *Proc. Linn. Soc. Lond.*, 1861, v, p. 245; *papouana* Bigot, *Bull. Soc. Zool. France*, 1887, p. 610; *variegata* Bigot, *Bull. Soc. Zool. France*, 1887, p. 610.

A testaceous yellow species, the dorsum of thorax more fulvous and with three broad chocolate coloured vittae which are connected by a similarly wide transverse band at their hind extremities some distance from hind margin of mesonotum. Abdomen coloured as thorax, hind margins of all tergites deep black, the basal one least broadly so, anterior margins of tergites 3 and 4 narrowly black, the transverse pale fascia on each of these tergites densely whitish yellow dusted. Legs yellow, tarsi darker. Wings browned, especially along veins.

Length, 11-12 mm.

Locality: Melville Is. (W. D. Dodd).

This conspicuously marked species has been described several times, the names known to me including *eristoloides* Walker, *variegata* Bigot, and *papouana* Bigot, while Johnston and Hardy recognize in it *calliphoroides* Walker.

The species does not appear to be a common one, and nothing is known of its immature stages. There is one female in the United States National Museum.

DEXOPOLLENIA CHRYSOTHRIX Bezzi.

Bull. Ent. Res., 1927, xvii, p. 231.

This species has recently been described from N.S. Wales, but is unknown to me.

Subfamily Chrysomyiinae.

The Australian members of this subfamily are distinguished from other subfamilies by the presence of hairs, or setulae, on the posterior upper side of the stem vein of wing, and the haired upper surface of lower calypter. Only the Rhiniinae have the setulae on the stem vein, and these have no hairs on the lower calypter. In addition to these characters there are only two sternopleural bristles present (1 + 1), the stigmal bristle is usually present and distinct, and in many species there are well developed hairs on the small knob-like protuberance below and in front of the wing base.

Patton has recently dealt with the species of *Microcalliphora*, which he did not separate from *Chrysomyia*, and he redescribed *varipes* Macquart and described two new species in the same paper. He was evidently unaware of the fact that the frons in the males of this genus is almost as wide as in the females, and his *annulipes* was described, not from a female as he states, but from a male, and undoubtedly that of *varipes* as it agrees in all particulars with that species. His *fulvipes* had previously been described by Aldrich as *flavifrons*. There are thus but two known species of the genus.

I attempt a provisional review of the species of the genera known to me herein but the paucity of material available does not lend itself to a comprehensive treatment of the group. It is highly probable that there are some more Australian species yet to be discovered. There are some species of the genus which cause

myiasis in man as well as in other mammals and which ought to be guarded against.

Below I present a synopsis of the three genera in my material now.

Key to Genera.

1. The small knob-like protuberance below and in front of wing base without any outstanding hairs *Eucompsomyia*, novum.
The small knob-like protuberance below and in front of wing base with numerous outstanding hairs 2
2. Eyes of male narrowly separated above, the frons almost linear *Chrysonomyia* Robineau-Desvoidy
Eyes of male widely separated above, the frons at least half as wide as either eye and but little narrower than that of female *Microcalliphora* Townsend

Genus *EUCOMPSOMYIA*, novum.

Generic characters.—Similar to the two other genera included above, the centre of propleura, prosternum, and entire pteropleura, haired; basal sclerite of stem vein of wing on under side haired, but, like in the American genera of the subfamily, the knob-like protuberance below and in front of wing base is bare. The American genera, however, have the anterior half of the pteropleura bare, and the lower calypter in these is haired at base only, not on the entire upper surface as in the Australian genera.

Genotype, *Eucompsomyia semimetallica*, n. sp.

There are two species of this genus known to me which may be distinguished as below.

Key to Species.

- Eyes of male very narrowly separated above, almost touching at middle of frons; abdomen honey yellow, second tergite centrally, third on most of disc, and all of fourth, metallic blue, with whitish dusting *semimetallica*, n. sp.
- Eyes of male quite widely separated above, width of frons at narrowest part about one-sixth that of head; abdomen honey yellow, with the following bluish black markings: First visible tergite with a narrow apical fascia, second with a moderately broad central mark which extends along hind margin and narrows laterally into a slender fascia, third with a still broader mark of similar nature, and fourth with a narrow incomplete central vitta *latifrons*, n. sp.

EUCOMPSOMYIA SEMIMETALLICA, n. sp.

Male.—Head fulvous yellow, hairs on cheeks, parafacials and lower half of occiput, yellow. Thorax fulvous, dorsum almost entirely violet-blue, pleura darkened on lower posterior part, metanotum blackish blue. Abdomen honey yellow, dorsum largely violet-blue, fourth tergite more greenish, and with whitish dusting. Legs fulvous, hind tibiae slightly browned. Wings yellowish hyaline. Calyptres and halteres fulvous.

Frons linear above; eye facets a little enlarged on upper half; cheek over one-third as high as eye; palpi normal. Thorax with 2 + 4 dorsocentrals, 2 bristles on the presutural area, one behind the humerus and the other transversely placed from its hind margin; only one pair of prescutellar acrostichals present; sternopleurals 1 + 1; anterior intra-alar short. Abdomen short ovate. Tibial bristles short, similar to those of *Chrysonomyia* species. Apical cross vein much curved.

Length, 7 mm.

Type, Kuranda, Queensland (F. P. Dodd).

EUCOMPSOMYIA LATIFRONS, n. sp.

Male.—Similar to the above species but the third antennal segment largely brown, facial ridges with numerous black hairs above vibrissae which extend to above middle; pteropleura, sternopleura, and hypopleura bluish black, with grey dusting; legs yellow, with the apices of tarsi darkened; otherwise as stated in the key.

The facets are but little enlarged on upper half of eye, the parafacials are bare centrally. Thorax as in the above species, but the anterior intra-alar is absent in type. In other respects as *semimetallica* except as stated in key.

Length, 7.5 mm.

Type, Loowanna, E. Dorriggo, N.S.W., 31 Jan., 1923.

This species presents almost the same divergence from the genotype as does *Microcalliphora* from *Chrysomyia*, but I retain them both here because of lack of a knowledge of the characters of both sexes, and paucity of material.

Genus MICROCALLIPHORA Townsend (1916).

As stated on a previous page in this paper there are but two known species of this genus. I have examined both of these in the United States National Museum and give below a synopsis for their recognition.

The small size of the species and the widely separated eyes of the males ought to readily distinguish the insects even in the field. Intensive collecting may result in the discovery of yet unknown species of the genus. The female of *flavifrons* has not been described.

Key to Species.

1. Femora and tibiae entirely yellow; frons, in male at least, blackened only on the upper third, the anterior third bright yellow; fore femur in male with no conspicuous white hairs *flavifrons* Aldrich
- Femora largely black, tibiae partly so; frons in both sexes fuscous to anterior margin; fore femur in male with dense erect white hairs above *varipes* Macquart

MICROCALLIPHORA FLAVIFRONS Aldrich.

Proc. U.S. Nat. Mus., 1925, lxvi, art. 18, p. 20; *fulvipes*, Patton, *Phil. Jour. Sci.*, 1925, xxvii, p. 410.

Known only from Gordonvale and Cairns, Queensland, the former the type locality of *flavifrons*, the latter the type locality of *fulvipes*, both of the types collected by Dr. J. F. Illingworth and sent by him to the describers.

MICROCALLIPHORA VARIPES (Macquart).

Lucilia varipes Macq., *Mém. Soc. Sci. Lille*, 1850, p. 222, (1851); *Dipt. Exot.*, Suppl. 4, p. 249, Pl. xxiii, fig. 4; *annulipes* Patton, *Phil. Jour. Sci.*, 1925, xxvii, p. 410.

I have already indicated that *annulipes* Patton appears to me to be this species. My specimens are from Sydney, N.S.W.; it occurs also in Queensland.

Genus CHRYSOMYIA Robineau-Desvoidy (1830).

It must be noted that the original spelling of this genus name is *Chrysomya*, and that the emendation given above, which has been generally accepted, causes a conflict with *Chrysomyia* Macquart, a genus of Stratiomyiidae, which was erected at a later date, and which is generally given the name *Microchrysa* Loew.

This is the most generally distributed genus of the family in the Old World, and the one which is of most economic importance. As is usual in the case of species that enter into economic relations with man and domestic animals there are doubts as to the exact distribution and names of several of the species, one of them being recorded under several names and from Africa, Asia, and Australia. It is very desirable that accurate data be obtained to determine if it is one species or several that occur over this territory, but I am not in possession of material in sufficient quantities to do this work at this time. Under the species in the text I present some points which appear to call for investigation. The following key is given to facilitate identification of the four species which I recognize or have reason to accept as occurring in Australia.

Key to Species.

1. Abdomen honey-yellow, with a narrow black hind marginal band on each of the basal three visible tergites, and a broad metallic blue suffusion on disc of same tergites; legs honey-yellow, tarsi black; hairs on the knob-like process below base of wing golden yellow; calypterae yellowish white; frons of female at vertex not over one-fifth of the head width *incisuralis* Macquart
 Abdomen entirely metallic blue or green, with dark apices to tergites; legs black; frons of female over one-fifth of the head width at vertex 2
2. Calypterae white or yellowish; coverings of both prothoracic and metathoracic spiracles white; hairs on knob-like process below wing base pale *albiceps* Wiedemann
 Calypterae fuscous or dark brown, white on outer or connecting angles; coverings of both pairs of thoracic spiracles and hairs on knob-like process below base of wing black or fuscous 3
3. Facets of upper half of eyes in male exceptionally enlarged and sharply differentiated from those of lower half; a number of black setulae on vibrissal angle; hairs on fourth tergite practically all black on dorsum, the pale hairs on sides inconspicuous; base of scutellum darker than apex *megacephala* Fabricius
 Facets of upper half of eyes in male only moderately enlarged; no black setulae on vibrissal angle besides the single bristle; hairs on fourth tergite practically all white in female, in male they are mixed black and pale on disc, yellow and conspicuous on sides *micropogon* Bigot

CHRYSOMYIA INCISURALIS (Macquart).

Mém. Soc. Sci. Lille, 1850, p. 219 (1851); *Dipt. Exot.*, Suppl. 4, p. 246, 1851; *Psilostoma incisuralis* Surcouf, *Nouv. Arch. Mus. Nat. Paris*, 1920, (5), p. 58.

Macquart originally included this species in his genus *Ochromyia* because of its yellow colour, and Surcouf erected the genus *Psilostoma* for its reception, but it differs but little in structure from the other species of the genus and is a member of *Chrysomyia* without any doubt.

The species does not occur outside of Australia so far as I know at present. My specimens are from Cairns and Eungella, Queensland, and Sydney, N.S.W.

CHRYSOMYIA ALBICEPS (Wiedemann).

albiceps Wiedemann, *Aussereurop. Zweifl. Ins.*, ii, p. 404, 1830; ? *rufifacies* Macq. *Mém. Soc. Sci. Lille*, 1850, p. 216 (1851); *Dipt. Exot.*, Suppl. 4, p. 243.

If this identification is correct this is the most widely distributed species of the genus, being originally described from Africa, and recorded from southern Asia, most of the islands in the Indian and South Pacific Oceans, and Australia. There is some question as to whether *putoria* Wiedemann is distinct from *albiceps*, but lack of material prevents me from arriving at a definite decision on the point. It appears worth mentioning that there is considerable variation in the colour of the hairs on the upper side of the lower calypter in my specimens.

In some these are all black, in others the black hairs are confined to the central part of disc, while in others they are all white.

I hope to be able later to decide the matter of specific relations here if I become possessed of sufficient material.

I have specimens from Queensland and New South Wales.

CHRYSOMYIA MEGACEPHALA (Fabricius). (Text-figure 20.)

Ent. Syst., iv, p. 317, 1794.

This species has been recorded as occurring in Australia but so far as my material is concerned I have not seen any specimen which agrees absolutely with those I have from the Orient. I have used in the foregoing key the characters which appear to me to be of value in distinguishing it from *micropogon*, but I am not at all satisfied that they will suffice for that purpose in all cases. I made a dissection of the hypopygia of the males of two specimens which I believed were distinct but found there were no outstanding characters in these organs by means of which the species might be distinguished. I figure the hypopygium of the true *megacephala* from the Philippines (Text-fig. 20). A comparison of this figure with any of those of the other genera figured herein will at once show characteristic differences.

CHRYSOMYIA MICROPOGON Bigot.

Bull. Soc. Zoo. France, 1887, xii, p. 601.

I have but one pair of this species before me, which form the basis for the distinguishing characters given in the key and the notes in above paragraph. The hypopygium of the male specimen was badly eaten by some pest so that only the major features were distinguishable but they are identical with those of *megacephala*.

It is not impossible that the variation in size of eye facets in this species from that of typical *megacephala* is not an indication of specific distinction, but this character is quite dependable in related groups so that I do not care to suggest that it is not here. I have already indicated that the hypopygia of the males of closely related species in the genus *Musca* are so similar that they cannot be depended upon to identify readily the species involved, and it is quite within the bounds of possibility that the same applies here.

Localities: Marwood, near Mackay, Queensland, Jan., 1924 (W. C. Harvey), and Glenreagh, N.S.W., 2 Febr., 1923.

Careful field work may develop whether or not there are two species in this complex, but laboratory findings are not satisfactory in such cases.

Subfamily Rhiniinae.

The members of this subfamily have setulae or hairs on the basal section of stem vein on its upper side, and the sternopleurals invariably two in number (1 + 1). The lower calypter is usually much narrower than in Chrysomyiinae, rounded at apex, and without hairs on its upper surface, characters which distinguish the species from those of Chrysomyiinae.

The group is, if we except *Pollenia* and its nearest allies from it, exclusively Old World in its distribution, and its centre of dispersal appears to be Africa and the Orient, a few species overlapping into Australia and Europe. I have recently published a key for the recognition of the genera known to me, and include below one which includes those genera I have seen from Australia.

In this subfamily, as in the others, there are several species described by Macquart which are difficult to identify with certainty. I have attempted to make out these species in my material, but with what success remains to be determined by an examination of the types, if such are in existence.

Very little is known of the immature stages of the members of the group.

Key to Australian Genera.

1. No outstanding stigmatal bristle present, the stigmatal hairs white or yellow; arista with rather long hairs on upper side, bare below 2
 One or two outstanding black stigmatal bristles present which are readily distinguished from the pale stigmatal hairs; arista with very short hairs both above and below *Metallea* van der Wulp
2. First posterior cell of wing closed at apex, the apical fused part of veins 3 and 4 quite conspicuous *Chlororhinia* Townsend
 First posterior cell open, or closed only in margin of wing 3
3. Hind margin of mesopleura with but two bristles, at upper corner
 Hind margin of mesopleura with a complete series of bristles *Rhinia* Robineau-Desvoidy
 *Stomatorhinia* Rondani

Genus METALLEA van der Wulp (1880).

This genus has the centre of propleura haired, and the arista with very short pubescence. The inner margins of the processes of fifth abdominal sternite in males of the Australian species are furnished with closely placed short stubby black bristles (Text-fig. 21), which are not so evident in the Oriental species referred here, and the genital segment of the females has distinct spines as in some other genera of the group.

Rhyncomyia differs from this genus in having the centre of propleura bare, but in other respects is similar; the genus does not occur in Australia so far as I am aware; the species referred here by Macquart possibly belong to *Metallea*. I am of the opinion that the species described by Aldrich as *illingworthi* is *gracilipalpis* Macquart, but an examination of the type of the latter is essential to determine if this supposition is correct. What the other species described as *Rhyncomyia dubia* Macquart may be I do not hazard a guess.

In the following key I have used mostly colour characters, which though not of outstanding significance as a rule, appear here to be reliable. My material is not sufficient to permit of an extensive examination of the genitalia of the males, the most dependable method for identification of the species.

Key to Species.

1. Frons of male at narrowest point about one-seventh of the head width; large species, about 10 mm. in length, with a dark mark on cheek in front of the raised part; parafacials with black setulose hairs; cheeks entirely yellow haired; fourth visible abdominal tergite with two series of long bristles on disc *robusta* Aldrich
 Frons of male reduced to a mere line, at narrowest point not one-twelfth of the head width 2
2. Males 3
 Females 6
3. Entire parafacials and cheeks with fine yellow hairs, those on the former almost imperceptible unless under a strong lens, the ground colour of face, parafacials, and cheeks yellow; abdomen testaceous yellow, with a dark dorsocentral vitta or series of spots, and dark spots on lateral curved portions of tergites, sometimes with these markings much reduced, and at other times with them much diffused and widened *illingworthi* Aldrich

- Either the parafacials or cheeks, or both, partly or entirely black haired 4
4. No black hairs on cheeks except directly below parafacials; abdomen testaceous yellow, with a black dorsocentral vitta, a black transverse band close to apex of third tergite, most of fourth black, and a black postspiracular spot on tergites 2 and 3, the incurved lateral portions of basal three tergites yellow *insularis*, n. sp.
- Most or all of the hairs on cheeks black or fuscous 5
5. Cheeks and parafacials entirely yellow; two or three of the abdominal tergites quite extensively and conspicuously testaceous on lateral anterior- portions of disc *nigribarba* Aldrich
- Cheek with a mark at middle, and the upper posterior part, fuscous, the parafacials slightly darkened along eye on lower half *puncticeps*, n. sp.
6. Parafacials and cheeks yellow haired, sometimes with a few of the parafacial hairs dark; femora largely yellow *illingworthi* Aldrich
- Parafacials with the hairs all black; femora fuscous 7
7. Small species, not over 8 mm. in length; parafacial hairs fine .. *nigribarba* Aldrich? Larger species, over 9 mm. in length; parafacial hairs strong *insularis*, n. sp.

METALLEA ROBUSTA Aldrich.

Proc. U.S. Nat. Mus., 1926, lxi, art. 22, p. 9.

I have seen only the two specimens of this species from which the species was originally described. The abdominal bristles are stronger than in any other species and the frons of male is broader, as indicated in the above key.

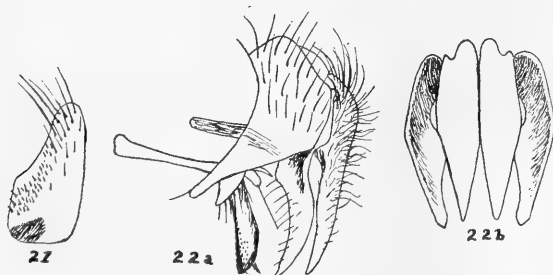
Western Australia.

Type in United States National Museum.

METALLEA ILLINGWORTHII Aldrich. (Text-figures 21 and 22.)

Proc. U.S. Nat. Mus., 1926, lxi, art. 22, p. 7; ? *gracilipalpis* Macq., *Mém. Soc. Sci. Lille*, 1854, p. 129, (1855); *Dipt. Exot.*, Suppl. 5, p. 109, Pl. vi, fig. 3, 1855.

This is evidently a common species in eastern Australia as I have a long series from New South Wales, Queensland, and South Australia. I am almost certain that this is *gracilipalpis* Macquart, but having received a name which we are positive of in its application I use it pending an examination of the type specimen of Macquart's species if it is still available. Hypopygium as in Text-fig. 22. Bezzi's *M. divisa* is probably the same.



Text-figure 21. One process of fifth sternite of *Metallea illingworthi*.

Text-figure 22. Hypopygium of *Metallea illingworthi*. a, side view; b, forceps from behind.

METALLEA INSULARIS, n. sp.

Male and female.—Head testaceous; occiput black, and with grey dusting except below level of eyes; frontal orbits in male fuscous almost to bases of antennae, and parafacials slightly darkened along eyes, the dark parts of both

grey dusted, cheek in same sex with a very faint dark central mark; orbits, parafacials, and cheeks in female less noticeably darkened than in male; antennae brownish yellow; palpi yellow. Thorax metallic blackish green, with bronzy or coppery reflections, and slight whitish dusting, the hairs and bristles on dorsum inserted in dark dots, the dorsal vittae faint. Abdomen of male as described in key, hypopygium black, with greenish tinge, entire surface with slight whitish dusting; female with the abdomen more extensively blackened apically, the hairs and bristles on dark parts in both sexes inserted in dark dots. Legs black, femora with greenish tinge on parts, tibiae and bases of at least the fore and mid tarsi reddish yellow. Wings greyish hyaline, yellowish at bases. Calyptres and halteres yellow.

Male.—Frons linear above, inner orbital series of bristles strong, outer parts of orbits with black setulose hairs, similar hairs continued on parafacials to, or almost to, level of vibrissae, the hairs on cheeks carried almost to vibrissae, black anteriorly, yellow on raised part; numerous black setulae above vibrissae; arista pubescent. Thorax with four bristles on presutural area, the usual weak anterior sublateral bristle absent; dorsocentral bristles 2 + 4; one propleural and one stigmal bristle, both strong. As usual in the Australian species of this genus there is no ventral bristle on the mid tibia in this sex; hind tibia with about six irregular anterodorsal, one anteroventral, one posterior, and three posterodorsal bristles. Wings normal, one setula below and two or three above at base of third vein.

Female.—Frons at vertex about one-fifth, at anterior margin over one-third, of the head width, interfrontalia of uniform width on entire length, orbits much widened anteriorly. Hind tibia with 4-5 anterodorsal, two posterodorsal and two anteroventral bristles.

Length, 9-10 mm.

Type male, and allotype, Milson Island, N.S.W.

METALLEA NIGRIBARBA Aldrich.

Proc. U.S. Nat. Mus., 1926, lxi, art. 22, p. 10.

A female, which is evidently of this species, is from Eidsvold, Queensland (Bancroft). I have examined the type male of this in the United States National Museum. It is from eastern Australia.

METALLEA PUNCTICEPS, n. sp.

Male.—A much darker species than any of the others, being without noticeable testaceous markings on the abdomen. The markings on the head are constant in the three males before me and appear to be of specific import. The abdomen is blackish green, with whitish dusting through which the coppery reflections show faintly on the sides of the tergites, the dorsum has a trace of a dark central vitta, and there are dark dots at bases of the hairs and bristles only on the sides of the tergites. In other respects similar to *insularis*.

In nearly every case is there a shorter bristle below the propleural one in the type series of this species, while there is such a bristle on one side only in the type of *insularis* and none on the allotype.

Length, 6.7-25 mm.

Type and two paratype males, Perth, Western Australia (Nicholson).

Genus CHLORORHINIA Townsend (1917).

This genus is common in the Orient. The only species occurring in Australia is readily distinguished from any other of the subfamily by its brilliant metallic blue colour, besides the characters cited in the foregoing key.

CHLORORHINIA VIRIDIS Townsend.

Rec. Ind. Mus., 1917, xiii, p. 191.

The dorsum of the abdomen is largely opaque black in most specimens of the species.

Localities: Illawarra and Sydney, N.S.W.; Kuranda and Cairns, Queensland.

Genus RHINIA Robineau-Desvoidy (1830).

This genus is very similar to *Stomatorhinia* in all particulars, but besides the presence of only two bristles on the upper hind angle of mesopleura, which is rarely departed from, instead of a complete series on its entire length, the males have invariably a series of long bristles on the hind margin of the first visible tergite, usually divided more or less at middle, which are not developed in the other genera of the subfamily, and the hind tibia has a series of regular short anterodorsal setulae with one or two slightly longer. In the species before me there is a large glossy black undusted area covering the lower anterior angle of mesopleura and the anterior portion of sternopleura in *Rhinia*, while in *Stomatorhinia* the entire pleura is densely grey dusted. The presence of this glossy area readily distinguishes the species listed below from those of the species of *Stomatorhinia* occurring in Australia, but it may not hold throughout the genus in other faunal regions.

RHINIA QUADRINOTATA Bigot.

Ann. Soc. Ent. France, 1874, p. 238.

I identify as this species several specimens amongst my Australian material. These have been carefully compared with specimens from the Philippine Islands and appear to agree perfectly with them, there being no structural or other differences.

Localities: Cairns, N. Queensland (Dodd); Sydney, N.S.W.

Genus STOMATORHINIA Rondani.

This genus is most closely related to *Rhinia*, but is distinguished as stated in the key and under the preceding genus.

The species of the genus are difficult to separate satisfactorily and even the two Australian species require further elucidation, though the two forms accepted in this paper are undoubtedly distinct, the species listed as *subapicalis* being very similar to one or two others occurring in the Orient.

I present a synopsis of the species below.

- A. Testaceous yellow species, with yellow palpi, orbits and lower half of face castaneous, thorax largely fuscous, obscured by dense whitish grey dusting, scutellum testaceous, with a conspicuous black spot at base of each of the four marginal bristles; no well developed posteroventral bristles on basal half of hind femur of female; wing without an evident preapical dark costal mark; black spots of frontal orbits biseriate *pallida*, n. sp.

AA. Greenish black species, with black or dark brown palpi, anterior half of cheeks as well as lower half of face glossy black or castaneous, the scutellum at most testaceous on margin, and with inconspicuous dark dots at bases of the four marginal bristles; abdomen with lateral testaceous marks on basal two or three tergites; hind femur with one or two long bristles on basal half of posteroventral surface; black setigerous spots on frontal orbits triseriate anteriorly *subapicalis* Macquart

STOMATORHINIA PALLIDA, n. sp.

Female.—Head testaceous yellow; orbits castaneous, densely whitish dusted. with two series of glossy black piliferous spots; face glossy, with a broad central band of whitish dust, the lower undusted half castaneous; parafacial white dusted, with a few piliferous spots and, near lower extremity, a large glossy mark; cheeks densely white dusted, anterior half with an oblique glossy area; antennae testaceous, third segment more or less browned; palpi testaceous. Thorax largely fuscous, densely whitish grey dusted, the entire pleura covered with white dust, and, like the dorsum, with many dark piliferous spots; scutellum testaceous, dusted and dotted like the mesonotum, and with a conspicuous black spot at base of each of the four marginal bristles. Abdomen testaceous, with dark apices to the tergites, dusted and dotted like thorax, the dots at apices of tergites most evident. Legs testaceous, apices of tarsi darkened. Wings hyaline. Calyptrae white. Halteres yellow.

Structurally similar to the other species of the genus, but in the two females I have seen there are no noticeable bristles at base of the posteroventral surface of hind femur.

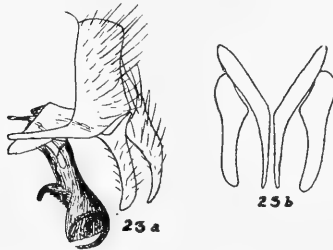
Length, 6 mm.

Type, Cairns, N. Queensland. One paratype, same locality (J. F. Illingworth) [U.S.N.M.].

STOMATORHINIA SUBAPICALIS (Macquart). (Text-figure 23.)

Mém. Soc. Sci. Lille, 1846, p. 98 (1847); *Dipt. Exot.*, suppl. 2, p. 82, pl. v, fig. 4, 1847; *australis* Walker, *Cat. Dipt. Brit. Mus.* iv, p. 809, 1849; *murina* Schiner, *Reise Novara*, Dipt., p. 309, 1868.

This species resembles *lunata* Fabricius, but the dorsum of thorax has many black piliferous dots and no evident vittae, the pleura are more densely grey



Text-figure 23. Hypopygium of *Stomatorhinia subapicalis*; a, side view; b, forceps from behind.

dusted and more conspicuously black dotted, the wing has a more or less evident dark preapical costal cloud, and the mid femur has a series of short stout spines at apex on posteroventral surface which is not present in the African male before me. Hypopygium as Text-fig. 23.

Length, 6-8 mm.

Localities: Eidsvold, Queensland; Sydney and Botany Bay, N.S.W.; Beaconsfield, Victoria and Myponga, S. Australia.

STOMATORHINIA CRIBELLATA Bezzi.

Stomatorhina cribellata Bezzi, *Bull. Ent. Res.*, 1927, xvii, p. 233.

I have not seen this species, unless it may be the species I accept as *subapicalis*. It is not *pallida*.

STOMATORHINIA DISCOLOR Fabr.

Ent. Syst., iv, p. 320, 1794. (Doubtful record.)

STOMATORHINIA XANTHOGASTER Wied.

Aussereurop. Zweifl. Ins. ii, p. 349, 1830. (Doubtful.)

Subfamily Sarcophaginae.

The members of this subfamily occurring in Australia have been competently handled by other workers so that it is unnecessary for me to do more than mention some unconsidered characters here.

In no work dealing with the genus *Sarcophaga* has there been any mention made of such characters as the hairs on prosternum, centre of propleura, and centre of the declivous portion of thorax above calyptrae. I find that by the use of these characters, which are present or absent in certain groups, it is possible to associate more readily the sexes than it is by any other means, and believe that the adoption of their use in classification would simplify the identification of the species, at least in so far as the females are concerned.

I have on a previous page dealt with the structure of the hypopygial forceps as an indication of group location. It is also possible to use the structure of the genital segments of the females as specific indices, but very little has been done in this respect by any worker in this genus. There are some very characteristic features of these segments in some of the species, possibly arising from adaptations to some peculiarity in oviposition, but whether they lend themselves to grouping of the species as well as to identification of individual species I have not determined as yet.

Subfamily Metopiinae.

This subfamily has most frequently been placed in the Tachinidae, but it undoubtedly has closer affinities with Sarcophaginae than with any subfamily of Tachinidae.

The second abdominal sternite is fully exposed and overlies the lateral margins of the second tergite as in other subfamilies of Calliphoridae, but the arista is always bare or pubescent, the lower calypter is always bare on upper disc and in most, if not all, genera bulged up near base, with an inflated appearance; the sternopleurals are frequently 1 + 2 or 3; and the notopleurals are two in number. The small knob-like protuberance before base of wing on upper part of pleura is well developed and stands out from the side more than does the upper margin of the pleura, as in Calliphoridae, while in Tachinidae it is as a rule less developed and about level with the upper edge of pleura.

The species so far as known occur in the immature stages in nests of solitary bees, but the life-histories are but little known, and whether they are parasites or scavengers is not definitely known.

There appear to be two genera in my Australian material, both of them already known to science. They may be distinguished as below.

- A. Vibrissae not differentiated, the bristles of uniform length from some distance below vibrissal angle to well above it *Miltogramma* Meigen
- AA. Vibrissae well developed and quite distinct from the setulae above and below them *Protomiltogramma* Townsend

Genus MILTOGRAMMA Meigen.

I appear to have two species of this genus, but represented by single specimens.

Genus PROTOMILTOGRAMMA Townsend.

I have seen the genotype of this species in the United States National Museum, and have several specimens which are either the same or a closely allied species. Pending receipt of more material I leave these genera in abeyance. The genotype is *cincta* Townsend, described from Queensland.

Unrecognized Species.

- Calliphora elliptica* Macq. *Mem. Soc. Sci. Lille*, 1846, p. 99 (1847); *Dipt. Exot.*, suppl. 2, p. 83, pl. v, fig. 6, 1847.
- Pollenia ruficornis* Macq. *Mem. Soc. Sci. Lille*, 1846, p. 101 (1847); *Dipt. Exot.*, suppl. 2, p. 85, pl. v, fig. 8, 1847.
- Pollenia viridiventris* Macq. *Mem. Soc. Sci. Lille*, 1846, p. 100 (1847); *Dipt. Exot.*, suppl. 2, p. 84, pl. v, fig. 9, 1847.
- Pollenia tasmanensis* Macq. *Mem. Soc. Sci. Lille*, 1850, p. 227 (1851); *Dipt. Exot.*, suppl. 4, p. 254.
- Pollenia ruficornis* Macq. *Mem. Soc. Sci. Lille*, 1850, p. 227 (1851); *Dipt. Exot.*, suppl. 4, p. 254.
- Pollenia moretonensis* Macq. *Mem. Soc. Sci. Lille*, 1854, p. 136 (1855); *Dipt. Exot.*, suppl. 5, p. 116, 1855.
- Anastellorhina bicolor* Bigot. *Bull. Ent. Soc. France*, 1885, p. xxvi.
- Rhyncomyia incisuralis* Macq. *Mem. Soc. Sci. Lille*, 1850, p. 214 (1851); *Dipt. Exot.*, suppl. 4, p. 241, pl. xxii, fig. 8.
- Rhyncomyia dubia* Macq. *Mem. Soc. Sci. Lille*, 1854, p. 129 (1855); *Dipt. Exot.*, suppl. 5, p. 109, pl. vi, fig. 4, 1855.
- Rhyncomyia tigrina* Bigot. *Ann. Soc. Ent. France*, 1874, Ser. 5, iv, p. 242.

Principal recent papers on Australian Calliphoridae as limited in catalogue.

- ALDRICH, J. M.—*Proc. U.S. Nat. Mus.*, 1925, lxiv, art. 18. Deals with *Microcalliphora*. *Id.*, *Proc. U.S. Nat. Mus.*, 1926, lxix, art. 22. Deals with *Metallea*.
- BEZZI, M.—*Bull. Ent. Res.*, 1927, xvii, pt. 3. Keys to species of South Pacific Islands and Australia, with a few descriptions of new Australian species.
- HARDY, G. H.—*Proc. Roy. Soc. Qld.*, 1925, xxxvii (1926). Deals with the Australian species of *Calliphora*.
- JOHNSTON, T. H., and HARDY, G. H.—*Proc. Roy. Soc. Qld.*, 1922, xxxiv, No. 3. Biology. *Id.*, 1922, No. 10. Synonymic list of species.
- MALLOCH, J. R.—*Ann. Mag. Nat. Hist.*, 1926, (9), xvii, p. 507.
- PATTON, W. S.—*Phil. Jour. Sci.*, 1925, xxvii, No. 3. Deals with *Calliphora*, *Lucilia* and *Chrysomyia sens. lat.*

NOTES ON AUSTRALIAN DIPTERA. No. xii.

By J. R. MALLOCH.

(Communicated by Dr. I. M. Mackerras.)

(Two Text-figures.)

[Read 31st August, 1927.]

In this part of the series of papers which I have been intermittently presenting I include some data upon the family Tachinidae which may be of interest to students of the group who intend to take up a more intensive survey of these interesting and, in some cases at least, valuable economic species.

The group appears to be a comparatively recent one, and, as in most such groups, the generic and specific limits are not as sharply drawn as in the older groups, and there is a greater diversity of characters, with a corresponding lack of distinctness in some of these, than is present in more definitely established groups and species. It is to be regretted that much of the work already done has been based upon rather trivial and variable characters, and, in addition to that, practically all of it done outside of Europe has been grafted upon the basis supplied by earlier work upon the fauna of that continent, and without considering either the fauna of the world as a whole or that of each particular faunal region as a separate unit. Consequently many of the species described as belonging to particular genera do not belong to, and are often quite distinct from, the genera they were originally placed in, having been relegated to their generic position without a proper consideration of many important characters, because of a lack of knowledge of the groups and their characters. Even the major groups which have in many cases been accepted as of family and subfamily status are not entitled in most cases to such distinction, and herein I include in the family the group Dexiidae of authors, and such concepts as Rutiliinae, etc., limiting the family as follows: Hypopleura with distinct bristles in one or more series below the spiracle, or adjacent to it; postscutellum quite prominently convexly developed immediately below the scutellum; lower calypter always much larger than upper; none of the abdominal sternites overlapping sides of tergites on their entire length. Usually the small knob-like protuberance immediately in front of and below base of wing is inconspicuous, but in some of the groups it is as prominent as in Muscidae.

There are a number of groups which may be accepted as subfamilies or tribes, such as Dexiinae, Rutiliini, Phasiinae, etc., and hereinafter I deal with one segregate which has been accorded tribal rank by Townsend and the present writer, and which is essentially Oriental and Australasian so far as I am at present aware.

The figures which I presented in my recent paper (These PROCEEDINGS, 1927) on the Australian Calliphoridae will be found useful in the study of this family also, most of the characters shown therein being used here also.

Tribe *Palpostomini*.

This group is distinguished from its allies by the following combination of characters: Scutellum with four strong bristles; prosternum setulose; lower calypter narrow, rounded at apex, and standing well clear of lateral basal angle of scutellum, its inner basal portion straight; third wing vein ending in costa close to apex of wing; first wing vein bare; central portion of upper occiput with two groups of short black setulae on lower half or more; palpi well developed. The proboscis may or may not have the apical labellae separated and palp-like.

There are three genera at present known to me, two of them occurring in Australia. I give below a key for their recognition.

Key to the Genera.

1. Centre of propleura with setulose hairs *Eustacomylia*, n. gen.
Centre of propleura bare 2
2. First posterior cell of wing usually closed and distinctly pedunculate, rarely closed at extreme margin of wing *Palpostoma* Robineau-Desvoidy
First posterior cell of wing distinctly open in margin of wing
..... *Ochroameigenia* Townsend

Genus *OCHROMEIGENIA* Townsend.

There is but one described species of this genus, *ormoioides* Townsend, which occurs in the Orient and is parasitic upon beetles.

Genus *EUSTACOMYIA*, n. gen.

This genus is very similar to *Ochroameigenia*, having the first posterior cell of wing open, but it differs from both the other genera in having the central part of the propleura with numerous setulose hairs, and the setulae on base of third vein confined to the node both above and below, instead of only below. In addition to these characters the parafacial is wider, being noticeably wider below than is the third antennal segment, and the arista is much shorter, being barely as long as antennae, and more thickened on basal half, with almost indistinguishable pubescence. Genotype, *Eustacomylia breviseta* Malloch. Named in honour of the late Dr. Eustace W. Ferguson, who submitted the material.

EUSTACOMYIA BREVISETA, n. sp.

Male.—Head yellowish ochreous, occiput, ocellar spot, frontal orbits, and parafacials, fuscous, with grey dusting, third antennal segment and arista fuscous, palpi ochreous. Thorax fuscous, more yellowish on humeral angles and apex of scutellum, the surface with changeable grey dusting, mesonotum with four linear black vittae, which are interrupted at suture and cease behind middle, and a blackish mark laterad of these on each side at suture, all of which are best seen when the thorax is viewed from behind; metanotum greyish dusted. Abdomen ochre-brown, with a darker central vitta, and dots at bases of the hairs and bristles, the anterior and posterior margins of tergites pale grey dusted. Legs ochreous yellow, fore and hind femora, and apices of tarsi, infuscated. Wings slightly smoky. Calyptreae pale brownish. Halteres dusky yellow.

Frons at anterior ocellus fully as wide as third antennal segment and about half as wide as height of cheek, vertical and ocellar bristles very short, orbits with a series of short bristles along inner margins, and short setulose hairs laterad of these which are continued downward over parafacial in about six series, the parafacial at middle about 1.5 as wide as third antennal segment,

the latter fully twice as long as second segment; arista thickened to about middle, almost bare; cheek about one-third as high as eye; vibrissae short, with numerous black bristles adjacent to them; proboscis without differentiated apical processes. Thoracic dorsum with the hairs longer and stronger than in *Palpostoma*, the presutural acrostichals as long as the dorsocentrals, in other respects as in that genus. Tibial bristles rather weak. First posterior cell narrowly open.

Length, 6 mm.

Type, Sydney, N.S.W., December 16, 1923.

Genus PALPOSTOMA Robineau-Desvoidy.

This genus is known only from Australia and Tasmania, and was originally placed in the heterogeneous assemblage "Muscidae Testacea" by its describer, but has little in common with most of the other genera therein included, these being mostly Calliphoridae, the only character they had in common being their testaceous yellow colour.

Aldrich in 1922 dealt with the genus, briefly redescribed the two known species, and added one new one.*

I have examined his material and, having a number of additional specimens as well as some new data upon the genus, I present some notes herewith.

In redefining the genus Aldrich gave a comprehensive description of the thoracic bristling, which unfortunately does not apply in all respects to the material I have examined, there being in at least one species more than two prosternal bristles, in nearly all specimens there are two intra-alars, and the posterior mesopleural bristles are more than four in number. It is also noteworthy that the palp-like apical labellae of the proboscis are not always conspicuous, there being specimens in which they are even undivided, or almost so.

It is extremely difficult to decide from the material now in my hands exactly how many species are represented, as some are from widely separated localities from those that yielded others, and there is but one sex represented from certain of those localities. No taxonomist is more ready to admit than I am the dangers attendant upon the elucidation of species from a small amount of material, and without a knowledge of the habits, or biology, of a species, or the circumstances of its occurrence in nature, and were I to attempt the presentation of complete data upon this material I fully realize that there would be considerable risk of falling into error in my conclusions as to specific distinctions, so I refrain from making a complete survey pending receipt of further accessions.

One of the specimens before me appears to represent a species quite distinct from any of the three in Aldrich's material and is described below. In addition to it there are apparently four other species in my possession, one of these is represented by 10 specimens, all taken in Sydney, N.S.W., and appears to be distinct from the form accepted by Aldrich as *testacea* Robineau-Desvoidy, though it seems to be even more likely to prove the true *testacea* than the other one. Two females from Sydney belong either to two distinct species, or if they belong to but one they present an unusual dimorphism, one having the frons very little wider at anterior ocellus than the distance across the posterior ocelli and not as wide as third antennal segment, while the other has it twice as wide as either of these standards. The genus appears to me to present an interesting field for study by some person having access to the insects in their natural

* *Proc. U.S. Nat. Mus.*, 1922, lxii, art. 11, pp. 2-5.

surroundings; any decisions based upon material such as I have, and under laboratory conditions, must of necessity be largely conjectural.

In a paper published recently in the *Philippine Journal of Science*, Townsend has erected the genus *Pseudopalpostoma* for the reception of *Palpostoma desvoidyi* Aldrich. This genus is absolutely uncalled for, as none of the characters cited for its distinction are absolute, and some of them, such as the single strong median marginal bristle on the second apparent abdominal tergite, are abnormal. Every student who has a desire to keep systematic entomology on a practical basis must deprecate this erection of illusory genera, and especially in faunal regions which are *terra incognita* to the worker who merely dabbles in inventions, without aiding either beginners or those who are really versed in the taxonomy of the group. The literature of this family is in worse condition than that of any other, and unless one is prepared to disregard most of it and proceed with his work along conservative lines he must perforce devote a tremendous percentage of his time to untangling the figments of imagination tendered as serious contributions to our knowledge of the family since the latter part of the last century.

PALPOSTOMA APICALIS, n. sp.

Female.—Shining fulvous-testaceous. Ocellar spot and a streak on each side of occiput above blackish; frontal orbits and upper part of parafacials slightly infuscated, and, like the face, white dusted; third antennal segment brown except at base. Thorax without evident dorsal dusting. Abdomen fuscous and with rather dense brownish dusting on apical three tergites, the basal tergite entirely fulvous-testaceous. Apices of mid and hind femora blackened above, the mid pair least distinctly so and to a lesser extent. Wings hyaline. Calyptrae and halteres yellow.

Frons at vertex about one-fifth of the head width, about twice as wide as third antennal segment, and three times as wide as distance across posterior ocelli; the forwardly directed upper orbital bristles and the ocellars very weak, the four verticals well developed; third antennal segment over three times as long as second and not as wide as half the height of cheek; arista subnude; cheek fully one-third as high as eye. Thoracic dorsum more sparsely haired than usual, the bristles fine but distinct, anterior intra-alar short. Legs slenderer than usual, the tibial bristles all short and weak, none on anterodorsal surface of fore pair. No evident bristles at apex of fourth abdominal tergite. First posterior cell closed in margin of wing, not petiolate.

Length, 5.5 mm.

Type, Woy Woy, N.S.W., September 22, 1923 (Mackerras).

A rather slender and weakly bristled species, distinguished from any known to me by the dark apices to the mid and hind femora. I hope to obtain enough material to deal further with the genus at some future time.

I have been unable to decide just what group to place the following genus in, but the evident though short hairs on the arista would apparently indicate that it is dextine in its affinities. There are several Oriental species allied to the one now dealt with, but these cannot be completely described here.

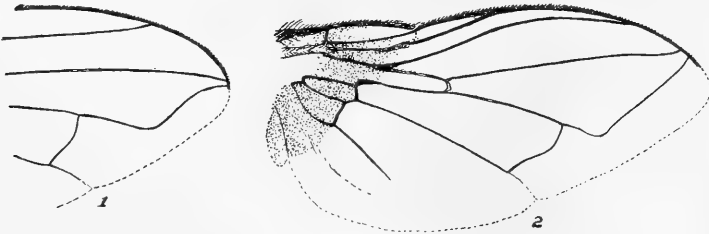
Genus SEMISUTURIA, n. gen.

Generic characters.—If one considers the very short haired arista as indicating group affinities, this genus runs to *Morphomyia* Rondani in Williston's

key to the genera of Dexiinae of North America. A comparison with the genotype, *tachinoides* Fallen, shows many points of resemblance, but the abdominal tergites in the new genus are not separated by distinct sutures except laterally, while in *Morphomyia* and other genera known to me the sutures dividing the tergites are complete. If, on the other hand, one disregards the short arista hairing as of no value in indicating group relationships, and assigns the genus to Tachininae, the genus will run to *Oestrophasia* in the same manual, but here the same character as above indicated will suffice for its recognition. A summary of the characters of the new genus is as follows: Arista very short haired; eyes with sparse microscopic hairs; face without a vertical carina; antennae in profile inserted close to middle of eyes; cheek not one-third of the eye height; vibrissae situated a little above mouth margin, some bristles above them; parafacial bare; proboscis short; palpi well developed. Thorax with 2 or 3 + 3 dorsocentral bristles, 1 or 2 + 2 acrostichals; only two bristles on presutural area, the posterior sublateral lacking; postsutural intra-alars two pairs; prosternum, propleura, postalar declivity, and metanotum, bare; sternopleurals 1 + 1; posterior spiracle with pronounced posterior flap. Abdomen ovate, or elongate ovate, the tergites apparently fused centrally; a pair of macrochaetae on middle of hind margin of each tergite except on first in two species. Costal thorn present; inner crossvein well before apex of first vein; bend of fourth vein subangular; first posterior cell open, its apex quite close to wing tip; third vein setulose at base; other veins bare; lower calypter lobulate at base on inner margin and lying close to scutellum. Genotype, *Semisuturia australis*, n. sp.

SEMISUTURIA AUSTRALIS, n. sp. (Text-figure 1.)

Female.—Fulvous testaceous, shining, third antennal segment and aristae black. Wings yellowish hyaline.



Text-fig. 1. Apex of wing of *Semisuturia australis*.

Text-fig. 2. Wing of *Amenia imperialis*, male.

Frons at vertex a little less than one-third of the head width, gradually widened to anterior margin where it is about two-fifths of the head width, orbits shining, whitish dusted like the parafacials, upper bristle sloping backward, two forwardly directed bristles on upper half, and about six inwardly curved bristles along inner margin of each orbit; ocellar bristles over twice as long as postvertical pair, divergent and forwardly directed; eye sparsely haired; cheek over one-third of the eye height, the raised part with three or four strong bristles above; several short bristles above vibrissa; arista pubescent; palpi of moderate length. Thorax with 2 + 3 dorsocentrals and 2 + 2 or 3 acrostichals, three humerals, two bristles on presutural area, two pairs of intra-alars, and no bristle between the posterior dorsocentral and postalar bristles; scutellum with 6-8 marginal bristles. First tergite without central apical bristles, second with a

strong pair, third, fourth, and fifth, with practically complete series of apical bristles, and none on disc. Anterodorsal series of bristles on fore tibia quite pronounced; ventral bristle on mid tibia very short and weak; hind femur with one or two bristles before and beyond middle on anteroventral surface. Inner crossvein well before apex of first vein and close to middle of discal cell; apical venation as in Text-fig. 1.

Length, 6.5 mm.

Type, Eidsvold, Queensland, December, 1922.

There are several Oriental species of this genus known to me, none of which I have been able to identify with published descriptions. These will be dealt with in another paper published in England. To establish these species, some of which may occur in Australia, I present below a key to the whole of the species of the genus now before me, reserving the full descriptions for the other paper.

Key to the Species.

1. Bend of fourth wing vein with a quite conspicuous vein emanating from it at the angle, which is quite sharp 2
 Bend of fourth wing vein without any evidence of a vein emanating from it 4
2. Abdominal tergites except first each with a pair of discal macrochaetae in line with the apical central pair; metanotum and abdomen glossy black, basal, and sides of second tergite, yellow *nitidiventris*, n. sp.
 Abdominal tergites except fourth without discal macrochaetae; abdomen not coloured as above 3
3. Third antennal segment black; abdomen glossy brownish black, apex of fourth tergite yellow *nigricornis*, n. sp.
 Antennae entirely yellow; abdomen yellow, brownish apically *flavicornis*, n. sp.
4. Third antennal segment black 5
 Third antennal segment not black, yellow, or at most brownish 6
5. Entire insect except third antennal segment and arista fulvous testaceous
 *australis*, n. sp.
 Thorax with black dorsal vittae, abdomen glossy black on dorsum, apex of fourth visible tergite fulvous *pahangensis*, n. sp.
6. First visible tergite with a pair of macrochaetae on middle of hind margin; outer crossvein, and costa apically, without clouding *hyalipennis*, n. sp.
 First visible tergite without developed macrochaetae on middle of apical margin; outer crossvein, and costa beyond apex of second vein, clouded
 *triangulifera*, n. sp.

I give below the type localities of the new species and the collections in which they are to be found.

SEMISUTURIA NITIDIVENTRIS, n. sp.

Type, Lubok Tamang, Pahang, Federated Malay States, 3,500 feet, June 9, 1923 (H. M. Pendlebury), British Museum.

SEMISUTURIA NIGRICORNIS, n. sp.

Type, Gunong Tahan Padang, Pahang, Federated Malay States, 5,550 feet, January 3, 1923 (H. M. Pendlebury). British Museum.

SEMISUTURIA FLAVICORNIS, n. sp.

Type, Singapore, Straits Settlements (C. F. Baker). Author's collection.

SEMISUTURIA PAHANGENSIS, n. sp.

Type, Gunong Tahan, Pahang, Federated Malay States, 6,000-7,000 feet, December 13, 1921 (H. M. Pendlebury). British Museum.

SEMISUTURIA HYALIPENNIS, n. sp.

Type, Singapore, Straits Settlements (C. F. Baker). Author's collection.

SEMISUTURIA TRIANGULIFERA, n. sp.

Type, allotype, and two paratypes, Cuernos Mts., Negros, Philippine Islands (C. F. Baker). Author's collection.

I have another specimen which appears to belong to a distinct species, from the Federated Malay States, but it is teneral and I do not care to describe it.

Tribe Ameniini.

This group is a difficult one to place satisfactorily. Most authors have placed it in the same group as *Rutilia* Robineau-Desvoidy, but it does not appear to me to be very closely related to that genus. In fact there is a very noticeable difference in the structure of the postscutellum in the two genera I refer here from that of typical tachinids, which *Rutilia* more closely resembles. In Ameniini there is a very much smaller postscutellum than usual in Tachinidae, and, while in the latter group there is always a rounded chitinized portion which bends forward at upper margin, in the group now under consideration the chitin does not noticeably bend forward, and the convexity is therefore much less pronounced. Were the postscutellum totally lacking I might be inclined to refer the genera involved to Calliphoridae, but in the latter the second abdominal sternite always overlaps the lateral margins of the second tergite, while in *Amenia* and *Stilbomyia* it does not. It is noteworthy that the small knob-like process in front of wing base on the pteropleural suture is quite prominent and more like that of a calliphorid than that of a tachinid, the typical forms of the latter group having this knob about on a level with the one immediately below the notopleural suture. A point of distinction between Ameniini and Calliphoridae is that the anterior one of the two outermost bristles on the presutural area is in line with, or mesiad of, the posterior one; in Calliphoridae it is as a rule laterad of it.

A definite conclusion as to the exact location of the Ameniini will depend upon a knowledge of all stages, and pending this information I retain the tribe in the Tachinidae.

Genus AMENIA Robineau-Desvoidy.

This genus contains species of a bright metallic blue or blue-green colour, with conspicuous spots of white dust or tomentum on the thorax and abdomen. The parafacials are bare, the prosternum, centre of propleura, mesonotum below calyptrae, and the hind coxae above bases of femora, are furnished with fine hairs. The centre of the declivous portion of thorax between base of wing and scutellum is furnished with stiff hairs, the suprasquamal ridge is bare, and there are usually four bristles on the presutural area, the anterior one of the posthumeral being almost in line with or mesiad of the posterior one.

Dr. Engel in a recent paper recognized three species as occurring in Australia and gave a diagnosis of their characters, but I do not agree with his conclusions as to the species names. The species he calls *leonina* Fabricius is quite evidently *imperialis* Robineau-Desvoidy. Wiedemann had before him the type specimen of *leonina* when he re-described the species, and his very full and lucid description does not apply at all to the species designated by this name in Engel's paper, but it does apply to that referred to as *stictica* Schiner *in litt.* It is quite clear from an examination of Schiner's description of *parva* and his remarks on *leonina* that

he misidentified the latter, placing *imperialis* and it under the same specific name, and Engel apparently followed suit. I have attempted in this paper to rectify what I consider to be errors of preceding workers, and at the same time separate material before me on the basis of what I take to be specific characters. I have what appear to me to be four species in the material available to me, all of it from the United States National Museum collection, kindly made accessible by Dr. Aldrich of that institution. In the determination of *parva* Schiner there is some doubt, but it appears highly probable that the single specimen which I refer here is correctly named, at least it is the only one which I can reliably distinguish from *leonina*, except the forms without the dorsal thoracic vittae.

Key to the Species.

1. Thorax without evident submedian white dusted dorsal vittae in front of suture; abdomen without trace of white submedian spots on second tergite, only the one on each lateral curve present; frons of male at narrowest point much more than twice as wide as distance across posterior ocelli; presutural acrostichals not noticeably differentiated from the surrounding hairs 2
 Thorax with a pair of very evident white dusted submedian vittae in front of suture 3
2. Ocellar bristles well developed and widely divergent in male, the frons at vertex in same sex five or six times as wide as distance across posterior ocelli *imperialis* Robineau-Desvoidy
 Ocellar bristles almost indistinguishable in male, the frons at vertex in same sex not four times as wide as distance across posterior ocelli *dubitalis*, n. sp.
3. Anterior postsutural dorsocentral bristles of thorax short and weak; postocular orbits very little paler on upper half than below; second abdominal tergite with a pair of submedian whitish dusted spots, sometimes faint *leonina* Fabricius
 Anterior postsutural dorsocentral bristles of thorax well developed and quite strong; postocular orbits silvery white on upper half, contrasting with the yellow dusting of the lower half; second abdominal tergite without submedian white dusted spots, only the usual one at each lateral curve present *parva* Schiner

AMENIA IMPERIALIS Robineau-Desvoidy. (Text-figure 2.)

This species is bright metallic green in colour, with the usual three white spots along each side of thoracic dorsum, and there is a very faint dusting on the anterior portion of thoracic dorsum which, however, is not in the form of vittae and is visible only when seen from behind. There is no submedian pair of white spots on the second abdominal tergite, only the lateral pair being present. The fine hairs on the orbits laterad of the series of fine bristles are yellow in colour.

Structurally this species differs from the next one in having the frons wider, and the submarginal cell of wing more obviously widened at middle than is the case with that species (Text-fig. 2).

Length, 12-13 mm.

Localities: Cairns, N. Queensland (Illingworth), and Buderim Mt., Queensland.

AMENIA DUBITALIS, n. sp.

This species is similar in colour to the above one but is smaller, and differs as indicated in the key to species, and in the above notes on *imperialis*.

It is possible that with a large series of specimens available the distinction will fail and the specimen may really represent only an aberration of *imperialis*.

Length, 10.5 mm.

Type, National Park, Sydney, N.S.W., November 1, 1902 (W. W. Froggatt).

AMENIA LEONINA (Fabricius).

This species is apparently the commonest one of the genus and is readily distinguished by the characters mentioned in the above key. The fourth visible tergite is usually much darker than the others in both sexes which is not the case in any of the other species.

The frons in the male is reduced to a mere line above, and that of the female is about one-fourth of the head width at vertex, becoming wider anteriorly and at the antennae about one-third of the head width, with the interfrontalia always wider than either orbit, and the forwardly directed bristles quite weak.

Length, 9-12 mm.

Localities: Buderim Mt., Qld.; Kuranda, Qld.; Hamilton, Qld.; and Shoalhaven, N.S.W.

AMENIA PARVA Schiner.

The specimen before me to which I assign this name is bright metallic blue-green in colour, and readily distinguished from typical specimens of *leonina*, which are normally deep blue or violet-blue in colour. The white upper portion of the postocular orbits and lack of submedian white spots on second tergite as well as the green colour of the fourth visible tergite, are the outstanding features in the differences in the colour markings between this species and *leonina*, but the second antennal segment is largely fuscous in *parva* and entirely yellow in *leonina*, and while the fuscous cloud in the costal cell of wing ceases quite abruptly a little beyond the humeral crossvein in *leonina* it gradually tapers off apically in *parva*, the entire cell being evidently darkened. The fourth visible tergite is the same colour as the others in *parva*. It is also noteworthy that all the hairs on the head in *parva* are black, while in *leonina* those of the cheeks and occiput are golden yellow. The interfrontalia of female is not wider than either orbit.

Length, 9.5 mm.

Locality: Buderim Mt., Qld.

I give the lengths of the species in accordance with the material before me. It appears pertinent to indicate that Schiner gives the length of *parva* as 2.2-5 lines, which is about 4.25-5 mm., and Engel gives the length of this species as 8-11 mm. As Engel had the type specimens of *parva* before him I accept his statement as correct. It would appear that this genus would furnish an interesting field for investigation to some resident entomologist just as all of the others would, and it may develop that there are more species in Australia than is as yet suspected.

Genus STILBOMYIA Macquart.

This genus is very similar in almost every respect to *Amenia*, and the character cited for their separation by Engel does not hold good for all the species. This character is the length of the third antennal segment as compared with the horizontal diameter of the eye. In *Stilbomyia* the third antennal segment is given as greater than the horizontal diameter of the eye, while in *Amenia* it is stated to be not over three-fourths of that diameter. I find, however, that in a Chinese species of the former the antenna is about as short as in *Amenia*, and in an Australian species the third antennal segment is about equal to the diameter of the eye. The height of the cheek in *Amenia* is always much higher than the entire length of antenna, whereas in *Stilbomyia* it is not as high except in the Chinese species already referred to where the two are nearly equal. The frons

of the males of *Amenia* is very much narrower than in the females, and never has strong forwardly directed bristles on the upper half on the outside, while in the males of *Stilbomyia* the frons of the male is as wide as it is in the female, and in both sexes there are at least two strong forwardly directed outer bristles on the upper half; the females of *Amenia* have such forwardly directed bristles but they are much weaker than in *Stilbomyia*. In both genera the abdominal sternites are widely visible between the tergites apically, the exposed surface narrowing considerably from apex to base.

Engel does not record this genus from Australia though he gives one species as occurring in New Guinea. I have before me one specimen belonging to the United States National Museum which is referable here.

STILBOMYIA OPULENTA (Walker).

This species may be the same as *costalis* (Walker), placed in the genus by Engel, but the face is only slightly browned in the antennal fovea, not dark brown, and there is a silvery dusted spot on the mesopleura, not on the sternopleura as stated by Engel for *costalis*. *S. costalis* is the species recorded by Engel from New Guinea.

Locality: Kuranda, Qld. (F. P. Dodd).

I accept the identification on the specimen as correct.

Tribe Rutilini.

Brauer and von Bergenstamm used the name Rutiliidae for a group which included only the genus *Rutilia* Robineau-Desvoidy. In a recent paper Dr. Engel has dealt with "Rutiliidae *sensu lat.*", including in his treatment 11 genera, and amongst them *Amenia* and *Stilbomyia*.

I consider the group dealt with by Engel to be heterogeneous, but several of the genera he included are unknown to me at this time so that it is not possible for me to allocate them definitely.

Townsend in 1916 designated *vivipara* (Fabricius) Robineau-Desvoidy as the genotype of *Rutilia*. Engel cited *desvoidyi* Guerin as the genotype in his paper and gave as the same species *vivipara* Robineau-Desvoidy. I consider these species distinct, and as *desvoidyi* was not originally included it can not be accepted as the genotype even if it were the same as *vivipara*, which I cannot admit is possible. In the following pages I discuss the identity of these species.

In the collection of the United States National Museum there are several species which are referable to *Rutilia*, and from an examination of these I have drawn the following as evident generic characters: Suprasquamal ridge with numerous long hairs, often curled and very conspicuous; centre of declivous area above these hairs bare; face with a broad central vertical carina; arista pubescent; abdominal sternites covered by the lateral margins of the tergites, sometimes narrowly visible at apices; third and fourth visible tergites each with apical central bristles, except sometimes the fourth in the male, and rarely the second with a few shorter stout central apical bristles. In most of the Rutiliini before me there is a very evident vein-like linear weak mark between the fifth and sixth wing veins which simulates a vein, but this is not confined to this group and recurs in Dexiinae of various groups.

My deductions as to specific characters hereinafter given are predicated upon an examination of the species in the United States National Museum, no material having been received by me from Australia direct. As is only to be expected in

the case of such large, and usually brilliantly coloured, species there have been many descriptions placed on record, and unfortunately it is very difficult to decide definitely just how many valid species there are, and also to decide what species are intended by certain of the descriptions. An extensive collection of the group will undoubtedly provide a basis for a decision as to the number of species involved, but only an examination of the type specimens will definitely decide the exact specific names applicable to each, and when the type specimens are scattered as in this case the work is too great to be undertaken by any one individual.

RUTILIA VIVIPARA (Fabricius).

In the United States National Museum collection there is a specimen labelled by Coquillett as this species. I have carefully gone over the specimen with the original description and believe that there is a great probability that it is correctly named. Wiedemann did not see the type specimen of this Fabrician species and I do not know if it is in existence. There are, however, two other specimens mentioned below which appear to confuse the issue somewhat and it will require careful work by someone on the ground to discover to what extent, if any, the species varies in the characters mentioned below.

The specimen bearing Coquillett's label has the following characters: Hind margin of the mesonotum with 4-6 strong bristles; prescutellar and presutural acrostichal bristles well developed, 4 + 3-4 pairs; scutellum slightly convex, with about 14 marginal bristles and a number of short but evident discals; supra-squamal ridge with a few distinct hairs; second abdominal tergite with six short stout central apical bristles; parafacials haired only on upper part to about apex of second antennal segment; both spiracular coverings testaceous; submedian thoracic vittae divergent behind, not continued much beyond suture; prosternum and centre of propleura haired; anterodorsal bristles on hind tibiae irregular in female.

Locality: Leura, N.S.W. (W. W. Froggatt). One female.

One specimen from Mittagong has two bristles on middle of apical margin of second abdominal tergite, and has no presutural acrostichals, and two or three pairs of prescutellars. The suprasquamal ridge is more pronouncedly haired than in the above one.

Another specimen has no bristles on second abdominal tergite, but is very similar to the preceding specimen in other respects.

It appears to be pertinent to note here that the presence of bristles on the central apical portion of second abdominal tergite has been accepted as important in distinguishing genera in this group, and if it is a variable character, which is not at all unlikely, from an examination of the above three specimens, its value is much less than indicated by Engel. Of course there may be more than one species in the material before me, but it is impossible to be certain of this without access to a larger series of specimens, and in better condition than those now available.

RUTILIA DESVOIDYI Guerin.

Specimens accepted as this species by Townsend possess the following characters: Parafacials haired to lowest margin of eyes; mesonotum with 4-6 hind marginal bristles; only prescutellar acrostichal bristles present; no pronounced discal bristles on scutellum, and 8-10 marginals, the disc subconvex; no distinct

bristles on apical margin centrally of second tergite; male with the series of bristles on antero-dorsal surface of hind tibia quite regular and close; in other respects as the two last mentioned specimens of the preceding species.

Mittagong, N.S.W. (W. W. Froggatt); two males with label Australia only.

This species is decidedly more metallic green tinged on dorsum than is the one accepted as *vivipara*.

RUTILIA INORNATA Guerin.

This species is usually much darker in colour than *vivipara*, being black, or fuscous, with black legs, fuscous calyptrae, a dark mark near bases of wings, and the dorsum of thorax and abdomen more or less bluish or violet coloured, especially noticeable on the scutellum and abdomen.

The hind margin of mesonotum has a transverse series of 8-10 strong bristles, the outer one on each side being the posterior dorsocentral; the scutellum is flattened above, slightly angulate at apex in middle, and has about 14 strong evenly spaced bristles, and no outstanding discals. The second abdominal tergite has no central apical bristles, and the suprasquamal ridge is densely long haired; while the parafacials are haired only to about apex of second antennal segment.

Locality: Queensland.

RUTILIA SPLENDIDA Donovan.

A brilliant metallic green or blue-green species. Head orange-yellow, upper occiput green, the postocular orbits white dusted above; hairs on cheeks yellow. Thoracic dorsum with four narrow black vittae, conspicuously white dusted between the anterior portions of the vittae, on humeri, two lateral presutural spots, and on an elongate spot above wing base; scutellum blue-green; mesopleura with a large white dusted spot; pleural hairs black. Abdomen with a broad black-blue dorsocentral vitta, and an apical fascia on second and third visible tergites of same colour which widens out about midway to lateral curve, and usually connects with a narrower basal fascia at that point leaving a large submedian spot of green on each side of each tergite. Legs black. Bases of wings blackened to apices of basal cells except for the usual central hyaline spot. Calyptrae whitish at bases, brown beyond.

Frontal lunule with some hairs; parafacials haired to below middle of eyes; mesonotum with four or six posterior marginal bristles, the presutural acrostichals small, but usually quite evident; postalar callosity with 4-5 bristles; sternopleurals 2-3 + 1; scutellum slightly convex, with about 12 marginal bristles, and some short bristles along edge of disc. Bristles at apices of third and fourth tergites not very long. Anterodorsal fringe on hind tibia quite regular in both sexes.

Locality: Cairns, N. Qld.

RUTILIA FORMOSA Robineau-Desvoidy.

A brilliant metallic coloured species. The thorax is usually pale blue-green, with a slightly opalescent shade because of the presence of pale dusting, and the abdomen is more emerald green, with a coppery tinge. The dorsum of thorax has two faintly indicated dark submedian vittae anteriorly which are divergent behind, and there are no distinct white spots present. The abdomen has a blue-black dorsocentral vitta, and on apices of second and third visible tergites a rather broad fascia of same colour which becomes obsolete at the lateral curve, and is not present below. Head orange-yellow, frontal orbits and parafacials paler,

becoming whitish along eyes, the orbits green at upper extremities; occiput and the raised part of cheeks pale green, white dusted, postocular orbits white dusted; occipital and genal hairs yellow. Legs black. Wings black near bases. The fine thoracic hairs yellow.

Thoracic bristling as in *splendida*. Parafacials haired to, or almost to, lowest level of eyes.

Localities: Townsville and Cairns, North Qld.

A female specimen from Shoalhaven has the third antennal segment black except at base, but is otherwise the same as the above specimens.

A specimen from the old Fitch collection in the United States National Museum, named by Bigot, agrees with the description given above.

In addition to the above-mentioned specimens I have one from New Guinea, sent to me by Dr. Karny, which has the thoracic and cephalic hairs black, and the basal dark mark on the wings very faint; and another female, from China, belonging to the U.S. National Museum, which agrees very well with the one from New Guinea, except that the hairs on occiput are yellow, except those on margins above.

These variations may represent distinct species, but I have no males.

I have carefully examined the two specimens in the United States National Museum that were accepted as *formosa* by Townsend, and used as a basis for his genus *ChrySORutilia*. These are larger and more robust than the specimens dealt with above, and are darker in colour, with the genae much less conspicuously green, and the face below carina, and the third antennal segment entirely fuscous. In addition to these characters the female has a quite conspicuous apical central depression on the fourth visible tergite as in typical species of *Rutilia*, which is not the case in the other females before me.

In my opinion *ChrySORutilia* is not a good genus, and the genotype is not correctly identified if Engel's identification is correct, the latter being the form with the yellow thoracic hairs first listed in this paper.

I have examined several additional species of *Rutilia* in the United States National Museum collection, but at the time of writing cannot be absolutely certain of the specific identity of any of them except the following two, so leave them aside temporarily.

RUTILIA ERICHSONI Engel.

Head yellowish fulvous, occiput and raised part of cheek brassy green, occiput, genae, and parafacials, yellow haired. Thorax violet-black, with black hairs and the following bluish or greenish silvery marks: Two presutural submedian dorsal vittae, four spots on each lateral margin of mesonotum, the middle pair one above the other, and a spot on mesopleura. Abdomen coloured as thorax, second and third visible tergites each with an anterior marginal, metallic green, or blue-green, centrally interrupted, fascia, fourth tergite with a black central spot on anterior margin, the remainder of surface metallic coppery green. Wings dark at bases. Calyptreae yellowish white.

Parafacials haired to lowest level of eyes. Scutellum convex, with eight marginal, and some short discal, bristles. Second tergite of abdomen with a pair of short apical central bristles, fourth tergite weakly bristled, not concave at apex.

Length, 13 mm.

Locality: Waroona, W.A., 25 Jan., 1909 (G. F. Berthoud).

RUTILIA ARGENTIFERA Bigot.

Head as in *erichsoni*. Thorax violet-black, posteriorly and on scutellum markedly more bluish, the presutural pair of vittae vestigial and narrow, each lateral margin of mesonotum in the specimen before me with but two bluish white marks, and the mesopleura with one. Abdomen violet-black, second and third tergites each with four round greenish or bluish silvery spots, fourth with a large silvery white spot on each side. Wings blackened at bases. Lower calypter browned apically. Thoracic hairs black.

Structurally similar to *erichsoni*.

Length, 13 mm.

Locality: Cairns, North Qld.

There are a few slight discrepancies between the above descriptions and that of this species given by Engel, but they are not important enough to justify a belief that they do not belong to the same species.

I present below a key to the foregoing species.

Key to the Species.

1. Parafacials not haired below middle of eyes; species not bright metallic green nor blue-green 2
 Parafacials haired to below middle, often to lowest level of eyes; if only to middle the species is largely metallic green 3
2. Hind margin of mesonotum with 4-6 strong bristles; scutellum subconvex
 *vivipara* (Fabricius)
 Hind margin of mesonotum with 8-10 strong bristles; scutellum flattened on disc
 *inornata* Guerin.
3. Thorax fuscous, with slight greenish or bluish metallic tinge, and no conspicuous white markings on either it or abdomen *desvoidyi* Guerin.
 Thorax either brilliant metallic green or blue-green, if black then with conspicuous white markings, and with white or green markings on abdomen 4
4. Thorax brilliant metallic emerald green, without white markings .. *formosa* Rob.-Desv.
 Thorax either metallic blue-green, or black, with metallic reflections, and always with conspicuous white markings 5
5. Thorax and abdomen brilliant metallic blue-green, the former with four narrow blackish vittae anteriorly and between these the ground colour is quite conspicuously obscured by white dusting, lateral margins of mesonotum each with four white spots, the median pair one above the other; abdomen with black basal and apical fasciae on second and third tergites which are usually connected midway from the central black vitta to lateral curve so as to leave two large green spots on each side of each of the tergites *splendida* Donovan.
 Thorax and abdomen violet-black 6
6. Abdominal tergites 2 and 3 each with four rather small round bluish, or greenish, silvery spots on disc, the fourth with two larger white spots .. *argentifera* Bigot.
 Sides of first tergite, and anterior margins of second and third on sides, broadly metallic green, fourth tergite metallic green, with a central black spot on anterior margin *erichsoni* Engel.

N.B.—This key should be used carefully in connection with the foregoing notes on the included species to prevent errors in identification.

Genus AMPHIBOLIA Macquart.

This genus is similar to *Rutilia* in having the suprasquamal ridge haired, and the declivity above these hairs bare. The specimen of the genotype, *valentina* Macquart, which I have examined, has the second and third visible tergites of abdomen each with two small bristles near anterior margin in centre, and some others near apex in centre. The parafacials are bare below middle, and there are but three strong bristles on the postalar callosity.

I have seen only one species referable here, the other one included by Engel, *speciosa* Erichson, being a species of *Formosia*.

Genus FORMOSIA Guerin.

This genus as included in Engel's paper may be heterogeneous, but my definition of it is based upon *mirabilis* Guerin and *flavipennis* Macquart, the former being the genotype. It is distinguished from *Rutilia* by the lack of hairs on the suprasquamal ridge, and the presence of long hairs on centre of the postalar declivity. The arista is also often much more distinctly haired, the posterior margin of mesonotum and of second abdominal tergite in centre are more strongly bristled as a rule; and the prosternum is bare, while the centre of the propleura is haired. In addition to these characters the species before me all have a series of very prominent erect spines on the apical margin of the tergites below, and the parafacials bare below bases of antennae. The colour of the parafacials cited by Engel as a distinguishing character of the genus is valueless, in my opinion, though it appears to distinguish the two groups here included, those with the distinctly haired aristae having a green colour while those with the pubescent aristae have no green colour present on the parafacials.

FORMOSIA FLAVIPENNIS Macquart.

This species differs from its congeners of metallic green colour in having the legs fulvous yellow, only the apices of the tarsi being infuscated, and the pleural hairs entirely yellow. The thorax is emerald green, with the sutures fulvous yellow, and dorsum faintly quadrivittate anteriorly; the head is fulvous yellow, with occiput, frontal orbits, and the greater part of parafacials and cheeks, opalescent green. Abdomen fulvous, first tergite above, and apices of other tergites black, disc of second tergite and sides of third and fourth, coppery red, disc of third and fourth tergites largely blue, sides of second green. Wings yellow at bases, not darkened; calyptrae and halteres yellow.

Arista with the longest hairs about as long as width of third antennal segment. Only the posterior dorsocentral bristles present; sternopleural 1; scutellum flattened above, broadly subtriangular, with about 14 irregular marginal bristles.

Locality: Cape York, N. Qld.

FORMOSIA MIRABILIS Guerin.

This species, as identified by Townsend in the United States National Museum, is very similar to *flavipennis*, but the legs are fuscous, and the hairs on mesopleura are black. The thoracic dorsum has four quite distinct black vittae on the metallic emerald-green ground colour. The abdomen is coppery green, black on first tergite, a median vitta on all tergites which is wider behind, the apices of all tergites, with a large spot-like enlargement on each side of each tergite, the black apical margin continued below, and becoming rather abruptly linear near lateral margin. Wings hardly darkened at bases. Calyptrae brownish yellow.

Eyes of male separated by not over the width of third antennal segment; arista rather long haired.

Locality: Aru Island.

This specimen looks like a dark example of *flavipennis*, but may be distinct. The apex of abdomen is paler than in the above female, instead of darker which one would expect to be the case if they are the same species.

FORMOSIA ATRIBASIS (Walker).

This species was included in *Rutilia* by Engel, but apart from the pubescent arista there is no character of any import that one can use for its separation from *Formosia* as herein accepted.

It is readily separated from the preceding two by the fuscous head, which has dense whitish dust everywhere except on the interfrontalia, instead of being green, the black thorax, which is greenish tinged and quadrivittate on dorsum, the presutural portion being quite distinctly white dusted, and has a large white dusted mark on the mesopleura. The abdomen is black, with second tergite green, conspicuously reddish coppery tinged, and with a large transverse black mark at bases of the apical central bristles, third tergite coppery green on anterior margin each side of the black central mark. Legs, bases of wings to apices of basal cells, and the calyptrae, deep black.

Arista pubescent. Dorsocentrals 3 + 5, the anterior two pairs of postsuturals weak, presutural acrostichals weak but evident; scutellum subconvex; sternopleurals 1 + 1, anterior one weak.

Locality: Kuranda, Qld. (F. P. Dodd).

FORMOSIA SPECIOSA (Erichson).

This species agrees with *atribasis* in having the arista merely pubescent, but differs markedly in colour, entirely lacking metallic tinge, being entirely black, with markings of dense greyish white dust on thorax and abdomen. Head testaceous, frons and upper occiput fuscous, all except the interfrontalia densely grey dusted; third antennal segment blackish except at base; palpi testaceous yellow. Thorax opaque black, with the following white dusted marks: four vittae and a small anterior central mark in front of suture, four spots behind suture, a spot on mesopleura and another on sternopleura. Abdomen densely whitish grey dusted, black on the following parts: first tergite, a transverse spot near apex of second tergite in centre, a cordate central spot and a much larger one on each lateral curve of third tergite, all of which connect with larger spots on fourth, and a spot on extreme lateral margin of each tergite below. Legs fulvous yellow. Wings slightly infuscated at bases. Pleural hairs yellow.

Thoracic bristling as in *atribasis*, but the presutural acrostichals lacking.

Locality: Wickham, N.S.W.

This is the genotype of *Euamphibola* Townsend, but I do not consider it entitled to generic separation from *Formosia*, the only character distinguishing it being the pubescent arista. It may ultimately be accorded subgeneric rank with *atribasis*. I have seen several other species that would also fall in the group, but cannot now identify them.

GENUS PRODIAPHANIA TOWNSEND.

This genus is distinguished from all three of this tribe previously dealt with in this paper by the absence of hairs on the suprasquamal ridge and postalar declivity. Other distinguishing characters lie in the extremely small palpi, all of the others having these organs long and slender, and the long narrow upper calypter, which is as long as the lower one and has some small black hairs invading the disc basally on the outer half. The arista is long haired, and the postalar bristles normally four in number. The conspicuously explanate costa is not confined to this genus, as I have before me a species of *Rutilia* which very closely resembles in superficial appearance the only known species of *Prodiaphania*, and has the same costal character.

Prodiaphania has the prosternum bare and the propleura haired in centre, and except for the peculiar upper calypter is closely similar to some genera of Dexiinae. I had thought it might be possible to use this lengthening of the upper

calypter as a group character, as it is evident in *Rutilia* and *Formosia*, but it is not so marked in either of these genera, and is slightly variable in the different species.

The only species of *Prodiaphania* is *testacea* Macquart, which I have seen from Cairns, North Queensland.

Of the other genera dealt with by Engel I have not seen the following: *Paramenia* Brauer and von Bergenstamm; *Microtropeza* Macquart, *Chrysopasta* Brauer and von Bergenstamm, *Senostoma* Macquart, and *Paramphibola* Brauer and von Bergenstamm.

Judging from the descriptions the first two do not fall within the group as accepted in the present paper, having no facial carina, and without an examination of the others it is impossible for me to indicate their relationships.

In the United States National Museum there are several genera placed in this group by Townsend which were not mentioned by Engel, and some of these are properly referable here, though one or two are not. I have already referred to *Chrysorutilia* and *Euamphibolia*, and below deal with some of the other genera which may be considered as referable to the group or in its immediate vicinity. I do not guarantee the correctness of the specific identifications given, as that must await type examination.

Genus GRAPHOLOSTYLUM Macquart.

I have not seen *dorsomaculatum* Macquart the type species of this genus, but in the United States National Museum there is a specimen identified by Townsend as *decorum* Guerin which is placed in this genus. This specimen agrees with one other so named by Bigot in the same collection. Engel places *decora* as a synonym of *splendida* Donovan, but the two specimens before me are quite different in the colour and markings of the abdomen from the series identified as *splendida*. The general colour of the abdomen is a deep bluish black, on the disc of tergites 2 and 3 there is a pair of small round green spots, on the lateral curves of tergites 1 to 3 there is a larger transverse green mark, and on each side of fourth tergite there is a large green mark, the margins of all of these markings suffused with Prussian blue colour.

Parafacials haired to lowest level of eyes.

Locality: Sydney, N.S.W.

This species is a genuine *Rutilia*, but *dorsomaculatum* may not be.

In the key to the species of *Rutilia* given on a previous page in this paper the present species will run down to *splendida*, but the smaller size of the dorsal spots on abdomen, and the greater proportion of the parafacials which is haired will readily distinguish the two forms, which may not be distinct species but only varieties of one.

Genus RUTILODEXIA Townsend.

This genus is doubtfully referable to this group. The face in profile is more protuberant than in *Rutilia*; postalar declivity, suprasquamal ridge, and prosternum bare; centre of propleura with hairs; parafacials bare below bases of antennae; arista pubescent. Calyptrae as in typical Dexiinae. Postalar bristles 4-5. Abdomen as in *Rutilia*, with no discal bristles except on fourth tergite. The genotype is identified as *angustipennis* Walker.

Genus CHAETOGASTER Macquart.

This genus is similar to the preceding one, but has quite distinct presutural acrostichal bristles on thorax, and the abdominal tergites 2-4 have each one or more pairs of quite strong discal bristles. Facial carina not so prominent. Genotype, *violacea* Macquart.

Occurs in Victoria and New South Wales.

Genus CHLOROTACHINA Townsend.

This genus has no facial carina and does not come within the scope of the group as accepted herein. It would run to *Microtropeza* Macquart in Engel's key to the genera if one cared to consider it as belonging to "Rutiliidae *sensu lat.*", but the third antennal segment is much longer than the second, and the insect is a bright metallic blue-green in colour, two characters which exclude it from Engel's concept. The genotype is *flaviceps* Macquart.

Locality: Cairns, North Qld.

DESCRIPTIONS OF NEW SPECIES OF AUSTRALIAN COLEOPTERA.

PART XIX.

By ARTHUR M. LEA, F.E.S.

[Read 27th July, 1927.]

The species dealt with in the present paper all belong to the family Curculionidae.

COPTORHYNCHUS ALBIVARIUS, n. sp.

Black, legs sometimes obscurely reddish. With numerous white spots and patches of scales, and many white setae.

Head with numerous punctures in front, with a somewhat horseshoe-shaped impression between eyes. Rostrum slightly dilated to between antennae; with crowded naked punctures in front. Antennae long and thin. Prothorax about as long as the greatest width, sides strongly rounded, with dense punctures, each with a white seta. Elytra ovate, strongly convex, greatest width about twice that of prothorax; with rather shallow striae containing large punctures. Legs long, femora clavate. Length, 3.5-5 mm.

Habitat.—Queensland: Coen River (W. D. Dodd and H. Hacker).

In appearance close to *C. jansoni*, but the vitta on each side of the base of pronotum subtriangular in shape with the point in front; it is usually connected at the base with a longer and wider one, which touches the coxa and is curved upwards in front so that its tip is visible from above. The rostrum is clothed with white scales, on some specimens appearing as two lines, each of which is dilated near an eye. On the elytra the spots vary considerably, often on the sides of an individual; there is usually a semi-double one on the suture just beyond the middle (absent from one specimen), on the third interstice there are one, two, three, or four round ones, and a long one near apex (on the right elytron of one specimen there are seven spots on the third interstice), on the fifth there are one or two round ones about the middle, a long one at base and another beyond the middle; the seventh and ninth usually have two spots on each, and the lateral interstice is usually narrowly white. There is a white spot on each side of the mesosternum and metasternum, and other white scales on the under parts.

COPTORHYNCHUS OCULARIS, n. sp.

Black, antennae and usually parts of the legs obscurely reddish. Clothed with white setae and numerous spots of white scales.

Head depressed between eyes, these unusually prominent. Rostrum suddenly elevated above head at base, in front with naked punctures and a short median line. Antennae long and thin. Prothorax distinctly longer than wide, sides strongly rounded; with dense punctures each containing a seta. Elytra ovate,

strongly convex, greatest width about twice that of prothorax; with rows of large punctures, mostly wider than interstices, becoming smaller and in deeper striae posteriorly. Legs long, femora clavate. Length, 4-5 mm.

Habitat.—Queensland: Darnley Island (H. Elgner and A. M. Lea).

The base of the rostrum appears elevated and subtriangularly produced between the eyes; the latter from behind appear to be separated from the head by slight notches; the prothorax is longer than is usual. The white scales on the best preserved specimen are fairly dense on the basal two-thirds of rostrum and between the eyes, form a short basal vitta on each side of the pronotum and are dense on the sides (but invisible from above); on each elytron (as seen from the side) there is a short basal fascia (close to two large spots on the under surface), another before the middle (composed of three conjoined spots, one on each interstice), and a subtriangular patch beyond the middle; at the apex there is a short vitta on the third interstice, connected with a narrow marginal stripe, there are several feeble spots elsewhere, including one on the suture. On three other specimens the markings are less defined, partly due to abrasion. On another the white scales are much more numerous, but the markings are less sharply indicated.

COPTORHYNCHUS TRIVITTATUS, n. sp.

Black, parts of antennae and of legs obscurely reddish. Clothed with white setae and spots of white scales.

Head with numerous punctures in front, with a small interocular fovea. Eyes prominent. Rostrum in front with numerous naked punctures, and a median depression. Antennae long and thin. Prothorax moderately transverse, sides strongly rounded, base very little wider than apex; with crowded punctures, each containing a seta. Elytra ovate, strongly convex, almost twice the width of prothorax; with rows of large, deep punctures, much wider than interstices, even posteriorly. Legs long, femora clavate. Length, 4-5 mm.

Habitat.—Queensland: Darnley Island (H. Elgner).

The base of the rostrum and the eyes are very different from those of the preceding species. The white scales are dense on the basal two-thirds of rostrum and around the eyes; on the pronotum they form three basal vittae and a stripe adjacent to each coxa, with its ends turned upwards. On the elytra they form two spots on the suture, four on the third interstice (and a large spot near apex where several interstices join), three on the fifth, three on the seventh and three or four on the ninth, with the margin narrowly white from near the base. The sides of the under surface from the mesosternum to the apex of the first abdominal segment are densely clothed with white scales; the middle of the first segment is slightly depressed, with long thin setae. The type is probably a male, a second specimen has the abdomen evenly convex, with the sides of the first segment less densely clothed; some of the spots on its upper surface are less defined than on the type.

RHINOSCAPHA INTERRUPTA, n. sp.

♂. Black. Sparsely clothed with inconspicuous scales, except on elytra, on which they form distinctive markings.

Head with sparse and minute punctures. Rostrum almost the length of prothorax; median groove deep and single at base, becoming trifid in front; sublateral sulcus rather deep, both ends closed. Antennae rather thin. Prothorax

slightly longer than wide, widest at apical third, somewhat depressed along middle but with an irregular carina, sides vermiculate; with small scattered punctures. Elytra elongate-subcordate, base bilobed, sides widest about middle; with regular rows of large punctures, the interstices in places faintly wrinkled and with sparse minute punctures. Legs rather long. Length (excluding rostrum), 14-19 mm.

♀. Differs in having the rostrum slightly stouter, prothorax slightly wider, elytra much wider, abdomen more convex and legs somewhat shorter.

Habitat.—Queensland: Murray Island (A. M. Lea), Darnley Island (C. T. McNamara).

On each elytron there are several spots or patches of white scales having a distinct greenish gloss, and usually mixed with a reddish meal: two near base, of which the inner one is slightly oblique, and about half the length of the prothorax, and a smaller one behind the shoulder, and partly visible from above; on the fourth interstice before the middle there is a short vitta, behind this an oblique one on the third, and level with the apex of this a smaller one on the second, towards the side there is a small one on the seventh and eighth, on the fifth there is a distinct one on the apical fourth; the marginal interstice from near the base, and the next two near apex are densely clothed. On each side of the prothorax, but invisible from above, there is a vitta of whitish scales with a greenish gloss. The specimen from Darnley Island is a large female, with the elytral markings white and slightly more extended. Its nearest ally before me appears to be *R. tricolor*, from New Guinea, on which the subbasal and submedian markings on the elytra are connected, and which has distinctive markings on the sides of the prothorax.

MANDALOTUS.

In my recent revision of the genus I stated¹ of the apparently allied genus *Timareta*, "Several species *with* ocular lobes". This should have been "*without*".

MANDALOTUS PYRIFER Lea.

Rec. S. Aust. Museum, 1926, p. 167.

A female, from the Victorian Alps, in the National Museum, Melbourne, evidently belongs to this species. It differs from the type male in having the mesosternum without the intercoxal process produced, two basal segments of abdomen slightly convex, and not setose, front tibiae without distinct teeth, and hind ones less curved.

MANDALOTUS MIRABILIS Lea.

Trans. Roy. Soc. S. Aust., 1907, xxxi, p. 152.

Four males, in the National Museum, Melbourne, from the Howitt collection, belong to this species, but the long hairs on the under surface are plastered down on three of them, so that the character given in the 1926 key of the genus: "Under surface with dense and long hairs" does not appear to apply to them. Each middle coxa is seen to have an obtuse tooth (the end of the arcuate carina). *M. campylocnemis*, somewhat similarly armed, has the middle coxae more than twice as wide apart, and very different legs; *M. valgus* is a smaller species, with shorter and sparser clothing on the under surface.

¹ Lea, *Rec. S. Aust. Mus.*, 1926, p. 148.

Two females, associated with the males, apparently belong to the species; they differ in being smaller, sides of prothorax more evenly rounded, elytra more parallel-sided, metasternum and abdomen flat along middle, middle coxae unarmed and tibiae simple. On one of them there are four conspicuous pale spots on the head: a small one margining each side, a still smaller one at the base of the rostral carina, and a large medio-basal one; on the other female and on the males the spots are feeble or scarcely traceable.

MANDALOTUS STERNOCERUS, n. sp.

♂. Black, antennae tarsi and parts of tibiae reddish. Densely clothed with muddy-brown scales, interspersed with setae.

Rostrum with median carina concealed or absent. Antennae fairly long and thin. Prothorax moderately transverse, sides evenly rounded, with numerous small rounded granules traceable through clothing. Elytra wider than prothorax, base almost evenly arcuate, with rows of large punctures, much wider than interstices, but appearing much smaller through clothing, alternate interstices slightly elevated and in places subtuberculate. Mesosternum with a five-sided projecting intercoxal process, widest at about one-third from base, the apex truncated and about half the width of base. Metasternum and abdomen each with a basal row of large punctures, and with a wide shallow depression continued on to second segment. Front coxae widely separated, front tibiae with a large obtuse tubercle near base, the sides flanged and apex armed; hind tibiae with a fairly large tooth near base, between it and apex shining and multicarinate. Length, 5.6 mm.

♀. Differs in being slightly wider, mesosternum unarmed, two basal segments of abdomen evenly convex, tibiae unarmed near base, and the hind ones not multicarinate.

Habitat.—Victoria: Types in National Museum, Melbourne.

Another species of the genus with remarkable tibiae. In the 1926 key of the genus¹ it could be associated with *M. intercoxalis*, from which it differs in the smaller size of the intercoxal process and the remarkable tibiae; *M. carinatipes* has the hind tibiae multicarinate, but the front tibiae are very different and the mesosternal process is shorter and broader. The front tibiae from some directions appear to have an acute apical tooth, projecting downwards about the same length as the subbasal one, but from other directions it is seen to be a thin flange, with its apex semidouble. On the elytra the setae are more numerous on the odd than on the even interstices, and a few are clustered together in places, but hardly enough to form fascicles, at the base on the male they form two rather pale spots; there is an oblique series of feeble elevations crowning the apical slope, but the only distinct tubercle on each elytron is one on the side near the shoulder.

MANDALOTUS ARMICOXIS, n. sp.

♂. Black, antennae and tarsi obscurely reddish. Densely clothed with sooty-brown scales sparsely interspersed with setae, but the latter becoming longer and more numerous on legs.

Rostrum with median carina concealed or absent. Antennae moderately long and thin. Prothorax moderately transverse, roughly and irregularly granulate. Elytra slightly narrower than widest part of prothorax, base trisinate, with rows

¹ Lea, *Rec. S. Aust. Mus.*, 1926, p. 149.

of large partially concealed punctures, third, fifth and seventh interstices irregularly elevated or subtuberculate, a distinct tubercle on the side behind each shoulder. Metasternum and abdomen shallowly concave and each with a basal row of large punctures. Front coxae widely separated, very large, semidouble, the hind part of each with a conspicuous subconical tubercle; front tibiae strongly curved at apex; hind tibiae less strongly curved but still conspicuously so. Length, 5.5-5 mm.

Habitat.—Victoria: Two males in National Museum, Melbourne.

In the 1926 key of the genus, this species could be associated with *M. valgus*, but it is readily distinguished from that species, as from all others, by the front coxae, these being of unusual size, semidouble and conspicuously tuberculate. The front trochanters are also peculiar; from one direction they appear to be transverse and to isolate completely the coxae from the femora, although from another direction the femora are seen to junction with the coxae.

BARIS BITUBERCULATA, n. sp.

Black, shining. With sparse white setae, nowhere forming distinct spots.

Head with fairly dense but not very sharply defined punctures; with a small interocular impression. Rostrum evenly curved; punctures more sharply defined than on head, although no larger. Scape inserted about two-fifths from apex of rostrum in female, slightly nearer in male. Prothorax almost parallel-sided except near apex, which is suddenly narrowed; with dense punctures of moderate size on sides, becoming smaller and somewhat sparser in middle, but quite as sharply defined. Elytra elongate-subcordate; with narrow striae containing small punctures, but becoming larger about base; interstices with very minute punctures, but some fairly distinct ones about base and apex (where also the derm is subopaque); a small preapical callus on each side just before the junction of the third and sixth interstices. Sterna with crowded punctures about as large as those on sides of prothorax, becoming smaller and sparser on abdomen. Femora acutely dentate. Length, 3.5 mm.

Habitat.—Queensland: Murray Island (A. M. Lea).

Belongs to Section 1¹ of the genus, but distinct from all other species of the subfamily (except *B. niveodispersa*) by the elytral tubercles. The groove in front of the prosternum can be seen only after the head has been removed. From the sides there appears to be a shallow notch between the head and rostrum.

BARIS COELESTIS, n. sp.

Deep metallic blue. Setae minute and inconspicuous.

Head with minute punctures, with a shallow interocular impression. Rostrum strongly curved in a line with that of the head; with small punctures more distinct than on head, sides opaque. Antennae inserted about one-third from apex of rostrum. Prothorax moderately transverse, sides almost evenly decreasing in width from base to apex; with rather small and not very dense, sharply defined punctures, becoming very small in front, on the sides larger and more crowded, but an impunctate polished space on each side. Elytra with sides very feebly decreasing in width from shoulders to near apex; with narrow striae containing small deep-set punctures, distinct only about basal fourth; punctures on interstices scarcely visible. Metasternum with crowded, sharply defined punctures, becoming

¹ Lea, *Trans. Roy. Soc. S. Aust.*, 1906, p. 84.

smaller and sparser on the rest of the under surface. Front femora very minutely dentate, the others not at all. Length, 2 mm.

Habitat.—Queensland: Cairns district (F. P. Dodd).

A beautiful blue species. As the prosternum has a groove bounded by distinct walls, it must be referred to Section 1 of *Baris* rather than to *Ipsichora*; the groove, however, can be seen distinctly only after the head has been removed. The legs are somewhat darker than the upper parts, and the under parts have a slight greenish gloss; the antennae are almost black. Owing to the opacity of the sides of the rostrum, its middle appears to be finely ridged; it is narrowed between the eyes, these being larger than usual. The polished space on each side of the prothorax is invisible from above. The male has a large, shallow, intercoxal depression.

BARIS PULCHRIPARVA, n. sp.

Bright metallic blue, antennae blackish. Prothorax with a small spot of white scales on each side of base, a similar spot on each side of metasternum, elsewhere sparsely clothed or glabrous.

Head minutely punctate, with a small depression in front. Rostrum strongly curved, with minute but rather sharply defined punctures. Antennae inserted two-fifths from apex of rostrum. Prothorax gently narrowed from base to near apex and then strongly to apex itself; with rather small but sharply defined punctures, becoming larger and more crowded on sides. Elytra with sides nowhere quite parallel, with narrow striae containing deep-set punctures, distinct only on basal third; interstices very minutely punctate. Metasternum with crowded punctures, about as large as on sides of prothorax, the abdomen with very irregular ones, but mostly sparser and smaller than on metasternum. Femora edentate. Length, 2.5 mm.

Habitat.—Queensland: Cairns district (F. P. Dodd). Unique.

Another beautiful blue species of Section 1; readily distinguished from the preceding species by the white spots on the prothorax and metasternum. The rostrum from above appears parallel-sided, from the sides it appears to be separated from the head by a feeble notch, to be angularly bent at the middle, with the apex much narrower than the base. As its abdomen has a shallow depression on the two basal segments the type is probably a male.

BARIS HOPLOCNEMIS, n. sp.

Deep metallic blue, legs and antennae blackish. Upper surface glabrous, except for a white spot on each side of base of pronotum; under surface sparsely clothed, but a conspicuous white stripe on each side of metasternum.

Head with minute punctures, and with a shallow interocular depression. Rostrum strongly and separately curved, with numerous small but sharply defined punctures. Antennae inserted one-third from apex of rostrum. Prothorax almost as long as wide, sides almost parallel to near apex; with numerous sharply defined punctures of moderate size, becoming minute in front and larger and crowded on sides. Elytra slightly wider than prothorax, parallel-sided to near apex; striae narrow and apparently impunctate, interstices impunctate except close to base. Under surface with crowded and coarse punctures, except on most of abdomen and middle of metasternum. Legs rather long; femora edentate; front tibiae with a conspicuous projection on middle of lower surface. Length, 2 mm.

Habitat.—Queensland: Cairns district (F. P. Dodd).

A narrow, beautiful species, with distinctive front tibiae. The prosternal groove is rather shallow, and its sides are not bounded by acute ridges in front, but it seems desirable to refer it to Section 1, with the other blue species of the genus. It differs from *B. pulchriparva* in being more parallel-sided, prothorax less narrowed to apex, with larger punctures, metasternal episterna clothed throughout, abdomen without a longitudinal impression and in the front tibiae.

A specimen, from Glen Lamington in the Stockholm Museum, differs in being larger (2.5 mm.) and more greenish than blue. The abdomen of both specimens is evenly convex, but the armature of the front tibiae is probably confined to the male.

BARIS ORTHODOXA, n. sp.

Black, somewhat shining, with a faint bronzy gloss; under parts with small white setae, upper surface glabrous.

Head opaque and with very minute punctures. Rostrum strongly curved, almost in a line with curvature of head; with small seriate punctures behind insertion of antennae (at apical third), more sharply defined in front. Prothorax strongly transverse, sides almost evenly narrowed from base to apex; middle with rather small, sharply defined punctures, becoming larger and crowded towards and on sides. Elytra cordate, outlines continuous with those of prothorax; with narrow striae, containing small angular punctures, deeply set posteriorly; interstices each with an inconspicuous row of punctures. Under surface with crowded punctures, smaller and sparser on parts of abdomen than elsewhere. Femora edentate. Length, 2 mm.

Habitat.—Queensland: Cape York. Unique.

A small species of Section 1, slightly wider than *B. vagans*, and with the pectoral canal more sharply defined, it is narrow and rather deep, but without acutely ridged margins. As the basal segment of its abdomen has a distinct median impression, the type appears to be a male.

BARIS PARVONIGRA, n. sp.

Black, slightly shining, some parts opaque. Upper surface glabrous, under parts with minute white setae.

Head minutely punctate. Rostrum strongly curved, in a line with curvature of head; with fine ridges, alternated with rows of small punctures to apical third (where the antennae are inserted), then with punctures only. Prothorax moderately transverse, apex about half the width of base; with rather small punctures in middle, becoming crowded and larger on sides. Elytra cordate, outlines not quite continuous with those of prothorax; with narrow striae containing small, deep-set punctures, vanishing posteriorly; interstices each with an inconspicuous row of punctures. Under surface with crowded punctures, somewhat sparser on abdomen than elsewhere; basal segment with a faint depression. Femora edentate. Length, 1.75 mm.

Habitat.—Northern Queensland (Blackburn's collection). Unique.

A minute comparatively narrow species of Section 1, in general appearance like *B. subopaca*, and with the prosternum similarly grooved. It is about the size of *B. vagans*, but the prothoracic punctures are more crowded.

BARIS SETISTRIATA, n. sp.

Black, tarsi obscurely diluted with red. Moderately clothed with white setae, on the elytra forming a distinct row on each interstice.

Head with minute punctures. Rostrum about the length of prothorax, moderately curved, with rows of squamiferous punctures to middle (where the antennae are inserted), in front of which the punctures are smaller, more numerous and naked. Prothorax slightly transverse, sides almost parallel to near apex; with dense and rather small punctures, becoming larger on sides. Elytra suboblong, base bilobed, with narrow striae containing deep-set punctures, fairly distinct about base only. Femora edentate. Length, 1.5 mm.

Habitat.—Queensland: Rockhampton (A. M. Lea).

A small, suboblong species, with a line of white setae on each elytral interstice; it belongs to Section 1, but the pectoral canal, although distinct in front, is bounded by rather feeble ridges. On the male the antennae are inserted slightly nearer the apex of the rostrum than on the female, and the base of its abdomen has a slight longitudinal impression. The outlines are much as on *B. oblonga*, but the elytral clothing does not conceal the derm on which it rests, whereas on that species, there appear to be alternating white and black lines. *B. vagans* is slightly larger, less parallel-sided, and has elytra without seriate clothing. *B. australiae* is smaller and has more conspicuous clothing.

BARIS TRISINUATA, n. sp.

Black, parts of under surface and of legs obscurely diluted with red. Upper surface glabrous, under parts almost so.

Head minutely punctate. Rostrum thick, strongly and equally curved; with coarse, crowded punctures on sides, smaller and more sharply defined on upper surface. Antennae inserted nearer apex than base of rostrum. Prothorax with base almost twice as wide as median length, apex less than half the width of base; with numerous rather small punctures, becoming larger and closer together on sides. Elytra very wide, outlines subcontinuous with those of prothorax, sides nowhere parallel, base distinctly trisinate; with narrow striae, containing deep-set punctures, but becoming round on basal half of two sutural ones; interstices polished and impunctate, but about outer apex opaque and with small punctures. Under surface with very variable punctures; crowded in front of prosternum, and on apex of abdomen, almost absent from third and fourth segments. Femora grooved, edentate, and coarsely punctate. Length, 3 mm.

Habitat.—North Queensland (Blackburn's collection). Unique.

A short species of Section 1, wider in proportion than any species of the genus previously recorded from Australia. The pectoral canal is wide and shallow, in front it is somewhat deeper in the middle with feebly carinated sides. As the two basal segments of its abdomen are depressed in the middle the type is probably a male.

BARIS MELANOSTETHA, n. sp.

♂. Castaneous-brown, scutellum, suture and metasternum black or blackish. Upper surface with sparse white clothing but forming a small medio-basal spot on pronotum; on under parts rather dense.

Head with small, crowded punctures, and a faint interocular depression. Rostrum scarcely the length of prothorax, with fine ridges and irregular punctures to apical third (where the antennae are inserted), in front with punctures only. Prothorax longer than apical width, which is about half that of base; with rather dense punctures of moderate size. Elytra with outlines subcontinuous with those of prothorax, sides in part subparallel, base trisinate; with narrow striae,

containing punctures distinct only near base; interstices each with a row of distinct punctures. Abdomen with a shallow medio-basal depression. Femora edentate. Length, 1.75-2.75 mm.

♀. Differs in having the rostrum thinner, slightly longer than prothorax, ridges finer, punctures smaller, antennae inserted somewhat nearer the middle, and abdomen evenly convex.

Habitat.—North-western Australia: Fortescue River (W. D. Dodd).

The seventeen specimens obtained vary considerably in size, but only to a slight extent in colour; the head and abdomen are sometimes infuscated, and the sutural infuscation is more widely dilated towards the base on some specimens than on others. It belongs to Section 1, and is structurally close to *B. angophorae*, *sororia*, and *bryanti*, but those species are deep black. The only distinct spot on the upper surface is the small medio-basal one on the pronotum, but there is usually a very feeble spot near the middle on each side, on the elytra there are usually a few scales on the odd interstices.

BARIS ILLEPIDA, n. sp.

Dull reddish-brown, scutellum, suture, metasternum and base of abdomen deeply infuscated or black. Upper surface very sparsely clothed with whitish scales, but a small medio-basal spot on pronotum and a less distinct one in middle on each side; under parts moderately densely clothed.

Head with sharply defined punctures between eyes, becoming smaller and shallower posteriorly. Rostrum moderately curved, slightly longer than prothorax; punctures at base as between eyes, becoming smaller in front. Antennae inserted two-fifths from apex of rostrum. Prothorax almost as long as basal width, which is fully twice that of apex; with rather dense, sharply defined punctures, becoming smaller in front and larger on sides. Elytra slightly wider than prothorax at base, sides nowhere parallel; with narrow striae, containing distinct punctures on basal half; interstices each with a distinct row of transverse punctures, becoming larger towards base, and crowded and irregular on second and third near base. Under surface with punctures varying considerably in size and density. Femora edentate. Length, 3.3-5 mm.

Habitat.—Northern Territory: Darwin (G. F. Hill).

Belongs to Section 1. Structurally and to a certain extent in colour and clothing resembles the preceding species, but is larger and with a different rostrum. *B. bryanti*, also from the Northern Territory, is deep black. The two specimens taken appear to be females.

BARIS MELANOCHROA, n. sp.

♂. Black. Upper surface glabrous, under parts almost so.

Head with rather small but sharply defined punctures in front, elsewhere with very minute ones. Rostrum the length of prothorax, strongly curved; with rather dense, sharply defined punctures, becoming coarser and crowded on sides. Antennae inserted about one-third from apex of rostrum. Prothorax longer than apical width, which is only about half that of base; punctures not very close together and rather small, but sharply defined, becoming larger and more crowded on sides. Elytra subcordate, outlines subcontinuous with those of prothorax; with narrow striae containing deep-set punctures, but some fairly distinct ones towards base and sides; interstices each with a row of scarcely visible punctures, but becoming fairly distinct on sides. Most of sterna and tip of abdomen with crowded

punctures, elsewhere (and especially on third and fourth segments) sparser and smaller; first segment depressed along middle. Femora edentate. Length, 3.3-75 mm.

♀. Differs in having smaller punctures between eyes, rostrum slightly longer than prothorax, and abdomen evenly convex.

Habitat.—Queensland: Cairns district (E. Allen, F. P. Dodd and A. M. Lea).

Belongs to Section 1 of the genus, but is strikingly close in appearance to *B. cyaneotincta* of Section 3. On several specimens the claw joint and parts of the under surface are obscurely reddish. The specimen (a female) taken by Mr. Allen has the punctures in front of the head somewhat larger than on the other (8) specimens, and its rostrum is slightly gibbous at the base.

BARIS VULNERATA, n. sp.

Black. Glabrous except for sparse white setae on under parts.

Head almost impunctate; with a large, round, deep, interocular cavity. Rostrum rather wide and curved; with rows of distinct punctures, becoming crowded and irregular on apex and sides. Antennae inserted two-fifths from apex of rostrum. Prothorax almost as long as its basal width, sides obliquely narrowed to apex; with sparse and very minute punctures, becoming fairly distinct about apex, and denser and coarser on sides at base and apex. Elytra slightly wider than prothorax, but their outlines almost continuous with those of prothorax; with fine striae almost vanishing about middle of each elytron, and containing punctures only near suture and sides. Metasternum with rather coarse, crowded punctures; episterna arched downwards, each with a single row of punctures. Basal segment with a shallow depression in male, apical segment with fairly large, crowded punctures, sparse and small or absent elsewhere. Legs rather long, femora edentate. Length, 2 mm.

Habitat.—Queensland: Cairns district and Mount Tambourine (A. M. Lea); Bellenden Ker (Dr. E. Mjoberg).

An elliptic species of Section 2, with elytral striae vanishing in parts; and distinct from all other members of the subfamily by the large interocular fovea. A specimen from Cairns has the prothorax and rostrum reddish, probably from immaturity.

BARIS EPISTERNALIS, n. sp.

Black. Upper surface almost glabrous; under parts with sparse white setae, but each side piece of metasternum densely clothed.

Head minutely punctate, with a faint interocular impression. Rostrum long, thin, and moderately curved; with rows of small punctures. Antennae inserted about two-fifths from apex of rostrum. Prothorax decidedly transverse, apex not half the width of base; with fairly dense, sharply defined punctures, becoming crowded on sides. Elytra wide, slightly wider than prothorax, but with outlines continuous with those of prothorax; with narrow striae, containing small punctures; interstices each with a row of distinct punctures. Under surface with irregularly distributed punctures, larger towards sides of metasternum than elsewhere. Femora edentate. Length, 1.5 mm.

Habitat.—Northern Queensland (Blackburn's collection): Cairns district (F. P. Dodd).

A minute rather wide species, with each metasternal episterna appearing as a white line, although when greasy the white disappears. *B. vagans* is a proportionately larger species, without special clothing on the metasternum.

B. australasiae, which has somewhat similar clothing on the metasternum, is a smaller and decidedly narrower species, with seriate clothing on elytra. From behind the base of the elytra appears bilobed, but from directly above it is seen to be trisinate. The male has a conspicuous depression on the basal segment of abdomen. The pectoral canal is deep in front and bounded by carinated ridges, it is quite as deep between the front coxae, but is narrower, so the species might almost be considered as belonging to *Solenobaris*, but the subcontinuous outlines of prothorax and elytra and the general appearance are as on many species of *Baris*, to the second section of which genus it seems desirable to refer it.

BARIS SETIPENNIS, n. sp.

Black, antennae, tip of rostrum and parts of legs obscurely reddish. With stramineous setae, on elytra forming a regular row on each interstice; on under parts mostly white.

Head with small sharply defined punctures. Rostrum slightly longer than prothorax, moderately curved, subgibbous at base, with dense punctures of moderate size, becoming crowded at base and sides. Antennae inserted two-fifths from apex of rostrum in male, almost in middle in female. Prothorax moderately transverse, basal half almost parallel-sided, then strongly narrowed to apex; with dense, sharply defined punctures of moderate size, becoming denser on sides. Elytra slightly wider than prothorax, almost parallel-sided to beyond the middle, base bilobed; with deep striae, containing deep-set punctures; interstices each with a distinct row of punctures. Under surface with sharply defined, irregularly distributed punctures, varying from small to fairly large. Femora edentate. Length, 4.25-4.5 mm.

Habitat.—Queensland: Endeavour River (Blackburn's collection), Cairns district (A. M. Lea).

The pectoral canal is rather short and narrow, but is bounded by well defined ridges, and as the rostrum is subgibbous at base it seems best to refer it to Section 3 of the genus, from all the previously described species of which it differs considerably in appearance. It is allied to *B. elliptica*, but is larger and has sparser clothing. It is about the size of *B. basirostris*, of Section 6, but has a slight depression only instead of a deep notch between the head and base of rostrum. In general appearance it is like several of the narrow species of *Melanterius* of the Cryptorhynchides. The setae on the elytra are regularly disposed, but about one-third of them are stouter than the others, and white. The abdomen of the male is less convex than that of the female, and its rostrum is slightly shorter, stouter, and with stronger punctures.

BARIS CYANEOTINCTA, n. sp.

Black, prothorax and elytra with a metallic-blue gloss, becoming faint on under surface; club and tip of rostrum obscurely reddish. Upper surface glabrous, under parts with a small seta in each puncture.

Head with very minute punctures, and with a small interocular impression. Rostrum about the length of prothorax, moderately curved, somewhat gibbous at base; with numerous well defined but rather small punctures, becoming larger and crowded on sides. Antennae inserted about one-third from apex of rostrum. Prothorax slightly transverse, sides feebly diminishing in width to near apex, and then strongly to apex itself; with sharply defined punctures of moderate size, fairly numerous in middle, but crowded on sides. Elytra slightly wider than

prothorax, nowhere quite parallel-sided, base trisinate; with narrow striae containing fairly distinct punctures; interstices each with a distinct row of small punctures, becoming rather large about base. Sterna and apical segment of abdomen with crowded and rather large punctures, smaller and sparser elsewhere. Femora each with a small acute tooth. Length, 3.5-4 mm.

Habitat.—Queensland (H. J. Carter), Cairns district (F. P. Dodd and A. M. Lea).

A somewhat metallic species of Section 3, in general appearance, except colour, like large *B. sororia* and *angophorae*, but prothoracic punctures less crowded, and seriate ones on the interstices much less distinct. *B. glabra* is smaller, with much smaller punctures, and more polished interstices. The male differs from the female in having the rostrum slightly shorter, antennae inserted slightly nearer the apex, and basal segment of abdomen with a slight depression.

BARIS NIVEODISPERSA, n. sp.

Black, shining, base of antennae and claw joints reddish. With depressed white scales, forming small spots on sides at base and apex of prothorax, a distinct transverse spot on each elytron at summit of apical slope, a few small spots or single scales elsewhere, dense on metasternal episterna, and sparse on the rest of the under surface, but legs and front of prosternum with some white setae.

Head with minute punctures. Rostrum slightly longer than prothorax, strongly curved, subgibbous at base; with rows of punctures becoming smaller and crowded in front, and coarse on sides. Antennae inserted about one-third from apex of rostrum. Prothorax moderately transverse, sides gently rounded, but suddenly becoming subtubular at apex; with sparse and small but sharply defined punctures, altering to longitudinal scratches on sides. Elytra elongate-subcordate, sides diminishing in width from near base; with narrow striae, in which punctures are deeply set; interstices each with a row of very minute punctures, becoming larger (but still small) at base, junction of fourth and fifth on each elytron with a small tubercle immediately behind the white spot. Under surface with irregularly distributed punctures of varying sizes, but two large ones or small foveae in front of prosternum. Femora minutely dentate. Length, 4 mm.

Habitat.—Queensland: Brisbane (H. W. Brown).

A well defined species of Section 4. The small elytral tubercles are rendered more distinct by the surface behind them being depressed; *B. vituberculata*, with somewhat similar tubercles, has very different punctures, and the upper surface glabrous. The absence of elongated spots from the elytra distinguishes it from the descriptions of *B. albopicta* and *albigutta* (the latter also belongs to Section 4). *B. niveonotata* is somewhat more robust, with more numerous scales on elytra, larger prothoracic punctures, and different rostrum. From *B. apicinivea* it differs in the prothorax being without white vittae, and by the elytra having some white scales on the basal third. The tips of the elytra are lengthened, so that the pygidium is practically concealed. A second specimen differs from the type in having the rostrum slightly longer and thinner, and with much less distinct punctures on its upper surface, where also they are scarcely seriate; but its abdomen is similar to that of the type.

BARIS PRAEMORSA, n. sp.

Black, parts of antennae obscurely diluted with red. Some snowy-white scales at sides of base of rostrum, forming a small spot on each side in front of

prothorax (invisible from above), two elongate spots on third interstice: one at base, the other beyond the middle, a spot on submarginal interstice, a spot on each side of second segment of abdomen, and some on metasternum between the coxae.

Head with rather dense and small, shallow punctures. Rostrum suddenly elevated above head, fairly stout; with coarse, crowded punctures on sides and base, becoming smaller in front. Antennae inserted one-third from apex of rostrum. Prothorax almost as long as the basal width, sides feebly dilated to near apex and then suddenly narrowed; with fairly dense, sharply defined punctures of moderate size, becoming crowded and larger on sides. Elytra elongate-cordate, base bilobed not much wider than prothorax; with narrow striae containing deep-set punctures; interstices each with a row of small, irregular punctures, becoming crowded posteriorly and larger towards base. Under surface with crowded punctures, becoming smaller and sparser on parts of abdomen; basal segment of abdomen of male with a shallow median depression; pectoral canal short and feeble, but with two small foveae in front. Femora edentate. Length, 3.3-5 mm.

Habitat.—Queensland: Cornwallis Island (C. T. McNamara), Magnetic Island (A. M. Lea).

A well-marked species of Section 4; the spots noted are well defined and constant on four specimens, but in addition a few single scales are scattered about. It differs from the description of *B. albigutta*, with which it could be associated in the table, in having only four spots (excluding the marginal ones) on the elytra. Seen from the side there is a distinct notch between the head and base of rostrum. The female differs from the male in having the rostrum slightly thinner, with the punctures in front somewhat smaller and not quite so crowded, and the abdomen evenly convex. One of the specimens from Cornwallis Island has the legs obscurely diluted with red and the scape entirely red. The specimen from Magnetic Island is of a piceous-brown, becoming black in parts.

BARIS LATERICOLLIS, n. sp.

Black, shining. Upper surface glabrous, under parts sparsely clothed.

Head with small and fairly dense punctures. Rostrum slightly longer than prothorax, strongly curved, slightly elevated above head at base, parallel-sided to insertion of antennae (almost in middle) and then slightly narrowed to apex; with numerous rather small, but sharply defined punctures on basal half, becoming crowded and larger on sides, apical half with smaller and sparser punctures. Prothorax moderately transverse, sides rounded, apex subtubular and not half the width of base; with numerous small (but not crowded), sharply defined punctures, becoming larger on sides, where many are connected by oblique scratches. Elytra elongate-cordate, base not much wider than prothorax; with narrow striae containing deep-set punctures, less distinct in middle than about base and apex; interstices each with a series of minute punctures, becoming irregular about base. Under surface with irregular punctures, crowded and fairly large on parts of sterna, smaller and sparser on abdomen; pectoral canal almost absent, but with two large punctures in front. Legs rather long, femora edentate. Length, 4.4-5 mm.

Habitat.—Queensland: Cairns district (F. P. Dodd and Dr. E. W. Ferguson).

A large, polished species of Section 5; much larger than any glabrous species previously known from Australia. In general appearance it is close to *Myctides balaninirostris*, but the rostrum and prosternum are different. On each side, in

front of the prothorax, the punctures for a short distance are connected by deep striae, rather than scratches, so that from behind it appears to be almost notched there. There are three fairly large but shallow depressions towards the side on each elytron. One specimen has a shallow depression along the middle of the two basal segments of abdomen, and as its rostrum has somewhat coarser punctures than the other, and the antennae are stouter, it is probably a male, the other probably being a female.

BARIS DILATATIFRONS, n. sp.

Black, somewhat shining. Upper surface glabrous, under surface and legs very sparsely clothed.

Head with small, dense punctures; a shallow depression between eyes. Rostrum about the length of prothorax, distinctly wider in front of insertion of antennae (about two-fifths from apex), than behind same; with numerous but not very sharply defined punctures, and with a rather feeble median ridge. Prothorax about as long as its greatest width; with numerous, but not crowded, punctures of fairly large size, becoming smaller and sparser in front. Elytra elongate-cordate, near base about one-fourth wider than prothorax; narrowly striate, the striae containing fairly large punctures towards base, these becoming rapidly smaller towards middle, and disappearing posteriorly; interstices impunctate. Under surface with punctures varying from rather sparse and small, on parts of abdomen, to fairly dense and large on parts of sterna. Prosternum rather widely grooved, the grooves bounded by a ridge on each side in front of the coxa. Abdomen with a depression on basal segment, and another on apical segment. Legs rather long and thin, femora scarcely perceptibly dentate. Length, 2.5-3 mm.

Habitat.—Queensland: Cairns district (F. P. Dodd).

An ordinary looking species, except that the rostrum is dilated in front, so as to be suggestive of *Cossonus*. It is nearer Section 7 than any other of the genus, but the pectoral canal is bounded by carinated ridges. The eyes are not sufficiently coarsely faceted to entitle the species to be referred to Section 2. The scutellum from some directions appears to be feebly bilobed. On one of the three specimens, the middle coxae and parts of the antennae are obscurely reddish.

BARIS PULCHRIPENNIS, n. sp.

Black, most parts with a greenish gloss, elytra metallic blue, parts of legs and tip of rostrum obscurely reddish. Elytra with elongated spots of white scales; under surface and legs with irregularly distributed white scales, but becoming dense on side pieces of metasternum.

Head with minute punctures, becoming fairly distinct in front. Rostrum slightly longer than prothorax, moderately curved, rather thin; with dense and rather small punctures, becoming larger on sides behind antennae. Prothorax about as long as the greatest width (at extreme base), sides gently bisinuate and strongly narrowed to apex; with sharply defined punctures, becoming larger and more numerous about base than elsewhere. Elytra elongate-cordate, outlines subcontinuous with those of prothorax, deeply and narrowly striate, the striae containing punctures visible only from directly above; interstices with rows of minute punctures, becoming fairly coarse about apex. Under surface with punctures, varying from rather sparse and small on three median segments of abdomen, to crowded and rather large. Prosternum feebly grooved in middle in front. Legs rather long, femora edentate. Length, 4.4-5 mm.

Habitat.—New South Wales: Clarence River (Blackburn's collection).

This species cannot apparently be referred to any of the eight sections previously noted; the prosternum is shallowly grooved in front, but the groove is not bounded by carinated ridges, and punctures or small foveae if present are concealed by the clothing, which is denser only on the sides of the metasternum. It apparently resembles *B. albopicta*, but the elytral spots are somewhat differently disposed, and the femora are edentate. The prothorax is more triangularly shaped than in *B. niveonotata*, and its punctures are smaller. There are two distinct and two feeble spots on each elytron; of the distinct spots the first is an elongated one on the third interstice at the base, and the second is on the fifth interstice at the apical third; the small spots (apparently easily abraded) are on the fifth interstice near the base, and on the third near apex. On parts of the third and fifth interstices, there are two quite regular rows of punctures, on each of the others there is but one row, but towards the sides they become irregular and fairly numerous. On three specimens the rostrum is metallic green almost to the tip, on a fourth it is obscurely reddish throughout; on one the suture is of a different blue to the rest of the elytra, but this is probably a *post mortem* variation.

BARIS ANGOPHORAE Lea.

Trans. Roy. Soc. S. Aust., 1906, xxx, p. 86.

Five specimens from Stradbroke Island and Bunya Mountains probably belong to this species, but each of them has a row of sparse white depressed setae in the alternate interstices of elytra; on the types there are fewer similar setae, but others may have been abraded.

BARIS TRANSVERSICOLLIS Lea.

Proc. Linn. Soc. N.S.W., 1914, xxxix, p. 686.

The types were evidently partly abraded. Numerous specimens from Cairns are in perfect condition, and have a distinct row of scales sometimes semidouble, on each elytral interstice.

BARIS SORORIA Lea.

Trans. Roy. Soc. S. Aust., 1906, xxx, p. 87.

Numerous specimens of this species from Queensland are larger than the type (almost up to 4 mm.). Fresh localities are Brisbane, Cowell Creek, and Magnetic, Thursday, and Moa Islands.

BARIS MICROSCOPICA Lea.

Trans. Roy. Soc. S. Aust., 1906, xxx, p. 89.

A specimen from Cairns agrees with the types of this species, previously known only from Western Australia.

BARIS GERALDTONENSIS, new name.

B. oblonga Lea, *Trans. Roy. Soc. S. Aust.*, 1906, xxx, p. 89.

Baris oblonga having been used by Bohemann in 1859 for an ex-Australian species, I have to propose the above substitute for the Australian species.

BARIS CAIRNSENSIS, new name.

B. glabra Lea, *Trans. Roy. Soc. S. Aust.*, 1906, xxx, p. 91.

Baris glabra was used by Herbst in 1784.

BARIS BARRONENSIS, new name.

B. ebenina Lea, *Trans. Roy. Soc. S. Aust.*, 1906, xxx, p. 95.

Baris ebenina was used by Pascoe in 1885.

IPSICHOA TIBIALIS, n. sp.

Black, most parts with a slight greenish gloss, elytra deep blue. Upper surface glabrous, under surface and legs with short, sparse clothing.

Rostrum moderately curved, about one-fourth shorter than prothorax, upper surface shining and with sparse and small punctures about base, becoming numerous at apex, on the sides dense and rather coarse. Prothorax distinctly shorter than the basal width, which is about twice that of the apex; with numerous but not crowded punctures of moderate size, becoming somewhat denser on sides. Elytra cordate, outlines continuous with those of prothorax; with regular rows of round punctures, the interstices with very minute punctures. Under surface with punctures varying from small and sparse on parts of abdomen, to dense and fairly large on parts of sterna. Basal segment of abdomen with a shallow median depression, apical segment with a round one. Femora edentate, front tibiae with a small downward projection at apical third. Length, 3.75 mm.

Habitat.—Queensland: Cairns (E. Allen). Unique.

As its femora are edentate this species in the table of *Ipsichora* could be associated with *I. desiderabilis*,¹ from which it differs in being less brightly coloured, front tibiae with a small subapical tooth (closer to the apex than on *Baris hoplocnemis*) and apical hook smaller and black. On the type the head has been forced back so as to conceal most of its base. The larger punctures on the elytra are in regular rows, but not in striae, except that about the suture and sides (but not to base) a few striae are present. The type appears to be a male.

IPSICHOA BIMACULIBASIS, n. sp.

Brilliant metallic blue, altering to green on head and rostrum, under surface and legs partly blue and green; parts of antennae and of tarsi obscurely reddish. Elytra with an elongated spot of white scales on third interstice at base, under surface, and under surface of femora, moderately clothed with white scales.

Head with small punctures, sharply defined only near eyes. Rostrum almost as long as prothorax, moderately curved; with numerous small, sharply defined punctures, becoming larger and more crowded on sides. Prothorax about as long as the basal width, sides feebly bisinuate and strongly narrowed to apex; with fairly numerous and small, but sharply defined punctures. Elytra elongate-cordate, outlines subcontinuous with those of prothorax; narrowly and deeply striate, the striae containing punctures visible only from directly above. Under surface with punctures varying in size and density with their positions. Legs rather long and thin, femora edentate. Length, 3 mm.

Habitat.—Queensland: Cairns (F. P. Dodd). Unique.

Smaller than the previously named Australian species of the genus and elytra with two white basal spots. The front of the prosternum is similarly clothed and in general is close to that of *Baris pulchripennis*, but as it is a conspicuously blue species it appears better to refer it to *Ipsichora* than to a doubtful section of *Baris*. The two basal segments of the abdomen have a large shallow depression, so that although the apical segment is non-foveate, the type is probably a male.

¹ Lea, *Trans. Roy. Soc. S. Aust.*, 1906, xxx, p. 98.

IPSICHOHA DESIDERABILIS Lea.

Trans. Roy. Soc. S. Aust., 1906, xxx, p. 98.

Two males of this species are unusually small (3 mm.). Several have the pronotum more purplish than blue. On greasy specimens the metallic gloss is lost, and the derm becomes black.

SOLENOBARIS CRYPTORHYNCHOIDES, n. sp.

♂. Black, highly polished. Under surface and legs with sparse, short clothing.

Head with dense and small but well defined punctures. Rostrum almost the length of prothorax, moderately curved and stout, dilated in front of antennae (these inserted slightly in front of middle); upper surface with small punctures, becoming crowded in front, and rather coarse on sides. Prothorax almost as long as the basal width, which is much wider than apex; punctures sparse and small in middle, becoming denser about base and apex, and denser and fairly large on sides. Elytra cordate, outlines continuous with those of prothorax; with rows of fairly large punctures, rapidly becoming smaller and disappearing beyond the middle; narrow striae near suture and sides only. Punctures small and sparse on parts of abdomen, larger and denser elsewhere; basal segment with a shallow depression continued on to metasternum, apical segment with a shallow subtriangular one. Legs long, femora acutely dentate. Length, 2.5-2.75 mm.

♀. Differs in having the rostrum somewhat longer and thinner, with smaller punctures, antennae inserted slightly nearer base than apex, abdomen without depressions, and legs somewhat shorter.

Habitat.—Queensland: Cairns district (F. P. Dodd and A. M. Lea).

At first glance the pectoral canal appears to terminate against a narrow transverse wall belonging to the mesosternum, but on separating the prothorax from the mesothorax the wall is seen to be part of the former; on this account, and also the continuous outlines of prothorax and elytra, the species should perhaps have been referred to a new genus; it is certainly very different from the other species of *Solenobaris*. With the rostrum at rest in the canal the resemblance to *Idotasia* of the Cryptorhynchides is a striking one; but the distinct pygidium and side pieces of mesosternum thrust like a wedge between the elytra and prothorax, are typical of the Baridiides.

SOLENOBARIS EDENTATA Lea.

Trans. Roy. Soc. S. Aust., 1906, xxx, p. 103.

Three specimens, from Cairns, differ from the types in being slightly larger (2.2-2.5 mm.) and with a faint bluish gloss on the elytra. The male has a shallow depression on the first segment of abdomen, and another on the fifth, and its eyes are even closer together than on the female. In both sexes the rostrum is slightly dilated at the insertion of antennae, but in the female it is subulate in front of them.

LEPIDOBARIS, n. g.

Head moderately large. Eyes large, ovate, obtusely pointed below, widely separated, finely faceted. Rostrum long, thin, and strongly curved. Antennae inserted in middle of rostrum in male, nearer the base in female; scape not quite extending to eyes. Prosternum faintly depressed along middle in front. Without visible pygidium. Front coxae widely separated; femora edentate. Body densely squamose. Other characters as in *Baris*.

The only known species appears at first to belong to *Baris*, but there is no visible pygidium; the prosternum is faintly depressed along the middle but without ridges there, as in *Gymnobaris*; from that genus also it differs in its clothing, edentate femora, insertion of antennae, etc. Genotype *L. metasternalis*, n. sp.

LEPIDOBARIS METASTERNALIS, n. sp.

♂. Dark reddish-brown, head almost black, antennae legs and part of rostrum reddish. Densely clothed with variegated scales on upper surface, white on under surface and legs, head and rostrum sparsely clothed.

Head subopaque (faintly shagreened) with numerous small punctures. Rostrum slightly longer than prothorax; with numerous small, sharply defined punctures, becoming rather coarse on sides behind antennae. Antennae inserted almost in exact middle of sides of rostrum, scape much shorter than funicle, its tip distant from eyes about two-thirds the length of the following joint. Prothorax moderately transverse, basal half subparallel, then strongly rounded to apex, base bisinuate; with crowded, partially concealed punctures, and with a feeble median line. Elytra subcordate, outlines subcontinuous with those of prothorax, widest near base; narrowly and deeply striate, the striae with deep-set punctures; interstices with crowded, mostly concealed punctures. Basal segment of abdomen slightly depressed in middle. Length, 3.5-3.75 mm.

♀. Differs in being wider, rostrum thinner, conspicuously longer than prothorax, with sparser clothing, and smaller punctures on sides behind antennae, these inserted nearer the base, with the tip of the scape nearer the eyes, prothorax more transverse, its sides more evenly rounded, and abdomen larger and more strongly and evenly convex.

Habitat.—New South Wales: Eccleston, in flood debris (J. Hopson).

The head is clothed only near eyes, the rostrum only on the sides behind the antennae. On two females the clothing on the prothorax and elytra is mostly mouse-coloured, with scattered whitish scales on the former; on the latter there is a white vitta on the suture from the base to beyond the middle, where it is joined to an oblique vitta on each side on to the fourth interstice, single whitish scales are also scattered about; on the under surface the clothing is dense, notably on the metasternal episterna; just before each episternum there is a narrow shining line, with a row of squamiferous punctures. On the male the clothing on the upper surface is paler and less variegated, but the sutural and oblique vittae are distinct; on the sides of its prothorax some of the scales have a slight golden gloss. The elytra are really flattened along the middle of the apical slope, but from some directions, owing to the adjacent clothing, they appear to be slightly concave there.

APINOCIS, n. g.

Eyes widely separated and with facets of moderate size. Rostrum long, thin, and strongly curved. Prosternum not at all concave along middle. Pygidium small. Front coxae widely separated. Femora edentate. Other characters as in *Baris*.

The prosternum is entirely without a depression along the middle, the surface there being in fact rather strongly convex; this precludes the species from being referred to *Baris*. In the fifth section of that genus all the species are without a longitudinal groove, but there are two distinct punctures or small foveae in the transverse subapical constriction; on *A. variipennis* the constriction is deep, but

is entirely without foveae. The pygidium is small, and on one specimen is concealed, but evidently from pressure. Genotype *A. variipennis*, n. sp.

APINOCIS VARIIPPENNIS, n. sp.

♂. Reddish-castaneous, some parts darker. Irregularly clothed with stramineous setae or thin scales, becoming paler on under surface and legs.

Head very minutely punctate. Rostrum slightly longer than prothorax, feebly dilated at base and apex; with small punctures, seriate in disposition behind antennae, irregular in front, and larger on the sides than elsewhere. Antennae inserted about two-fifths from apex of rostrum, scape not quite extending to eyes. Prothorax almost as long as the basal width, which is about twice that of apex; with irregularly distributed punctures of various sizes, but mostly small. Elytra elongate-cordate, sides subcontinuous with those of prothorax; with narrow striae, containing fairly large punctures about base, but becoming small posteriorly; interstices each with a row of punctures, fairly large about base, very small elsewhere. Under surface with larger and denser punctures than on upper surface. Two basal segments of abdomen with a large, shallow depression. Length, 3.5-3.75 mm.

♀. Differs in having the rostrum distinctly longer and thinner, antennae inserted nearer the base than apex of rostrum, prothorax slightly shorter, and abdomen more strongly and evenly convex.

Habitat.—Victoria: Natya and Cheltenham in October, Coburg in June (C. Oke), Melbourne (National Museum). Type in South Australian Museum.

The four specimens under examination all vary in colour; the only male has the head, pronotum and metasternum darker than the adjacent parts, but not black, the elytra have the base and apex paler than the median parts, but the two shades not sharply limited. All the females have the mesosternum, metasternum, and abdomen black or blackish; on the Natya specimen the upper surface is entirely reddish, on the one from Cheltenham it is somewhat as on the male, except that the median part of the elytra is almost black, with two rather conspicuous pale spots behind it; on the Melbourne specimen the upper surface is black, except that all the margins of the prothorax, and the base and apex of elytra are obscurely reddish. The clothing on the Cheltenham specimen is fairly dense on the margins and middle of pronotum, and about base and apex of elytra, it also forms a single distinct row on each interstice; from the others it has evidently been partly abraded; as it is sparser on the prothorax and elytra, and on the latter the rows are absent from the interstices. On the under surface the setae are moderately and almost evenly distributed. The largest punctures on the pronotum are about as large as the largest on the elytra and are irregularly placed on each side of the middle, the middle itself being almost impunctate.

PENTARTHURUM.

In the revision of the *Cossonides* by Wollaston¹, *Pentarthrum* is referred to on pp. 434, 446, 513 and 598-601; but he nowhere notes the separation of the front coxae. He states, however, that the type of the genus is the British *P. huttoni*, and on that species the front coxae are widely separated; on the New Zealand *P. zealandicum* the front coxae are also widely separated. Broun,² when revising the New Zealand species of the genus *Pentarthrum* and proposing many new genera

¹ Wollaston, *Trans. Ent. Soc. Lond.*, 1873.

² Broun, *Trans. N.Z. Inst.*, 1908, xli, p. 155.

at its expense, leaves in the genus those species having "coxae widely separated, the anterior included". Of the named Australian species at present standing in the genus, *P. nigrum* (if the specimens before me are correctly identified) has the front coxae rather feebly separated, in *P. millingtoni* the separation is about the same, in *P. nepeanianum* the separation is wide, in *P. australe* they are fairly widely separated, although not as widely as in *huttoni* or *zealandicum*. Wollaston, however, when describing a species from Japan, says of the legs, "antici ad basin parum . . . distantes".¹ Of the following species only the first, *P. orthodoxum*, will probably remain in the genus, as all the others have the front coxae more or less close.

PENTARTHURUM ORTHODOXUM, n. sp.

♂. Blackish-brown, legs and antennae paler.

Head with dense and sharply defined but not very large punctures in front, disappearing posteriorly; with a slight interocular impression, continued, but very feebly, almost to apex of rostrum. Rostrum flattened and straight, about as long as the width at base of prothorax, about twice as long as its own apical width, parallel-sided to near base, where it is triangularly dilated and with punctures as between eyes, smaller punctures elsewhere. Antennae inserted in middle of rostrum, first joint of funicle longer than second, second than third, and third than fourth, fourth and fifth transverse. Eyes small and prominent. Prothorax somewhat pear-shaped, widest about one-fourth from base, constricted near apex, where the width is but little more than half of that near base; with dense but not very large punctures, becoming crowded on sides. Elytra parallel-sided to near apex, slightly narrower than greatest width of prothorax; striate-punctate, punctures large and wider than interstices, each of these with an inconspicuous row of punctures. Under surface with dense punctures, much smaller than on pronotum, but becoming almost as large on sides; front coxae widely separated; basal segment of abdomen with a wide, shallow, median depression, apical segment with a shallow semicircular one. Length (excluding rostrum), 3.3-25 mm.

♀. Differs in having the rostrum thinner and quite cylindrical almost to extreme base, with smaller punctures and without median line, abdomen without depressions and legs somewhat thinner.

Habitat.—Tasmania: Hobart, Frankford (A. M. Lea), Franklin, Launceston (British Museum).

With the rostrum sexually variable as in *P. zealandicum*, but a smaller species and differently coloured; the punctures of the under surface are much smaller than on *P. nigrum*. The knees are somewhat darker than the rest of the legs; the club appears paler than the rest of the antennae, but this is due to minute whitish pubescence. The longitudinal impression on the rostrum of the male is very feeble and usually traceable from oblique directions only. The pronotum has a faint medio-basal depression, which in some lights is traceable almost to the middle. The distance between the front coxae is about equal to the width of the apex of rostrum.

PENTARTHURUM FOVEIVENTRE, n. sp.

♂. Dark brown, antennae and legs slightly paler.

Head with numerous (but not crowded) sharply defined punctures of rather small size in front, vanishing posteriorly. Rostrum subcylindrical, slightly

¹ Wollaston, *Trans. Ent. Soc. Lond.*, 1873, p. 14.

curved, almost twice as long as the basal width; basal half with punctures about as large as on front of head, but more crowded, smaller and sparser on front half. Antennae inserted slightly nearer apex than base of rostrum. Eyes small and prominent. Prothorax slightly constricted near apex, sides obliquely dilated to near base, where the greatest width is about once and one-half of that of apex; punctures rather dense (but not crowded) and of moderate size. Elytra parallel-sided to near apex, the width of widest part of prothorax; striate-punctate, punctures large and mostly wider than interstices, each of these with an inconspicuous row of punctures. Under surface with coarser punctures than on pronotum but somewhat irregular; front coxae slightly separated; metasternum and two basal segments of abdomen with a wide shallow depression, apical segment with a large round fovea. Length, 3.3-5 mm.

♀. Differs in having a somewhat smaller rostrum, without a depression common to metasternum and abdomen and apical segment not foveate.

Habitat.—Tasmania (Aug. Simson): Franklin (British Museum), Hobart (A. M. Lea).

At first glance strikingly close to the preceding species (the British Museum specimen was, in fact, mounted on a card with a male of that species), but with front coxae much less widely separated (almost touching), rostrum slightly curved, not grooved along middle, and apical segment of abdomen of male foveate. The club is clothed with minute white pubescence, in consequence of which it appears paler than the rest of the antennae.

PENTARTHURUM FOVEICEPS, n. sp.

♂. Black, antennae and legs obscurely dilated with red.

Head with a small interocular fovea, and with sharply defined and fairly dense, but not crowded, punctures of moderate size, terminated before base. Rostrum slightly curved, about as long as greatest width of prothorax, sides gently incurved to middle; punctures at base much as on front of head, becoming smaller and more numerous in front. Antennae inserted in middle of rostrum; first joint of funicle as long as second and third combined, second to fifth transverse. Eyes small and prominent. Prothorax about twice as long as the apical width, sides slightly constricted near apex, then slightly dilated posteriorly, and rounded to base itself, which is slightly wider than apex; punctures dense, sharply defined and fairly large, becoming crowded on sides. Elytra parallel-sided to near apex, striate-punctate, punctures large and wider than interstices, each of these with a row of minute punctures. Prosternum with crowded punctures, many of which are transverse; front coxae slightly separated; basal segment of abdomen with a shallow depression, apical segment with a semi-circular one. Length, 4-5 mm.

♀. Differs in being somewhat smaller, rostrum thinner, abdomen simple, and legs shorter.

Habitat.—Tasmania: Hobart, Frankford (A. M. Lea), Franklin (British Museum).

About the size of *P. nigrum*, but prothorax constricted near apex and with somewhat smaller punctures; on the female the rostrum is narrower towards the apex than on the male, but it is not truly cylindrical as on *P. orthodoxum* and *P. zealandicum*. The funicle is somewhat darker than the rest of the antennae; on most specimens the base of the head is obscurely dilated with red. On several there are remnants of an impunctate median line on the pronotum.

PENTARTHURUM INTEROCULARE, n. sp.

♂. Black, antennae and legs obscurely dilated with red.

Head with sharply defined and numerous, but not crowded, punctures of moderate size in front; without an interocular fovea. Rostrum about as long as width of apex of prothorax, sides feebly diminishing in width to antennae, thence parallel-sided to apex; with punctures at base and between eyes, becoming smaller and more numerous to apex. Prothorax somewhat pear-shaped, slightly constricted near apex, dilated to near base; with rather dense, sharply defined and fairly large punctures, becoming crowded and longitudinally confluent on sides. Elytra parallel-sided to near apex; striate-punctate. Prosternum with punctures much as on middle of pronotum; basal segment of abdomen with a shallow median depression, the apical segment with a semicircular one. Length, 3.3-5 mm.

♀. Differs in having a slightly thinner rostrum and basal segment of abdomen evenly convex.

Habitat.—Tasmania (Aug. Simson): Franklin (British Museum), Hobart (C. E. Cole), Launceston (A. M. Lea).

Somewhat smaller than the species I have identified as *P. nigrum*, and with more crowded punctures on the sides of prothorax, many being confluent. In many respects it is close to *P. foveiceps*, but is smaller, head without an interocular fovea, rostrum parallel-sided in front of antennae, prothorax wider, with coarser punctures, mostly longitudinally confluent on the sides, and prosternum with sparser, larger and rounded punctures.

PENTARTHURUM STRIGICOLLE, n. sp.

♂. Black or blackish, parts of antennae and legs obscurely dilated with red.

Head with numerous well-defined punctures of moderate size in front, but absent from base; with a small interocular impression, continued as a feeble groove on basal half of rostrum. Rostrum about as long as width of base of prothorax, slightly curved, sides feebly incurved to middle, with minute punctures, somewhat larger at base. Antennae inserted almost in middle of rostrum. Eyes small and prominent. Prothorax twice as long as the basal width, sides constricted near apex, dilated posteriorly and evenly rounded at base; with sharply defined and numerous comparatively small punctures, becoming larger on sides but not confluent. Elytra parallel-sided to near apex, striate punctate. Prosternum densely punctate, becoming strigose at apex and near coxae; front coxae almost touching; basal segment of abdomen with a wide shallow depression, apical segment semicircularly impressed. Length, 4.5-5 mm.

♀. Differs in having the rostrum thinner and without a median groove, and basal segment of abdomen evenly convex.

Habitat.—New South Wales. Illawarra (H. W. Brown), Sydney, in September (British Museum from J. J. Walker).

Near *P. foveiceps*, but rostrum of male feebly grooved, prothorax with smaller punctures, prosternum transversely strigose and abdominal depression deeper in the middle. On several specimens the sterna, and on one, the elytra, are dark brown instead of black; on most of them the antennae, except the club, are almost as dark as the rostrum.

NOTIOSOMUS INSULARIS, n. sp.

♂. Deep black and shining, antennae and tarsi obscurely reddish; club paler. Head dilated and almost impunctate about base, with distinct punctures and

a small fovea between eyes. Rostrum about once and one-half as long as apical width, slightly curved, parallel-sided in front of antennae, incurved at their positions, punctures slightly coarser and more crowded than those between eyes. Antennae inserted slightly nearer base than apex of rostrum, first joint of funicle about as long as second and third combined, second to seventh strongly transverse and subequal. Prothorax about twice as long as the apical width, constricted near apex, sides dilated to near base, which is about one-fourth wider than apex and finely margined; with sharply defined and fairly dense punctures, about as large as those between eyes, becoming crowded on sides; with a feeble, shining median line. Scutellum small. Elytra parallel-sided to beyond the middle, as wide as widest part of prothorax; striate-punctate, punctures large, becoming smaller posteriorly; interstices with minute punctures and in places faintly wrinkled. Under surface with sharply defined punctures, larger and denser on prosternum and sides of metasternum than elsewhere. Basal segment of abdomen with a wide shallow depression, slightly continued on to second, sutures between second to fifth segments wide, and each with a row of large punctures. Length, 4.5 mm.

♀. Differs in having the rostrum slightly shorter less incurved at insertion of antennae and abdomen evenly convex.

Habitat.—Norfolk Island (J. C. Wiburd and A. M. Lea), Lord Howe Island (A. M. Lea and wife).

This species is stouter and less depressed than the mainland forms of *Notiosomus*, and the rostrum is nearer to that of *Cossonus*, the third tarsal joint is narrow and entire. It is still more robust and with a much wider (but not shorter) rostrum than the three New Zealand species of *Phlaeophagosoma* known to me (*P. corvinum*, *P. dilutum* and *P. pedatum*). The rostrum is too long for *Stereoborus*. The front tibiae are feebly bisinuate on the lower surface, the apical sinus with fine pubescence invisible from several directions. The specimens from Lord Howe Island have slightly coarser punctures and more wrinkled elytra than the others, but the differences are very slight. Abundant on both islands.

ISOTROGUS IRREGULARIS, n. sp.

Black, antennae and legs more or less obscurely reddish.

Head with a distinct interocular impression, continued as a groove to middle of rostrum, with a few small punctures near eyes. Rostrum slightly curved, very little longer than wide, sides slightly incurved at insertion of antennae (somewhat nearer apex than base) and but little dilated in front; punctures denser and more distinct than on head, but still small. First joint of funicle fairly long, the second shorter, third to seventh strongly transverse. Prothorax more than twice as long as the apical width, sides dilated posteriorly and rounded off at base, which is considerably wider than apex; with irregular and rather large punctures on each side of a narrow median line, somewhat similar punctures on sides, the intervening spaces with minute ones. Elytra parallel-sided to near apex, almost the exact width of widest part of prothorax; strongly striate-punctate, the interstices impunctate. Under surface with large and irregular punctures on sides, on prosternum, forming a semidouble row between middle coxae, in middle of basal segment of abdomen on apical segment and in some of the sutures. Length, 3.5-4 mm.

Habitat.—Northern Territory: Darwin (G. F. Hill and British Museum).

A depressed species. The conspicuous punctures on each side of the median line of the pronotum, although not in single rows, indicate that it is allied to *Isotrogus bilineatus* and *I. castelnavi*, and it is therefore referred to *Isotrogus*, although as Pascoe wrote when dealing with the former species, "The genus might well be united to *Cossonus*". From *bilineatus* it differs in having the rostrum decidedly shorter, straighter, and with a longitudinal groove, as well as in the prothoracic punctures. From *castelnavi* (which has more irregular rows of punctures than on *bilineatus*, but still in single series) it differs in being smaller, and with a conspicuous groove on the rostrum, in continuation of the interocular impression. The male has a shallow depression on the basal segment of abdomen, the female being flattened there, these being apparently the only external indications of sex. The funicle is slightly darker than the rest of the antennae; the legs are almost black.

Ten specimens, from Roebuck Bay, in the British Museum, appear to represent a variety; they differ in being of a rather dark brown, with the elytra bright castaneous, except that the suture and tips are slightly infuscated, parts of the under surface and of the legs are also castaneous.

ADDITIONAL FLORA OF THE COMBOYNE PLATEAU, 1926.

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

[Read 29th June, 1927.]

In These PROCEEDINGS, 1925, p. 284, I gave an account of the general conformation and flora of the Comboyne Plateau; I now present some additional records of the plants found there.

Fungi: *Polyporus (Ovinus) mylittae* Cooke.—A stipitate fungus of the family Polyporaceae the sclerotium of which is frequently ploughed or dug up on the basalt, the pileus or fructifying portion being rarely seen and apparently being thrown above ground only when conditions are favourable. A specimen of sclerotium brought to me was dark brown in colour and of hard consistency, roughly oval in shape and concavo-convex on its broadest surfaces, measuring six inches by three and a half inches and weighing ten ounces. Its interior on fracture is of a creamy white colour. This is known as "Blackfellow's bread".

Muscineae: *Dawsonia superba*.—This moss is fairly common, growing in patches on mixed strata, especially in shady and moist gullies.

Polypodiaceae: *Arthropteris obliterated* R.Br.—A climbing fern found on stems of trees; only seen on the eastern side of the Plateau growing on mixed strata.

Cyclophorus serpens Forst.—This and *C. confluens* are mostly found on basalt covering the trunks of *Sambucus xanthocarpa* (Native Elderberry), for which they seem to have an attraction.

Platyserium grande A. Cunn.—An epiphyte on trunks and branches of brush trees. This is quite a rare form here though quite common in the brushes near sea level. It is only quite lately that I have come across it on the Plateau.

Typhaceae: *Typha angustifolia* Linn.—Bullrush; plentiful, growing in the creeks.

Liliaceae: *Philydrum lanuginosum* Banks.—An aquatic plant not very plentiful, only seen on the eastern side of the Plateau. It has a conspicuous yellow flower.

Kreyssigia multiflora Reichb.—A low growing plant with a pale mauve flower. Only found on the eastern side of the Plateau growing on mixed strata.

Cordylone stricta Endl.—Palm Lily, not common and only seen on the eastern side. It bears a handsome mauve flower.

Orchidaceae: *Dipodium punctatum* R.Br.—Uncommon and only found off the basalt on the mountain side.

Microtis porrifolia R.Br.—A small orchid with an inconspicuous greenish flower. It grows fairly plentifully on the cleared land.

Moraceae: *Ficus henneana* Miq.—A rare fig here, its habitat appears to be further north. I know of only one tree.

Ficus eugenioides F.v.M.—Common in the brushes, having small leaves and small yellow fruit.

Proteaceae: *Persoonia linearis* Andr.—Not common and found on sedimentary soil.

Loranthaceae: *Loranthus pendulus* Sieb.—The commonest mistletoe of the hardwood country and found mostly on the fringe of the Plateau growing on Eucalypts.

Lauraceae: *Cryptocarya* sp.—A tall tree with blue fruit commonly called "Corduroy Beech" from the fact that its trunk has a twisted appearance and is deeply fluted. This is fairly plentiful in the brushes.

Pittosporaceae: *Pittosporum revolutum* Ait.—Not very plentiful. It has a yellow flower and is found in the brushes.

Leguminosae: *Oxylobium trilobatum* Benth.—I have met with this only on the eastern side growing on mixed strata.

Goodia lotifolia Salisb.—Not plentiful and found mostly on the northern side off the basalt. It bears a yellow flower.

Swainsonia coronillifolia Salisb.—This grows in the same situation as the last and is frequently seen just off the edge and down the mountain side. It has a mauve or light purple flower.

Tremandraceae: *Tetratheca thymifolia* Sm.—Only found growing on the eastern side on mixed strata.

Sapindaceae: *Guioa semiglauca* Radlk.—Not plentiful and found growing on basalt.

Violaceae: *Viola betonicifolia* Sm.—Uncommon and only found on the outskirts of the Plateau amongst hardwood timber.

Myrtaceae: *Eugenia australis* Wendl.—Rare, found growing some distance down the southern side of the Plateau on basalt, having large elongate crimson fruit and a white flower. It is one of the "Brush Cherries".

Eugenia coolminiana C. Moore.—Another "Brush Cherry", the fruit being pink in colour, of large size and flattened at the poles. It is an inhabitant of the brushes and grows into a fine tree.

Labiatae: *Brunella vulgaris* A. DC.—Uncommon, found growing on basalt.

Campanulaceae: *Lobelia trigonocaulis* F.v.M.—Plentiful, growing on the basalt amongst the brush timber.

Wahlenbergia gracilis A. DC.—Bluebell, not very plentiful, found on basalt but of stunted growth, the flowers being very small.

Goodeniaceae: *Goodenia* sp.—Apparently a new species, found on mixed strata on the eastern side of the Plateau. The affinities of this are being worked out at the National Herbarium, Botanic Gardens.

Compositae: *Gnaphalium purpureum* L.—Common on cleared land on the basalt.

ON THE PHYLOGENY OF SOME DIPTERA BRACHYCERA.

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(Two Text-figures.)

[Read 29th June, 1927.]

The section of Diptera referred to here has long been known as the Brachycera division of the suborder Orthorrhapha, but Dr. R. J. Tillyard (1926, p. 345) has reversed the status of these two names making Brachycera a suborder that incorporated all Diptera except the Nematocera and the term Orthorrhapha becomes the name of the division.

The relationship between the various families is deduced from the researches of various authors. The families are fast becoming better understood so it is possible to illustrate their supposed affinities diagrammatically and to discuss them from this aspect. J. R. Malloch (1917, pp. 173-181) dealt with the larval and pupal characters of these families and he formed six superfamilies which are now reduced by Tillyard to three as instanced by the table given below. The simplicity brought about by this reduction has much to commend it.

| Family. | Superfamily name used by: | |
|--|---------------------------|--------------|
| | Malloch. | Tillyard. |
| LEPTIDAE TABANIDAE | } TABANOIDEA | } TABANOIDEA |
| STRATIOMYIIDAE (Some non-Australian families) | | |
| NEMESTRINIDAE CYRTIDAE | } CYRTOIDEA | |
| SCENOPINIDAE THEREVIDAE | } THEREVOIDEA | |
| ASILIDAE APIOCERIDAE MYDAIDAE BOMBYLIIDAE | } ASILOIDEA | |
| EMPIDIDAE DOLICHOPODIDAE | } EMPIDOIDEA | } EMPIDOIDEA |

A diagram of the relationships between these families is very readily formed and it is the purpose of this paper to point out some of the more striking features arising from this method of allying the families, to indicate some of the weaker points and to incorporate some of the lines along which my own researches are tending to show a development regarding the superfamily Asiloidea.

The genealogical tree given below contains three main branches, the first of these is the superfamily Tabanoidea into which come all forms containing a pulvilliform empodium, and it is further divided into three divisions, the Tabanid-Leptid stem, the Stratiomyiid stem and the Cyrtid-Nemestrinid stem.

The first two of these contains insects that are largely associated with water, many breeding in marshes and such-like places, but the third, the Cyrtid-Nemestrinid stem is not associated in this manner. It is of interest to note that the land-breeding family Nemestrinidae contains species that have a wing-venation in which there is a marked tendency for the apex of the veins to move towards the costa and this is repeated in the other entirely land-breeding section the Asiloidea. In the light of our present knowledge this must be regarded as parallel development but possibly it has a deeper significance, for the position of the Cyrtid-Nemestrinid stem within the superfamily Tabanoidea appears to be somewhat anomalous, differing so markedly as it does in many structures. It has apparently parasitic habits throughout the entire group, though possibly some cases may prove to be an advanced type of predatory habits, differing in this respect from the other Tabanoidea.

The Tabanidae and Leptidae have amongst their numbers what may be regarded as the nearest to the primitive venation for this particular superfamily, but in antennal structures they are considerably advanced and specialized, the nearest to the primitive type being perhaps that of the genus *Pelecorrhynchus*.

The Stratiomyiidae, on the other hand, have a very specialized venation as the radial vein has moved bodily forward towards the costa, which specialization must not be confused with that of the Nemestrinidae and of the Asiloidea where only the apical parts of the veins have so moved forward. The most advanced type in the Stratiomyiidae is to be found in the genus *Ophiodesma* (Kertész, 1923, p. 118 under the name *Diapontomyia*) where not only has the radial moved forward but also the median, this vein becoming fused with the radial, the radial-median crossvein being obliterated in the process. In antennal structures there are many forms that must be regarded as approaching the ten-segmented primitive type, and many forms have also preserved the primitive elongate abdomen, where each, or most, of the segments are as long as, or longer than, wide.

The primitive interradiial crossvein seems to have become atrophied in the Tabanid-Leptid stem, missing in the Stratiomyiid stem and preserved in the Nemestrinid-Cyrtid stem; it occurs in the genera *Cyclopsidea*, *Trichopsidea* and *Exeretoneura*, the last of these has also retained a strong trace of the primitive ten-segmented antennae and moreover it is the only form known to me that indicates the possibility of its stem having arisen from a type with an elongate abdomen.

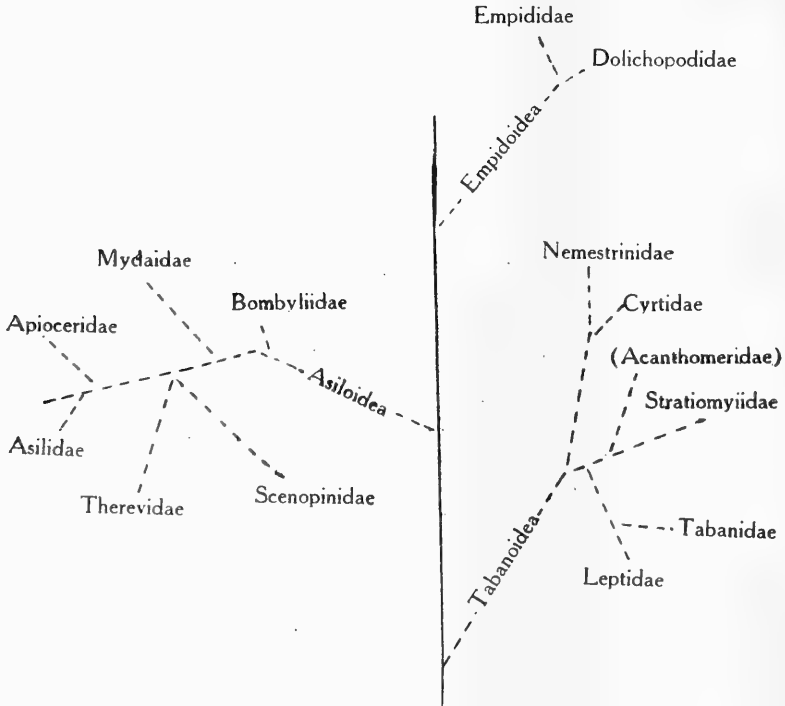
The second superfamily, the Asiloidea, contains insects that do not have a pulvilliform empodium and apparently have evolved from a somewhat advanced land-breeding type. This hypothetical type differs from that of the Tabanoidea by having only seven distinct antennal segments, a larger number has not been found represented in any existing genus and indeed the occurrence or the traces of this seven segmented antennae is persistently represented throughout the

superfamily. The small family Scenopinidae is said to be allied to the Therevidae owing to the similarity it bears to that family in the larval stages, but the relationship is very anomalous.

There are two main branches in this superfamily, the Bombyliid stem and the Asilid stem. The first of these seems to have lost entirely one of the branches of the median vein but in other respects there is a marked parallel development to that of the Asilid-stem.

In the Bombyliidae the first radial vein often becomes short, running to the wing margin much nearer to the base than is usual and this has allowed the other branches of the radial to run to the costal margin when they have curved upwards as is found to be the case in so many genera. The median vein also shows a tendency to curve upwards as M_1 runs into R_5 in certain cases.

In the Asilid stem, the first radial remains normal and when the following veins are strongly curved upwards they run into this vein and not to the costal



Text-fig. 1.

margin. This is a parallel development to that of the Bombyliidae resulting in a strikingly distinct vein pattern.

All the Mydaiidae and Apioceridae, and practically all the Therevidae (the exceptions may not belong to this family) are provided on the female with genital spines that are similar in every respect to those of certain groups of the Asilidae, and which are not found in the Bombyliidae or families other than the Asiloidea.

The third superfamily, Empidoidea, is composed of two families, the Empididae and Dolichopodidae, both of which contain flies that have larvae associated with water as is the case with the Tabanoidea, but besides being without the pulvilliform

empodium they are also marked by the restriction of the cubital and anal veins, these being considerably reduced in length.

The diagram (Text-fig. 1) of the relationship so far discussed would conform, I believe, to something near the average diagram that would be drawn by any entomologist who had a fairly comprehensive knowledge of the Brachycera, and to the work so far accomplished in building up the relationships between the various families. Differences of opinion would centre chiefly about the position of the Nemestrinid-Cyrtid stem and of the family Scenopinidae, and also concerning the exact relationships of the Asiloidea families, excluding the Bombyliidae.

There can be little doubt that the spines at the apex of the female abdomen, spines used for raking the ground when oviposition takes place, are significant in so far as all those insects that contain them must be considered as derived from a common stock and that they do not occur outside the Asiloidea suggests that they originated within the Asiloidea itself probably remote from the deviation of the Bombyliid stem which itself has an analogous row of genital bristles that are used in quite a different manner.

I have stated above that the Asiloidea were derived from a stock having but seven antennal segments and this is probably correct in the main in so far as the other segments had largely amalgamated with one or other of these seven. It is possible that the whole ten may have been indicated by annulations, etc., and in building up the structure from the lowest type of antenna in the Asiloidea I have yet found, that of the Mydadae, I would unhesitatingly place the first two segments as 1 and 2, the shaft following as 3 and 4 (these are clearly enough indicated), the apical flattened sections as 5, 6, 7 and 8, the minute process at the extreme apex, situated on the edge just within a depression as 9, and finally the minute spine on this minute process as 10. These last two are so easily overlooked, the 5-8 so completely amalgamated that there thus becomes only five of the original ten segments clearly defined but nevertheless seven are indicated. The abdomen of the Mydadae is quite primitive but modified in its type and the vestige of the interradiation is present, but in every other respect the wings have a very specialized venation. The head is deeply excavated between the eyes very much as it is on most of the Asilidae. There are plenty of hairs above the oral opening but they do not form the appearance of the typical moustache of the Asilidae as they are soft and slender.

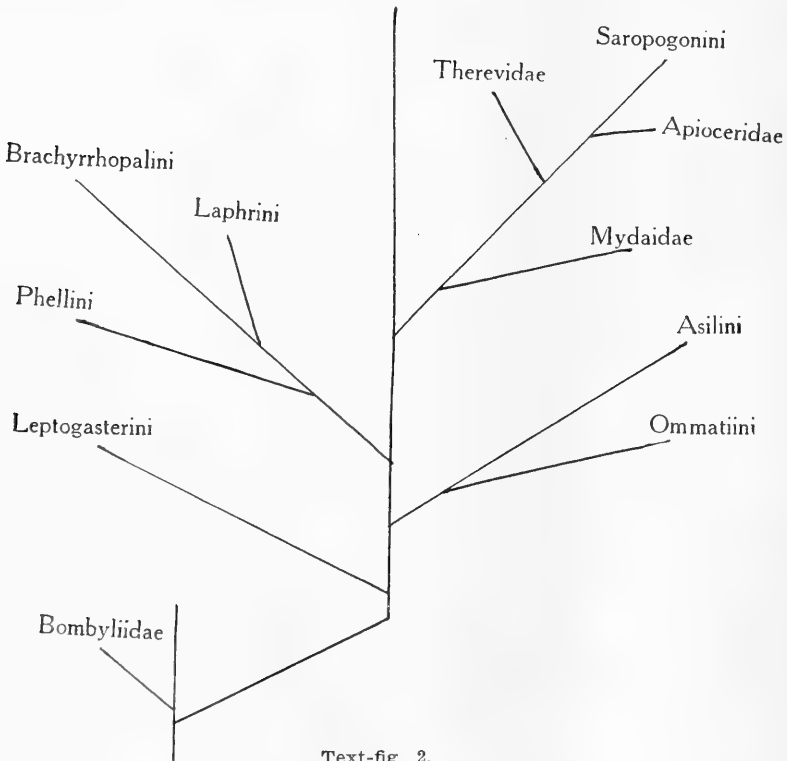
The Apioceridae have only four antennal segments clearly defined, the last being a short and strong spine. The head is slightly excavated between the eyes as on certain Asilidae, the abdomen is much shortened, and the antennae are situated too near the oral opening to permit of a moustache being formed there; the hairs on the very small area so formed are soft and slender. It is evident that the Apioceridae are very advanced along their line of development, the venation being specialized and the interradiation crossvein is entirely missing.

The Therevidae consists of a number of genera of diverse forms and amongst their numbers are to be discovered many primitive forms, one specimen that has a rather long abdomen also has five antennal segments, all easily detected, the last being a spine, and in addition there is the rudiment (or possibly remnant) of an Asilid-like moustache; the hairs along the oral margin consisting of a series of bristles such as is found on certain Asilidae but more slender, comparable with that of *Neocyrtopogon*. In no case has there been discovered any form with the head that is to be compared with the excavated head of the Asilidae and Mydadae. With regard to venation, this is fairly simple but invariably lacks

the interradiial crossvein; at most M_4 runs into M_3 whilst the cubital and anal veins may also meet near the apex. The genus *Clesthena* is excluded from these remarks and given special consideration below.

As already pointed out, all the three families, Mydidae, Apioceridae and Therevidae are provided with spines at the apex of the female abdomen. This character occurs in many Asilidae and in view of the similarity of other characters already referred to, characters that unite these four families, it seems probable that these genital spines indicate a common origin for all those forms containing them.

If it were possible to separate the family Asilidae into two or more sections, one stem of which has arisen from a stock containing these spines, the remainder from a stock that did not develop them, then it would be reasonable to suppose that the Mydidae, Apioceridae and Therevidae had a common origin with one stem of the Asilidae, which in the present case would be the tribe Saropogonini, a section of the Asilidae, not the whole stock. It does not seem reasonable to suppose that the spines could have developed independently and assumed identical formations as is to be found in the four families.



Text-fig. 2.

The genus *Clesthena* was originally placed in the Leptidae by White, but subsequently removed by me to the Therevidae; I now believe the position here to be anomalous. It is certainly one of the Asiloidea and shows a marked advance from the primitive stock. Five antennal segments are discernible, the abdomen is rather short and conical, the venation lacks the interradiial crossvein and M_4 runs

into M_3 , otherwise the veins are simple. It may be an off-shoot of a more primitive Asilid type rather than that of the Therevid stem and if so the genus should prove of exceptional interest. Similarly the American genus *Pherocera* Cole, which is said to be without the genital spines, would also need to be placed elsewhere.

Doubtless these views will be modified by further research, but if they are adopted for a working hypothesis, it will be necessary to amend the portion of the genealogical tree relating to the Asiloidea as in Text-fig. 2.

In concluding these remarks I would draw attention to the apex of the female abdomen which, in the Tabanoidea, is provided with simple cerci in all its three stems whilst, in the Asiloidea, these cerci have not been found or perhaps are modified in certain cases such as to provide the lamellae on the female ovipositor of the *Asilini*. It is possible other characters of the female genitalia have yet to be found that would be suggestive in regard to these relationships and so a study of this aspect should yield some important data.

To the list of works referred to in this paper, there are also added others that bear upon the subject dealt with and amongst these will be found diagrams that will serve to illustrate the remarks made above.

Postscript, added 13th September, 1927.

Whilst the above paper was going through the press, a Bombyliid of the genus *Comptosia* was found using the bristles at the apex of the abdomen in the manner identical to that exhibited by the *Saropogonini* when ovipositing. The genitalia of this Bombyliid were thereupon studied in considerable detail and the conclusions drawn were to the effect that the type of ovipositor exhibited by it approached nearer than any other examined to the hypothetical type from which the *Saropogonini* and Therevidae were derived. Moreover this hypothetical type which can now be defined with some assurance, may have been the origin of all the widely varying types found in the Asiloidea, for certain features of the *Asilini* type are to be traced to it through the genus *Neoaratus* and the spines of the ovipositor on the genus *Philonicus* may yet be shown to have had the same origin as those on the *Saropogonini*.

For the immediate purposes of this paper it is necessary to draw attention to the order in which the relationships of the various families and tribes have been built up. This was done on the understanding that the primitive type of ovipositor was represented only by a pair of valves generally greatly reduced, and the end segments of the abdomen were more or less telescopic as in Mecoptera (Tillyard, 1926, p. 340). If this be the case, then somehow in the Asiloidea at least, a modification must have arisen resulting in the building up from a simple to the complex ovipositor that in many cases became permanently exerted. It now becomes advisable to revise this view and perhaps a better conception of the phylogeny within the Asiloidea may be gained by completely reversing the order of the Asilid stem so as to bring the Mydaid-Saropogon branch to the foot where other characters would ally it, and by placing the *Leptogasterini* at the top.

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FURTHER NOTES ON A NEW CLASSIFICATION OF AUSTRALIAN
ROBBERFLIES (DIPTERA-ASILIDAE).

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For loan of, or access to material that aided in the formation of this outline on a proposed new classification of Australian Asilidae, I would again express my indebtedness to the Directors and Curators of Museums and to various entomologists all of whom have been enumerated in an earlier paper (Hardy, 1926, p. 306); for the loan of further material to Mr. Alan Dodd, chief of the staff engaged upon the biological control of prickly pear, and to his co-workers Messrs. A. R. Taylor, G. R. Bassingthwaite and T. A. Cole, who have submitted for identification genera and species I have not seen represented in other collections. Those new species from Chinchilla, Queensland, often labelled "Chilla" in handwriting, are liable to lead to errors if they ever find their way into collections abroad and become described from there; the corruption is too near "Chile" unless very clearly written.

My knowledge of the world's genera of Asilids and their structure is mainly based upon the few papers available to me, to Lundbeck's *Diptera Danica*, and to Melin's excellent studies on the Swedish species. The last mentioned author anticipated many of the views I was slowly evolving and so the enlightenment afforded by him gave me greater confidence than I would otherwise have had in the classification proposed. To these works I must add an acknowledgment to the value of the exotic Asilids sent by Professor M. Bezzi, consisting for the most part of genera related to the Australian forms. I have insufficient knowledge of the genus *Dasyopogon* itself, therefore I have made no attempt to place it in the present work; but from what I can gather it will form the typical genus of a tribe not represented in Australia.

In 1921, I revised the characters of various genera of Australian Asilidae, and again in two papers of 1926 reconsidered some of these. These three papers marked a stage in a search for an adequate classification which is further advanced in the present paper wherein the family is treated as a whole. Three proposed tribes have already been diagnosed and these are maintained in the present paper, though a different conception is given to some of them and four more tribes are added, two of which have already been mentioned.

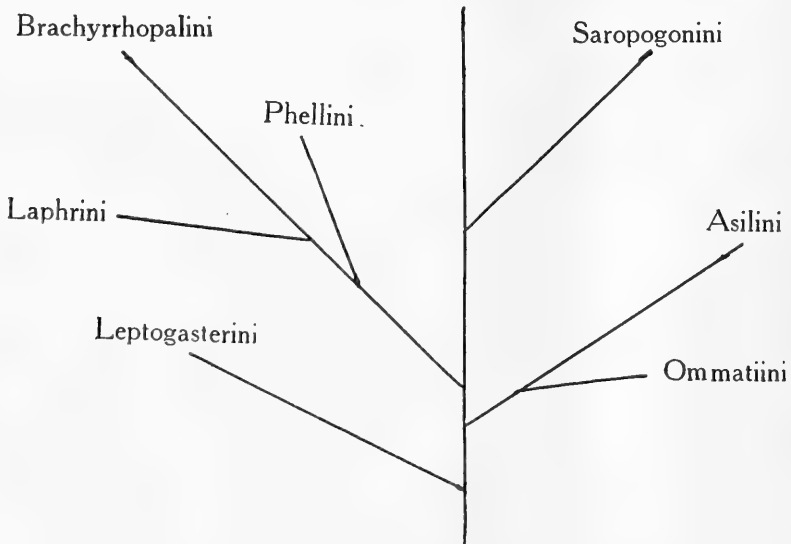
An improvement will be found in the incorporation of part of the old subfamily Laphrinae with the *Saropogonini*, two genera being thus transposed, whilst the *Cerdistus-Neoitamus* complex is more adequately isolated though very little altered in effect, the genus *Stilpnogaster* being now excluded from that complex.

Three subfamilies only are recognized, the tribe *Laphrini* being too intimately connected with *Brachyrrhopala* and *Phellus* to permit of its isolation except perhaps under quite a different conception to that understood by the old subfamily Laphrinae. *Saropogonini*, judging from Australian collections, seems to warrant subfamily rank, but this is not followed in the present paper. The subfamily Asilinae is now divisible into two tribes, *Ommatiini* and *Asilini*, whilst the typical genus of the latter, *Asilus*, is excluded from the Australian fauna.

These tribes are recognizable from the following key:—

1. Antennae with a long hair-like arista at apex 2
 Antennae never with an arista, at most with a minute hair-like spine that is usually situated within a cavity, depression or in a notch. (Subfamily DASYPOGONINAE.) 4
2. Venation very simple, alula of wings much reduced in size; female genitalia simple and not formed with an ovipositor. (Subfamily LEPTOGASTERINAE.) (One tribe only.) LEPTOGASTERINI
 Venation with the vein R_{2+3} joining R_1 before reaching the wing border, also M_2 similarly runs to M_4 . (Subfamily ASILINAE.) 3
3. Arista of antennae pectinate; female with simple genitalia, not being formed with an ovipositor OMMATINI
 Arista of antennae simple; female genitalia formed with an ovipositor ASILINI
4. Female abdomen with genital spines at apex. Venation more or less simple, or R_{2+3} runs into R_1 or M_2 runs into M_4 , but both sets of veins do not coalesce in the same species SAROPOGONINI
 Female never with genital spines at apex, but if spine-like hairs occur these are numerous and do not take the form of strong curved spines as in the Saropogonini 5
5. Wings never with M_3 running into M_4 BRACHYRRHOPALINI
 Wings always with M_3 running into M_4 6
6. Wings never with R_{2+3} running into R_1 PHELLINI
 Wings always with R_{2+3} running into R_1 LAPHRIINI

The hypothetical genealogical relationship between these tribes is shown in the following diagram where an attempt has been made to interpret the relations



by the degree of specialization taking into account genital characters of the female, antennal structure and other outstanding characters. If the isolation of the *Saropogonini* is maintained, as illustrated in the diagram, it will be necessary to erect a subfamily name for the group.

Subfamily LEPTOGASTERINAE.

This subfamily contains but one tribe under which the characters are dealt with. It conforms nearest to the Asilinae in antennal structure but to the *Brachyrrhopalini* in venation, only being more simple in this respect. The female genitalia are simple as far as I can see, consisting of a vent between the ninth dorsal and ventral sclerites. Lundbeck refers to a small, generally quite hidden, ovipositor, and although the ninth segment does not bear the grey tomentum of the others and hence is black, it does not seem to be specially shaped into an ovipositor in the Australian forms.

Tribe *Leptogasterini* (new tribal name).

This tribe contains flies that are very slender and have a much reduced alula on the wing, thus giving the insect the pedicellated wing structure that is reminiscent of dragonflies of the suborder Zygoptera. The simple venation with all the veins running to the wing border without unduly curving, and the absence of the interradiial crossvein, which is but rarely indicated by a stunted vein, the absence of pulvilli on all legs and the very long claws between which an elongate, slender empodium occurs, are consistent characters occurring on all species of the only genus yet recognized from Australia.

Genus LEPTOGASTER Meigen.

Under this genus Melin recorded a resting habit where the flies "swoop down on a grass-stem with the wings lying parallel in order to rest. In doing so they usually catch hold of the stem with the tarsi and hang down with the abdomen at an angle of 45° to the stem (Fig. 14)". He then quotes Lundbeck: "When sitting the hind legs are generally stretched forward so that all six tarsi are placed near each other", adding his own remark, "I have never seen this, on the contrary, the flies sat as shown in the figure with the back tarsi widely separated from the anterior pair". It so happens with the Australian species the temporary resting position on an upright stem of grass is always as Melin reports, but they are liable to rest at the extreme apex of a horizontal twig, the body held in a direct line with the twig which the head almost touches, and are usually sluggish or in a state of coma when so found. The best time to observe this is in the early morning and late afternoon, although they may be so found at any hour of the day. Further it should be noted that the elongate hind legs are quite near the anterior pair, being placed on the twig just anteriorly to them. It will be readily realized that the fly in such a position looks so like a part of the twig on which it rests, that the attitude may be taken as a case of protective mimicry which is heightened by the elbowing of the legs downwards, these looking like triangular pieces of cobweb around a notch; an excellent "camouflage". These observations suggest that Lundbeck recorded the resting habit when in a state of coma, whilst Melin observed only the temporary resting periods.

The following species are described from Australia:—

Gonops geniculatus Macquart, 1850.

Leptogaster

- pedanus* Walker, 1849.
- antipodus* Bigot, 1878.
- australis* Ricardo, 1912.
- bancrofti* Ricardo, 1912.
- dissimilis* Ricardo, 1912.

Leptogaster

- vernalis* White, 1913.
- aestiva* White, 1913.
- fumipennis* White, 1913.
- occidentalis* White, 1913.
- autumnalis* White, 1916.

Of these eleven names, Walker's and Bigot's species have been placed as synonyms of Macquart's, although Walker's name should have taken priority. In the various collections examined, I can recognize only six distinct species, three of which are apparently undescribed. The most satisfactory method of recognizing the various species is by the shape of the male genitalia, but unfortunately there are few authentic specimens in the Australian collections and only one type. The usually accepted colour characters, upon which most species were founded, are quite inadequate for specific determination but may give a clue to identity, so I sent drawings of the genitalia to Dr. G. A. K. Marshall, Director, Imperial Bureau of Entomology, asking to have these compared with specimens in the British Museum collection, expecting in this way to get satisfactory determinations, and although the drawings were compared, I received word that they did not correspond to any genitalia in the specimens in the British Museum. Further notes indicate that the type of *L. pedanus* Walker has lost the tip of its abdomen, and there are no males representing *L. vernalis* White, *fumipennis* White and *autumnalis* White.

Subfamily ASILINAE.

Four papers have already appeared (1920-1926) treating with this subfamily, mainly dealing with the descriptions of species, but in one (1921), an attempt was made to deal with generic conceptions and in another (1926) with genera allied to *Cerdistus*. In the first preliminary survey the genera were not at all adequately placed and the relationships were inferiorly dealt with. In the meanwhile it has become possible to recognize some very marked lines of division making two groups worthy of at least tribal value.

Tribe Ommatiini (new tribal name).

Ommatius stands alone, having no apparent relationship with any other genus. The female genital apparatus appears to be more in keeping with the *Leptogasterini*, being apparently primitive and in no way comparable with the highly developed ovipositor type of the other Asilinae.

There is but one genus in Australia which is represented by a large number of species for which twelve specific names are available. They are all provided with a pectinate arista which enables both sexes to be easily relegated to this tribe, and the males have their genitalia of a characteristic shape.

Tribe Asilini (new tribal name).

This tribe contains six genera in Australia that are readily grouped into three groups of related genera, and diagnosed in the following key:—

- 1. Interradial crossvein present *Promachus*
- Interradial crossvein absent 2
- 2. Eighth and ninth ventral sclerite of abdomen clearly defined in the ovipositor
 *Cerdistus*, *Neocerdistus*
- Ninth ventral sclerite of the abdomen not discernible in the formation of the
 ovipositor *Neoaratus*, *Pararatus*, *Blepharotes*

I have recently discovered that a wrong interpretation has been given by me in previous papers concerning the term "lamellae." The position where they occur marks the anus as pointed out by Melin. For the whole structure, when compact, I used the term "lamella" in the singular where the plural should have been used, unconsciously regarding the complete organism as a unit, much in the same way as a segment of the abdomen is singular though composed of two sclerites. Moreover Melin shows the presence of lamellae in *Philonicus*, which character was overlooked by me, the line of division being obliterated on my specimen. Also I have since found them on *Neocerdistus*; they were overlooked till a specimen with the ovipositor buckled was examined in detail, the division between the eighth and ninth dorsal sclerite being clearly defined on this specimen, as also is the division between the lamellae when seen dorsally.

The genera referred to by me (1926) as being allied to the *Cerdistus-Neoitamus* complex may be divided now on the following and better characters:—

1. Ovipositor with only one ventral sclerite, the ninth ventral abdominal sclerite not being defined 2
- Ovipositor with two clearly defined ventral sclerites 4
2. Lamellae with long spines placed dorsally *Philonicus*
- Lamellae without such spines 3
3. The ninth dorsal segment extending above lamellae thus limiting the range of its movements; i.e. lamellae wedged in *Dysmachus*, *Eutolmus*
- Lamellae free *Heligmonoura*, *Machimus*, *Tolmerus*, *Epitriptus* and *Stilpnogaster*
4. The two upper lamellae fixed, each being produced into a spinelike appendage at the apex of the abdomen *Neocerdistus*
- Lamellae free and simple *Cerdistus*, *Neoitamus*, *Paritamus*, *Trichoitamus* and *Rhabdotoitamus*

It will be noted that *Stilpnogaster* is now eliminated from the *Cerdistus-Neoitamus* complex and so the name is no longer available for subgeneric purposes. *Machimus* is removed from the *Dysmachus* group, the lamellae being shown as free in Melin's illustration; on my specimen it is doubtfully so.

In describing the ovipositor on different species of the Asilinae, Melin wrote (p. 219): "The dorsal part of the ninth abdominal segment, which is often more or less semicircular, is usually drawn out ventral-terminally into a horizontal lamella which bounds the anus beneath. In consequence of this the terminal lamellae, even when they are called free, are more or less wedged into the ninth dorsal segment". This is quite a justifiable criticism but nevertheless there appears to be a considerable amount of movement in the lamellae, the lower plate of which moves in unison with the upper ones and hence must be flexible. This does not appear to be the case with forms referred to as having the lamellae "wedged in".

Genus PROMACHUS Loew.

This genus is unique amongst Australian robberflies by having the interradiial crossvein forming an apparent continuation of R_4 . This vein runs parallel to the main stem of R_{4+5} to near where R_{2+3} branches off. In antennal and general characters it conforms fairly well with other *Asilini*. The ovipositor is clearly composed of the eighth and ninth abdominal segments, both ventral and dorsal sclerites of each being conspicuous. There is sometimes a tendency to incorporate within the ovipositor the sixth and seventh segments much in the same way as is accomplished with *Neoitamus*, but in such cases these segments retain the tomentose covering. In a specimen before me of *P. lacinosus* Becker, from Tunis (Algeria), the eighth segment of the abdomen is covered with hair similar in

quantity and length to that on other segments, but the tomentose covering is absent, nevertheless it has the general appearance of the anterior segments. The ninth ventral sclerite is clearly indicated and at first sight appears to be the only one incorporated in the ovipositor; there are Australian species that approach this form.

Genus CERDISTUS Loew.

This genus is a complex under which come species having an ovipositor that is usually very compressed, always with normal free lamellae and the ninth ventral segment clearly defined. Another genus, as yet only represented in Australia by two females from Westwood, Queensland, has the appearance of those belonging to *Cerdistus*, but is without a discernible ninth ventral sclerite, the ovipositor is of moderate length, very compressed.

CERDISTUS FULVIPUBESCENS Macquart.

? *Glaphyropyga australasiae* Schiner, *Reise Novara Dipt.* 1866, p. 187.

Synonymy.—From the description of *Glaphyropyga australasiae*, there can be little doubt that the species should be placed under the complex *Cerdistus*, but the German in which the description is written is rather difficult to translate and even with a fresh description made for me by Mr. F. Rose I have been unable to satisfy myself regarding Schiner's meaning in some characters he gives. Miss Ricardo states that the description reads suspiciously like that of *Heligmoneura lascus* Walker a New Zealand species, but should it prove Australian as recorded then it is likely to be the same as *C. fulvipubescens* Macquart. I know of no other light coloured species that approximates the description so well.

Genus NEOCERDISTUS Hardy.

There is a necessity to amend some characters given for this genus the reasons for which are incorporated in the discussion above. The ovipositor is sub-compressed, showing a convex dorsal surface, the ninth dorsal and ventral sclerites are clearly defined in it, the lamellae are somewhat difficult to detect in outline, the two dorsal plates are produced, each into a spinelike process that stand apart from each other; the presence of the ventral plate is problematical. The first median cell (that formed by the branching of M_1 and M_2) is strongly constricted subapically. In other respects the genus resembles *Cerdistus*.

Genus NEOARATUS Ricardo.

Including *Asilus* of Australian authors.

The Australian forms hitherto placed under the genus *Asilus* (Hardy, 1920, pp. 250-259) do not belong to it, for the female ovipositor differs fundamentally from that of the typical *Asilus*; the habits of oviposition are also quite distinct. Melin described and illustrated the ovipositor of *Asilus crabroniformis* which is a complex of the eighth and ninth dorsal sclerite, the lamellae and the eighth ventral sclerite. In the Australian forms they vary slightly, but the eighth dorsal sclerite may be covered with tomentum and therefore similar in colouration to the rest of the abdomen and in such cases forms a covering from which protrude the ninth dorsal sclerite and lamellae, and the ventral sclerite which is apparently of one piece, more depressed than compressed. From this, which occurs on the typical form there is a tendency to vary towards incorporating the eighth dorsal sclerite which then becomes black and shining but does not alter in shape to any extent and therefore never reaches the form found in *Asilus*.

Melin described the supposed mode of oviposition by *Asilus crabroniformis*; the ovipositor inserts the eggs between particles of cattle droppings in which action the short spiny bristles at the apex of the ovipositor are supposed to play a part, but the Australian forms deposit eggs exposed on a drooping leaf, the bristles referred to in *Asilus* are therefore not required and hence not present; another distinguishing feature.

I observed the oviposition in a garden at Edgecliff, Sydney, where early one morning I found *N. inglorius* Macleay depositing on a leaf of a shrub. Already one complete orderly row was formed and a second nearly so. There were several gaps in the second row which were being filled, the lamellae operating as a feeler for the purpose. The fly later took a step forward and started a third row this constituting two eggs together, then two further eggs wide apart. Later when I returned four rows were completed and the fly was gone, but the gaps in the third row were filled and in all four rows there were only three or four breaks in the sequence of the eggs, whilst three or four eggs were misplaced. Early one morning exactly a week later the larvae hatched and fell to the ground. I was fortunate enough to see this, having been on the look out morning and evening every day. Miss V. Irwin Smith obtained oviposition in the case of the typical *Neoaratus* under artificial conditions in a manner that suggests that that species has similar egg-laying habits.

Genus PARARATUS Ricardo.

The female ovipositor is well developed and without a ninth ventral sclerite, but ventrally, at the apex which tapers to a point, there are a pair of flanges strongly developed. Where such flanges occur on species of other genera they are small and mainly hidden. The lamellae, composed of three flat plates, are distinctly defined and not at all compact as on *Asilus*, *Neoaratus* and *Cerdistus*. Only one species is known, *P. macrostylus* Loew, recorded from Western Australia, Queensland and Victoria.

Genus BLEPHAROTES Westwood.

This genus is readily recognized by the broad depressed abdomen containing conspicuous tufts at the sides. In the ovipositor the ninth dorsal segment is clearly defined as also the three plates of the lamellae but ventrally only one segment is defined, this seen laterally, is broadly rounded at the apex.

Under this genus the male genitalia of four species were illustrated in outline (Hardy, 1921, p. 296), two being described as new. The figures were correctly given in the text but the names were transposed under the explanation to the figures. Text-fig. 9 is *B. brisbanensis*, since found to be a synonym of *B. flavus* Ricardo (Hardy, 1923, p. 176); Text-fig. 10 is *B. punctatus* Hardy; Text-fig. 11 which was left unnamed is the common form found around Sydney to which I now apply the name *B. corarius* Wiedemann. Text-fig. 12 is a rare undescribed form of which I have seen only the male. The readily recognized *B. abdominalis* is in nearly every collection. *B. vivax* Hermann is represented by two females only and there are no further species in any collection examined. The females are best allied to the males by noting the proportional length of the antennal segments as these coincide in the sexes, no two species having the same proportions. With regard to colour both light and dark yellow abdomens occur in three of the described forms and colour therefore has no significance for identification purposes.

Tribe *Phellini*.

The tribe *Phellini* contains but two genera *Phellus* and *Psilozona*, both of which require a more intensive study. The female of a new species from Chinchilla, Queensland, is in such excellent condition that all the genital parts are readily recognized and conform in type to no other ovipositor I have seen in the *Dasygogoninae*; very distinctly does it show the absence of genital spines such as found on the *Saropogonini*. This new form, red and black in colouration is an undoubted *Phellus* of which previously I had studied only old specimens; presumably the spines discovered on them will ultimately prove to be but modified hairs that have no relation to the spines of *Saropogonini*.

On *Phellus* the moustache is very thick and depressed, the hairs all pointing more or less towards the apex of the proboscis, whilst on *Psilozona* they conform to the more usual types, the hairs being upstanding, issuing more or less at right angles to the face. On *P. glaucus* and *P. piliferus* the moustache is overlaid with a quantity of flattened out scales that arise from the face, expand in width, then become ribbon-like and finally taper to a point. These specialized hairs are not found on the specimen from Chinchilla nor yet does the apical prolongation on the intermediate tibiae occur on that form.

Tribe *Laphrini* (new tribal name).

This tribe is constituted by that part of the old subfamily *Laphrinae* which has three antennal segments with or without a hair-like spine but when present it is placed dorsally as in many *Brachyrrhopalini*. It is further distinguished by the veins R_1 and R_{2+3} amalgamating before reaching the wing border and by the veins M_3 and M_4 doing likewise. Even when so limited the tribe is complex.

Six genera are placed here, namely: *Nusa*, *Atomasia*, *Adelodus*, *Cyanonedys*, *Laphria* and *Maria* all of which are recognized in the various collections except the last. *Aphesia* has been used for one species which Hermann suggests is an *Adelodus*.

Tribe *Brachyrrhopalini*.

This tribe has already been satisfactorily diagnosed and four genera defined in key form (Hardy, 1926, p. 307). In none of the species do any of the radial or the median veins meet each other before reaching the wing margin, but occasionally M_1 runs into R_2 . Most of the species are recognized and suitably labelled in collections and the status of each species is fairly well assured. The following is a complete list with synonyms:—

- Brachyrrhopala* Macquart, 1847 (*Cabasa* Walker, 1850).
- **pulchella* Macquart, 1846 (*Dasygogon*).
- venno* Walker, 1849 (*Dasygogon*).
- rufithorax* Walker, 1850 (*Cabasa*).
- rubrithorax* Macquart, 1850 (*Dasygogon*).
- **ruficornis* Macquart, 1847.
- fenestrata* Macquart, 1850 (*Codula*).
- victoriae* Roder, 1892.
- maculata* Roder, 1885.
- fulva* Ricardo, 1912.
- ? *quadricincta* Bigot, 1878 (*Codula*).
- Codula* Macquart, 1850.
- **ambipennis* Macquart, 1850.
- ? *vespiformis* Thomson, 1868.
- Chrysopogon* Roder, 1881.
- **albopunctata* Macquart, 1846 (*Dasygogon*).
- spintha* Walker, 1849 (*Dasygogon*).

- **crabroniformis* Roder, 1881.
- **mulleri* Roder, 1881.
- fasciatus* Ricardo, 1912.
- punctatus* Ricardo, 1912.
- queenlandi* Ricardo, 1912.
- **splendissimus* Ricardo, 1912.
- **rufulus* White, 1913.
- **nigriscens* White, 1913.
- pallidipennis* White, 1917.
- rubripennis* White, 1917.
- Opseostlengis* White, 1913.
- **insignis* White, 1913.

Note.—Species bearing the names here given with an asterisk may be regarded as correctly named in collections; doubt may be raised concerning some of the others.

Tribe *Saropogonini*.

To this tribe now come all forms of the Australian Asilidae that are provided with strong curved spines in the genital complex of the female, four or five segments in the antennae, the last of which consists of a minute spine inserted in a cavity at the apex of the penultimate segment. Two genera, *Clinopogon* and *Bathypogon* are exceptions in so far as the last antennal segment is of considerable size, being more segment-like and not a hair-like spine. It will be noted that those species hitherto described fall into two groups on characters that appear to be suitable for key purposes; those with the tibial spur on the anterior legs and those without, the latter a complex, the former being again divisible on the shape of the abdomen though all the forms are apparently closely related.

For convenience the first group is divided in the key on the presence or absence of the scutellar bristles as this works well, and it leaves only the genus *Saropogon* in an anomalous position. A more natural grouping of the genera would be accomplished by separating those forms with a tapering abdomen or allied thereto from those with a clubbed abdomen or related thereto, but these forms meet towards having the abdomen somewhat cylindrical and it is not always easy to determine to which category a specimen should be aligned. Apparently all the described forms with the tapering abdomen or related thereto have scutellar bristles, only one undescribed form is without them, whilst all those with clubbed abdomen or related thereto are without bristles except *Saropogon*.

The isolation of genera hitherto proposed and which are grouped in the key given below is offering considerable difficulty as many of them are joined by related but undescribed species. Even *Thereutria* and *Metalaphria* cannot be isolated satisfactorily for there are two species as yet undescribed that are like each other in every respect except the veins R_1 and R_{2+3} are separate in one from South Australia and run together in the other from Queensland, thus joining the *Thereutria* type of wing to the *Rachiopogon* type.

Key to the genera of the *Saropogonini*.

- 1. Anterior femora with a curved spur at apex 2
- Anterior femora without the curved spur 3
- 2. Always with scutellar bristles; abdomen tapering from base to apex, rarely otherwise and slightly clubbed only in *Saropogon*
 *Questopogon*, *Rachiopogon*, *Thereutria*, *Metalaphria* and *Saropogon*
- Never with scutellar bristles; abdomen club-shaped, basal segments always narrower than some of the more remote ones, rarely quite cylindrical and never tapering
 *Neosaropogon*, *Deromyia*, *Neocyrtopogon* and *Erethopogon*

3. Antennae with the apical segment reduced to a hair-like spine 4
- Antennae with the apical segment not so reduced 5
4. Wings without an interradial crossvein *Stenopogon*, *Neodioctria*
- Wings with an interradial crossvein *Cryptopogon*
5. The veins M_3 and M_4 running to the wing border independently *Clinopogon*
- The veins M_3 and M_4 meeting considerably before reaching the wing border *Bathypogon*

Those species that fall into couplet "2" of the key given above may be placed in their correct genera in many cases by aid of the following temporary key, but some species which presumably are undescribed and cannot be made to conform to the genera of this key are at present regarded as belonging to new genera:—

Key to the genera of the Saropogonini that have a tibial spur.

1. Abdomen strongly tapering; scutellum almost invariably provided with bristles .. 2
- Abdomen clubformed, at most cylindrical, never tapering, rarely with scutellar bristles 5
2. Veins R_1 and R_{2+3} meeting before the wing margin 3
- Veins R_1 and R_{2+3} running independently to the wing margin 4
3. Moustache bushy, not confined to the oral margin *Thereutria*
- Moustache confined to the oral margin *Metalaphria*
4. Antennae with three segments and a minute spine; moustache confined to the oral margin, face bare *Rachiopogon*
- Antennae with four segments and a minute spine; long soft hairs on face above moustache *Questopogon*
5. Scutellum with bristles; antennae with four segments and a minute spine *Saropogon*
- Scutellum without bristles 6
6. Vein M_3 meeting M_4 before reaching the wing border *Deromyia*
- Veins M_3 and M_4 running independently to the wing border 7
7. Antennae with three segments and a minute spine. Face prominent, bare, moustache confined to the oral margin *Neocyrtopogon*
- Antennae with four segments and a minute spine. Face normal 8
8. Moustache confined to the oral margin; face bare *Neosaropogon*
- Face above moustache with slight soft hairs *Erethropogon*

Genus THEREUTRIA Loew.

Three common species are recognized in collections and in all of them the moustache differs in colour according to sex; all have white lateral spots usually discernible from the second to sixth abdominal segments. *T. amaricus* Walker, a common Sydney form that extends into Queensland, has the basal half of the tibiae yellow. *T. pulchripes* White, which is plentiful in the Blue Mountains, New South Wales, has the basal half of both femora and tibiae brown, which gives the insect the superficial appearance of a common *Laphria*. *T. pulchra* Schiner has the tubercle and moustache smaller than those of the other two and the legs are entirely black but white hairs are abundant on the posterior side of the intermediate and posterior tibiae; it is abundant around Brisbane. The outstanding name placed here, *T. luctuosa* Macquart, may possibly belong to *T. pulchra* Schiner.

Genus METALAPHRIA Ricardo.

This genus differs from *Thereutria* only by having the moustache reduced to a row of bristles along the oral margin. A rare Brisbane species is certainly congeneric with *M. australis* Ricardo and may be identical with it. Although *M. aurifacies* White agrees in generic characters it seems to be related more to *Thereutria* than here. White's species is not uncommon around Sydney during November and December. There is a black species from Chinchilla which has the abdominal spots of a *Thereutria*, the moustache of *Metalaphria* and the wing venation of *Rachiopogon* and *Questopogon* and it is certainly a connecting link.

Genus ————— ?

Neosaropogon Ricardo in part.

Attention has already been drawn to the fact that *Neosaropogon* Ricardo, was a composite genus when established and of those species originally placed under the name only *N. princeps* could be retained there. The other species have not yet been allied to any genus. *D. salinator* Walker, *N. claripennis* Ricardo, *N. nigrinus* Ricardo and *N. froggatti* Dakin and Fordham are all described as having the tibial spur present and with bristles on the scutellum and hence must belong to the *Rachiopogon-Questopogon* group. At least two of these forms are provided with tapering abdomens that are unusually long, resembling in this respect the genus *Neoaratus*, one of the *Asilini*.

A pair of *N. froggatti* agrees remarkably well with the description and conforms to this unnamed genus; the male has quite normally shaped genitalia with no outstanding features as seems to have been expected by Dakin and Fordham (1922). *N. claripennis* is congeneric, *N. nigrinus* has not been recognized and *N. salinator* is represented by two species so named in Australian collections, one certainly congeneric, the other doubtfully so.

Genus SAROPOGON Loew.

Saropogon semirufus Bigot has been recognized and there are two other species, apparently undescribed, that come here. *Saropogon (Dasyopogon) suavis* Walker is applied to specimens in Australian collections to a small species of *Neosaropogon*, Miss Ricardo having labelled one as doubtfully this. *Brachyrrhopala bella* White was removed to this genus tentatively by me; I have not been able to check its characters since. *Saropogon rubescens* White, the type of which I have before me, belongs to the *Rachiopogon-Questopogon* group; it is small in size, but the abdomen tapers strongly. I also suspect that *S. dissimulans* White does not belong to this genus, but I have not recognized it.

Typically the genus contains species that have a slightly clubbed abdomen and scutellar spines and is related to the *Neosaropogon* group rather closely.

Genus NEOSAROPOGON Ricardo.

There are now three species described that are recognized as belonging to this genus, *Dasyopogon princeps* Macquart, *D. nitidus* Macquart and *D. suavis* Walker, but there are quite a number of species in collections that must be placed here.

Genus DEROMYIA Philippi.

In Australia this genus appears to be confined to the higher mountains and the relationship is undoubtedly with *Neosaropogon* from which it differs by the veins M_2 and M_4 uniting before reaching the wing border.

Genus NEOCYRTOPOGON Ricardo.

I have recently seen the typical form of this genus from Westwood, Queensland, and find it conforms in every respect to the generic characters previously given by me, though based upon other species. The whole head is very inflated, the excavation between the eyes being eliminated; the moustache is confined to the oral margin and is remarkably reduced in regard to the size of the bristles. It is further distinguished from *Neosaropogon* by the entire absence of the fourth antennal segment. Other species that have been placed by me in this genus are

less developed with regard to the head characters, but agree in antennal structure and therefore cannot be confused with other genera of the *Neosaropogon* group. The typical form may be mistaken for a Therevid on structural grounds but it is, nevertheless, a member of the *Saropogonini*.

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Pub. No. 100, N.W. 1877

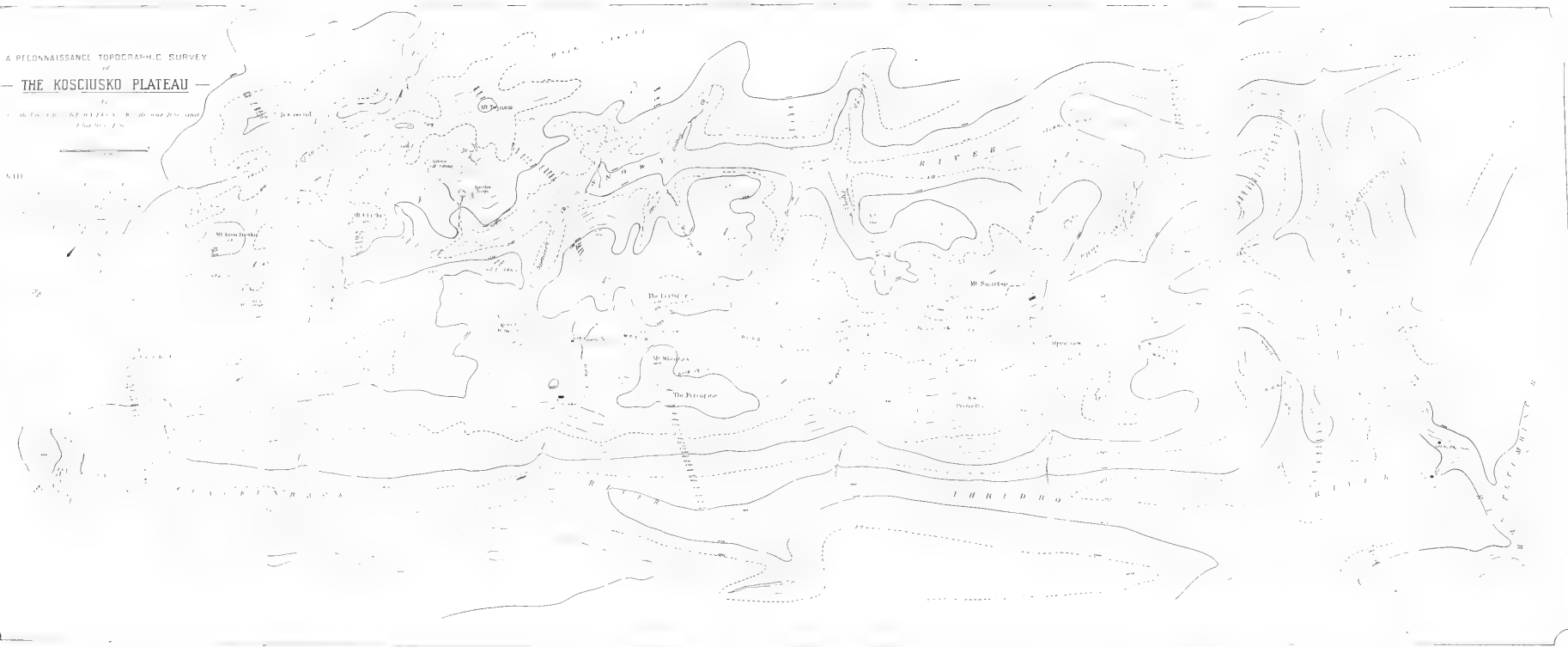
A RECONNAISSANCE TOPOGRAPHIC SURVEY

of
— THE KOSCIUSKO PLATEAU —

BY
CAPTAIN J. D. BYRNE, U. S. ARMY, AND
LIEUTENANT J. S.

1877

24





MOUNT KOSCIUSKO.

1. Slope of a shallow valley at about 5,100 feet. *E. coriacea* consociation at rear. *Poa* consociation on the slopes at sides.
2. Shallow valley at about 5,500 feet, showing destruction of *E. coriacea*.



MOUNT KOSCIUSKO.

1. View at 5,200 feet, showing *E. coriacea* in the background and *Callistemon* in the foreground.
2. *Restio* associates at 5,500 feet.
3. Shallow valley at 5,600 feet with *E. coriacea* on the ridge and *Poa* in the foreground.



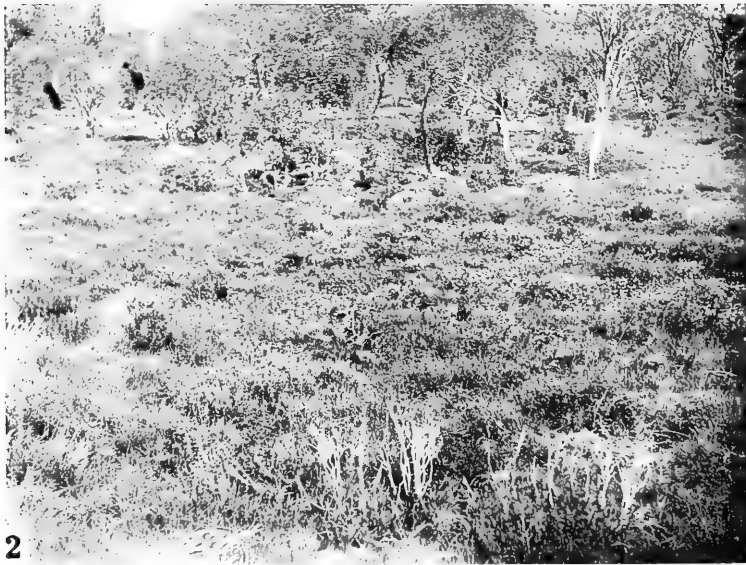
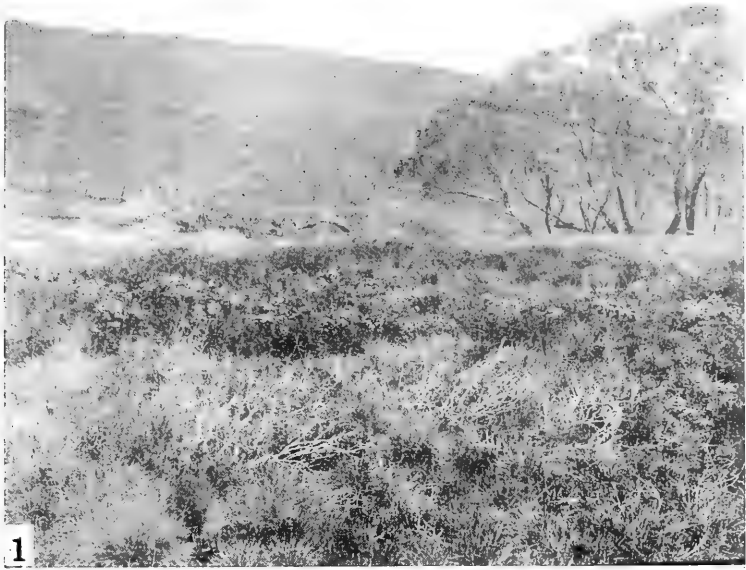
MOUNT KOSCIUSKO.

1. Granite boulder at 6,000 feet with *E. Gunniana* flattened against it.
2. *V. Derwentia* in a dead *E. coriacea* forest at 5,500 feet.



MOUNT KOSCIUSKO.

1. Regenerating plant of *C. Sieberi*.
2. Snowy River, at 4,000 feet with *E. Gunnii* in the background and *Leptospermum* lining the river bank.



MOUNT KOSCIUSKO.

1. *Ep. paludosa* in flower in middle distance, *E. coriacea* in background, 5,100 feet.
2. *Ep. paludosa* in flower, with *Poa-Hypolaena* passing into the *Poa* society.



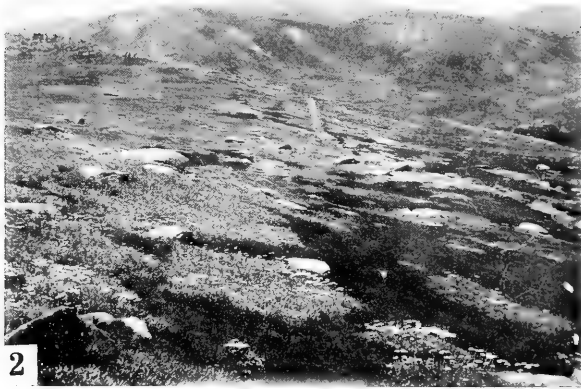
MOUNT KOSCIUSKO.

1. Alpine region at 6,700 feet.
2. *Ep. paludosa* at 5,100 feet.
3. *E. Gunnii* at 4,000 feet.
4. Shallow valley at 5,800 feet.



MOUNT KOSCIUSKO.

1. *Poa-Hypolaena* ecotone developing into *Epacris* associates.
2. Ridge in slate area at summit of plateau occupied by *Ep. petrophila*.



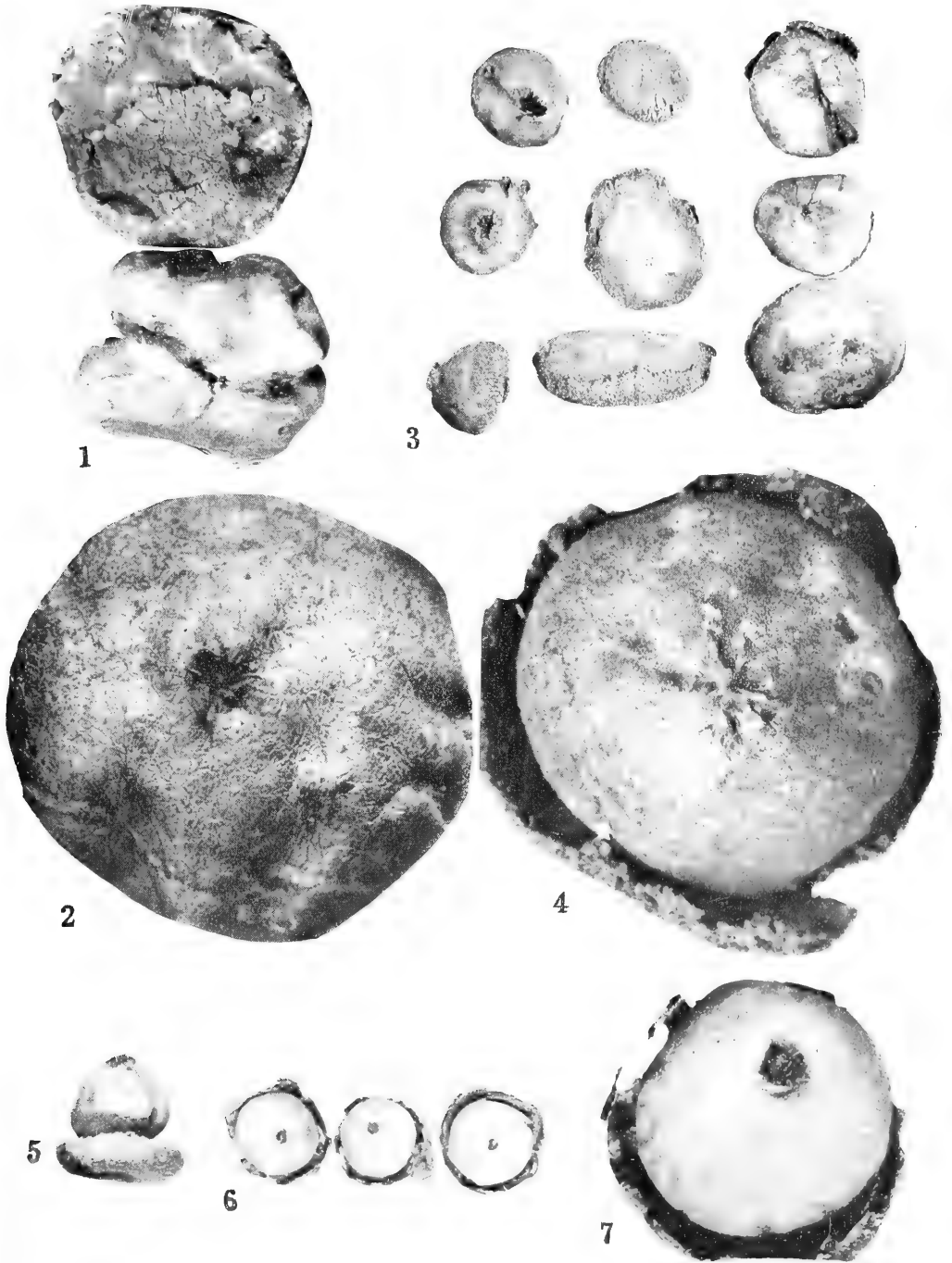
MOUNT KOSCIUSKO.

1. *E. coriacea* at 5,200 feet showing regeneration after fire.
2. *Poa-Celmisia* association at 7,000 feet.
3. Alpine region seen from summit, 7,328 feet.

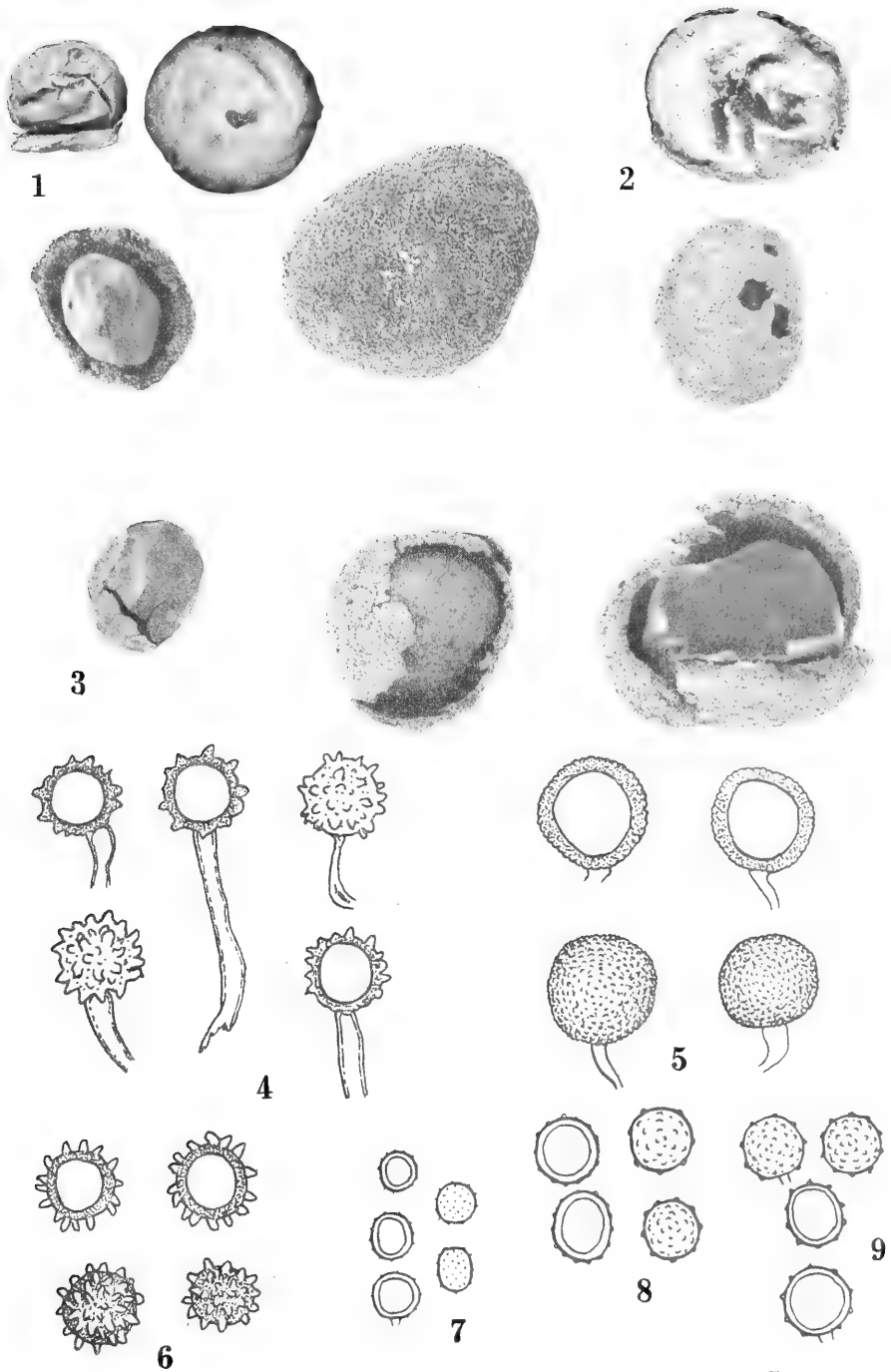


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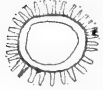
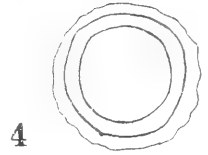
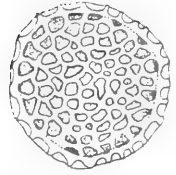
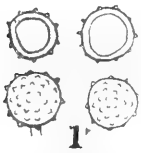
1. *Podocarpus alpina* in the shelter of a boulder at 7,000 feet.
2. Scene at 6,000 feet.
3. *Celmisia* in flower at 7,000 feet, with dense societies of *Euphrasia Brownii*.



Australasian species of *Disciseda*.



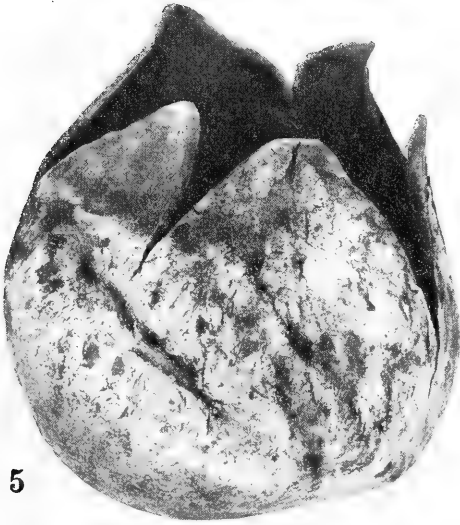
Australasian species of *Disciseda* and *Abstoma*. Spores of *Disciseda*.



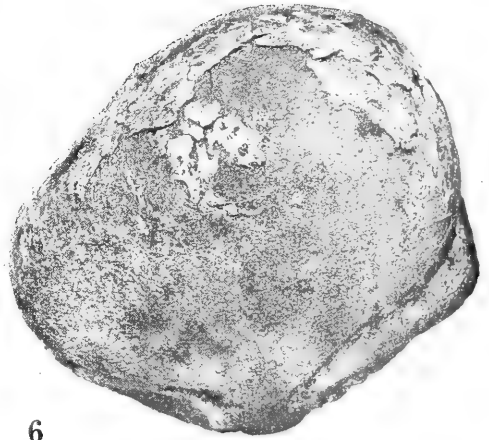
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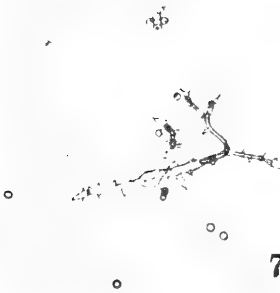
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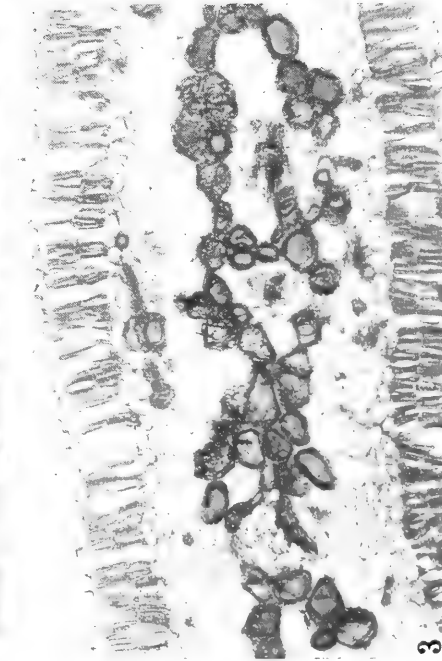
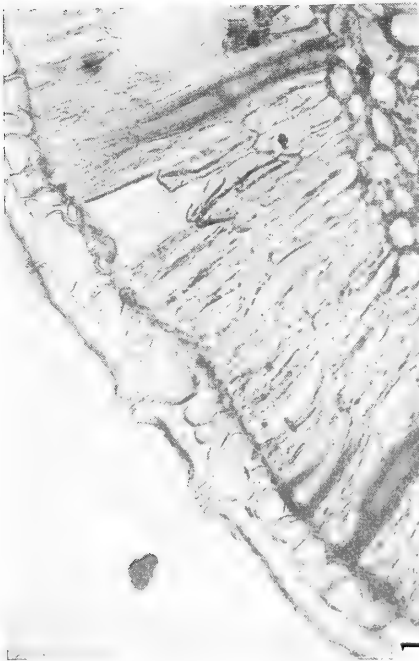
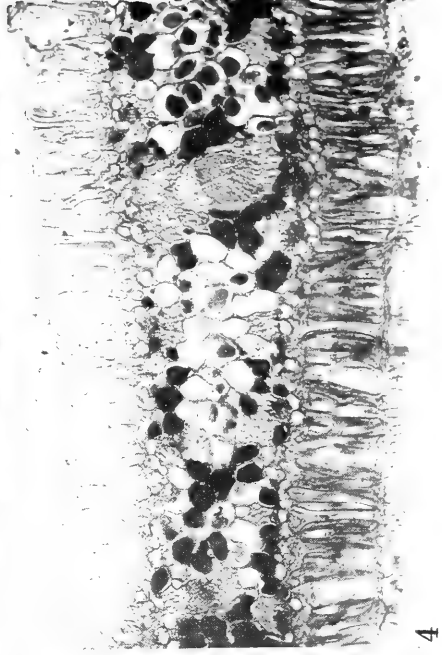
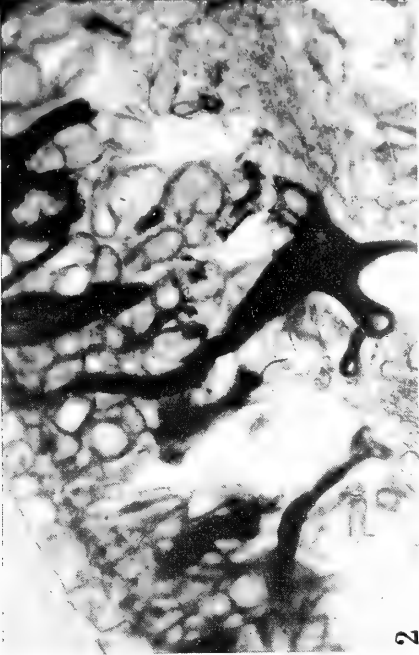


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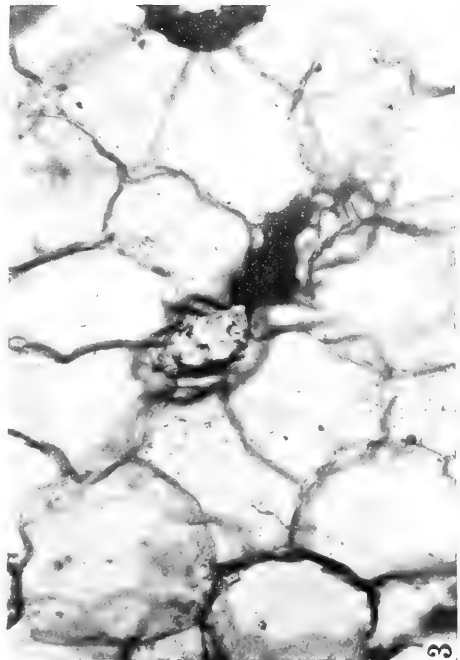
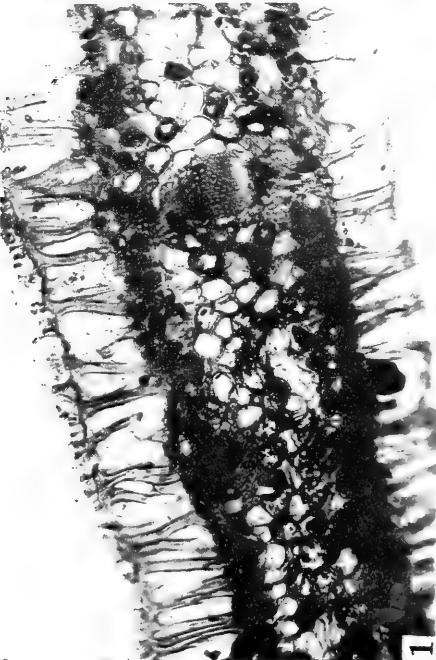
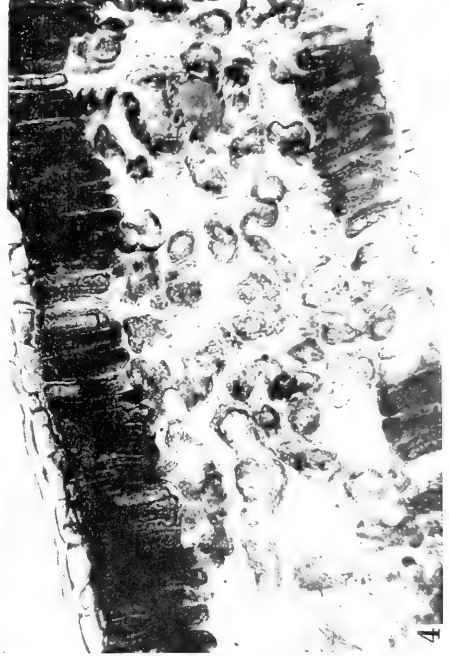


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Mycenastrum corium. Spores of *Disciseda*, *Abstoma* and *Mycenastrum*.

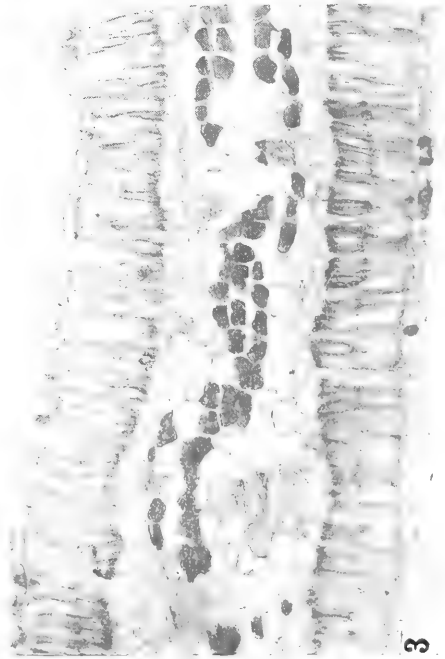
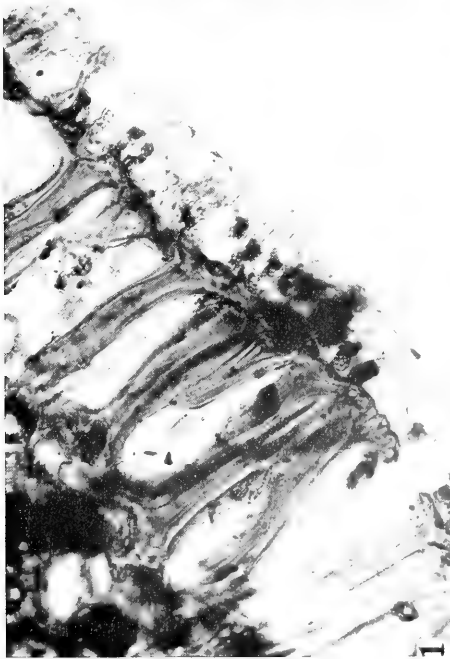
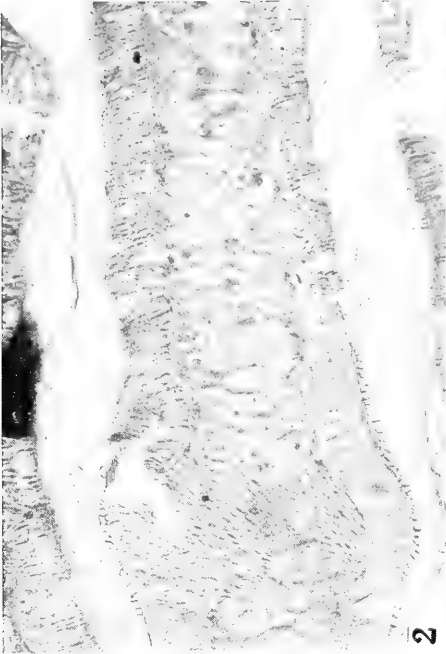


Sections of leaves of *Habea*.

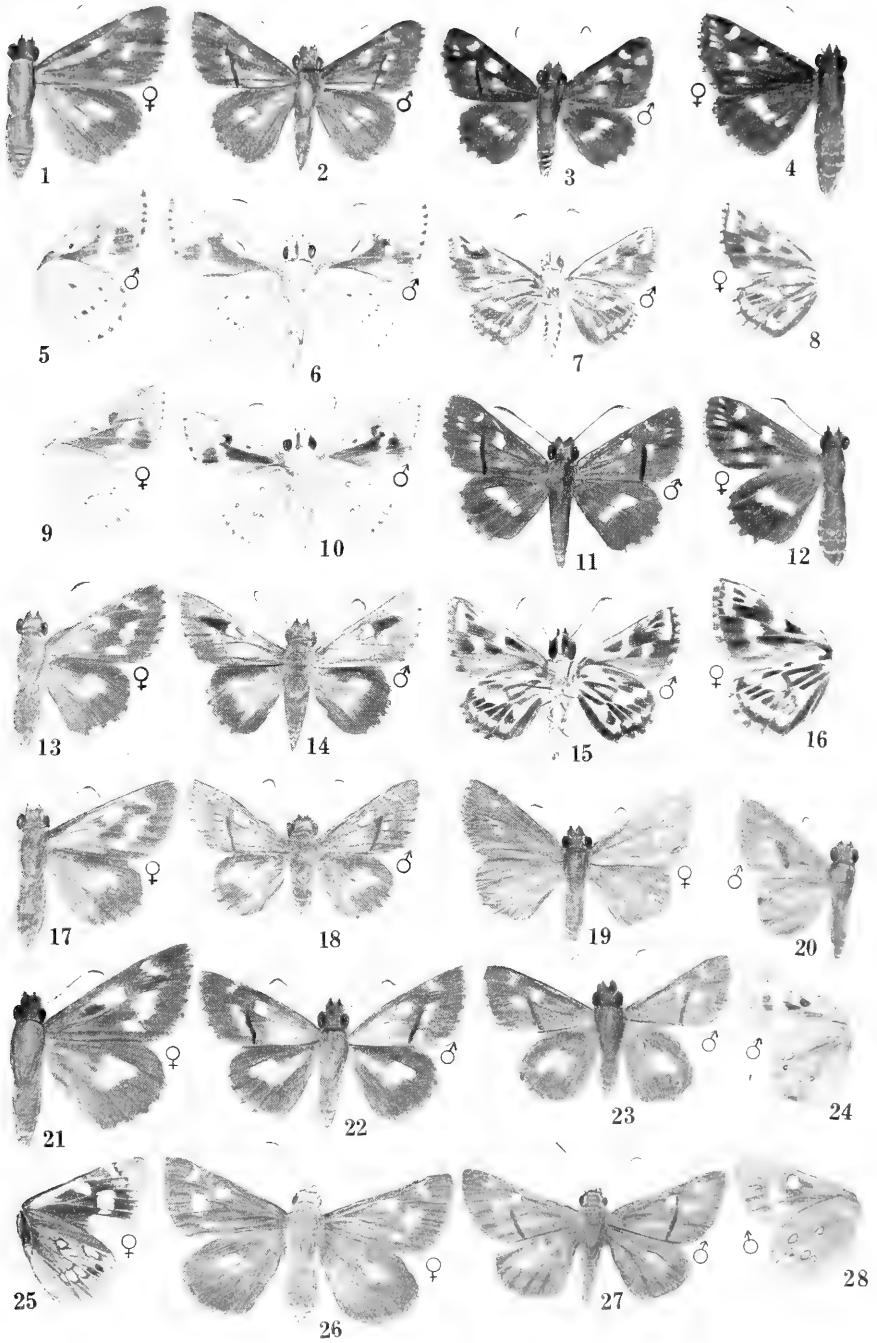


Sections of leaves of *Hakea*.





Sections of leaves of *Hakea*.



Australian Hesperiiidae.

NOTES ON AUSTRALIAN DIPTERA. No. xiii.

By J. R. MALLOCH.

(Communicated by Dr. I. M. Mackerras.)

(Fifteen Text-figures.)

[Read 28th September, 1927.]

In this paper I present descriptions of a number of species sent to me by Mr. A. L. Tonnoir, mostly from Tasmania, the type specimens of which are to be deposited in the Cawthron Institute, New Zealand. The paratypes, which I am permitted to keep, will be sent by me for disposition in some suitable Australian museum. In the paper I also present some keys for the recognition of genera and species in the Acalyptratae, the types of the new species in most cases being from material sent to me by the late Dr. E. W. Ferguson, and these will be returned to Australia later.

Family **Sapromyzidae.**

Though there are I believe some genera of this family still to be discovered in Australia I am presenting now a generic synopsis which will I hope permit students of the group to locate material they may become possessed of, provided it belongs to an included genus. About half of the genera are confined to Australia and most of the species are.

Key to Genera.

1. Hind tibia with two strong curved black apical ventral spines, the longest one over twice as long as apical diameter of the tibia; costa without short stiff black spines, fine haired from base to apex of fourth vein; hairs on cheeks, thorax, femora, and tibiae, long and bristly; anterior orbital bristles incurved 1. *Amphicyphus* de Meijere.
Hind tibia with, or without, one short, almost straight, apical ventral bristle, which is not longer than the apical diameter of the tibia; part of costal vein with short closely placed stiff black bristles 2
2. The short stiff black bristles on costal vein not extending to apex of third vein, gradually discontinued beyond apex of second 3
The short stiff black bristles on costal vein extending to apex of third vein where they cease abruptly, giving the costa the appearance of being slightly thickened to that point 15
3. Second wing vein unusually close to costal vein, the cell (marginal) between these veins therefore not one-third as wide just beyond apex of first vein as the one (submarginal) behind second vein 4
Second wing vein at the normal distance from costal vein, the cell between these veins just beyond apex of first vein usually as wide as the one behind second vein 5
4. Anterior orbital bristles incurved; basal segment of antennae quite evident in profile, at least as long as second, and with some fine hairs at apex below; inner cross-vein of wing at or slightly before middle of wing 2. *Steganopsis* de Meijere.
Anterior orbital bristles curved backward; basal segment of antennae not exposed in profile; inner cross-vein at about one-third from apex of wing 3. *Depressa* Malloch.

5. Posthumeral bristle not present on thorax 6
 Posthumeral bristle generally strong, always present 7
6. Anterior orbital bristles incurved; cheek bristled 4. *Trigonometopus* Meigen.
 Anterior orbital bristles curved backward; cheek haired 5. *Paranomina* Hendel.
7. Anterior pair of orbital bristles incurved 8
 Anterior pair of orbital bristles curved backward, or indistinguishable 10
8. Thorax with four pairs of strong dorsocentral bristles, the anterior pair in front of suture 9
 Thorax with two or three pairs of dorsocentral bristles, the anterior pair behind suture 6. *Incurviseta* Malloch.
9. Face glossy, quite prominently convex on upper half, depressed below; arista white except at base 7. *Poecilohetaerella* Tonnoir and Malloch.
 Face not, or but slightly shining, almost flat; arista entirely dark 8. *Poecilohetaerus* Hendel.
10. Frons with but one well developed pair of bristles, the anterior pair lacking or almost indistinguishable 11
 Frons with two distinct pairs of orbital bristles 12
11. Arista lanceolate on basal half, and with very short dense black hairs which give it a more thickened appearance; face quite prominently convex on upper half, with a median impression which is very distinct when seen in profile 9. *Ceratolauwania* Hendel.
 Arista not exceptionally thickened on basal half, and with normal pubescence; face not prominently convex on upper half, if convex then regularly so and not impressed at middle when seen in profile 10. *Paralauwania* Hendel.
12. Eye much, head slightly, longer than high, face receding below 11. *Trigonometopsis* Malloch.
 Eye and head not conspicuously longer than high, the former usually almost round 13
13. Face except the parafacials glossy black, and prominently, subconically, convex (Text-fig. 2) 12. *Melanina*, n. gen.
 Face not glossy black, and very little or not at all convex 14
14. Frons in profile projecting beyond anterior margin of eye about half as far as length of eye; basal antennal segment longer than second; ocellar bristles lacking 13. *Rhagadolyra* Hendel.
 Frons in profile projecting in front of eye much less than half the length of eye; basal antennal segment almost invariably much shorter than second 14. *Sapromyza* Fallen.
15. Mesopleura with a strong downwardly directed bristle near middle of disc, in addition to the one on hind margin 15. *Trypanooides* Tonnoir and Malloch.
 Mesopleura with only fine hairs on disc, no strong bristle present 16
16. Face slightly or not at all convex; frons little if any longer than wide; lower part of occiput normal 16. *Homoneura* van der Wulp.
 Face with a prominent subconical central prominence; frons about three times as long as wide; lower part of occiput with a tumid spot close to eye on which there is at least one strong bristle 17. *Australina* Malloch.

1. Genus AMPHICYPHUS de Meijere.

I have recorded the occurrence of *reticulatus* (Dol.), the only species of this genus, in Australia (These PROCEEDINGS, 1926, p. 550). There are a few slight differences in the markings of the single Australian specimen I have seen and one I had from Java, but not sufficient to cause a doubt as to their identity.

2. Genus STEGANOPSIS de Meijere.

So far I have seen but one species of this genus from Australia, which I identify as *melanogaster* (Thomson).

I have a key to the known species of this genus now ready to send to press.

3. Genus DEPRESSA Malloch.

I erected this genus originally for the reception of one species, *atrata* Malloch. Mr. Tonnoir has sent me two additional species which I describe below, I present in the following key diagnostic characters of the three species.

Key to the Species.

1. Face glossy black, but slightly yellowish on upper margin, the black colour extending over anterior two-thirds of cheeks; fore coxae and bases of fore femora yellow, mid and hind femora fuscous; costal margin of wing narrowly hyaline from base to the hyaline preapical fascia, the costal vein pale yellow on same section; longest hairs on arista three or four times as long as its basal diameter *albicosta*, n. sp.
Face largely or entirely fulvous yellow; legs not coloured as above; costal margin not hyaline from base to preapical fascia; longest hairs on arista about twice as long as its basal diameter 2
2. Thorax almost entirely black; mid and hind femora and bases of their tibiae black; no conspicuous pale streaks along middle of cells of wings *atrata* Malloch.
Thorax yellow on lateral margins of mesonotum and entire pleura; mid and hind legs yellow; a conspicuous hyaline streak along middle of most of the cells of wings and one along costal vein from apex of first vein to the preapical hyaline fascia *striatipennis*, n. sp.

DEPRESSA ALBICOSTA, n. sp.

Male.—Head glossy black, centre of frons reddish in front, upper part of face slightly yellowish, occiput with a broad yellow streak from middle to lower margin of cheek behind each eye; antennae fuscous, third segment fulvous yellow; palpi black. Thorax black, yellowish round prothoracic spiracle and on pleural sutures, the pleura more shining than mesonotum, the latter and the scutellum quite distinctly shagreened or alutaceous. Abdomen shining black, not shagreened. Legs stramineous, mid and hind coxae, apices of fore femora and practically all of mid and hind pairs, fore tibiae except bases, and all of fore tarsi, black, bases of mid and hind tibiae slightly browned. Wings blackish, with a slightly diagonal fascia beyond middle just apical of inner cross-vein and over lower extremity of the outer one much as in *atrata*, but there is a quite noticeable hyaline streak extending from the fascia along costal vein to humeral vein which is not evident in *atrata*, tips of wings hyaline, costal vein yellow from base to fascia. Knobs of halteres black.

Ocellar bristles microscopic; longest hairs on arista over half as long as width of third antennal segment. Thorax with three pairs of postsutural dorso-central bristles, the anterior pair weakest, a moderately long pair of prescutellar acrostichals, and four series of intradorsocentral hairs. Fore femur without an anteroventral comb; fore tarsus longer than fore tibia, and as thick as it. Venation as in *atrata*.

Length, 3.5 mm.

Type, Killara, N.S.W., 29th Oct., 1921 (A. Tonnoir).

DEPRESSA ATRATA Malloch.

This species is about the same size as *albicosta*, but has the head almost entirely fulvous yellow, only the ocellar spot being black, the antennae and palpi are entirely fulvous, the legs are more extensively blackened, there is no evident white or hyaline margin to the costa, and the dorsal surfaces of thorax and scutellum are not noticeably shagreened.

Originally described from Sydney, N.S.W. I have before me a specimen from National Park, Tasmania, 6th Dec., 1922 (A. L. Tonnoir).

DEPRESSA STRIATIPENNIS, n. sp.

Female.—Head fulvous yellow, glossy, ocellar region fuscous, along each margin of each orbital plate there is a brown or fuscous suffusion; parafacials white dusted as in the other two species; antennae fulvous yellow; labrum and a

large mark on each cheek entirely glossy black; palpi yellow at bases, black at apices. Thorax dull fulvous yellow, mesonotum and scutellum brownish or fuscous. Abdomen fuscous. Legs coloured as pleura, fore tarsi blackened except at bases. Wings fuscous, with the same oblique hyaline fascia as in the other two species, but there are narrow hyaline streaks along the middle of most of the cells, and one from apex of first vein to near apex of second along hind margin of costal vein. Halteres brown. It must be noted that the type specimen is teneral and in all probability mature individuals will have the thoracic, abdominal, and leg colours darker in part and more contrasted with the pale parts than is the case here.

Structurally similar to *atrata*, the hairs on arista not nearly half as long as width of third antennal segment, but the dorsal surfaces of thorax and scutellum are evidently shagreened.

Length, 4.5 mm.

Type, Mt. Wilson, N.S.W., 19th Nov., 1921 (A. L. Tonnoir).

4. Genus TRIGONOMETOPUS Meigen.

Some time ago I described a species which I placed in this genus. It does not agree with the genotype, but there are so many species in this immediate vicinity in the family that are distinguished by characters of chaetotaxy and structure of the head that I hesitate to add another genus to the list for the reception of one species. Consequently this species, *fuscifrons* Malloch, may be allowed to remain in this genus pending an elucidation of the family in this region.

5. Genus PARANOMINA Hendel.

I have not seen this genus, which was erected for the reception of one species, *unicolor* Hendel, described from Cape York.

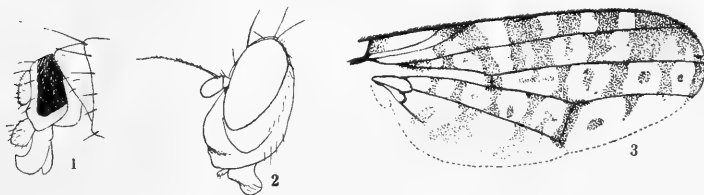
6. Genus INCURVISETA Malloch.

This genus was originally erected for the reception of *maculifrons* (Macquart), but there are many other species which, though not agreeing absolutely with the genotype in certain characters that might be considered as of at least subgeneric value, appear to find their closest affinities here. I present below a synopsis of the species now available to me, and indicate distinctions in structure, both in the synopsis and descriptions, which may justify further division of the group.

Key to the Species.

1. Frons yellow, with a pair of deep velvety black marks on the interfrontalia 2
 Frons either with only the ocellar spot black, the remainder yellow, or almost entirely black 4
2. Face prominently convex and glossy, central part readily visible in profile; entire antennae, arista, and palpi deep black *maculifrons* (Macquart)
 Face flat, or but slightly convex, not, or very slightly, visible in profile, the surface almost dull; antennae and palpi not entirely black 3
3. Apices of all femora and tibiae blackened, those of mid and hind femora very narrowly so *affinis*, n. sp.
 Apices of none of the femora and tibiae blackened *wilmoti*, n. sp.
4. Frons largely black, yellow only on the anterior portion of the triangle, orbital stripes and triangle glossy on their entire length and extending to anterior margin of frons, the narrow intervening and lateral areas velvety black; face prominently convex, readily seen from the side, and glossy yellow, the parafacials densely white dusted; wings luteous, quite noticeably infuscated at bases; thorax, abdomen, legs, except the bases of mid and hind tarsi, and the knobs of halteres, shining black *flaviceps*, n. sp.

- Frons yellow, only the ocellar region blackened, triangle and orbits not conspicuously differentiated on their entire length, and not extending to anterior margin of frons; face rarely convex; species not coloured as above, the legs more extensively yellow and the halteres usually pale coloured 5
5. Basal two segments of antennae yellow, third entirely deep black; thorax testaceous yellow, with two linear black vittae along the lines of dorsocentrals which extend from anterior margin to well beyond middle; intradorsocentral hairs in four series *vittigera*, n. sp.
- Antennae not conspicuously bicoloured, third segment never deep black; thorax not coloured as above, if yellow then without linear black dorsal vittae 6
6. Intradorsocentral hairs in but two series and rather strongly developed; thorax and abdomen fuscous, with a pronounced green tinge, both greyish dusted, the thorax more densely so and with the humeral angles yellow; apices of palpi darkened; face quite noticeably convex and glossy in centre *biseriata*, n. sp.
- Intradorsocentral hairs in at least four distinct series which are more or less regular, sometimes very short and fine 7
7. Thorax with three pairs of strong dorsocentral bristles, the anterior pair close to suture, and one pair of strong prescutellar acrostichals which are conspicuously differentiated from the very short and fine intradorsocentral hairs which do not closely approach them; halteres fuscous *tasmaniensis*, n. sp.
- Thorax with two distinct pairs of dorsocentral bristles and sometimes a weak pair anterior to them which is not close to suture, the prescutellar pair of acrostichals sometimes not much longer than the hairs immediately in front of them, the latter usually quite prominent and approaching close to the prescutellars 8
8. Intradorsocentral hairs very fine and short, in six series; thorax fulvous yellow, shining, with a poorly defined greenish dorsocentral vitta which suffuses disc of scutellum also; palpi blackish at apices; anterior sternopleural well developed *fulvoviridis*, n. sp.
- Intradorsocentral hairs in four series, usually quite long, and always rather conspicuous; thorax not coloured as above; palpi usually yellow 9
9. Thorax and legs entirely fulvous yellow, the former usually with one pair of the acrostichals in front of the prescutellar pair quite long and strong; anterior sternopleural bristle of moderate length; face slightly concave in profile; abdomen usually yellowish at base, metallic blue-green beyond *flavipalpis*, n. sp.
- Thorax always largely black; legs usually partly blackened 10
10. Face quite conspicuously glossy and convex in centre; palpi yellowish testaceous *viridana*, n. sp.
- Face flat or slightly concave, very slightly or not at all shining 11
11. Palpi brownish or fuscous; head not broader than thorax; abdomen brilliant metallic blue-green *viridula*, n. sp.
- Palpi yellow; head distinctly broader than thorax; abdomen glossy black, without distinct metallic blue tinge *latifrons*, n. sp.



Text-fig. 1. *Incurviseta affinis*, apex of abdomen of male from side.
 Text-fig. 2. *Melanina plebeia*, head from side.
 Text-fig. 3. *Sapromyza ocellaris*, wing.

INCURVISETA MACULIFRONS (Macquart).

I have seen specimens which I refer to this species from various localities in Tasmania. The characters cited in the above synopsis ought to serve to distinguish it from the two next described species, which are similarly coloured and have the

distinctive frontal markings. The protuberant face of *maculifrons*, however, ought readily to identify the species. The hypopygium is similar to that of *affinis*, but the fore femora are sometimes entirely pale, and at best only browned, the mid and hind femora are not blackened at apices, the apices of all tibiae are black, as are the apices of mid and hind tarsi, and usually all of the fore tarsi.

Length, 3.4-5 mm.

Localities.—Magnet, Burnie, Mt. Wellington, Mt. Field, and Cradle Valley, Tasmania (A. M. Lea and A. L. Tonnoir).

INCURVISETA AFFINIS, n. sp. (Text-fig. 1.)

This is the species I previously identified and recorded as *maculifrons*.

Both species are testaceous yellow, with the ocellar spot, two large, elongate, and sometimes subtriangular, marks on frons, apices of tibiae and of tarsi, black.

In addition to the characters listed in the key *affinis* has the abdominal tergites each with a large black or fuscous mark on each side, including the apical one (Text-fig. 1), but sometimes, as in the Seaford specimen, the abdomen appears to be entirely blackened. The wings in both species are yellowish hyaline, and the arista in both are almost bare.

The close similarity of those two species and my evident misidentification of the one described by Macquart is but another argument against identifications of imperfectly described species except on the basis of type examination.

Length, 3.3-5 mm.

Type, Sydney, N.S.W., 30th Nov., 1924. Paratypes, Mooni, near Cotts, 14th Febr., 1925; Seaford, Victoria (G. F. Hill); and Burnie, Tasmania, 31st Jan., 1923 (A. L. Tonnoir).

INCURVISETA WILMOTI, n. sp.

This species is very similar to *affinis*, but the two black frontal marks are not so extensive, the black paired spots on abdomen are quite small and are confined to tergites 3 to 6 inclusive, and the legs are entirely yellow. Both these species have the four series of intradorsocentral hairs stronger and more regular than is the case in *maculifrons*, the outer two series in the latter being less complete and finer than the inner two. Only females of this species are available to me now.

Length, 3 mm.

Type and one paratype, Wilmot, Tasmania, 8th Jan., 1923 (A. L. Tonnoir).

INCURVISETA LATIFRONS, n. sp.

Female.—Head testaceous yellow, the frons more brownish and entirely shining, face white dusted, not shining; antennae and palpi testaceous yellow, arista fuscous. Thorax shining black, fulvous yellow on propleura, anterior margin, and on two vittae which extend along lines of dorsocentrals the whole length of mesonotum. Abdomen glossy black, with very faint indications of a bluish cast. Legs black, tarsi testaceous. Wings distinctly yellow, most noticeably on costa, the veins yellow. Calyptrae greyish, with black margins and fringes. Knobs of halteres black.

Head wider than thorax; frons about two-fifths of the head width and about as wide at vertex as long, slightly narrowed anteriorly; orbits not differentiated, anterior orbitals farther from eye than posterior pair; ocellars widely divergent, about as long as the postverticals; space between bases of antennae almost as great

as distance of either antenna from eye; third antennal segment not over 1.5 as long as wide; arista with very short pubescence; face almost flat; cheek with fine marginal hairs which extend some distance upward on sides of face. Thorax with two pairs of postsutural dorsocentral bristles, four series of intradorsocentral hairs, a pair of prescutellar acrostichals, two sternopleurals, and the propleural quite strong. Fore femur without an anteroventral comb; all tibiae with a distinct preapical dorsal bristle. Inner cross-vein at about two-fifths from apex of discal cell; ultimate section of fourth vein about 2.5 as long as penultimate.

Length, 5 mm.

Type, Wahroonga, Sydney, N.S.W., 31st Oct., 1926.

This species has the head wider, and the eyes more divergent below when seen from in front, than any other species of the genus now known to me.

INCURVISETA FLAVICEPS, n. sp.

Female.—Shining black, anterior extremity of central part of frons, the face, and cheeks, fulvous yellow, antennae a little darker; parafacials white dusted; bases of tarsi of mid and hind legs testaceous yellow. Wings brownish hyaline, slightly infuscated at bases. Calyptae and halteres fuscous.

Frons a little longer than wide, triangle and orbits sharply differentiated, all three extending to anterior margin of frons, the triangle narrow and about parallel-sided on its apical third or more; postvertical bristles shorter than the ocellars; anterior orbitals a little farther from eye than posterior pair; face quite prominently convex in centre, glossy; cheek about as high as length of antenna. Thorax with the two pairs of postsutural dorsocentrals rather short, the series continued forward as rather strong hairs, the intradorsocentral hairs in two series and rather long, posteriorly but little shorter than the prescutellar acrostichals; anterior sternopleural present; scutellum slightly flattened above. Abdomen stout, very weakly bristled. Legs as in *latifrons*. Inner cross-vein a little beyond middle of discal cell.

Length, 3 mm.

Type, Cradle Valley, Tasmania, 20th Jan., 1923 (A. L. Tonnoir).

The very prominently convex face and high cheeks might justify one in erecting a subgenus for the reception of this species but there is nothing to be gained by adopting this course without a fuller knowledge of the group.

INCURVISETA VITTIGERA, n. sp.

Female.—Head testaceous yellow, ocellar region with a narrow fuscous triangle; third antennal segment and aristae black; palpi yellow. Thorax testaceous yellow, a little darker on dorsum, and with two narrow blackish vittae along the lines of dorsocentrals from anterior margin to the anterior pair of postsutural dorsocentrals. Abdomen discoloured in type specimen, more brownish yellow than thorax. Legs testaceous, apices of fore and hind femora and tibiae, and of all tarsi, blackened. Wings hyaline. Halteres yellow.

Frons a little longer than wide, orbits a little shining, the anterior pair of bristles farther from eye than posterior pair, all bristles of moderate length; face slightly convex; cheek fully as high as width of third antennal segment. Thorax with two pairs of postsutural dorsocentrals and a rather strong setula representing a third pair, four series of short intradorsocentral hairs, one pair of prescutellar acrostichals, and only one distinct sternopleural. No preapical dorsal bristle distinguishable on hind tibia. Inner cross-vein a little beyond middle

of discal cell; ultimate section of fourth vein about twice as long as penultimate section.

Length, 3.5 mm.

Type, Mt. Wellington, Tasmania, 9th Nov., 1922 (A. L. Tonnoir).

Structurally very similar to *maculifrons*, but the face is not so distinctly convex, and if the absence of the preapical dorsal bristle from the hind tibia is a normal character, the species is readily distinguished.

INCURVISETA BISERIATA, n. sp.

Male and female.—Head testaceous yellow, ocellar spot, upper half of occiput except on sides, aristae, and apices of palpi, fuscous; frontal orbits very slightly shining; face very distinctly shining in centre, the parafacials dull. Thorax black, with a greenish tinge, humeral and propleural regions testaceous yellow, the entire surface with rather dense greyish dust. Abdomen coloured as thorax, but more noticeably green tinged, and less densely grey dusted. Legs testaceous yellow, blackened on most of fore femora, apices of hind femora and of fore and hind tibiae, less distinctly on mid tibiae, and on apices of tarsi, the fore pair almost all black. Wings hyaline. Halteres yellow.

Frons very slightly convex, all bristles distinct, the anterior orbitals closer together than the posterior pair; face quite prominently convex; cheek about as high as width of third antennal segment; arista with very short pubescence. Thorax with three pairs of postsutural dorsocentrals, the anterior pair short, the intradorsocentral hairs in two series, setulose and quite long, and the anterior sternopleural not developed; scutellum convex. Preapical dorsal bristle on fore and hind tibiae long and fine, the one on fore tibia fully as long as the basal segment of fore tarsus. Inner cross-vein very slightly beyond middle of discal cell and a little before apex of first vein; ultimate section of fourth vein twice as long as penultimate.

Length, 3.3-5 mm.

Type, male, and allotype, on same mount, and originally mounted in copula, Eaglehawk Neck, Tasmania, 15th Nov., 1922; paratypes, male and female, Launceston, Tasmania, 29th Oct., 1922 (A. L. Tonnoir).

INCURVISETA TASMANIENSIS, n. sp.

Female.—Head coloured as in *biseriata*, but the palpi almost entirely black. Thorax entirely black, shining, with a slight aeneous tinge, the dorsum slightly greyish dusted. Abdomen glossy black, with a more or less pronounced blue-green tinge. Legs black, knee-joints and bases of tarsi testaceous. Wings brownish hyaline. Knobs of halteres fuscous.

Head as in *biseriata*, but the face is slightly concave in profile, and the cheek is not as high as width of third antennal segment. Thorax with three pairs of outstanding postsutural dorsocentrals, the anterior one close to suture, and one pair of prescutellar acrostichals, the other hairs very short and fine, the intradorsocentrals in six series, but not continued to prescutellar acrostichals; both sternopleurals quite prominent; scutellum convex. Legs as in *biseriata*, but the preapical dorsal bristle on mid and hind tibiae shorter. Inner cross-vein usually a little beyond level of apex of first vein.

Length, 3.3-5 mm.

Type and one paratype, Cradle Valley, Tasmania, 17th Jan., 1923; two paratypes, same locality, 10th Jan., 1923 (A. L. Tonnoir).

INCURVISETA FULVOVIRIDIS, n. sp.

Female.—Head almost fulvous testaceous, frons slightly and almost evenly shining, the orbital stripes hardly distinguished, ocellar spot, arista, and apices of the palpi, fuscous; third antennal segment slightly darkened above. Thorax fulvous yellow, distinctly shining, and slightly whitish dusted, the dorsum with a faint greenish central suffusion or vitta which extends over disc of scutellum. Abdomen bright metallic blue-green. Legs fulvous yellow, slightly darkened on apices of fore tibiae and fore tarsi. Wings yellowish hyaline. Halteres yellow, knobs brownish.

Frons a little wider than long, anterior orbitals quite small and fine, and separated by less than twice the distance either is from eye; face quite noticeably concave in profile; cheek about as high as width of third antennal segment. Thorax with only two pairs of postsutural dorsocentrals, the anterior pair much shorter than the posterior, one pair of prescutellar acrostichals, six series of short fine intradorsocentral hairs, and both the sternopleurals strong; scutellum convex. All tibiae with a preapical dorsal bristle, the hind pair with the short hairs near apex on posteroventral side denser than usual, and erect. Inner cross-vein slightly before middle of discal cell and apex of first vein; last section of fourth vein not over 1.5 as long as penultimate section.

Length, 3 mm.

Type, Cradle Valley, Tasmania, 16th Jan., 1923 (A. L. Tonnoir).

INCURVISETA FLAVIPALPIS, n. sp.

Male.—Similar to the last preceding species in colour, the head, thorax, and legs being almost fulvous yellow, and the abdomen metallic blue-green. The antennae and palpi are, however, entirely pale, and there is no greenish central suffusion on the thorax.

Structurally the two species are very similar, but the frons is about as long as wide and more shining, the thorax has a short anterior third pair of postsutural dorsocentrals, all the hairs longer, the intradorsocentral series four in number and usually a pair of those in front of the prescutellar acrostichals quite long, while the anterior sternopleural is shorter. Inner cross-vein at or very close to middle of discal cell; ultimate section of fourth vein about twice as long as penultimate section.

Length, 3.3-5 mm.

Type, Geeveston, Tasmania, 7th Dec., 1922; paratypes; two, Eaglehawk Neck, Tasmania, 22nd to 27th Nov., 1922; one, Burnie, Tasmania, 5th Oct., 1922 (A. L. Tonnoir).

INCURVISETA VIRIDANA, n. sp.

Male.—Head fulvous testaceous, parafacials paler, dull; frontal orbits shining, face glossy; arista and ocellar spot fuscous. Thorax fuscous, with a greenish tinge, humeral angles, propleural and postalar regions, yellowish, the whole slightly grey dusted. Abdomen metallic blue-green. Legs fulvous testaceous, rather obscurely darkened on most of fore femora, apices of fore tibiae and tarsi, and apices of hind femora and tibiae. Wings hyaline. Halteres yellow.

Frons subquadrate; orbits a little differentiated, the anterior bristles quite long, separated by a distance about four times as great as that of either from eye; face quite prominently convex; cheek as high as width of third antennal segment. Thorax with two pairs of postsutural dorsocentrals and a weaker pair in front of

these; intradorsocentral hairs quite long, in four series, the outer two series not regular; anterior sternopleural bristle short but distinct. Outer cross-vein a little beyond middle of discal cell and distinctly before apex of first vein; ultimate section of fourth vein twice as long as penultimate section.

Length, 3.5 mm.

Type and paratype, Mt. Wellington, Tasmania, 25th Nov., 1922 (A. L. Tonnoir).

INCURVISETA VIRIDULA, n. sp.

Very similar to *viridana*, but the palpi are blackened at apices, the thorax has only two distinguishable pairs of postsutural dorsocentrals, and the four series of intradorsocentral hairs are quite regular and the hairs are short and quite even. The face is a little concave instead of prominently convex.

Length, 3.3-5 mm.

Type, Cradle Valley, Tasmania, 24th Jan., 1923; paratype, Fern Tree, 10th Nov., 1922 (A. L. Tonnoir).

7. Genus POECILOHETAERELLA Tonnoir and Malloch.

This genus was described for the reception of some New Zealand species and no representative of it has been seen from either Tasmania or Australia.

8. Genus POECILOHETAERUS Hendel.

This genus was originally erected for the reception of an Australian species, *decora* Schiner, which was renamed *schineri* by Hendel. The species was originally recorded as from New Zealand but it does not occur there. There is a second species referred here, *punctifacies* Tonnoir and Malloch, which occurs in New Zealand.

9. Genus CERATOLAUXANIA Hendel.

This recently erected genus contained originally only *tetanocerina* Hendel, but I have now before me a second species, from Tasmania.

The genus is very similar to *Paratauxania* as represented by the Australian forms, but is distinguished from it by the lanceolate arista, which is densely short haired.

I have not seen the genotype, but it is evidently distinct from the present species.

CERATOLAUXANIA TASMANIENSIS, n. sp.

Male.—Head fulvous yellow, glossy, much shrunken in the type specimen which is immature, but the following colour markings are evident: ocellar spot and orbital stripes darkened, a black spot between each antenna and eye, with white dusting below it; third antennal segment and arista fuscous. Thorax shining black, fulvous anteriorly. Abdomen shining black. Legs black, apices of tibiae, and the tarsi, testaceous yellow, fore tarsi apparently darkened from before tip of first to tip of fourth segment. Wings hyaline, bases narrowly black. Halteres black.

Ocellar bristles short; anterior orbitals lacking; third antennal segment not as much tapered as in genotype, almost imperceptibly narrowed apically, about three times as long as its basal width; vertical bristles long. Thorax with two pairs of postsutural dorsocentrals; scutellum convex. Inner cross-vein at middle

of discal cell and below apex of first vein; penultimate section of fourth vein about three-fifths as long as ultimate section.

Length, 4 mm.

Type, Mt. Wellington, Tasmania (A. M. Lea).

In *tetanocerina* Hendel the third antennal segment is browned at apex only, the thorax is blackened on dorsum only posteriorly, the legs are black-brown, with the tips of the tibiae and tarsi reddish yellow. This species was described from Victoria.

10. Genus PARALAUXANIA Hendel.

I have placed some Australian species in this genus because they agree with the genotype in having but one pair of orbital bristles. I have recently examined the genotype and though it is a duller coloured species than those from Australia it has no very striking characters by means of which it can be distinguished from them apart from colour and the presence of dusting on the face. I propose to retain the generic name for the two species already included in this genus from Australia and for some others now dealt with, but at some future time when the relationships of the species of the family are better known it may be that some other disposition may have to be made of the Australian species or some part of them.

Below I present a key to the species as I have aligned them.

Key to the Species.

1. Thorax fulvous yellow, with three black dorsal vittae, the median one continued to near apex of scutellum, the laterals not reaching posterior margin of mesonotum, and with only two series of intradorsocentral hairs, one on each lateral margin of the central vitta, the notopleural suture, and a large triangle on sternopleura blackish; abdomen metallic blue-green; legs yellow, fore femora, tibiae, and tarsi deep black, the fore tarsi thickened *atrimana*, n. sp.
 Thorax largely black, or if fulvous yellow then not marked with black vittae, and always with at least four series of intradorsocentral hairs; fore tarsi not noticeably thickened 2
2. Thorax fulvous yellow, slightly darkened on middle posteriorly, on disc of scutellum, and along notopleural suture, and with three pairs of strong postsutural dorso-central bristles, the anterior pair close to suture and without strong setulae in front of it; mid and hind femora dirty yellow *flavipennis*, n. sp.
 Thorax with the greater part of its surface blackened, and with two or three pairs of postsutural dorsocentral bristles, when three pairs are present the anterior pair is much shorter than the others and quite far from suture, with some strong setulae in front of it 3
3. Mid and hind femora yellow; frons longer than wide, shining fulvous yellow, with narrow fuscous lines along both sides of the orbital plates, across anterior margin of frons, and down its centre *scripta*, n. sp.
 All femora deep black; frons of variable width, but never marked with fuscous lines as in above species 4
4. Frons distinctly longer than wide, shining, uniformly fulvous yellow, with only a black ocellar spot; no dark mark at upper extremity of each parafacial close to antennal bases, but a quite distinct one at lower extremity of each against the eye; ocellar bristles extremely small and fine; palpi entirely bright fulvous yellow *fulviceps* Malloch.
 Frons blackened on more than the ocellar spot; parafacials with a dark mark at upper extremity close to bases of antennae 5
5. Frons widest at anterior margin where it is about 1.5 as wide as its length at middle; ocellar bristles widely divergent and not half as long as the postvertical pair; parafacial with an upper and a lower black mark; wings quite conspicuously blackened across anal angles; fore metatarsus whitish, blackened at apex *elevata* Fabricius.

- Frons subquadrate; ocellar bristles quite large, as long as the postverticals; parafacial with a dark mark at upper extremity close to base of antenna, but without one at lower extremity; wings blackish at bases, but without a noticeable black mark across anal angles 6
6. Fore tarsi entirely black; palpi fuscous at apices *nigrimana*, n. sp.
 Fore tarsi black, basal three-fourths or more of the basal segment testaceous; palpi yellow *flavipalpis*, n. sp.

PARALAUXANIA ATRIMANA, n. sp.

Male and female.—Head fulvous yellow; frons glossy, ocellar spot black; face glossy, parafacials rather densely white dusted; inner mouth margin with a dark transverse line; antennae and palpi fulvous yellow; arista fuscous. Thorax shining fulvous or orange-yellow, with three black vittae, the central one carried over the scutellum almost to apex, the lateral pair not extending to hind margin of mesonotum, a blackish vitta along the notopleural suture, and a large triangular fuscous mark on the sternopleura. Abdomen brilliant metallic blue-green, the sternites yellowish. Legs concolorous with thorax, fore pair except the coxae deep black. Wings yellowish hyaline, faintly darkened at bases behind. Halteres dark brown at apices.

Frons a little longer than wide; ocellar bristles about half as long as the postvertical pair; anterior orbitals not distinguishable; face slightly convex, and receding a little below; antennae large, third segment tapered slightly to apex and over three times as long as its basal width; arista with extremely short pubescence; cheek about as high as width of third antennal segment. Thorax with two distinct pairs of postsutural dorsocentral bristles and a series of setulae in front of them, the posterior one of the series rather strong, one pair of strong prescutellar acrostichals, two series of intradorsocentral hairs, the anterior sternopleural very weak, and the propleural bristle minute; scutellum slightly elongated. Legs normal, but the fore tarsi much thicker than in any other species of the genus known to me, the basal segment fully as thick as apex of tibia. Inner cross-vein at middle of discal cell.

Length, 4.4-5 mm.

Type, male, Wahroonga, Sydney, N.S.W., 31st Oct., 1926; male paratype, Eaglehawk Neck, Tasmania, 23rd Nov., 1922; allotype and two paratype females, Cradle Valley, Tasmania, 11th, 13th, 16th Jan., 1923; one female paratype, Mt. Wellington, Tasmania, 29th Nov., 1922 (A. L. Tonnoir).

PARALAUXANIA FLAVIPENNIS, n. sp.

Female.—Head fulvous yellow; frons shining, ocellar spot black, subtriangular; parafacials white dusted, slightly browned opposite bases of antennae; face shining; antennae and arista black, third segment of former a little reddish at base; palpi black, yellow at extreme bases. Thorax shining fulvous yellow, slightly darkened in centre of hind margin and on disc of scutellum, and with a dark vitta on notopleural suture. Abdomen glossy bluish black. Legs fulvous yellow, apices of fore femora, most of fore tibiae, and all of fore tarsi, apices of hind tibiae, and of mid and hind tarsi, obscurely browned. Wings deep honey yellow, brown at extreme bases. Knobs of halteres brown.

Frons a little wider than long; ocellar bristles much longer than the postverticals and posterior orbitals; anterior orbitals represented by a pair of microscopic fine hairs; face rather sharply convex vertically; receding below in profile; cheek higher than width of third antennal segment; antennae not as long as in *atrimana*, the third segment tapered apically and about 2.5 as long as its

basal width; arista subnude. Thorax with three pairs of strong postsutural dorso-central bristles, the anterior pair close to suture, one pair of strong prescutellar acrostichals, the surface hairs quite short, the intradorsocentral series six in number, and the anterior sternopleural and propleural bristles long; scutellum semicircular. Legs normal, fore tarsi not noticeably thicker than the other pairs. Inner cross-vein close to middle of discal cell; outer cross-vein and ultimate section of fourth vein slightly sinuate.

Length, 4.5 mm.

Type, Cradle Valley, Tasmania, 17th Jan., 1923 (A. L. Tonnoir).

A stronger development of the anterior pair of orbital bristles might incline one to place this species in the genus *Sapromyza*.

PARALAUXANIA SCRIPTA, n. sp.

Male.—Head fulvous yellow; frons shining, with a central fuscous vitta which is widest behind, a fuscous line around the orbital plates except posteriorly, and one across anterior margin above antennae which connects with the dark mark on upper extremity of each parafacial; face shining; parafacial white dusted, with a dark mark at upper and another at lower extremities; antennae and palpi fulvous yellow; aristae fuscous. Thorax blackish, with a green lustre, becoming fulvous anteriorly. Abdomen metallic blue-green. Legs dusky fulvous yellow, the fore pair more obscured, but without sharply defined markings. Wings yellowish hyaline, more yellow anteriorly. Halteres fuscous.

Frons a little longer than wide; ocellar bristles widely divergent and about as long as postvertical pair; anterior orbitals represented by weak microscopic hairs; face convex above in middle, depressed near mouth; cheek about as high as width of third antennal segment; antennae smaller than *atrimana* and *flavipennis*, third segment but little tapered apically and about twice as long as its width at base; arista subnude. Thorax with three pairs of postsutural dorsocentrals, the anterior pair weak and short, well behind suture, four series of rather long and unevenly spaced intradorsocentral hairs, the anterior sternopleural and propleural bristles rather long.

Length, 4 mm.

Type, Cradle Valley, Tasmania, 23rd Jan., 1923 (A. L. Tonnoir).

PARALAUXANIA FULVICEPS Malloch.

Since describing this species I have seen additional specimens from Wahroonga, Sydney, N.S.W., 24th Oct., 1926.

PARALAUXANIA ELEVATA Fabricius.

Mr. Tonnoir has sent me a specimen of this species from Adventure Bay, Tasmania, 29th Dec., 1922. Originally the species was not definitely recorded from any locality, but Hendel gives it from Nova Cambria and New South Wales. I have seen only Tasmanian specimens so far.

PARALAUXANIA NIGRIMANA, n. sp.

Female.—Head fulvous yellow; frons shining, rather extensively blackened round ocelli and on anterior extremities of orbital plates; parafacials white dusted, with a brown mark at upper extremity of each; face shining; antennae largely infuscated, third segment palest below basally; arista fuscous; palpi black at apices. Thorax shining black, yellow on humeral angles and propleura, and with

slight greyish dust. Abdomen glossy black. Legs black, mid and hind tarsi testaceous at bases. Wings yellow, blackened at bases, the dark shade hardly showing on anal angle. Halteres black.

Frons slightly depressed near front, and about as long as wide, entirely glossy; ocellar bristles as long as postverticals; anterior orbitals represented by microscopic hairs; antennae as in *scripta*; face slightly convex; cheek as high as width of third antennal segment. Thorax as in *scripta*, but the four series of intradorsocentral hairs are shorter and quite regular. Inner cross-vein at middle of discal cell.

Length, 5 mm.

Type, Cradle Valley, Tasmania, 12th Jan., 1923 (A. L. Tonnoir).

PARALAUXANIA FLAVIPALPIS, n. sp.

Male and female.—Similar to *elevata* and *nigrimana* in general colouration, but the palpi are entirely yellow, and the wings are not conspicuously blackened at bases, the anal angle being almost without a dark suffusion.

Like *nigrimana*, a more slender species than *elevata*, with narrower frons, shorter third antennal segment, and the characters cited in the foregoing key to species. The anterior pair of orbitals are entirely lacking in this species.

Length, 4 mm.

Type, male, Wahroonga, Sydney, N.S.W., 31st Oct., 1926; allotype, same locality, 24th Oct., 1926; female paratype in poor condition, Jenolan Caves, Nov., 1910 (J. B. Cleland).

11. Genus TRIGONOMETOPSIS Malloch.

I have seen but one species of this genus, the genotype, *binotata* Thomson, which appears to be not uncommon in New South Wales.

12. Genus MELANINA, novum.

This genus is similar to *Sapromyza* Fallen in the thoracic and wing characters, but the head is of entirely different structure, the frons being more or less depressed in front, entirely shining, with the orbital stripes a little more highly polished, the anterior pair of orbital bristles is smaller than the posterior pair, and are backwardly curved, the other bristles are all present, the face is highly polished and very distinctly convex (Text-fig. 2), arista pubescent; thorax without any presutural dorsocentrals. Genotype, *Melanina plebeia*, n. sp.

Key to the Species.

1. Inner cross-vein of wing at about one-third from apex of discal cell; apical two segments and a part of third of mid and hind tarsi fuscous, the rest pale yellowish testaceous; frons quite broadly yellowish in front, the anterior pair of orbital bristles very small and weak; only one pair of prescutellar acrostichals developed; scutellum with microscopic pile on entire surface *major*, n. sp.
- Inner cross-vein of wing at or very close to middle of discal cell; only the apical segment of mid and hind tarsi fuscous, the basal four segments pale yellowish testaceous; frons usually almost entirely black or very narrowly yellowish in front, the anterior pair of orbital bristles distinct 2
2. Only one irregular series of bristles besides the acrostichal two series, i.e., the intradorsocentral hairs in four series; scutellum with microscopic pile on entire surface, not appearing highly polished on disc *quadriseriata*, n. sp.
- Intradorsocentral hairs in six series 3
3. Scutellum with microscopic pile on margin only, highly polished on disc; colour deep glossy black; thorax with one or two of the pairs of intradorsocentral hairs developed bristle-like in front of the prescutellar acrostichals *plebeia*, n. sp.

Scutellum with a shagreened or dusted appearance and not highly polished on disc, under a very high power lens appearing as microscopically pilose; colour metallic blue-black or greenish black, the dorsum of thorax noticeably greenish posteriorly, and the face distinctly purplish or violaceous when seen from above; all the intradorsocentral hairs short *aenescens*, n. sp.

All the species are very similar in colour and structure, being distinguished essentially by the characters cited in the foregoing key. The general colour is glossy black, sometimes with a metallic blue or green tinge, the legs are black, with bases of the mid and hind tarsi testaceous yellow, the wings are yellowish hyaline, sometimes with the bases more or less distinctly infuscated to apices of the basal cells, the knobs of the halteres are black, antennae entirely fulvous yellow, and the aristae and palpi fuscous. In the brief descriptions below only the differentiating characters are noted.

MELANINA MAJOR, n. sp.

Male.—Deep glossy black, the frons bright orange yellow in front, becoming brownish above middle, but the interfrontalia distinct from the glossy black orbital stripes and the ocellar spot on all parts when seen from in front. The intradorsocentral hairs are short and in six series.

Length, 3.25 mm.

Type, Wahroonga, Sydney, N.S.W., 24th Oct., 1926.

MELANINA QUADRISERIATA, n. sp.

Male.—A deep glossy black species, which is rather more slender than the others in the genus and has the frons almost entirely black. The other characters may be gleaned from the key.

Length, 2.5 mm.

Type, Wahroonga, Sydney, N.S.W., 17th Oct., 1926.

MELANINA PLEBEIA, n. sp. (Text-fig. 2.)

Male and female.—Similar in colour and general habitus to *quadriseriata*, but the intradorsocentral hairs are in six series, and the frons is distinctly yellow on anterior margin. The hypopygium of this and of the next species are similar.

Length, 2.5-3 mm.

Type and six paratypes, Wahroonga, Sydney, N.S.W., 17th to 24th Oct., 1926.

MELANINA AENESCENS, n. sp.

Male and female.—Distinguished from *plebeia* by the characters cited in the key. The frons is rather more distinctly yellowish on anterior margin and the third antennal segment is less than 1.5 as long as wide, while in *plebeia* it is rather more than 1.5.

Length, 2.5-3 mm.

Type and eight paratypes, Cronulla, N.S.W., December, 1925 (H. Petersen).

13. Genus RHAGADOLYRA Hendel.

This monobasic genus is unknown to me. The genotype is *handlirschi* Hendel.

14. Genus SAPROMYZA Fallen.

I have before me several undescribed species of this genus, but consider it is not an opportune time to present a new key to the species as I have but recently published one in These PROCEEDINGS (1926, p. 34). Under each species described in this paper I discuss the characters by means of which the species is separated

from the one to which it runs in the key, and believe that with these notes in hand students may be able to identify reliably such species as are already described. There are yet many species of the genus to be discovered and every lot received by me has in it species unknown to me, so that any key presented now will of necessity prove quite inadequate for the identification of a host of species occurring in Australia, and especially those from the west and north, which are very sparingly represented in the material available to me at this time.

SAPROMYZA PLUMISETA, n. sp.

Male.—Frons orange yellow centrally, orbits, vertex, and triangle, fuscous, whitish dusted; face and cheeks testaceous yellow, with greyish dust, parafacial suture slightly darkened, a dark spot between each antenna and eye; occiput fuscous, grey dusted; antennae fulvous yellow; aristae and the hairs black; palpi fuscous. Thorax fuscous, more yellowish on sides anteriorly, dorsum with dense grey dust, two practically complete submedian vittae between acrostichals and dorsocentrals, two narrow interrupted vittae laterad of the dorsocentrals, and two partial sublateral vittae behind the suture; disc of scutellum suffused with brown. Abdomen blackish, distinctly shining, faintly grey dusted. Legs testaceous, at least the fore femora darkened. Wings greyish hyaline, with a broad costal fuscous cloud which begins at apex of auxiliary vein and extends to tip of wing, becoming obsolete posteriorly in the submarginal and first posterior cells on disc of wing, and not connecting with the more conspicuous fuscous clouds over the inner and outer cross-veins nor the fainter one over bases of second section of third and fourth veins, but suffusing entire apex of wing to behind fourth vein.

Frons about 1.25 as long as wide; orbits well differentiated, anterior orbital bristles closer together than posterior pair; all frontal bristles long; third antennal segment about 1.5 as long as its basal width; arista plumose; face sharply convex. Thorax with 1+3 dorsocentrals and 1+4 acrostichals; scutellum flat above. Fore femur with an anteroventral comb; all tibiae with preapical dorsal bristle; mid tibia with two apical ventral bristles. Inner cross-vein at two-fifths from apex of discal cell, and noticeably beyond apex of first vein; ultimate section of fourth vein about twice as long as penultimate section.

Length, 3 mm.

Type, Woy Woy, November, 1921 (A. L. Tonnoir).

SAPROMYZA PETERSENI, n. sp.

Female.—Head testaceous yellow; interfrontalia brown, becoming orange-red at anterior margin; orbits, and sides of triangle behind, densely whitish grey dusted, the former as wide as interfrontalia in front and extending to eyes; a deep brown mark between each antenna and eye, and another on occiput behind each eye which does not descend below level of eye; upper part of cheek silvery white dusted; face with a slight dark mark in each antennal fovea; antennae testaceous, third segment and aristae missing in type; palpi fuscous. Thorax fuscous, yellowish on humeri, densely pale grey dusted, mesonotum with two narrow dark brown vittae between the acrostichals and dorsocentrals, which fuse at posterior margin and continue as one almost to apex of the scutellum, and two much broader sublateral vittae of same colour; pleura with a pale-dusted vitta extending backward from prothoracic spiracle. Abdomen fuscous, slightly shining, densely grey dusted, each tergite except the first visible one with a dark brown irregular basal fascia. Legs testaceous, fore femora, and a subbasal and apical ring on each tibia,

fuscous. Wings hyaline, with a blackish cloud from apex of auxiliary vein to tips which extends inward over second vein at base, then over third vein from beyond the cloud over inner cross-vein, connects with a fuscous mark on middle of apical section of fourth vein, and extends round apex of wing to fourth vein, but does not connect with the clouds on the cross-veins; a dark cloud over the veins above base of discal cell, and fainter marks in second posterior and anal cells. Halteres yellow.

Frons about 1.5 as long as wide; ocellar bristles almost as long as frons; anterior orbital bristles very little farther from eyes than posterior pair; frons protuberant in front in profile; face carinate above, slightly receding below; cheek a little higher than length of frons in front of eye; antennae broken off in type. Thorax with bristles as in the preceding species. Fore femur with an antero-ventral comb; all tibiae with a short preapical dorsal bristle; mid tibia with one apical ventral bristle. Inner cross-vein at about two-fifths from apex of discal cell.

Length, 3 mm.

Type, Cronulla, N.S.W., December, 1925 (H. Petersen).

This species, which is named in honour of the collector, is placed with some doubt in *Sapromyza* as the third antennal segment is lacking in the type. The specimen was received from Dr. C. F. Baker, of the Philippine College of Agriculture, in a miscellaneous lot of insects and fragments of flowers, etc., collected by sweeping and shipped dry in a mass in a tin box. A number of other species described by me were received in the same manner.

This and *S. plumiseta* belong to a group in which there are four pairs of strong dorsocentral thoracic bristles and distinct wing markings present. I have described only one such Australian species, *suffusa* (These PROCEEDINGS, 1926, p. 37), and from it these two may be distinguished by the presence of an antero-ventral comb on the fore femora, and the strong biseriate acrostichal setulae. Possibly both species have the aristae plumose but it is impossible to say as to *peterseni*; *suffusa* has the arista pubescent.

SAPROMYZA HIEROGLYPHICA, n. sp.

Female.—Head testaceous, densely greyish yellow dusted; frons with a blackish brown spot at base of each bristle and a streak on each side from base of inner vertical to ocellar bristle which runs forward alongside of the narrow grey triangle to anterior margin, and then sends a branch diagonally backward to near eye between the orbital bristles; face with similarly coloured streaks on parafacial sutures, across lower margin, and on each side of central line of face, the two latter connected above and below middle; antennae testaceous yellow; aristae and palpi fuscous, the latter pale at tips. Thorax brownish testaceous, slightly shining, with patches of dense whitish grey dusting on disc and pleura, those on disc outlining two broad submedian vittae and a number of connected markings laterad of them; scutellum dark brown, with a spot of whitish dust in front of base of each basal bristle. Abdomen shining testaceous, darker at bases of the tergites. Legs testaceous, fore femora largely brown, mid and hind pairs and all tibiae brown near bases and apices, third and fourth segments of fore tarsus fuscous. Wings yellowish hyaline, fuscous from bases to apices of basal cells and beyond humeral vein. Knobs of halteres fuscous.

Frons subquadrate, all bristles strong, anterior orbitals close to anterior margin and not farther from eyes than posterior pair; antennae normal; arista

pubescent; face flat. Thorax with 1+3 pairs of strong dorsocentrals, two intradorsocentral series of short closely placed hairs, a pair of strong prescutellar acrostichals, and two strong sternopleurals. Fore femur without a distinct comb; all tibiae with preapical dorsal bristle, mid pair with one apical ventral bristle. Inner cross-vein at about one-third from apex of discal cell; last section of fourth vein three times as long as penultimate section.

Length, 4.4-5 mm.

Type and one paratype, Donnybrook, W.A., 29th Aug., 1926 (E. W. Ferguson).

Belongs to the same group as *plumiseta* and *peterseni*, but closer to *suffusa*, the arista being pubescent, and the intradorsocentral hairs short and fine. It is distinguished from *suffusa* by the presence of fuscous markings on the wings being confined to the bases, and by the thoracic markings.

SAPROMYZA OCELLARIS, n. sp. (Text-fig. 3.)

Male and female.—Head testaceous, frontal orbits, face, and cheeks, densely white dusted, interfrontalia yellow, ocellar spot, a line along inner margin of each orbital stripe, and a triangular mark between each antenna and eye, velvety black; face with a pair of brown spots at middle; antennae, aristae, and palpi, black; occiput with a dark mark behind upper angle of each eye, and a brown streak on lower half. Thorax dull brownish, or testaceous yellow, densely grey dusted, dorsum with four dark brown vittae, the submedian pair fused behind and carried on to disc, but not to apex, of scutellum; pleura with the following dark brown marks; a streak on upper margin of mesopleura, another on its lower margin, a third one below sternopleural bristles, and two spots on centre of mesopleura. Abdomen coloured as thorax, tergites with a dark central vitta, and dark spots at bases of the larger bristles. Legs testaceous, femora sometimes brownish or fuscous, fore legs from near bases of tibiae, apices of mid and hind tibiae and tarsi black. Wings with many dark brown markings, many of them ocellate (Text-fig. 3). Halteres yellow.

Frons a little longer than wide, all bristles long, orbits broad and distinct; face in profile quite prominent above, with a transverse impression below; third antennal segment about twice as long as wide; arista with rather dense hairs, the longest less than half as long as width of third antennal segment. Thorax with three pairs of dorsocentral bristles, the anterior pair close to suture, the intradorsocentral hairs in four series, the inner two rather long, the outer two irregular, and the prescutellar acrostichal pair long; scutellum flat, rather long. Fore femur with a very weak anteroventral comb; mid tibia with three apical ventral bristles, one much weaker than the others.

Length, 3.4 mm.

Type, male, allotype, and one male and one female paratypes, Burnie, Tasmania, 24th and 27th Oct., 1922; paratypes, two, Adventure Bay, Tasmania, 27th Dec., 1922, and 1st Jan., 1923; one, Geeveston, Tasmania, 8th Dec., 1922; one, Eaglehawk Neck, Tasmania, 3rd Nov., 1922; one St. Patrick R., Tasmania, 30th Oct., 1922; one, Adelaide, S.A., 20th Oct., 1921 (A. L. Tonnoir).

This species runs to section 20 in my published key to the species of this genus, but is distinguished from any species in the subsequent part of the key, and in fact from any other Australian species, by the wing markings.

SAPROMYZA AVICOLA, n. sp.

Male.—Belongs to the group in which *regalis* Malloch occurs, running to this species in my published key. It differs from *regalis* in having the humeri normal,

not exceptionally prominent, with one long bristle and a few very weak hairs, and the hairs on adjoining region sparse and fine close to humerus, becoming more numerous and stouter beyond, but not so conspicuous as in *regalis*. The post-humeral bristle is quite short. Inner cross-vein at a point about one-fourth from apex of second costal division. Mid tibia with one apical ventral bristle.

Length, 6 mm.

Type, Eaglehawk Neck, Tasmania, 18th Nov., 1922 (A. L. Tonnoir).

SAPROMYZA TONNOIRI, n. sp.

Male.—Glossy fulvous yellow, entire frons shining; ocellar spot, two sub-triangular spots near centre of face, and usually one near each vibrissal region, fuscous; antennae and palpi yellow; arista fuscous. Abdomen glossy black on dorsum except the basal tergite. Legs and halteres yellow. Wings hyaline.

Frons broader than long, slightly convex, all bristles present, anterior orbitals much weaker than the posterior pair; face slightly convex; arista pubescent. Thorax with the dorsocentrals arranged 1+3, and usually a similar number of acrostichals, the latter rather irregular and not strong; sternopleurals 2; scutellum rather short and convex. Fore femur without an anteroventral comb; all tibiae with a preapical dorsal bristle, mid tibia with one apical ventral bristle. Inner cross-vein much beyond level of apex of first vein, and about two-fifths from apex of discal cell; ultimate section of fourth vein about twice as long as penultimate section.

Length, 2.75-3.25 mm.

Type, Launceston, Tasmania, 9th Oct., 1922; single paratypes, Wilmot, Tasmania, 8th Jan., 1923; Hobart, Tasmania, 4th Jan., 1923; and Zeehan, Tasmania, 7th Feb., 1923 (A. L. Tonnoir).

This species runs to section 5 in my published key to the species of this genus, but is distinguished from any species between that section and 8, in which all those with four pairs of dorsocentral bristles and unmarked wings are included, by the marked face, fulvous yellow thorax, and pubescent arista.

SAPROMYZA STRAHANI, n. sp.

Male.—Fulvous yellow, thorax and abdomen glossy. Frons with the orbital stripes a little more shining than remainder of frons, ocellar spot fuscous; face shining, whitish dusted on sides; antennae and arista black, third segment of former a little reddish at base; palpi yellow, darkened at apices. Thorax with a faint dark streak along upper margin of mesopleura. Abdominal tergites in type specimen slightly dark at apices. Legs black, all coxae, mid and hind femora except their apices, bases of mid tibiae, and basal segment of fore and hind tarsi, yellow. Wings slightly and almost evenly smoky, darkest along costa. Halteres yellow.

Frons a little wider than long, orbits slightly differentiated; ocellar bristles microscopic; anterior pair of orbitals about half as long as posterior pair, much closer together than these, distance between them not much greater than distance of either from eye; third antennal segment slightly tapered, about twice as long as its basal width; arista microscopically pubescent; face almost flat, and a little receding below. Thorax with three pairs of strong dorsocentrals, the anterior pair close to suture, intradorsocentral hairs very short, in four series in front only, and the inner postalar and anterior sternopleural bristles weak. Fore femur with an anteroventral comb; all tibiae with a preapical dorsal bristle; mid pair

with one long apical ventral bristle. Inner cross-vein slightly beyond middle of discal cell and level of apex of first vein; ultimate section of fourth vein not over 1.5 as long as penultimate section.

Length, 4 mm.

Type, Strahan, Tasmania, 6th Feb., 1923 (A. L. Tonnoir).

This species runs to section 23 in my key but is distinguished from any in the subsequent part of key by the fulvous yellow thorax, which is not dusted nor vittate.

SAPROMYZA FLAVODORSALIS, n. sp.

Male and female.—Head testaceous yellow; frons orange-yellow, shining only on the orbital stripes, the latter, vertex, and ocellar region, greyish dusted; ocellar spot and upper occiput fuscous, grey dusted; antennae and arista black; basal antennal segment rufous; palpi black. Thorax fuscous, dorsum, including the humeral angles, fulvous testaceous, the whole greyish dusted, dorsum shining. Abdomen fuscous, slightly shining, with dense even grey dust. Legs testaceous yellow, blackened on all of fore femora and bases of mid and hind pairs, all except bases of fore tibiae, and the apices of mid and hind pairs; all of fore tarsi and the apices of mid and hind pairs. Wings yellowish hyaline. Halteres yellow.

Frons not longer than wide, with some microscopic black surface hairs, all bristles distinct; anterior orbitals about one-third from anterior margin of frons and farther from eyes than posterior pair; third antennal segment rather wide at base, tapered to apex, and not twice as long as its basal width; arista practically bare; face concave in profile, a little receding below; cheek not as high as width of third antennal segment. Thorax with three pairs of postsutural dorsocentral bristles, the anterior pair quite short and rather close to suture, the hairs anterior to the bristles quite long and strong so that sometimes there may be four, or even more, almost bristle-like; intradorsocentral hairs biseriate, two or three of the pairs behind, and sometimes even up to or in front of suture, quite long, and laterad of these two series there are usually some scattered short hairs so that in some cases the hairs may appear quadriseriate; sternopleurals two. Fore femur without an anteroventral comb; all tibiae with distinct preapical dorsal bristle, mid pair with one long and one very short apical ventral bristle. Wings narrow; inner cross-vein very slightly before the middle of discal cell and distinctly before apex of first vein; ultimate section of fourth vein not over 1.5 as long as penultimate section.

Length, 4 mm.

Type, male, and allotype, Mt. Field, Tasmania, 21st Dec., 1922 (A. L. Tonnoir).

If this species is accepted as having the anterior pair of postsutural dorsocentrals much weaker than the posterior two pairs, which is evidently the case, it will run to section 11 in my key, but it differs from any species in the sections between 11 and 19 inclusive in having the mesonotum fulvous testaceous and the pleura and metanotum fuscous. If it is placed amongst the species with three strong pairs of postsutural dorsocentrals it will run to section 23, but, like *strahani*, it differs from any included in the subsequent sections in the colour of the thorax.

15. Genus *TRYPANEOIDES* Tonnoir and Malloch.

This genus contains, so far as I know at present, species which are as a rule a little smaller than the average of those in *Sapromyza*, some being less than 2 mm.

in length, and the wings of the known species are always conspicuously pictured. The presence of a strong bristle on middle of the mesopleura, which is always more or less downwardly directed, readily distinguishes the genus from any other except one which occurs in Formosa. The species very closely resemble small Trypetidae. There are no species of the genus known to me from Australia, the genotype was described from New Zealand, but there are about a dozen species distributed throughout the Orient.

16. Genus HOMONEURA van der Wulp.

I have in the press a paper in which I erect some new subgenera of this genus and two of the species now before me from Australia are used as the types of new subgenera in this paper.

HOMONEURA (EUHOMONEURA) ORNATIPENNIS (de Meijere).

I have compared the type specimen of this species with that of *atrogrisea* Malloch and can find no characters that would justify me in distinguishing them as different species. Originally the species was described from the Nederland Indies and its occurrence in Australia may be due to commerce, though there is nothing yet known of its larval and pupal stages to indicate how it may be transported.

I erect for this species and three others which occur in the Orient the new subgenus, *Euhomoneura*, with *ornatipennis* as type.

The distinguishing character is found in the dorsocentral bristles of thorax which are arranged 1+2. The most closely related subgenus is *Xenohomoneura* described below and the differentiating characters are noted thereunder.

Subgenus XENOHOMONEURA novum.

This subgenus is erected for a species which has the same arrangement of the dorsocentral bristles of thorax as has *Euhomoneura*, but the wings are hyaline, not conspicuously pictured as in that subgenus, and the distance from lateral edge of central portion of face to eye and the width of central portion and its lower angle are about equal. In *Euhomoneura* the central portion of face is about three times as wide at lower margin as the distance from its edge to eye. The type is *testacea*, n. sp.

HOMONEURA (XENOHOMONEURA) TESTACEA, n. sp.

Male and female.—Dull testaceous yellow; aristae and ocellar spot fuscous; disc of mesonotum, and to a lesser extent that of scutellum, infuscated, and rather copiously grey dusted; metanotum fuscous, and grey dusted; abdomen of female with a dark dorsocentral vitta. Wings hyaline.

Frons about one-third of the head width and a little longer than wide, all the bristles strong, the anterior orbitals close to anterior margin of frons; antennae rather small, third segment about 1.5 as long as wide; arista minutely pubescent; lower occiput slightly bulging; cheek higher than width of third antennal segment; face almost flat. Thorax with all three pairs of dorsocentrals long and strong, the prescutellar acrostichals short and fine, and the intradorsocentral hairs in four irregular series; scutellum flattened above, not elongated; sternopleurals both present. Fore femoral comb not conspicuous; all tibiae with preapical dorsal bristle; mid pair with two apical ventral bristles. Inner cross-vein at about two-

fifths from apex of discal cell; ultimate section of fourth vein less than twice as long as penultimate section.

Length, 3 mm.

Type, male, and allotype, Adventure Bay, Tasmania, 7th Dec., 1922 (A. L. Tonnoir).

HOMONEURA (HOMONEURA) FERGUSONI, n. sp.

Male and female.—Testaceous yellow, slightly shining. Antennae and palpi yellow; aristae fuscous. Thorax slightly dusted, usually with faint traces of two brownish vittae just mesiad of the dorsocentrals. Abdomen of male usually with a faint series of dark dorsocentral spots on apical half, that of female with the spots quite distinct and in addition a larger one on each side of the fifth tergite. Legs yellow. Wings hyaline, normally with seven dark spots, those over inner cross-vein and at least the anterior extremity of outer cross-vein, just before apex of second vein, and at apex of third vein, most distinct, those at apex of fourth vein, at base of antepenultimate section of same vein, and between apices of auxiliary and first veins, least noticeable, sometimes very faint. Halteres yellow.

Frons subquadrate, orbits faintly differentiated, all the bristles long, surface hairs microscopic and sparse; third antennal segment almost twice as long as wide, slightly angulate on upper apical extremity; arista with very short pubescence. Thorax with three pairs of postsutural dorsocentrals and six series of intradorsocentral setulae. Fore femur with an anteroventral comb; all tibiae with distinct preapical dorsal bristle; mid tibia with two subequal moderately long apical ventral bristles. Inner cross-vein about two-fifths from apex of discal cell; ultimate section of fourth vein a little longer than penultimate section.

Length, 4-5 mm.

Type, male, allotype and four paratypes, Geraldton, W.A., 5th Sept., 1926 (E. W. Ferguson).

Named in honour of the collector, to whom I am indebted for most of the material received from this region.

In my recently published key (These PROCEEDINGS, 1927, p. 12) to the species of this genus from Australia this species will run down to section 4, but is distinguished from *apicinebula* Malloch, the only species in the first alternative, by the fact that the dark spot on second vein is not at extreme apex, and the base of antepenultimate section of fourth vein is clouded; from the second alternative it is distinguished by the pubescent arista.

HOMONEURA (HOMONEURA) FLAVOFEMORATA, n. sp.

Male and female.—Fulvous yellow, thorax and abdomen glossy, frons except the orbits, sides of face, and cheeks, not shining. Ocellar region with a dark mark on inner margin of each ocellus; antennae yellow, third segment and aristae, and the apices of palpi, black. Legs yellow, blackened from near bases of tibiae to apices of tarsi. Wings yellowish hyaline, both cross-veins slightly clouded. Halteres yellow.

Frons subquadrate, all bristles long, anterior orbitals a little farther from eye than posterior pair and about one-third from anterior margin of frons; third antennal segment about 1.5 as long as wide; arista microscopically pubescent; face slightly convex in profile; cheek fully as high as width of third antennal segment. Thorax with three pairs of strong postsutural dorsocentrals, the anterior pair close to suture, and eight or more irregular series of intra-

dorsocentral hairs; scutellum slightly flattened. Female with about eight short bristles on genital segment. Fore femur with a slight anteroventral comb; all tibiae with a distinct preapical dorsal bristle, mid pair with two apical ventral bristles. Inner cross-vein a little beyond apex of first vein and middle of discal cell; ultimate section of fourth vein not 1.5 as long as penultimate section.

Length, 4.4-5 mm.

Type, male, and allotype, Eaglehawk Neck, Tasmania, 15th Nov., 1922 (A. L. Tonnoir).

This species runs down to section 12 in my key to the species of this genus, but is distinguished from all the species included thereafter by the colour of the legs, all the others having the tibiae, and usually also the tarsi, yellow.

17. Genus AUSTRALINA, Malloch.

I have seen only the two original specimens of the genotype of this genus, *geniseta* Malloch, described from Darwin, N.T.

There are some species of this family still in my hands which I do not care to describe from single specimens in rather teneral condition.

Family Agromyzidae.

Genus CRYPTOCHAETUM Rondani.

This genus is of considerable economic importance in Australia and the south-western United States, feeding upon certain scale insects, in which the larvae are internal parasites. Two species were brought from Australia to California about 35 years ago, and are now established there as parasites of a scale insect infesting citrus trees. The genus occurs also in Europe and Asia.

Two subgenera have been recognized by Bezzi, based upon the structure of the frons, presence or absence of hairs on the eyes to some extent, and some trivial wing characters. The known Australian species fall into the subgenus *Lestophonus*, all having the eyes hairy, and the frontal triangle wide at anterior margin. Below I give a synopsis of the characters by means of which the Australian species known to me may be recognized. I am accepting the specific names applied to the two old species, but whether these are correct or not I cannot be absolutely certain.

The genus is the only one in the Acalyptratae in which the antennal arista is lacking (Text-fig. 4). The species have a habitus very similar to those of *Leucopis* Meigen, which are so far as known predacious enemies of aphides and scale-insects, and with which I linked them in a paper on Agromyzidae published a number of years ago. The most recent work on the families of Acalyptratae by Hendel has, however, placed a great deal of emphasis upon the structure of the basal half of the costal vein of the wing and the degree of development and individuality of the auxiliary vein, and if we accept these characters as criteria for the segregation of families then *Cryptochaetum* can hardly be considered as Ochthiphiline. All the members of this latter group have the auxiliary vein complete, though sometimes closely approaching first vein near its apex, and the costal vein is not broken at the point where the auxiliary vein connects with it. In *Cryptochaetum* the auxiliary vein is almost obsolete, being visible only under a very high power lens, and the costa is slightly interrupted where the rudimentary auxiliary vein connects with it. There is no cross-vein between the discal cell and the anterior basal one in *Cryptochaetum*, while there is always such a cross-vein in the Ochthiphilinae.

All the species of the genus are bluish black in colour, and the frontal triangle, which is the same colour, is very large, occupying most of the frons, the latter lacks distinct lateral bristles and, like the dorsum of thorax, scutellum, mesopleura, and abdomen, is furnished with short hairs. Differences in venation, and the structure of the fore tarsi in the males, are the principal distinguishing characters.

Key to the Species.

1. Inner cross-vein of wing nearly one-third from apex of discal cell; ultimate section of fifth vein not over two-thirds as long as penultimate section; third antennal segment with a sharp apical upper angle; fore tarsus in male without exceptional structure or hairs; calyptrae fuscous *monophlebi* Skuse.
Inner cross-vein of wing close to, or even proximad of middle of discal cell; ultimate section of fifth vein at least three-fourths as long as penultimate section; third antennal segment rounded at apex, or obtuse 2
2. Fore tarsus of male dilated (Text-fig. 5); calyptrae white; inner cross-vein a little beyond middle of discal cell; ultimate section of fifth vein about three-fourths as long as penultimate section *latimana*, n. sp.
Fore tarsus of male not dilated, with some short fine erect hairs along the anterior side (Text-fig. 6); inner cross-vein sometimes a little proximad of middle of discal cell; ultimate section of fifth vein about as long as penultimate section *iceryae* Williston.



Text-fig. 4. *Cryptochaetum latimana*, head from side.

Text-fig. 5. *Cryptochaetum latimana*, fore tarsus of male.

Text-fig. 6. *Cryptochaetum iceryae*, fore tarsus of male.

CRYPTOCHAETUM LATIMANA, n. sp. (Text-figs. 4 and 5.)

Male.—Glossy blue-black, frons on sides of the triangle, and the antennae, deep opaque black. Legs shining black, tarsi testaceous. Wings hyaline. Calyptrae white. Halteres black.

Frontal triangle gradually narrowed from vertex to anterior margin, at the latter point narrower than distance of its side from eye; third antennal segment not angulate but broadly rounded at apex. Scutellum margined as in other species. Abdomen rather wide, third and fourth visible tergites subequal in length. Fore tarsus as in Text-fig. 5.

Inner cross-vein almost exactly at middle of discal cell; penultimate section of fourth vein a little over one-fourth as long as ultimate, the latter diverging from third, and at its apex a little farther from third, measured on costa, than third is from second; ultimate section of fifth vein about three-fourths as long as penultimate.

Length, 1.5 mm.

Type, Wahroonga, Sydney, N.S.W., 24th Oct., 1926.

CRYPTOCHAETUM MONOPHLEBI Skuse.

I have before me Australian specimens of this species, or at least specimens so labelled, and which agree with the characters cited for its distinction. Some

of the specimens were reared from *Monophlebus*. These specimens all have the third antennal segment with a very pronounced angular production on its upper apical angle which character appears to ally them very closely with *curtipenne* Knab, the type specimen of which I have compared with the specimens referred to. The type of Knab's species is in very poor condition and it is impossible to say whether or not it is the same species, though one of the Australian specimens of *monophlebi* bears this name label. The male has the fore tarsus normal

CRYPTOCHAETUM ICERYAE Williston. (Text-fig. 6.)

Readily distinguished from the other two species by the characters cited in the foregoing key. Fore tarsus of male as in Text-fig. 6. I have before me Australian and American specimens.

There are probably Australian species of this genus yet undiscovered.

Genus CERODONTA Rondani.

I have previously described two species of this genus from Australia and now present a third one. To facilitate the identification of these three species I am giving below a synopsis of their distinguishing characters.

Key to the Species.

1. Scutellum lemon yellow, with a deep black spot on each basal angle; thorax shining yellow, mesonotum with the following glossy black marks; a broad complete central vitta, a slightly narrower vitta each side of it, which does not extend to anterior margin, and a narrower one behind suture laterad of these; humeri with a black spot; intradorsocentral hairs in about six irregular series; third antennal segment as in *robusta*, shorter than usual and acute at apex *vittigera*, n. sp.
 2. Stout species; pleura largely lemon yellow; disc of mesonotum black, with slight grey dusting, the margins lemon yellow, the hind margin narrowly so; intradorsocentral hairs in at least four irregular series on almost the entire length of thorax; apices of abdominal tergites lemon yellow; third antennal segment shorter than usual and with a sharp apex; metanotum small .. *robusta* Malloch.
- Thorax black, with dense grey dust, and nowhere distinctly shining, mesonotum with two faint brownish vittae posteriorly on the lines of dorsocentrals; intradorsocentral hairs biseriate, sparse, and present only anteriorly; abdominal tergites black; third antennal segment normal, more elongate than in *robusta*, and with a sharp point at upper apical angle; metanotum prominent, extending to apex of scutellum *australis* Malloch.

CERODONTA VITTIGERA, n. sp.

Male.—Head orange-yellow, frontal orbits paler, ocellar region with a large black mark; aristae black; third antennal segment with a very small part of apex black; inner mouth margin and occiput black. Thorax lemon yellow, dorsum with five glossy black vittae as described in the key; pleura largely black, the sclerites yellow on margins. Abdomen black, apices of tergites yellow. Wings hyaline. Halteres yellow.

Head as in *robusta*. Thorax with 1 + 3 pairs of dorsocentrals, about six series of long intradorsocentral hairs which are continued almost to scutellum, the intra-alar bristle hardly distinguishable from the hairs, and no differentiated prescutellar acrostichals; metanotum not well developed. Legs stout, the femora quite pronouncedly so. Wings normal, inner cross-vein at about one-third from apex of discal cell, outer cross-vein vestigial in both wings, ultimate section of

fourth vein about nine times as long as penultimate; ultimate section of fifth vein longer than penultimate.

Length, 2.75 mm.

Type, Koolanooka, W.A., 9th Sept., 1926 (E. W. Ferguson).

Genus AGROMYZA Fallen.

I have been accumulating material for a review of the Australian species of this genus for some time, but have not yet obtained sufficient to warrant my publishing on the entire genus. Below I deal with some of the available species which belong to the group in which the halteres are entirely black or fuscous, and the entire insect is black, usually with some part of thorax or abdomen, or both, with a distinct blue or green tinge, sometimes quite noticeably metallic. There are at least two segregates of this group, those before me from Australia being referable to *Melanagromyza* Hendel, and *Ophiomyia* Braschnikow. These have been accepted by Hendel as genera, but I think subgeneric rank is all they are entitled to, and I so treat them herein. Below I present a synopsis of the characters that are of value in distinguishing them. Hendel has cited the difference in the course of the auxiliary vein in the two major groups in his recent paper on the European species of *Agromyza* as a character for their separation, but I can not see any fundamental distinction here. In neither group is this vein absolutely fused with the first vein according to my opinion, though in certain species it appears to be so owing to the bending up of the membrane between the first vein and the vestigial auxiliary vein. If the wing is carefully flattened out, or turned round, in examining it it will be seen that there is practically no distinction between the two groups that are so distinguished in his key.

Synopsis of Subgenera.

- A. Face without a broad central vertical carina, sometimes with a linear one which is not much elevated and does not appreciably separate the antennae at bases, the antennae projecting parallel, or almost so; vibrissal angle not prominently projecting and never with a fasciculus of bristles in male *Melanagromyza* Hendel.
- AA. Face with a quite prominent central vertical carina, more or less widened above middle, which very distinctly separates bases of antennae, the antennae almost invariably distinctly diverging to sides; vibrissal angle projecting, and with two or more long bristles forming a curved fasciculus in male *Ophiomyia* Braschnikow.

Subgenus MELANAGROMYZA Hendel.

The larvae of the great majority of the species in this subgenus mine in the roots and stems of low plants and some are quite destructive. One of the worst species is *M. phaseoli* Coquillett, which affects beans in Australia.

In the key given below I include three named and two unnamed species.

Key to the Species.

1. Thorax with three pairs of well developed dorsocentral bristles *trispina*, n. sp.
Thorax with but two pairs of distinct dorsocentral bristles 2
2. Calyptrae white, their margins yellowish, or whitish, and fringes white 3
Calyptrae greyish or fuscous, their margins and fringes fuscous, or dark brown .. 4
3. Inner cross-vein of wing at middle of discal cell; ultimate section of fourth vein about three times as long as penultimate; ultimate section of fifth vein hardly over half as long as penultimate section *albisquama*, n. sp.
Inner cross-vein of wing about one-third from apex of discal cell; ultimate section of fourth vein not less than five times as long as penultimate; ultimate section of fifth vein about two-thirds as long as penultimate section sp. 1

4. Frontal triangle polished greenish black, extending narrowly to, or almost to, the anterior margin of frons *phaseoli* Coquillett.
 Frontal triangle slightly shining, black, wider than in *phaseoli*, and extending to about middle of frons sp. 2

AGROMYZA (MELANAGROMYZA) TRISPINA, n. sp.

Male.—Shining black. Frons shining on orbits and posterior part of triangle. Scutellum slightly dusted and not so shiny as mesonotum. Legs black. Wings hyaline. Calyptrae and their fringes white. Knobs of halteres black.

Eyes bare; frons over one-third of the head width; orbits narrow, each with about six bristles, and many short hairs; triangle distinct only on posterior half, obsolete anteriorly, its apex at about one-third from anterior margin of frons; ocellar bristles erect and divergent, as long as postvertical pair; face slightly carinate; vibrissal angle not produced, with a fine bristle and some long hairs; antennae small, third segment rounded; arista thickened basally, subnude; cheek barely as high as width of third antennal segment. Thorax with three pairs of dorso-central bristles, the anterior pair weakest and distinctly behind the suture, the intradorsocentral hairs in about ten series, prescutellar acrostichal bristles not developed, postalar bristle next to scutellum minute; intra-alar bristle distinct. Legs stout; mid tibia with one or two posterior setulae. Inner cross-vein at less than one-third from apex of discal cell; outer cross-vein at a little less than its own length from inner and over 1.5 its own length from apex of fifth vein; ultimate section of latter over three-fourths as long as penultimate; ultimate section of fourth vein deflected apically, and about five times as long as penultimate section.

Length, 3 mm.

Type, Merredin, W.A., 31st Aug., 1926 (E. W. Ferguson).

It is exceptional for a species in this subgenus to have three pairs of dorso-central bristles, nearly all having but two pairs.

AGROMYZA (MELANAGROMYZA) PHASEOLI Coquillett.

This species differs from the preceding one in having the dorso-centrals consisting of two pairs, the fronto-orbital bristles usually five in number, with the anterior two pairs incurved, the frontal triangle polished and extending narrowly to anterior margin of frons, the face with a low sharp central vertical carina, the vibrissal angle slightly produced and with one bristle, the inner cross-vein at about two-fifths from apex of discal cell, the ultimate section of fourth vein four or five times as long as penultimate, and the length of specimens about 1.5 mm.

A common enemy of beans.

AGROMYZA (MELANAGROMYZA) ALBISQUAMA, n. sp.

Male.—More distinctly metallic green-black than *phaseoli*, and with the calyptrae white, their margins yellowish and fringes white.

Structurally quite similar to *phaseoli*, but the frontal triangle is broader at posterior margin and is more evenly narrowed from there to anterior extremity which latter almost attains the anterior margin of frons. Thorax as in *phaseoli*. Inner cross-vein at middle of discal cell; ultimate section of fourth vein three times as long as penultimate; ultimate section of fifth vein about five-eighths as long as penultimate section.

Length, 2 mm.

Type, Eccleston, Allyn R., N.S.W., 28th Feb., 1921.

In addition to the above I have two other species on hand, but it is not advisable to deal with these on the basis of single specimens.

Subgenus OPHIOMYIA Braschnikow, 1897.

There is but one species of this subgenus before me at this time, unless a single specimen mentioned hereinafter belongs to a distinct species.

AGROMYZA (OPHIOMYIA) LANTANAE Froggatt.

This species is the same length as *phaseoli*, but belongs to a different subgenus, the face being more conspicuously carinate, with the carina broadened above middle and distinctly separating the bases of antennae, and a more prominent vibrissal angle on which there is a fasciculus of two or three long bristles in the male, and at least one prominent bristle in female. In other respects the species closely resemble each other, but the frontal triangle in *lantanae* is less shiny, and shorter and broader, extending only to about middle of frons. The inner cross-vein is at, or close to, one-third from apex of discal cell, the ultimate section of fourth vein is about seven times as long as penultimate section, and the posterior bristles on mid tibiae are extremely short.

Feeds on *Lantana*. Narrandera, North Harbour, Mosman, and Sydney, N.S.W.

I have before me a female specimen in poor condition which belongs to this subgenus, and may be a distinct species. It is a little larger than *lantanae* and has the inner cross-vein very slightly beyond middle of the discal cell. Sydney, N.S.W.

In connection with members of this genus, and especially those of the two subgenera above dealt with, it is highly desirable that rearing records be obtained wherever possible and that specimens of the mines, and larvae and puparia, be kept when specimens are reared.

Subgenus LIRIOMYZA Mik.

This subgenus contains species that are more slenderly built than in the two preceding subgenera, which have the halteres always yellow, and the auxiliary vein of the wing more evidently separated from the first at apex than appears to be the case in these and in the subgenus *Agromyza* Fallen.

I note also that there is a more constant lack of an intra-alar bristle here than in the other subgenera mentioned, but until I attempt a review of all the subgenera occurring in Australia I do not care to indicate the importance of this character. It appears to me at this time that the character used by Hendel for the separation of *Liriomyza* from *Dizgonomyza* is too trivial for such a purpose as it consists solely of a difference in the colour of the scutellum, yellow or partly yellow in *Liriomyza*, entirely black, or at least without yellow, in *Dizgonomyza*. The genotypes are not available to me so that it is impossible to determine if there are other characters that may be used for their separation. I do not use *Dizgonomyza* in my treatment of the Australian species at present.

I have several species of *Liriomyza*, as accepted by me, in my hands at this time, one of which, *pusilla* Meigen, I have already recorded from Australia. This species has a very wide range and feeds upon a great diversity of food-plants, mining in their leaves. It has also a large number of names applied to it, some of them at least being entitled to retention for subspecies and varieties. It may be that with a fuller knowledge of the immature stages some of these subspecies

or varieties may be established as good species, but careful work will have to be done to determine this point. I describe only the species which appear to me to be perfectly distinct from any known to me from any part of the world. Possibly some of the species recently described by Mr. M. Watt from New Zealand may be found to occur in Australia, but it is imperative that very careful examinations be made of any such species as appear to be identical with his as there appears to be a group of similar appearing species in this part of the world that only a specialist can definitely distinguish from each other.

AGROMYZA (LIRIOMYZA) PALLIDICENTRALIS, n. sp.

Female.—Head dull yellowish testaceous, upper occiput, ocellar spot, upper half of third antennal segment, aristae and clypeus, blackened, face usually with a dark mark in each fovea; frontal orbits and vertex each side of the ocellar spot paler than the interfrontalia; palpi yellow. Thorax fuscous, humeri and a stripe along centre of scutellum testaceous yellow, mesonotum brown dusted and entirely dull, with slight traces of darker vittae along the dorsocentral lines. Abdomen black, almost entirely dull, slightly grey dusted, and without conspicuous yellow apices to the tergites. Legs dusky testaceous, irregularly suffused with fuscous. Wings greyish hyaline. Calyptrae whitish, fringes pale brown. Halteres white.

Frons fully one-half of the head width, orbits narrow, well defined, each with three bristles, two outwardly and backwardly directed on upper half and one inwardly directed on anterior half, besides a short hair which is sometimes present anterior to the latter; ocellars longer than the postverticals; frons slightly projecting in profile; face with a slight central vertical carina; antennae of average size, third segment rounded at apex; arista bare; cheek at anterior margin about as high as width of third antennal segment, much higher at posterior margin, the marginal hairs very fine and sparse, vibrissa short and fine. Thorax with four pairs of dorsocentral bristles (1 + 3), no prescutellar acrostichals nor intra-alar, and almost devoid of surface hairs, at most with a few between anterior dorsocentrals; scutellum with four equal bristles. Legs slender, fore femora without posteroventral bristles; mid tibia without any posterior median setulae. Inner cross-vein slightly before apex of first vein and at middle of discal cell; ultimate section of fourth vein about five times as long as penultimate; ultimate section of fifth vein about 1.25 as long as penultimate.

Length, 2 mm.

Type and two paratypes, Sydney, N.S.W., 10th Oct., 1923, 26th Sept., 1923, and 24th Sept., 1924.

This species has much in common with *flavocentralis* Watt, but the wing venation is quite different, *flavocentralis* having the ultimate section of fifth vein over twice as long as penultimate, and there are other distinctions.

AGROMYZA (LIRIOMYZA) TRICOLOR, n. sp.

Male and female.—Head clay-yellow, interfrontalia more orange-yellow; ocellar spot, and upper occiput except on margins, and centre above, black; third antennal segment brownish above; aristae fuscous; palpi yellow; clypeus narrowly black. Thorax clay-yellow, mesonotum fuscous except between the lateral margins, the dark part densely grey dusted except between the dorsocentrals from near anterior margin, the central part brown dusted; scutellum fuscous, yellow at apex, densely grey dusted on sides, brown dusted in centre; metanotum broadly shining black

centrally; a black mark on each humerus, one behind it on notopleural suture, one on lower margin of mesopleura, another on lower part of pteropleura, and a large black triangle on the sternopleura. Abdomen clay-yellow, more or less brownish on centre of dorsum, the genitalia in both sexes black. Legs clay-yellow. Wings hyaline. Halteres clay-yellow, with a large brownish spot on each knob.

Frons fully one-third of the head width; orbits distinct, each with three bristles; ocellar and postvertical bristles subequal; third antennal segment rather large, rounded at apex; arista with short pubescence; face slightly carinate in centre; cheek at anterior extremity about half as high as width of third antennal segment, much higher posteriorly; vibrissae short. Thorax with four pairs of strong dorsocentral bristles (1 + 3), four series of intradorsocentral hairs anteriorly only, and no prescutellar acrostichal nor intra-alar bristles; scutellum slightly elongated, and narrowed at apex, slightly free from postscutellum at apex. Legs as in preceding species. Wing almost exactly as in Watt's figure of that of *citreifemorata* Watt, inner cross-vein slightly before middle of discal cell; ultimate section of fifth vein about twice as long as penultimate; ultimate section of fourth vein fully four times as long as penultimate.

Length, 1.5 mm.

Type male and allotype, Como, N.S.W., December, 1923, swept from flowers (H. Petersen).

Distinguished from any species in Australasia by the tricoloured thoracic dorsum.

Family Chloropidae.

Subfamily CHLOROPINAE.

Genus PACHYLOPHUS Loew.

I have already described one species of this genus from Australia, and now introduce other two, one of them so closely allied to *lutea* Malloch that it is not necessary to give a detailed description of it. The other species is rather divergent from type and I have included the essential characters for its separation from the other two in the following synoptic key. The genus has much the appearance of *Meromyza* Meigen, which genus contains species which mine in the stems of wheat and other cereal plants, causing what are known as "dead-heads", but nothing is at present known of the larval habits of the species of *Pachylophus*.

Key to the Species.

1. Hind femora with weak pale spinules in two faint series on a portion of apical half of ventral surface, which are evident only under a very high power lens; face without a dark mark in each antennal fovea, but with a complete blackish line along each parafacial suture; arista gradually tapered from near base of third segment to its apex; notopleural bristles 1 + 1 *alienus*, n. sp.
- Hind femora with quite evident minute black spines in two series on at least the apical half of ventral surface; face with a dark mark in each antennal fovea on upper portion, the parafacial suture not blackened; arista lanceolate, about equally wide almost to apex; notopleural bristles 1 + 2 2
2. Upper inner mouth margin with a central dark mark; pleura with a black streak along lower margin of mesopleura and a black spot in centre of hypopleura, sternopleura with most of its surface red, the upper posterior angle of the red mark faintly blackish, the dark mark below prothoracic spiracle very faint, reddish *lutea* Malloch.
- Upper inner mouth margin entirely black; pleura with a black streak along lower margin of mesopleura and another along upper margin of the red sternopleural area, a black mark in centre of hypopleura, one below prothoracic spiracle, and a poorly defined mark on pteropleura *secundus*, n. sp.

PACHYLOPHUS SECUNDUS, n. sp.

In addition to the characters cited in the above key this species is more slender and a little smaller than *lutea*, and though both have the characteristic black streaks on upper part of face and the black spot on each fore coxa at base, these are more conspicuous here than in *lutea*. The three dorsal vittae on the thorax are quite variable in colour, being sometimes nearly all rufous, and varying to nearly all black.

Length, 2.5-3 mm.

Type and four paratypes, Coolgardie, W.A., 12th Sept., 1926.

PACHYLOPHUS ALIENUS, n. sp.

Female.—Shining testaceous yellow like the other two species, but the frontal triangle has a rather broad black streak along each side, the parafacial suture has a complete blackish line on it, there are two fuscous spots on clypeus, the central mesonotal vitta is reddish, and the posterior two-thirds of the submedian, and all of the sublateral vittae, are black. There are five blackish spots on pleura, the one on sternopleura being confined to the upper margin of the red mark, and there is a black spot on each humerus.

Structurally similar to *lutea* except as stated in the key, and in having the hind femora less thickened.

Length, 3.75 mm.

Type, Woy Woy, N.S.W., November, 1921 (A. L. Tonnoir).

It is possible that the presence of but one bristle on hind part of the notopleura is abnormal, if not it is an interesting digression from type.

Genus CHLOROPISCA Loew.

This genus is the only one in this subfamily known to me which has a distinct oval sensory area on dorsal surface of the hind tibia. This sensory area consists of an elongate flattened section covering a variable extent of the posterodorsal surface of the tibia, generally slightly darker in colour than the remainder of the surface, and is furnished with microscopic erect pile. When I first mentioned the existence of this area in the literature of this family I considered it possible that it was of a sensory nature, and suggested that some morphologist examine it to discover its function if any. So far as I know this has not yet been done. The character is present in nearly all genera in Botanobiinae, but I have not noticed it in related families, though there exists on the basal segment of the fore tarsus of males of the South American Sapromyzid genus *Griphoneura* a small flattened area that suggests a similarity to the one under consideration, though here there are no erect hairs present.

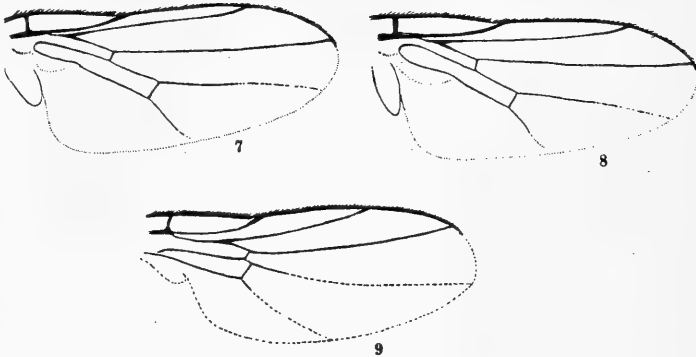
I present below the description of a species from Australia which appears to be undescribed, though it closely resembles *notata* Meigen.

CHLOROPISCA SUBNOTATA, n. sp. (Text-fig. 7.)

Female.—Head yellow, ocellar spot, apical margin of third antennal segment and the entire arista, black; frontal triangle more or less browned, but nowhere black; inner mouth margin sometimes brownish. Thorax with the usual five glossy black vittae, submedian pair not extending to anterior margin, laterals not extending in front of suture; pleura with a black spot on mesopleura and another on hypopleura, sternopleura red below, sometimes with a black spot above; metanotum black in centre; scutellum yellow. Abdomen with most of the tergites

blackened, fourth with two black spots. Legs yellow, fore tarsi slightly dark at apices. Wings hyaline. Halteres yellow.

Frontal triangle almost as wide as vertex, impunctate, with numerous fine lateral hairs, sides almost straight, apex almost at anterior margin of frons; arista subnude; cheek about as high as width of third antennal segment. Dorsum of



Text-fig. 7. *Chloropisca subnotata*, wing.

Text-fig. 8. *Chloropisca monticola*, wing.

Text-fig. 9. *Diplozoa tasmaniensis*, wing.

thorax with numerous fine short hairs; scutellum flat, elongate, with two long and two very short hairs. Fore tarsus slightly dilated apically. Wings as in Text-fig. 7, subcostal cell very narrow.

Length, 2.5 mm.

Type and paratype, Mosman, N.S.W., 2nd Apr., 1923.

Resembles *notata* Meigen, but it has the frontal triangle quite coarsely punctate on sides.

CHLOROPISCA MONTICOLA, n. sp. (Text-fig. 8.)

Female.—Head testaceous, upper occiput and entire frontal triangle glossy black; third antennal segment browned above; aristae fuscous; inner mouth margin hardly darkened; palpi yellow. Mesonotum glossy black, more brownish anteriorly on sides, yellow on lateral margins; scutellum yellow; metanotum black; pleura with four large black marks, situated on mesopleura, sternopleura, pteropleura, and hypopleura. Abdomen largely blackish brown above. Legs yellow, fore tarsi hardly darkened apically. Wings hyaline. Halteres yellow.

Frons a little over one-third of the head width, triangle not filling entire vertex, its sides slightly curved, apex extending almost to anterior margin of frons, surface smooth and polished; antennae normal; cheek about half as high as width of third antennal segment. Thoracic dorsum smooth, the hairs rather numerous and long; scutellum flat above, without a pronounced marginal rim, not elongate, the disc with a few black hairs, and apex bristled as in preceding species. Fore tarsus not widened. Wing as in Text-fig. 8.

Length, 1.75 mm.

Type, Blue Mts., N.S.W., 26th Mar., 1923.

This species is readily distinguished from *subnotata* by the entirely black frontal triangle, black disc of mesonotum, and different venation of the wings.

Genus CHLOROMERUS Becker.

This genus is readily distinguished from its allies by the thickened hind femora with the short dense spines on the apical halves of their ventral surfaces, and the normal venation, and shape of third antennal segment.

There are two described species, both from Australia, and to these I now add four new species. It is particularly difficult for the taxonomist to determine from a few dry specimens of certain genera in this family what are the specific limits. Some species vary very much in colour and markings and without large series it is often impossible to make certain of the specific characters. At times the colours and markings are very stable, but in other cases so variable that only careful field observations and critical examinations of series will suffice to identify species.

This condition of apparent variability obtains in this genus and it is impossible for me to be certain of whether the forms of *purus* described herein are really forms or valid species on the basis of the material on hand. It is quite possible that they will turn out to be distinct species, but a larger series of each is a desideratum to aid in determining this point.

Key to the Species.

1. All femora quite conspicuously marked with black 2
Femora entirely yellow, or only the fore and mid pairs with a faint blackish ventral mark at middle 3
2. Femora almost entirely glossy black; thoracic vittae and pleural spots entirely black; clypeus (inner mouth margin) fuscous *nigrifemur*, n. sp.
Femora yellow, with a blackish mark on upper surface at middle of each; thoracic vittae largely red, central one with a pair of small black spots on hind extremity, submedian pair each with a mark on outer side in front of suture, and the apical half, black, sublateral pair entirely black and present behind suture only; sternopleural mark red below, black on upper margin; clypeus yellow
..... *maculifemur*, n. sp.
3. Slender species, with the hind femora not much thickened, not over twice as thick as mid pair; frontal triangle entirely yellow, and without distinct lateral impressed lines; third antennal segment almost wholly black *gracilis*, n. sp.
Robust species, with hind femora much thickened, at least three times as thick as mid pair; frontal triangle either with an impressed line along each lateral margin which is usually quite conspicuously blackened, or the third antennal segment is entirely yellow or slightly blackened on its upper margin 4
4. Frontal triangle yellow, only the ocellar spot black; mesopleura, sternopleura, and hypopleura, each with a black mark 5
Frontal triangle yellow, with the lateral margins and ocellar spot black; pleura usually with five black marks (*purus* Becker.) 6
5. Clypeus yellow; thoracic dorsum with three glossy black vittae, due to a fusion of the sublateral and submedian pairs behind suture *pallidior*, Becker.
Clypeus partly black; thoracic dorsum with five glossy black vittae
..... *trimaculata*, n. sp.
6. Thoracic vittae largely red, only the posterior extremities, and sometimes the sublateral pair on outer edges anterior to suture, black
..... *purus*, form *varians*, novum.
Thoracic vittae entirely or almost entirely glossy black 7
7. Thoracic vittae totally glossy black; fore and mid femora each with a faint, but evident, blackish spot on ventral surface at middle
..... *purus*, form *maculifera*, novum.
Median thoracic vitta usually reddish near anterior extremity; fore and mid femora entirely yellow *purus*, form *purus*, Becker.

CHLOROMERUS NIGRIFEMUR, n. sp.

Male and female.—Head yellow, face more whitish, upper central part of occiput and especially a line on each side at angles of frontal triangle darkened; ocellar spot and a line along each side of triangle black; aristae fuscous; antennae

yellow, third segment darkened at insertion of arista; palpi yellow; clypeus fuscous. Thorax with three broad black dorsal vittae, and an elongate black mark on each side of these behind suture; humeri with a black spot; pleura with the usual five black marks, the one on sternopleura covering all except its upper margin. Abdomen brownish yellow, the apices of tergites paler, sometimes with two dark spots on each side of first tergite. Legs yellow, femora almost entirely glossy black. Wings hyaline. Halteres pale yellow.

Frontal triangle extending to anterior margin of frons, with an impressed line along each side; ocellar bristles divergent, forwardly directed; antennae short, distinctly separated at bases, third segment orbicular; arista microscopically pubescent, thickened basally, second segment about three times as long as thick; face not carinate; proboscis short; palpi normal; cheek about half as high as eye. Dorsum of thorax slightly punctured at bases of hairs. Not much difference between the three principal sections of costa.

Length, 3.3-25 mm.

Type, female allotype, and two female paratypes, Cradle Valley, Tasmania, 16th December, 1923 (A. L. Tonnoir).

CHLOROMERUS MACULIFEMUR, n. sp.

Female.—A much paler species than *nigrifemur*. Head coloured as in that species, but the palpi are brownish apically, and the hairs on middle of cheeks are yellow, not black. Thoracic vittae anteriorly, humeral spot, and lower portion of sternopleural mark reddish. Apices of abdominal tergites broadly pale yellow. All femora and the hind tibiae with a black partial annulus at middle, most distinct on dorsal surface. Wings clear. Halteres yellow.

Structurally the same as in *nigrifemur*, the hind femora about three times as thick as the middle pair, but the cheeks are not so high, and the second costal section is distinctly longer than the third.

Length, 3.5 mm.

Type, National Park, Tasmania, 17th Dec., 1922 (A. L. Tonnoir).

CHLOROMERUS GRACILIS, n. sp.

Male.—Head clay-yellow, the triangle glossy brownish yellow, ocellar spot, central half of upper occiput, arista, and third antennal segment, except its base on inner surface, black; palpi yellow; clypeus brownish yellow. Thorax glossy testaceous yellow, darker on dorsum, mesonotum with the usual five glossy black vittae, and a dark spot on each humerus; pleura with only the spot on lower portion of mesopleura deep black, the one on sternopleura blackened above, those on pteropleura, hypopleura, and below prothoracic spiracle, brownish; metanotum black. Abdomen clay-yellow, more or less infuscated above, and with a black spot on each side of second tergite. Legs honey-yellow. Wings hyaline. Halteres white.

Frons fully one-third of the head width; triangle filling vertex, its sides straight, apex at anterior margin, surface polished, each lateral margin with a series of fine hairs; inner vertical bristles much weaker than the outer pair; third antennal segment suborbicular; arista microscopically pubescent; cheek not over half as high as width of third antennal segment. Thoracic dorsum with quite coarse piliferous punctures; scutellum convex, rounded in outline, the two apical bristles quite long. Legs more slender than in the other species of the genus, the hind femora not over twice as thick as mid pair, and not thicker at setulose part than proximad of it; hind tibiae not noticeably curved. First costal division

(the one beyond humeral vein) not two-thirds as long as second and a little shorter than third; penultimate section of third vein about half as long as penultimate section of fourth, the latter shorter than ultimate section of fifth.

Length, 2.25 mm.

Type, Sydney, N.S.W., 29th Jan., 1925; paratype, Lindfield, N.S.W., 26th Febr., 1922 (A. J. Nicholson).

CHLOROMERUS TRIMACULATA, n. sp.

Brighter yellow than *gracilis*, frons yellow, with the exception of a black triangular mark on ocellar region; antennae orange-yellow; two blackish marks on the clypeus. Thoracic dorsum with the usual five glossy black vittae, each humerus with a black spot; pleura with only three spots, which are entirely glossy black, these situated on the lower part of mesopleura, on sternopleura, and hypopleura, metanotum broadly black in centre. Abdomen with a large black spot on each side of second tergite, and bases of other tergites blackened. Legs yellow, fore tarsi slightly browned. Wings hyaline. Halteres yellow.

Frontal triangle glossy, occupying almost the entire vertex, and extending to anterior margin of frons, its sides with some fine hairs, but not sulcate; cheek over half as high as width of third antennal segment. Thoracic dorsum with numerous piliferous punctures. Fore tarsi not dilated; hind femora about three times as thick as mid pair. First costal division fully two-thirds as long as second, and about equal to third; penultimate section of third vein a little shorter than penultimate section of fourth, the latter shorter than ultimate section of fifth.

Length, 2.75 mm.

Type, Barrington Tops, N.S.W., 25th Jan., 1922 (A. J. Nicholson).

CHLOROMERUS PURUS Becker.

I have distinguished in the foregoing key three forms of this species to which I have given names. It is possible that these may be entitled to specific rank, but my material is too scanty to permit of a full investigation of this point.

CHLOROMERUS PURUS, form PURUS Becker.

In this form the mesonotal vittae are either entirely black or there is a small portion at or near the anterior extremity of the central vitta reddish. In addition to this character the hind tibia has usually a dark dorsal mark near middle, the humeri are unspotted, and the frontal triangle always has a black marginal line on each side. The first costal division is distinctly longer than third.

Locality, Kosciusko, N.S.W., 27th Nov., 1922, and 7th Dec., 1922 (A. J. Nicholson).

CHLOROMERUS PURUS, form MACULIFERA, novum.

This form is distinguished from the typical form in having a blackish mark on underside of each femur at middle, and a black spot on each humerus. The hind tibia is dark marked as in *purus*. Penultimate section of fourth vein longer than ultimate section of fifth.

Type, Lake Margaret, Tasmania, 3rd Feb., 1923 (A. L. Tonnoir).

CHLOROMERUS PURUS, form VARIANS, novum.

This form has the dorsal vittae of the thorax largely, sometimes entirely, reddish, usually the black markings confined to posterior and lateral portions.

Type, and one paratype, Kosciusko, N.S.W., 7th Dec., 1922, two paratypes, Perth, W.A., 15th Nov., 1924 (Nicholson); two paratypes, Cradle Valley, Tasmania, 12th Jan., 1923 (A. L. Tonnoir).

In all probability many more species of this genus will be discovered by careful collecting and being an indigenous genus it will be of interest to find out what are its larval habits.

Genus DIPLOTOXA Loew.

This genus is similar to *Chlorops* Meigen, but has the cross-veins of the wings much closer together. In the only species of the genus amongst the material now before me from this region, the third antennal segment is short, and rounded at apex, but some of the American species have the third antennal segment much longer than wide. This latter segregate is the typical one, containing as it does the genotype, *versicolor* Loew, occurring in North America.

DIPLOTOXA TASMANIENSIS, n. sp. (Text-fig. 9.)

Male and female.—Clay-yellow. Frontal triangle wholly glossy, the colour brownish yellow, ocellar spot black; third antennal segment slightly darkened above; arista, centre of occiput above, and the clypeus, black. Thoracic dorsum with three broad black or brownish vittae which are slightly grey dusted, the median one not extending to posterior margin of mesonotum, and two narrow vittae behind suture laterad of these; metanotum broadly black in centre; scutellum paler in centre than on sides; pleura with five black marks. Abdomen more or less browned at bases of tergites. Legs without noticeable dark markings. Wings hyaline. Halteres yellow.

Frontal triangle extending narrowly to anterior margin of frons; third antennal segment not longer than wide; arista thinner than in *microcera* Loew, and a little longer, the pubescence very short. Thorax normal. Legs slender. Wing as in Text-fig. 9.

Length, 1.75 mm.

Type, male, and allotype, Eaglehawk Neck, Tasmania, 14th Nov., 1922 (A. L. Tonnoir).

This species is very similar to *microcera* Loew, a North American species that occurs commonly in marshy spots in the central states, but in the latter the frontal triangle is not polished and it does not extend to anterior margin of frons. Nothing is known of the larval habits of *microcera*.

I had intended to publish in this part of the series a key to the genera of Chloropidae but lack of time to finish the work on the Australian material causes me to defer this until a subsequent part, though it is possible now to present a key to the genera of the subfamily Botanobiinae, with keys to certain genera, herein.

Subfamily BOTANOBIINAE.

The members of this subfamily are distinguished from those of Chloropinae by the continuation of the costal vein to apex of fourth vein, and the invariable presence of a sensory area on the dorsal surface of the hind tibia.

In presenting the following key to genera I realize that there is a very great probability that it is far from complete as the material in my hands is not sufficient to warrant one forming the opinion that all Australian genera are represented in it, and the area covered by the collections is comparatively small. Later should there be material forthcoming to permit a fuller treatment I will publish a more complete synopsis.

Key to the Genera.

1. Fifth wing vein absolutely straight along discal cell 2
 Fifth wing vein with a more or less conspicuous flexure or bend at about middle of discal cell 4
2. Second wing vein very short, ending in costa close to apex of first vein, the second costal section not half as long as third *Siphunculina* Rondani.
 Second wing vein not exceptionally short, ending in costa far from apex of first vein, the third section of costa not longer than second 3
3. Scutellum about twice as long as its basal width, gradually tapered from base to apex, where it is about one-fourth as wide as at base, with a broad shallow central dorsal sulcus; mesonotum trisulcate; hind tibial spur quite large.
 *Euhippelates* Malloch.
 Scutellum not longer than its basal width, rounded in outline, and not sulcate; thorax not sulcate on dorsum; hind tibial spur microscopic *Platyina*, n. g.
4. Humeri each with two bristles, the inner one curved towards middle of dorsum, the outer one curved backward; dorsocentral bristles on thorax usually quite long, and more than two postsutural pairs present 5
 Humeri with no inwardly directed bristle 6
5. Arista normal in form in both sexes; hind tibia always with a more or less evident apical spur on anterior side, sometimes very small; scutellum with two or more fine discal bristles or hairs in addition to the marginal bristles
 *Parahippelates* Becker.
 Arista normal in form in the female, with the second segment much elongated and almost as long as third in male, geniculated at the division between these segments; hind tibia without an evident apical spur; scutellum without discal hairs, only the marginal bristles present *Ephydroscinis* Malloch.
6. Hind tibia with a more or less noticeable black spur at apex on anterior side
 *Hippelates* Loew.
 Hind tibia without any apical spur on anterior side 7
7. Mesopleura quite densely haired on its upper posterior portion; scutellum rounded in outline *Batrachomyia* Skuse.
 Mesopleura without distinct hairs, usually pollinose or microscopically tomentose on upper posterior portion 8
8. Frons flattened and precipitous from above middle, the posterior third horizontal, triangle not extending beyond the horizontal part, antennae situated well below middle of eye in profile; notopleural bristles 1 + 1 *Benjaminella* Malloch.
 Frons horizontal, or sloping downward, on entire length, antennae usually inserted at or above middle of eye; notopleurals 1 + 2 or 1 + 3 9
9. Scutellum longer than its basal width, flattened above, tapered to apex, and with some setigerous warts on margin apically; mesopleura tomentose on upper posterior portion *Thyridula* Becker.
 Scutellum not longer than its basal width, and without marginal setigerous warts 10
10. Face sharply carinate in centre, the anterior outline of mouth-opening seen from below in the form of a wide V; penultimate section of fourth vein fully six times as long as penultimate section of third *Deltastoma* Malloch.
 Face with or without a central carina, but in all cases with the outline of mouth-opening forming a transverse or arcuate line anteriorly 11
11. Frontal triangle not defined beyond immediate range of ocelli; scutellum flattened above, slightly tapered to apex, where it is narrowly transverse and furnished with two short stiff bristles, the disc with short spinules; face deeply concave
 *Caviceps* Malloch.
 Frontal triangle usually well defined, and always extending much beyond range of ocelli or the scutellum and face are not as above 12
12. Thoracic dorsum with three punctate linear furrows or sulci *Tricimba* Lioy.
 Thoracic dorsum without well defined sulci or furrows 13
13. Arista quite densely short haired, the longest hairs longer than its basal diameter
 *Gaurax* Loew.
 Arista bare or pubescent, the longest hairs not longer than its basal diameter
 *Botanobia* Lioy.

* The line of demarcation between these two genera is not very sharply drawn.

Genus SIPHUNCULINA Rondani.

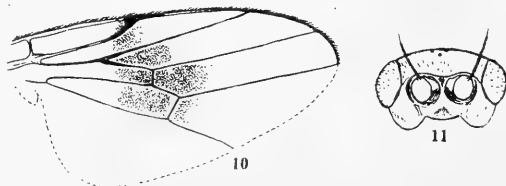
I have described an Australian species of this genus, *breviseta* Malloch, from New South Wales. The genotype, which is possibly cosmopolitan, ought to occur also.

Genus EUHIPPELATES Malloch.

The genotype, *pallidiseta* Malloch, was described from New South Wales.

Genus PLATYINA novum.

A peculiar genus, with no flexure of the fifth vein on its penultimate section. The cross-veins are quite noticeably approximated (Text-fig. 10), the frons and thorax are more flattened than usual, and the face has a central carina which widens below and above, leaving two lateral rounded cavities in which lie the divergent antennae (Text-fig. 11). Genotype, *P. nebulifera*, n. sp.



Text-fig. 10. *Platyina nebulifera*, wing.

Text-fig. 11. *Platyina nebulifera*, head from front.

PLATYINA NEBULIFERA, n. sp. (Text-figs. 10 and 11.)

Female.—Head testaceous, occiput and upper two-thirds of frons black, the whole greyish dusted; third antennal segment brownish above; aristae fuscous; palpi testaceous. Thorax black, upper parts of pleura and entire dorsum with greyish dusting, but quite noticeably shining, the short dorsal hairs yellow. Abdomen above concolorous with mesonotum. Legs testaceous, all coxae and femora almost entirely blackened, and usually at least the mid and hind tibiae browned at middle. Wings whitish hyaline, clouded centrally as in Text-fig. 10. Halteres white.

Frons nearly half of the head width, with short regular hairs, slightly projecting in profile, the vertical and postvertical bristles very short, ocellar bristles microscopic; third antennal segment not as long as wide; arista pubescent; cheek fully as high as width of third antennal segment; eyes haired, longer than high; palpi quite large. Thoracic dorsum smooth, with quite dense decumbent microscopic hairs, the humeral bristle as long as the notopleurals, the latter 1 + 2; scutellum wider than long, narrowly subtransverse at apex, the disc with microscopic hairs, the apex with two small incurved setulae. Legs normal. Wing venation as in Text-fig. 10.

Length, 1.75 mm.

Type and one paratype, Eaglehawk Neck, Tasmania, 14th Nov., 1922 (A. L. Tonnoir).

I am not absolutely certain of the sex of these specimens but think that they are females.

Genus PARAHIPPELATES Becker.

I have in preparation a new synopsis of the species of this genus, the one previously published by me (These PROCEEDINGS, 1923, p. 619) being incomplete owing to the subsequent description of some species.

Genus EPHYDROSCINIS Malloch.

There is but one known species of this genus, *australis* Malloch.

Genus HIPPELATES Loew.

There are several undescribed species of this genus in my hands now and below I present a key for the recognition of the species known to me up to this time.

It would be of interest to know whether the Australian species of this genus have the same habits as some of those occurring in America, where the adults are very persistent in flying about persons in the open, apparently attracted by perspiration, and they have been considered as transmitters of certain diseases of the eye.

Key to the Australian species.

1. Third antennal segment entirely deep black; hind tibial spur brownish yellow, not as long as the apex of the rather thick tibia, quite stout and curved, situated close to apex; mesonotum with three glossy black vittae on a yellow ground, the central one complete, the laterals abbreviated at both extremities, and slightly interrupted at suture *atricornis*, n. sp.
 Antennae either entirely yellow or with a very slight darkening of the upper edge of third segment; hind tibial spur deep black 2
2. Hind tibial spur much curved and distinctly longer than tibial diameter, situated well in front of apex of tibia; thoracic dorsum with a large quadrate mark in centre of hind margin, and a spot near each humeral angle, deep black, the ground colour yellow *bancrofti* Malloch.
 Hind tibial spur not as long as tibial diameter, slightly curved, and situated at, or very close to, apex of tibia; thorax not marked as above 3
3. Mesonotum and disc of scutellum with rather coarse setigerous punctures, the scutellum slightly rugose, disc of mesonotum black, the usual three black vittae fused on their entire length leaving only the lateral margins yellowish, the postsutural lateral vittae separated from the central black complex; scutellum broadly blackened across base; sternopleura entirely glossy black *nigridorsata*, n. sp.
 Mesonotum and disc of scutellum with a few weak setigerous punctures, sparsest on scutellum; disc of mesonotum with distinct black vittae; scutellum not blackened across base; sternopleura partly, or entirely, yellow 4
4. Pleura absolutely without black markings, entirely yellow; thoracic dorsum marked as Text-fig. 12, *d*; frontal triangle glossy black *atrisseta* (Malloch).
 Pleura with at least one black mark; thoracic dorsum not marked as above 5
5. Sternopleura largely black in centre, two black spots on mesopleura, and one on pteropleura; discal thoracic markings as Text-fig. 12, *a* *abbreviata*, n. sp.
 Sternopleura yellow, only one black mark on pleura 6
6. Discal thoracic markings as in Text-fig. 12, *b*; tibial spur moderate *unimaculata*, n. sp.
 Discal thoracic markings as in Text-fig. 12, *c*; tibial spur minute .. *fergusoni*, n. sp.

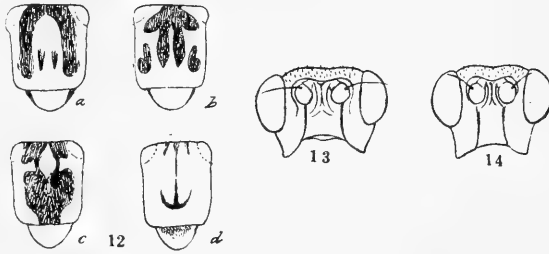
The first two species dealt with are distinguished by having the hind tibial spur extremely small and inconspicuous, so much so in fact that I originally described one of them as a species of *Gaurax*. I believe, however, that they are properly referable to *Hippelates*.

HIPPELATES ATRISETA (Malloch). (Text-fig. 12, *d.*)

Gaurax atriseta Malloch, PROC. LINN. SOC. N.S.W., 1924, xlix, p. 355.

Originally described as a species of *Gaurax*. Readily distinguished from any of those now included in the genus by the entirely yellow pleura and the inconspicuously marked thoracic dorsum (Text-fig. 12, *d.*).

Locality, Sydney, N.S.W.



Text-fig. 12. Dorsal thoracic markings of species of *Hippelates*. *a*, *abbreviata*; *b*, *unimaculata*; *c*, *fergusonii*; *d*, *atriseta*.

Text-fig. 13. *Tricimba carinifacies*, head from front.

Text-fig. 14. *Tricimba pollinosa*, head from front.

HIPPELATES FERGUSONI, n. sp. (Text-fig. 12, *c.*)

This species is fulvous yellow in colour, with the frons and scutellum more lemon-yellow, the frontal triangle with a central dark vitta, third antennal segment with a dark mark at insertion of arista, thoracic dorsum marked as in Text-fig. 12, *c*, the pleura with but one black mark, on lower margin of mesopleura, the abdomen black on dorsal surface except on first tergite, centre of second, and the sides of fifth.

Structurally the species is very similar to *atriseta*, but the lateral hairs on frons are stronger.

An additional character is that the palpi are brown instead of yellow, but the colour may be due to some unnatural cause, and abnormal.

Length, 2.5 mm.

Type, Sydney, N.S.W., 26th Aug., 1923.

I take pleasure in dedicating this species to the late Dr. E. W. Ferguson, to whom I was indebted for most of the material used in the compilation of this series of papers.

HIPPELATES ATRICORNIS, n. sp.

Female.—Head yellow, with yellow hairs and brownish bristles; ocellar spot, third antennal segment, and aristae, black. Thorax yellow, dorsum with three glossy black vittae, of which only the central one extends the entire length, and traces of two narrow reddish vittae laterad of these behind the suture; pleura with a black mark on each of the following parts: mesopleura, pteropleura, sternopleura, and hypopleura; scutellum yellow; metanotum broadly glossy black in centre; hairs pale, the bristles black or brown. Abdomen yellow, with a black suffused spot on each side of second tergite, third and fourth tergites almost entirely black on disc, fifth with a central black spot. Legs yellow. Wings hyaline. Halteres yellow.

Frons longer than wide, quite copiously fine-haired, the lateral margins with a series of short setulae, vertical and postvertical bristles quite well developed, ocellars short; eyes hairy, higher than long; cheek not half as high as width of third antennal segment, the latter orbicular; arista with very short pubescence; proboscis stout, geniculated. Thorax with quite long fine decumbent dorsal hairs, the surface hardly punctate, and the bristles well developed; scutellum slightly flattened above, with two long and two short apical black bristles. Legs stout, the hairs quite long, apical spur on hind tibia stout, curved, and about as long as diameter of tibia. Penultimate section of fourth vein about twice as long as penultimate section of third, and about equal in length to ultimate section of fifth.

Length, 3 mm.

Type, Cairns, N. Queensland (J. F. Illingworth).

Type in United States National Museum.

HIPPELATES NIGRIDORSATA, n. sp.

Female.—Head orange coloured, occiput in centre, and the ocellar region, black, a brown streak running forward from ocellar spot to front of triangle; clypeus black; antennae yellow; aristae black. Thorax orange-yellow, disc marked as stated in key, humeral angles unspotted; pleura black except in front and above. Abdomen brownish orange. Legs dirty orange-yellow, a dark spot near base of each fore coxa, and some dark suffusions on hind femora which may be abnormal. Wings hyaline. Halteres yellow.

Frons a little less than half the head width, triangle shining, not conspicuously differentiated on sides, microscopically striate laterally; ocellar bristles minute, postvertical pair much larger; orbitals distinct posteriorly; face concave, with a V-shaped elevation above between bases of antennae; eyes hairy; cheek about one-eighth of the eye height, not much produced anteriorly, with black hairs below; palpi elongate, not very slender; proboscis stout; antennae normal; arista pubescent. Mesonotal hairs short; subapical pair of bristles on scutellum much shorter than the apical pair. Legs normal, apical spur on hind tibia not half as long as the diameter of tibia, situated close to apex. Second section of costa a little longer than first and about 1.75 as long as third; apical sections of veins 3 and 4 parallel.

Length, 4 mm.

Type, King River, Tasmania, 4th Febr., 1923 (A. L. Tonnoir).^{*}

HIPPELATES UNIMACULATA, n. sp. (Text-fig. 12, *b*.)

Male.—The general colour of this species is paler than that of *nigradorsata*, the lateral margins of mesonotum, and especially the disc of the scutellum, being conspicuously so, lemon yellow. The abdomen is, however, extensively blackened on dorsum, the first visible tergite having a black spot on each side, the second and third largely black, only yellow on anterior and posterior margins laterally, and the fourth black except on its anterior lateral margins. Legs yellow, a small black spot behind on base of each mid coxa, and there is a black mark on middle of frontal triangle before ocelli. Wings clear. Halteres yellow.

Frons narrower than in *nigradorsata*, narrowest anteriorly, triangle glossy, well defined, extending to anterior margin of frons, orbital setulae rather strong; other characters as in *nigradorsata*. Scutellum more flattened than in that species, apex very slightly pointed between the apical bristles, the latter longer than in

nigradorsata, the subapical pair more remote from apical pair and not so short. Apical spur on hind tibia fully half as long as tibial diameter, rather stout, close to apex. Venation similar to that of *nigradorsata*.

Length, 3.5 mm.

Type, Burnie, Tasmania, 5th Oct., 1922 (A. L. Tonnoir).

HIPPELATES ABBREVIATA, n. sp. (Text-fig. 12, a.)

Male.—Similar to *unimaculata* in colour, the scutellum lemon-yellow, and the abdomen with lateral dark spot on first visible tergite and a dark apical fascia on each of the other tergites. Distinctions as in key.

The frontal triangle extends only two-thirds of the way to front margin of frons; the cheeks are narrower than in *unimaculata*; the apical spur on hind tibia is shorter, and the species is not so large.

Length, 2 mm.

Type, Burnie, Tasmania, 5th Oct., 1922 (A. L. Tonnoir).

Genus BATRACHOMYIA Skuse.

I have already described two species of this genus from Australia and having two new species from Tasmania present herewith a key for the identification of the four. The genotype is unknown to me, but appears to be distinct from these.

Key to the Species.

1. Thoracic dorsum rufous yellow, with four deep black vittae 2
 Thoracic dorsum brownish or yellowish, without distinguishable vittae 3
2. Notopleural area and scutellum not much paler than remainder of thoracic dorsum, the scutellum not blackened on basal lateral angles; humeri without a black spot; tibiae largely fuscous *major*, n. sp.
 Notopleural area and scutellum ivory-white, the latter blackened on basal lateral angles; humeri with a black spot; tibiae yellow *strigipes*, n. sp.
3. Third antennal segment deep black; femora largely black-haired .. *atricornis* Malloch.
 Third antennal segment yellow; femora entirely yellow-haired *flavicornis* Malloch.

BATRACHOMYIA MAJOR, n. sp.

Male and female.—Head yellow, opaque, variegated with brown, the frons sometimes brown except on anterior margin; clypeus blackish; antennae and palpi yellow, third segment of former more or less darkened at insertion of arista; aristae black; cephalic hairs black except on lower part of occiput. Thorax reddish yellow, shining; mesonotum with three broad black vittae which are fused on anterior half, and a narrow postsutural black streak which is separated from the submedian vitta; postnotum black; four large black spots on pleura, on lower part of mesopleura, on pteropleura, on hypopleura, and on all except the upper margin of sternopleura. Abdomen rufous yellow, with the apices of tergites darkened. Legs rufous yellow, the fore femora and all tibiae almost entirely black. Wings slightly greyish. Halteres yellow. Fine hairs on thorax mostly pale, the bristles, and many of the hairs on abdomen, black.

Frons about two-fifths of the head width, the surface with many black hairs; post-vertical bristles long; ocellar pair shorter, both pairs incurved; antennae narrowly separated at bases, third segment higher than long; arista rather thick basally, microscopically pubescent; cheek about one-fifth of the eye height, rather densely haired except on upper margins, the hairs ascending well above the mouth margin to vibrissal angle; palpi normal; eyes densely haired. Dorsum of thorax including that of scutellum quite densely haired, the hind margin of scutellum with a number of setulae. Abdomen more hairy than usual, but not so densely

so as mesonotum. Legs rather robust, tarsi slightly broadened apically. First section of costa subequal to second in the male, a little longer than it in female, third section about half as long as second in male, distinctly less than that in female.

Length, 4.5-5.25 mm.

Type male, allotype, and four paratypes, Cradle Valley, Tasmania, 10th to 26th Jan., 1923 (A. L. Tonnoir).

BATRACHOMYIA STRIGIPES, n. sp.

Male.—A paler species than *major*, the head, except ocellar spot, a part of occiput, and arista, pale yellow; mesonotal vittae not fused anteriorly, connected at hind extremities. Wings hyaline. Halteres cream coloured.

Hairs not so dense as in *major*; third section of costa about two-thirds as long as second, the latter subequal to first.

Length, 3.5 mm.

Type, Wilmot, Tasmania, 8th Jan., 1923 (A. L. Tonnoir).

Genus BENJAMINELLA Malloch.

There is but one species of this genus known, *albifacies* Malloch, which occurs in Tasmania and New South Wales.

Genus THYRIDULA Becker.

There are three species already described from Australia, and I now add a fourth one, which is as yet undescribed. Below I present a key for the identification of the species, and a description of the new one.

Key to the Species.

1. Scutellum paler at apex than at base, quite coarsely rugoso-reticulate on entire surface, its sides parallel on basal two-thirds of their extent, the apex broadly rounded, and with four subequal bristles situated on small warts; claws of hind tarsi not much longer and stronger than those of mid and fore tarsi *rugosa* Malloch.
- Scutellum darker at apex than at base, or with a black central vitta, and not coarsely rugoso-reticulate, the sides converging from base to apex, at the latter narrowly truncate and with a pair of quite long bristles situated on two small warts; claws of hind tarsi much stronger than, and at least twice as large as, those of mid and fore tarsi 2
2. Scutellum with a complete, deep black, central vitta; face broadly blackened centrally *centralis* Malloch.
- Scutellum black on apical half or less 3
3. Face and hind tarsi entirely yellow; frons yellow, ocellar spot black *atroapicata* Malloch.
- Face blackened in centre; fourth and fifth segments of hind tarsi black, the other segments yellow; frons dark brown, yellow only on anterior and posterior margins, the ocellar spot black *brunneifrons*, n. sp.

THYRIDULA (EUTHYRIDULA) RUGOSA Malloch.

I erect for this species the new subgenus *Euthyridula*, based upon the characters cited in the key.

THYRIDULA CENTRALIS Malloch.

This species is known only from the type specimen from Sydney, N. S. Wales.

THYRIDULA ATROAPICATA Malloch.

This species is known only from the type specimen from Bowral, N. S. Wales.

THYRIDULA BRUNNEIFRONS, n. sp.

Male.—Head brownish testaceous, centre of face blackish, frons dark brown, yellowish only on anterior and vertical margins, the ocellar spot glossy black; antennae testaceous yellow, third segment brownish except at base; aristae fuscous; palpi testaceous yellow. Thorax brownish testaceous, dorsum with three black vittae, a complete one in centre, and one on each side of it which is not carried to anterior nor posterior margin and is not interrupted at suture, and laterad of these behind suture a black streak; humeri unspotted; sternopleura mostly black, a black spot on lower part of mesopleura, one on pteropleura, one behind prothoracic spiracle, and one on hypopleura; scutellum black at about the apical half; metanotum glossy black. Abdomen testaceous yellow, with a dark mark on each side of at least the second tergite. Legs testaceous yellow, mid and hind femora and tibiae more or less darkened on middle; fourth and fifth segments of hind tarsi black. Wings hyaline. Halteres pale yellow.

Frons a little longer than its anterior width, quite densely haired, the orbital setulae hardly differentiated, triangle not extending to middle of frons; third antennal segment quite large, orbicular; arista distinctly pubescent; face slightly carinate above, distinctly produced below; eyes densely haired; palpi long; proboscis long, geniculated, and slender, the apical section as long as head; cheek almost linear. Thorax as in *centralis*. Legs stout, hind tarsal claws fully twice as long as those of mid and fore pairs.

Length, 2 mm.

Type, Strahan, Tasmania, 6th Febr., 1923 (A. L. Tonnoir).

Genus DELTASTOMA Malloch.

Only one species of this genus is known, *unipunctata* Malloch; Sydney, N.S.W.

Genus CAVICEPS Malloch.

Only one species of this genus is known, *flavipes* Malloch; Sydney, N.S.W.

Genus TRICIMBA Lioy.

Before me are four species of this genus which appear to be undescribed. All of them are very different from the genotype in structure, two having a very conspicuous flat carina on upper half of the face separating the antennae quite widely, and the frons quite noticeably protruded in front, projecting well over antennae, much as in the genus *Eurina* Meigen. One of the other species is much less robust than the genotype, without a facial carina, and with larger wings.

One might be justified in erecting a new subgenus for the reception of the two first mentioned species but for the fact that an Australian species, *carinata* Malloch, to a considerable extent bridges the gap between these and the genotype. In the Australian species the facial carina is present, but not so wide, and the frons is less protruded in front. The species now known to me are included in the key below.

Key to the Species.

1. Face with a quite broad conspicuous central vertical carina on upper half 2
Face not at all evidently carinate 4
2. Small species, not over 2 mm. in length; frons not projecting beyond anterior margin of third antennal segment in profile; facial carina rather narrow, not widened out at lower extremity, and extending well below middle of face
..... *carinata* Malloch.

- Larger species, not less than 3 mm. in length; frons projecting well beyond anterior margin of third antennal segment in profile; facial carina broad, distinctly widened out at lower extremity, and not extending below middle of face 3
3. Sternopleura grey dusted on upper and lower margins, the upper margin testaceous, the remainder black *carinifacies*, n. sp.
- Sternopleura entirely grey dusted, and all black *pollinosa*, n. sp.
4. Scutellum quadrate, flat on entire dorsal surface, and with a prominent setigerous wart near each posterior lateral angle; small species, not over 1.5 mm. in length, and rather robust 5
- Scutellum longer than wide, tapered to apex, the sides sloping basally, and the margin without setigerous warts; species averaging fully two mm. in length, and of slender build *convexa*, n. sp.
5. Mesonotum with but one evident series of microscopic pale hairs between the central and lateral sulci; frontal triangle with evident grey dusting, but distinctly shining, ending a little in front of middle of frons, and with no wedge-shaped mark in front of it, the anterior margin of frons orange-yellow; legs testaceous yellow; penultimate sections of third and fourth veins subequal in length *scutellata* Malloch.
- Mesonotum with about four series of microscopic dark hairs between the central and each lateral sulcus; frontal triangle densely grey dusted, and not shining, ending at middle of frons, but with a wedge-shaped pale-dusted mark in front of it which gives it the appearance of being continued to anterior margin of frons, the latter hardly paler than remainder of surface; mid and hind femora, and hind tibiae, with a brownish median mark; penultimate section of third vein about half as long as penultimate section of fourth *similata*, n. sp.

TRICIMBA CARINIFACIES, n. sp. (Text-fig. 13.)

Female.—Head yellowish testaceous, becoming fuscous on upper part of frons and occiput, third antennal segment dark above; clypeus fuscous. Thorax brownish testaceous, dorsum fuscous, with grey dusting, but distinctly shining on most of the surface, lower part of sternopleura and postnotum black, the latter shining. Legs testaceous yellow, femora mostly, and tibiae in middle, brown or fuscous. Wings hyaline. Halteres yellow. All hairs and bristles luteous.

Frons projecting beyond eye fully as far as height of cheek, the latter over one-third as high as eye; arista subnude; front view of head as in Text-fig. 13. Mesonotal hairs stubby, lateral sulci broadened posteriorly; scutellum flattened above, with rather dense stubby bristles or hairs on disc, and with two approximated bristles at apex. Legs normal. First costal section about four-fifths as long as second, third two-thirds as long as it.

Length, 3.5 mm.

Type and one paratype, Burnie, Tasmania, 25th Oct., 1922 (A. L. Tonnoir).

TRICIMBA POLLINOSA, n. sp. (Text-fig. 14.)

This species is very similar to *carinifacies*, but is smaller, and darker in colour, the frons is darker, being sometimes entirely fuscous, and the sternopleura is entirely grey dusted. In addition to the characters listed in the key the face is narrower, being at lower extremity of the parafacials not wider than the height of cheek, while in *carinifacies* it is distinctly wider, and the carina in this species does not extend to middle of face (Text-fig. 14), while in *carinifacies* it does extend to, or even very slightly below, the middle.

Length, 3 mm.

Type male, Woy Woy, N.S.W., 2nd Sept., 1923; one paratype, Lindfield, N.S.W., 19th Nov., 1922 (A. J. Nicholson); one paratype, Bridgetown, W.A., 29th Aug., 1926 (E. W. Ferguson).

The Western Australian specimen is slightly different from the others, but not so distinctly so as to justify me in accepting the distinctions as of specific value.

TRICIMBA CONVEXA, n. sp.

Female.—Differs from *carinifacies* in having the frons darker, the thorax and abdomen uniformly fuscous, shining, with greyish dust except on lower half of pleura, and the legs uniformly yellowish testaceous.

The frons is not half of the head width, the cheeks are almost linear, the mesonotum is more convex, with finer hairs, and the lateral sulci are not widened posteriorly, the legs are more slender, and the wings broader and longer.

Length, 2.2-5 mm.

Type and one paratype, King River, Tasmania, 4th Febr., 1923; one paratype, National Park, Tasmania, 6th Dec., 1922; two paratypes, Adventure Bay, Tasmania, Dec., 1922 (A. L. Tonnoir).

The most slender species of the genus known to me.

TRICIMBA SIMILATA, n. sp.

This species is so very similar to *scutellata* Malloch, which I recently described, that it appears unnecessary to describe it further than has already been done in the foregoing key. I have included all the essential differentiating characters therein, and a comparison of the specimens one may have, with this key and the description of *scutellata* ought to be sufficient to permit an accurate identification.

Length, 1.5 mm.

Type, Sydney, N.S.W., 9th Nov., 1924.

TRICIMBA CARINATA Malloch.

PROC. LINN. SOC. N.S.W., 1924, p. 356.

I have seen only the type female from Como, N.S.W., December, 1923.

TRICIMBA SCUTELLATA Malloch.

PROC. LINN. SOC. N.S.W., 1925, p. 337.

I have seen only the type male from Sydney, N.S.W., 9th Aug., 1924.

Genus *GAURAX* Loew.

As already stated by me this genus is very poorly differentiated from *Botanobia* Loey, only the more distinctly haired arista serving to separate it from that genus. When I come to publishing the key to the species of *Botanobia* I may decide to include in it all the species of both so that no errors may occur in identifications. I have before me a very pretty undescribed species which appears to be referable here.

GAURAX APICIPUNCTATA, n. sp.

Male and female.—Head orange-yellow, occiput, frontal triangle except extreme apex, and upper extremities of frontal orbits, glossy black; third antennal segment lemon yellow; arista and their hairs black; palpi yellow. Thorax glossy black, humeri and lateral margins of mesonotum and upper margin of pleura, fulvous yellow; scutellum black. Abdomen rather variable in colour, ranging from brownish to black. Legs yellow, all femora and tibiae blackened medially. Wings hyaline, with a fuscous spot at apex from a little before tip of third to just beyond tip of fourth vein which has usually a pale central spot. Halteres yellow.

Frons over half of the head width, with quite long black hairs; postvertical and ocellar bristles erect and convergent; triangle wide, extending fully two-thirds of the length of frons; third antennal segment higher than wide; arista thickened at base, very densely short haired and appearing thickened on entire length, the longest hairs about as long as the thick second segment; eyes hairy, a little higher than long; cheek almost linear. Thoracic dorsum not punctate, the hairs quite dense, long, and fine; scutellum convex, rounded in outline, with two long and two short fine bristles. Legs stout. Second costal section fully 1.5 as long as first, the latter a little longer than third; penultimate section of third vein over half as long as penultimate section of fourth.

Length, 2.2-2.5 mm.

Type female, allotype, and one female paratype, Sydney, N.S.W.

This is the only species known to me from Australia in which the wings are marked with a fuscous apical spot.

Genus *BOTANOBIA* Lioy.

I have been compiling a key to the species of this genus but am not yet ready to publish it as with every consignment of specimens of small Diptera received there are new species of this genus. Isolated descriptions are not of very much value in many genera and this is one in which only synoptic treatment will provide characters by means of which the species may be identified.

There appear to be about 30 species of the genus now before me from Australia and Tasmania.

Family *Asteiidae*.

This family contains but three genera and may ultimately be merged with the *Drosophilidae*, as it has been heretofore by many workers. Meanwhile I accept it in the status given to it by recent workers. I have already described a species of the genus *Leiomyza* from Australia and now add a species of a second genus. Below I present a key to the three described genera. The third genus may occur also in Australia.

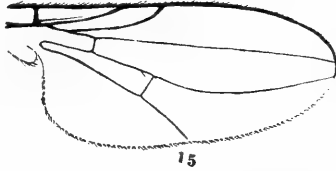
Key to the Genera.

1. Outer cross-vein of the wing lacking; second wing vein ending in apex of first vein, or in costa very close to apex of that vein; arista with quite long widely separated hairs above and below *Asteia* Meigen.
Outer cross-vein of wing present; arista bare or pubescent 2
2. Thorax with two pairs of well developed postsutural dorsocentral bristles; second wing vein ending in costa very close to apex of first vein; arista bare or pubescent *Sigaloessa* Loew.
Thorax with but one pair of well developed postsutural dorsocentral bristles; second wing vein ending in costa about midway between apices of first and third veins; arista bare or almost so *Leiomyza* Macquart.

SIGALOESSA MELBOURNENSIS, n. sp. (Text-fig. 15.)

Female.—Head testaceous, a broad dark mark on each side of upper occiput, frons reddish, face whitish, its lower rim and clypeus brown; antennae testaceous. Thorax brownish black, shining, lightly greyish dusted on dorsum, the lateral mesonotal margins yellowish; pleura yellowish, with two darker vittae; scutellum yellow. Abdomen fuscous on dorsum, yellow on membranous part. Legs testaceous yellow. Wings hyaline. Knobs of halteres dark brown above, pale below.

Frons about one-third of the head width, parallel-sided, almost flat, and nearly 1.5 as long as wide, with microscopic stiff black hairs; postvertical bristles microscopic, divergent as in the other genera in which they are present; both pairs of vertical bristles rather short, but longer than the single pair of orbitals; antennae normal; arista with very short pubescence. Thorax with a series of



Text-fig. 15. *Sigaloessa melbournensis*, wing.

short hairs on almost the entire length of the two dorsocentral lines and between these in front of suture an irregular series of similar acrostichal hairs; posterior pair of intra-alar setulae present; scutellum with two long apical and two short basal bristles. Legs slender. Wing as in Text-fig. 15.

Length, 2.25 mm.

Type, Melbourne, Victoria, found in jar with *Mónophlebus*.

Except for the dark colour in general, and especially that of mesonotum, this species is very similar in all respects to *flaveola* Coquillett, a North American species, but I consider it as distinct pending the receipt of more material from Australia.

NOTES ON AUSTRALIAN AND EXOTIC SARCOPHAGID FLIES.

By G. H. HARDY, Walter and Eliza Hall Fellow in Economic
Biology, Queensland University, Brisbane.

(Eleven Text-figures.)

[Read 26th October, 1927.]

Taxonomic studies of Sarcophagidae, undertaken since the publication in 1923 of "A Revision of the Australian Diptera belonging to the genus *Sarcophaga*", by Professor T. Harvey Johnston and myself, were pursued with the view of ascertaining the relationship between Australian species and those examined or that had been described from other parts of the world. The accumulation of odd notes so far compiled will prove, I believe, of considerable interest and perhaps help towards establishing a satisfactory method of arranging the unwieldy genus *Sarcophaga* into groups of naturally allied species.

The idea of grouping Sarcophagids on the genital characters of the male, which has been initiated by various authors, is extended and developed in the present paper. Already types like *S. tuberosa* have had placed around them names ranking as varieties or species according to the interpretations given by the authors concerned, but unfortunately drawings of the gross appearance of the male genitalia are usually relied upon in order to show the alliances whilst no attempt has been made to define the associations. The genital complex of the male is a structure worthy of detailed study and until it has been given adequate treatment relationships between species must remain obscure.

Although highly specialized structures such as the bifid anterior clasper of the *antelope*-group and the spiny anterior appendage of the *peregrina*-group would be enough to suggest the alliance, reliance is not placed on such characters alone, additional characters are taken into consideration and it is upon such combinations that relationships are best assessed. The counterpart of any one character may readily be found in the composition of the genitalia of species belonging to quite different groups as instanced by the *misera*-group, that has one or more of its characters found in *S. securifer*, *aurifrons* and *omega*. Owing to necessity for caution in these matters only three groups are dealt with in full. Biological data are given for one species.

For material supplied and used for the purpose of this paper, I am indebted to Dr. H. H. Karny for two species bred by him in Java, the types of which by request, are returned for preservation in the Museum there; also to Dr. R. J. Tillyard for three specimens of the only *Sarcophaga* described from New Zealand, one of which was returned to him for preservation in the Cawthron Institute; to Mr. R. R. Parker for a collection of Sarcophagids, mostly American but including some Indo-Australian forms; and to Mr. R. Senior-White for Oriental material in which I was specially interested.

Method of preparing and mounting genitalia.—The published methods, whereby the genitalia are prepared for examination (given by Parker, Senior-White, and Johnston and Hardy), differ fundamentally and for the purpose of detecting finer

points in the structure of genitalia in the first two cases mentioned, I find that given by Parker is superior to that given by Senior-White. For examination of genitalia *in situ*, I use a system of reflecting sunlight on the parts examined and any distortion or contortion is thus detected under the Greenough stereoscopic binocular microscope, moreover the finer structural details, so often overlooked, become clearly defined under this method. The genitalia may be removed and mounted without distortion, rendering all external details clear on a slide; after removal, passing through absolute alcohol, clearing in xylol or clove oil (boiling in potash is not permissible in this case), the genitalia can be mounted whole or in sections in Canada balsam in such a manner as not to flatten out the parts. The parts of the penis are then easily viewed through transmitted as well as reflected light in the position they would occupy relative to each other just as if left set in the normal way. This method of mounting has the advantage that higher powers of the microscope can be brought to bear upon details too small to be seen plainly under the binoculars, if left *in situ*; the densely spined nature of the anterior appendage of *S. peregrina* being a case in point.

S. antilope group.

The six species, referred to this group, agree in having the anterior clasper bifid and with a small knob placed anteriorly to it. The forceps are long, strong and angulated. The second segment of the penis lacks the lateral process, but the shape differs in other respects. Those species that have the anterior clasper bifid for only half the length, have also the apical process tridentate, whilst the two species that have this clasper short and bifid to the base do not have the tridentate character of the penis. As far as yet known the group consists of:

antilope Bottcher, 1913, Formosa.

**alpha* Johnston and Tiegs, 1921, Australia.

**beta* Johnston and Tiegs, 1921, Australia.

**zeta* Johnston and Tiegs, 1921, Australia.

**howensis* Johnston and Hardy, 1923, Lord Howe Island.

**antilopoides*, n. sp., Java.

The asterisk refers to species examined.

SARCOPHAGA ANTILOPOIDES, n. sp. (Text-fig. 1.)

Status.—There are eleven names previously attributed to Sarcophagids recorded from Java, and Dr. H. H. Karny has succeeded in breeding only two species. As pointed out below, *S. fuscicauda* has been misidentified and is described here under the name *S. karnyi*. *S. taenionata*, according to Senior-White, may possibly be *S. flavipalpis*, one of the *misera*-group. From the same source it is suggested that *S. javana* may be *S. aurifrons* Doleschall (i.e. *doleschali* J. and T.). Other names are *lineatocollis* Macquart, *flavinervis* Senior-White, *knabi* Parker, *albiceps* Macquart, *orientalis* Parker and *dux* Thomson. I can see no evidence to suppose that *antilopoides* has been referred to under any of these names, and all of them, with the exception, perhaps, of the unknown *lineatocollis* may be excluded from this consideration.

When this species was first received I considered it to be *S. antilope* Bottcher, originally described from Formosa, but later, when comparing the genitalia with the drawing of *S. antilope* from India by Senior-White, I became doubtful about the determination. Under the circumstances it seems advisable to give a new name to the species here described which cannot be considered identical to the Indian species and there is sufficient published evidence to conclude that the

Formosan species is also not the same. According to Senior-White's drawing there is an elongate lobe, hooklike in shape, and this appears to be indicated in the drawing by Bottcher, but hidden between the anterior process and the sheath of the penis. This shape is in no way indicated on any of the other forms. There can be no doubt that the Indian and Formosan forms belong to this group but their specific identity requires further consideration.

Description.—Male: Head, outer vertical bristles much smaller than the postoculars; thirteen frontals, two rows of eight facials; about nine orals; one



Text-fig. 1. Male genitalia of *Sarcophaga antilopoides*, n. sp.—second segment of the penis only. *E.* lateral view; *F.* ventral view.

Text-fig. 2. Outline at the apex of the puparium of *S. misera*, seen laterally.

Text-fig. 3. The same of *S. kohla*.

Text-fig. 4. The last abdominal sternite on *S. misera*—half of the apex only.

Text-fig. 5. Apex of the lateral process, *l.p.*, the lobe, *l.*, and the anterior

appendage, *a.a.*, of *S. misera*, seen laterally.

Text-fig. 6. The same of *S. ceylonensis*.

row of postoculars. Thorax, two intra-alars, the presutural and scutellar bristles well developed. Abdomen, on the first segment one row of only a few discal lateral bristles and one, sometimes two, submarginals, and on the third one median pair and two or three lateral submarginals; on the fourth segment five or six submarginals alternating with well developed marginals.

Genitalia: Similar to that of *S. beta*, but reddish, the forceps and claspers being identical. The anterior appendage is simple but there are three minute spine-like processes along the upper anterior edge of each half; the apical process is rather slender towards the apex which is tridentate and has a pair of lateral projections that are similar in position, but not shape, to those on *S. howensis*; the filaments pretrude.

Legs: The chaetotaxy conforms to the general type except in the two ventral rows on the posterior femora which are very much reduced; long hairs occur on all femora and on posterior tibiae.

Female: The frontal bristles may be as few as eight or nine and the first abdominal segment usually has two rows of discal lateral bristles and the ventral bristles on the posterior femora are well developed. In other respects the characters conform to those of the male, excluding the sexual characters.

Habitat.—Java: Buitenzorg, October, 1923, 26 males, 24 females (H. H. Karny), all bred.

SARCOPHAGA TRYONI Johnston and Tieg.

Amendment.—Subsequent to the publication of the figure of the genitalia of this species, a number of dissections was made for the purpose of studying the complex structure of the second segment of the penis and in so doing the filaments previously stated as absent were found to be present. When drawing Text-fig. 9 (Johnston and Hardy, 1923), they were mistaken for projections of the lobe and in consequence the lobe illustrated in Text-fig. 9, *E*, if corrected, should be rounded and the filaments made to coincide with what is there shown to be the projection of the lobe. The presence of this filament should also be corrected in the key and in the description. It is possible that the filaments will also be found (perhaps in a vestigial or rudimentary state) in other species, so for the character given in the key "filaments absent" should read "filaments apparently absent".

Biology.—The seasonal preponderance of certain Sarcophagas in Brisbane is a well recognized phenomenon. A few species are readily bred in carrion, the most persistent of which is *S. tryoni*. It was noticed, however, that for three months of the year, although adults were captured, they failed to appear in the carrion. The reason for this non-appearance amongst bred blowflies during June to August was discovered during experiments upon the pupal period conducted under uniform temperature control.

Of all the blowflies tested, and at every temperature experimented with, it was found that the pupal period was consistent in its duration; a formula was worked out from a chart, and the maximum temperature at which the flies would hibernate was calculated, the result being contrasted with the winter behaviour of the flies bred under more natural conditions.

Under normal conditions maggots of *S. tryoni* deposited on the 9th May, required 31 to 149 (average normal 133) days to complete their metamorphosis, or roughly from one to five months. Of this period seven days were spent in the carrion, five to eight subsequent days were passed before pupation took place, and from 19 to 136 (normal average 120) days were spent in the puparium. The number of adults reared in this experiment was 26. The normal average was based on figures that excluded a small percentage of abnormally quick developments.

A still more striking effect was produced by maggots deposited a month earlier, on the 7th April, when again seven days were spent in the carrion, 6 to 24 days elapsing before pupation took place and 17 to 163 subsequent days (well over five months) passed before the adult emerged, thus taking from 31 to 177 (normal average 165) days to complete metamorphosis, or roughly one month and nearly six months. The total number of adults bred in this batch was 111.

Further observations elicited the fact that the adults did not survive a cold night, but succumbed at a temperature of about 55° F., or perhaps higher.

When incubation tests were charted for the various species of *Sarcophaga* experimented with, it was found that the probable maximum hibernation

temperature varied with the species, that of *S. tryoni* being the highest, reaching 60° F. During much of the Brisbane winter the day temperatures scarcely rise above this, except in the sun, and even in the case where a puparium may be subjected to 65° F. continuously, 22 days must elapse before the adult emerges. A few hours daily at such a temperature would cause the pupa to develop exceedingly slowly, extending the three weeks to as many months. On the same formula at 70° F the puparium would be found to take 16 days to complete development, but above that the increase in temperature causes a much more rapid development, until at 95° only about 11½ days elapse.

There is a record during January of a nine-day pupal period, this being the minimum recorded, but 11 days seems to be the normal minimum whilst the absolute minimum according to formula is 10 days. The record of a nine-day period is possibly an error that should be applied to *S. froggatti* which was frequently bred with the present species.

Sarcophaga misera and *S. peregrina* are the two dominant winter species in Brisbane, and are readily bred during that season. Not only have they a hibernating temperature lower than that of *S. tryoni*, but also the ultimate minimum development period is about six and seven days, nor are the adults so liable to succumb during cold nights.

For *S. tryoni*, the formula is: $(x-10)(y-60) = 60$. In this x represents the period in days and y the temperature (Fahrenheit). It will be found approximately correct for all temperatures from 65° to 88° F., which is the range over which the temperature experiments were conducted.

The table given covered four years' research, but irrespective of the years, the months are given in sequence, and the flies were bred under more or less natural conditions. This is the only species of the genus with which the year's cycle was practically completed. Even in this case one month was missed, namely October, but an additional and early deposition in November has rectified the omission to some extent. From this table it will readily be recognized that on the average some eight or nine generations of *S. tryoni* occur during a year; the maximum could scarcely exceed ten and the minimum is seven.

LIFE CYCLE OF SARCOPHAGA TRYONI.

| Date of Deposition. | Jan. 18 | Feb. 5 | March 6 | April 7 | May 5 | Sept. 10 | Nov. 2 | Nov. 15 | Dec. 18 |
|---|------------|-----------|------------|------------|----------|-------------|-----------|------------|------------|
| Time spent in carrion .. | 6 | 6 | 6 | 7 | 7 | 7 | 6 | 6 | 5 |
| Time occupied before forming puparium after leaving carrion | 1-11 | 1-6 | 6-9 | 6-24 | 5-8 | 5-7 | 2-10 | 3-6 | 3-7 |
| Time spent in puparium | 9-14 | 11-15 | 13-16 | 17-163 | 19-136 | 16-18 | 12-14 | 13 | 11-12 |
| Maximum and Minimum number of days occupied in completing metamorphosis | 17-28 | 20-26 | 28-29 | 31-177 | 31-149 | 29-32 | 20-29 | 20-29 | 20-24 |
| Normal average number of days occupied in completing metamorphosis | 21 | 23 | 28 | 165 | 133 | 30 | 25 | 25 | 22 |
| Number of specimens bred | 53 | 85 | 12 | 111 | 26 | 25 | 60 | 7 | 11 |

S. misera-group.

Synonymy, *tuberosa*-group, *dux*-group.

The seventeen forms referred to here, agree very consistently in the shape of the second segment of the penis. The lobe is well indicated with regard to its position and may even contain a projection of considerable magnitude, whilst the lateral process is long, usually rigid and pointing more or less horizontally in direction. The apical process is almost invariably restricted to a minute point and the filaments project to at least just beyond the apex of the segment, always being conspicuous.

S. eta conforms to the above characters and therefore is placed here. The appendages, lobes and filaments are all exceptionally long but in other respects the species conforms to the *misera*-group. Bottcher gave the name *tuberosa*-group to this conception without defining it and the name was changed later by Parker to the *dux*-group but as *misera* was the first name published of those species considered here, the name apparently being correctly applied by Johnston and Tiegs, it became necessary to change the group name once more.

Senior-White sinks *S. luzonensis* and *S. ceylonensis* as variations of *S. dux*, but I think this conception is erroneous. Senior-White and Parker differ in their methods of examining genitalia and would naturally reach different conclusions. The following list of names are applicable to species of this group:

- **misera* Walker, 1849. Australia.
- aurifrons* Doleschall, 1858; preoccupied by Macquart, 1846. See *doleschali* Johnston and Tiegs.
- **dux* Thomson, 1868, Pacific Islands.
- tuberosa* Pandel, 1897, Europe, Asia.
- harpax* Pandel, 1897, North America, Europe, Asia, India, Philippine and Pacific Islands.
- exuberans* Pandel, 1897, Europe, ? Africa and North America.
- sarracenooides* Aldrich, 1916, N. America.
- knabi* Parker, 1917, Philippine Islands.
- luzonensis* Parker, 1919, Philippine Islands.
- **eta* Johnston and Tiegs, 1921, Australia.
- doleschali* Johnston and Tiegs, 1921 (new name for *aurifrons* Doleschall, *nec.* Macquart).
- **shermani* Parker, 1923, Canada.
- **ceylonensis* Parker, 1923, India, Ceylon and Malay Peninsula.
- craggi* Parker, 1923, India, Africa.
- marshalli* Parker, 1923, Europe.
- **kohla* Johnston and Hardy, 1923, Australia.
- flavipalpis* Senior-White, 1924, India.
- scopariiformis* Senior-White, 1927, Ceylon.

SARCOPHAGA MISERA Walker. (Text-figures 2, 4 and 5.)

Sarcophaga misera, Johnston and Hardy, PROC. LINN. SOC. N.S.W., 1923, p. 113, fig. 14.—*S. knabi*, Senior-White, *Rec. Ind. Mus.*, 1924, xxvi, p. 234 (N. S. Wales specimens only).

Synonymy.—Senior White refers to some New South Wales specimens sent to Patton by Froggatt under the name *aurifrons*. Froggatt used that name covering at least five species of which *S. misera* is one and moreover *S. knabi* to which Senior-White referred the specimens has not been found in Australia. It is very evident that the present case is one of misidentification, the identity of two species being confused owing to the general similarity of the male genitalia.

Structure.—Various drawings illustrate the apex of the last ventral segment of the male abdomen, showing conspicuously differences in the various species of

the *miser*a-group. The drawing of the same part of the typical form is given here (Text-fig. 4, representing half only), and it will be noted that this does not agree with that of any other species of the same group published by various authors.

SARCOPHAGA CEYLONENSIS Parker (Text-fig. 6.)

A paratype specimen of this species, compared with *S. misera* shows a marked difference in the dentations along the anterior edge of the anterior appendage (compare Text-figs. 5 and 6). Unfortunately my male specimen of *S. dux* from Hawaii has the penis missing, but judging from the results of comparing the other parts and characters with those of *S. misera*, it also should differ in detail from *S. ceylonensis*. The dentations referred to on *S. misera* are consistent for several hundred specimens examined, not one being found to vary to the extent of missing one of the dentations. Senior-White in discussing the synonymy leaves no doubt that he suggested *ceylonensis* was a synonym of *S. dux* without having made an attempt to separate the forms on differences in the genitalia, so it would seem this matter requires further consideration.

SARCOPHAGA KOHLA Johnston and Hardy. (Text-fig. 3.)

Johnston and Hardy, PROC. LINN. SOC. N.S.W., 1923, p. 113, Text-fig. 14.—*S. luzonensis* Parker, Bull. Brooklyn Entom. Soc., 1919, xiv, p. 43. (Specimens from Queensland only).

In referring to a specimen from Townsville (Q.), Parker drew attention to the fact that it did not agree with specimens from the Philippine Islands so he placed it with his *S. luzonensis* as an atypical specimen. Probably the specimen conforms to the one described later as *S. kohla*.

The male has long been known, but only a few specimens were to be found in the various collections. More recently the species was bred by me from the contents of decayed shells at Great Palm Island, near Townsville, and both sexes secured in this manner. Females were also captured on the wing and at the same time *S. beta*, *tryoni*, *aurifrons*, *omega*, *gamma* and *miser*a were captured but none of these was bred.

Description.—Female: The chaetotaxy is similar to that of the holotype male except the outer verticals are strongly developed, the frontals have eight bristles on one side, nine on the other, there are three rows of postoculars. Only two intra-alar bristles are present and the discal laterals on the first abdominal segment are reduced so that the second row is represented by one bristle. The legs are free of long hairs.

The puparium differs from that of *S. misera* by having protuberances (Text-fig. 3) around the apical cavity wherein the larval spiracles were situated; seen laterally this orifice is thus shown to be surrounded by conical projections whereas on *S. misera* (Text-fig. 2), the corresponding line is practically straight. This character is enough to confirm the specific status of *S. kohla* indicating that it cannot be a variation of *S. misera* as has been expressed in correspondence that I have received.

Habitat.—Queensland: Great Palm Island, May, 1925. Female allotype and a male bred from decayed Molluscs, and three paratype females captured on the wing. Other puparia were secured, but failed to develop.

S. peregrina-group.

The three forms referred to here, agree in the structure of the second segment of the penis. A most suggestive point with regard to the relationship is to be found

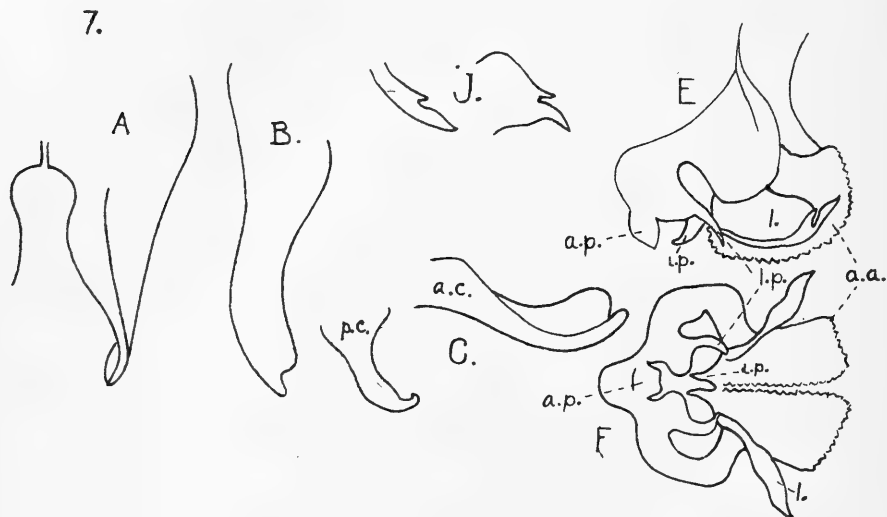
in the nature of the anterior appendage, a large surface of which is formed into a mass of minute spines. The widely expanding bifid lobe, the shape of the complex lateral process and the small apical processes are similar in each case, showing a very close affinity between the species. There are four names standing under this group:

**peregrina* Robineau Desvoidy, 1830. Australia.

**fuscicauda* Bottcher, 1912, Formosa.

**hudsoni* Parker, 1923, Ceylon; placed as a synonym of *fuscicauda* by Senior-White.

**karnyi*, n. sp. Java.



Text-fig. 7. Male genitalia of *Sarcophaga karnyi* n. sp. The lettering conforms to that given by Johnston and Hardy, 1923, namely: A., forceps or apical part of them seen posteriorly; B., the same lateral view; C., claspers; D., another aspect of one or both claspers; E., second segment of penis seen laterally; F., the same ventral view; G., the same or its apex seen posteriorly; H., the same, seen anteriorly; J., apex of the lobes seen from other aspects. a.a., anterior appendage; a.c., anterior clasper; a.p., apical process; fil., filaments; i.p., interior process; k., knob; l., lobe; l.p., lateral process; p.c., posterior clasper.

SARCOPHAGA KARNYI, n. sp. (Text-figure 7.)

Specific identity.—Although I unhesitatingly placed this species as a new form when first received, I now have reason to believe it may have been confused with *S. fuscicauda* Bottcher, originally described from Formosa and recorded from Java and subsequently other places. Mr. Senior-White has supplied *S. fuscicauda* from India and this has a very distinctive character differing from that of the Javanese form. The main sheath of the second segment of the penis is plain on the rear in *S. peregrina* and in the present species, whilst that of the Indian form is provided with a hood projecting rearwards, a character and position for an appendage that I have not seen equalled in any other Sarcophagid. As it seems advisable to record these differences under specific names, the Javanese species is given a new name and it is taken for granted that the Indian form is identical with that from Formosa, which I have not seen. *S. hudsoni* Parker is the same as the Indian *fuscicauda* as Senior-White pointed out.

Description.—Male: Head with the outer vertical bristles as short as the postoculars; ten to fourteen frontals; about six facials; about eleven orals; and two

rows of postocular bristles. On the thorax two or three intra-alars, the presutural and prescutellar bristles are present. The abdomen has on the first segment one row of three discal-laterals and two submarginal bristles; on the second two lateral submarginals and on the third one median pair and three lateral submarginal bristles.

The genitalia are remarkably like those of *S. peregrina*, the forceps being similar in outline as well as the penis. The anterior claspers are much longer than the posterior ones and provided with a broad flange on the inner side at the apex and on the outer side at the base. Anterior appendage with a minutely spined area that is represented in the figure by a serrated edge; lobe large and broad with two conspicuous projections; lateral process broad at the base and produced into a slender projection continuing from its lower edge; apical process unpaired and short; between the lobes there is a process that evidently represents the interior process found on *S. peregrina*, but where it arises from has not been determined; not only does this process appear to arise from a different position, but also it differs in shape.

The chaetotaxy of the legs conforms to the general type; scanty long hairs occur on the posterior femora only.

The female differs from the male in having the second postocular row of bristles weak or absent; the discal lateral bristles of the first abdominal segment are more numerous and are arranged in two rows.

Habitat.—Java: Buitenzorg; holotype, allotype and a female paratype were bred from a beetle (*Xylotrupes*) in June, 1924, whilst the paratypes male (16.5.1923) and female (11.5.1923) and another female undated were bred from *Gryllotalpa*. All these were received from Dr. H. H. Karny after whom the species is named.

Other Groups.

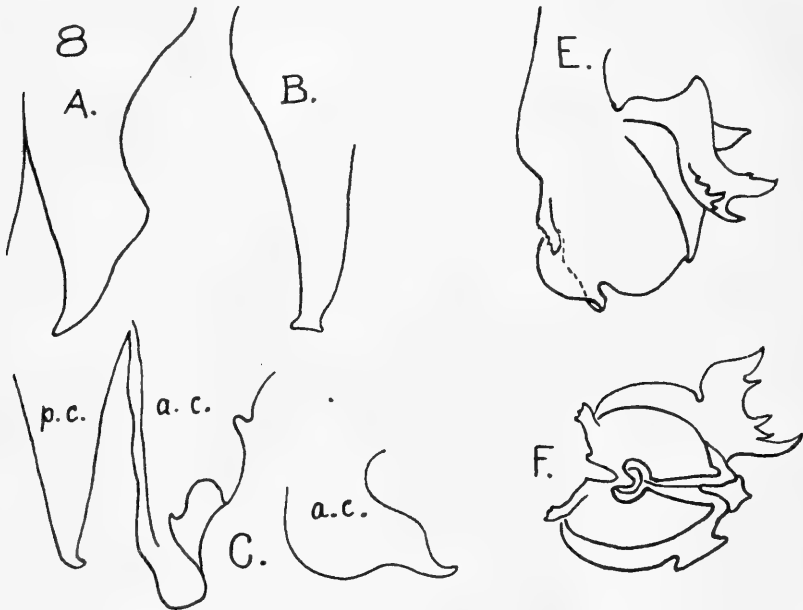
Sarcophaga bancrofti and *S. fergusonii*, two Australian forms, are undoubtedly allied, as also are *S. gamma* and *S. ochidea* judging from Bottcher's drawing of the latter. From a comparison of the illustrations I would have added to the latter pair *S. albiceps* Meigen, as being possibly allied but on receiving a consignment from Mr. Senior-White, from India, I was astonished to find that this form conformed to *S. omega* with regard to type, showing a third relationship and a quite unexpected one. The alliance of *S. synia* with *S. carnaria* has already been suggested and to these may be added, perhaps, *S. crinata* Parker, which in Senior-White's drawing appears to have the same shape of penis although this would not be suspected from Parker's illustration. I think enough has been given to indicate that a systematic search for alliances amongst the Sarcophagas for the purpose of forming groups based on suitable characters and arising from a detailed study of the genital parts must lead to a great advance in the taxonomic treatment of the at present rather unwieldy genus *Sarcophaga*. The following notes deal with the genitalia of exotic Sarcophagas that have been described in Australian literature, and the types of which have at some time or other become available to me. These new notes will make clear some fundamental characters that the original descriptions and drawings leave somewhat obscure.

SARCOPHAGA MILLERI Johnston and Tiegs. (Text-fig. 8.)

Rec. Aust. Mus., xiii, p. 185, 1922.

This is the only species yet described from New Zealand. When examining the type in the Australian Museum, I concluded the genitalia were mutilated, but

from further material received from Dr. R. J. Tillyard, it is evident that what was taken to be a mutilation was the normal shape of the genitalia. A drawing from the type is given here where it will be noticed that a large appendage having five or more digits, claw-like in shape though varying in size, is the leading feature of the structure. This occurs only on one side, in a corresponding position on the other side is a short stump giving the appearance of a mutilation. Another character that is not apparent on the original drawing is the outward directed apex of the anterior clasper. Much more material is required before the parts of the penis can be homologized with the corresponding structures in Australian species. The asymmetrical nature is unique unless, perhaps, this is also to be found in the next to be described, *S. multicolor*.

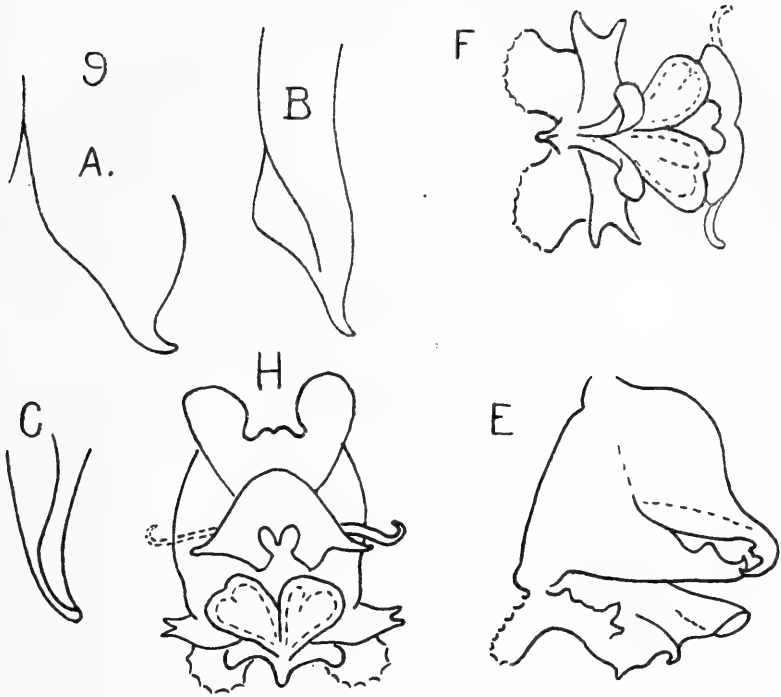


Text-fig. 8. Male genitalia of *Sarcophaga milleri* J. and T. from the type. Lettering as Text-fig. 7.

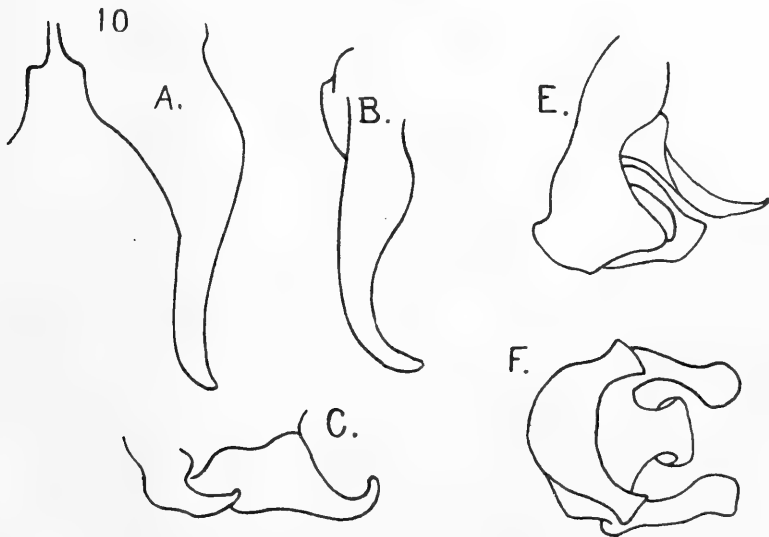
SARCOPHAGA MULTICOLOR Johnston and Tiegs. (Text-fig. 9.)

Rec. Aust. Mus., xiii, p. 187, 1922.

Although taken from the same specimen, the free-hand drawing made by Tiegs and that given here done by aid of the camera lucida, show fundamental differences in the structure of the forceps and clasper and in the general outline of the penis. It is scarcely likely that these differences are brought about by slight differences in the direction of view and so are best accounted for by differences in the individual conception of the genitalia. The penis is certainly a most complex piece of mechanism and it is extremely difficult to determine its components. A few of the parts remind one of the same parts on *S. milleri*, and were it not for the apparently mutilated process being on the opposite side of the penis, I would have suggested a possible alliance therewith. The two insects are distinct in every other respect.



Text-fig. 9. Male genitalia of *Sarcophaga multicolor* J. and T. from the type. Lettering as Text-fig. 7.



Text-fig. 10. Male genitalia of *Sarcophaga haemorrhoidalis* Fallen, from a specimen described by Johnston and Tiegs. Lettering as Text-fig. 7.

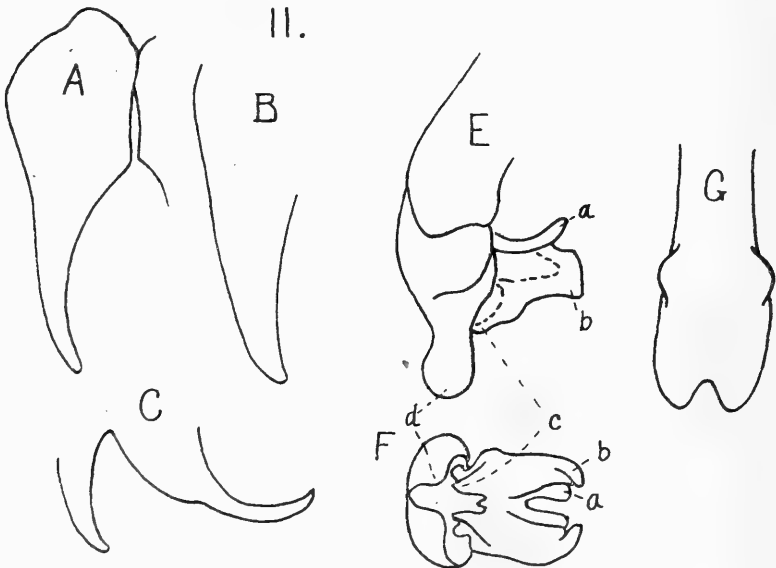
Only one of the claspers was detected on the type, and from its position would appear to be the posterior one. The penis is extremely complicated and a process present on one side appears to have been broken off from the other; its supposed shape is indicated by dotted lines in the figures. The species was described from Rabaul, New Britain, the type being unique.

SARCOPHAGA HAEMORRHODALIS Fallen. (Text-fig. 10.)

The Hawaiian specimen described by Johnston and Tiegs has been further studied and more detailed drawings of the genitalia are incorporated here.

SARCOPHAGA PALLINERVIS Thomas. (Text-fig. 11.)

The genitalia on that Hawaiian specimen illustrated by Johnston and Tiegs has been drawn in further detail and as it is not easy to homologize the parts given in the two figures, these are indicated by the letters a, b, c and d. Compare illustration with those of Aldrich "Sarcophaga and Allies", No. 49, *S. peniculata* Parker, and Nos. 120, 121, *S. communis* Parker; presumably these, *S. floridensis* and *S. pectinata*, are related.



Text-fig. 11. Male genitalia of *Sarcophaga pallinervis* Thomas, from a specimen described by Johnston and Tiegs. Lettering as Text-fig. 7.

List of Works Referred to.

- JOHNSON AND HARDY, 1923.—*Proc. Linn. Soc. N.S.W.*, xlviii, pp. 94-129. This incorporated a list of eighteen works to which must be added for the purposes of the present paper:
- PARKER, 1914.—*Proc. Boston Soc. Nat. Hist.*, xxxv, pp. 1-77.
- , 1917.—*Proc. U.S. National Museum*, liv, pp. 89-97.
- , 1919.—*Bull. Brooklyn Entom. Soc.*, xiv, pp. 41-46.
- , 1923.—*Ann. Mag. Nat. Hist.* (9), xi, pp. 123-129.
- SENIOR-WHITE, 1924.—*Rec. Indian Mus.*, xxvi, pp. 193-283.
- , 1927.—*Spolia Zeylanica*, xiv, pp. 77-83.
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NOTES ON AUSTRALIAN MARINE ALGAE.

IV. THE AUSTRALIAN SPECIES OF THE GENUS SPONGOCLONIUM.

By A. H. S. LUCAS, M.A., B.Sc.

(Plates xxvii-xxxv.)

[Read 28th September, 1927.]

In his Synoptic Catalogue of Australian and Tasmanian Algae, published in the concluding volume of *Phycologia Australica*, 1863, Harvey ranked fifty species, divided into seven sections, under Lyngbye's genus *Callithamnion*. In De Toni's *Sylloge Algarum* only nine of these are retained in *Callithamnion*. The rest have been drafted into the genera *Chantransia*, *Spermothamnion*, *Monospora*, *Spongoctonium*, *Warrenia*, *Antithamnion*, *Lasiothalia* and *Thamnocarpus*.

Harvey defined his Section 1, *Dasythamnion*, as including species with rather large fronds, stupose-spongiose, the stem and branches more or less covered with a veil of decurrent threads, intricate, free and anastomosing. The plants of this section have been divided between two genera, *Spongoctonium* and *Lasiothalia*, the former ecorticate and the latter corticated. Both have the characteristic cystocarps and sporangia of *Callithamnion*.

The history of the two genera has been somewhat remarkable. Both were proposed in 1854 almost simultaneously, so that it is apparently impossible to decide which may claim priority. *Spongoctonium* was proposed by Sonder, *Linnaea* xxvi, p. 515 on a specimen which he called *S. conspicuum*, and *Lasiothalia* by Harvey, *Trans. Roy. Irish Acad.*, xxii, p. 558, "founded on a very imperfect and battered scrap" (Harvey), which he called *L. hirsuta*.

In the *Flora of Tasmania*, 1860, Harvey gives a description of *Callithamnion conspicuum* Harv. and appends the comment: "Since this was written, I have ascertained that my *C. tingens* is the same as Sonder's *Spongoctonium conspicuum*, which name will be adopted if the plant be removed from *Callithamnion*. Another synonym is my *Lasiothalia hirsuta*, founded on a very imperfect and battered scrap of what I afterwards called *Callithamnion tingens* when more perfect specimens were collected". Presumably he called the species *C. conspicuum* Harv. because he as yet retained it in *Callithamnion*.

Of his *C. conspicuum*, which we see he identified with Sonder's plant, Harvey writes in the *Flora of Tasmania*: "The habit of this species is peculiar, and perhaps, with *C. plumigerum* and *C. superbiens*, it might form a separate genus, characterized by the peculiarly inarticulate and hirsute stem. But there are many intermediate links with species of more ordinary characters".

Sonder seems to have acquiesced in the inclusion of his species in *Callithamnion*, as in his enumeration of Australian Algae he drops *Spongoctonium* and lists his plant as *C. conspicuum*.

It might seem then that the matter was definitely settled, that but one species existed, and that the two authors had withdrawn their genera, leaving the plant

in question in the mother genus *Callithamnion*. But J. G. Agardh (*Analecta Algologica*, 1892) voiced his doubt of the identity of the species. His grounds appear somewhat slender. He says that Harvey, writing of *Lasiothalia*, says that the plant but slightly adheres to paper; Agardh's specimens (probably distributed by Harvey as *C. tingens*) adhered so closely that he could scarcely separate the least fragment, and he suggests that Harvey's name *hirsuta* of itself seemed to point to another plant. De Toni, in *Sylloge Algarum*, iv, 1903, on the other hand, regards *S. conspicuum* Sond., *C. conspicuum* Harv., *C. tingens* Harv. and *Lasiothalia hirsuta* Harv. as being synonymous, and, acting on Harvey's suggestion given above, adopts the Harveyan genus *Lasiothalia* incorporating in it *L. hirsuta* and the three Harveyan species *C. plumigerum*, *C. formosum* and *C. superbiens*.

In 1892 (*Analecta Algologica*) Agardh resuscitated Sonder's genus *Spongoconium*, incorporating in it the Harveyan *Callithamnion brownianum*, *C. wollastonianum*, *C. dasyurum*, *C. formosum*, and adding a new species, *S. wilsonianum*, but curiously left Sonder's type species amongst the *Callithamnion* as *C. conspicuum*. If then, as Agardh thought, *S. conspicuum* and *L. hirsuta* are not identical, the former has found no resting place in the *Sylloge Algarum*.

If the type species of a genus, the only species recognized by the author of the genus, is removed from it, it would seem that the genus lapses. Agardh does not seem to be justified in remodelling the genus without including in it *S. conspicuum*. He considered that *C. tingens* was a different plant, but still did not retain *S. conspicuum*. From material which I have gathered I believe that Agardh was right, that there are two species, that *C. tingens* is distinct from Sonder's plant, and I propose to retain *S. conspicuum* with his description in the genus *Spongoconium* Sonder, the retention of which is thus justified.

In 1894 (*Analecta Algologica* contd.) Agardh took into *Spongoconium* Harvey's *C. plumigerum* and added two new species of his own, *S. fasciculatum* and *S. scoparium*. R. M. Laing (*Trans. N.Z. Inst.*, xxxvii, 1905) contributed two fresh species from New Zealand, *S. pastorale* and *S. brachygonum*.

In *Sylloge Algarum*, iv, 1903, De Toni enlarged the genus *Spongoconium* by adding to it the Harveyan *C. latissimum*,* *C. angustatum*, *C. hirtum** (from New Zealand), *C. violaceum*,* *C. dasytrichum** (from Rio de Janeiro), *C. scopula*, *C. paradoxum*,* *C. crispulum** and *C. debile*,** together with Suhr's *C. stuposum** (from the Cape of Good Hope). The species bearing the asterisk he marks as doubtful *Spongoconia*. At the same time he removed *S. plumigerum* and *S. formosum* from the genus transferring them to *Lasiothalia*.

The critical distinction between *Spongoconium* and *Lasiothalia* seems to be that the former is monosiphonious, articulated, without any true cortex, and thus nearer to *Callithamnion*, while the latter possesses a true cortex, and is nearer to *Crouania*.

The object of the present paper is to illustrate as far as material will permit the Australian and Tasmanian species included by De Toni in the genus *Spongoconium*.

It must be admitted that of several of the species the material for investigation is scanty. Some are not represented in any of the Australian Herbaria and others but slightly. Many occur but rarely, and have eluded diligent search in the localities whence they have been recorded. The paper aims to set forth our present knowledge so that the gaps can be clearly recognized. It is based on the material existing in the Melbourne and Sydney Herbaria and that which I have accumulated from the coasts of Victoria and Tasmania.

I wish to acknowledge with gratitude the courtesy and kind help which Messrs. Audas and Morris, of the Melbourne Herbarium have shown me, and to thank the Curators of the Melbourne and Sydney Herbaria for permission to publish photographs of specimens in their Herbaria.

SPONGOCLONIUM Sonder.

"Frons teres, rosea, spongiosa, pinnatim decomposita, contexta filis articulatis callithamnoideis ramosis anastomosantibus, a tubo centrali articulado egredientibus, exterioribus vel periphericis laxis secundatim ramulosis ramulis incurvis liberis. Sphaerosporae sphaericae triangule quadridivisae, in ramulis periphericis latere inferiore evolutae, solitariae vel seriatiae, pedicellatae, pedicello simplici vel subdiviso.

"Genus habitu fere *Ptilocladiae*, sed fronde tereti molliori non regulariter distiche pinnata, praeterea filis periphericis liberis subincurvis secundato-ramulosis non ut in *Ptilocladia densis fastigiatis stratumque periphericum efficientibus diversum*. Ab *Haloplegmate*, cui filis exterioribus liberis et substantia molli spongiosa affine, facile distinguitur frondi tereti pinnata et axi centrali articulado". Sonder, *Linnaea*, xxvi, p. 515, 1854.

Agardh (*Analecta Algologica*, p. 39, 1892) gives this amended description of *Spongoclonium*.

"Frons articulata monosiphonia, initio et superne nuda alterne pinnatim decomposita, mox filis a ramorum basi extra cuticulam secus frondem descendentibus subfuniculariter contortis et anastomosantibus inferne stuposa, stupa nunc fere nuda, nunc hirta, nunc dense ramellis cooperta et spongiosa. Favellae ad apices ramulorum subterminales, involucre ramellis plurimis incurvatis constante circumcirca obtectae, plures circa rachidem tabescentem dispositae, singulis saepe bracteatis, in eundem nidum conjunctae; nucleis minoribus rotundatis gemmidia plurima rotundato-angulata intra periderma hyalinum foventibus. Sphaerosporae inferiore latere ramulorum paucae (aut saepe plures seriatiae), a singulis articulis transformatae, triangule divisae.

"Quale sub-genus *Dasythamnii* inter *Callithamnii* limitibus circumscriptis Harvey, genus autem proprium nomine *Spongoclonii* a Sondero institutum fuit".

Here we have the idea of an alternately pinnately decompound *Callithamnion*, which covers the axis of its stem and branches to a variable height with a growth of descending radicles which interweave into a close tegumentum; the cystocarps protected by an involucre of several small incurved branches; the sporangia, few or seriate, divided into tetrads.

Agardh has added the character of the cystocarps, and does not postulate that the sporangia be pedicellate.

We now give our working definition in the light of further investigation and so as to include *S. conspicuum*.

SPONGOCLONIUM Sonder.

Sonder, *Linnaea*, xxvi, p. 515, 1854; J. G. Agardh, *Anal. Algol.*, p. 39, 1892; Engl. and Prantl, *Natürl. Pflanzenfam.*, p. 491, 1897; De Toni, *Sylloge Algarum*, iv, p. 1357, 1903.

Frond erect, rounded, with alternately pinnate primary branches of unequal length, spreading in all directions; these bear similarly ramulose secondary branches, the whole frond being thus pinnately decompound. The lower cells of the branches emit much branched radicles, which becoming decurrent clothe the main stem and branches with a spongy network, at all events in the inferior

part of the plant. A central monosiphonious articulated axis is continuous throughout the stem and branches, ecorticate but invested below by the descending radicles and their branches.

Cystocarps numerous, scattered over the outer filaments of the frond, situated outside the close reticulum among the looser ramelli but with no proper involucre. The nucleus consists of a single gonimoblast divided in successive evolution into numerous globose-rounded few-celled gonimoblasts.

Sporangia shortly pedicellate or sessile, few or seriate, growing on the inner side of penultimate or ultimate filaments, divided into tetrads.

Antheridia thyrsoid.

Sections.

The species fall naturally into two sections with quite different aspects.

Section 1. *Conspicuae*.

The stem and greater part of the branches stupose-spongiose, formed of intricate funicular descending radicles, only the terminal plumules free and articulate.

S. conspicuum.
S. fasciculatum.
S. brownianum.
S. wollastonianum.
S. wilsonianum.
S. dasyurum.
S. paradoxum.

Section 2. *Violaceae*.

Only the lower part of stem and branches funicularly intricate, the greater portion of the frond free and articulate.

S. latissimum.
S. angustatum.
S. violaceum.
S. scopula.
S. scoparium.

We propose to exclude from the genus and to restore to *Callithamnion* the species—

S. (?) crispulum (Harv.) De Toni.
S. (??) debile (Harv.) De Toni.

Section 1. CONSPICUAE.

S. CONSPICUUM Sonder.

Linnaea, xxvi, p. 515, 1854.

Specimen 4 inches high, lacking the attachment. Primary frond terete, half a line wide, bipinnately branched. Branches for the most part distichous, mingled with some arising irregularly from the frond, subhorizontally patent, narrower by half than the caulis, the lower about an inch long, the upper longer, about 2 inches in length, all alternate with pinnae, 2-4 lines long. *Sphaerospores* on the inner side of subarcuate filaments, now solitary, now longitudinally seriate; on a short 1-2 jointed or a longer 4-6 jointed, simple or sub-branched, pedicel, spherical, the nucleus triangularly divided. Frond spongy, rose-sanguineous. A central axis monosiphonious, articulate, persisting through the whole frond, at the genicula beset with callithamnoid branching and anastomising threads, free towards the surface. Joints of the central axis 3-4 times as long as the diameter, of the ramelli twice as long.

Habitat.—Cape Liptrap, June, 1853.

S. FASCICULATUM J. Ag. (Plate xxvii.)*Anal. Algol. contd.*, p. 118, 1894.

Frond elate, to 26 cm., stout, caulescent, pinnately decomposed; primary branches alternate at distances of about 5 mm., pyramidal, rather patently ascending; branches of the second order, pinnae, 20 mm. long, emitted alternately at rather shorter distances, similarly patently ascending; ramuli of the third order, soft, fasciculate, with capillary ramelli, the ultimate branches of which are somewhat distant, ultra-capillary and but slightly diverging. The stem, primary and secondary branches are densely clothed by the intricate web of the ramelli which they emit. The secondary branches incurve towards the axis on which they grow.

The joints of the upper parts of the axis are 2-4 times as long as the diameter, those of the felted ramelli are often much shorter, even falling to half the diameter.

The colour of the fascicles is bright rose, of the felt covered stem and branches rusty brown.

Cystocarps "several among the fascicles and confluent into a conspicuous node" (J. Agardh).

Sporangia not seen.

Antheridia numerous, oblong, sessile, borne on the upper branches of the ramelli.

Habitat.—Port Phillip Heads and Western Port (Wilson). Apparently very rare. The antheridia-bearing specimen described and figured is in the Melbourne Herbarium. It is the only example we possess in Australian Herbaria.

S. BROUNIANUM (Harv.) J. Ag. (Plates xxviii and xxix.)

Callithamnion brounianum Harv., *Trans. Roy. Irish Acad.*, xxii, p. 561, 1854.

Frond elate—in the Western Australian forms, first described by Harvey, to 10 cm., in those afterwards obtained by him from Western Australia and Port Fairy to 30 cm.—caulescent, pinnately decomposed; primary branches alternate, spreading, to 10 cm. long, with lateral divisions often as thick as the main axis; secondary branches arising from these or from an undivided primary, to 2 cm. long, bearing alternately at very short intervals the fascicles of the last order. The stem and primary and the basal parts of the secondary branches densely stipose, invested by a close felt of squarrose-pilose alternately pinnate ramelli derived from descending radicular branches. A continuous ecorticate articulated axis persists through stem and branches. The joints in the lower portions about as long as the diameter, in the ramelli very variable, short to twice the diameter. The divisions of the ramelli copious, pinnate, capillary, the upper incurved.

Colour of the plumules deep rose red, of older axes paler and browner.

Cystocarps "nidulating among the ramelli below the corymbs" (De Toni).

Sporangia numerous, seriate on the inner side of the lower parts of the ramelli, very shortly pedicellate or almost sessile, with clear spherical envelope, dividing into tetrads.

Habitat.—Fremantle (Clifton), King George's Sound, Port Fairy, Queenscliff (Harvey), Port Phillip Heads (Wilson).

Cystocarpiferous plants seem to be rare.

R. M. Laing, *Trans. N.Z. Inst.*, xxxvii, pp. 392, 393, 1905, describes a form *Pleonosporium brounianum* Harvey Gibson from New Zealand, which he identifies with the Australian *Callithamnion brounianum* Harvey. In the New Zealand plants the sporangia are pear-shaped and develop 8, 16 or 32 radially arranged

spores, and hence Laing transfers the species to the genus *Pleonosporium*. In our plants the sporangia are spherical, and when mature divide each into a tetrad of spores. This I have fully verified in specimens distributed by Harvey in his *Algae Australicae Essiccatae*. Laing also places the New Zealand species *C. hirtum* H. and H. in *Pleonosporium* from the sporangia, and thinks that the tetrad sporangia figured by Harvey in *Flora Antarctica*, t. 78, are explained as being derived from some other plant. It would seem then that *Spongoctonium brounianum* is not known to occur in New Zealand, and that *S. hirtum* is really a *Pleonosporium*.

S. WOLLASTONIANUM (Harv.) J. Ag.

Callithamnion wollastonianum Harv., *Trans. Roy. Irish Acad.*, xxii, p. 561, 1854.

No example of this plant exists in any of our Australian Herbaria. The following is derived from Harvey's original description, supplemented from the description in the *Sylloge Algarum*.

Fronde elate, caulescent (according to Harvey, ultrasetaceous), 10 to 14 cm. high, thinly corticate at the base, the stem for a long distance upwards stipose-hairy with squarrose pile derived from radicles descending from the basal joint of superior branches, sub-distichously freely branched, the branches alternately pinnately decompose, those of the last order distichous, pellucidly articulate, alternately plumulate, the plumules very long, linear in outline; the pinnae slender patent (rather erect, Harvey) short, the inferior simple, the superior more often forked or pinnulate. The joints 2-4 times as long as the diameter (Harvey), of the branches $1\frac{1}{2}$ times (De Toni, *Sylloge*).

Cystocarps and *Antheridia* not noted.

Sporangia solitary along the ramelli, very shortly pedicellate.

Habitat.—Middleton Bay, King George's Sound, rare (Harvey).

S. WILSONIANUM J. Ag. (Plate xxx.)

Anal. Algol., p. 42, 1892.

Fronde elate, 10 to 15 cm. high, caulescent, alternately pinnately decompose; primary branches spreading in all directions, to 10 cm. long; secondary emerging at short intervals, patent, distichous, plumose, lanceolate in outline, to 15 mm. long, bearing tertiary alternate, distichous, plumulose ramelli, 1 or 2 mm. long; the stem and rachides of the primary and even of the secondary branches densely clothed with an intricate felt of the segments of ramelli of slender descending radicles; a continuous ecorticate monosiphonious axis persists through stem and branches, the joints throughout about equalling the diameter in length, the copious divisions of the ramelli all alternately pinnate, capillary, the upper incurved.

Colour a dull red, of older rachides brown.

Cystocarps and *Antheridia* not observed.

Sporangia numerous, nidulating within the free plumules, borne laterally on the lower joints of the ramelli, subpedicellate, spherical, divided into tetrads.

Habitat.—Port Phillip Heads (Wilson).

It will be seen that these four species conform to Sonder's conception of the genus, that they are all very closely related and form a very natural group. Harvey was at first doubtful whether or not to include the smaller and the larger plants he found in the one species *S. brounianum*, but finally combined them. Of the other three very few examples have been found, *S. fasciculatum* and

S. wilsonianum only in Wilson's dredgings, while of *S. wollastonianum* we have no specimen in Australian Herbaria.

The habit of *S. fasciculatum* differs from that of the others, the branches in these are spreading, in *S. fasciculatum* distinctly ascending. The terminal ramuli in the latter are fasciculate, and the segments more finely capillary and longer and more erect and possess longer joints. *S. wilsonianum* is more delicate than *S. brounianum*, with feather-like plumules in contrast with the more brush-like pinnules of *S. brounianum*. Of *S. wilsonianum* De Toni remarks that it is very near *S. wollastonianum* but larger and in every respect more evolved. I take the latter to mean more decomposed.

S. DASYURUM (Harv.) J. Ag. (Plate xxxi.)

Callithamnion dasyurum Harv., *Synoptic Catalogue*, p. 51, 1863.

Fronde elate, to 22 cm. high, alternately distichously pinnate-decompound, the pinnae and pinnules ascending virgate, most of the plant spongiose-stupose, with decurrent interwoven threads and even the smaller ramelli in the same way hairy, the pinnules scarcely stupose alternately closely plumulate, the plumules minute oblong pectinate-pinnate. Their pinnellae elongate incurved, simple or ramuliferous at the base; all joints very short. Colour intensely red.

Cystocarps, *Sporangia*, *Antheridia* not seen.

Habitat.—Port Phillip Heads (Harvey).

There are no specimens in the Melbourne Herbarium, and but one in that of Sydney, Harvey's No. 508E. This, the one figured, gives the appearance of a much denuded plant, the plumules being very weakly developed, and adhering so closely to the paper that it was impossible to dissect them under the microscope.

S. PARADOXUM (Harv.) De Toni. (Plate xxxii.)

Callithamnion paradoxum Harv., *Flora of Tasmania*, ii, p. 337, 1860.

Fronde terete, decomposed pinnate, branches and branchlets spreading in all directions, the main branches pyramidate in contour, the rachides stout below, gradually attenuate, all except the ultimate plumules densely spongy, formed of closely interwoven descending filaments; the surface of the frond consisting of the crowded pinnae of penultimate order, the lower branches of these greatly elongated, the upper markedly flexuose with distichous segments ending in blunt apices. The joints are three or four times longer than the diameter in the lower part of the frond, not much longer than the diameter in the ultimate free ramelli.

Colour.—A rich dark plum colour.

Cystocarps and *Antheridia* not seen.

Sporangia numerous, sessile, seriate on the upper or inner side of the ramelli near the surface of the plant, rather large, 62 μ in diameter,

Habitat.—Warrnambool (H. Watts), Sandringham, Port Phillip (Lucas); Tasmania, Brown's River (Gunn), estuary of the Derwent River and Orford (Lucas).

It is very abundant in the Lower Derwent. I have gathered many sporangiferous plants but was never fortunate to discover cystocarps.

De Toni placed this species in the genus with some doubt. It seems to me to fall under Sonder's definition admirably. It is the most clearly marked of all the species.

Section 2. VIOLACEAE.

S. LATISSIMUM (H. and H.) De Toni. (Plate xxxiii.)*Callithamnion latissimum* H. and H., *London Journal of Botany*, iv, p. 452, 1845.

Frond elate, caulescent, spreading pinnately decomposed, 8 to 12 or even to 25 cm. high and to equally broad; primary branches alternate, beset with very slender, repeatedly divided pinnae; the stem and main branches, primary and secondary, far upwards stupose-hairy from radicles descending from the basal joint of the next superior segment; a monosiphonious axis is continuous throughout the branching forming the design of the plant, entirely ecorticate but surrounded below by an intricate investiture of the radicles and their branches; all the free tertiary pinnules plumulose, much and finely divided, the ramifications throughout alternately pinnate.

Colour of the plumules rosy in young and sterile plants, duller and even a dark purple in fruiting plants, of the felted rachides brown.

Cystocarps single, terminal on short segments, involucreted by inferior incurved ramelli.

Sporangia spherical, about 35 μ in diameter, numerous, distinctly pedicellate, the pedicel unicellular nearly or quite as long as the diameter of the sporangium, often subserrate second on the inner side of the ramelli, forming tetrads.

Antheridia not observed.

Habitat.—Tasmania, especially in the Tamar River (Gunn, Harvey, Fereday, Lucas), Port Phillip (Wilson, less luxuriant, Lucas).

S. ANGUSTATUM (H. and H.) De Toni. (Plate xxxiv, fig. 1.)*Callithamnion angustatum* H. and H., *Flora of Tasmania*, ii, p. 334, 1860.

Frond elate, to 12 cm. high, pinnately decomposed, below funicularly contorted and somewhat stupose with radicles descending the rachis from the basal joints of the larger branches, and above and in greater part emitting free and very flaccid branches; the branches soft, in all directions pinnate, the pinnae, on an elongated axis with rather naked protruding apex, alternate, conspicuously attenuated from the base, the lowest pinnae of the larger branches subrecurved, the upper short patent; the joints four times as long as the diameter.

Colour a bright rose-red, brighter and lighter than in *S. latissimum*.

Cystocarps geminate, involucreted by subumbellate ramelli of unequal length.

Sporangia scattered on the ramelli, quite sessile, divided into tetrads.

Antheridia not observed.

Habitat.—Tasmania, Georgetown (Harvey), Tamar River, Ulverstone, D'Entrecasteaux Channel (Lucas), Port Phillip Heads (Wilson); grows on other algae.

The slender stem and primary branches are usually quite inconspicuous, and hence difficult to trace amidst the superabundance of ramuli of secondary and higher orders. In a cystocarpiferous plant from Ulverstone, however, they were as conspicuous as in the upper regions of *S. latissimum*. The larger branches are funicularly contorted and give off radicles, the radicle now passing down the stem from the basal joint of a branch, now formed from the lower pinnules of the branches.

The cystocarps opposite geminate, on a smaller ramus below the persisting apex, are surrounded by a sort of involucre of subumbellate unequal ramelli, several of the latter acuminate with shorter joints.

The habit is quite that of *Callithamnion*.

S. VIOLACEUM (Harv.) De Toni. (Plate xxxiv, fig. 2.)

Callithamnion violaceum Harv., *Flora of Tasmania*, ii, p. 334, 1860.

"Caespitose, purple, fronds capillary, stupose at the base to a considerable height with radicular threads interwoven into cords, pellucidly articulate compound pinnate; the branches in all directions pinnate at the base bipinnate at the apex, pinnate with simple plumules, pinnules patent filiform elongate; joints of the rami six times, of the ramuli three times, as long as the diameter; tetraspores sessile on the pinnules, subsolitary, globose.

"A small species 2-3 inches high. The principal branches are bundled together into ropes, and then closely interwoven by root-like fibres, which issue from the nodes, and proceed downwards along the stem, forming an accessory stupose stratum. The branches are alternately pinnate below, and bipinnate above, all the pinnules remarkably patent and elongate. Tetraspores are thinly scattered on the inner faces of the pinnules".—(Harvey.)

Colour a dull purple.

Cystocarps geminate with no involucre of ramelli (Lucas).

Antheridia not observed.

Habitat.—Tasmania: Georgetown (Gunn, Harvey), abundant in the Derwent Estuary (Lucas).

Specimens found by Gunn, much larger, with stronger and shorter ramuli of rather shorter joints, may, in the opinion of De Toni, constitute a distinct species. I have had no opportunity of seeing Gunn's specimens, nor have I gathered forms of the kind.

S. SCOPULA (Harv.) J. Ag.

Callithamnion scopula Harv. *Trans. Roy. Irish Acad.*, xxii, p. 562, 1854.

Frond small, an inch high, below funicularly contorted and rooting, at length stupose at the base, above terminated in free fascicles of branches, the greater branches gradually on all sides porrect pinnate, the pinnules subdistichous rather simple elongate, curved, the lower subhorizontal recurved, the upper patent, joints $2\frac{1}{2}$ times as long as the diameter.

Cystocarps and *Antheridia* not seen.

Sporangia elliptical, sessile, scattered among the pinnules.

Habitat.—Rottneest Island, Fremantle (Harvey).

We have no specimens in Australian Herbaria, but the plant would appear to be a smaller Western Australian representative of the Tasmanian *S. violaceum*.

S. SCOPARIUM J. Ag.

Anal. Algol. contd., i, p. 117, 1894.

Frond caespitose-rounded, expanded in every direction, composed of branches repeatedly fasciculately divided, the branches radiating above a stipes less conspicuously funicularly compound, branches and branchlets issuing on all sides erect-patent, rather rigid, of unequal length, joints slightly contracted at the dissepiments usually three or four times as long as the diameter. No fruits seen. The bushy fronds stout, measuring 10 cm. in expansion.

Habitat.—Western Port (Wilson), Orford, Tasmania (Mrs. Meredith).

We have no examples in the Australian Herbaria. There seems but little in this meagre description to separate the species from *S. violaceum* from the same region. Is it the same thing as Gunn's larger form of *S. violaceum*?

To be excluded from the genus *Spongoclonium*.

CALLITHAMNION DEBILE HARV. (Plate xxxv, fig. 1.)

Trans. Roy. Irish Acad., xxii, p. 563, 1854; *Spongoclonium* ?? *debile* (Harv.)
De Toni, *Sylloge Algarum*, iv, 1903.

Fronde small, caespitose, scarcely an inch high, ultracapillary, decomposed pinnate, the lower branches giving off ramuli on all sides, the upper distichously pinnulate, the pinnules very patent, inferior articuli 5-8 times, and those of the ramuli 3-4 times, as long as the diameter.

Colour purpurascens.

Cystocarps and *Antheridia* not seen.

Sporangia solitary, sessile on the ramuli (Harvey).

Habitat.—Rottneest Island, Fremantle (Harvey), "In shady crevices of rocks at half-tide level".

There are specimens in the Melbourne and Sydney Herbaria, distributed by Harvey. The specimen figured, named by Harvey, was gathered by himself at Geelong. De Toni states that he had not seen authentic plants. Examples of the genuine Western Australian plant are needed.

CALLITHAMNION CRISPULUM HARV. (Plate xxxv, fig. 2.)

Trans. Roy. Irish Acad., xxii, p. 562, 1854; *Spongoclonium* (?) *crispulum* (Harv.) De Toni, *Sylloge Algarum*, iv, 1903.

Fronde small, caespitose, 1-3 cm. high (half to three-quarters of an inch, Harvey), decomposed pinnate, with few pyramidal capillary branches bearing short crowded pinnules, the whole ecorticate and nowhere spongy, but with simple *Callithamnion* structure. From the stem, and from the same articulus, in a very few cases a branch proceeds upwards and a simple elongate free arcuately curved radicle hangs downwards. These radicles at first of the colour of the plumules, and with joints of the same length, become hyaline as they descend and the joints become longer. The plumules are alternately distichously pinnulate, the pinnules simple, elongate, incurved, the lower patent, the upper corymbose, the joints one and a half times as long as the diameter.

Colour dull red.

Cystocarps geminate (Harvey).

Sporangia and *Antheridia* not seen.

Habitat.—Rottneest Island, Fremantle (Harvey). Both Melbourne and Sydney Herbaria possess specimens distributed by Harvey.

The presence of occasional free radicles does not at all seem to warrant the inclusion of this well marked plant in Sonder's *Spongoclonium*, and it would, I think, be best left in *Callithamnion*.

EXPLANATION OF PLATES XXVII-XXXV.

Plate xxvii.

Spongoclonium fasciculatum. Bearing antheridia. Western Port (Wilson). Melbourne Herb.

Plate xxviii.

Spongoclonium brounianum. Bearing tetrasporangia. Port Phillip Heads (Wilson) Melbourne Herb.

Plate xxix.

Spongoclonium brounianum. Fremantle (G. Clifton). Melbourne Herb.

Plate xxx.

Spongoclonium wilsonianum. Port Phillip Heads (Wilson). Melbourne Herb.

Plate xxxi.

Spongoclonium dasyurum. Harvey, Alg. Austral. Exsicc. Sydney Herb.

Plate xxxii.

Spongoclonium paradoxum. Orford, Tasmania (Lucas).

Plate xxxiii.

Spongoclonium latissimum. Tasmania. Melbourne Herb.

Plate xxxiv.

1. *Spongoclonium angustatum*. Georgetown, Tasmania (Harvey).

2. *Spongoclonium violaceum*. Derwent River, Tasmania (Lucas).

Plate xxxv.

1. *Callithamnion debile*. Geelong (Harvey). Melbourne Herb.

2. *Callithamnion crispulum*. Fremantle (Harvey). Melbourne Herb.

STUDIES IN THE GOODENIACEAE.

I. THE LIFE-HISTORY OF DAMPIERA STRICTA (R. BR.).

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(Plates xxxvi-xxxvii and fifty-eight Text-figures.)

[Read 28th September, 1927.]

Introduction.

One of the final attainments of botanical research will be the realization of an absolute Natural System of Classification of plants.

How far this goal is from attainment is manifest, and even more apparent is the difficulty of such an achievement. The nature of the problem does not permit of its being resolved by the brilliancy of the individual. The arrangement of plants in such a manner as to show their phylogenetic relationships can be achieved only through the cumulative results of researchers throughout the ages. The magnitude of the task is colossal, but the lure of it is a splendid incentive to effort, and each worker may contribute his mite.

No phylum has received so much attention as the Angiosperms—a fact readily understood—yet, despite the efforts of systematists from the time of Linnaeus to the present day, the so-called Natural System of Classification of Angiosperms, is still largely artificial, and a matter of surmise. The Orders and even many Families are, in the main, merely aggregations of forms with similar gross characters, that is, are form groups, which may or may not consist of closely related members. The variety of Systems, which claim precedence at the present day, bears testimony to the above statement. Agreement has not even been reached as to what constitute the most primitive forms of flowering plants.

It would seem that further progress may most confidently be expected along that line of investigation which deals with the life-histories of representatives of those Families about which little or nothing beyond gross morphology is known. In this way assumptions or suspicions may be tested, and unsuspected relationships exposed.

For obvious reasons our knowledge of the life-histories of Angiosperms is largely confined to cosmopolitan forms, or to those prevailing in the Northern Hemisphere, and particularly to the Temperate Regions. It is the more desirable then to gain information regarding representatives of floras typical of the great land masses south of the Equator, such as South Africa, South America and Australasia. Most particularly does this apply to Australia, which, on account of its long isolation from adjacent continents, may well harbour forms of peculiar significance. In addition the study of endemic forms may shed light on the vexed question of the original centre of distribution of Flowering Plants.

So far, very little indeed has been done along such lines in Australia, which with a flora noted for its high percentage of endemism may supply some interesting information concerning the course of evolution.

Only two Families of plants are confined to Australia, viz. Brunoniaceae and Tremandraceae, but at the same time many Families find their chief expression in Australia, and beyond its borders are represented only by a few widespread species. An outstanding example of this is furnished by the Goodeniaceae, a Family which has many points of interest, but which is chiefly noteworthy on account of its indusiate stigma, and peculiar pollinating mechanism.

Such abnormalities, coupled with the puzzling distribution of the genera and species comprising the Family certainly held the attention of the writer, and suggested that an investigation of the life-history of a representative of one or more genera might not be an unprofitable undertaking.

THE GOODENIACEAE.

The Goodeniaceae comprises 12 genera which have been divided into two sections (Bentham and Hooker, 1869).

Section A. *Leschenaultia*, *Anthotium*, *Velleia*, *Goodenia*, *Calogyne*, *Selliera*, *Catosperma*—consisting of forms with two or more ovules in each loculus of the ovary, or on each side of the imperfect or rudimentary dissepiment.

Section B. *Scaevola*, *Diaspasis*, *Verreuxia*, *Dampiera*, *Brunonia*—having one or two ovules in each ovary.

Some authorities prefer to exclude *Brunonia* from the Goodeniaceae and recognize a Family—the Brunoniaceae—which is monotypic.

Engler and Prantl (1887) subdivided the Goodeniaceae into I. Goodenioideae (including all the above genera except *Brunonia*) and II. Brunonioideae with a single genus *Brunonia*.

An investigation of the life-history of *Brunonia* is obviously to be desired.

Of the twelve genera quoted nine are confined entirely to Australia (Bentham and Hooker, 1869), viz.:

| | | |
|---------------|---------|--------------|
| Goodenia | | with 69 spp. |
| Dampiera | | „ 34 .. |
| Leschenaultia | | „ 16 .. |
| Velleia | | „ 12 .. |
| Verreuxia | | „ 2 .. |
| Anthotium | | „ 2 .. |
| Catosperma | | „ 1 .. |
| Diaspasis | | „ 1 .. |
| Brunonia | | „ 1 .. |

while of the remaining three genera, *Scaevola* with 65 species is distributed throughout Australia, Polynesia and various other warmer sea coasts of the world. Only a few species, however, are found outside Australia.

Calogyne with three species occurs in Australia (2 spp.), and on the coasts of China (1 sp.).

Selliera with 2 species, occurs in Australia, one species being endemic, while the other extends to New Zealand and extra-tropical South America.

Willis (1919) gives a larger number of species in three of the above mentioned genera, viz. *Goodenia* 100 species, *Dampiera* 35 species and *Verreuxia* 3 species, while the Index Kewensis supplies the following: *Goodenia* 101 species, *Dampiera* 48 species, and *Verreuxia* 2 species.

Manifestly, then, Australia is the headquarters of the Goodeniaceae, since only three of the twelve genera, and these comprising only a few species, occur outside its borders.

The Goodeniaceae in conjunction with the Cucurbitaceae, Campanulaceae, Candolleaceae, Calyceraceae, and Compositae form an Order—the Campanales

(Engler and Prantl, 1889)—and it will be interesting to compare the life-history of one of the species of the Goodeniaceae with the life-histories representative of other families in the Order.

The vegetative features and general floral structure alike indicate that the Goodeniaceae are highly specialized, and relatively recent in evolution.

Genus DAMPIERA.

The genus *Dampiera* has been selected as the type for this investigation primarily because it is endemic to Australia, but also on account of its wide distribution throughout the Continent, and its highly specialized floral structure.

Seven of the thirty-four species occur in New South Wales. Two of these are common in the neighbourhood of Sydney, viz. *D. stricta* and *D. Brownii*, the former providing the material for this research.

Dampiera stricta is typically found growing in the bush in poor sandy soil, and in distribution ranges from the coastal districts to the dividing ranges. Reference to Plate xxxvi shows the habit to be erect, shrubby, and almost herbaceous. Normally it attains a height of from twelve to eighteen inches. The stem and leaves are of a dark green colour. The former is distinctly angular, while the alternate exstipulate leaves vary from elliptical to almost linear in shape, with the lower ones broader, toothed or entire. The leaves vary from one-half to one and a half inches in length.

The flowers which are shortly pedunculate, occur mostly in the axils of the upper leaves, but may be terminal and are either solitary or in clusters. The number and relative positions of the various floral organs are shown in Text-figs. 8-11.

The brownish gamosepalous calyx which is partially fused with the ovary is densely tomentose, and terminates in five tapering lobes. The zygomorphic corolla is blue with a yellow centre and is about three-quarters of an inch in length. This corolla is five-lobed and split deeply in the transverse plane in such a way that two almost free perianth segments occupy an adaxial position while three sympetalous segments are on the abaxial side. The infolding adjoining edges of the two adaxial segments form a pouch-like structure. All lobes are densely hairy except for the membranous margins which are glabrous.

The androecium consists of five stamens which alternate with the perianth segments, the filaments being inserted singly on the receptacle while the anthers are connate.

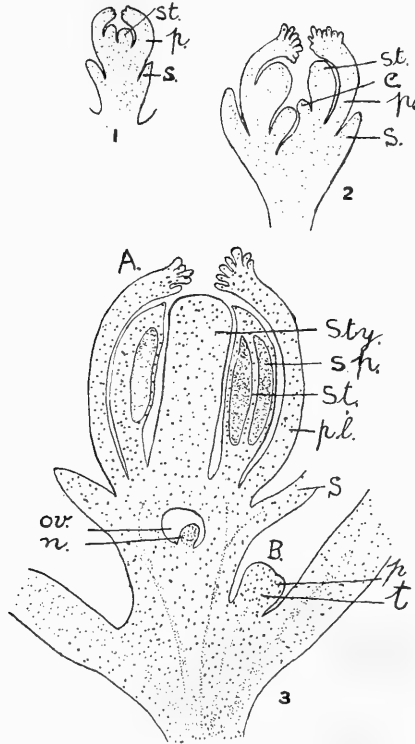
The ovary is bicarpellate, inferior, possesses one loculus, and contains a single erect anatropous ovule. When the flower is opening the style elongates rapidly, carries the terminal indusium up through the connate anthers, and curving slightly near the distal end pushes the indusium into the pouch-like receptacle formed by the auricles in the line of junction between the two adaxial segments of the corolla.

Organogeny.

The four whorls of floral organs—sepals, petals, stamens and carpels—arise in acropetal succession. The members of any one whorl alternate with the members of the whorl immediately above or below. This latter fact is shown in Text-figs. 8-11 which represent a flower bud in transverse sections. These sections are arranged in basipetal sequence.

In Text-fig. 3 at *t.* is shown the thalamus of a very young flower bud in longitudinal section. The primordia of the first or sepaline whorl are just apparent.

Text-fig. 1 shows a young bud in longitudinal section. The young sepals, petals and primordia of the stamens are easily recognizable, and are quite distinct from each other.

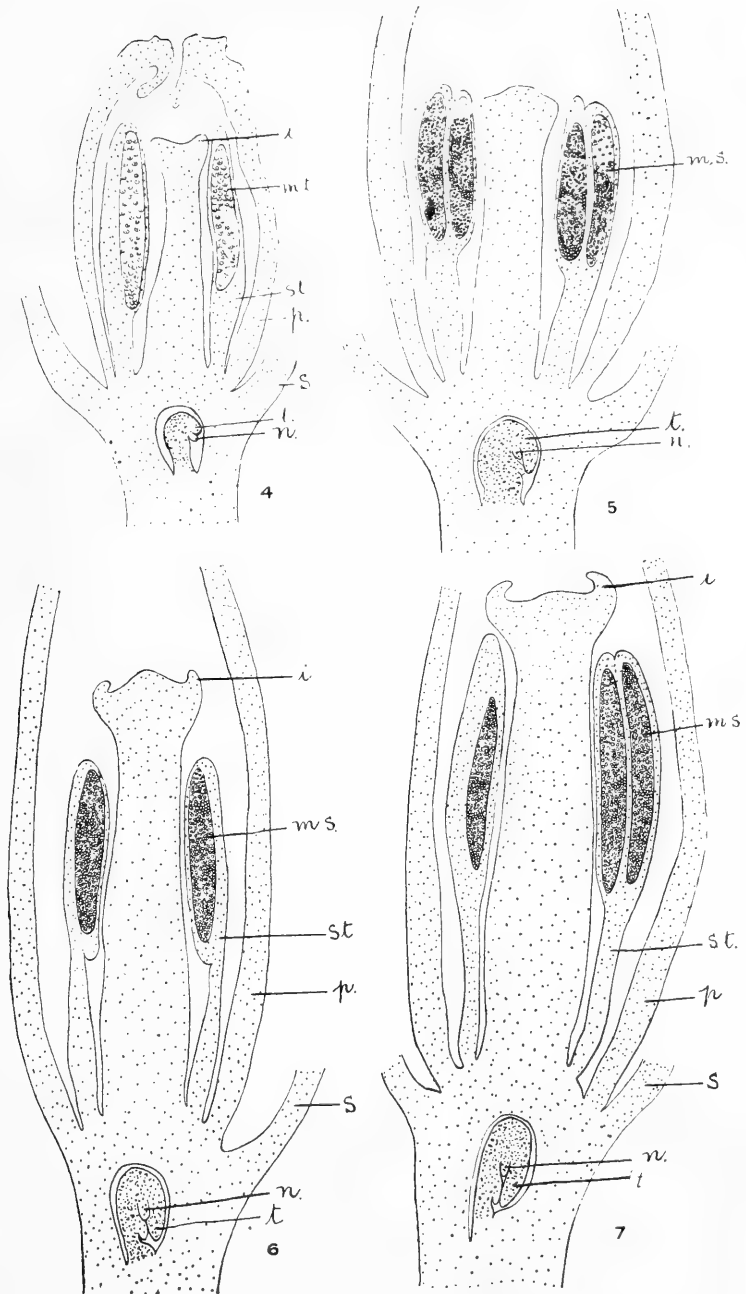


Text-fig. 1. A median longitudinal section of a very young flower bud showing young sepals, petals and stamens. *s.*, sepals; *p.*, petals; *st.*, stamen primordium. $\times 33$.

Text-fig. 2. A median longitudinal section of a flower bud slightly older than that in Text-fig. 1. In this case the primordia of the carpels are apparent. *s.*, sepal; *p.*, petal; *st.*, stamen; *c.*, carpel. $\times 33$.

Text-fig. 3. A median longitudinal section of a still older flower bud A, also young floral axis B. *s.*, sepal; *pl.*, petal; *st.*, stamen; *sp.*, sporogenous cells; *sty.*, style; *ov.*, cavity of ovary; *n.*, nucellus; *p.*, primordium of sepal on floral receptacle; *t.*, thalamus. $\times 33$.

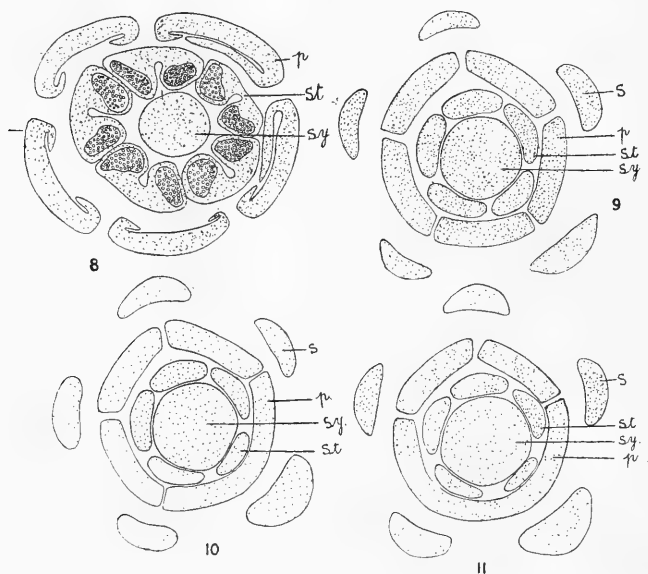
A slightly older bud shows the organs just mentioned, but in this case they have increased in size, and the primordia of the carpels are now apparent, Text-fig. 2. Even at this early stage the characteristic hairs in the distal region of the petals are apparent. Text-figs. 4-7 form a series of longitudinal sections of successively later stages in floral development. In the mature flower the sepals are fused, but the explanation supplied above indicates clearly that the primordia of these floral organs arise separately on the thalamus, and that fusion



Text-fig. 4. A median longitudinal section of a flower bud slightly older than that of Text-fig. 3. *s.*, sepal; *p.*, petal; *st.*, stamen; *mt.*, microspore tetrads; *i.*, indusium; *n.*, nucellus; *t.*, integument. $\times 25$.

Text-figs. 5, 6 and 7. Series of longitudinal sections of flower buds showing various stages in development. *m.s.*, microspores; interpretation of other parts as in Text-fig. 4. $\times 25$.

is brought about later by an increase in extent of the various merismatic regions until they coalesce, and produce the gamosepalous calyx. In the case of the corolla the primordia also arise separately and continue growing independently until five distinct lobes are produced (Text-fig. 9). Later the three abaxial segments fuse (Text-figs. 10 and 11), thereby producing the lower lip of the mature structure. The two adaxial primordia, however, retain their identity until maturity is almost attained. Thus, in the fully developed flower, the corolla consists of a lower lip composed of three fused segments and an upper region, the two segments of which are distinct from the abaxial lip, and almost from each other.



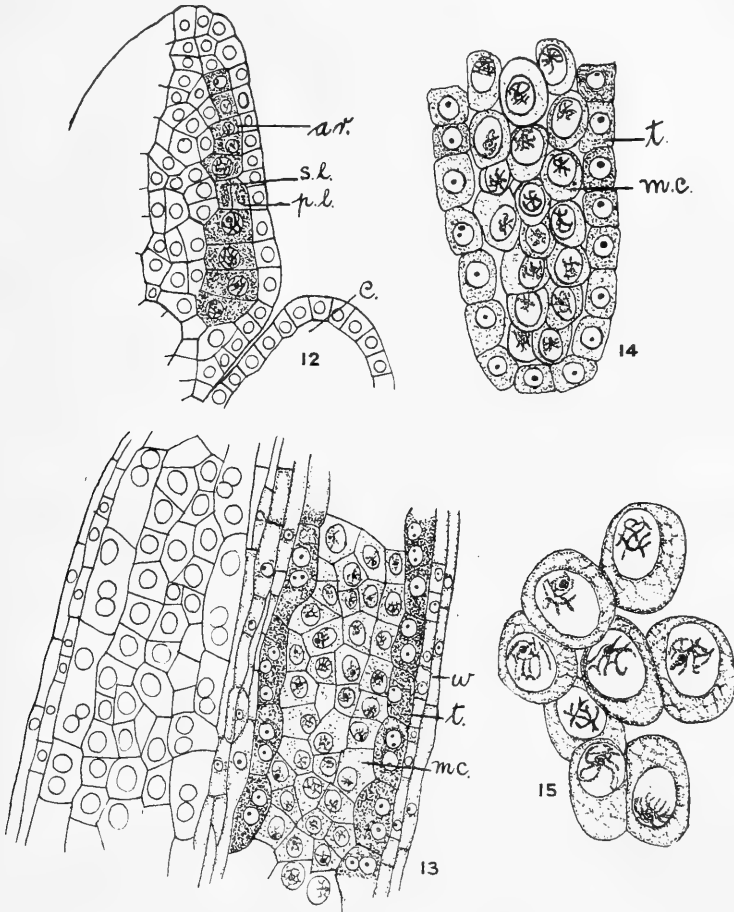
Text-figs. 8-11. Series of transverse sections in basipetal sequence of a flower bud about the same age as that shown in Text-fig. 7. The relative positions of the various parts, and their gradual fusion is illustrated. *s.*, sepal; *p.*, petal; *st.*, stamen; *sy.*, style. $\times 16$.

The development of the androecium, however, forms a distinct contrast. In this case there is no increased merismatic activity in the region of the thalamus which gives rise to the androecium, and so the primordia of the stamens always remain distinct from each other. At a later stage the anthers increase in size with extraordinary rapidity, and the pressure set up by the impinging cells of the various stamens results in the connate condition seen in the anthers at the stage of development immediately preceding the final and very rapid elongation of the style. (Text-figs. 8 and 20).

In the young flower bud (Text-fig. 3) there is no indication of an indusium or pollen cup. As development proceeds the apex of the style becomes slightly concave (Text-figs. 4, 6 and 7), owing first of all to the relatively slow growth now taking place at the organic apex, and secondly to the increased activity of the cells around the margin of the style apex. This differential growth eventually

results in the formation of the pollen cup characteristic of the more mature flower bud (Text-fig. 53).

Again reference to Text-figs. 3-7 shows that during floral development there are from time to time most striking differences in the relative rates of growth of the style and stamens. The result of the phenomenon is that at several stages of floral development the anthers overtop the style apex, while at other intervening periods the style rises above the stamens. However, before the bud is ready to open the connate anthers overtop the apex of the style, the extremity of which



Text-fig. 12. Longitudinal section of young anther. *a.r.*, arche-sporium; *p.l.*, primary parietal layer; *s.l.*, primary sporogenous layer cell; *c.*, young carpel. $\times 266$.

Text-fig. 13. Longitudinal section of anther slightly older than that of Text-fig. 12. *w.*, wall of sporangium; *t.*, tapetum; *m.c.*, spore mother cells. $\times 266$.

Text-fig. 14. Longitudinal section of anther slightly older than that in Text-fig. 13. *t.*, tapetum; *m.c.*, spore mother cells. $\times 266$.

Text-fig. 15. Spore mother cells in synapsis. $\times 600$.

is cup-shaped. The anthers are now mature, and the stimulus exerted by the friction of the style in passing up through the mature anthers causes the pollen sacs to split longitudinally along their inner surface and dehisce introrsely. Consequently the cup-shaped apex of the style becomes filled to overflowing with pollen grains. (Plate xxxvii, figs. 3, 4 and 5). Surely it would be hard to find a more exact or a more wonderful device in pollinating mechanisms. It may also be observed that only a very small proportion of the microspores are left behind in the pollen sacs.

Within the stamen whorl, and around the base of the style five nectaries are situated. One of these organs is shown in detail in Text-fig. 58. Such structures obviously find their role in connection with insect visitation.

A comparison between the development of the stamens and carpels in point of time shows that the procedure is normal, the former anticipating the latter stage by stage until these organs are mature. For example, the archesporial cells of the microsporangium are differentiated, while the tissue of the megasporangium is still quite homogeneous and before the integuments make their appearance (Text-figs. 3 and 12); microspore mother cells are produced before the archesporium of the nucellus is apparent (Text-figs. 13, 14, 15); pollen tetrads are segregated by the time the megaspore mother cell is distinguishable (Text-figs. 4, 26 and 27); the uninucleate microspore stage is attained, while the megaspore mother cell is dividing and giving rise to the four megaspores; dehiscence of the microsporangia and the deposition of the binucleate pollen grains in the cup-shaped indusium of the elongated style has occurred by the time the mature female gametophyte has been formed; the 8-nucleate stage of the female gametophyte is not attained until the flower bud is ready to open.

Although the microspores in the pollen cup are fully developed at this stage, they do not germinate, the stigma not yet being fully developed or receptive.

The Microsporangium—Development and Structure.

The anther consists of four microsporangia held together by connective tissue of the filament. The anthers become connate by fusion of the cuticle of contiguous cells when the stage of development—tetrad stage—shown in Text-fig. 4 is reached. The fragile nature, and the very restricted amount of tissue controlling this cohesion are illustrated in Text-fig. 20.

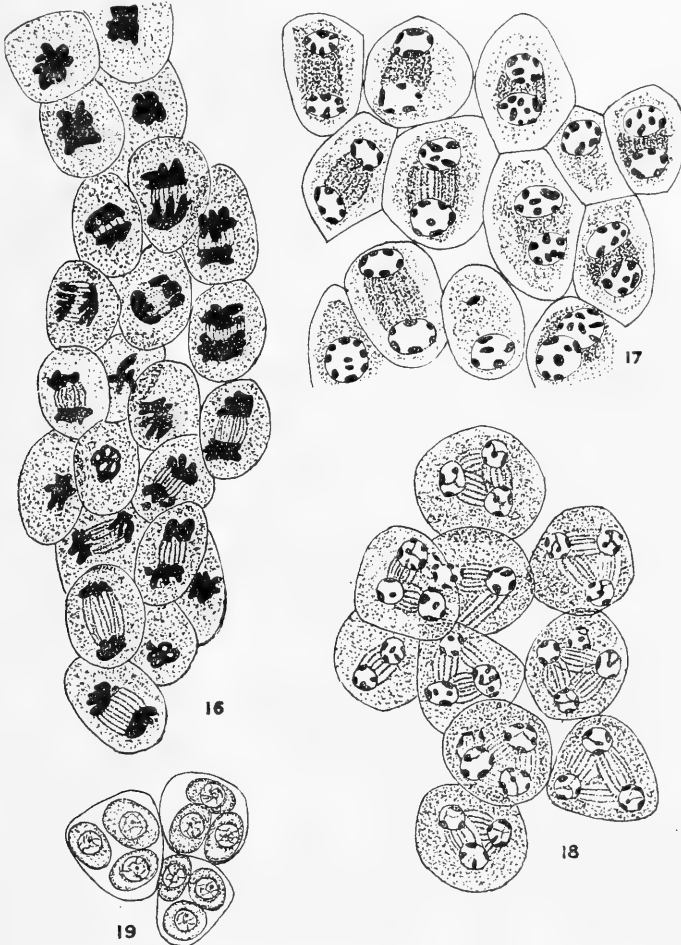
A longitudinal section through the archesporium is shown in Text-fig. 12. The archesporial cells each divide once by periclinal walls giving rise to the primary sporogenous layer (*s.l.*) and the primary parietal layer (*p.l.*). The latter divides producing the tapetum on the inside, and a wall layer one cell thick on the outside (Text-fig. 13).

Later the inner wall layer by differential thickening becomes the fibrous layer, while the multinucleate tapetal cells become absorbed by the developing microspores. Vestiges of the tapetum are still distinguishable in Text-fig. 20.

The sporogenous cells divide twice or thrice in giving rise to the spore mother cells.

At the stage when the microspore mother cells are produced, a distinct tapetum with multinucleate cells, and dense granular cytoplasm is present (Text-fig. 13). This in turn is encased by the wall of the sporangium which on the outer side is two cells thick. Most of the spore mother cells, as shown on a higher scale of magnification in Text-fig. 15, are in the condition known as synapsis, the nuclei being relatively large, and the chromatin drawn together.

This phase is quickly followed by that indicated in Text-fig. 16, where short thick individual chromosomes can be discerned, and where various stages in reduction division are evident. These cells are found in a longitudinal section of a single microsporangium, and a series illustrating the chief phases in reduction division may be recognized on passing from one end of the section to the other. This testifies to the rapidity in development of the organ concerned. After the separation of the chromosomes, daughter nuclei are formed (Text-fig. 17). The



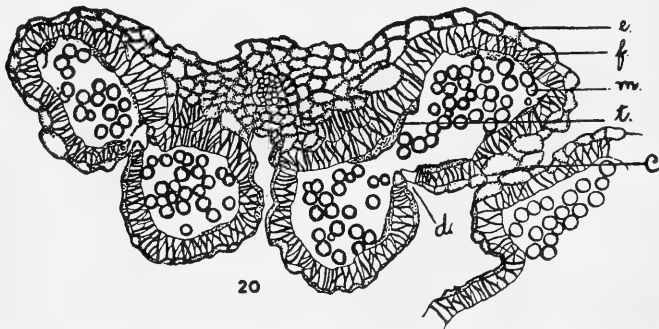
Text-fig. 16. Longitudinal section of microsporangium containing microspore mother cells with nuclei in various stages of reduction division. $\times 600$.

Text-fig. 17. Binucleate condition resulting from reduction division in microspore mother cells. The spindle fibres are still visible in some cases. $\times 600$.

Text-fig. 18. The four-nucleate stage preceding the formation of the microspore tetrad. The spindle fibres are still evident. $\times 600$.

Text-fig. 19. Microspore tetrad stage. Only three of the four young microspores are shown. $\times 600$.

two daughter nuclei in various stages of completeness are evident, the spindle fibres still persisting. This phase is of very short duration, and is followed without interval by division of the daughter nuclei, so that the simultaneous production of the four nuclei of the tetrad is effected (Text-fig. 18). The fibres indicating the existence of the spindle between such nuclei are quite evident, and the view shown in Text-fig. 18 is taken from another part of the same microsporangium as that portrayed in Text-fig. 17. This again testifies to the extreme rapidity of the development of the contents of a microsporangium. The fibres soon disappear, each nucleus is invested by its share of cytoplasm, and a wall forms round each young cell, and thus the pollen tetrad still enclosed in the common wall of the mother cell, is evolved (Text-fig. 19). Eventually the pollen grains are set free by the dissolving of the enclosing wall. The tetrads are produced while the flower-bud is at the relatively early stage of development shown in Text-fig. 4. Thereafter the nucleus of each microspore divides (Text-fig. 21, A) and the binucleate condition of the pollen grain is realized (Text-fig. 21, B). Soon after, but in many cases before the opening of the flower bud, four equidistant protuberances are seen to have arisen from the wall of the microspore, thus imparting the characteristic tetrahedral shape of the mature pollen grain (Text-fig. 21, C).



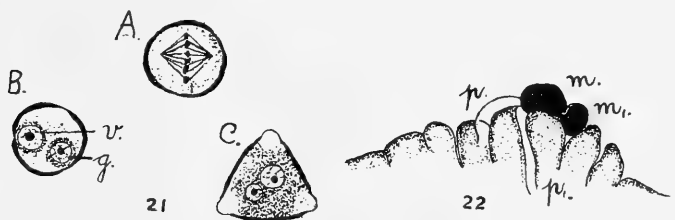
Text-fig. 20. Transverse section of one anther and part of another at the stage immediately preceding dehiscence. *e.*, epidermis; *f.*, fibrous layer; *m.*, binucleate microspores; *t.*, remains of tapetum; *d.*, unthickened cells of fibrous layer indicating region of dehiscence; *c.*, connate cells belonging to two adjacent anthers. $\times 110$.

During microsporogenesis well marked changes fail to be recorded in the development of the tapetum, and wall of the sporangium. As the stamen approaches maturity the cells of the inner layer of the wall—which is only two cells thick—increase in size, and become possessed of a well-marked fibrous thickening (Text-fig. 20). The cells of the outer or epidermal layer, however, shrink, especially those on the side of the microsporangium adjoining the style, and when the time for dehiscence arrives, these epidermal cells have almost collapsed and form no significant part of the mature structure. The fibrous layer completely surrounds the microspores except at the line of dehiscence, and is two cells thick in the region adjacent to the connective. An examination of the fibrous layer reveals the *modus operandi* of dehiscence. The partition wall separating the pairs of microsporangia has already been ruptured, resulting in the formation of two pollen sacs in each anther. The tapetal cells have meantime been absorbed,

their substance being used in the nourishment of the developing pollen grains, and only remnants of the tapetum are now visible. In transverse section the fibrous layer is seen to be complete except in the region *d.*, where two impinging cells (one from each microsporangium of the pollen sac) remain unthickened. Thus a region of weakness extends the whole length of the sac, and when dessication occurs in the mature sacs a strain is set up in the wall, which lends itself to ready dehiscence. It will be obvious that were dehiscence to occur while the anthers still overtop the apex of the style, the microspores shed must drop into the hollow of the indusium. But at this stage, the elongating style begins to push the cup-shaped indusium up through the narrow passage between the connate anthers, and in no case have pollen grains been found in this cup prior to its passage up through these anthers. Accordingly, the friction set up by the indusium rubbing against these anthers is the stimulus which determines the actual time of dehiscence. It is worthy of note that this rapid elongation of the style terminates in the opening of the bud, and at the time when the microspores have just reached the binucleate condition. The full significance of this exact mechanism for abstracting the contents of the pollen sac, and the placing of the pollen grains in a position favouring dispersal by visiting insects, will be appreciated later when the problem of pollination is under discussion.

The Male Gametophyte.

The flower of *Dampiera stricta* is markedly protandrous, and the uninucleate microspores are produced in the young flower bud (Text-fig. 5). Soon after, and before the flower opens the nucleus undergoes division (Text-fig. 21, A) and the



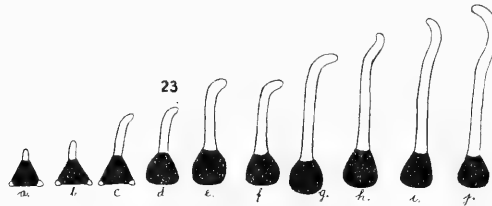
Text-fig. 21. Three consecutive stages in development of male gametophyte. $\times 600$. A. Nucleus of microspore dividing. B. Binucleate stage. *v.*, vegetative nucleus; *g.*, generative nucleus. C. Tetrahedral condition of mature microspore with slight protrusion of intine at three of the four corners.

Text-fig. 22. Two microspores *m.* and *m₁*, with pollen tubes *p.* and *p₁*, passing down among receptive papillate cells of stigma. $\times 266$.

binucleate stage is reached (Text-fig. 21, B). Meanwhile the outer wall of the spore is steadily increasing in thickness until a relatively thick exine is produced. This thickening is not uniform, however, and in the mature pollen grain four thin areas are discernible (Text-figs. 21, B, and 21, C). By the time the flower bud opens the pressure of the protoplasm within the pollen grain has in many cases increased to such a degree that four distinct protuberances are produced by the protrusion of the spore wall at the four unthickened regions. This gives the microspore the tetrahedral shape characteristic of the mature pollen grain.

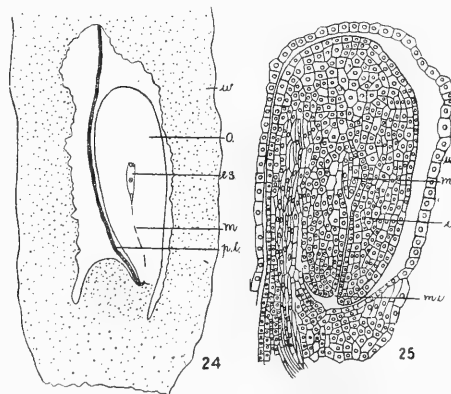
In order to study the further development of the male gametophyte a number of mature microspores were removed from the flower and placed in a five per cent.

solution of cane sugar contained in a well-slide. This preparation was then placed under the objective of a microscope. After half an hour one of the four protuberances in each of several microspores under observation was seen to have increased in size as shown in Text-fig 23, *a*. Thereafter the young pollen tube steadily increased in length, and its appearance at intervals of fifteen minutes was noted and drawn (Plate xxxvii, fig. 6). Thus was obtained the series of



Text-fig. 23. Series showing development of pollen tube in a five per cent. sugar solution. $\times 225$ (approx.).

drawings indicated in Text-fig. 21, *a-j*. The last drawing of the series, 21 *j*., accordingly represents the development attained in 2 hours 45 minutes. It will be observed that the other three protuberances steadily contract as germination proceeds, and eventually disappear. The pollen tube therefore develops with great rapidity, and several such tubes may be detected when a mature style is teased out under the microscope.



Text-fig. 24. Pollen tube within ovary, and passing from style to micropyle. *w.*, wall of ovary; *o.*, ovule; *m.*, micropyle; *p.t.*, pollen tube; *e.s.*, embryo sac. $\times 16$.

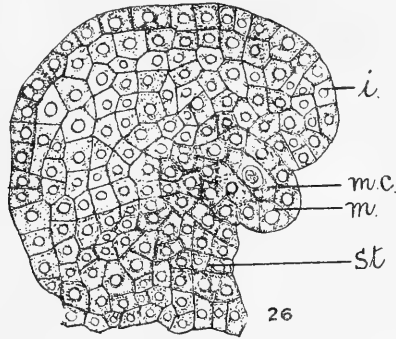
Text-fig. 25. Median longitudinal section of ovary showing anatropous nature of young ovule. *i.*, single massive integument; *m.i.*, micropyle; *m.*, megaspore; *w.*, wall of ovary. $\times 66$.

Further development was traced by examining longitudinal sections of the ovary. In Text-fig. 24, a pollen tube is seen passing from the base of the style to the micropyle of the ovule. In this case only a single pollen tube is shown, but in nearly every case examined several pollen tubes were in evidence. These either grew along the surface of the ovule or adhered to the inner wall of the

ovary until the region of the micropyle was reached. One of the pollen tubes eventually makes its way through the micropyle and enters the embryo sac in the region of the egg-apparatus.

The Megasporangium.

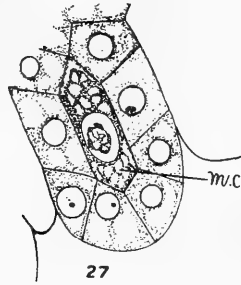
The gynoeceium is composed of two carpels, the origin and early development of which have already been referred to. The young carpels arise separately, but as growth proceeds fusion occurs, and a common style, stigma, and ovary arise. Growth at the apex of the thalamus is, however, relatively slow, and so the carpel producing region is gradually overtopped by the stronger growth around it. The ovary thus becomes inferior, but the style and stigma protrude above the encircling thalamus. The cavity of the ovary is shown in Text-fig. 3, with a young nucellus arising therein. So far there is no indication of an integument. A slightly older stage is shown in Text-fig. 4. Even at this early stage the anatropous nature of the mature ovule is foreshadowed. A single massive integument has



Text-fig. 26. Median longitudinal section of very young ovule. The thick integument partially enclosing the megasporangium is seen. *i.*, integument; *m.*, megasporangium; *m.c.*, megaspore mother cell; *st.*, funiculus. $\times 266$.

made its appearance, and partly encloses the nucellus which forms a relatively small portion of the ovule. Text-fig. 26 illustrates the structure of the very young ovule, at a stage slightly younger than that just referred to. The funiculus, integument and megasporangium are apparent, the last named consisting of an axial row of cells surrounded by a jacket one-cell thick. The megasporangium is therefore of the reduced type characteristic of the more highly developed Angiosperm families. As development proceeds the integument soon outstrips the nucellus, which becomes completely enclosed except for the micropylar passage at the distal end. Various stages of this envelopment are illustrated in Text-figs. 4, 5, 6, 7, 25, 26 and 29. The long micropyle leading from the apex of the nucellus is shown in Text-figs. 25 and 29. It is to be noted that thus early the cells of the integument bordering on that region of the micropyle adjacent to the megasporangium are densely cytoplasmic, and clearly in a state of high nutrition (Text-fig. 29). Later on, the functional megaspore and embryo sac grow forward into the micropyle, and eventually attain a position just beyond this nutritive jacket, which functions as a tapetum, a feature not uncommon in representatives of the more highly developed Angiosperms.

In dealing with this structure Coulter and Chamberlain (1915) point out that it is usually derived from the integument, but arises from the nucellus in *Armeria*. They observe: "This jacket has been definitely observed as conspicuous in *Helosis* (Chodat and Bernard, 1900), *Sium*, many Scrophulariaceae (Balicka-Iwanowska, 1899), *Campanula* (Barnes, 1885), Stylidiaceae (Burns, 1900) and certain



Text-fig. 27. Median longitudinal section of megasporangium. The large cell terminating the axial row of the megasporangium is the megaspore mother cell, *m.c.* × 450.

Compositae, and by Billings (1901) in numerous Sympetalous forms, among the most conspicuous being *Lobelia*. Primulaceae (except *Leptosiphon*), *Linum*, *Forsythia*, *Amsonia*, *Menyanthes*, Polemoniaceae, *Myoporum*, *Globularia*, *Scaevola*, *Calendula*, etc."

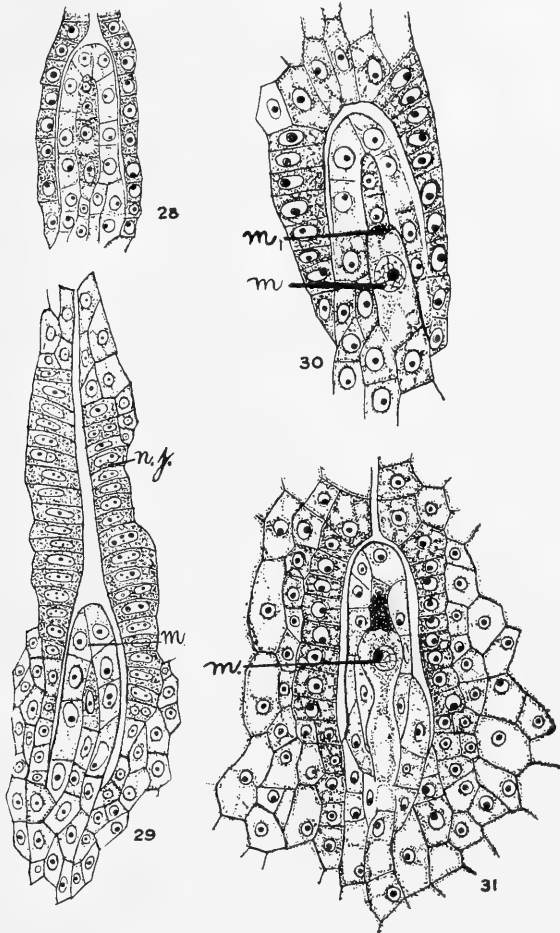
From this list it is evident that a nutritive jacket around the embryo sac is of frequent occurrence among the Sympetalae (especially amongst the more highly developed families) but is also known amongst the Archichlamydeae though to a much less extent.

Just when the anatropous nature of the ovule has become apparent, it is seen that the distal cell of the axial row of the nucellus is large relative to the others, and has a nucleus in proportion. This cell is clearly a megaspore mother cell, and it continues to enlarge until of the dimensions shown in Text-figs. 26 and 27. The nucleus is in synapsis, but examination of numerous longitudinal sections of buds about this stage of development, failed to demonstrate actual reduction division. However, a subsequent stage is indicated in Text-fig. 28 where the four nuclei of the megaspore tetrad are visible. These are not separated by cell walls. A further stage in development is shown in Text-fig. 30 where the two nuclei towards the distal end are quite evident, but the third is undergoing disintegration. The reason for this is seen when the fourth, innermost, or chalazal nucleus is examined. It easily exceeds all the others in dimensions and is clearly the functioning megaspore. Its growth has resulted in the partial disintegration of the adjacent nucleus which is seen in a matrix of deeply stained matter. The steady increase in size of the functional megaspore results in the disorganization of the other three megaspores as illustrated in Text-fig. 31, where only a remnant of the distal nucleus is discernible, the other two non-functional megaspores having completely disappeared. Their former position is occupied by a dark coloured mass which stains very deeply with Haidenhain's iron alum and Fleming's triple stains respectively. Eventually this mass—which evidently is used in the

nutrition of the functional megaspore—completely disappears, and the young embryo sac with its large nucleus is evolved (Text-fig. 32).

The Female Gametophyte.

Meanwhile the nutritive jacket is becoming more and more evident, extending well down the micropyle, and also completely surrounding the megasporangium.



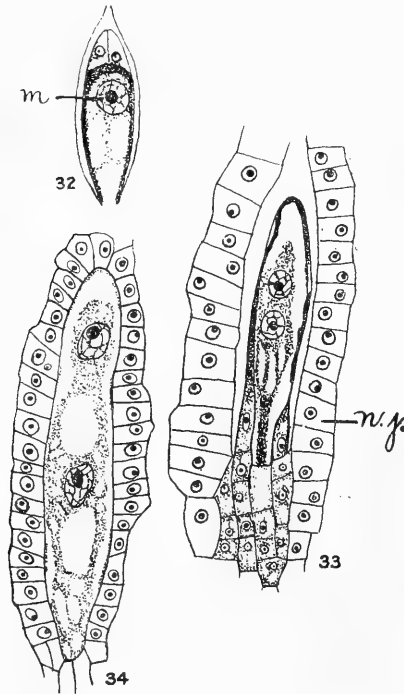
Text-fig. 28. Median longitudinal section of slightly older ovule showing 4 megaspores not separated by walls. $\times 266$.

Text-fig. 29. Longitudinal section through micropyle showing nutritive jacket, *n.j.*, formed by innermost cells of integument. The megasporangium, *m.*, is not quite in median section. $\times 266$.

Text-fig. 30. Median longitudinal section of megasporangium showing enlarged functional megaspore, *m.*, and the adjoining megaspore, *m.*, disintegrating. $\times 333$.

Text-fig. 31. Median longitudinal section of megasporangium showing functional megaspore, *m.* The disintegration of the other three megaspores is almost complete. $\times 333$.

As the functional megaspore increases in size, the single layer of cells forming the wall of the megasporangium is steadily encroached upon and absorbed (Text-fig. 32), so that by the time the young embryo sac has been formed, the wall cells have practically disappeared. The nucleus of the surviving megaspore now divides, producing the first two nuclei of the female gametophyte (Text-fig. 33).



Text-fig. 32. Longitudinal section of ovule showing functional megaspore, *m.*, and remains of nucellar tissue now almost absorbed by developing embryo sac. $\times 300$.

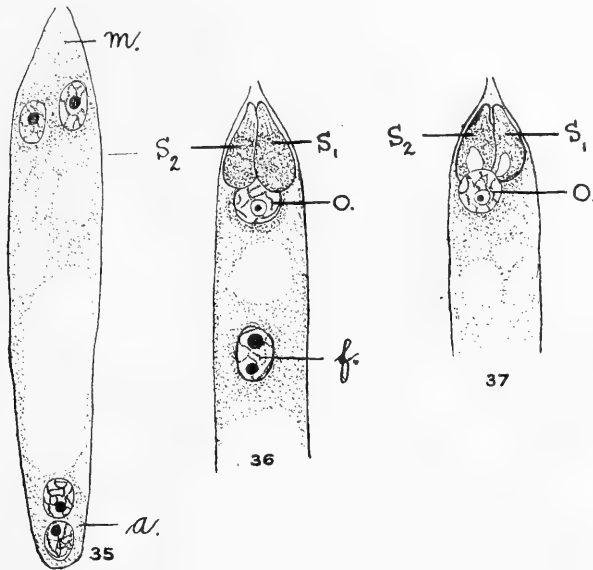
Text-fig. 33. Portion of median longitudinal section of an ovule showing binucleate condition of embryo sac. *n.j.*, nutritive jacket. $\times 300$.

Text-fig. 34. Binucleate condition of embryo sac slightly older than that figured in previous drawing. $\times 310$.

The embryo sac and nuclei enlarge rapidly, the latter being gradually separated (Text-fig. 34), and eventually occupying opposite ends of the sac. Each nucleus divides again producing the four-nucleate stage illustrated in Text-fig. 35. A subsequent division of each of these nuclei results in the eight-nucleate stage of the mature gametophyte. Text-figs. 36 and 37 respectively show the micropylar portions of the two embryo sacs. In each case the egg apparatus is depicted, while in the former the endosperm nucleus is represented.

Text-fig. 38 shows three successive sections of a mature and enlarged embryo sac. In *B* a single synergid and the egg are apparent; in *A* a second synergid and the micropylar polar nucleus are evident; while in *C* the antipodal polar nucleus and the three antipodal cells are found. The synergids are pyriform, their

tapering ends invade the micropyle to some slight extent, and each possesses a nucleus and a large vacuole. The oosphere is apparent at the lower extremities of the synergids. The tapetum is figured on one side of the embryo sac only. This nutritive jacket is now at the height of its development, and its dense deeply

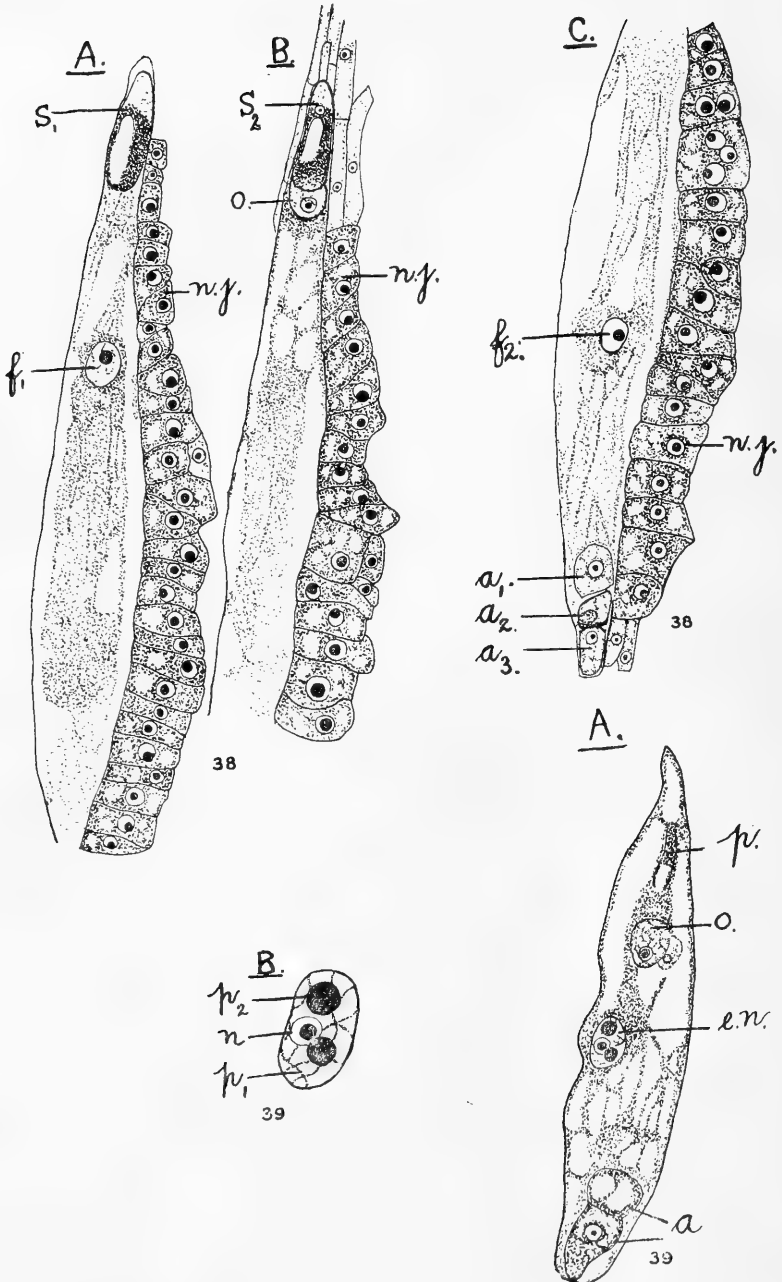


Text-fig. 35. The four-nucleate condition of the embryo sac.
m., micropylar region of sac; *a.*, antipodal region of sac. $\times 266$.
 Text-figs. 36 and 37. Micropylar region of two embryo sacs.
s₁, *s₂*, synergids; *o.*, oosphere; *f.*, primary endosperm nucleus. $\times 266$.

stained cytoplasm, coupled with the regular arrangement of its constituent cells brings it out in bold relief in the sections. It will be seen that the micropylar region of the sac has grown slightly beyond the tapetal cells of this region. A slightly older stage of the sac is seen in Text-fig. 39, A. Therein the egg, the fusing polar nuclei, and two of the antipodal cells are delineated. Part of the pollen tube is visible, and what are interpreted as the two male nuclei—one in contact with the egg and another with the fusing polar nuclei—are indicated.

It must be admitted, however, that these preparations were not distinct enough to diagnose the male nuclei with absolute certainty nor to place the behaviour of the male nuclei beyond the possibility of doubt. The view of what is regarded as the triple fusion nucleus, as obtained under the oil-immersion lens, is shown in Text-fig. 38, B.

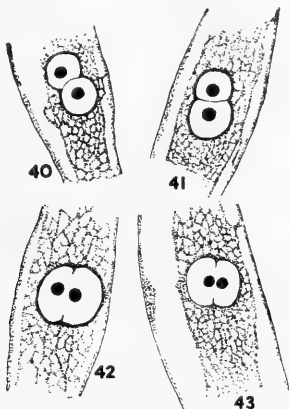
The behaviour of the polar nuclei, however, presented no difficulties, as their history could be traced with considerable ease. Their gradual fusion is illustrated in Text-figs. 40-43, but in none of the cases illustrated is the second male nucleus in evidence.



Text-fig. 38. Text-figs. 38A, 38B and 38C show views seen in three successive sections of embryo sac. s_1 , synergid; s_2 , synergid; o , oosphere; f_1 , micropylar fusion nucleus; f_2 , antipodal fusion nucleus; a_1 , a_2 and a_3 , antipodal cells; $n.j.$, nutritive jacket shown on one side of embryo sac only. $\times 266$.

Text-fig. 39. A. Another embryo sac. o , oosphere; $e.n.$, endosperm nucleus; a , antipodal cells; p , pollen tube. $\times 266$. B. Fusion of polar nuclei, p_1 and p_2 , with male nucleus, n . $\times 600$.

The chalazal region of the embryo sac is occupied by three antipodal cells. These are well developed and vary in shape and size, the one occupying the lower extremity of the sac being somewhat elongated, while the other two are almost



Text-figs. 40-43. Polar nuclei in various stages of fusion. $\times 300$.

isodiametric. These cells remain active until after fertilization, evidently functioning in passing nourishment from the chalaza of the ovule into the developing sac, but unlike the antipodals found in many of the higher Sympetalae, e.g. *Aster novae-anglicae* (Chamberlain, J. C., 1895), *Sherardia arvensis* (Lloyd, F. E., 1902), do not become unduly enlarged, nor do they encroach to any extent on the chalazal region as haustorial invaders.

The endosperm nucleus divides before that of the fertilized egg or oospore giving rise to free endosperm nuclei as demonstrated in Text-fig. 44. The embryo sac is long and narrow at this stage, so that comparatively few free endosperm nuclei are formed before wall formation is initiated. This is accompanied by rapid expansion of the sac. The nutritive jacket still persists unimpaired.

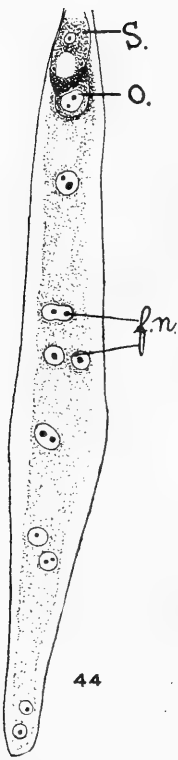
Embryogeny.

When the oospore divides and commences to produce the embryo, a large mass of endosperm tissue awaits invasion. The details of embryogeny are illustrated in a series of drawings (Text-figs. 45-52).

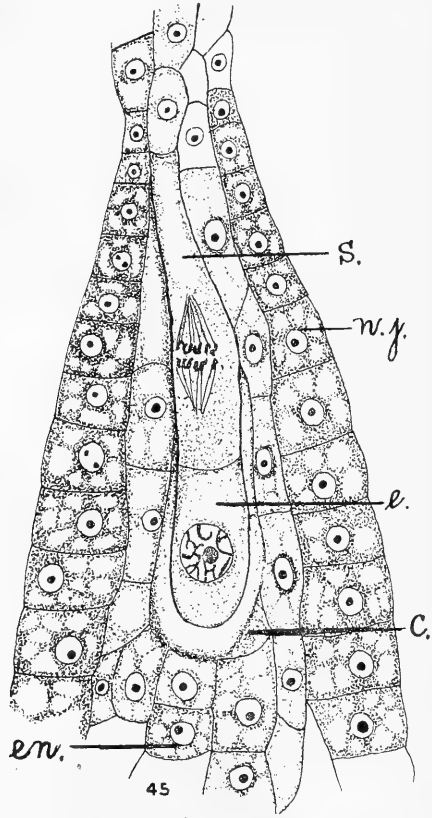
Actual division of the oospore has not been demonstrated, but Text-fig. 45 shows the stage immediately subsequent. Examination reveals a pro-embryo of two cells—a basal or embryo cell proper, and a suspensor cell. The nucleus of the latter is in mitosis.

The pro-embryo invades the endosperm tissue, the cells of which are being absorbed. The cells of the young embryo evidently secrete an enzyme which gradually brings the contingent endosperm cells into solution, preparatory to absorption. The digestive action of the embryo is indicated by the corroded appearance of the adjacent endosperm cells. This feature is apparent in Text-figs. 45, 48 and 51.

The cells of the nutritive jacket still preserve their form, but are now distinctly vacuolate. Text-figs. 45, 46 and 48 show the gradual production of the suspensor which pushes the embryo cell well down amid the endosperm cells.



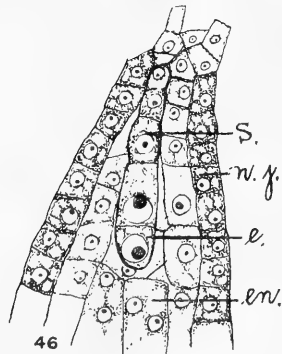
44



45



47



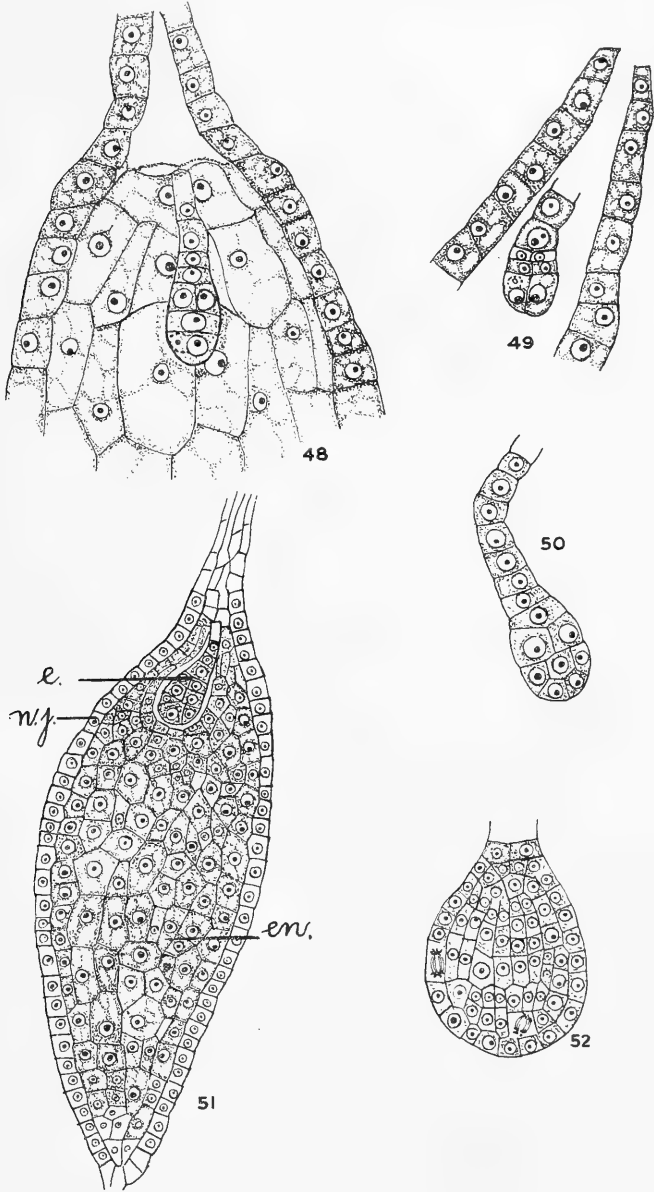
46

Text-fig. 44. A longitudinal section through an embryo sac after fertilization. *s.*, synergid; *o.*, oospore; *f.n.*, free endosperm nuclei. $\times 266$.

Text-fig. 45. Very early stage in embryology soon after division of oospore. *e.*, embryonal cell; *s.*, first cell of suspensor with nucleus undergoing division; *n.j.*, nutritive jacket; *c.*, corroded cells of endosperm tissue. $\times 600$.

Text-fig. 46. A slightly older stage of embryo. The suspensor has elongated. *e.*, embryonal cell; *s.*, suspensor; *en.*, endosperm; *n.j.*, nutritive jacket. $\times 266$.

Text-fig. 47. A further stage in development of embryo. The embryonal cell has divided and approached the octant stage, *o.* $\times 600$.



Text-figs. 48-50 show further stages in embryogeny. $\times 266$.

Text-fig. 51. Embryo, *e.*, invading the endosperm, *en.*; *n.j.*, nutritive jacket around sac. $\times 150$.

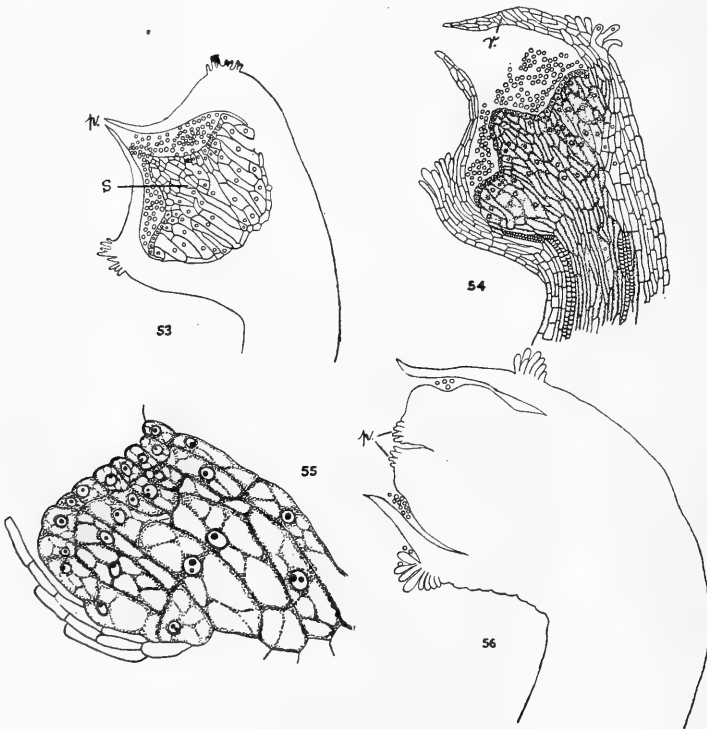
Text-fig. 52. Late stage in embryogeny. The dermatogen, periblem and plerome are differentiated. $\times 266$.

Finally the terminal cell divides so that the quadrant stage, and later the octant stage, are arrived at (Text-fig. 47).

Further cell division follows the octant stage, as indicated in Text-figs. 49-52, and eventually the relatively mature condition depicted in Text-fig. 52 is arrived at. Therein the dermatogen is well defined, and the differentiation into periblem and plerome suggested. Beyond this stage the development of the embryo was not traced.

Pollination.

The problem of pollination and the mechanisms incidental thereto in the Goodeniaceae have attracted widespread attention. Several investigators—notably Brown, R. (1818, 1866), Mueller, H. (1883), Haviland, E. (1884, 1885), Haviland, F. E. (1914), and Hamilton, A. G. (1885, 1894), have placed the results of their



Text-fig. 53. Longitudinal section of apex of style. The young stigma, *s*., is growing up from the base of the pollen cup, and forcing out the microspores through the apical pore, *p*. × 73.

Text-fig. 54. Another view of same showing conducting tissue of style. The portion of the cup *r*. has been slightly displaced in cutting the section. × 73.

Text-fig. 55. Part of stigma of previous figure shown under a higher power of magnification in order to illustrate nature of component cells. × 133.

Text-fig. 56. Longitudinal section of an older stage of style showing stigma occupying centre of pollen cup. The bi-lobed nature of stigma, and the central papillate cells, *p*., are evident. × 33.

investigations on record in the case of certain species of *Goodenia*. The conclusions arrived at are so varied, however, that a careful study of the method of pollination in other genera of the family seems advisable.

In the case of *Dampiera stricta* the method of dehiscence of the anthers, and the depositing of the pollen grains within the hollow indusium have already been described. The cup is filled to overflowing, the spores forming a pyramidal mass. Thereafter the indusium closes owing to the contraction of the margins.

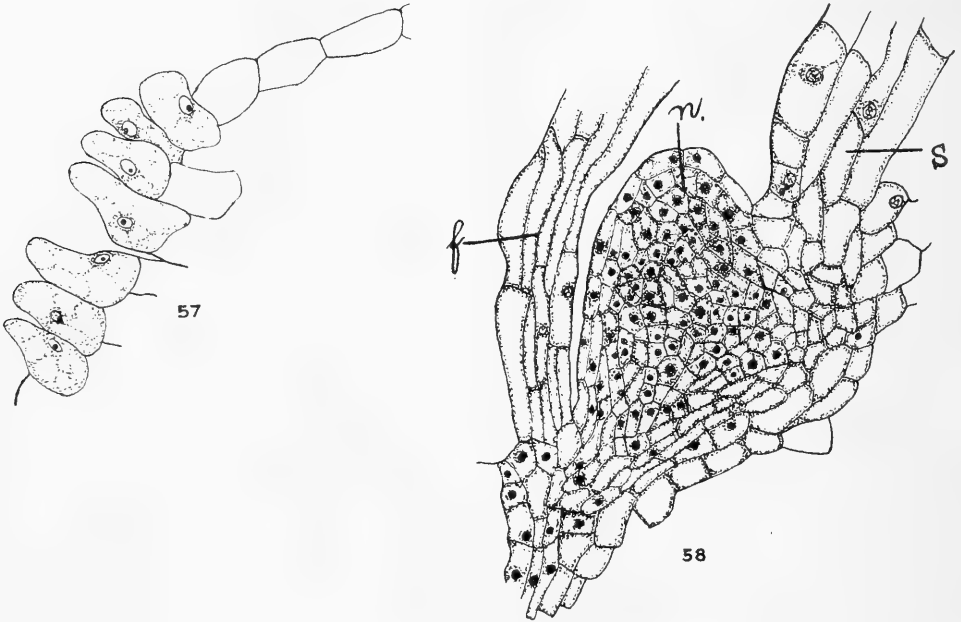
At the time when the style finally elongates, and the flower bud is on the point of opening, the indusium is forcibly thrust into a chamber formed by the auricles in the line of junction between the two posterior petals. The two flap-like appendages aid in the complete enclosing of the indusium, which is orientated so as to face the anterior side of the flower. At no period then, has the pollen been exposed, although part of the bent style is visible, outside the corolla between the two posterior petals. By this time the anthers have withered, and are of no further significance. The rudimentary stigma at the base of the closed indusium now commences to grow rapidly (Text-figs. 53 and 54) and gradually pushes the pollen in front of it, and out through the narrow aperture now present at the top of the fringed pollen cup (Plate xxxvii, figs. 3, 4 and 5). The pollen thus ejected either lodges on the outer sloping sides of the indusium, as indicated in the photographs just referred to, or is deposited in the chamber in which the indusium is imprisoned. Obviously such pollen grains cannot regain their former position resting on the apex of the stigma. Eventually the steadily expanding and rounded stigma protrudes above the rim of the inner cup of the indusium (Text-fig. 56) and occupies the cavity formerly filled by pollen grains. A few microspores may remain lodged between the lower portion of the stigma and the inner wall of the indusium, but such are ineffective from the point of view of pollination. The stigma finally becomes slightly two-lobed, and the cells within and around the depression so formed become papillate, and eventually receptive in relation to the pollen grains (Text-figs. 56, 57 and 22). Furthermore, the sub-epidermal cells immediately within this cleft, and also the tissue leading therefrom, and down through the centre of the style are of a loose, thin-walled nature. Such cells have all the characters of a typical conducting tissue for the nutrition of the advancing pollen tube. Pollen tubes in considerable number were found when the central tissue of the style was dissected out, and examined under a microscope.

In no case were microspores seen to germinate while still within the indusium, although at this stage they are in the binucleate condition, and in many cases show the slight protrusion of the intine through the four weak areas in the exine characteristic of the mature microspore. Judging from the various stigmas examined, at different stages of growth up to and including the emergence of the stigma from the indusium, it seems clear that the pollen grains do not germinate within their own indusium.

Evidently, then, the stigma does not become receptive until the pollen grains from the same flower have been ejected from the pollen cup.

Now, five well developed nectaries are found at the base of and within the whorl of stamens. These are obviously related to insect visitation, and it is well known that bees are frequent visitors to the flower in question. That insects are instrumental in the transference of pollen is proved by the fact that in one case foreign pollen was actually found on a stigma examined. The contrast which this pollen (which was round and spiny) made with the characteristic microspores of *Dampiera*, rendered this point peculiarly easy of elucidation. The foreign

pollen had not germinated. From what has already been demonstrated in regard to the rate of growth of the pollen-tube (Text-fig. 23), it follows that fertilization may occur within a few hours of the pollen being deposited on the ripe stigma. An insect entering the flower pushes the two adaxial perianth segments apart, and, at the same time releases the pollen cup from its chamber. Pollen thus falls on the visitor, and such action will continue until all the pollen has been removed,



Text-fig. 57. Papillate cells of stigma under higher power of magnification. $\times 266$.

Text-fig. 58. Longitudinal section of nectary, *n.*, situated at base of style, *s.*, and within filament of stamen, *f.* $\times 150$.

a consummation which may well be effected before the stigma becomes receptive. Pollen from the pouch is also removed at this stage. It was also observed that a considerable proportion (about 20% or more) of the pollen grains never reach maturity. Thus when the stigma becomes receptive the pollen grains have either been removed by insects or have been pushed aside, and so subsequent insects will deposit pollen from their backs or heads on the surface of the receptive stigma.

It must be conceded then, that pollen is actually transferred by insects from one flower of *Dampiera stricta* to another flower on the same or on another plant, and so cross pollination is effected.

It is not impossible, however, that self pollination may occur in the event of the flower not being visited by the insects, although the writer is of the opinion that the available evidence is against the view that self-fertilization does actually occur. The point can be settled only by taking means to prevent the access of foreign pollen, and then determining whether embryos have formed in the ovaries concerned. The writer hopes to elucidate this point in the near future.

An experiment of this nature has already been carried out in the case of

Goodenia cycloptera by Haviland, F. E. (1914), who found that embryos were not formed.

A survey of the facts laid bare by this investigation of various phases in the life-history of *Dampiera stricta* reveals few features differing markedly from those characteristic of the various forms comprising the higher Sympetalae. The details of organogeny, microsporogenesis, megasporogenesis and embryogeny conform to type, and indicate that the Goodeniaceae find their natural position in the order Campanales. The genus *Dampiera* despite its being endemic to Australia does not show any signal aberrant features, such as was laid bare by an examination of another great Australian family, namely the Epacridaceae, a member of which, *Styphelia longifolia* (Brough, 1923, 1924), showed unique characters more especially in megasporogenesis.

Reverting to *Dampiera* it is interesting to observe the syngenesious anthers—a feature so characteristic of the Campanales. The piston-like action of the style is also typical, but *Dampiera* with its protandry, pollen cup, delicate anther dehiscence, method of dispersing the pollen, and the very late exposure of receptive stigmatic cells is perhaps the most outstanding in an Order noted for its highly developed pollinating mechanisms. The genus would seem to present an epitome of the many peculiarities portrayed by the various members of the most recent and specialized of all the Orders of flowering plants.

On looking for genetic relationships between the Goodeniaceae and the other members of the Order Campanales certain striking features already noted in *Dampiera* are seen to be reflected in the tribe Lobelioideae of the Campanulaceae. In this tribe one finds the herbaceous habit, the zygomorphic flowers, the blue corolla often split to the base, the syngenesious anthers, the piston-action of the style, and the nutritive jacket around the embryo sac. The genus *Lobelia* is represented by eighteen species in Australia (Bentham and Hooker), and the writer has come to the conclusion that all the available evidence goes to show that the genus *Dampiera*—if not the Goodeniaceae as a whole—has been derived from the Lobelioideae.

Summary.

Organogeny. The primordia of the various sets of floral organs arise separately and in acropetal succession. The five young sepals eventually fuse, and form a gamosepalous calyx joined to the ovary. The five petal primordia maintain their identity until an advanced stage of bud development has been attained, when the three abaxial segments fuse to form the lower lip, while the two remaining adaxial segments form the upper lip which is split almost to the base. The two lips are separate throughout. The stamens retain their identity until about the microspore mother cell stage, when the syngenesious condition arises by fusion of contiguous cuticles of the anthers.

The two young carpels fuse to form a common style and inferior ovary.

The characteristic pollen cup arises during late bud development by the relatively slow rate of growth at the organic apex of the style, and the increased merismatic activity in the marginal region.

Microsporangium. The archesporial cells divide by periclinal walls giving rise to a primary parietal layer and a primary sporogenous layer. The cells of the former divide once thereby producing a wall layer and the tapetum. The cells of the primary sporogenous layer divide two or three times before attaining the spore mother cell stage.

The spore mother cells undergo reduction division and then ordinary somatic division, whereby simultaneous pollen tetrads are produced. The great rapidity in growth is attested by the wide range in development depicted in the longitudinal section of a single sporangium. In the mature pollen sac the spores are binucleate, each spore wall bears four equidistant thin areas, the hypodermal cells constitute the fibrous layer, and dehiscence is effected by longitudinal splitting along two median vertical contingent rows of unthickened cells of the hypodermal layer. The mature stamens are short, and are never exposed outside the flower.

The male gametophyte. The mature tetrahedral pollen grain contains a generative and a vegetative nucleus. During germination a single pollen tube grows out through one of the four unthickened areas of the mature microspore. Evidence testifying to the rapidity in growth of the pollen tube was obtained by careful observation of its development in a five per cent. sugar solution. Pollen tubes were traced from the receptive cells of the stigma, throughout the style, and in the ovary from the base of the style to the micropyle. The tube grows through the micropyle, and enters the embryo sac in the region of the egg apparatus.

The megasporangium. A solitary nucellus arises within the ovary. A single thick integument gradually encloses the young megasporangium, which consists of an axial row of cells surrounded by a jacket one cell thick. The anatropous nature of the ovule is early foreshadowed. The megaspore mother cell is formed at the micropylar end of the axial row of the megasporangium. The mother cell gives rise to a linear tetrad of megaspores, the innermost of which is the functional megaspore; this develops rapidly and absorbs the other three megaspores. The wall cells of the megasporangium are also absorbed. Meantime the cells of the integument lining the micropyle enlarge, become densely cytoplasmic, and eventually form a very definite and noteworthy nutritive jacket around the embryo sac.

The female gametophyte. The functional megaspore increases in size, and steadily invades the micropyle. During this development, the bi-nucleate, four-nucleate, and eight-nucleate stages of the female gametophyte are attained. The egg apparatus, polar nuclei, and antipodal cells are normal in structure and polarity. These are described in detail.

Fertilization. The pollen tube enters the embryo sac. One male nucleus fertilizes the oosphere, while the other joins the partially fused polar nuclei.

Endosperm formation. The endosperm nucleus divides before that of the oospore—free endosperm nuclei being formed. Wall formation, accompanied by rapid growth of the embryo sac then supervenes. A massive endosperm is formed.

Embryogeny. The oospore commences development soon after wall formation in the endosperm has been initiated. A long suspensor is formed which pushes the terminal cell well down into the soft endosperm tissue. The embryonal cell attains the quadrant and octant stages respectively. Later periclinal walls cut off the dermatogen, and in the final stages examined, the periblem and plerome had been differentiated.

Pollination. Many investigators, for example R. Brown, H. Mueller, E. Haviland, F. E. Haviland, and A. G. Hamilton, have carried out investigations regarding the methods of pollination in members of the Goodeniaceae. Conflicting views have been expressed. In the case of *Dampiera stricta* the elongating style carries the pollen cup up through the syngenesious mature anthers causing

introrse dehiscence of the microsporangia, and the filling of the cup with pollen grains. The style further elongates and thrusts the cup into a pouch in the line of junction of the two adaxial segments of the corolla. The cup is orientated so as to face the centre of the corolla. The stigma then arises from the base of the pollen cup, and very gradually forces the microspores out through the pore at the apex. Such microspores are then in a suitable position for removal on the backs of visiting insects. Eventually the fully developed and slightly bi-lobed stigma occupies the whole of the interior of the cup. Then, and not till then, do receptive cells appear in the apical region of the stigma, which is now ready to receive pollen from insect visitors coming from less mature flowers.

A very exact mechanism to ensure cross pollination is thus demonstrated. It would seem, however, that self pollination is possible in the absence of insect visitors.

The evidence derived from this investigation strongly supports the view that the genus *Dampiera* is derived from the Lobelioideae.

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EXPLANATION OF PLATES XXXVI-XXXVII.

Plate xxxvi.

1. General habit of *Dampiera stricta*; about one-third natural size
2. Flowers of *D. stricta*; about one and a half times natural size.

Plate xxxvii.

3. Style supporting pollen cup with narrow orifice through which microspores are being gradually ejected.
 4. A style slightly more advanced than that of previous figure. The pollen cup is now at right angles to main style. The gradual ejection of microspores from the pollen cup is illustrated.
 5. View showing the short stamens arranged around the style. The anthers have separated, and dehiscence has occurred.
 6. Microspores germinating. $\times 100$ (approx.).
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PLACENTATION AND OTHER PHENOMENA IN THE SCINCID LIZARD
LYGOSOMA (HINULIA) QUOYI.

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Society in Zoology.

(From the Department of Zoology, University of Sydney.)

(Plates xxxviii-xl and twenty-three Text-figures.)

[Read 26th October, 1927.]

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- I. Introduction.
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- III. Description of Material.
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 2. Period of ovulation and fertilization.
 3. Period of placental activity.
 - Stage A. Early development of the placentae.
 - Stage B. The stage of placental maturity.
 - Stage C. The placentae immediately prior to the birth of the foetus.
 4. Period after birth.
- IV. Comparison with the lizards, *Chalcides tridactylus*, *Lygosoma (Liolepisma) entrecasteauxi* and *Tiliqua scincoides* and with the marsupial, *Perameles*.
- V. Theoretical Considerations.
- VI. Summary and Conclusions.

I. INTRODUCTION.

In a "Note on Reproductive Phenomena in some Lizards" communicated to this Society in May, 1927, the placentation of the Scincid lizard *Lygosoma (Hinulia) quoyi* was described briefly and compared and contrasted with that of the Scincid lizards *Chalcides tridactylus*, *Lygosoma (Liolepisma) entrecasteauxi* and *Tiliqua scincoides* and with that of the marsupial *Perameles*. It is proposed to describe the placentation of *L. quoyi* and to discuss its relationship with that of the three above-mentioned Scincid lizards and of the marsupial *Perameles* in more detail in this communication.

In a previous paper (Harrison and Weekes, 1925) in which the occurrence of the placentation of the Scincid lizard *L. entrecasteauxi* was described, *L. quoyi* was mentioned, specimens of both having been collected at Barrington Tops during January and February, 1925, by the members of a party from the University of Sydney, under the leadership of Professor Harrison. In this paper (p. 471) it was stated that examination of pregnant females of *Trachysaurus rugosus*, *T. scincoides*, *L. quoyi*, *Egernia striolata* and *E. whitei* revealed "highly vascularized external allantoic and uterine walls with their respective circulations in close apposition but no marked placental area such as is described below" (for *L. entrecasteauxi*). A study of the condition in *L. quoyi* has shown that there is a very definite type of allantoplacenta present, although there is not the same degree of external differentiation of the uterine placental area. A further study has shown that a

somewhat similar placental condition occurs in *E. striolata* and *E. whitei* and probably also in *T. rugosus*.

Definite placentation among lizards has now been recorded in *Chalcides tridactylus* and *C. ocellatus* by Giacomini (1898) and (1906) respectively; in *Tiliqua scincoides* by Flynn (1923); in *Lygosoma (Liolepisma) entrecasteauzi* by Harrison and Weekes (1925); in *Lygosoma (Hinulia) quoyi*, *Egernia striolata* and *E. whitei* by Weekes (1927); and omphaloplacentation in *T. scincoides* by Weekes (1927). In addition Haacke (1885) mentions certain relations between the wall of the uterus and that of the yolk-sac in *Trachysaurus rugosus*. It is probable that a further investigation of the viviparous reptiles will reveal many interesting phenomena with regard to placentation.

I wish to thank Professor L. Harrison, in whose department this investigation was carried out, for the personal interest he has taken in the work and for the help he has given; Dr. I. M. Mackerras for specimens of *L. quoyi* collected at Barrington Tops; Mr. J. Hopson for collecting and forwarding material; Miss L. Wood, Mr. W. Graham, Mr. G. Vance and Miss B. White for help in collecting material; the Department of Zoology, University of Sydney, for grants covering the cost of collecting.

This investigation was begun under a Science Research Scholarship of the University of Sydney, and continued after my appointment as a Linnean Macleay Fellow of this Society.

II. MATERIAL AND METHODS.

Specimens of *L. quoyi* containing young were collected from Barrington Tops, 150 miles north of Sydney, at a height of 4,500-5,000 feet, during January, February and December, 1925; from Mount Kosciusko, 300 miles south of Sydney, at a height of approximately 5,000 feet, during November and December, 1925; from the Blue Mountains, 70 miles west of Sydney, at a height of approximately 3,000 feet, during January and February, 1927; from Sydney, at sea level, during November and December, 1925, and September, October, November, December, 1926, and January, 1927; from Kiama, on the Coast, 70 miles south of Sydney, during January, October and November, 1926.

The study of *L. quoyi* is interesting apart from the factor of placentation. The specimens collected from Barrington Tops and Mount Kosciusko, at a height of approximately 5,000 feet, differ from those collected at sea level, although each type has been identified as *Lygosoma (Hinulia) quoyi*. Those collected at Barrington Tops and Mount Kosciusko have an average length of five inches and the pregnant females contain from three to five young; those from the coast are much larger measuring from ten to thirteen inches and the pregnant females contain from five to nine young. The difference in scale marking between the two types of lizard is slight, since members of the same type vary among themselves, and the placentae in both are identical. The difference in the number of young carried during the gestation period seems to depend on the size of the parent lizard, although this conclusion may not be correct, since the increase in the size of the adult is naturally followed by a corresponding increase in the size of the embryo, those of the mountain type measuring approximately 3 cm. at the time of birth, and those of the coastal type measuring approximately 5 cm. Those females collected at the Blue Mountains, at 3,000 feet, were intermediate in size between the two above described types measuring on an average eight inches in length and containing from three to five young.

The reason for the difference in the size of the mountain and coastal types of lizard is not apparent, but in January, 1927, an intermediate type was collected at a height of 3,000 feet indicating that altitude may be the determining factor, and that the change from the small to the large type of lizard may be gradual as the altitude decreases.

L. quoyi is essentially a water loving animal and always lives near a creek or water hole. The flat marshy land at Barrington Tops and Mount Kosciusko with its network of small watercourses is infested with them. They live in holes in the banks of the watercourses, and at the coast they live in similar holes in the banks of coastal streams.

As mentioned, pregnant females were collected from Mount Kosciusko during November and December, 1925, and from Barrington Tops during January and February, 1925. They were first collected from Mount Kosciusko on the 14th November and the contained embryos are estimated to be one week old, hence fertilization occurred during the first week in November. The females collected from Barrington Tops during the first week in February contained embryos which were within a few days of hatching, but since it is at present unknown to the writer whether the times of the fertilization of the ova of the lizards at Mount Kosciusko and Barrington Tops correspond, the exact length of the gestation period of the mountain type is unknown.

Females of the coastal type collected at Sydney on 10th September and 7th October, 1926, had the ova still within the ovaries. On the 18th October females were collected which had the ova in early stages of segmentation within the oviducts, so that fertilization in these lizards occurred in the middle of October, which is two weeks earlier than at Mount Kosciusko. Lizards were collected from the same locality at Sydney, from the time of the fertilization of their ova until the time of the birth of the young, which was the second week in January. Hence the development of *L. quoyi* at sea level covers a period of approximately three months. Females were kept alive until the young were born and thus *post partum* stages were obtained.

Summarizing the above, specimens of *L. quoyi* were collected at a height of 4,500-5,000 feet which contained embryos in stages of development ranging from the first week after fertilization until the time of hatching; specimens were collected at sea level at all stages ranging from the condition of non-pregnancy to the condition after birth.

All material was fixed in Bles' Solution (90 parts of 70% alcohol, 7 parts of 5% formol, and 3 parts glacial acetic acid). The ventral body wall of each female was cut longitudinally to expose the oviducts, the female with young *in situ* then being immersed in the fixative. It is not advisable to leave the material in the fixative indefinitely as Bles' Solution hardens yolk.

As most of the material contained much yolk it was found difficult at first to get satisfactory results when infiltrating without using the method of double embedding in celloidin and paraffin, a method which has many disadvantages when dealing with yolky material. Embedding in paraffin alone was successful when the following precautions were taken: (a) to secure a thorough dehydration of the material, the latter, if bulky, being passed through many changes of absolute alcohol over a period of at least two days; (b) to use pure clearing agents, preferably xylol or cedar wood oil. As an inferior quality of xylol is usually sold which gives a white precipitate when mixed with alcohol, it is advisable to use cedar wood oil. However, if the xylol will mix with 70% alcohol without

giving a permanent precipitate, it will give better results than the cedar wood oil. Cedar wood oil which is sold as pure often contains water, but it was found that by mixing the oil with a fair quantity of anhydrous copper sulphate, shaking well and allowing to stand for twenty-four hours and then filtering, the water and other impurities were removed and the oil made perfect for use; (c) to infiltrate gradually, leaving the cleared material at room temperature in a solution of the clearing agent saturated with paraffin for about twenty-four hours, then leaving it another twenty-four hours at about 30° C., more paraffin having been added, and finally passing it through several changes of pure wax inside the paraffin bath for a few hours before embedding. If the material became brittle a shorter time in the solution of clearing agent and wax was allowed. I have successfully cut lizards' ova 8 mm. in diameter when these precautions were taken.

When staining,*if the yolky sections washed off the slides this was usually due to imperfect floating out of the wax ribbons on the slides, and imperfect drying of the ribbons after floating out. The floating out was most successful when done gradually and at a moderate temperature. Floating out on the top of a paraffin bath is not a perfect method as the copper bath is usually much too hot and the floating out dangerously rapid. I use a large piece of thick plate glass arranged at a suitable distance above an electric light bulb, so that the glass is just warm and the slides may be left on it for hours without damage, until they are thoroughly dry. This method of dry heating eliminates the danger of imperfect fixation due to a moist atmosphere.

It was found more important to take these precautions than to use a greater quantity of egg albumen, since ribbons that are well floated out and thoroughly dried should not leave the slides even when passed into 0.5% acid alcohol.

For an examination of anatomy the material was stained in bulk in carmalum. For histological work, sections were stained in Delafield's haematoxylin and counterstained in eosin.

III. DESCRIPTION OF MATERIAL.

The material is described in four parts. The first part covers the period of "pro-oestrus", the second the period of ovulation and fertilization, the third the period of placental activity and the fourth the period after birth. The period of placental activity is divided into three stages, Stage A presenting the early development of the placenta and covering the first two weeks of the gestation period; Stage B presenting the mature placenta, and covering the following eight weeks of the gestation period; and Stage C presenting the placenta immediately prior to the birth of the foetus and covering the last two weeks of the gestation period.

The description of the periods of "pro-oestrus" and of ovulation and fertilization are based on examinations of lizards collected at sea level. However it is more than probable that during these periods the condition of the reproductive organs of females inhabiting the mountain regions is the same.

The descriptions of the period of placental activity and of the period after birth are based upon an examination of both types of lizard, and as the placenta of both are identical no distinction is made between them.

1. *Period of "pro-oestrus".*

As mentioned above, females, which presumably had not copulated, were collected at Sydney on 10th September, 1926. The reasons for assuming that copulation had not taken place are: when collected the ova were still within

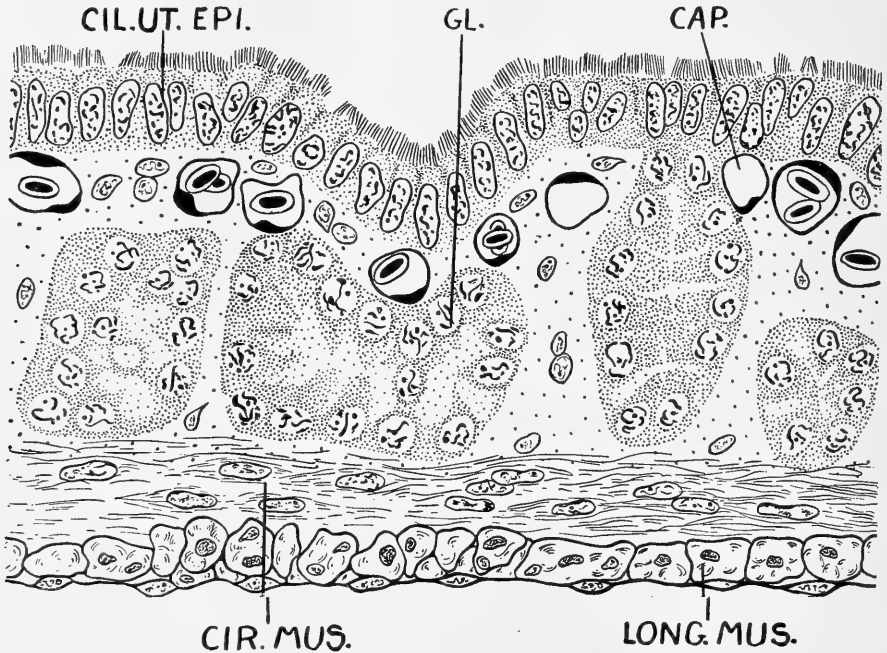
the ovaries and had not reached maturity, the largest ovum measuring 6 mm. in diameter, the measurement at maturity being approximately 13 mm.; also, during the beginning of September the weather is not warm enough to bring the lizards out in any number, only three being caught on 10th September after searching for two days; again, fertilization does not take place until the middle of October and one would expect copulation to occur nearer the time of fertilization than 10th September, which is five weeks earlier, and although actual copulation was not observed during the middle of October, it is extremely probable that it occurred then, since the lizards were observed living in pairs, a male with a female, the females being easily distinguished by their greater girth due to the presence of the enlarged ovaries.

The female reproductive organs consist of a right and a left ovary each equally well developed, and two oviducts which open separately into the cloaca. Each ovary is situated at the middle of the length of the corresponding oviduct. In each of the two females collected on 10th September, the right ovary was more anteriorly situated than the left, and the stomach was on the left side above the left ovary and closely pressed against it. In one female there were four large ova in each ovary, in the other there were four large ova in the right ovary and three in the left. This species of lizard has only one breeding season each year and the development of the ova is regulated accordingly, so that there is little gradation in the size of the ova at this stage, but a marked contrast between a number of small ova, all at approximately the same stage of development, to a number of larger ova, also at approximately uniform stages in development. At this stage these large ova have the same structure as that described for the developing ova of *Lacerta agilis* (Hett, 1924), where the follicle cells are of two varieties, some being enormously enlarged and the others comparatively small.

The oviducts are pleated, twisted and flattened against the dorsal body wall of the lizard, the average length of an extended oviduct being 5 cm. The width varies considerably, from 5 mm. to 2.5 mm. owing to an indication of division into "incubatory chambers", which is due to the failure of the oviducts to regain completely their natural shape after the preceding year's gestation period. Giacomini (1891) wrote that these chambers are evident in the oviducts of *C. tridactylus* three months after birth. In *L. quoyi* it seems that they never completely disappear.

The structure of the oviducts in these females is regarded as normal and only variations from it, found in the oviducts during the period of placental activity, are considered placental modifications. In section the wall of the oviduct at this stage is more or less uniform in structure throughout its length with the exception of the extreme anterior end which is modified for the reception of the ova. The arrangement of the tissues of the oviductal wall seems uniform for lizards in general, as it occurs in every species examined by the writer as well as in *C. tridactylus*. The wall at the anterior end is thrown into folds, is comparatively thin and the epithelium lining the lumen of the oviduct in this region is glandular and ciliated, consisting of deep columnar cells which are much larger than those lining the rest of the lumen. The wall of the remaining part of the oviduct (Text-fig. 1) consists of the following layers: an external layer of peritoneum; a thick muscular coat consisting of an outer coat of longitudinal muscle and an inner coat of circular muscle; a thick mucous membrane in which glands are embedded and which is lined by ciliated epithelium. The glands embedded in the mucosa are simple or branched and open into the lumen by short narrow mouths.

They are saccular, the cells being composed of vacuolated cytoplasm with small oval nuclei arranged round the periphery, and the cell walls being usually indistinct. Many of the nuclei are undergoing mitosis, indicating the growth of the glands. The epithelium lining the lumen of the oviduct is composed of narrow ciliated cells, closely crowded together, with many of their nuclei also dividing.



Text-fig. 1. Section of the wall of the oviduct of a non-pregnant female. CAP., capillary; CIL. UT. EPI., ciliated uterine epithelium; CIR. MUS., circular muscle; GL., gland; LONG. MUS., longitudinal muscle. $\times 706$.

The active cell division in the epithelium and glands indicates a "pro-oestrus" condition. The ordinary stimulus is certainly not copulation, since the ova in the females under discussion are at a stage about five weeks prior to ovulation, and it is extremely unlikely, as indicated above, that copulation has taken place. It is more likely that the stimulus is an external periodical one in which temperature is the main factor. That the breeding season of *L. quoyi* is influenced by climatic conditions is evident from the fact that the lizards inhabiting the warmer regions at sea level, Sydney, are at least two weeks earlier in their sexual season than those inhabiting the colder regions at Mount Kosciusko, 300 miles south of Sydney and with later seasonal changes.

2. Period of ovulation and fertilization.

On the 7th October, females containing ova at a stage prior to ovulation were collected from the same locality as on the 10th September. The ova had reached their maximum size and were packed with yolk. The membranes correspond with those described by Hett (1924) for *Lacerta agilis* at this stage, the cells of the

follicular epithelium being uniform in size and much smaller and flatter than those surrounding the younger ovum described above. There is a thicker band of thecal connective tissue in which numerous large blood vessels are present.

The oviducts have reached the final stage of preparation for the entrance of the ova. Each is roughly divided into three regions, namely, the anterior end described above, the more extensive middle region containing the majority of the glands, and the extreme basal region leading to the cloaca containing no glands and having its wall deeply convoluted. In section these regions differ somewhat from the corresponding regions of the oviducts of females collected four weeks earlier (10th September). At the anterior end the epithelial cells lining the lumen of the oviduct are markedly glandular and their free surfaces are covered by a thick secretion obviously derived from them and serving to facilitate the entrance of the ova. In the middle region the glands are most numerous and their cells are full of secretion and are distended until the central cavity is obliterated, thus indicating a period of glandular activity. The nature of the secretion from these glands is not apparent. At first, from the abundance of the glands and their position in the middle region of the oviduct, it was naturally supposed that they were for the secretion of albumen, but an examination showed that there is no sign of albumen surrounding the ovum after its passage into the oviduct or at any stage in its development. With the stretching of the "uterus" upon the entrance of the ova and the consequent squeezing of the glands, their secretion is forced out into the surrounding tissues of the uterus and some of it passes between the muscle layers and in stained material is identical in appearance with the substance of the shell membrane. The shell membrane is occasionally found adhering to the mouth of one of the glands when it has been torn away from the rest of the uterine wall, and a substance similar to it is present in the mouth of the gland. The cells of the epithelium lining the lumen of the oviduct in this region are also full of secretion, their cilia being matted together by the exuded secretion which is thought to be for the general purpose of lubrication.

It is not definitely known to the writer whether the process of ovulation in *L. quoyi* depends on some physiological stimulus such as the act of copulation, or whether it is independent of such stimulus; also, whether the liberated ova pass into the body cavity and thence into the oviduct with the aid of ciliary action, or whether they pass directly into the oviduct as a result of the latter actively clasping the ovum while still in the ovary.

As in other animals it is usual for the ova in each ovary to pass into the oviduct on the corresponding side, but a female was collected which had received an injury on the left side, damaging the left oviduct, so that, when ovulation took place, the mature ova, five in number, passed into the right oviduct. The liberation of ova from both ovaries was indicated by the presence of two burst follicles in the left ovary and three in the right. The five ova in the right oviduct were so tightly squeezed as to bend the oviduct completely out of position. The passage of ova across the body cavity is not uncommon among mammals, having been recorded for mammals "with a bicornuate uterus becoming pregnant in the uterine horn on the side opposite to that on which the ovary had discharged" (Marshall, 1910, p. 136).

When the ovum enters the oviduct and is fertilized, it becomes surrounded by a thin shell membrane which is divided into three layers composed of matted fibres. The uterus surrounds each egg as an expanded chamber called by Giacomini the "incubatory chamber". The wall of each incubatory chamber is uniform in

thickness measuring approximately 0.025 mm. and hence being much thinner than the wall of the uterus of a non-pregnant female. This decrease in thickness is due to the stretching of the uterus on the entrance of the eggs. Owing to this stretching, the coats of longitudinal and circular muscle are compressed into a thin band of tissue and the glands, which are swollen and saccular in the uterus of a non-pregnant female, are greatly compressed at this stage.

The epithelial cells lining the mucosa are much larger and not as crowded as in the non-pregnant condition, and are of uniform size over the entire area of the incubatory chamber.

There is a curious substance surrounding the ovaries after ovulation, which, in prepared sections, has the appearance of a deep blue coagulum mixed with blood clot containing corpuscles and numerous small round cells.

Immediately after ovulation the ruptured follicles are visible as large white flat oval sacs, each with the cicatrix present as a median longitudinal groove. However, a few days after ovulation they become smaller, spherical, yellow and richly vascular, the alteration in the appearance of the follicles being due to the presence of a corpus luteum in each, the growth of which is rapid, each follicle being completely filled with luteal cells a few days after ovulation. It is not probable that the corpora lutea have any influence on the retention of the ova of reptiles comparable with their supposed function in mammals, since they occur in ovaries of the oviparous lizard *Lacerta agilis*, which lays its eggs immediately after their passage down the oviducts (Hett, 1924).

3. Period of placental activity.

Stage A. Early development of the placentae.

Twenty females were collected containing young embryos with placentae at early stages in development, nine at Mount Kosciusko, eight at Sydney and three at Kiama. Of the nine from Mount Kosciusko, seven contained three young, one five and the remaining one six; of the eight from Sydney, four contained six, two seven and two eight; of the three from Kiama, one contained six, one seven and one eight. In every case where a female contained an even number of young, half were in each oviduct, and where a female contained an odd number of young the right oviduct held one more than the left. This arrangement of embryos was found to be the same in all lizards collected during the rest of the gestation period.

In the paper on the placentation in *L. entrecasteauxi* (Harrison and Weekes, 1925, p. 472) the authors wrote that "it seems remarkable that the number should be odd in every one of nine examples, and we cannot find any explanation for this condition", also, "of the six females examined, four had more embryos in the right oviduct than in the left". Taking into consideration the conditions in both *L. entrecasteauxi* and *L. quoyi*, it seems that there is a tendency for the female to contain an odd number of embryos, and for the right oviduct to contain more than the left. This may be due to the fact that the stomach of the non-pregnant female is almost invariably on the left side and closely pressed against the left ovary thus possibly interfering with the number of ova developing in this ovary.

The developing embryo is dorsal in position with regard to the parent and lies with its head directed mesially whether the embryo be in the right or left oviduct. The embryos in the one female are not all at identical stages of development, but the range of difference is negligible, *L. quoyi* resembling *L. entrecasteauxi* and not *C. tridactylus* in this respect. The uterus surrounds each egg as a thick

white envelope which persists as the expanded incubatory chamber on the extraction of the egg. These chambers are connected each to each by a short, narrow, strap-like portion of the uterus which is deeply folded. Occasionally the uterus is pigmented, the pigment being sometimes scattered over the surface of each incubatory chamber, but usually restricted to the dorsal body wall of the parent. The uterine wall shows as a smooth, semi-transparent membrane whose uniformity is broken only by its thick opaque blood vessels, since there are no villous foldings such as occur in *C. tridactylus* and *L. entrecasteauxi*. However, when viewed through the binocular microscope the uterine wall is seen to be covered by numerous branched glands (Text-fig. 2, A and B), which are homologous with the saccular glands in the uterine wall of the non-pregnant female (described above). They are present throughout the development of the embryo and are outstanding and characteristic.

The vascularization of the wall of the incubatory chamber of *L. quoyi* is on the same plan as that of *L. entrecasteauxi*. A single large artery and vein run longitudinally along the dorsal wall of each uterus, the artery giving off branches which pass transversely round the uterus to the base of the yolk-sac of the contained blastocyst, where they break up into a rich network of capillaries, and the vein receiving branches which also pass round the incubatory chamber from the base of the yolk-sac, parallel to and roughly alternating with the arteries (Text-fig. 2B). The villous folds in the wall of the uterus of *L. entrecasteauxi* are fed by short branches from the main artery and vein and by branches from the branch arteries and veins. In *L. quoyi* the allantoplacental region is similarly vascularized.

In the early stages of development the uterus fits closely round the contained embryos and keeps them in a fairly steady position, but with the preparation for allantoplacentation a more perfect state of fixation results when the cells of the chorion attach themselves to the epithelium of the uterus. However, before this occurs the intervening shell membrane must disappear and in early stages of development the chorionic cells appear to attack and absorb it. When the allantoplacenta is mature there are often areas where a thin remnant of membrane can be detected between the uterus and the modified chorion. The expansion of the growing embryo aids the chorionic cells in their destruction of the shell membrane by causing it to break and gradually fall away from the sides of the embryo taking up a position at the base of the yolk-sac in the form of a flat fibrous pad. This may be the "nodule" which occurs at the base of the yolk-sac of the embryos of *C. tridactylus*, and which Giacomini (1891) terms the vitelline membrane.

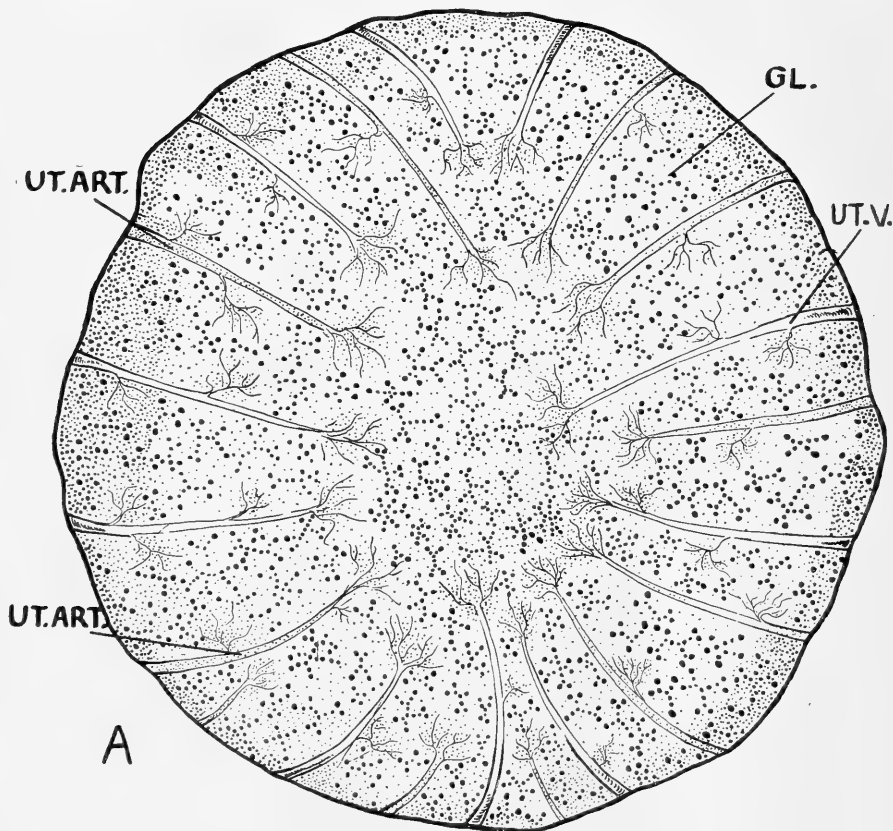
In *L. quoyi* the vitelline membrane is delicate and almost imperceptible and could not possibly be confused with the shell membrane.

Of the two placentae the omphaloplacenta is the first formed, since its requisites from the embryo, namely the chorionic ectoderm and a vascularized yolk-sac, are formed early in development, whereas the allantoplacenta, depending as it does on the presence of an allantois of sufficient extent to lie immediately under the chorion, is comparatively late in its development.

The Omphaloplacenta. The embryos which show the earliest signs of omphaloplacental modification are approximately one week old (Text-fig. 3, A), their average length being 5 mm. Each has turned on to its left side, its head being flexed and its body slightly curved. The amnion is completed and the allantois present as a small swelling at the posterior end of the embryo. There

are three gill slits and approximately thirty somites. The chorionic ectoderm completely surrounds the blastocyst and the extra-embryonic mesoderm extends over a small area at the surface of the yolk-sac, which is entirely lined by endoderm.

Although there are indications of foetal omphaloplacentation at this stage, the uterine wall is as yet unmodified. In all earlier stages the development of the extra-embryonic tissues is normal, the chorionic ectoderm cells being small and in all respects resembling those in the chorion of oviparous lizards, but at this stage the chorionic ectoderm at the base of the yolk-sac is slightly modified with the beginning of omphaloplacentation and the further growth of the extra-



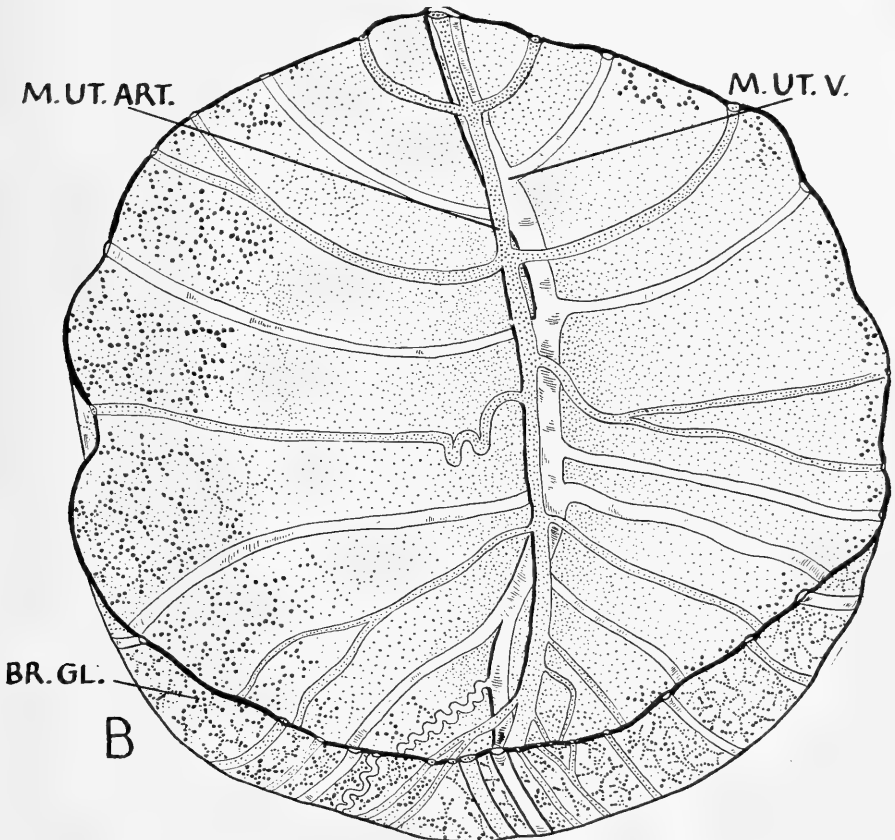
Text-fig. 2A. Incubatory chamber cut in half horizontally. Dorsal view of ventral half showing the termination of the uterine arteries and veins in the region of the base of the yolk-sac of the contained blastocyst, $\times 7.5$; GL., gland; UT. ART., uterine artery; UT. V., uterine vein.

embryonic mesoderm is abnormal. In the former case, a few of the cells of the chorionic ectoderm at the lower pole multiply and become enlarged until a small area of enlarged cells is formed (Text-fig. 3B and 4).

Occasionally there is more than one centre of modification, but each is small and they gradually join together to form a single area. As the development of the embryo proceeds and the omphaloplacenta approaches maturity, the modification

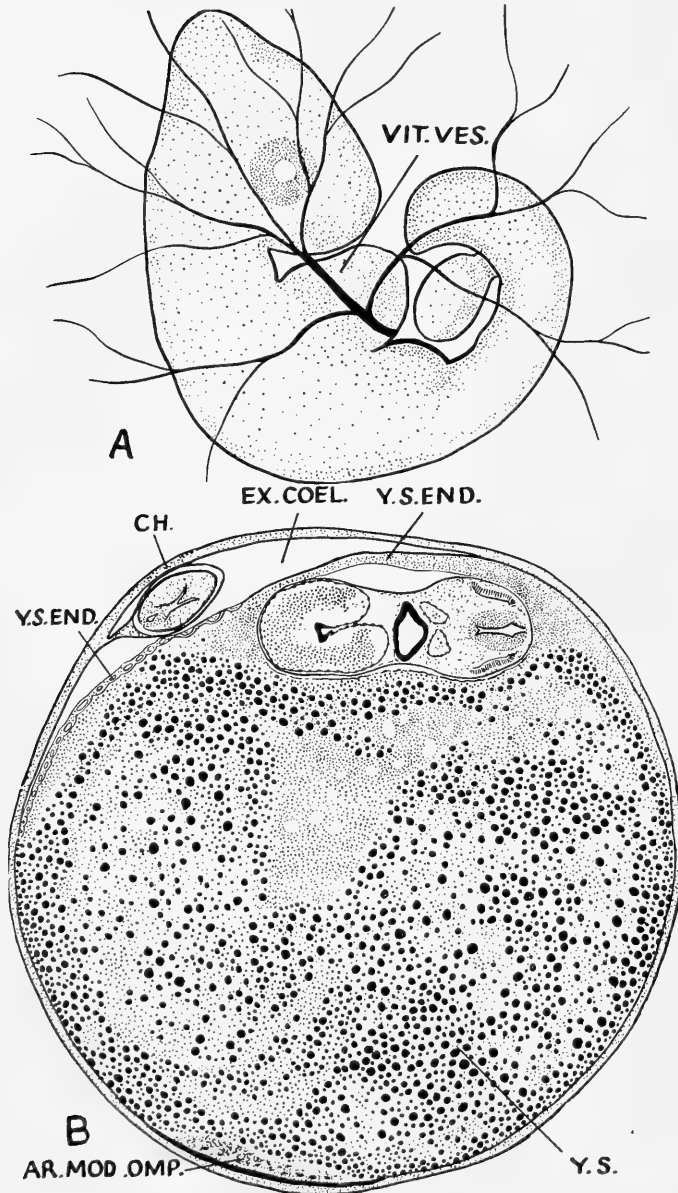
of the chorionic ectoderm spreads over the entire under surface of the yolk-sac, until a continuous sheet of moderately large columnar cells is formed.

In the embryos selected for description the area of modified ectoderm measures approximately 0.8 mm. in diameter by 0.1 mm. in height, being thickest at the centre (Text-fig. 4). It consists of a mass of deeply staining cytoplasm containing irregularly arranged nuclei, there being no definite cell boundaries present, even at the edge of the area where it merges into the unmodified chorionic ectoderm which covers the rest of the yolk-sac. The yolk-sac endoderm immediately overlies and mingles with the modified ectoderm and consists of a similarly staining cytoplasm with scattered nuclei. The cytoplasm of the ectoderm is denser than that of the



Text-fig. 2B. Ventral view of dorsal half showing the main uterine artery and vein, $\times 7.5$. BR. GL., branched gland; M. UT. ART., main uterine artery; M. UT. V., main uterine vein.

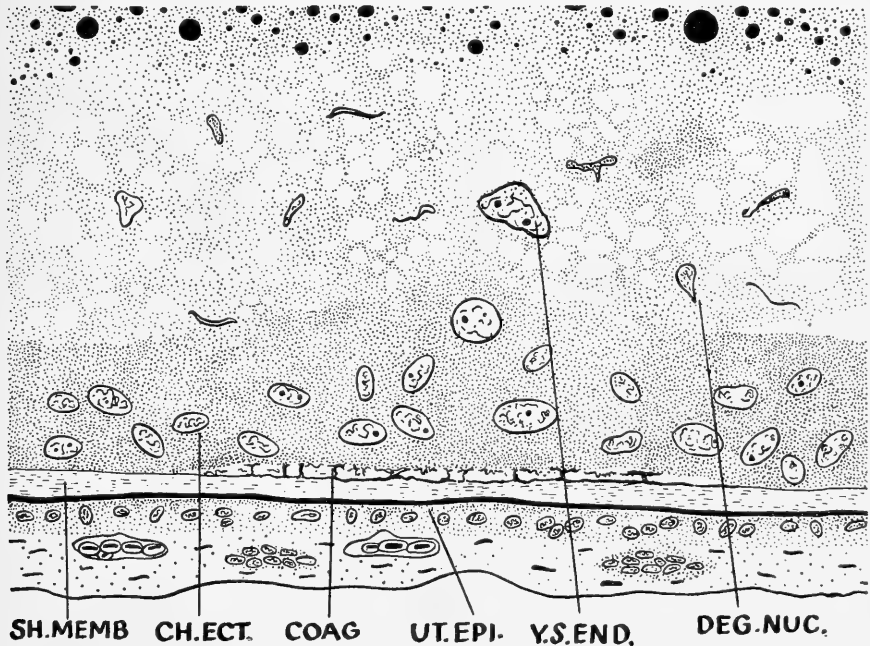
endoderm, which is vacuolated and has the appearance of having been mixed with a fluid which coagulated during the process of fixation (Text-fig. 4), and hence the line of junction between the two cytoplasmic regions is evident. The nuclei embedded in the ectodermal cytoplasm are large and irregular in shape, with no outstanding characteristics, and are easily distinguished from the endodermal nuclei, which are larger when healthy but which are mostly degenerating, many



Text-fig. 3. A, embryo approximately one week old, $\times 21.5$; B, transverse section of blastocyst containing an embryo about one week old, showing the position of the area first modified for omphalopmentation, $\times 11$; AR. MOD. OMP., area modified for omphalopmentation; CH., chorion; EX. COEL., extra-embryonic coelome; VIT. VES., vitelline vessel; Y.S., yolk-sac; Y. S. END., yolk-sac endoderm.

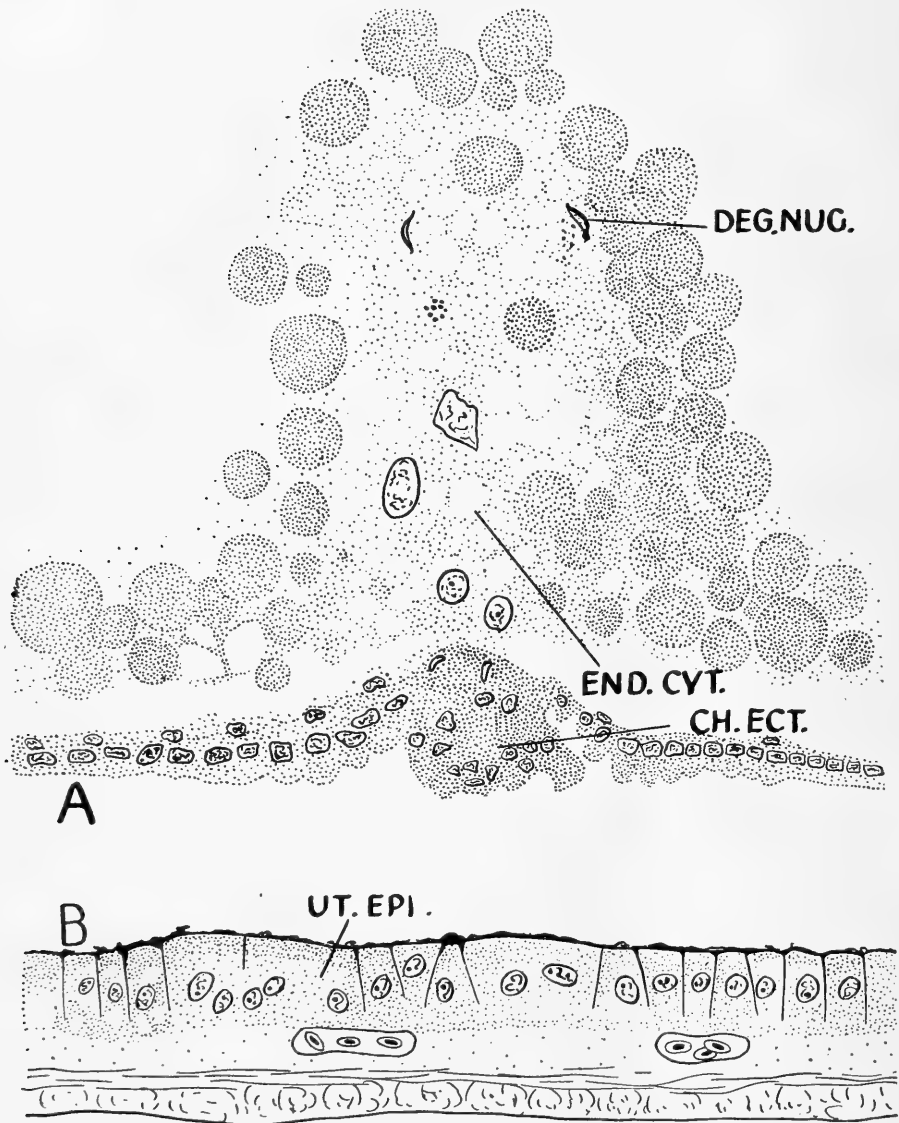
having been reduced to scattered groups of granules. The shell membrane underlies the chorionic ectoderm and between them is a gap which is partly filled with a coagulum stained deeply by haematoxylin, and thought to be maternal secretion passed through the shell membrane. It is possibly the presence of this secretion in the protoplasm of the yolk-sac endoderm which gives the latter its peculiar appearance. The uterine wall is pressed closely against the shell membrane and, as stated, shows no indication of placental modification.

In embryos taken from a female collected during the second week of pregnancy, the chorionic ectoderm cells are modified over a considerable area of the yolk-sac, but the original centre of modification is evident at the middle of the base of the yolk-sac where the cells are especially large and where the plug of endodermal cytoplasm is still present (Text-fig. 5, A; Pl. xxxviii, fig. 1). Some of the chorionic ectoderm cells are enlarged more than others, but are only about one-third the height they eventually attain. They are narrow but definite, with their free surfaces rounded and often bulging into peculiar shapes (Text-fig. 5, A, CH. ECT.; Pl. xxxviii, fig. 1). The nuclei vary in size sometimes almost filling the cell and they are arranged at the cell bases, staining deeply and standing out from the rest of the cell cytoplasm. The cells are closely attached to an underlying layer of yolk-sac endoderm, the cells of which are smaller than the ectoderm cells and lie at the bases of the latter with the appearance of dovetailing. They are so closely attached to the ectoderm cells that, when the layer of ectoderm is torn away



Text-fig. 4. Section of the omphaloplacental region, Stage A, showing the area of modified tissue, $\times 511$. CH. ECT., chorionic ectoderm; COAG., coagulum; DEG. NUC., degenerating nucleus; SH. MEMB., shell membrane; UT. EPI., uterine epithelium; Y. S. END., yolk-sac endoderm.

from the overlying yolk-sac in the preparation of material for sectioning, the endoderm cells come away with it. The structure of the mass of endodermal cytoplasm at the approximate middle of the base of the yolk-sac is unchanged.



Text-fig. 5. A, section of the foetal portion of the omphaloplacenta of embryos collected during the second week of the gestation period, $\times 562$; B, section of the maternal portion of the omphaloplacenta, $\times 562$; DEG. NUC., degenerating nucleus; CH. ECT., chorionic ectoderm; END. CYT., endodermal cytoplasm; UT. EPI., uterine epithelium.

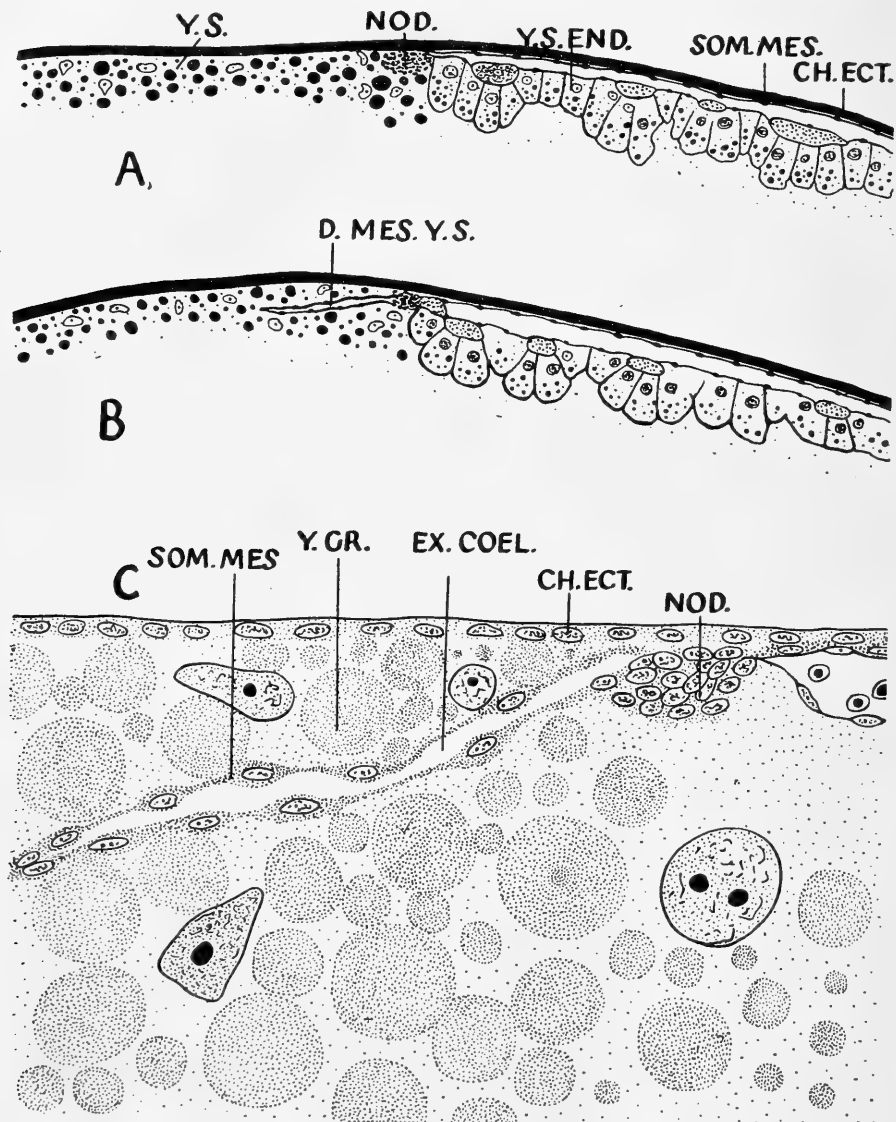
The structure of the uterine wall has changed slightly in this region. The epithelial cells have increased in length, are definite and columnar, the protoplasm at the free margins staining deeply, but they are very narrow and crowded together and have not the same regular appearance as in more advanced stages in the development of the omphaloplacenta.

The layer of endoderm underlying the area vasculosa on the dorsal surface of the sac differs from the rest, consisting of large columnar cells, each with a definite boundary and with its base rounded and buried in the yolk. The cells are vacuolated and contain large nuclei and many small yolk granules (Text-fig. 6, Y. S. END.). This layer of endoderm is homologous with that underlying the area vasculosa in chick embryos (Lille, p. 129). The boundaries of the endoderm cells filling the rest of the yolk-sac are difficult to determine, their cytoplasm being full of yolk granules and large vacuoles. It will be recalled that the yolk-sac endoderm is closely attached to the overlying chorionic ectoderm, and this close attachment plays an important part in determining the structure of the omphaloplacenta by bringing about the modification in the growth of the extra-embryonic mesoderm as mentioned above. The growth is normal up to a certain stage, the sinus terminalis being arrested for a short time at the junction of the chorionic ectoderm and the yolk-sac endoderm. The area vasculosa under these conditions measures on an average 7 mm. and consists of two main vitelline arteries and veins. But the period of quiescence in the growth of the mesoderm is short and the omphaloplacenta does not function for long in a non-vascularized condition. The mesoderm cells at the circumference of the area vasculosa divide fairly rapidly, but so close is the connection between the yolk-sac endoderm and the chorionic ectoderm that the cells cannot force their way between them, and consequently their progress is delayed and a thick margin of mesoderm cells is formed surrounding the area vasculosa, which in transverse section has the appearance of a rounded nodule of small dark cells (Text-fig. 6, A, NOD.). Since there is no longer a passage for the extension of the mesoderm between the ectoderm and endoderm it is forced to dip into the yolk-sac and continue its growth round the yolk-sac, not over its surface as is usually the case, but embedded in its substance (Text-fig. 6, B and C; Pl. xxxviii, fig. 2).

As the mesoderm pushes into the yolk-sac endoderm it splits into somatopleural and splanchnopleural layers as it does in the normal condition when forming the extra-embryonic coelome, and thus separates an outer layer of endoderm from the main bulk of the yolk-sac endoderm. This outer layer is fairly regular in width at the sides of the yolk-sac, measuring approximately 0.075 mm. in some embryos. However, at the base of the yolk-sac in the region of the persistent area of modified ectoderm and endoderm, the mesoderm may grow up into the yolk-sac for a considerable distance and so cut off an outer layer of endoderm measuring as much as 0.210 mm. in width. At this stage (one week after fertilization) the mesoderm has commenced to dip into the yolk-sac for the short distance of 0.615 mm. and the area vasculosa still measures approximately 7 mm., there being no sign of haematopoiesis in the mesoderm within the yolk-sac (Text-fig. 6, C). Since the mesoderm does not entirely surround the yolk-sac until the embryo is at least four weeks old, the vascularization of the yolk-sac is not completed until then and will be described at Stage B.

The Allantoplacenta.—Although the development of an allantois of sufficient extent to lie immediately under the chorion is necessary for the formation of the allantoplacenta, the maternal wall becomes modified in anticipation of placentation

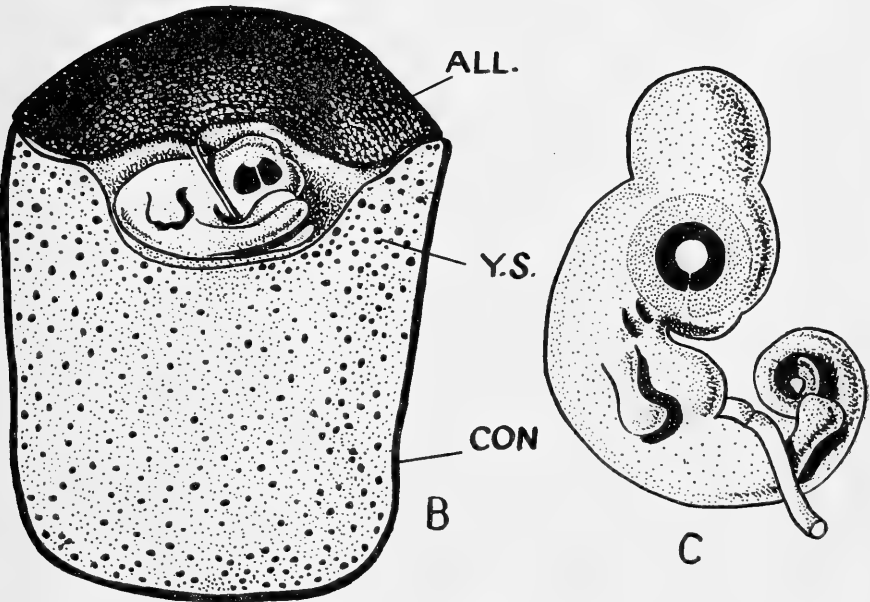
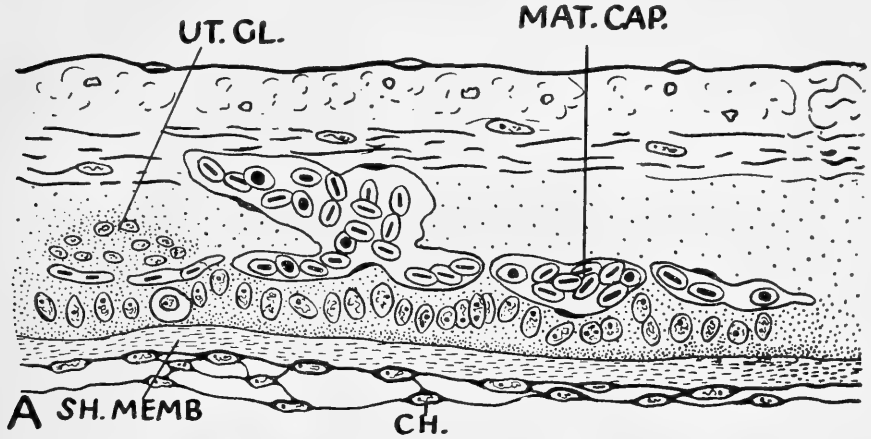
when the embryo is a week old (Text-fig. 7, A), at the time when the allantois is but a small swelling at the posterior end of the embryo and the omphaloplacenta first begins to function. It is not until the embryo is approximately two weeks



Text-fig. 6. A, section of the yolk-sac at the edge of the area vasculosa showing the formation of the nodule of mesoderm; $\times 159$. B, section of yolk-sac of an older embryo showing the downgrowth of the mesoderm into the sac; $\times 159$. C, the same, under higher power; $\times 511$. CH. ECT., chorionic ectoderm; D. MES. Y. S., downgrowth of mesoderm into the yolk-sac; EX. COEL., extra-embryonic coelome; NOD., nodule; SOM. MES., somatic mesoderm; Y.S., yolk-sac; Y.S. END., yolk-sac endoderm; Y. GR., yolk granule.

old that the chorio-allantoic membrane is formed and the allanto-placenta established.

At a stage a week after fertilization the amniotic folds have met above the embryo to complete the chorionic membrane and it is in this region that the uterine wall is first modified. The modification is brought about by the multiplica-



Text-fig. 7. A, section showing the modification in the maternal wall before the formation of the chorio-allantoic membrane; $\times 560$. B, section through the blastocyst at the end of the second week when the chorio-allantoic membrane is first formed; $\times 8.5$. C, the embryo at this stage; $\times 13$. ALL., allantois; CH., chorion; CON., constriction; MAT. CAP., maternal capillary; SH. MEMB., shell membrane; UT. GL., uterine gland; Y.S., yolk-sac.

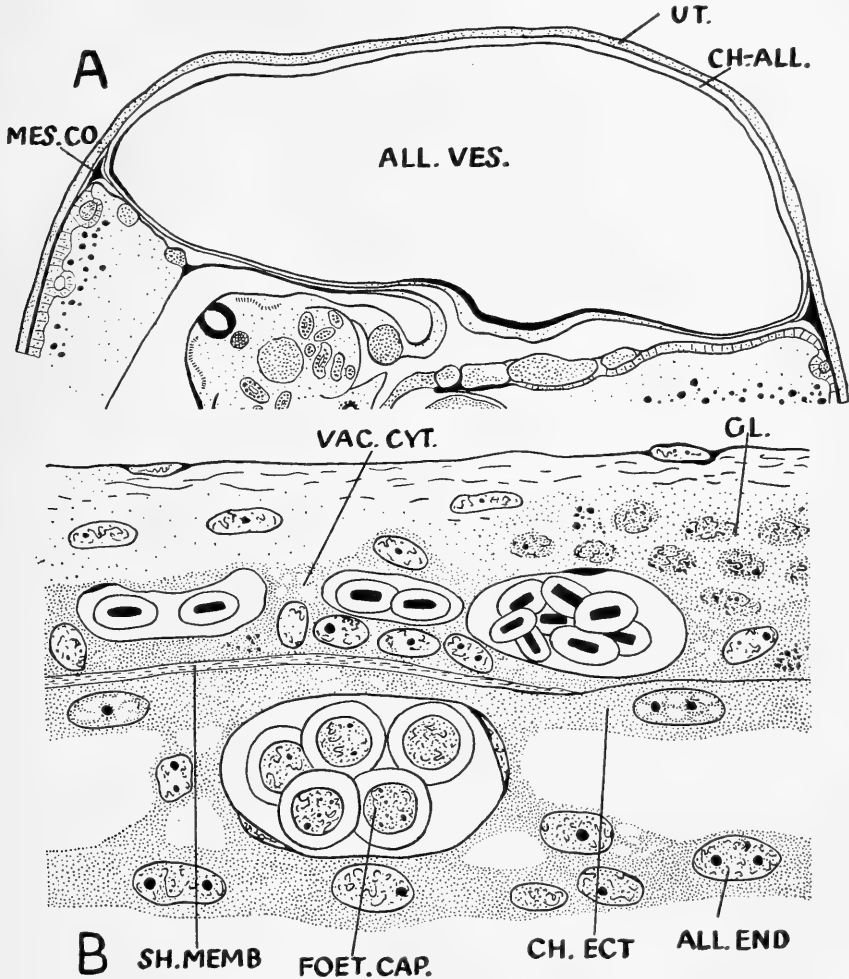
tion and expansion of a few of the maternal capillaries present in the mucosa between the saccular glands and the epithelium, and by their attempt to invade the overlying epithelium (Text-fig. 7, A). The invasion of the epithelium by the capillaries has not advanced far, the epithelium being intact over the surface of the uterus with no breaks in its continuity such as occur at the stage of placental maturity. It will be recalled that the epithelium lining the incubatory chambers is a single layer of fairly large columnar cells. The pressure on these cells in the region of the invading capillaries causes them to become flattened, so that they now measure about 0.016 mm., one-third of their original height. The compression of the cells is followed by their degeneration, which is most marked in later stages, the compressed cells at this stage retaining their individuality although their cytoplasm may be slightly vacuolated. Since the embryo is but a week old the shell membrane between the uterine epithelium and the chorionic membrane is practically unchanged, although the chorionic ectoderm cells have attacked it and are embedded in its substance. The chorionic membrane is normal in structure, the ectoderm cells being small, flat and unmodified. The growth of the allantoic vesicle and the formation of the chorio-allantoic membrane occur during the following week, so that, when the embryo is two weeks old (Text-fig. 7, B) the main requisites for the formation of an allantoplacenta are first acquired, there being a uterine wall in close proximity to a well vascularized chorio-allantoic membrane. The blastocyst from the coastal type of female containing a two weeks old embryo measures approximately 1.3 cm. \times 0.9 cm., and the contained embryo 0.6 cm., but its body is so curved, the head and tail almost meeting, that it is impossible to give exact measurements, the length given being the crown-rump measurement. The head is large, the eyes are prominent, and the limb buds present, the stage in development roughly approximating that of a four-day-old chick embryo (Text-fig. 7, C). The embryo lies on its left side and is sunk down into the yolk-sac, the top of the sac often being level with that of the embryo (Text-fig. 7, B). The area vasculosa extends a little more than half-way round the yolk-sac and its boundary is marked by a constriction of the sac, which can be seen in the living as well as in the fixed condition (Text-fig. 7, B, CON.).

The allantoic vesicle measures approximately 0.4 cm. in diameter. As the embryo grows the vesicle expands radially until its wall meets the upper surface of the yolk-sac which automatically stops further progress, the vesicle only expanding as the yolk-sac decreases in size. As yet there is no definite, long allantoic stalk, the allantoic vesicle opening directly into the hind gut and being vascularized by two main arteries and veins.

The area of allantoplacentalation is not limited, placental modifications of maternal and foetal tissues occurring over the entire area embraced by the allantois (Text-fig. 8, A). As the embryo develops, its yolk-sac is gradually absorbed and the allantoic vesicle expands filling the former position of the yolk-sac. The expansion of the allantoic vesicle and consequent radial extension of the chorio-allantoic membrane is accompanied by a corresponding extension of the placental region. It is peculiar that the uterine wall is always modified for a short distance beyond the limit of its proximity to the allantois, and is thus always prepared for the growth of the allantois and the extension of the placental region.

At this stage the uterus is distinct from the chorionic membrane even when there is no shell membrane present to divide them, the chorionic cells not having yet begun to attach themselves to the uterus.

(a). *Maternal Portion of the Placenta.*—The wall of the uterus is thinner in the placental than in the non-placental region due to the degeneration of the glands and muscle layers and the partial degeneration of the epithelium. The decrease in the number of glands in this region is particularly apparent when the uterus is viewed through the binocular microscope (Text-fig. 2, A). The few glands present are so compressed as to have no resemblance to their former shape, the cell nuclei being arranged in a flat ring, and the cell cytoplasm being



Text-fig. 8. A, section of the dorsal portion of a blastocyst during the third week of the gestation period, showing the extent of the allantoplacenta and the general disposition of the membranes. B, section through the allantoplacenta, stage A; $\times 1685$. ALL. END., allantoic endoderm; ALL. VES., allantoic vesicle; CH.-ALL., chorio-allantoic membrane; CH. ECT., chorionic ectoderm; FOET. CAP., foetal capillary; GL., gland; MES. CO., mesoderm; SH. MEMB., shell membrane; UT., uterus; VAC. CYT., vacuolated cytoplasm.

intensely vacuolated. The degeneration of the glands is accompanied by a deposition of pigment granules.

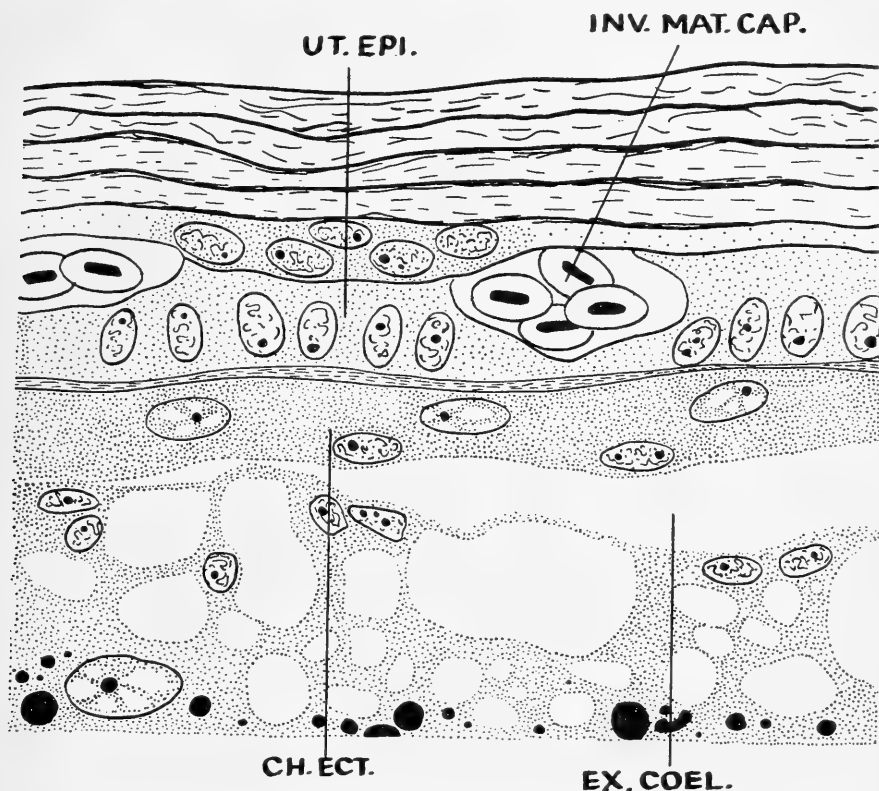
The vascularization of the uterus is richer than in the first week of pregnancy. The large vessels are situated in the mucosa overlying the glandular region and the capillaries are dispersed among the glands particularly above the epithelium. Each capillary has a distinct endothelial lining containing small dark nuclei. The capillaries are mostly small and flat and are not as numerous as at later stages. They contain a few elongated corpuscles each with a deeply staining ellipsoidal, almost rectangular nucleus. The capillaries have progressed in their invasion of the epithelium and appear to push against the overlying epithelial cells, but they have not as yet reached the surface of the uterus (Text-fig. 8, B). The degeneration of the epithelium is more marked than in earlier stages. The cell walls and many of the nuclei have disappeared and the cell cytoplasm is well vacuolated. A few healthy cells are present and each has a small oval granular nucleus.

The persistence of the shell membrane varies for different embryos, some at this stage having no membrane, some having a thin remnant, and others having quite an appreciable amount. The membrane when present is pressed between the chorion and the uterine wall, but there is a tendency for it to break away from the uterine wall and remain attached to the chorion, this being due to the absorption of the substance of the membrane by the underlying cells of the chorionic ectoderm. That the shell membrane is being absorbed by the chorionic cells is obvious, since the chorionic cells are found embedded in its substance and in stained sections the cell cytoplasm has the same appearance as the membrane; also the membrane is present in some places and not in others, and is thinner in the placental than in the non-placental region.

(b). *Foetal Portion of the Placenta.*—There is little modification of the chorio-allantoic membrane, possibly due to the restricting presence of the shell membrane, since the chorionic ectoderm cells must first destroy it before they can come into contact with the uterus. The chorionic ectoderm consists of a single layer of small, uniform, tapering cells with no visible dividing walls (Text-fig. 8, B). Each cell contains an oval nucleus with usually two bright nucleoli, the nuclei staining deeper than those of the uterine epithelium and hence being easily distinguished from them throughout the life of the placenta.

The chorio-allantoic membrane is well vascularized by a rich network of capillaries underlying the chorionic ectoderm. The capillaries measure 0.025 mm. in diameter, being much larger than the maternal capillaries, and are full of young corpuscles which are easily distinguished by their round shape and round nuclei from the oblong maternal corpuscles. The connective tissue in which the vessels and capillaries are carried is comparatively thick, consisting of a network of young tapering cells, there being as yet no muscle fibres present among them. There is a single bounding layer of allantoic endoderm, the cells of which resemble those of the connective tissue. The restrictions to the efficient functioning of the allanto-placenta are the presence of the shell membrane and the absence of any modification of foetal tissue in the placental region. However it is evident that a certain amount of maternal secretion is being absorbed by the foetal tissue, since in this region there is none of the secretion from the compressed glands in the mucosa such as is present in the non-placental area, described below. That the chorionic ectoderm cells are ingesting is shown by their absorption of the shell membrane and it is probable that at the same time they receive maternal materials through it.

The maternal portion of the placenta at this stage, then, is represented by a general thinning of the uterine wall due to a partial degeneration of the muscle layers and glands; by increased vascularization; by the invasion of the uterine epithelium by the overlying capillaries and by the consequent compression, flattening and degeneration of the epithelial cells. The foetal portion of the placenta consists of a thin chorion attacking and absorbing the shell membrane and overlying a well vascularized allantois.



Text-fig. 9. Section of the region of partial maternal placentation; $\times 1685$.
 CH. ECT., chorionic ectoderm; EX. COEL., extra-embryonic coelome; INV. MAT. CAP., invading maternal capillary; UT. EPI., uterine epithelium.

(c). *Region of Partial Maternal Placentation.*—It will be recalled that the uterine wall overlying the yolk-sac at the edge of the allantoplacental area is influenced for some distance by allantoplacentation and is modified accordingly (Text-fig. 9). Here the uterine wall is thicker than in the placental region and the glands although still flattened are more prominent. The secretion which is forced from these glands on the stretching of the uterus is present in abundance among the tissues of the mucosa (Text-fig. 9). The uterine epithelium is thick and the cells uniform, with indefinite boundaries, yet the capillaries have begun to invade them, this invasion being the main placental modification. The shell membrane is thick but is degenerating apparently through the activity of the

underlying chorionic ectoderm cells, which, however, are more easily separated from it here than in the allantoplacental region. The chorionic ectoderm immediately overlies the extra-embryonic mesoderm as far as the sinus terminalis, when the mesoderm dips down into the yolk-sac as described, the chorionic ectoderm then being attached to the endoderm cells of the yolk-sac. That the uterine wall is secreting materials is quite possible but the presence of the glandular secretion among the tissues of the mucosa in this region and its absence in the placental region indicates the contrary.

Stage B. *The Stage of Placental Maturity.*

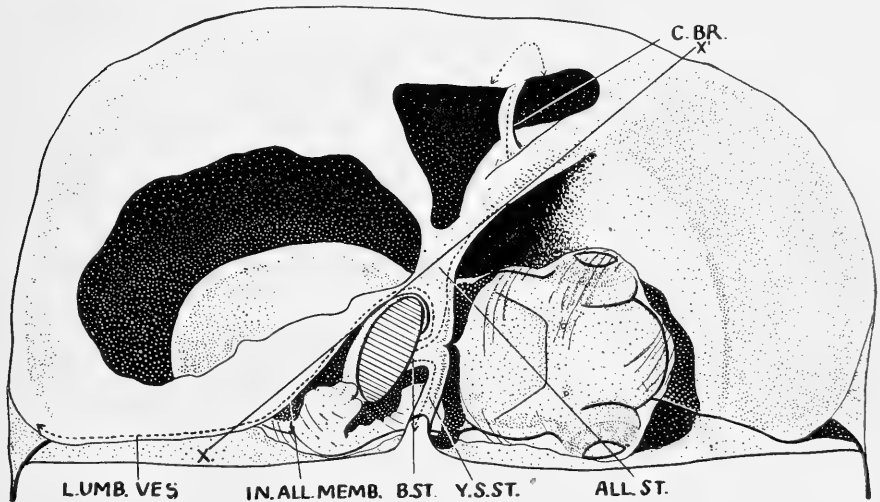
The stage of omphaloplacental and allantoplacental maturity covers the last two months of the gestation period. The mature omphaloplacenta is not uniform in structure, being more specialized in some embryos than in others and even in its most specialized form is not as well developed as that in specimens of *L. entrecasteausi*, *T. scincoides* and *E. whitei* examined by the writer. The difference in the degree of specialization of the placenta makes it difficult to estimate the exact time of its maturity, since the placentae in embryos at the same stage in development may vary in structure, but the third week is thought to be the most probable time of omphaloplacental maturity. The mature allantoplacenta is more uniform in structure and the time of its maturity is consequently more easily ascertained. The allantoplacenta is fully specialized to function as a nutritive and respiratory organ when the embryo is between three and four weeks old, and so functions with slight alterations in histological structure over the ensuing two months prior to the birth of the foetus. The structure of the placenta of a fully formed foetus is influenced by approaching birth and will be described separately as Stage C.

Nine females containing embryos with a mature omphaloplacenta and allantoplacenta were collected from Barrington Tops at intervals during January and December, 1925; twelve from the Blue Mountains during January, 1927, and eight from Sydney during November and December, 1926. The embryos in the females collected from Barrington Tops ranged in age from four to nine weeks; those in females from the Blue Mountains from about nine to ten weeks; and those in females from Sydney from three to ten weeks.

The difference in size between the blastocyst from the mountain type of female and that from the coastal type is most noticeable, the blastocyst of the mountain type measuring on an average one-half that of the coastal type. The number of young present in each female corresponds with the figures quoted for stage A, the females from the mountain region carrying from two to five young and those from the coastal region from five to nine young. When there is only a moderate number of blastocysts within the uterus and each embryo has room to grow without interference from the others, the blastocyst is roughly oblong in shape with its long axis parallel to that of the female, and each is isolated in its incubatory chamber; but when they are crowded and pressed together their depth is as great as, if not greater than, their length. They are sometimes pressed so closely together that the uterus is no longer constricted between them to form definite incubatory chambers but remains distended so that the embryonic membranes over a small area at both ends of one blastocyst are in close proximity with those of the two adjacent blastocysts.

As in *L. entrecasteausi* (Harrison and Weekes, 1925, p. 473) certain structures are more or less visible through the thin and much distended uterine wall, and

"as the parent lies upon her back, with the ventral body wall opened up, and the uteri exposed, the region of the yolk-sac for each embryo shows as a creamy area, ventral and lateral, *i.e.*, anti-mesometrial in position". The placentae of embryos obtained from females during the fourth week of the gestation period are selected for description and such variations as are found in the placentae of embryos at later stages will be described separately. When the four weeks old blastocyst is examined ventrally, although the yolk-sac has been absorbed from the immediate region of the embryo and reduced to half its original size, it obscures from view most of the underlying embryo, which is only completely visible when the blastocyst is turned round. The embryo can then be seen lying on its left side on the yolk-sac with its body curved so that head and tail meet, and with the tail coiled round the limbs. The vascularization of the uterine wall, allantoic vesicle and yolk-sac can be clearly seen. Beyond a general enlargement of the vessels in the uterine wall the maternal circulation does not differ from that described at stage A, the vessels encircling each incubatory chamber as far as the base of the yolk-sac.



Text-fig. 10. Four weeks old embryo lying upon the yolk-sac, showing the general disposition of the foetal membranes; \times 7.5. ALL. ST., allantoic stalk; B. ST., body stalk; C. BR., cellular bridge; IN. ALL. MEMB., inner allantoic membrane; L. UMB. VES., left umbilical vessels; Y. S. ST., yolk-sac stalk.

The embryo at this stage (Text-fig. 10) is closely wrapped in the amnion and is a uniform white colour, there being no scale marking nor any indication of scales in sectioned material. The head is large, the eyes prominent, the nasal apertures formed, and the mouth distinct with upper and lower jaws, tongue and rudimentary teeth forming. The joints and digits of the fore and hind limbs are fairly well developed. The body stalk leaves the posterior end of the embryo in the region of the hind limbs and soon separates into yolk-sac and allantoic stalks. The yolk-sac stalk passes immediately downwards carrying the vessels connecting the vascularization of the yolk-sac with that of the embryo. The allantoic stalk passes up and round the embryo expanding into the allantoic vesicle which

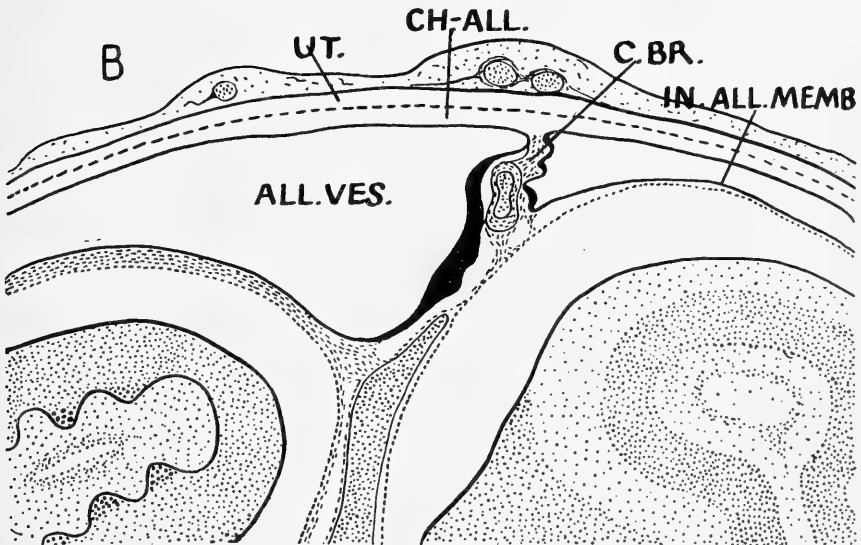
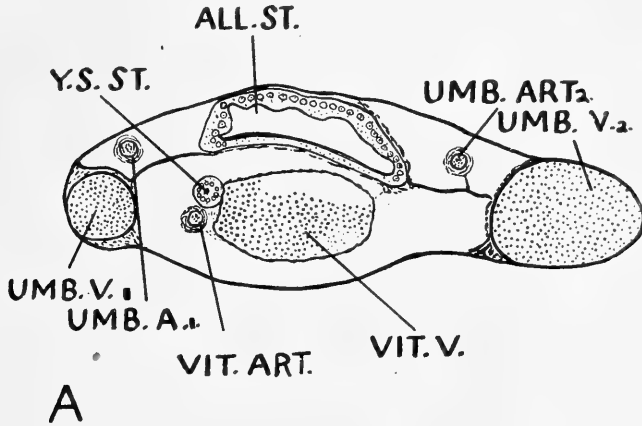
measures approximately 5 mm. if the embryo is from a female of the mountain type and 13 mm. if from one of the coastal type. As in earlier stages the allantois does not surround the yolk-sac and only expands in a downward direction as the yolk-sac decreases in size.

In the body stalk the allantoic stalk has the appearance of being folded round the yolk-sac stalk, owing to the presence of allantoic vessels on either side of the embryo, while the yolk-sac receives vessels from one side only. The yolk-sac stalk is narrow in comparison with the allantoic stalk and its cavity has almost disappeared, being lined with fairly large columnar cells (Text-fig. 11, A). The cavity of the allantoic stalk is much larger and is also lined with large regular cells. The yolk-sac stalk enters the gut immediately anterior to the allantoic stalk. The various bloodvessels are slung in thick folds of mesenchyme arranged round the two stalks, the mesenchyme of both stalks intermingling. There are two umbilical arteries and two veins arranged round the cavity of the allantoic stalk, and one vitelline artery and one vein round the cavity of the yolk-sac stalk. In Text-fig. 11, A, the relationship between the allantoic and yolk-sac stalks within the body stalk is shown.

Within the body of the embryo the vitelline artery is given off by the main dorsal aorta, and the vitelline vein enters the liver. Each umbilical artery is a separate branch from the dorsal aorta in the region of the sciatic artery. As the umbilical veins enter the embryo they unite and pass to the liver where they join the intra-hepatic vessels and the ductus venosus and so pass to the heart. The vitelline artery and vein branch over the flat upper surface of the yolk-sac, at the edge of which they dip into its substance (as described at Stage A), and so completely encircle the sac. The upper surface of the yolk-sac is covered with a layer of large compact endoderm cells (described at Stage A) into which the vessels sink until they lie in deep grooves. The cells lining the grooves prevent the vessels from penetrating into the interior of the yolk-sac and it is not until the vessels have passed beyond the region of these cells and have reached the sides of the yolk-sac that penetration of the interior is possible. It is curious that the interior of the yolk-sac is vascularized by the vessels from the sides and base of the sac and never by branches of those on its upper surface. However, the large endoderm cells are thought to be probable yolk absorbers, since they retain their characteristic appearance throughout the life of the yolk-sac and are always packed with minute yolk granules.

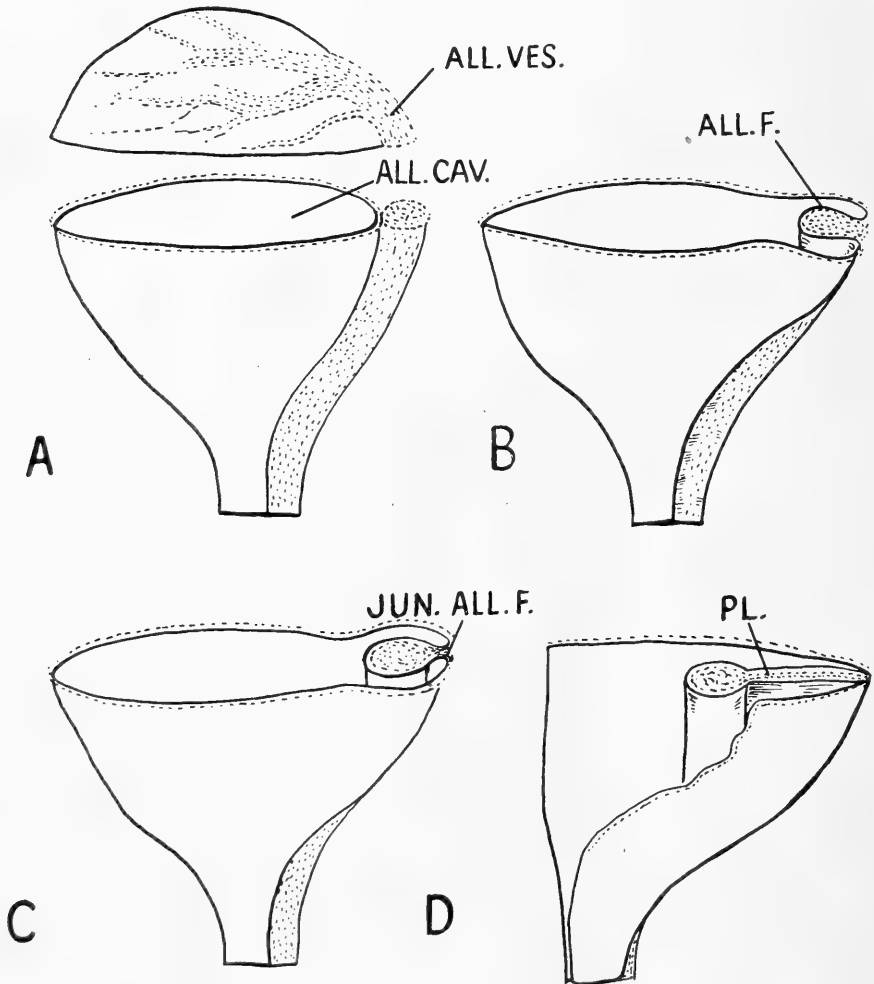
The area vasculosa extends right round the yolk-sac and so the extra-embryonic coelome is completed. It will be seen at once that the position of the coelome is abnormal, since it actually lies within the yolk-sac, and the somatopleure is formed from mesoderm, endoderm and ectoderm instead of from the normal layers of mesoderm and ectoderm. At the edge of the yolk-sac the somatopleural mesoderm lining the chorionic ectoderm remains attached over a short distance to that of the splanchnopleure of the yolk-sac, and the mesoderm of the allantois joins this mesenchyme connection, so that the extra-embryonic coelome is divided into two parts, one lying in the embryonic region between the chorionic membrane and the amnion and being almost completely filled by the allantoic vesicle, and the other lying within the yolk-sac. The attachment of the allantois to the chorionic and yolk-sac mesoderm in this region was detected when the embryonic membranes were dissected away from the embryo under the binocular microscope and was puzzling until sections were made which showed its nature. The blood is collected from the chorio-allantoic membrane by the two large

umbilical veins one of which passes around the inner allantoic wall and thence to the allantoic stalk; the other, invested by allantoic mesoderm and endoderm, reaches the allantoic stalk by passing directly across the cavity of the allantoic



Text-fig. 11. A, section of the body stalk showing the general relationship between the allantoic and yolk-sac stalks; $\times 86$. B, section of the allantoic vesicle in the region of the vascular bridge; $\times 16.5$. ALL. ST., allantoic stalk; ALL. VES., allantoic vesicle; C. BR., cellular bridge; CH. ALL., chorio-allantoic membrane; IN. ALL. MEMB., inner allantoic membrane; UMB. ART., umbilical artery; UMB. V., umbilical vein; UT., uterus; VIT. ART., vitelline artery; VIT. V., vitelline vein; Y. S. ST., yolk-sac stalk.

vesicle (Text-fig. 11, B). Each of the veins is accompanied throughout its ramification in the chorio-allantoic membrane by one of the umbilical arteries. This method of transmission of blood vessels across the cavity of the vesicle is interesting but is evidently of common occurrence since it is found in embryos of some mammals and reptiles examined. Hubrecht (1889, pp. 307-8) records it for the hedgehog, Flynn (1923, p. 77, and fig. 1, p. 74) for *Tiliqua scincoides*, and Harrison and Weekes (1925, p. 476) for *L. entrecasteauxi*. For the hedgehog Hubrecht (1889, pp. 307-8) described "cellular bridges" which crossed the allantoic cavity to carry blood vessels from the inner to the outer allantoic membrane. Flynn wrote, "But the outer wall of the vesicle is also supplied by vessels which leave the allantoic stalk near the body of the embryo and pass right across



Text-fig. 12. Diagrammatic representation of the formation of the vascular bridges across the allantoic cavity. ALL. CAV., allantoic cavity; ALL. F., allantoic fold; ALL. VES., allantoic vessels; JUN. ALL. F., junction of allantoic folds; PL., pleat.

the vesicle to ramify through the mesenchymal layer of the placental face of the allantois". Harrison and Weekes (p. 476) described a somewhat different method of transmission for *L. entrecasteauxi* where "a pleated fold arises from the inner allantoic wall (Plates xlvii, fig. 3; xlviii, fig. 2; xlix, fig. 5, Pl.), within the inner free edge of which the vessels are carried. Since this pleat is covered externally with endoderm continuous with that lining the allantois, there would appear to be no doubt that it has arisen originally as a fold of the allantoic wall". The authors also noted that "In our fourth series a somewhat different condition occurs. In place of the flat fold a blunt finger-like process is pushed out from the inner wall and passes across the lumen to bring about the same ultimate result".

An examination of the various available early stages in the development of *L. quoyi* reveals the surprisingly simple method of the formation of the bridges across the allantoic cavity and indicates a similarity between the methods of transmission in *L. quoyi*, *L. entrecasteauxi* and *T. scincoides* and possibly in the hedgehog.

The position of the blood vessels in the allantoic vesicle in *L. quoyi* is due to the comparatively rapidly growing wall of the vesicle enfolding the more slowly growing blood vessels present in its mesenchyme (Text-fig. 12B, ALL. F.). The arms of the folds from either side meet (Text-fig. 12, C), and thus separate the vessels from the rest of the vesicle wall except for a pleat-like connection which may remain helping to hold the suspended vessels in position (Text-fig. 12, D, PL.). Such a pleat may evidently persist in *L. entrecasteauxi* as quoted above, but in *L. quoyi*, in one of the four specimens of *L. entrecasteauxi* examined, and apparently in *T. scincoides*, it becomes disconnected from the main vessels which then have the appearance of being carried across the cavity in "blunt finger-like processes" pushed out from the walls of the vesicle. The enfolding of the vessels by the wall of the vesicle accounts for the presence of the coat of allantoic endoderm surrounding them, and, I think, for the substance of the "cellular bridges" in *T. scincoides* mentioned by Flynn, although he has not indicated the nature of their tissue either in the text or the accompanying figure.

Since the embryo lies on its left side, the underneath wall of the allantoic vesicle is pressed against the posterior end of the embryo and the yolk-sac and is so prevented from expanding in a downward direction; consequently the lower wall of the vesicle, which is vascularized by the left umbilical vein and artery, does not grow to the same extent, nor as rapidly, as the upper wall, and this, I think, accounts for the absence of "cellular bridges" carrying the left umbilical vein and artery across the cavity of the allantoic vesicle. The inner allantoic wall is so tenuous and so closely wrapped round the tail and hind limbs of the embryo, that in serial sections one may easily be misled into believing that the allantoic stalk passes downward and outward over the surface of the embryo. However, a glance at Text-fig. 10 will show that sections cut along the plane x-x', in the region of the left umbilical vein and artery, would have this appearance. In Text-fig. 10 the embryo is drawn lying upon the yolk-sac with the body stalk (B. ST.), leaving the posterior end of the body and dividing into the yolk-sac stalk (Y.S. ST.), and the allantoic stalk (ALL. ST.). A portion of the wall of the allantoic vesicle has been removed so that the transmission of the blood vessels across the allantoic cavity in the "cellular bridge" can be seen (C. BR.) as well as the folding of the inner allantoic membrane round the tail of the embryo (IN. ALL. MEMB.), and the consequent passage of the left umbilical

vein and artery (L. UMB. VES.), to the chorio-allantoic membrane in a groove of the inner allantoic wall.

The Omphaloplacenta.—The lack of uniformity in the degree of specialization of the omphaloplacenta in different embryos is, as stated, most probably due to the varying amount of shell membrane present underlying the yolk-sac. It will be recalled that the shell membrane falls away from the sides of the blastocyst and collects at the base of the yolk-sac between it and the uterine wall. When the wall of an incubatory chamber is cut in half round its circumference, and the lower half is gently lifted from its position underlying the yolk-sac, the remnant of the shell membrane in the form of a round flat pad of crumpled fibrous matter falls away from the base of the yolk-sac, since it is no longer supported by the uterus. The pad gradually thickens as the embryo grows and more membrane falls to the base of the yolk-sac, so that, while it is comparatively thin in the majority of embryos at four weeks, in embryos collected during the second and last month of the gestation period, it is of considerable thickness, and impresses its shape upon the overlying yolk-sac, forming a barrier between it and the uterine wall and so interfering with the modification of the foetal tissue of the omphaloplacenta. When the shell membrane is thin the foetal tissue reaches its highest degree of specialization; when it is thick in some places and thin or absent in others the modification of the foetal tissue is correspondingly patchy; and when it is abundant, as in embryos collected during the latter half of the gestation period, there is only slight modification of the foetal tissue. In *L. entrecasteauxi* (Harrison and Weekes, 1925, p. 474) there was no trace of shell membrane in any of the embryos examined, and consequently the placenta is more or less uniform in its development and is more highly specialized than that of *L. quoyi*, even at the late stage described when retrogression of its structure is suspected (p. 476).

The embryos collected during the fourth week of the gestation period have the most fully specialized omphaloplacenta (Text-fig. 13). Here, although the shell membrane completely covers the surface of the yolk-sac, it is thin and the pad at the base of the sac comparatively small.

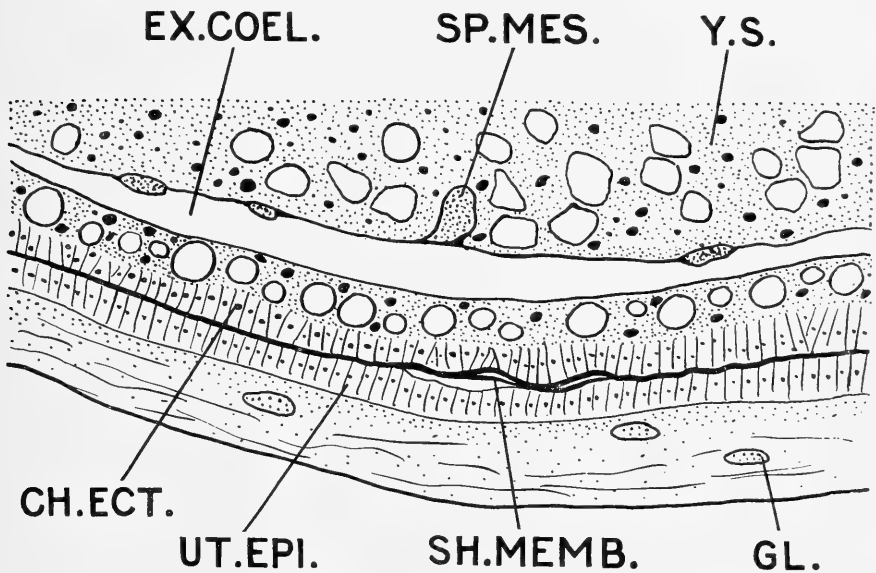
(a). *Maternal Portion of the Placenta.*—The maternal portion of the placenta is much less influenced by the presence of shell membrane than the foetal portion, and is comparatively uniform in structure throughout the period of omphaloplacental maturity.

There is a tendency towards a thickening of uterine tissue at the base of the yolk-sac which is fairly consistent in all embryos and especially marked in those at four weeks. The increase in thickness is brought about by a thickening of the muscular tissue and the mucosa, and by the enlargement of the epithelial cells. There is a tendency toward slight folding of the uterus, the folds being irregular and the crypts shallow. The glands in the allantoplacental region described at Stage A are conspicuous throughout the mucosa over the placental area, but although fairly numerous do not appear to function, since the cytoplasm of the gland cells is vacuolated and the cells are arranged round a large central cavity. The capillaries are numerous and mark the termination of the uterine vessels which pass round the incubatory chamber (Text-fig. 2, A). They are flat, but not as flat as in earlier stages (Text-fig. 5, B), and often bulge beneath the epithelium as in *L. entrecasteauxi*. The thickening of the uterus restores to it something of its appearance in the non-pregnant condition, but signs of placentation are present in the increased vascularization and the modified epithelium. The epithelium is formed of fairly large columnar cells with oval nuclei and with

the cell cytoplasm concentrated at their rounded free margins, this concentration being probably due to the secretory activity of the cells, since a coagulum is found adhering to many of them.

In some embryos at various stages in development the connections between the incubatory chambers are so deeply convoluted that when met with in sectioned material the uterine wall in these regions appears to be thrown into deep regular folds, which may be at first thought to be a placental modification.

(b). *The Foetal Portion of the Placenta.*—The modification of the foetal tissue extends over the entire under surface of the yolk-sac in proximity with the uterine wall by the radial extension of the original area of modified tissue at the approximate middle of the base of the yolk-sac. At this stage the chorionic ectoderm is thickest at the base of the sac and is composed of two or three layers of cells. The lower layers of the ectoderm are flat and squamose, and the difference between the outermost layer of cells and the underneath layers is



Text-fig. 13. Section of the mature omphaloplacenta; $\times 103$. CH. ECT., chorionic ectoderm; EX. COEL., extra-embryonic coelome; GL., gland; SH. MEMB., shell membrane; SP. MES., splanchnic mesoderm; UT. EPI., uterine epithelium; Y.S., yolk-sac.

marked, the cells of the outer layer being tall and narrow with many of the individual cell boundaries distinct. Although the majority of the cells are columnar others may be crowded together until they have no definite shape. At the sides of the yolk-sac the ectoderm is thinner and the cells of the outer layer are smaller. There is a comparatively thin layer of shell membrane adhering to the chorionic ectoderm over the placental face but it is being absorbed by the cells and has no apparent influence on their development.

The yolk-sac endoderm underlying the chorionic ectoderm contains yolk-granules and is composed of large, vacuolated cells with large deeply staining nuclei. It is not so intimately attached to the chorionic ectoderm as in earlier

stages and the degree of attachment varies with the embryo. The boundaries of the cells are not definite, and it is impossible to estimate the number of cells in the depth of the layer. The endoderm cells are bounded by a layer of non-vascularized extra-embryonic mesoderm.

The chorionic ectoderm, together with the underlying yolk-sac endoderm and extra-embryonic mesoderm, is separated from the main bulk of the yolk-sac, with the exception of a small area at the approximate middle of the base of the sac where the mesoderm remains attached to that lining the sac.

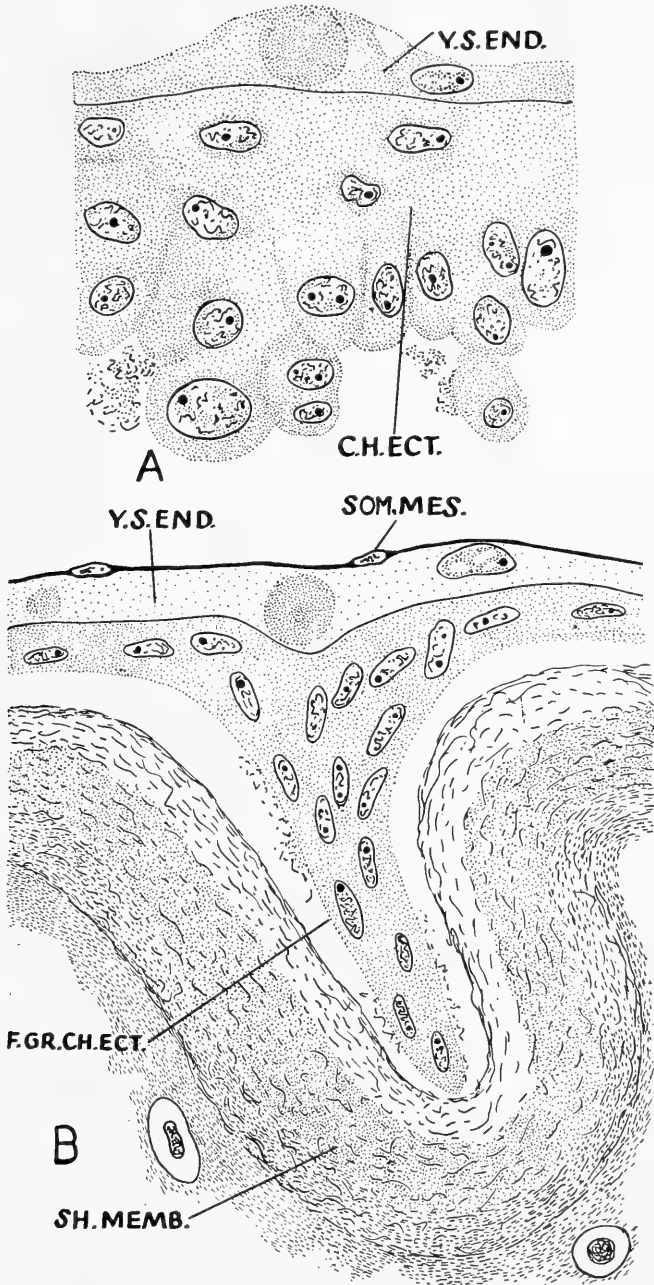
The maternal secretion absorbed by the chorionic ectoderm must be passed through the narrow layer of yolk-sac endoderm and somatopleural mesoderm and across the cavity of the extra-embryonic coelome before it reaches the blood vessels in the yolk-sac. Hence the fine coagulum within the extra-embryonic coelome, which contains corpuscles and cell debris, is thought to be maternal secretion.

The omphaloplacenta, then, present in embryos four weeks old is fairly well developed and is formed by a richly vascular uterine wall with epithelium modified for secretion overlying a many layered sheet of modified chorionic ectoderm cells, attached to a thick layer of large vacuolated endoderm cells followed by a layer of non-vascular mesoderm; the sheet of combined foetal tissue being separated by a narrow extra-embryonic coelome from the vascular system of the yolk-sac. The extra-embryonic coelome is completely cut off from the rest of the coelome in the embryonic region by a mesenchymal connection between the allantois, chorion and yolk-sac.

In embryos obtained from females collected during the sixth and subsequent weeks of the gestation period, the omphaloplacenta is not so well specialized. The maternal placenta in these corresponds with that described above and needs no further comment. During the sixth and seventh weeks, when there is a patchy accumulation of shell membrane at the base of the yolk-sac, some areas of foetal tissue are more specialized than others, the foetal placenta in the embryo selected for description being roughly divisible into two regions of varied specialization. The first region covers about one-half of the yolk-sac extending from the edge of the sac to its base and consists of practically unmodified foetal tissue underlain by a convoluted layer of shell membrane. The second region covers the rest of the yolk-sac, and as there is very little shell membrane here, the foetal tissue is well modified, the chorionic ectoderm cells attaining a height of 0.087 mm. (Text-fig. 14, A).

The chorionic ectoderm in the first region consists of two or three layers of cells which are small and flat with no dividing walls visible. The cell cytoplasm stains a deep pink with eosin and the nuclei stand out as oval darkly stained bodies. The free margins of the cells are irregular, since the cells are embedded in the shell membrane which is surrounded and impregnated by a thick coagulum thought to be maternal secretion.

The cells of the chorionic ectoderm in the second region are arranged in many layers, those of the outermost layer ranging from short, wide, cubical cells to tall, narrow, irregularly shaped cells with a tendency to columnar structure (Text-fig. 14, A). These enlarged cells are phagocytic and have ingested material, often uterine epithelial cells and maternal corpuscles, in their cytoplasm. Between the uterine wall and the chorionic ectoderm there is the same pale staining coagulum which occurs in the first region and which adheres to the edge of the chorionic cells giving them a ragged appearance. This coagulum contains the



Text-fig. 14. A, section of the foetal tissue of the omphaloplacenta of a six weeks old embryo showing the irregularly shaped chorionic ectoderm cells; $\times 1050$. B, "finger-like" downgrowth of chorionic ectoderm in the omphaloplacental region of an eight weeks old embryo; $\times 1050$. CH. ECT., chorionic ectoderm; F. GR. CH. ECT., finger-like growth of chorionic ectoderm; SH. MEMB., shell membrane; SOM. MES., somatic mesoderm; Y.S. END., yolk-sac endoderm.

scattered cells and corpuscles which the chorionic ectoderm cells ingest. The underlying layer of yolk-sac endoderm is thinner than in the placenta of the four weeks old embryo, the narrow cells tapering and occasionally bulging round relatively enormous yolk granules. The extra-embryonic coelome is wide and in some of the embryos examined is filled with a coagulum which is stained a deep blue by haematoxylin and which in patches has a peculiar scale-like appearance. It is full of corpuscles and has a fine granular matrix at its edges, which has the appearance of congealed blood. It is not known whether the corpuscles are maternal or foetal but both varieties are possibly present. Its occurrence between the uterine wall and the chorionic ectoderm, within the yolk-sac and within the allantoic vesicle as well as within the extra-embryonic coelome makes the problem of its origin a difficult one. A similar coagulum was observed in the yolk-sac of *L. entrecasteauxi* (Harrison and Weekes, 1925, Pl. xlviii, fig. 5) and in *E. whitei*. It was at first thought to be albumen, but this is not likely as it was not present in young embryos examined nor in the majority of older ones. Some of it is probably maternal secretion but it is not likely that this is the sole source since there is such a large quantity of coagulum present. Owing to its blood-like appearance it was thought that its presence may be due to the breaking of vessels damaged when the parent lizard was caught (Pl. xxxix, fig. 3).

In embryos present in females collected during the last month of the gestation period, the pad of shell membrane practically covers the under-surface of the yolk-sac, and there is consequently only slight specialization of the foetal tissues. For a considerable distance on either side of the yolk-sac the chorionic ectoderm cells are normal, each being flattened and having a small dark nucleus. In the central region where the shell membrane is thrown into deep folds the chorionic ectoderm is formed of many layers of small cells. These cells proliferate and grow down between the folds of the shell membrane in the form of long "finger-like" growths which may measure as much as 0.25 mm. in length and which are usually about three or four cells thick (Text-fig. 14, B). The hollows between the folds of the shell membrane on the side nearest the uterus are full of a thick coagulum which contains corpuscles and which stains pink in some places and a deep blue in others (eosin and haematoxylin). It is most probably maternal secretion and is thought to supply the stimulus for the down-growth of the chorionic ectoderm into the folds of the shell membrane. The cytoplasm of the cells of the proliferated areas has the same dense pink and blue appearance as the coagulum which the cells are obviously absorbing. Over a small area at the edge of the yolk-sac where the shell membrane is not folded but is flat and comparatively thin, the chorionic ectoderm cells are much larger and resemble the cubical chorionic ectoderm cells in the omphaloplacental region in the six weeks old embryo.

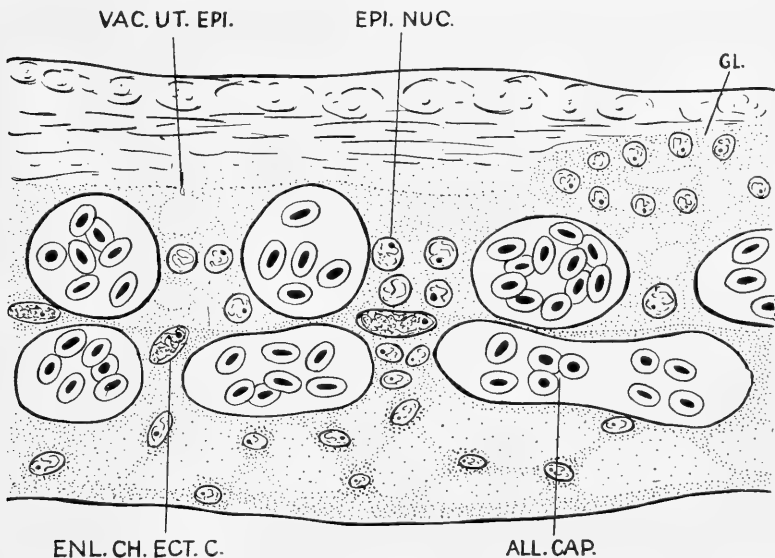
The underlying layer of yolk-sac endoderm has the same general structure as in the six weeks old embryo, being composed of either long tapering cells or large vacuolated cells. Often for a considerable distance at one side of the yolk-sac the chorionic ectoderm and strip of yolk-sac endoderm are attached to the yolk-sac.

The omphaloplacenta, then, functions best during the first six weeks of the gestation period when the foetal tissues are most highly specialized and the shell membrane covers the yolk-sac as a smooth layer. During the latter half of the gestation period its activity is diminished by the presence of the thick pad of shell membrane underlying the yolk-sac, which interferes with the passage

of maternal secretion from the uterus to the embryonic tissues, some of the secretion being retained among the folds of the membrane.

The Allantoplacenta.—By the end of the fourth week of the gestation period there is usually no shell membrane left and the chorio-allantoic membrane is pressed closely against the smooth face of the uterus and the fixation of the tissue is brought about by the attachment of scattered enlarged cells of the chorionic ectoderm to the uterine epithelium. In the handling and sectioning of the material, part of the foetal tissue may separate from the maternal tissue but there are always large areas of foetal tissue left attached to the uterus. The attachment though efficient is not as close as that in *Perameles* and there are no villous folds in the uterine wall to aid in fixation.

(a). *The Maternal Portion of the Placenta.*—The uterine wall is about three times thicker than in the allantoplacenta of a two weeks old embryo and the placenta is uniformly developed over its entirety, there being no special thickening of the uterine wall at the centre of the placental region such as occurs in the omphaloplacenta. With the thickening of the uterus the muscle layers, the mucosa and the few glands present have resumed something of their normal structure, but the glands show no signs of activity. The numerous capillaries have reached the surface of the epithelium and are now only separated from the underlying foetal tissue by their own endothelial walls and perhaps a thin layer of maternal cytoplasm (Text-fig. 15). They are crowded at the surface of the epithelium with their walls often touching, but with usually the width of their diameter apart. The capillary walls are thin but definite, with occasional small sickle shaped nuclei present in their substance. The capillaries are circular, packed with corpuscles, and are overlain by a series of larger vessels in the mucosa which are often found pressing against the underlying capillaries.



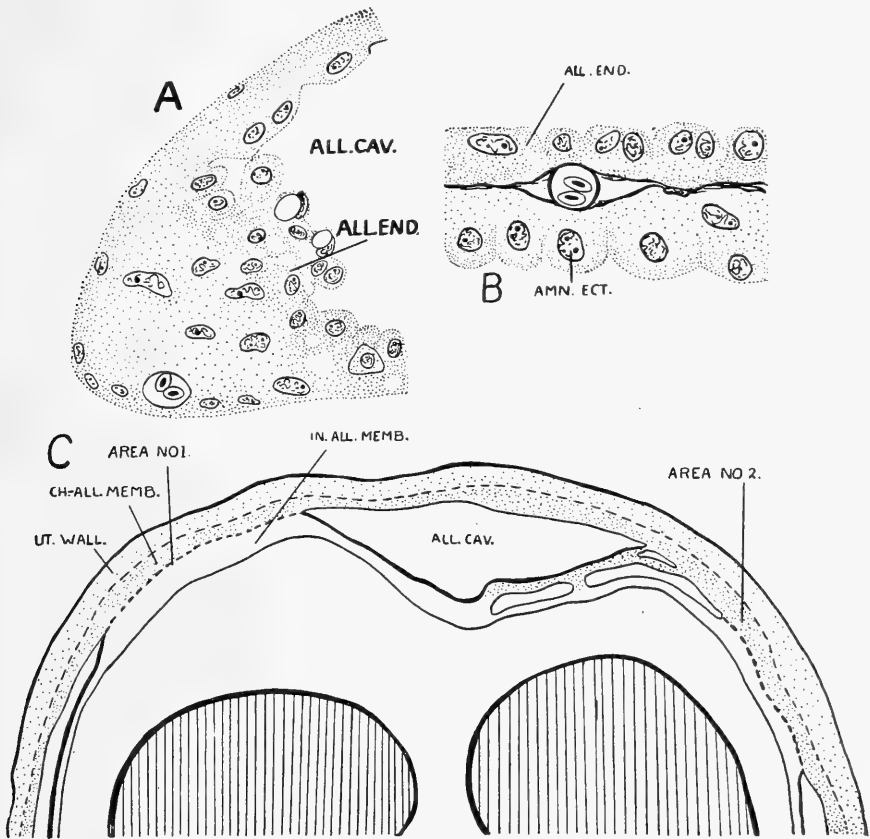
Text-fig. 15. Section of the allantoplacental region of a four weeks old embryo; $\times 1270$. ALL. CAP., allantoic capillary; ENL. CH. ECT. C., enlarged chorionic ectoderm cell; EPI. NUC., epithelial nuclei; GL., gland; VAC. UT. EPI., vacuolated uterine epithelium.

There are few definite epithelial cells present, since most of them have degenerated, the cell cytoplasm being full of small vacuoles, the cell walls having disappeared, and a few of the degenerating nuclei being represented by groups of small dark granules. The healthy nuclei are round, stain but slightly, have one or two nucleoli, and are quite characteristic and always distinguishable from the nuclei of the chorionic ectoderm. These nuclei have been pushed aside by the invading capillaries and are now grouped in the cytoplasm between them. The cytoplasm has not the appearance of that of typical secreting cells such as are seen lining the villous ridges of *L. entrecasteauxi*, and hence is not regarded as an active secreting agent.

The absence of shell membrane allows the chorionic ectoderm and the uterine wall to come into immediate contact, but although they are attached, the connection is such that the line of division between maternal and foetal tissue is often visible, there being no mingling of the chorionic ectoderm with the maternal tissues such as occurs in the placentae of some mammals. The chorionic cells which attach themselves to the uterine epithelium are comparatively widely separated and have no definite shape, consisting of a large deeply staining nucleus surrounded by cytoplasm which insinuates processes into the maternal cytoplasm, so that when the attached maternal and foetal tissues are separated both surfaces are jagged and torn. For the rest the chorionic ectoderm consists of long tapering cells with fairly large nuclei, the tapering ends of the cells extending over the bulging allantoic capillaries or degenerating to allow the capillaries to come into immediate contact with the maternal capillaries (Text-fig. 15). It is difficult to determine whether there is more than one layer of ectoderm cells present. In some places there is a narrow gap between the maternal and foetal tissues which is filled with a coagulum staining lightly with haematoxylin, and which is possibly maternal secretion, although it may be the remains of shell membrane.

The allantoic blood vessels vary in size from small round capillaries to much larger vessels. The capillaries have distinct nucleated walls and are filled with corpuscles which closely resemble the maternal corpuscles at this stage. A narrow band of connective tissue underlies the capillaries and contains less muscle fibre than that in *L. entrecasteauxi*. The single layer of endoderm bounding the chorio-allantoic membrane consists of fairly regular, moderately enlarged tapering cells. At the edge of the placental area, where the outer wall of the allantois bends at the surface of the yolk-sac and continues as the inner wall, the endoderm cells may proliferate until they hang in bunches in the allantoic cavity (Text-fig. 16, A). Here, cell boundaries are difficult to determine, some of the cells appearing to be multinucleate. Each cell has a narrow base and a swollen apex which often contains one or more large vacuoles. The modification of the cells may extend over the inner wall of the allantois, where the cells enlarge and separate from each other at their margins (Text-fig. 16, B). They are often intensely vacuolated with a deeply staining nucleus at the surface of the cell. In the allanto-placental region of some rodents the endoderm cells have the same peculiar structure, but this modification is not a placental adaptation as is shown by a similar modification of some of the endoderm cells lining the allantoic vesicle of the oviparous Agamid lizard *Amphibolurus barbatus*. The peculiar structure of the cells is thought to be possibly caused by their absorption of the excretory fluid which fills the allantoic vesicle.

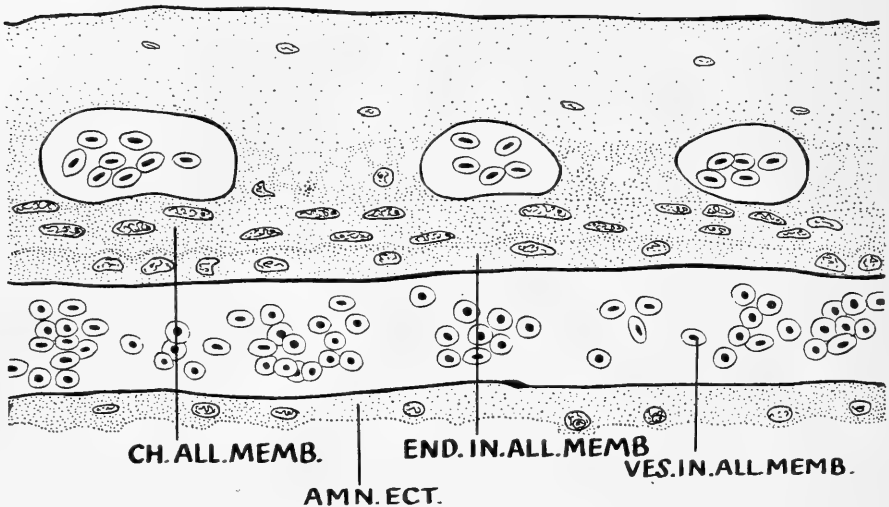
The inner allantoic membrane may unite with the amnion and the junction may extend completely over the surface of the latter, so that the blood vessels of the inner allantoic membrane come to lie between a layer of allantoic endoderm and amniotic ectoderm (Text-fig. 16, B). The ectoderm cells of the amnion are also modified, their structure resembling that of the endoderm cells just described, and this similar modification is possibly due to their absorption of excretory fluid from the endoderm cells.



Text-fig. 16. A, endoderm cells lining the allantoic vesicle at the surface of the yolk-sac; $\times 405$. B, section showing the structure of the fused inner allantoic membrane and amnion; $\times 405$. C, section of the allantoic vesicle and allantoic membrane showing the junction of the inner allantoic membrane and amnion with the chorio-allantoic membrane; $\times 17.5$. ALL. CAV., allantoic cavity; ALL. END., allantoic endoderm; AMN. ECT., amniotic ectoderm; CH. ALL. MEMB., chorio-allantoic membrane; IN. ALL. MEMB., inner allantoic membrane; UT. WALL., uterine wall.

In the majority of placentae examined an interesting condition exists, where all the extra-embryonic membranes—the chorion, the outer allantoic and inner allantoic membranes, and the amnion—join together in some places to form the foetal portion of the allanto-placenta (Text-fig. 16, C; Pl. xl, fig. 7). In some

of the placentae examined the area so formed is comparatively large, measuring as much as 5 mm. in one of the embryos obtained from a mountain type of female. The presence of the additional membranes modifies the structure of the chorio-allantoic membrane in their vicinity, as described below.



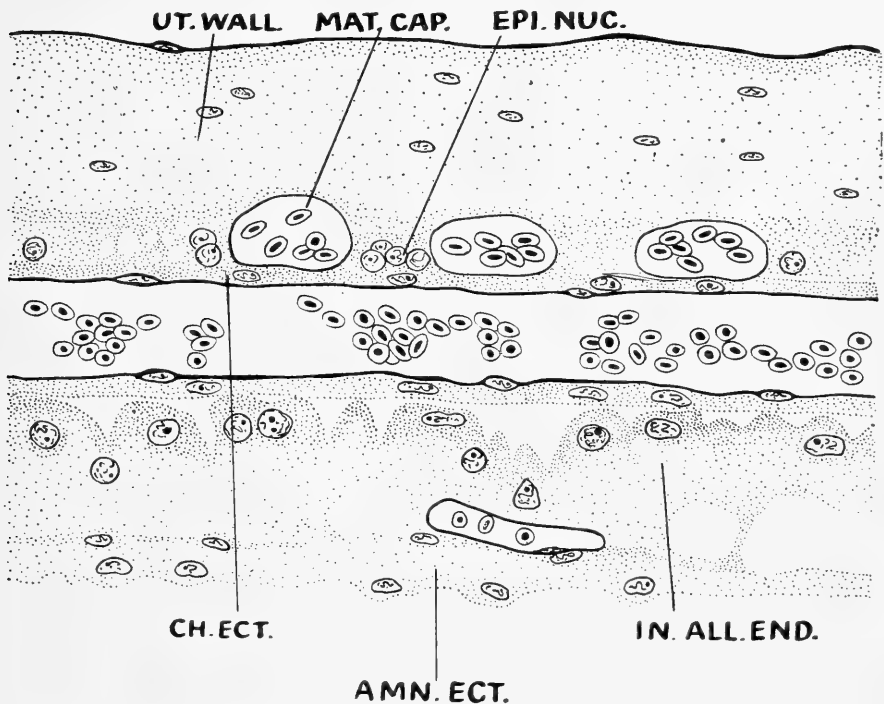
Text-fig. 17. Section of the first area of combined foetal membranes in the allantoplacental region, showing the compressed chorio-allantoic membrane and well vascularized inner allantoic wall; $\times 519$. AMN. ECT., amniotic ectoderm; CH. ALL. MEMB., chorio-allantoic membrane; END. IN. ALL. MEMB., endoderm of inner allantoic membrane; VES. IN. ALL. MEMB., vessel in the inner allantoic membrane.

In one of the four weeks old embryos an area of combined extra-embryonic membranes is present on either side of the allantoic stalk, each of which is most conspicuous. In one of these areas the chorio-allantoic membrane is flattened against the uterine wall, and the cells of the chorionic ectoderm, mesenchyme and allantoic endoderm are so compressed that the chorio-allantoic membrane, in section, has the appearance of a narrow band of undifferentiated tissue (Text-fig. 17). One of the most obvious modifications is the absence of blood vessels in the chorio-allantoic membrane in this region (Text-fig. 17). The layer of endoderm cells lining the inner allantoic membrane is pressed closely against the chorio-allantoic membrane and there is a thin layer of coagulum between them, which fills what is left of the allantoic vesicle after the junction of its inner and outer walls, and which resembles that in the omphaloplacental region described above. The endoderm cells of the inner allantoic wall are moderately large with large oval nuclei, but have been compressed by the junction of the two membranes, until they are smaller than those in the regions of non-attachment. The underlying mesenchyme is richly vascularized and obviously feeds and drains the placenta in this region, since blood vessels are absent in the mesenchyme of the overlying chorio-allantoic membrane. The mesoderm of the amnion is joined to the mesenchyme and it and the amniotic ectoderm are normal.

On the opposite side of the allantoic stalk, the inner allantoic membrane and the attached amnion are in process of joining with the chorio-allantoic membrane

and consequently the tissues concerned here have a different structure (Text-fig. 18). The chorio-allantoic membrane is practically normal with blood vessels present in the mesenchyme. The endoderm cells of the inner allantoic membrane are greatly enlarged, measuring as much as 0.04 mm. in length, and where they touch the chorio-allantoic membrane, have attacked the substance of its endodermal lining, one of the endodermal nuclei having been torn away from its surrounding cytoplasm on the separation of the outer and inner allantoic walls in the preparation of the material for sectioning. The cells have square free margins with large vacuoles at their bases, and on the whole resemble the endoderm cells described above as lining the inner allantoic membrane in its normal position and condition. There are as yet no large blood vessels in the mesenchyme underlying the endoderm cells, but small vessels are present. The ectoderm cells of the amnion are slightly enlarged and rounded (Pl. xl, fig. 7).

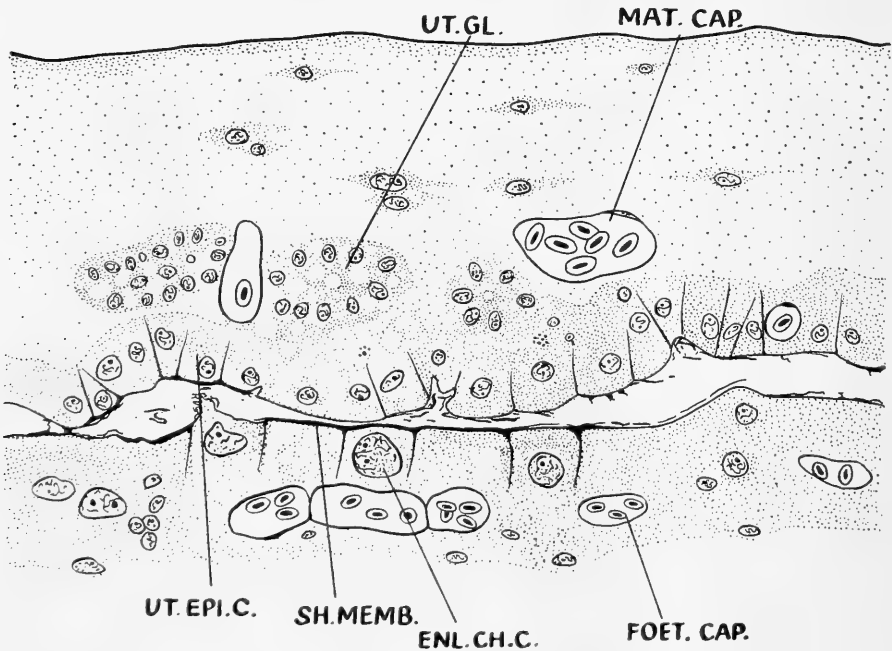
The folds of tissue which surround the blood vessels in their passage across the allantoic cavity have the same general structure as the rest of the allantoic tissue. The endoderm cells forming the outer covering of the bridges are enlarged and many layers deep, and the connective tissue is thick and muscular, carrying branch vessels as well as the main vessels across the cavity.



Text-fig. 18. Section of the second area of combined foetal membranes in the allantoplacental region showing the junction of the endodermal lining of the inner allantoic membrane with the endoderm of the chorio-allantoic membrane; $\times 485$. AMN. ECT., amniotic ectoderm; CH. ECT., chorionic ectoderm; EPI. NUC., epithelial nuclei; IN. ALL. END., inner allantoic endoderm; MAT. CAP., maternal capillary; UT. WALL., uterine wall.

The apposition of inner and outer allantoic walls results in the formation of a short cut for the maternal secretion in its passage to the embryo. Instead of being collected by the vessels in the chorio-allantoic membrane and passed into the main right vein and thence across the cavity of the allantoic vesicle into the allantoic stalk, the secretion passes through the chorio-allantoic membrane into the vessels of the inner allantois, and thence direct to the allantoic stalk and so into the embryo. As far as can be ascertained there is no mechanical pressure upon the inner allantoic membrane which might have effected its union with the outer allantoic membrane, the embryo lying apart from the region of junction, but there is no positive evidence that the union has been caused by an urge for quicker transport of blood to the embryo. In its downward growth the inner wall of the allantois meets the amnion and the union of the two membranes is the natural result. This is established before the junction of the inner and outer allantoic membranes and so the amnion is carried to the placenta by the agency of the inner allantoic membrane, and obviously can have no new function in the placental region.

The anticipation of the extension of the allantoic vesicle by the uterine wall overlying the yolk-sac is as marked as in earlier stages. However, during the last two weeks of the gestation period when the yolk-sac is rapidly absorbed and reduced to a small bag, the allantois advances rapidly and the changes which take place in the uterus are most marked and will be described at Stage C.



Text-fig. 19. Section of the folded allantoplacental region present in one of the embryos examined; $\times 450$. ENL. CH. C., enlarged chorionic ectoderm cell; FOET. CAP., foetal capillary; MAT. CAP., maternal capillary; SH. MEMB., shell membrane; UT. EPI. C., uterine epithelial cell; UT. GL., uterine gland.

In one of the embryos examined the allanto-placenta differs from the normal condition described above. That the variation is individual and not representative of a stage in the development of the placenta is shown by its presence in the one embryo and not in the other embryos of the same female nor in embryos of females collected at the same time, and hence approximately at the same stage in development. The embryo is about six weeks old and the allanto-placenta presents an interesting variation in the form of slight folding of the maternal and foetal tissues in the region of the main vein and artery, the folded area being 5 mm. in length and 3.5 mm. in width. The rest of the placental area is smooth as in all other embryos examined. The folds are not nearly as definite as the villous folds in the allanto-placental region of *C. tridactylus* and *L. entrecasteauxi* and in the omphaloplacental region of *T. scincoides*, and were not visible to the unaided eye. The degree of folding is shown (Text-fig. 19; Pl. xxxix, fig. 5), where the foetal tissue is seen fitting loosely into the shallow maternal crypts. The uterine wall is much thicker than in the non-folded region. The structure of the mucosa and glands is normal, but the epithelium and capillaries merit special attention. Although the epithelium of the folds has not degenerated, the cells are not as uniform in shape as in the non-pregnant condition, being crowded together in some places until they are cone shaped (Text-fig. 19). Each is slightly enlarged, has a rounded free margin and a central round or oval nucleus. The cells appear to be secretory, being non-vacuolated, and somewhat resemble those lining the villous folds of *L. entrecasteauxi*. In addition the epithelium is not interfered with to any extent by the maternal capillaries, only a few having penetrated into its substance, the remainder lying in the mucosa beneath the epithelium. However the whole area is not as well vascularized as the non-folded region.

Between the maternal and foetal tissues there is a thin remnant of shell membrane extending over the whole of the placental area. The chorionic ectoderm cells have not degenerated to the same extent as they have in the non-folded region and some are larger here than in any other of the allanto-placentae examined, but the majority are normal in size and have no dividing walls or definite shape. Each cell contains a large oval or round deeply staining nucleus, which has one or two nucleoli, and which in some cases almost completely fills the cell. The foetal capillaries are numerous, the connective tissue is comparatively thick, and the structure of the endoderm corresponds to that in a normal placenta.

In the non-folded region the maternal capillaries are numerous and have reached the surface of the epithelium which for considerable stretches has completely degenerated. The allantoic capillaries have also reached the surface of the foetal tissue, the chorionic ectoderm cells being few and scattered.

In the allanto-placenta of each of the embryos collected during the last month of the gestation period the main differences from the placenta described as typically mature are (a) an increase and enlargement of the maternal and foetal capillaries to meet the increasing demands of the rapidly growing embryo; (b) the further degeneration of the uterine epithelium between the maternal capillaries; (c) pronounced bulging of the maternal and foetal capillaries over the placental face, the capillaries being closely apposed often with no maternal or foetal cytoplasm between them, and with their own walls reduced in thickness.

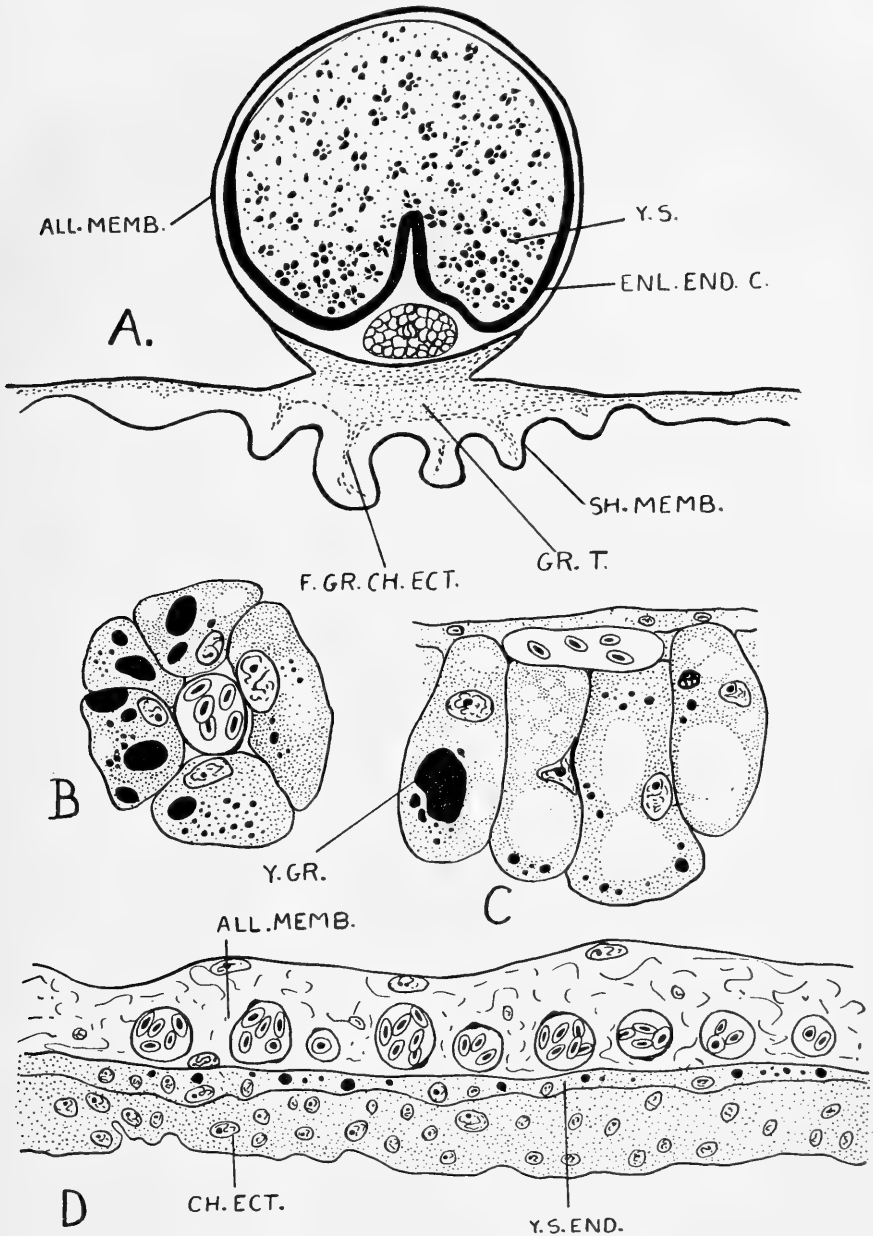
Stage C. *The placentae immediately prior to the birth of the foetus.*

Females were collected from Barrington Tops, the Blue Mountains and Kiama (coast) which contained young ranging from within two weeks to one day of

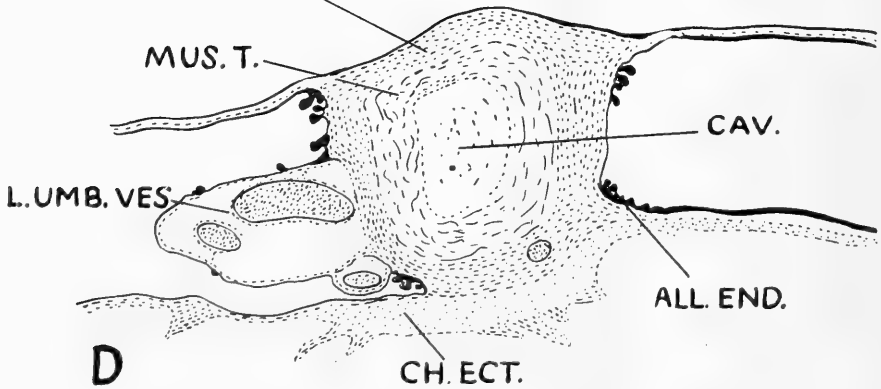
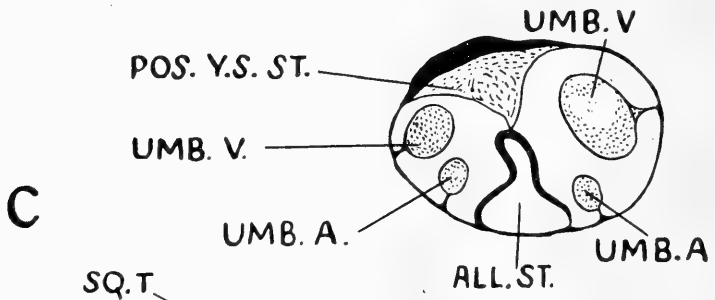
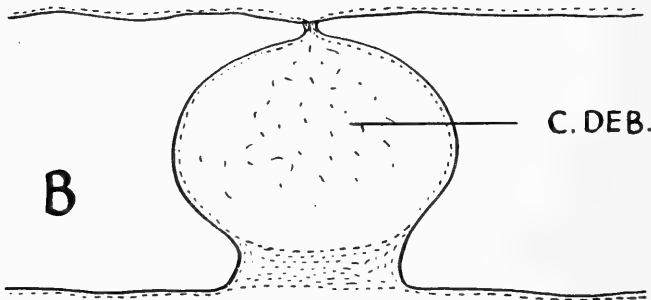
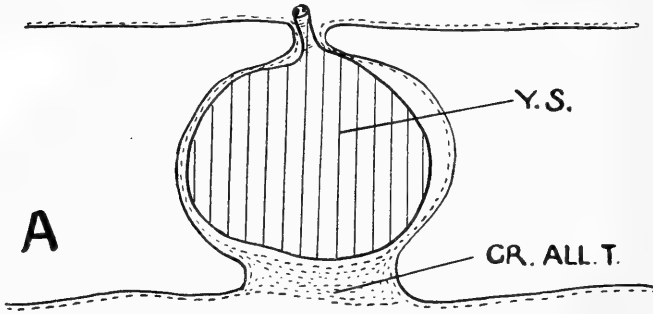
birth. Altogether four females were collected from Barrington Tops during the first two weeks of February, 1925, and the young are estimated to be about ten weeks old. Females were collected from the Blue Mountains during the last two weeks of January, 1927, and of these, five were kept until the 12th February, when the young were still unborn although those in the bush were born by the last week in January. By the 12th February all but two of the females had died, so it was thought advisable to open the remaining two and fix the contained embryos, which are taken as being at the stage immediately prior to birth, since it was obviously the captivity of the parents and not the condition of the young which inhibited birth. Three females were collected from Kiama during the first week of January, 1926, and were kept alive in Sydney until the end of the second week when the young were born.

The blastocyst taken from a female of the mountain type when the foetus is within one week of birth measures on an average 2 cm. in length and that from a coastal type 2.7 cm. When a female is opened up along the ventral body wall the yolk-sacs of the contained blastocysts are no longer conspicuous as in earlier stages, each being reduced to a small bag of yolk about 3 mm. in diameter, which may be in its normal position pressed against the overlying uterus, but is usually withdrawn from the latter until it lies hidden among the limbs and tail coils of the embryo. The embryo can be distinctly seen lying among its membranes, which are thin and greatly expanded by the large amount of embryonic excretion present in the allantoic vesicle. The excretion oozes out as a clear colourless fluid when the allantois is punctured. The embryos are well formed with definite scale markings and when touched wriggle about within their membranes. The limbs of some of the young lizards within a week of hatching were pressed against and almost embedded in the yolk-sac and in one instance the tail was coiled round it several times. This position of the limbs may indicate an effort on the part of the embryo to aid the withdrawal of the yolk-sac into its body, since some of the embryos when only about three weeks old were capable of movement when stimulated and even crawled for some distance when freed from their membranes.

From the sixth to the tenth week of the gestation period there is no marked decrease in the size of the yolk-sac, but during the eleventh and last weeks the reduction is pronounced, the sac decreasing to about one-twelfth its size at six weeks. The large cells described at Stage B as lining the upper surface of the yolk-sac now completely cover the sac, and by intense proliferation have filled the interior, which in section appears to be divided into numerous rounded areas usually composed of three or four cells surrounding a central blood vessel (Text-fig. 20, A and B). The cells are efficient yolk absorbers and rapidly empty the yolk-sac, passing the yolky material to the blood vessels. They are relatively enormous, each being definitely bounded and containing one large, deeply staining, irregular nucleus and many small or large vacuoles. The cell cytoplasm is stained a deep pink by eosin and is obviously packed with yolk material having the same appearance as the yolk granules. Many of the cells are actively ingesting yolk granules and their cytoplasm is packed with them, some completely filling the cell, others being extremely small and obviously prepared by the cells for their passage into the blood vessels (Text-fig. 20, C). The blood vessels encircled by the groups of cells are in many cases newly formed, haematopoiesis in the yolk-sac being active at this stage.



Text-fig. 20. A, section of yolk-sac of an eleven weeks old embryo showing the junction of the allantoic membranes at the base of the sac, the shell membrane and the "growth" of allantoic tissue; $\times 26$. B, transverse section through the enlarged endoderm cells in the yolk-sac surrounding a blood vessel; $\times 562$. C, section of a portion of the yolk-sac wall; $\times 562$. D, section of the membrane formed by the junction of the outer allantoic membrane with the layers of somatic mesoderm, yolk-sac endoderm and chorionic ectoderm; $\times 562$. ALL. MEMB., allantoic membrane; CH. ECT., chorion ectoderm; ENL. END. C., enlarged endoderm cell; F. GR. CH. ECT., finger-like growth of chorionic ectoderm; GR. T., growth of tissue; SH. MEMB., shell membrane; Y. GR., yolk-granules; Y.S., yolk-sac; Y.S. END., yolk-sac endoderm



With the reduction in size of the yolk-sac space is provided for the further extension of the allantois and at this stage the allantoic membranes completely envelop the yolk-sac, meeting and fusing at its base. The fusion is accompanied by a considerable growth of tissue (allantoic mesoderm and endoderm, Text-fig. 20, A; Pl. xl, fig. 6), which was observed in all the embryos examined and in the living condition was visible as a circular, flat, white area beneath the yolk-sac, or in the former position of the yolk-sac when the latter was no longer present. This "growth" of tissue varies in size, measuring on an average about half the diameter of the sac in the mountain type of blastocyst. The main mass of tissue is muscular with blood vessels embedded, and contains numerous yolk spheres and small dark granules which are possibly the remains of degenerating nuclei. Here, the vessels from the inner allantoic membrane pass to the outer allantoic membrane slung in thick folds of mesenchyme (Text-fig. 21, D) and lining the allantoic cavity the endoderm cells are similar in structure to those described above (Stage B, Text-fig. 16, A), having narrow bases and swollen apices. In this region they contain many small and a few large yolk-granules which, together with those in the main mass of tissue, were possibly derived from the outer layer of yolk-sac endoderm attached to the chorion and now overlying the outer allantoic membrane, these granules being passed intact from cell to cell. The under surface of the mass of proliferated tissue is bound by the chorionic ectoderm which formed part of the original foetal portion of the omphaloplacenta. The small yolk-sac now passes out from the encircling folds as indicated in Text-fig. 21, A and B, and into the gut of the embryo, where it is absorbed. The vitelline artery and vein with their branches are naturally withdrawn and absorbed with the sac. The yolk-sac stalk is torn away from the allantoic stalk and its position is marked by a thick proliferation of mesenchyme (Text-fig. 21, C).

The allantoic stalk contains a main artery and vein on either side as in earlier stages but the vessels are smaller. With the withdrawal of the yolk-sac and its stalk the allantoic stalk now appears to divide longitudinally a short distance from the body of the embryo, the upper stalk passing upwards and carrying an umbilical artery and vein which pass across the allantoic cavity as described at Stage B, the lower stalk passing downwards and carrying the remaining umbilical artery and vein directly to the allantoic membrane. In some embryos obtained from the Blue Mountains on 20th January, 1927, the yolk-sac was just entering the body and the ventral wall of the embryo was distended round the sac. After the removal of the sac the allantoic folds which surrounded it meet and join, a further proliferation of tissue occurring at the junction (Text-fig. 21, D), which is an extension of the original "growth" of tissue formed beneath the yolk-sac, and described above. There is a cavity at its centre containing corpuscles, debris and loose cells which were torn away from the yolk-sac when removed from the vicinity of the membranes and most of which are

Text-fig. 21. A, diagrammatic representation of the yolk-sac of an eleven weeks embryo encircled by the allantois. B, diagrammatic representation of the allantoic membranes immediately after the withdrawal of the sac. C, section of allantoic stalk showing the proliferated tissue in the former position of the yolk-sac stalk; $\times 30$. D, section of the mass of proliferated allantoic tissue filling the former position of the yolk-sac; $\times 30$. ALL. END., allantoic endoderm; ALL. ST., allantoic stalk; CAV., cavity; CH. ECT., chorion ectoderm; C. DEB., cell debris; GR. ALL. T., growth of allantoic tissue; L. UMB. VES., left umbilical vessels; MUS. T., muscular tissue; POS. Y.S. ST., position of yolk-sac stalk; SQ. T., squamous tissue; UMB. A., umbilical artery; UMB. V., umbilical vein; Y.S., yolk-sac.

now degenerating. The tissue is composed of a thick, inner muscular coat formed from the allantoic mesoderm, and a thick coat of uniform squamose cells formed from the allantoic endoderm, the outer layer of which consists of enlarged cells containing yolk granules. The amnion may be joined to the inner allantoic membrane and when so joined shares the fate of the allantois at the birth of the foetus. It is not known what becomes of the allantois at birth, since the young were born from the females in captivity while unobserved, but there were no membranes left in the uteri of these females, which were opened immediately upon the discovery of the birth of the young, which was approximately twenty-four hours later. It is possible that the young are born with these membranes attached as described for *T. scincoides* (Harrison, 1926), the embryos of which dispose of their membranes by biting the allantoic stalk and eating them. At birth the young lizards are quite able to fend for themselves, those born escaping out of the box and through several rooms into the open where they were found the day after birth.

The Omphaloplacenta.—As the yolk-sac is reduced in size the area of omphaloplacenta is naturally correspondingly reduced until, finally, when the yolk-sac is withdrawn from its position underlying the uterus and the allantoic membranes have extended under the sac, there is no longer an area of omphaloplacenta, since one of its main requisites, the foetal blood supply in the yolk-sac, is being removed with the sac, and its chorionic ectoderm is now part of the newly extended chorio-allantoic membrane. Allantoplacental modifications of maternal and foetal tissues extend under the yolk-sac in the place of the former omphaloplacental modifications, so that the maternal and foetal tissues in this region are twice modified for placentation. However the position of the omphaloplacenta is marked until the time of birth by the remains of enlarged chorionic ectoderm cells which line the mass of proliferated tissue at the junction of the allantoic membranes beneath the yolk-sac (Text-fig. 21, D).

The Allantoplacenta.—As the allantois grows under the yolk-sac the outer allantoic membrane unites with the layers of somatic mesoderm and chorionic ectoderm so that a peculiar arrangement results, where instead of the normal chorio-allantoic membrane forming the foetal portion of the allantoplacenta, a membrane is established which contains in addition a layer of yolk-sac endoderm between the chorionic ectoderm and the outer allantoic membrane (Text-fig. 20, D). The condition of the foetal tissues of the allantoplacenta is further complicated by the previous modification of the chorionic ectoderm for its functioning as part of the omphaloplacenta. However it is remodified for allantoplacenta by its degeneration over the surface of the placental face, with the exception of the area underlying the mass of tissue formed at the junction of the allantoic membranes. Here the chorionic ectoderm is composed of many cell layers, the cells resembling those of the omphaloplacental region described at Stage B, being enlarged and irregularly shaped, with the lower layers squamose. The "finger-like" downgrowths of cells are present among the folds of the shell membrane and are sometimes disconnected from the rest of the chorionic ectoderm and lie loose among the folds. Over the rest of the newly extended allantoplacental area with its well vascularized outer allantoic membrane, the chorionic ectoderm partly degenerates (Text-fig. 22, B), and is only represented by the isolated enlarged cells which serve to attach the foetal tissue to the uterus and which are characteristic of the main allantoplacental area. The layer of yolk-sac endoderm beneath the chorionic ectoderm also degenerates, the contained yolk granules being

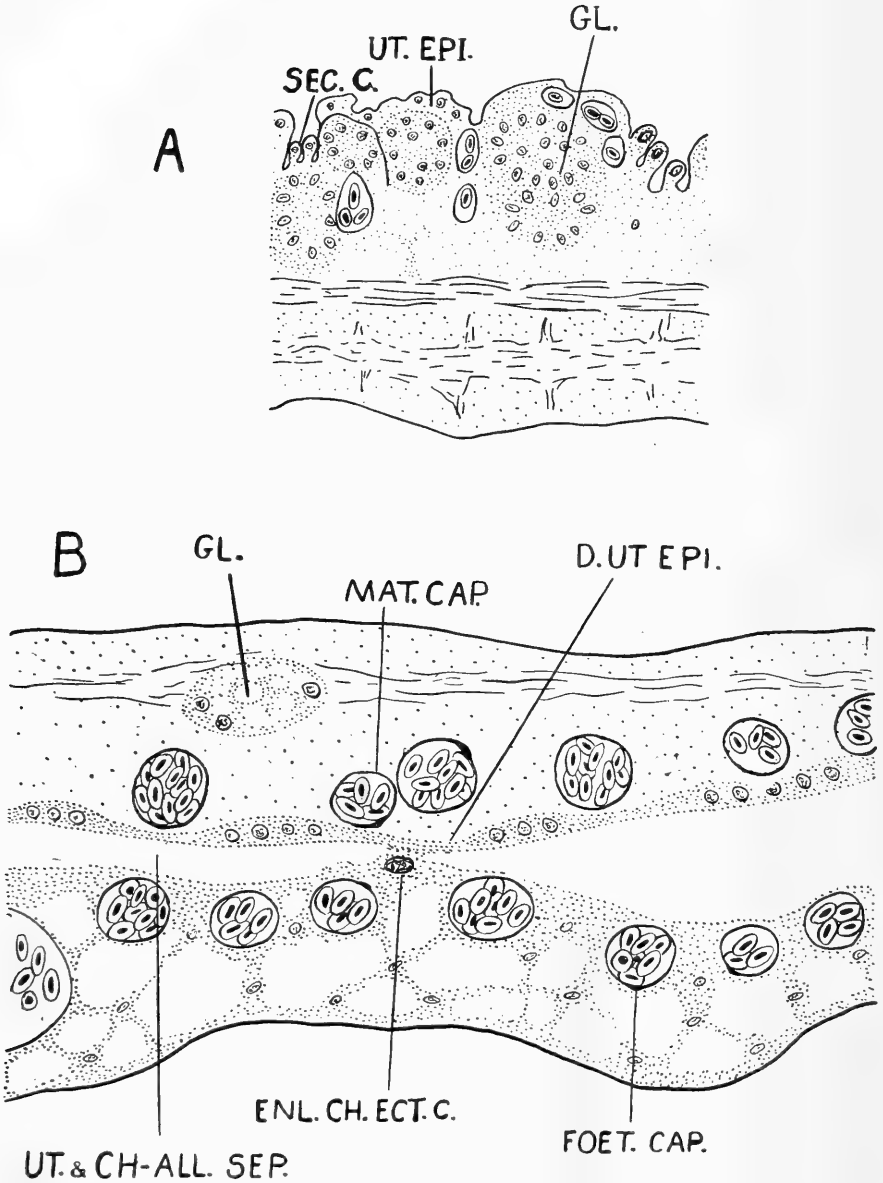
absorbed by the underlying allantoic tissue. The degeneration of the chorionic ectoderm and yolk-sac endoderm is probably directly due to the presence of the underlying allantoic capillaries, since, in the region of the junction of the allantoic membranes where the thick pad of tissue underlies the chorionic ectoderm and yolk-sac endoderm instead of numerous allantoic capillaries, the chorionic ectoderm and yolk-sac endoderm remain practically intact.

The changes which occur in the allantoic membrane in this region correspond to those which occur in the main allantoplacental region, the capillaries invading the overlying degenerating foetal tissue. The numerous capillaries are typically round, packed with corpuscles and have thin walls, and before the degeneration of the chorionic ectoderm and yolk-sac endoderm lie embedded in a thick coat of mesenchyme (Text-fig. 20, D), but after the degeneration of these tissues they may take up the whole width of the allantois. The pad of shell membrane is in the same position and in much the same condition as in earlier stages, having the same coagulum among its folds. The fate of the shell membrane at the birth of the foetus is not known, it being either absorbed before birth by the foetal tissues, removed with the foetus at birth or left behind in the uterus and subsequently absorbed. It is unlikely that the foetal tissues can absorb such a quantity of membrane in the few remaining days before birth, since it remained practically intact at the base of the yolk-sac for two months.

The extension of the allantois and the modification of the foetal tissue is accompanied by a change in the structure of the overlying uterine wall, the maternal tissue being modified for some distance beyond its proximity to the allantois, as at Stage A. The uterus passes from a condition of modification for omphaloplacentation, where it is thick, with small capillaries overlying a layer of fairly deep columnar epithelium, to a condition of modification for allantoplacentation, where the epithelium degenerates and the capillaries enlarge and pass to the surface of the uterus (Text-fig. 22, B). Over some areas the epithelium may remain intact but in a reduced condition as a layer of small cells, however, there are large areas where the degeneration is as marked as in the main allantoplacental region.

Where the uterus was previously slightly folded in the omphaloplacental region, an interesting condition results when the tissues are remodified for allantoplacentation (Text-fig. 22, A). Each fold is mainly filled by vacuolated glandular tissue, containing many small round nuclei. Between the folds there may be large oval capillaries while numerous smaller, typically rounded capillaries lie at the surface of the folds either exposed or covered by a thin layer of epithelium. In the crevices between the folds where the maternal capillaries are comparatively widely separated from the foetal capillaries the epithelial cells do not degenerate but become enlarged and glandular, with narrow bases and swollen apices (Text-fig. 22, A), and function for food secretion. Early in this investigation only advanced stages in the development of the placenta were available and upon the discovery of such an area of placentation it was at first thought to represent the type of allantoplacentation for *L. quoyi*. However the study of earlier stages has clearly shown that this area was originally modified for omphaloplacentation and its present folded structure is a result of such modification.

The females kept in cavity until the 12th February contained embryos which are taken to be at a stage immediately prior to birth, where the yolk-sac is completely withdrawn into the body of the embryo and the allantoic membranes from both sides of the yolk-sac have met and fused. In the main allantoplacental



Text-fig. 22. A, section of the folded uterine wall remodified for allanto-placentation; $\times 460$. B, section of the allanto-placental region in the former position of the omphaloplacental region; $\times 613$. D. UT. EPI., degenerating uterine epithelium; ENL. CH. ECT. C., enlarged chorionic ectoderm cell; FOET. CAP., foetal capillary; GL., gland; MAT. CAP., maternal capillary; SEC. C., secretory cells; UT. EPI., uterine epithelium; UT. & CH. ALL. SEP., uterus and chorio-allantoic membrane separated.

region of these embryos the maternal and foetal tissues are much thinner, the muscle layers and glands of the uterus being markedly flattened. The maternal and foetal capillaries are not as numerous nor as full of corpuscles as in earlier stages and the foetal tissue is easily separated from the maternal wall when dissecting or sectioning the material.

It is thought that the structure of the uterus changes in anticipation of allantoplcantation and not as a result of stimulus from the immediate proximity of the allantois, since it will be recalled that in embryos examined one week after fertilization, the uterus shows early indications of placental modification when the allantois is merely a small swelling at the posterior end of the embryo; also the uterus overlying the edge of the yolk-sac is modified for placentation before the extension of the allantois to its vicinity; in addition, in some embryos eleven weeks old the allantois underlying the yolk-sac is covered by a thick coat of chorionic ectoderm cells and the conditions resemble those of omphaloplacentation, the uterine wall being in contact with and having its materials absorbed by the specialized chorionic ectoderm, yet here the uterus does not retain its omphaloplacental modifications, but is well modified for allantoplcantation; also the uterus is modified for allantoplcantation even when separated from the allantois by a thick pad of shell membrane. However it may be regarded as peculiar that the modification progresses roughly parallel with the extension of the allantois and does not occur simultaneously over the uterus, and this may be taken as indicating a direct relationship between the two processes, but it is most probably a result of the uterus retaining its omphaloplacental modifications and only replacing them by allantoplcantation modifications as the foetal omphaloplacentation yields to allantoplcantation.

The modification of the foetal and maternal tissues for allantoplcantation as late as the last two weeks of the gestation period shows that the allantoplacenta is essential until the birth of the foetus.

4. *Period after birth.*

Females were available in a condition ranging from one day to one week after the birth of the young. In these females the uteri were thick, much convoluted and distinctly restricted into incubatory chambers. The wall of the uterus extracted from one of the females one day after the birth of the young measures about 0.4 mm. in its thickest part, the muscle layers being thicker than in the normal non-pregnant condition and the glands having partly regained their normal shape and structure. The cytoplasm of the gland cells encloses small yolk granules derived from the debris in the cavity of the uterus, and the granules are also present in the epithelial cytoplasm. The inner surface of the uterus is thrown into deep folds which are covered by a thin layer of regenerating epithelium. However the capillaries are still concentrated at the surface of the mucosa and in places are almost exposed and have the typical rounded appearance of the capillaries in the allantoplacental region. The epithelial cells are largest in the crevices between the folds, being narrow and columnar with an oval nucleus at the base. The uterine cavity contains a dark staining coagulum mixed with yolk spheres and cell debris which fills the crevices between the folds and is being rapidly absorbed by the uterus.

At the end of the first week after the birth of the young the uterus is more normal in structure, but is still obviously influenced by the preceding gestation period. Its wall is thinner but the glands have not completely regained their

normal structure, the nuclei being still grouped closely together. The mucosa contains many more small capillaries than in the normal condition, but the epithelial cells, although as yet comparatively small, are uniformly arranged over the surface of the uterus, the majority being definite and columnar. Most of the coagulum in the cavity has been absorbed and there are fewer yolk spheres in the mucosa.

IV. COMPARISON WITH THE LIZARDS *Chalcides tridactylus*, *Lygosoma (Liolepisma) entrecasteauxi* AND *Tiliqua scincoides* AND WITH THE MARSUPIAL *Perameles*.

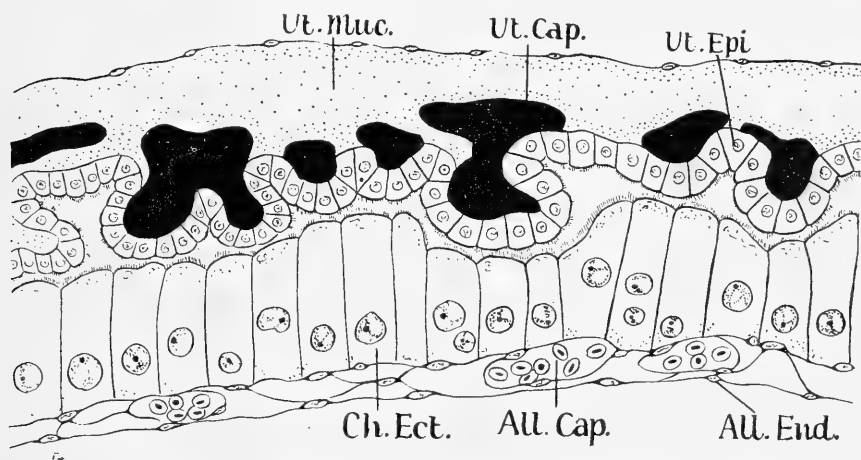
(a). Comparison with *C. tridactylus* and *L. entrecasteauxi*.

The structure of the allantoplacenta in *L. entrecasteauxi* is so remarkably similar to that in *C. tridactylus* that it is unnecessary to compare and contrast the placenta in each with that in *L. quoyi*. *L. entrecasteauxi* has been chosen in preference to *C. tridactylus* for a detailed comparison with *L. quoyi*, since the author has described the placentation of that lizard in conjunction with Professor Harrison (Harrison and Weekes, 1925), and since material is available for examination in the sectioned and unsectioned condition.

The discovery of allantoplacentation in *L. entrecasteauxi* and in *L. quoyi*, two species of the one genus *Lygosoma*, is more important than might be at first supposed, since their methods of allantoplacentation differ more than might be expected after a study of the placenta in related species of mammals. The two lizards were collected from Barrington Tops and Mount Kosciusko, although *L. quoyi* was restricted to the marshy regions and *L. entrecasteauxi* to the hills surrounding them. *L. entrecasteauxi* is a much smaller lizard than *L. quoyi*, being about one-third the size of the coastal type of the latter, and its eggs are correspondingly smaller. However, although the yolk-sac is only about one-third the size of that in *L. quoyi* the omphaloplacenta is more highly developed. In the stages available for examination there was no indication of the abnormal growth of the extra-embryonic mesoderm into yolk-sac, but this may be evident in earlier stages. The omphaloplacenta of *L. entrecasteauxi* differs from that in *L. quoyi* in that the cells of the uterine epithelium are much larger and more uniform in structure; the chorionic ectoderm cells are also larger, there being a single row of evenly enlarged cells with large dark nuclei, in the place of the multilayered chorionic ectoderm in *L. quoyi* with its cells varying in length and shape; the area of omphaloplacentation is relatively greater and this is thought to be due to the absence of the thick pad of shell membrane in the embryos of *L. entrecasteauxi* examined and its invariable presence in the omphaloplacental region of *L. quoyi*.

Harrison and Weekes (1925, p. 475) describe the maternal portion of the allantoplacenta as being restricted to "a fusiform to elliptical opaque whitish area" and the extent of the foetal placentation as slightly exceeding that of the maternal placental area. In *L. quoyi*, however, the placental area is not restricted, modifications of maternal and foetal tissue occurring over the entire area embraced by the allantois. In *L. entrecasteauxi* the elliptical placental area is marked by complicated villous folds of the maternal wall which can be seen with the unaided eye, but in *L. quoyi* the placental face is smooth and discernible only in sectioned material. As well as the differences in general appearance, the histological differences between the two allantoplacentae are marked. In the placenta of *L. entrecasteauxi* two elliptical epithelial sheets with every cell clearly bounded are closely apposed but are in no way joined or fused (Text-

fig. 23). The epithelium lining the maternal ridges is composed of enlarged ciliated cells. The villous folds impress their form upon the closely underlying ciliated chorionic ectoderm causing irregularities in its surface and variations in the size of the cells, some growing up into the crypts and being extremely elongated, in all cases being twice as long as they are wide. The maternal folds are fed by large capillaries while the foetal vascular network lies close at the base of the chorionic cells and is bound internally by a sheet of mesenchymatous connective tissue of varying thickness. In *L. quoyi* the maternal wall is not covered by enlarged ciliated epithelial cells, there being at the most a thin bounding layer of epithelial protoplasm with occasional nuclei embedded; there is a network of small rounded maternal capillaries instead of the few large capillaries in the villous folds of *L. entrecasteauxi*, and these are exposed at the surface of the uterus and do not lie beneath a thick epithelial layer; the foetal tissue is attached to the maternal wall, the attachment being efficient although superficial; the cells of the chorionic ectoderm do not become enlarged but degenerate, allowing the allantoic capillaries to bulge at the surface, so that the maternal and foetal blood streams are in close apposition.



Text-fig. 23. Section of the elliptical allanto-placental area in *L. entrecasteauxi*. All. Cap., allantoic capillary; All. End., allantoic endoderm; Ch. Ect., chorionic ectoderm; Ut. Cap., uterine capillary; Ut. Epi., uterine epithelium; Ut. Muc., uterine mucosa.

Hence it can be seen that the allanto-placenta in *L. quoyi* is fundamentally different from the elliptical and restricted allanto-placental region in *L. entrecasteauxi*, since food transition in *L. quoyi* is carried on by the apposed maternal and foetal bloodstreams and not by the glandular activity of the uterine epithelium and the phagocytic and absorbing powers of the chorionic ectoderm as in *L. entrecasteauxi*.

The omphaloplacenta in *C. tridactylus* (Giacomini, 1891, p. 348) "se forme tardivement et reste rudimentaire" consisting of enlarged chorionic ectoderm cells in the region of the yolk-sac. No mention is made of any modification of the uterine tissues in this region. It is possible that the development of the omphaloplacenta

may be restricted by the small size of the eggs (2.5 to 3 mm.) in such a comparatively large lizard. The growth of the extra-embryonic mesoderm into the yolk-sac in *L. quoyi* has no parallel in *C. tridactylus* since Giacomini says, 1891, p. 343, "tant que les oeufs ne sont pas arrivés à un certain degré de développement, la connexion immédiate entre l'ectoblaste et l'entoblaste vitellin persiste telle qu'elle a été décrite. Le feuillet moyen s'arrête aux limites de la connexion, de sorte que, pendant quelque temps, la paroi vitelline, sur ce point, est privée de sa structure caractéristique, et ne se trouve pas vascularisée. Dans des états avancés de développement, le mésoderme envahit aussi la région en question, laquelle, alors, est également vascularisée". This is the only reference Giacomini makes to the growth of the extra-embryonic mesoderm over the yolk-sac and it is taken to mean that the sinus terminalis remains quiescent for some time at the outer limits of the area of junction of the chorionic ectoderm with the yolk-sac endoderm, finally continuing its growth round the sac in the normal way between the ectoderm and endoderm.

An interesting and important phenomenon has been observed in the placentation of *L. entrecasteauxi* since the publication of the papers by Harrison and Weekes, 1925, and Weekes, 1927. The area of apposed maternal and foetal tissue in *L. entrecasteauxi* other than the omphaloplacental and the elliptical allantoplacental areas was regarded as unimportant and non-placental in the investigation in 1925, the maternal and foetal tissues being so thin and flattened here that it was difficult to make a histological study of them. However in one of the series of sections a relatively thick area was recently observed, attention being first arrested by the very close attachment of the foetal to the maternal tissues in this region which persisted even when the tissues in the elliptical allantoplacental area were fairly widely separated. Upon a closer examination it was found that the structure of this region corresponds closely to that of the allantoplacenta in *L. quoyi*. The maternal and foetal epithelial cells have degenerated, the epithelial nuclei in the maternal wall are grouped between the capillaries and have the same typical rounded appearance as in *L. quoyi*, and the foetal tissue is attached to the maternal tissue by scattered enlarged chorionic ectoderm cells. The only obvious differences between the structure of this region and that of the allantoplacenta in *L. quoyi* are the smaller number of maternal and foetal capillaries, their ellipsoid cross section and the presence of a thick coat of mesenchyme underlying the foetal capillaries. It is thought that in younger stages in the development of *L. entrecasteauxi* this specialized region may be more extensive.

It will be recalled that at Stage B a condition of allantoplacentation is described for one of the embryos of *L. quoyi* examined, where the uterine wall and chorio-allantoic membrane are thrown into rudimentary folds and where the epithelium of the maternal folds has not degenerated, and where, in addition, the chorionic ectoderm cells have not degenerated to the same extent as in the allantoplacenta of other embryos, a few of them being larger than in any of the other allantoplacentae examined. When this folded area is compared with the elliptical placental area of *L. entrecasteauxi* the resemblances are noticeable. The position of the folds in the region of the main longitudinal artery and vein resembles the position of the folds in *L. entrecasteauxi*; the maternal epithelial tissue obviously plays the important part in food secretion since the capillaries are not present at the surface of the uterus, and since the epithelial cells are enlarged and obviously modified for secretion; the chorionic ectoderm cells are comparatively large and contain enormous nuclei, the shape of the cells being to

some extent modified by the shape of the overlying uterine wall; and finally, the foetal capillaries lie at the bases of the chorionic ectoderm cells.

There are, however, many differences. The area in *L. quoyi*, although in a much larger lizard, is only half the width of that in *L. entrecasteauxi* and the folds are only rudimentary when compared with the well formed complicated folds in that lizard; the uterine epithelial cells vary in shape and size and are not ciliated nor uniformly enlarged nor arranged; the chorionic ectoderm cells are neither ciliated nor granular and are not definite in shape, cell boundaries being recognizable only at the free margins and in addition in some places they are degenerating and the allantoic capillaries passing to the surface; there is no deep layer of mesenchymatous tissue underlying the chorion and the allantoic capillaries.

The significance of the occurrence of the second type of allanto-placentation in *L. entrecasteauxi* and of the folded area in one of the embryos of *L. quoyi* examined will be discussed below.

(b). Comparison with *Tiliqua scincoides*.

T. scincoides is a much larger lizard than either *L. entrecasteauxi* or *L. quoyi* and is slightly larger than *C. tridactylus*. The habitat of this lizard resembles that of *L. quoyi* in that it varies from sea level to an altitude of 3,000 feet. The pregnant females contain a greater number of young than those of *L. quoyi*, the two described by Flynn (1923) containing eleven and fifteen. The general disposition of the blastocyst is the same as in *L. quoyi*.

According to Flynn the yolk-sac circulation of *T. scincoides* extends over the outer surface of the sac with the exception of a small area at the lower pole. In *L. quoyi* the circulation completely surrounds the sac. Flynn notes (1923, p. 75) that "a sinus terminalis could not be definitely made out". This was since discovered (Weekes, 1927) to be due to the downgrowth of the extra-embryonic mesoderm into the yolk-sac as in *L. quoyi*. The omphaloplacenta in *T. scincoides* (Weekes, 1927) is much more highly specialized than that of *L. quoyi*, the uterine wall being thrown into definite villous folds which are visible to the unaided eye, and the cells of the epithelium are much larger and more regular than those of the maternal epithelium in *L. quoyi*. It is possible that the rudimentary folding of the uterine wall in *L. quoyi* is the forerunner of such a specialized condition. The most outstanding differences between the omphaloplacentae are the regular folding of the foetal tissue in *T. scincoides* to fit into the maternal crypts and the regular modification of the chorionic ectoderm cells.

The omphaloplacenta in both lizards is of the same type, the food transition being carried on by apposed maternal and foetal epithelial faces, and the foetal tissues vascularized by vessels embedded in the yolk-sac and separated from it by the extra-embryonic coelome.

The general relationship between the allantois and the embryo is the same in both lizards with one exception. In *Tiliqua* (Flynn, 1923, p. 77) the allantoic stalk passes downwards and outwards while in *L. quoyi* it passes upwards and outwards. The method of transference of blood vessels across the allantoic cavity in the two lizards has been compared at Stage B. In both lizards the inner allantoic membrane fuses with the amnion, but as Flynn does not mention any connection between the chorio-allantoic and the inner allantoic membranes. It seems that as far as those lizards for which placentation has been described are concerned, this arrangement is peculiar to *L. quoyi*. The area of allanto-placenta-

tion in *T. scincoides* is smaller than that in *L. quoyi* since its extension is restricted by the central portion of the allantois alone becoming attached to the chorion, the marginal zone being free and unattached. Flynn gives no figures illustrating the histological relations in the allantoplacenta of *Tiliqua* and it is therefore difficult to compare the placenta with that in *L. quoyi*. He says (1923, p. 76) that "the union between chorion and uterine epithelium is very intimate. The uterine epithelium apparently consists of a single layer of very flattened cells, while the chorionic ectoderm has proliferated greatly, is much vacuolated, resembling a typical plasmodium and is formed in the main of markedly enlarged cells with large nuclei and connected together by amoeboid processes. These processes insinuate themselves into and between the maternal cells in much the same way as Hill has described for the chorionic cells in the formation of the metrioplacenta of *Dasyurus viverrinus*". No special mention is made of the maternal circulation and in describing the foetal circulation Flynn says (1923, p. 77) that the allantoic vessels "ramify through the mesenchymal layer of the placental face", but makes no mention of any unusual position of the allantoic capillaries. It is evident from these observations and the above description of the placental area that there is not the same degeneration of epithelial surfaces and apposition of capillaries as in *L. quoyi*. The "very flattened cells" of the uterine epithelium may present a stage intermediate between the condition of enlarged cells in *C. tridactylus* and *L. entrecasteauxi* and of degenerated epithelium in *L. quoyi*. Hence it is deduced that the maternal and foetal epithelial tissues in *Tiliqua*, although not enlarged to the same extent as in *C. tridactylus* or *L. entrecasteauxi*, carry on the function of food transition and therefore the type of placentation differs essentially from that in *L. quoyi*. However, the two types have in common the attachment of the foetal tissues to the maternal wall, both being of the conjoint type, and the establishment of this attachment by enlarged chorionic ectoderm cells which do not invade the maternal tissue to any extent, the attachment in each being superficial.

(c). Comparison with *Perameles*.

Perameles is the only marsupial for which allantoplacentation has been recorded. The placentation of *Perameles* was described by Hill (1897), redescribed by Flynn (1923), and these authors hold different opinions as to the nature of the placenta. Hill claims (1897, p. 387) that the uterine mucosa undergoes hypertrophy; that the vessels in the mucosa increase in size and number; that the uterine epithelium changes into a vascular syncytium, the nuclei becoming grouped together in nests situated in lobular projections of the deeper surface of the syncytium; and that the maternal capillaries pass up between the syncytial lobules and form a network beneath the epithelial protoplasm. He claims further that the embryo becomes attached to the prepared maternal wall by means of enlarged chorionic ectoderm cells, which eventually degenerate over the placental area proper; that the allantoic capillaries now directly reach the vascular surface of the maternal placental syncytium to which they become intimately attached, dipping down into the depressions on its surface and forming a regular interlocking system, and that finally the foetal and maternal blood streams are now only separated by their thin endothelial walls and perhaps a layer of syncytial protoplasm.

Flynn claims that the chorionic ectoderm does not completely degenerate but actively invades the maternal tissues and thus brings the type of placentation

found in *Perameles* in line with that found among the eutherian mammals, more especially the Carnivora "where there are the same characteristics of passivity of uterine epithelium and activity of the trophoblast".

By the kind permission of Professor Harrison of the Zoology Department, University of Sydney, I have been able to obtain some of the *Perameles* material prepared by Hill and used by him and Flynn. This consists of two slides, one containing sections of the placenta of an embryo 7 mm. in direct length and the other of one 1.5 mm. in length. An examination of this material has convinced me that Flynn's interpretation of the structure of the placenta is the correct one. The most important and convincing evidence is the invasion of the deep maternal syncytial lobules by the large nuclei of the trophoblast, which is so plainly evident that as Flynn himself says it is impossible that there can be any other conception than the one he suggests. Flynn has ably and thoroughly discussed the placenta in *Perameles* (1923), and there is no need for further comment here, but while I agree with his interpretation of the structure of the placenta I do not support his claim that its similarity to that of the placenta in some of the Carnivora is of fundamental phylogenetic importance.

The relationship between the embryo, its yolk-sac and the allantois in *L. quoyi* is somewhat similar to that in *Perameles*, allowance being made for the difference in the relative size of the yolk-sac and the allantois in each, the yolk-sac in *Perameles* occupying the main portion of the blastocyst and the allantois being restricted to the remaining portion. In each the embryo is sunk down into the yolk-sac being partially surrounded by the yolk-sac wall and the yolk-sac is vascularized by one main artery and vein. But the vascularization does not completely cover the sac in *Perameles* as in *L. quoyi*, there being a definite sinus terminalis present, and the method of the growth of the extra-embryonic mesoderm over the sac is normal. The vascularization of the allantois is similar in both, each of the two main arteries being accompanied by one of the veins in its ramifications over the placental face, the arrangement being confined to the main trunks. However there are none of the "cellular bridges" passing across the allantoic cavity in *Perameles* as in *L. quoyi*, possibly on account of the smallness of the allantoic vesicle and the consequent lack of any need for a short cut for the vessels. In both, the allantoic stalk enters the body of the embryo immediately posterior to the yolk-sac stalk, but in *L. quoyi* both stalks are joined by mesenchyme and have the appearance of one.

There is little similarity between the omphaloplacentation of these forms, since in *Perameles* the uterine epithelium degenerates to form a syncytium with the maternal capillaries at the surface, the capillaries being closely apposed to a flat layer of chorionic ectoderm which is separated by blood vessels from a layer of enlarged yolk-sac endoderm cells.

According to Flynn's interpretation of its structure, the allanto-placenta in *Perameles* consists of a fused area of complexly folded maternal and foetal tissue. The maternal wall is thick and modified for the attachment of the foetal tissue by the proliferation of the nuclei of the epithelium and their migration to the deeper parts of the epithelium which has now markedly thickened, the result being the formation of a syncytium in which the deeply situated nuclei assume a particular form and arrangement. Flynn (1923, p. 137) says "the nuclei become aggregated mainly in rounded masses or nests situated in the lobular projections of the syncytial protoplasm. The lower surface of the syncytium has a wavy appearance due to the presence of the lobules . . . at this stage the syncytium

is well vascularized, each capillary being enclosed in its delicate endothelial layer". The maternal capillaries pass up between the lobules and form a network at the surface of the epithelial protoplasm. To this prepared maternal tissue the chorion attaches itself by a single layer of enlarged ectoderm cells. These cells divide (p. 141) "to give rise to nucleated groups in which cell outlines have disappeared. . . . At various points these nuclei invade the uterine syncytium and the remaining basal cells of the trophoblast layer form the cytotblast or cytotrophoblast". Further (p. 167) "the outward migration of the basal cytotblast cells where converted into plasmodiblast gives opportunity for the maternal and foetal vessels to come into intimate apposition . . . all maternal vessels have definite endothelial walls, hypertrophy of the endothelial cells does not occur and lacunae are not formed". In my own observations most of the maternal capillaries were seen to lie immediately above the allantoic capillaries, both sets of capillaries being round.

The following are the main differences between the placentation of *Perameles* and that of *L. quoyi*.

1. The uterus in *Perameles* is much thicker than that in *L. quoyi*, and the uterine epithelium is deeper both before and after it is modified for placentation, and when modified is constricted into lobules containing distinct nests of nuclei, which arise by proliferation.

2. There is no shell membrane and the foetal tissue is attached to the maternal wall before the fusion of the allantois with the chorion.

3. The enlarged chorionic ectoderm cells proliferate and invade the maternal syncytium, firmly fixing the foetal tissue in position and absorbing food by their phagocytic action.

However the points in common are outstanding and fundamental.

1. The uterine epithelium in *L. quoyi*, although a narrow layer degenerates and forms a syncytium containing the rounded, palely staining nuclei which resemble those of the syncytial lobules in *Perameles* in structure and in that they "lack staining qualities" (Flynn, p. 137).

2. The maternal capillaries multiply and invade the degenerating epithelial cytoplasm and pass to the surface of the uterus.

3. The foetal tissue is attached to the maternal wall by enlarged chorionic ectoderm cells which remain throughout the life of the placenta.

4. The maternal and foetal capillaries are closely apposed, being separated only by their thin endothelial walls and perhaps a layer of maternal and foetal cytoplasm. The capillaries have definite endothelial walls, hypertrophy of the cells does not occur and the foetal capillaries lie beneath the maternal.

Some of the differences, however, are due to the natural conditions in *L. quoyi*. The narrowness of the uterine epithelial layer does not lend itself to the formation of a deep syncytium, and the presence of the shell membrane hinders the early fixation of the chorion to the uterine wall. So that, the only important difference between the placentae is, that in *Perameles* the chorionic ectoderm proliferates and invades the maternal syncytium, whereas in *L. quoyi*, with the exception of scattered enlarged cells, it degenerates. Hence can be seen the similarity between the two types of placentation and the reason for the statement in the previous paper on the placentation of *L. quoyi* (Weekes, 1927, p. 29) that the allanto-placenta in *L. quoyi* more closely resembles that of the Mammalia than any hitherto recorded in a reptile.

V. THEORETICAL CONSIDERATIONS.

A discussion of the relationship of the placentation of *L. quoyi* with that of other reptiles, and of its similarity to the placentation of the marsupial, *Perameles*,

must be deferred until an examination of other viviparous forms of reptiles is made. Also the as yet undescribed placentation of *E. whitei* and *E. striolata*, which closely resembles that of *L. quoyi*, must be taken into consideration. However, attention is called to a statement (Weekes, 1927, p. 29) that "in the genus *Lygosoma* two members, namely *L. entrecasteauxi* and *L. quoyi* have each developed distinct types of placentation". This is true for the folded elliptical area of placentation in *L. entrecasteauxi*, but with the discovery of the second area of placentation (described above) the difference between the two types is no longer so marked. It may be that the placentation in these two lizards is related, the common ancestral type being similar to that in *L. quoyi*, the placentation of *L. entrecasteauxi* becoming independently specialized by the development of the restricted elliptical region; or it may be that placentation was independently acquired by each, by *L. entrecasteauxi* before *L. quoyi*, this supposition being supported by the absence of shell membrane in *L. entrecasteauxi* and by its presence and the rudimentary condition of the omphaloplacenta in *L. quoyi*. The folded area in one of the embryos of *L. quoyi* examined might be regarded as representing a developing area in *L. quoyi* such as occurs in *L. entrecasteauxi*, but it is probably only a freak in placental development, since it occurs in only one of the many embryos examined.

VI. Summary and Conclusions.

The placentation of the Scincid lizard *Lygosoma (Hinulia) quoyi* is described in detail in the present communication and compared and contrasted with that in the Scincid lizards *Chalcides tridactylus*, *Lygosoma (Liolepisma) entrecasteauxi* and *Tiliqua scincoides* and with that in the marsupial *Perameles*. The following is a summary of the work and of the main conclusions drawn.

1. The lizard is not strictly viviparous, there being a shell membrane present which accumulates at the base of the yolk-sac as a thick pad in advanced stages of development.
2. An omphaloplacenta is present which even in its mature condition is less specialized than that in *L. entrecasteauxi*, *T. scincoides*, *E. whitei* and *E. striolata*.
3. An allantoplacenta of the conjoint type is present consisting of degenerated maternal and foetal epithelial tissue and apposed maternal and foetal blood streams.
4. A modification of the structure of the allantoplacenta occurs in some embryos by the junction of the inner allantoic membrane and the amnion with the placental area.
5. The right umbilical artery and vein pass to the allantoplacental region across the allantoic cavity and the method of the establishment of its passage is described.
6. The placentation of *L. quoyi* is described as being different from that in *L. entrecasteauxi* and *C. tridactylus*, where the function of food transition is mainly carried on by the modified maternal and foetal epithelial tissues.
7. The occurrence of a second area of allantoplacentation in *L. entrecasteauxi* is recorded, the structure of which resembles that of the allantoplacentation in *L. quoyi*. No deductions are made at this stage, a further study of possible placentae among the other viviparous members of the genus *Lygosoma* being necessary.
8. After an examination of some of the *Perameles* material used by both Hill and Flynn, Flynn's interpretation of the structure of the allantoplacenta in *Perameles* is supported in this communication.
9. The type of allantoplacentation in *L. quoyi* is found to be essentially similar to that in the marsupial *Perameles*, with differences in detail.

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EXPLANATION OF PLATES XXXVIII-XL.

Plate xxxviii.

- Fig. 1. Photomicrograph of section of omphaloplacental region of embryo collected during the second week of the gestation period.
- Fig. 2. Photomicrograph of section of yolk-sac of a young embryo showing the down-growth of mesoderm into the yolk-sac.

Plate xxxix.

- Fig. 3. Photomicrograph of section of yolk-sac of six weeks old embryo showing the dense coagulum with corpuscles and scale-like appearance.
- Fig. 4. Photomicrograph of section of mature allantoplacental region showing apposition of maternal and foetal tissues.
- Fig. 5. Photomicrograph of section of folded allantoplacental region present in one of the embryos examined.

Plate xl.

- Fig. 6. Photomicrograph of section of yolk-sac of eleven weeks old embryo showing the enlarged endoderm cells, growth of allantoic tissue and shell membrane.
- Fig. 7. Photomicrograph of section of allantoplacental region showing the junction of inner allantoic membrane with the chorio-allantoic membrane.

LEGENDS TO PLATES XXXVIII-XL.

A.C., allantoic cavity; AMN., amnion; B.V., blood vessels; C., coagulum; C.E., chorionic ectoderm; E. CYT., endodermal cytoplasm; E.C.E.C., enlarged chorionic ectoderm cell; E.E.C., extra-embryonic coelome; E.N. E.C., enlarged endoderm cell; F.C., foetal capillary; F.F.T., folded foetal tissue; F.G.R., finger-like growth; GR. T., growth of tissue; I.A.M., inner allantoic membrane; M.C., maternal capillary; P.S.C., peculiar shaped cells; SP. M., splanchnic mesoderm; SC. M., scale-like material; SO. M., somatic mesoderm; S.M., shell membrane; U.E., uterine epithelium; UT., uterus; Y.S., yolk-sac; Y.S.E., yolk-sac endoderm.

NOTES ON AUSTRALIAN MARINE ALGAE. v.

By A. H. S. LUCAS, M.A., B.Sc.

(Plates xli-xlvi.)

[Read 30th November, 1927.]

Contents.

1. Algae of Michaelmas Cay.
2. Chlorophyceae from Bowen.
3. Two forms of *Codium*.
4. Notes on *Caulerpa*. Edible Chlorophyceae.
5. Fucoideae. Distribution Notes.
6. Two new species of *Chondria*.

1. *Algae collected at Michaelmas Cay, 27 miles off Cairns, Qld., by T. Iredale and G. P. Whitley in June, 1926.*

Under the auspices of the Great Barrier Reef Committee a bore was put down in Michaelmas Cay, a narrow sandbank lying 27 miles off Cairns. The Cay is about 300 yards long and runs from N.E. to S.W. and is quite low. Rough accommodation was provided on the Cay for the workmen and naturalists. Messrs. Iredale and Whitley spent a month there engaged in the study of the fauna of the reefs and in collecting zoological specimens for the Australian Museum, Sydney. At my request they kindly undertook to gather the algae as well.

The prevalent winds blow from the S.E. On that side corals flourish, but algae cannot obtain a foothold on the living coral. On the N.W. are dead corals in abundance, and the weeds grow freely on the blocks, from sea level to a depth of some two fathoms at least.

A first and larger collection was unfortunately swept away by an unusually high and unexpected tide, and lost. A second collection included the following species:

CHLOROPHYCEAE.

- Boodlea coacta* (Dickie) Murray. New for Australia.
Dictyosphaeria favulosa (Mert.) Decaisne.
Valonia Forbesii Harv. New for Australia.
Halimeda opuntia (Linn.) Lamour.
Halimeda tuna (Ellis and Soland). Lamour.
Caulerpa clavifera (Turn.) J. Ag.

PHAEOPHYCEAE.

- Hydroclathrus cancellatus* Bory.

RHODOPHYCEAE.

- Gracilaria taenioides* J. Ag.
Hypnea seticulosa J. Ag.
Laurencia obtusa (Huds.) Lamour.
Laurencia rigida J. Ag.
Digenea simplex (Wulf.) J. Ag.
Acanthophora orientalis J. Ag.
Leveillea jungermannioides (Mart. and Hering) Harv.
Ceramium clavulatum (Mont.) J. Ag.
Jania rubens Lamour.

2. *Chlorophyceae* from Bowen, Port Denison.

Mr. E. H. Rainford, of Bowen, has favoured me with numerous valuable consignments of algae from that locality. He has very generously put himself to the labour of freely, carefully and judiciously collecting the seaweeds growing on the reefs of Stone Island and the shores generally of Port Denison. He has already sent some 50 species.

Sonder in his *Algen des tropischen Australiens*, 1871, recorded and described a number of forms sent to him from Port Denison by Fitzalan and Kilner. Some of these have been gathered by Mr. Rainford, and also some others not noted by Sonder. The Chlorophyceae are particularly interesting.

Boodlea coacta (Dickie) Murray was found in Australian waters for the first time around the Michaelmas Cay, as recorded above. It is evidently abundant in Port Denison.

Anadyomene Brownii (Gray) J. Ag. This was described from Port Denison as a new species under the name *A. Muelleri*, by Sonder, but he had been anticipated by Gray. Mr. Rainford sent a number of excellent specimens. The plant also occurs around Celebes.

Dictyosphaeria favulosa (Mert.) Decaisne. A fine suite of specimens. Not recorded by Sonder, but known from the Sandwich and Friendly Islands and from Ravak and north Australia. Another species, *D. sericea* Harv., is found on the south-west and southern coasts of Australia and around Tasmania. Harvey thought it might be a form of *D. favulosa* but gave it a specific name. Agardh regarded it as distinct.

Valonia confervoides Harv. A single specimen, apparently rolled into a ball by the waves, so that at first I thought I was dealing with a globular *Codium*. It has previously been recorded from Stone Island, but not by Sonder.

Caulerpa laetevirens Mont.

C. sedoides (R. Br.) J. Ag. Upright fronds 3 to 4 inches long.

C. tristicha J. Ag. The rammenta regularly tristichous, short and mucronate. Probably the form attributed to *C. cupressoides* by Sonder.

Udotea orientalis A. and E. S. Gepp. Not noted by Sonder, but recorded from Cape Flattery, Dunk Island and Port Denison (A. and E. S. Gepp, Codiaceae of the Siboga Expedition).

U. argentea Zan. Not noted by Sonder, but collected by Banfield at Dunk Island, and also sent to the British Museum from Queensland by Bailey.

One example of each of the Udoteas but in each case a fine specimen with typical frond filaments.

Neomeris dumetosa Lamour. A single frond growing on a fragment of coral, but identical in structure with specimens in the Sydney Herbarium, distributed by Harvey from the Friendly Islands. I do not know of any previous record of this plant from Australia.¹

Avrainvillea erecta (Berkeley) A. and E. S. Gepp. = *A. papuana* Murray and Boodle. A single frond, dark green, stipitate, fan shaped with finely crenulate-lacerate edges. Stipes 10 mm. long, 15 mm. wide near the base; lamina 30 mm. long, 45 mm. wide. The filaments are cylindrical and yellow by transmitted light, with a diameter of 30 to 40 μ and somewhat swollen extremities.

Known to range from Madras and Ceylon to New Guinea, but not previously recorded from Australia. (See Plate xli, fig. 3.)

¹ Since writing the above, I have received further clumps of fronds from Mr. Rainford.

An allied species, *A. clavatiramea*, has been described by A. and E. S. Gepp from plants gathered by J. Bracebridge Wilson in Corio Bay (Port Phillip) and at Port Phillip Heads.

Otherwise, the genus is not represented in Australia.

Halimeda. Mr. Rainford has forwarded four species: *H. tuna* (Ellis and Soland.) Lamour; *H. opuntia* (L.) Lamour; *H. incrassata* (Ellis) Lamour; *H. polydactylis* J. Ag.

Codium. Sonder had no *Codia* from Port Denison but two forms from Rockingham Bay, which he ascribes to *C. tomentosum*, "the smaller scarcely two inches, the larger in contrast over a foot long".

Mr. Rainford also sends me two forms from Bowen; the smaller, a little over two inches long and compressed, appears to agree in characters with *C. lineare* J. Ag., previously recorded from Port Denison and from Moreton Bay; the larger, about six inches long and terete, agrees with *C. tomentosum* (Huds.) Stackh. The utricles of both are obovate-pyriform with very thin apical membrane.

3. Two forms of *Codium*.

Mr. Rainford sent me a series of examples of a *Codium*, which has puzzled me. The first two specimens were saccate and of a very dark green, and I thought that I might be handling specimens of *C. ovale* Zan., described from New Guinea as follows:

"Fronde pumila, substipitata, obovata, intus cava, intense colorata, exsiccatione atrovirente". (De Toni, *Sylloge Algarum*, ii).

Plants sent later by Mr. Rainford were much more varied in form, some resembling the irregular dense-textured and closely adhering plants of *C. adhaerens*, which is common on our southern coasts, and others growing out into ultimately hollow lobes.

Amongst the *Codia* of the Siboga Expedition collections from the East Indian seas, A. and E. S. Gepp give *C. adhaerens*, *C. difforme* and *C. ovale*. De Toni in the *Sylloge* includes *C. difforme* Kuetz. under *C. adhaerens*. Mr. and Mrs. Gepp evidently regard *C. difforme* as a distinct form. We have no copy of Kuetzing's work in Australia, and I have had no opportunity of seeing his description. I had drawn up a description of the Bowen plant, considering it to be distinct from *C. adhaerens*, and I append the description. After reading the Siboga Monograph, however, I suspect that the plant may very well be *C. difforme*, and that it bridges the gap between *C. adhaerens* and *C. ovale*. The former grows between tides and the latter is recorded at 16 m. from North Ubian, Sulu Archipelago, and at 27 m. from Banda. (*Codiaceae of the Siboga Expedition*.)

Frons polymorpha varie lobata vel tuberiformis hinc et illinc byssis ad saxa adfixa; cutis epidermea ex ultimis utriculis parallelis constans firma, fila interiora laxa mucosa, utriculi ultimi cylindranei obtusi rarius subpyriformes, 75-108 μ lati, plerumque 350-380 μ longi; frons matura intus cava; substantia firma, fronde ad atmosphaeram exposita vel in aqua dulci immersa haud faciliter deliquescente; color obscure viridis, in sicco nigrescens. Sporangia non visa.

Habitat.—Bowen, Queensland (E. H. Rainford). (See Plate xli, figs. 1 and 2.)

I take the opportunity of describing here a form of *Codium*, which I gathered in 1909 at Caloundra, South Queensland, but which was not forwarded to me by Mr. Rainford.

CODIUM GLOBOSUM, n. sp. (Plate xli, fig. 4.)

Frons globosa solida, bysso filorum sericeorum adfixa, 10-20 mm. diametro, intus plexu filorum intricato, extus lobis periphericis inflato-cylindraceutis ad superficiem frondis directis, apicibus liberis eminentibus, constans. Fila interiora circ. 30 μ lata, insuper viridia, flexuosa nunc dichotoma. Lobi terminales singulo peripherico strato appositi, circ. 3 mm. longi, 275-350 μ lati, valde obtusi, contentum viridem exhibentes, e filis singulis vel pluribus surgentes. Sporangia non visa. Color laetevirens.

Habitat.—Caloundra, S. Queensland (Lucas).

Fronde globose solid, attached by a bysso of silky threads, 10-20 mm. in diameter, consisting of an inner intricate plexus of fibres, and externally of peripheric inflated-cylindrical utricles directed to the surface, the apices freely projecting. The interior fibres about 30 μ wide, flexuose and now and then dichotomous, green in their upper range. Utricles addressed in a single peripheric stratum, about 3 mm. long and 275-350 μ broad, bluntly obtuse with a green content, arising by one or more branches from the fibres. Sporangia not seen. Colour light green.

Habitat.—Caloundra, S. Queensland (A. H. S. Lucas).

A small form having the general shape and habit of *C. bursa* and *C. mammillosum*, and apparently intermediate in characters between these two species. The main distinction lies in the dimensions of the ultimate green lobules. The diameter in the three species has the width as follows:

C. bursa from Victoria and Tasmania 120-200 μ .

C. globosum from S. Queensland 275-350 μ .

C. mammillosum from Warrnambool 600-770 μ .

The surface texture shows a corresponding difference in the three forms, close in *C. bursa*, more openly papillate in *C. globosum* and much more coarsely mammillate in *C. mammillosum*. The colour of the two latter is a brighter and lighter green than that of *C. bursa*. (See Plate xli, fig. 4.)

4. Notes on *Caulerpa*.

In the Herbarium of the Botanic Gardens, Sydney, were examples of a *Caulerpa*, which appeared to me to be *C. ligulata* Harv., recorded only from South Africa. The specimens had been obtained from the herbarium of R. Helms, and no locality was indicated. Later, however, I came across the plant growing abundantly on mud-covered rocks at Sandringham, Botany Bay; and still later I found many large plants washed up at Balmoral, Middle Harbour, Sydney. They agree well with Harvey's description, attaining a height of over a foot and forming stout clumps with matted surculi spreading over an extensive base of several square inches. The colour is a most vivid green. This is a very remarkable distribution of a *Caulerpa*, a member of a genus in which reproduction by means of spores is quite unknown, and throws an unexpected light on former land connections. (See Plate xlii.)

Mr. R. Baxter sent a large collection of Algae from Lord Howe Island to the Australian Museum, Sydney, which by the courtesy of the Director, Dr. Charles Anderson, I was enabled to examine. Amongst them were fine specimens of *Caulerpa fastigiata* Mont. This makes an addition to the Australian *Caulerpa* flora, which now includes 41 species. We may anticipate that other *Caulerpas* of the Pacific Islands will also be found on our tropical shores and reefs. (See Plate xliii, fig. 1.)

In 1909 the collections of Algae made on an extensive voyage of the Government trawler "Endeavour" were submitted to me. Mr. Charles Hedley accompanied the expedition and to his judgment and care the value of the algal collection was due. When off Kangaroo Island, a *Caulerpa*, represented by four or five specimens, was dredged in some eight fathoms of water. The plant was evidently quite new to Australia, and I proposed to describe it under the name of *C. Hedleyi* from the discoverer. To make sure that it was an altogether unknown form, I sent a specimen to Mrs. E. S. Gepp of the British Museum, who had kindly assisted me on other occasions. Mrs. Gepp forwarded it to Madame Weber van Bosse in Belgium, who was working on *Caulerpa* at the time. The latter then described the plant as new, and I am glad to say adopted the name *C. Hedleyi*.

I append the description, which was published in the *Annales de l'Institut Océanographique* (Prince de Monaco) ii, 1, pp. 1, 2, 1910, as this publication is not generally available in Australia.

CAULERPA HEDLEYI A. Weber van Bosse. (Plate xliii, fig. 2.)

Frondibus constantibus surculo repenti, squamuloso, unde truncus ramosus surgit. Squamuli identidem dichotomi, fere quadripartiti, apicibus bifurcis et mucronatis surculum cingunt ordinibus compluribus, densatis.

Truncis ramis oppositis, patentibus; truncus et rami ramulosi sunt. Ramuli identidem dichotomi sunt, adpressi, 500-600 μ longi, apicibus bifurcis et mucronatis, circum truncum et ramos verticillis irregularibus constantibus densatis positi.

Le *C. Hedleyi* ressemble par sa ramification, savoir—un axe central portant des branches opposées, distiques, très serrées—aux *Caulerpes* de la section des *Araucaroideae* (including the four Australian species, *C. flexilis*, *C. hypnoides*, *C. Muelleri* and *C. abies*), et par la forme des squamules et des ramules, à celles des *Bryoideae*, et dans cette section, dont les ramules entourent l'axe principal et les branches, surtout à la forme *tormentella* du *C. Webbiana* ou au *C. Pickeringii*, algues endogènes du Pacifique. (See Plate xliii, fig. 2.)

Madame van Bosse also alludes to the depth of the water in which *C. Hedleyi* was growing. Most of our *Caulerpas* have been gathered in rock pools and in channels through which the tides scour, but they probably extend into deeper water, and flourish there more luxuriantly. At a depth of 4-6 fathoms in Port Esperance, Tasmania, I dredged abundance of fine plants of *C. trifaria*, much larger than those in the rock pools of Port Phillip Heads, and also dredged *C. Brownii* at similar depth in the D'Entrecasteaux Channel, while Mr. L. Rodway dredged *C. cactoides* at 20 fm. near Actaeon Island.

Edible Green Algae. In a collection forwarded by my friend, Dr. Olive Wood, from Nukualofa, Tonga, were three plants, which she informs me are eaten by the natives, *Caulerpa clavifera*, *Codium tomentosum* and *C. difforme*. Of the first Dr. Wood writes: "No. 1 is a great delicacy, and especially appeals to the palate of women during pregnancy, who frequently leave their homes inland, and live with relatives in a seaside village, so as to be near the source of supply".

Miss Minnie Reed in a paper on "The Economic Seaweeds of Hawaii and their Food Value", published in the *Annual Report of the Hawaii Agricultural Experiment Station*, 1906, states that there are over 70 distinct species of algae used for food by the Hawaiians. Two of these are *Codium adhaerens* and *C. tomentosum*.

5. *Fucoideae. Distribution Notes.*

In Notes on Australian Marine Algae, i (PROC. LINN. SOC. N.S.W., 1913, xxxviii, p. 51) I recorded *Hormosira articulata* (Forsk.) Zan. from Port Stephens, and ventured to predict its occurrence further north. Since that time, 1913, I have received specimens from New Caledonia (C. Dézarnaulds), and now from Bowen, Port Denison (E. H. Rainford). (See Plate xliv.)

In the same paper I suggested that the *Haliseris* of N.E. Queensland was probably not *H. Muelleri* but *H. acrostichoides*. Mr. Rainford has sent me typical plants of *H. acrostichoides* from Bowen. Mr. H. A. Longman sent me specimens from Noosa Hd., and I gathered it at Sandgate, Moreton Bay, so that this seems to be the commonly occurring *Haliseris* of the east coast of Australia.

J. G. Agardh, *Spec. Sargass. Australiae*, gives the range of *Sargassum cristatum* J. Ag. as southern coasts of Australia (F. von Mueller, Watts, Collie). The Mesdames Harrison and Waterhouse gathered most characteristic fruiting specimens on the beach at Geraldton, W.A.

Sargassum verruculosum (Mert.) J. Ag. appears to be very shy of fruiting. Acres of the bottom of many Tasmanian harbours and estuaries are covered with this plant but I never found a specimen in fruit.

It is very noteworthy that the Sargassa met with round the coasts of Tasmania are almost or quite confined to the subgenera *Phyllotricha* and *Arthrophyucus*, while the species of *Eusargassum* abound in the warmer seas of Western and North-eastern Australia.

6. *Two New Species of Chondria.*

Chondria is well represented in Australian seas. De Toni lists 11 species. Certain of these seem to be very close counterparts of European and West Indian species. Thus Harvey distributed Australian forms under the names of *C. dasyphylla*, *C. sedifolia* and *C. tenuissima* (?). By later writers these identifications have not been accepted.

In the present paper I venture to add two new species, one from Bowen closely allied to *C. tenuissima*, and the other from N. S. Wales closely allied to *C. caeruleascens*. The former belongs to the section *Euchondria*, with the punctum vegetationis freely produced at the tip of attenuate segments and the latter to the section *Coelochondria*, with the punctum vegetationis immersed in a pit at the apex of the blunt segments.

CHONDRIA RAINFORDI, n. sp. (Plate xlv, Plate xlvii, fig. 2.)

Frons robusta, plexu fibroso radicata caespitosa, pedalis et ultra, alterne decomposito-pinnata; caulis teres vix compressus, a basi tenui gradatim superne incrassatus, regione media pennam columbae crassitie aequans; rami alterni ad 20 uncias longi, 12-25 mm. distantils quoquoversum egredientes, ambitu lanceolati vel fere lineares; rami ramulique (pinnae) utrinque conspicue attenuati; pinnae superne bi- vel tripinnata copiosas pinnellas fere ad instar scoparum gerentes; pinnellae lineares utriusque attenuatae, 4-7 mm. longae, longitudine 10-20 es latitudinem excellente.

Substantia mollissima mucosa unde frons ad chartam tenacissime adhaeret. Color purpurascens.

Cystocarpia subsessilia fructus Punicae-granati facies referentia, in parvis inferioribus ramis modo involutis sedentia, sporas magnas pyriformes 150 μ longas foventia.

Stichidia, ramulos ultimos pinnellae constituentia, sterilibus ramellis omnino similia, vix torulosa nec tumida, sporangia supra mediam partem sparsa triangule divisa gerentia.

Antheridia nondum visa.

Habitat.—Bowen, Queensland.

Frond robust, caespitose, attached by a plexus of fibres, a foot or more high, alternately decomposit-pinnate; stem round, scarcely compressed, from a slender base gradually thickened upwards, in the median region equalling a pigeon's plume in thickness; branches alternate, to 20 inches long, emerging in all directions at intervals of 12-25 mm., lanceolate or almost linear in outline; branches and branchlets (pinnae) conspicuously attenuated at both extremities; pinnae bearing in their distal part copious bi-tripinnate almost brush-like pinnellae; pinnellae linear attenuate at both extremities 4-7 mm. long, the length exceeding ten times the breadth.

Substance very soft mucous so that the frond adheres most closely to the paper.

Colour purpurascens.

Cystocarps subsessile like tiny pomegranates seated on small lower not greatly developed branches, forming large pyriform spores 150 μ long.

Stichidia consisting in the ultimate divisions of a pinnella, altogether resembling the sterile divisions, scarcely swollen or torulose, bearing triangularly divided sporangia dispersed above the middle of the stichidium.

Antheridia not seen.

Habitat.—Bowen, Queensland.

I dedicate this elegant *Chondria* to Mr. E. H. Rainford, of Bowen, who gathered a fine sequence of specimens and mounted them while fresh. I am greatly indebted to Mr. Rainford for excellent collections of algae from Port Denison.

This is probably the plant recorded from Port Denison by Sonder under the name *C. tenuissima* J. Ag. He states that the plants were 1-1½ feet high (*Die Algen des tropischen Australiens*, p. 51).

By way of comparison I give photographs of *C. fusifolia* H. and H., which I gathered in the Tamar and in the Derwent. The plants are crowded with tetrasporangia, but I have not found any bearing cystocarps. (Plate xlvi, Plate xlvi, fig. 1.)

CHONDRIA IRIDESCENS, n. sp. (Plate xlviii.)

Frons teres, plexu fibroso radicata, pyramidatim decomposito-pinnata, ad 25 cm. alta; rami copiosi, distantibus 5-10 mm. orti, quoquoversum vagi, ad 15 cm. longi, pyramidatim evoluti, apices versus acuminati; ramuli creberrimi, alterni, quoquoversum crescentes, distantibus 3-4 mm. egredientes, plures aequaliter ad 12 mm. longi, ramellos pinnatim gerentes; ramelli cylindranei, ad 2 mm. longi, fovea apicali obtusi. Rachides flexuosae. Substantia gelatinoso-carnea ergo plantu chartae tenacius adhaeret. Color obscure purpureus, in vivo pulchre coeruleo-iridescens.

Cystocarpia, *Antheridia*, nondum visa.

Stichidia ramellis conformia, subtorulosa, sporangia praecipue supra medium foveantia triangule divisa.

Sub lente cellulae superficiales ramellorum diametro aequales, ramulorum et ramorum plures longiores apparent.

Habitat.—N. S. Wales (Port Hacking, Botany Bay, Port Stephens).

Fronnd round, attached by a fibrous plexus, pyramidate decomposed pinnate, to 25 cm. high, branches copious, at distances of 5-10 mm., spreading in all directions, pyramidate, acuminate towards the apices; secondary branches crowded, alternate, at distances 3-4 mm., growing out in all directions, the greater part of the middle ones equal, to 12 mm. long, bearing ramelli pinnately; ramelli cylindrical to 2 mm. long, obtuse with terminal hollow pit. Rachides flexuose.

Substance gelatinous fleshy so that the plant very closely adheres to paper.

Colour dark purple, when growing beautifully bluish iridescent.

Cystocarps and *Antheridia* not seen.

Stichidia quite like the sterile ramelli, subtorulose, bearing triangularly divided sporangia chiefly above the middle.

Under the microscope the superficial cells of the ramelli are as broad as long, those of the ramuli and rami many times as long as broad.

Habitat.—N. S. Wales (Port Hacking, Botany Bay, Port Stephens).

This form is clearly very nearly related to *C. coerulescens* but of larger dimensions. I examined specimens of *C. curdieana* Harv. in the Melbourne Herbarium but the aspect of these was quite unlike that of the N.S.W. plants.

EXPLANATION OF PLATES XLI-XLVIII.

Plate xli.

- 1 and 2. Forms of *Codium difforme?* Bowen, Qld. (Rainford.)
3. *Avrainvillea erecta* = *A. papuana*. Bowen. (Rainford.)
4. *Codium globosum*, n. sp. Caloundra, Qld. (Lucas.)

Plate xlii.

Caulerpa ligulata. Balmoral, Middle Harbour, Port Jackson. (Lucas.)

Plate xliii.

1. *Caulerpa fastigiata*. Lord Howe Is. (R. Baxter.)
2. *Caulerpa Hedleyi*. Kangaroo Is. (C. Hedley.)

Plate xlv.

Hormosira articulata. Bowen, Qld. (Lucas.)

Plate xlv.

Chondria Rainfordi, n. sp. Bowen. (Rainford.)

Plate xlvi.

Chondria fusifolia. R. Tamar. Tas. (Lucas.)

Plate xlvii.

1. *Chondria fusifolia*. R. Derwent, Tas. (Lucas.)
2. *Chondria Rainfordi*, n. sp. Base. Bowen (Rainford.)

Plate xlviii.

Chondria iridescens, n. sp. Port Hacking, N.S.W. (Kretschman.)

MOSQUITO CONTROL IN THE MUNICIPALITY OF LANE COVE,
NEW SOUTH WALES.

By B. BERTRAM.

(Communicated by Dr. I. M. Mackerras.)

(Plates xlix and l and one Text-figure.)

[Read 30th November, 1927.]

Introduction.

Mosquito control may be instituted as a prophylactic measure against disease or to abate a nuisance. While there does not appear to be any serious danger from mosquito borne diseases in the area under consideration, mosquitoes were sufficiently abundant to be a public nuisance. A survey was therefore carried out in 1925 and a report, with recommendations, presented to the Lane Cove Council, which authorized a small expenditure enabling control work to be carried out over a limited area. The results obtained were so satisfactory that adequate provision is now made for maintaining this work and extending it to other parts of the Municipality.

Mosquito surveys have been carried out in various parts of New South Wales by Ferguson (1922, 1927*a*) and Mackerras (1926), the last named dealing with the Sydney district as a whole. Control work has also been undertaken more or less thoroughly in several areas, of which Kyogle may be particularly mentioned. This town had in the recent epidemic a dengue fever incidence of 10% as compared with 90% for neighbouring towns in which no control had been attempted (Ferguson, 1927*b*). No description of the methods adopted or the results obtained have, however, been published. Since the local problem has presented some interesting features, it seems desirable that the results of the present investigations should be made available.

I was indebted to the late Dr. Eustace W. Ferguson for determinations and other assistance during the early part of the work.

Topography.

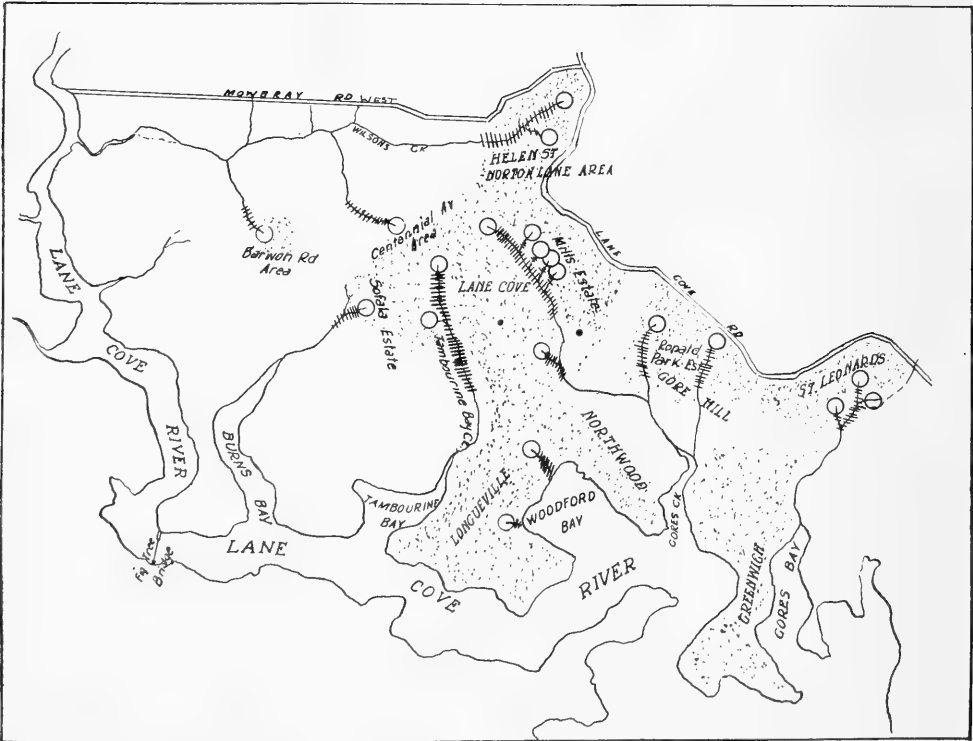
The Municipality of Lane Cove is a suburb of Sydney situated on the northern slopes of Port Jackson. Though only four square miles in extent, it comprises a variety of topographical features. It is bounded on the south and west by the waters of Port Jackson and the Lane Cove River and includes high wind-swept ridges of shale formation, and deeply dissected, shaded sandstone gullies, along which flow permanent creeks, some direct into open bays in the Harbour and some in salt water estuaries fringed with mangroves and headed by reedy brackish swamps.

There is always some flow of water in these creeks even during the driest weather, but in many places they consist of chains of rock pools or small ponds dammed back by sand bars or debris. The foreshores consist partly of precipitous

sandstone cliffs fringed by saline rock pools and partly of mangrove covered mud flats and in some places the low lying rock foreshores slope gently back towards the ridges.

The more elevated parts of the area are more or less densely settled, and only a small section is sewerred, namely the St. Leonards area and portion of the Greenwich area. Over the remainder of the area the greater part of the house drainage eventually flows into the creeks, which are usually set aside as drainage reserves in most subdivided land. This household effluent causes a considerable pollution of the creeks, which extends for a variable distance down stream until removed by aeration, filtration, and dilution by clear water tributaries and the addition of subsoil water. The extent of this pollution, which is the most important factor in the mosquito problem, is shown by cross lines in Text-fig. 1. The extension of sewerage facilities is gradually reducing the amount of pollution, while the institution of pipe drainage has eliminated the pollution in certain areas. Unfortunately, however, the trouble caused by the presence of organic pollution is not entirely eliminated by the institution of pipe drainage, though it may transfer the point of outlet of the drainage to a more remote and less settled area except in cases where the pipe line terminates in tidal waters.

LANE COVE



Text-fig. 1. Map of the Municipality of Lane Cove. The area of denser settlement is stippled, the points of pollution of the creeks are shown by circles, and the extent of pollution by small cross lines.

Results of the Survey.

The following ten mosquitoes have been found in the district:

Culex fatigans Wiedemann.—This species was found to be a serious pest in the densely settled areas, frequenting the dwellings in and around the business and shopping centres to the detriment and inconvenience of the residents. The factors governing the prevalence of this species are dealt with fully below.

Aedes (Ochlerotatus) vigilax Skuse.—Specimens were taken in the bush gullies. It does not occur in the vicinity of dwellings in sufficient numbers to warrant attention. It is not uncommon in the bush, but certainly does not appear to be nearly so prevalent as it is in other parts of the Sydney district.

Aedes (Ochlerotatus) flavifrons Skuse.—Only two specimens of this species have been taken, one biting about midday in June and one in the late afternoon in October, 1927, in bush gullies.

Aedes (Finlaya) alboannulatus Macquart.—Larvae have been taken in soakage pools and creek ponds, and on rare occasions in slightly stagnant and polluted water. The adult appears to be more numerous in the bush than *Aedes vigilax*, and it attacks viciously in such situations, but does not seem to be a pest in houses.

Aedes (Finlaya) queenslandis Strickland.—Adults were taken occasionally in shaded gullies.

Aedes (Finlaya) notoscriptus Skuse.—Adults were taken occasionally in houses. Larvae were first taken in a small collection of rain water in an artificial container. This water became very warm with the sunlight and contained a quantity of decaying gum tree leaves. Similar collections of water have been found to favour the breeding of this species.

Aedes (Pseudoskusea) concolor Taylor.—Larvae were found in saline littoral pools at Greenwich in water with a high temperature due to direct sunlight, whilst there was also a crust of salt forming around the edges of the pools. It does not frequent houses.

Lutzia halifaxi Theobald.—Larvae have been taken in clear rock pools in the creeks, usually in company with larvae of *Aedes alboannulatus*, on which it is a predator.

Culex (Neoculex) fergusonii Taylor.—Larvae were collected in a clear rock pool in the bush near Fig Tree. It was very plentiful on the occasion of the first visit. A few days later no larvae in any stages of development were found, but larvae of Zygoptera had become numerous.

Anopheles annulipes Walker.—Adults were shy biters and rarely met with. In fact on only one occasion was a specimen observed on the wing. Adults were found trapped on an oil film in a small soakage pool. Larvae have been taken in clear water, in small numbers, and in fairly large numbers in early summer in more or less muddy pools in company with *C. fatigans*.

From these findings it was apparent that *Culex fatigans* was the only species requiring serious attention and it was decided from the point of view of economy and efficiency to limit all attempts at control strictly to this species. It was further considered desirable that adequate control should be obtained on Council lands before attempting any house to house campaign.

The problem was to deal with *C. fatigans* breeding in natural collections of water such as in creeks and drainage easements rather than in artificial collections of water.

The dominant factor determining the extent of the breeding of *C. fatigans* in all creeks and drainage easements was found to be the extent of the pollution.

In clear unpolluted water numerous predatory aquatic insects were found and *C. fatigans* was absent, except at the very beginning of the season before predatory life became abundant.

In only one instance, where natural waters were polluted, was it found that larvae of *C. fatigans* were not present at some time during the season. In this particular case a large dam used for manufacturing purposes received heavy organic pollution from the waste water returning from the machines, and the fact that kerosene oil, which is used largely in the manufacturing process, gained access to the dam undoubtedly accounted for the absence of larvae of *C. fatigans*.

In all other instances, however, the drainage-polluted bodies of water in the creeks and drainage easements were found to be prolific sources of the breeding of *C. fatigans*, and as these drainage easements and creeks came directly under the Council's control the work of control under such conditions was decidedly a Council matter.

After the measures of control instituted by the Council became properly established, the only instance where mosquitoes were reported to be on the increase, was found on investigation to be due to a septic tank effluent gaining access to the surface of the ground, due to faulty rubble absorption drains. With the reconstruction of the rubble drains, and the effectual disposal therein of the septic tank effluent, no further complaints were received.

That the presence of pollution due to a high content of organic nitrogenous and other waste products was found to be favourable to the breeding of *C. fatigans*, was indicated by the presence in large numbers of these larvae in the effluent of the septic tank previously mentioned. In that case the effluent was seen to be flowing over the ground surface for about 30 yards with a width of about 4 feet, terminating in a grass covered area of several square yards. Here small pools had been formed and each pool was found to contain hundreds of larvae of *C. fatigans*.

Naturally such breeding areas would contain no aquatic predators, and there is further evidence to indicate that both the type of nutriment and the absence of predators determine the selection of breeding grounds by this species. This was clearly demonstrated in one case, where three large ponds in a disused quarry were inspected at various intervals during the season. No mosquito larvae were found until towards the end of the season, when a rain storm carried a certain amount of house drainage into one pond, and when visited about a week later, this particular pond was found to contain enormous numbers of larvae of *C. fatigans*, whilst the other unpolluted ponds remained free from mosquito larvae.

METHODS OF CONTROL.

Oiling.

Oil spraying was carried out only in correlation with the extent of pollution; that is from the point of origin of pollution to the point where the presence of gill breathing animals or insects indicated the elimination of organic putrescible matter. In some cases this line of demarcation was fairly definite, as for instance where at the end of a run of several hundred yards the water filtered through a large natural sand filter in the form of a sand bar, or where a small drainage easement entered a fast moving stream with a greater volume of water. Sometimes, however, it was not so definite, but the operator soon became skilled in the work of oiling in such a manner as to produce the best results with the least amount of damage to useful or harmless forms of life.

Plant.

The plant provided at the commencement of the season was rather obsolete, and for want of staff the maintenance staff were given the work of oiling. Even under such conditions favourable results were obtained, and at the commencement of the following season two knapsack sprays and a horse and vehicle (the latter in place of the wheelbarrow formerly used to transport equipment and oil) were provided. The entire work was then given to one man engaged as a weekly hand, his sole duties being that of mosquito eradication.

The results from then on were very satisfactory and mosquito control is now looked upon by the Council as part of its ordinary duties, the Council no longer allowing mosquitoes to breed on any country over which it has direct control.

This has placed the Council in the happy position of being able to guide and direct the residents and ratepayers to take the necessary steps to rid their premises of mosquitoes without themselves being the subject of adverse comment.

Channelling and Clearing.

The termination of the oil spraying at the end of last summer did not end the Council's activities in the work of mosquito control. As the result of a recommendation the same weekly hand previously engaged on the spraying work was employed on the work of channelling and clearing the drainage easements and watercourses on which summer control measures had been adopted. It is a well-known fact that *C. fatigans* seeks fairly still or sluggish water, and is also very partial to shaded situations for breeding purposes, and, while the clearing and channelling work will undoubtedly tend towards greater efficiency in mosquito control during the coming season, it is also a sanitation measure which has long been overlooked. Ponds of polluted water have been eliminated whenever possible by channel cutting and in some localities rock channels have been made by blasting with gelignite. Logs and debris have been removed and drainage polluted swamps eliminated. From observations made during the following twelve months on channels cut during the summer of 1926, there is every indication that a well cut channel will require very little maintenance in this district besides greatly reducing the expenditure on oil (Plate 1, fig. 4).

Educational.

With a view of enlisting the co-operation of the residents and in the interests of propaganda work on mosquito control, the Council accepted a recommendation to provide the necessary equipment in the way of a projecting lantern and suitable lantern slides to enable the writer to lecture to several local audiences. In this respect every assistance and courtesy has been shown by the various head masters of the schools and the leaders of other local organizations. The exhibition of lantern slides at the local picture theatre free of charge has been due to the interest and kindness shown by the proprietor to whom thanks are due.

Experiments with Automatic Oil Stations.

Drip oilers made from empty tins were found to be unsuitable, due to the unwanted attention from the ubiquitous small boy. Bags of sawdust saturated with oil, and submerged in the various drainage easements were not effective owing to the excessive amount of solids and grease present in the drainage forming an impervious scum around the bags.

Laboratory Experiments.

Crude oil was found in laboratory experiments to be too heavy and flocculent, allowing a clear area to form at the edge of the jar containing the larvae, and it was also noticed that the larvae were capable of living beneath the oil film for a period of three days. Close observation also showed that they were capable of piercing the film, with their siphons, and on descending from the surface minute pin holes were observed in the film.

An unrefined kerosene known as Solar oil produced efficient larvicidal results in 13 minutes.

A mixture of equal parts of Solar oil and tar oil produced the desired results in 7 minutes. The tar oil used without the kerosene oil did not form as complete a film as when the two oils were mixed.

As a result of these experiments the Council is now using a mixture of three parts of unrefined kerosene and one part of tar oil in the field and the effects are being carefully noted.

List of Former Prolific Breeding Grounds of Culex fatigans.

Phoenix Street at the outlet of drainage from Mills Estate was the first area treated. Approximately 100 houses drain into the drainage easement at this point. Here, prior to operations, the water immediately below the point of pollution was dense with larvae, whilst a natural rock shelter near by was seen to be sheltering myriads of the adult mosquitoes. (Plate xlix, fig. 2.)

From Little Street a drainage easement received drainage from the premises on the eastern side of the shopping centre at the Lane Cove tram terminus, and this easement for a distance of several hundred yards, together with two subsidiary easements, formed another prolific source of mosquito breeding.

The drainage easements in the Helen Street-Norton Lane area were formerly the origin of swarms of adult mosquitoes. (Plate l, fig. 1.)

Tambourine Bay Creek required considerable attention for several hundred yards down stream from the point of pollution. (Plate l, fig. 3.)

Sofala Estate drainage which discharged into the Trouve Street drainage easement, was effectually treated.

The Ronald Park Estate drainage easement, formerly ideal for mosquito breeding, is now free from the pests.

Centennial Avenue and Barwon Creek have also been successfully treated, whilst many other small unnamed drainage easements have received their quota of expenditure.

Summary of the Work and its Results.

There is every indication that the work has been economically sound from a Local Government expenditure point of view and will therefore be continued in the future, whilst from a health and convenience standpoint there is every indication that the residents have greatly benefited. In this respect one is inclined to believe, judging by the benefit felt by residents at some considerable distance from former breeding areas, that the range of flight of *Culex fatigans* is considerably greater than previously thought by workers in sanitary entomology.

EXPLANATION OF PLATES.

Plate xlix.

1. Pipe drain pouring polluted house drainage into a creek.
2. The pool to the left was heavily polluted and contained large numbers of larvae, while myriads of adult *C. fatigans* were found sheltering under the overhanging rock to the right of the picture.
3. A pool of still, clear water above the entry of the house drainage. No larvae of *C. fatigans* were found here.
4. A small swamp in the course of a creek far enough below the point of pollution for the water to have become again clarified. No larvae of *C. fatigans* were found here.

Plate I.

1. A small heavily polluted pool in which large numbers of larvae of *C. fatigans* were found.
2. The same pool as shown in Plate I, fig. 1, after channelling and clearing had been carried out.
3. A channel cut further down the creek where it runs in a sandstone gully.
4. An area which had been channelled and cleared twelve months before the photograph was taken, during which time it had received no attention whatever.

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- , 1927a.—Mosquito Surveys of Some Inland Towns of New South Wales. *Ibid.* for *Yr. 1925*, Sec. IV, 188-193.
- , 1927b.—The 1925-26 Outbreak of Dengue Fever in New South Wales. *Ibid.* for *Yr. 1926* (in press).
- MACKERRAS, I. M., 1926.—Mosquitoes of the Sydney District. *Aust. Naturalist*, vi, 3 33-42.
-

A NEW *DENDROBIUM* FOR NEW SOUTH WALES AND QUEENSLAND.

By REV. H. M. R. RUPP.

(Four Text-figures.)

[Read 30th November, 1927.]

DENDROBIUM TENUISSIMUM, n. sp.

Planta semper pendula, cum ramis tenuissimis et lentis, 30-100 cm. longis. Folia tereta, tenuissima, saepe brevia, obscure striata. Flores solae vel 2-3. Sepala $1\frac{1}{2}$ cm. longa, lata, purpureo-fusca vel fusco-virida. Petala angusta, virida. Labellum album, cum 5-6 maculis stipatis purpureis utrimque, et marginibus crispis. Columna tenuis, apice purpureo.

An extremely slender, pendulous species occurring in dense brush-forests. Stems almost like fine wire, very flexible, much branched. Leaves terete, in young plants and branches somewhat robust, but becoming very slender in maturity, occasionally as much as 15 cm. long, but more often very short, obscurely fluted. Flowers solitary or in racemes of 2 or 3. Sepals equal, about $1\frac{1}{2}$ cm. long, rather broad, purplish-brown, or dark-green on the inner surface. Petals shorter and very narrow, green. Labellum nearly as long as the sepals, recurved, white with a yellowish-green median raised line, on either side of which are 4-6 closely-packed oval bright-purple blotches. Margins crisped-undulate, pure white. Column slender, its apex and the stigmatic plate purplish. Ovary rather long, pedicel long and exceedingly slender. Fl. September-October.

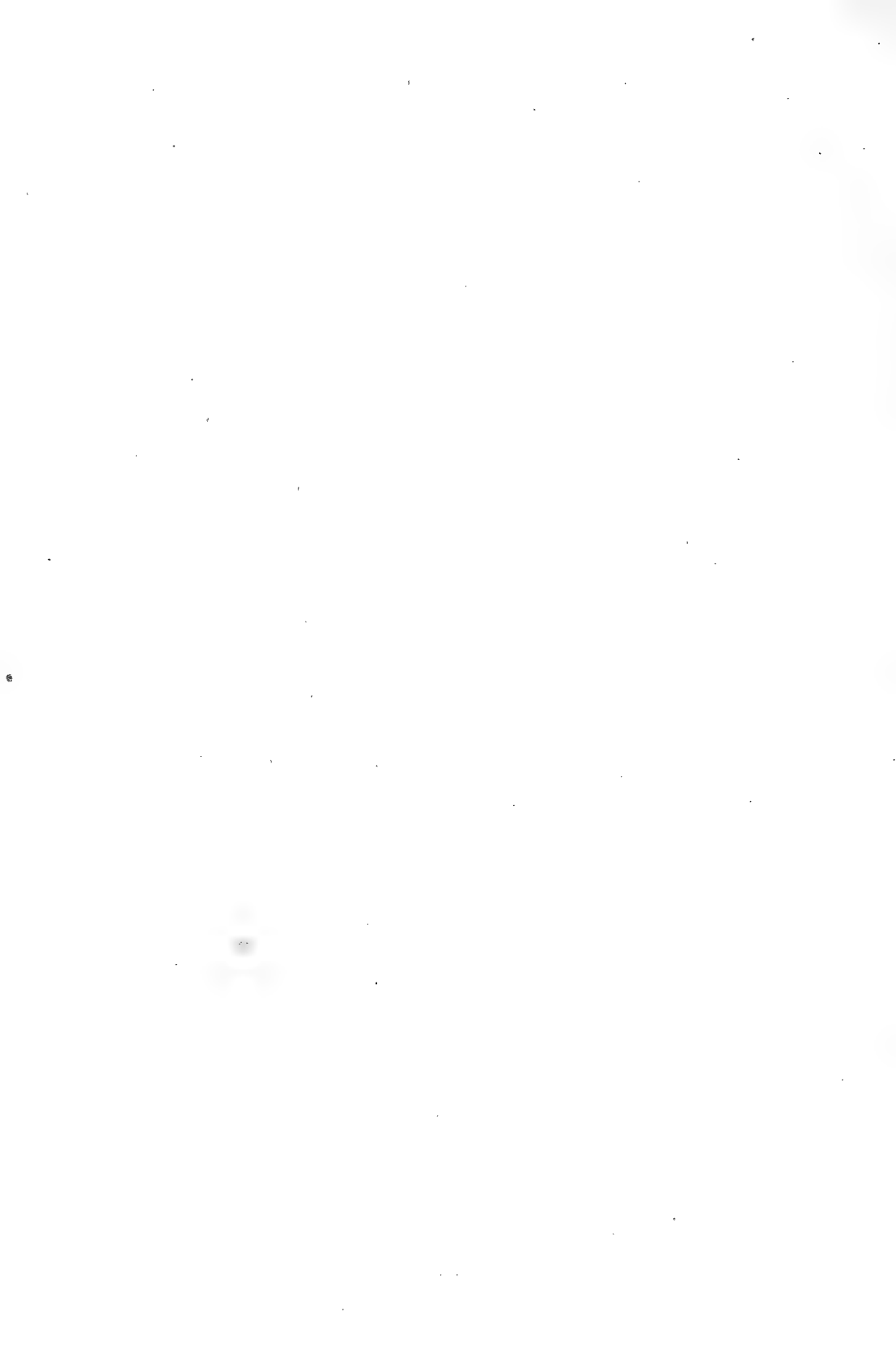
This plant has obvious affinities with *D. Becklerii* F.v.M., and *D. Mortii* F.v.M., but could never be mistaken for either. It is far more slender than even the less robust forms of *D. Becklerii*, and never has the erect or semi-erect habit of that species; the sepals are relatively much broader, the petals shorter; the labellum is more obscurely lobed, and its margins are never bordered with purple, while the brilliant purple blotches closely set on either side of the median plate are never found in *D. Becklerii*. It differs from *D. Mortii* (which flowers in late summer and autumn) in the slenderness and flexibility of the much longer branches; the absence of angularity in the leaves; the relative dimensions of sepals and petals (the latter in *D. Mortii* being very broad); and the brilliant purple markings of the labellum. The ovary and pedicel in the new species are both relatively longer than in either of the others. The perfume is very distinctive, and unlike that of any other terete-leaved *Dendrobium* known to me. It is not particularly pleasant, and has considerable resemblance to that of the common little liliaceous plant *Anguillaria dioica*.

Habitat.—Upper Allyn River, Oct., 1925 (John Hopson and H.M.R.R.); Upper Williams River, Oct., 1926 (C. Barrett); Upper Paterson River, 1927 (P. Laney); Tambourine Mountain, Queensland, Sept., 1927 (Mrs. H. Curtis).

This orchid is found throughout the brushes among the foothills of the Barrington Tops in New South Wales, the three rivers all having their origin in that range. As it occurs also in South Queensland, it may be confidently looked for in between.



Text-fig. 1. *Dendrobium tenuissimum*, n. sp., small flowering branch, about natural size.
 Text-fig. 2. Enlarged front view of flower of *D. tenuissimum*.
 Text-fig. 3. The same of *D. Becklerii*.
 Text-fig. 4. The same of *D. Mortii*.





Spongoclonium fasciculatum.



Genus *Spongoclonium*
Species *brounianum* Har.

Locality—Port Phillip Heads. Sm 7.

Collected by J. BRACEBRIDGE WILSON.

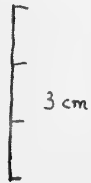
Date 29. 1. 1895

Spongoclonium brounianum from Victoria.



Very rare.
Furness & Co
Collected 1905
No. 101/102

Spongoconium brownianum from Western Australia.



Genus *Callithamnion*

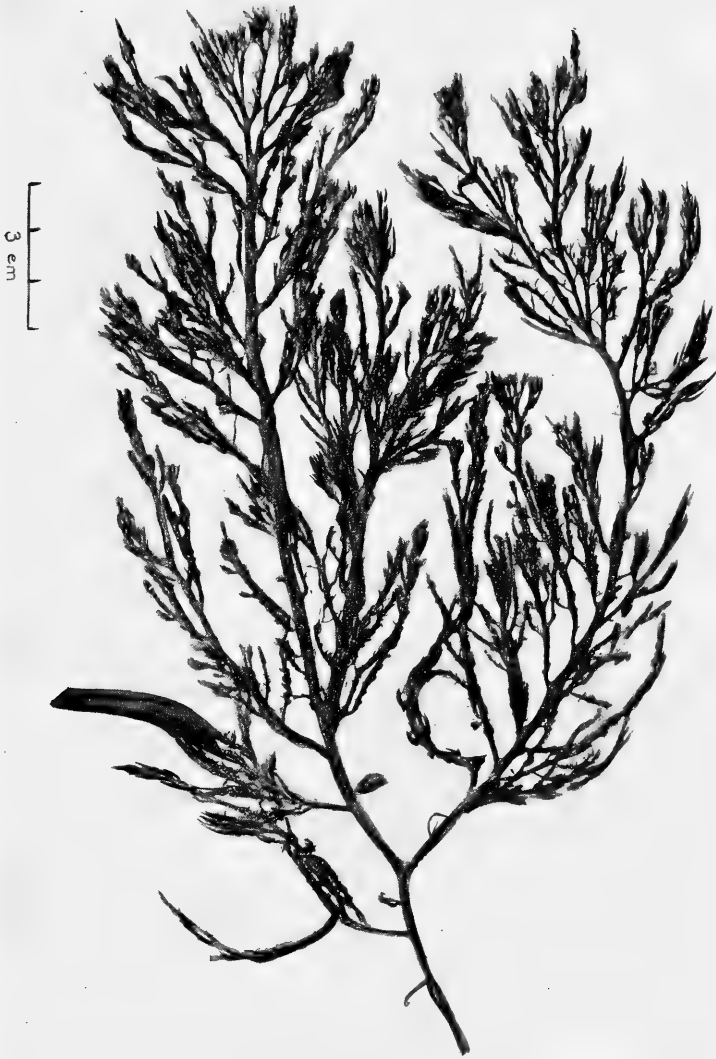
Species *wilsonianum* J. Ag.

Locality—Port Phillip Heads. Station 10

Collected by J. BRACEBRIDGE WILSON.

Date 3 11 1894

Spongoclonium wilsonianum.



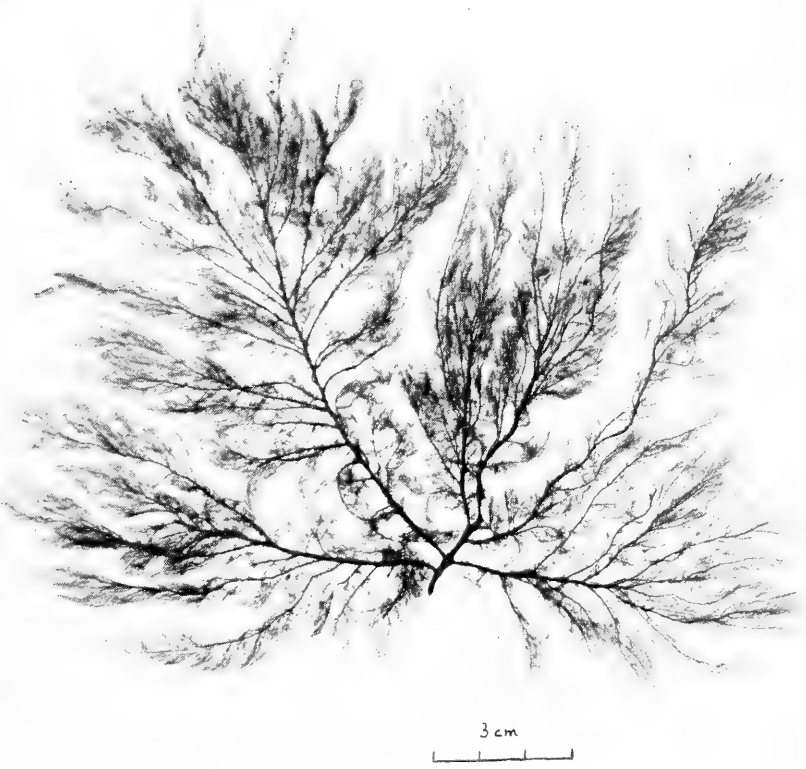
Spongoelonium dasyurum.



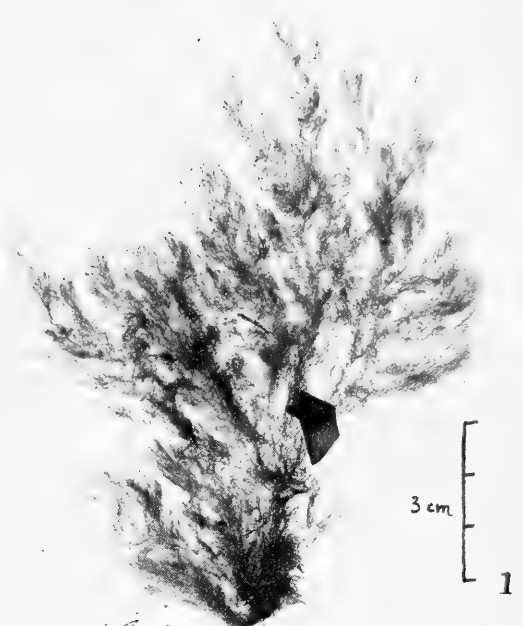
Orford, T.

Nov. 1923 A.H.S. Lucas

Spongoclonium paradoxum.



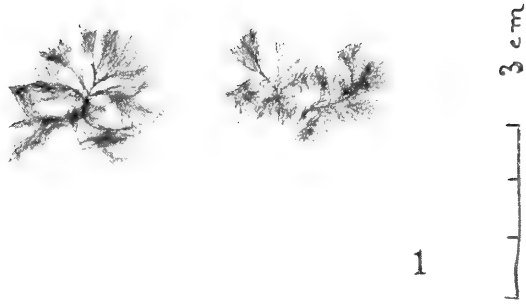
Spongoclonium latissimum.



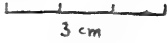
Callithamnion angustatum Harv
Georgetown, Van Diemenland
C. D. Harvey



1. *Spongoconium angustatum*.
2. *Spongoconium violaceum*.



350 *gularis* *debile* *Callithamnion debile* H.



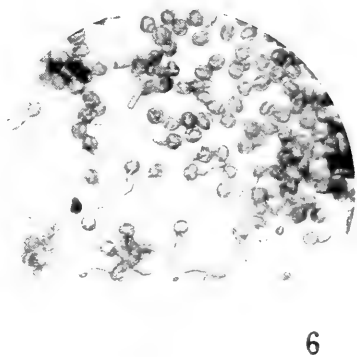
Callithamnion crispulum Harv.
 Fremantle, Western Australia

532 A by Dr. Harvey

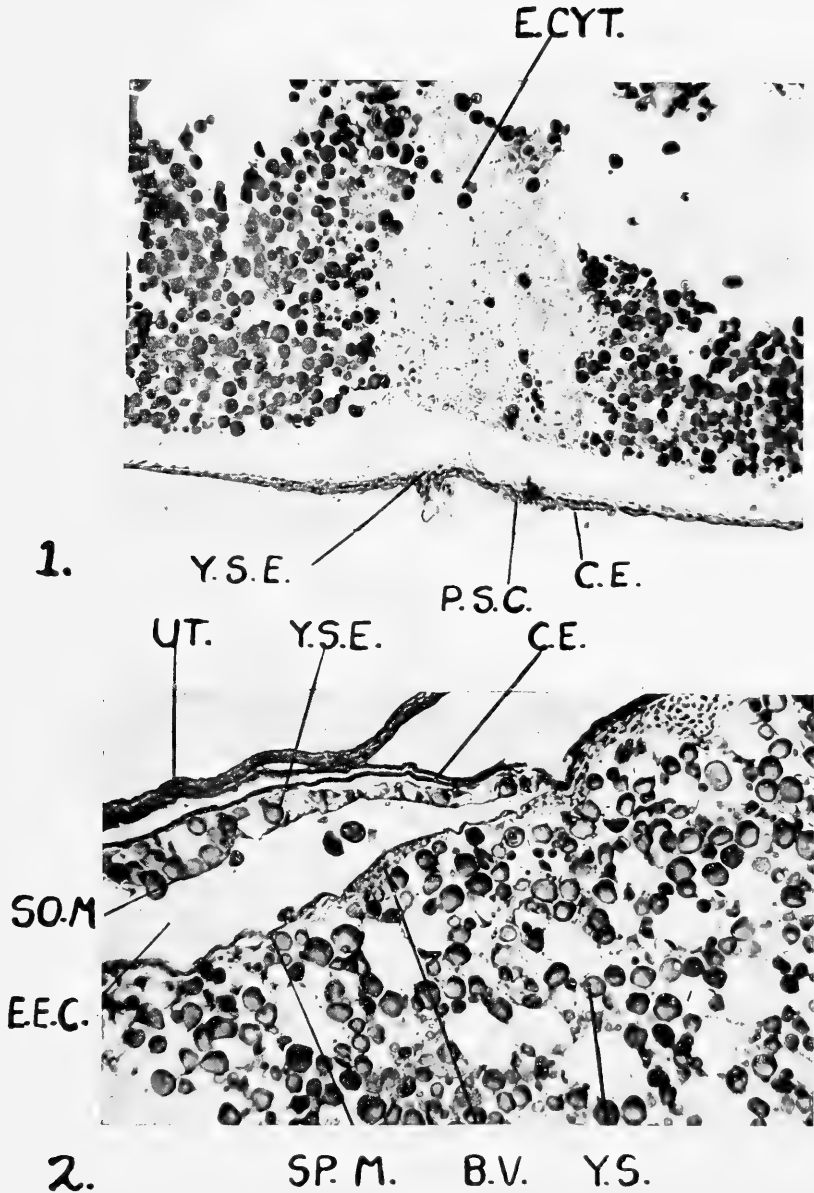
- 1. *Callithamnion debile*.
- 2. *Callithamnion crispulum*.



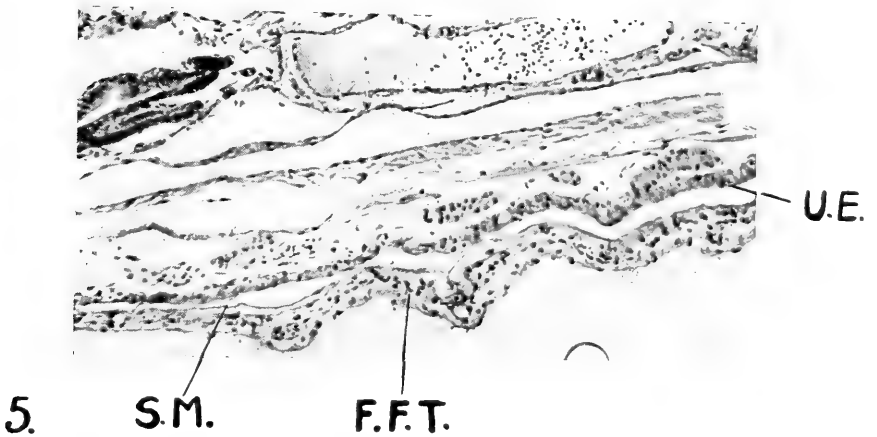
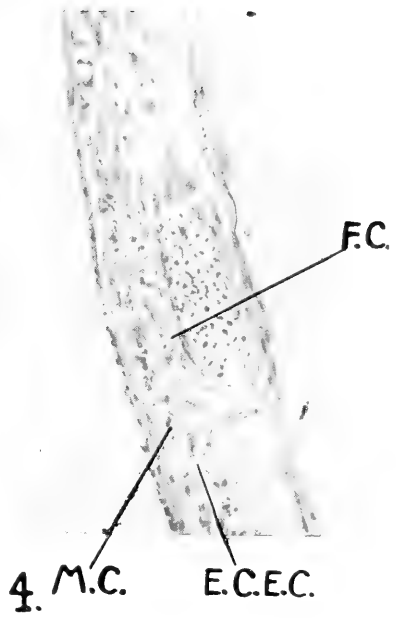
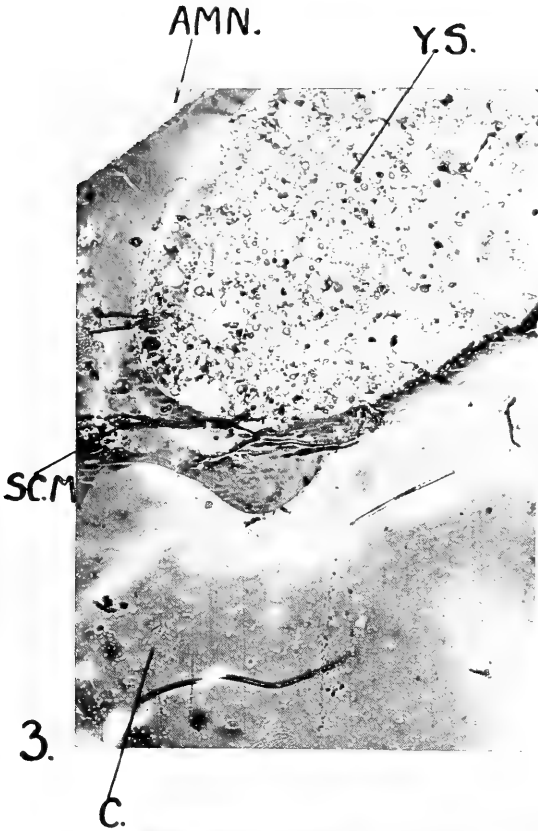
Dampiera stricta R.Br.



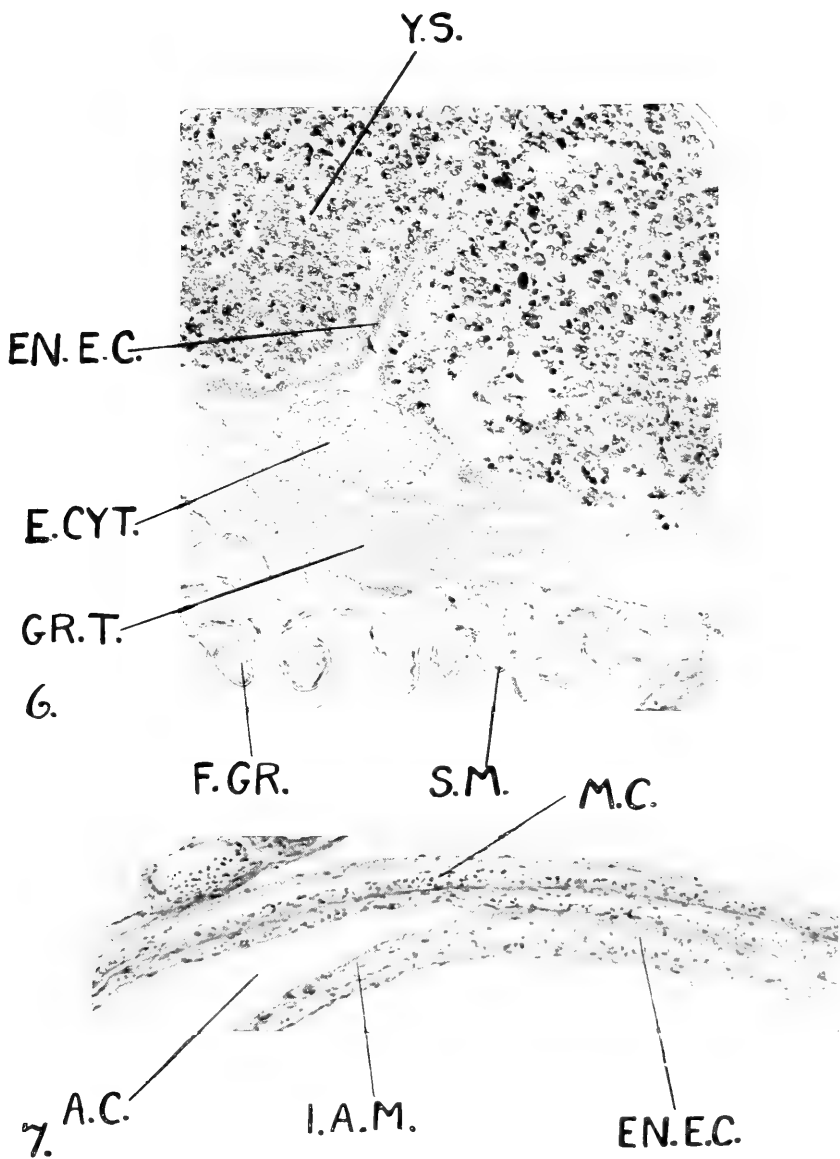
3-5. Style of *Dampiera stricta* in various stages.
6. Microspores germinating.



1. Omphaloplacental region of a two weeks old embryo.
 2. The downgrowth of mesoderm into the yolk-sac.

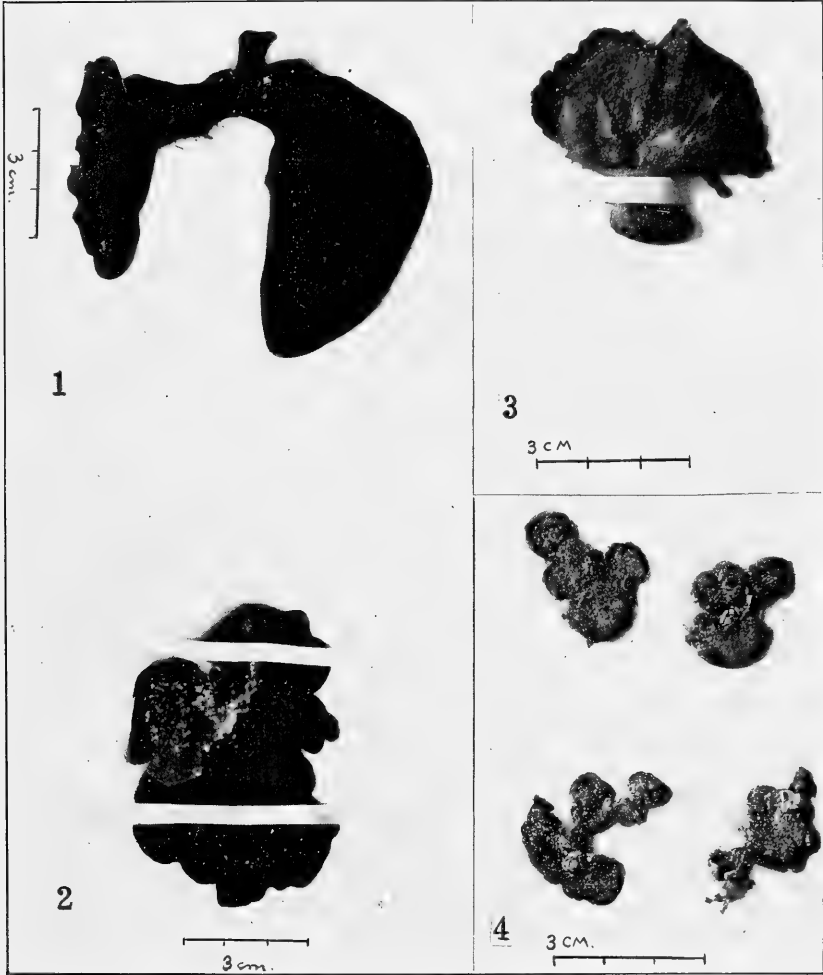


3. Yolk-sac of six weeks old embryo.
4. The mature allantoplacental region.
5. Folded allantoplacenta in one of the embryos examined.



6. Yolk-sac of eleven weeks old embryo.

7. The junction of inner and outer allantoic membranes in placental region.



1 and 2. Forms of *Codium difforme*?
3. *Avrainvillea erecta*.
4. *Codium globosum*, n. sp.

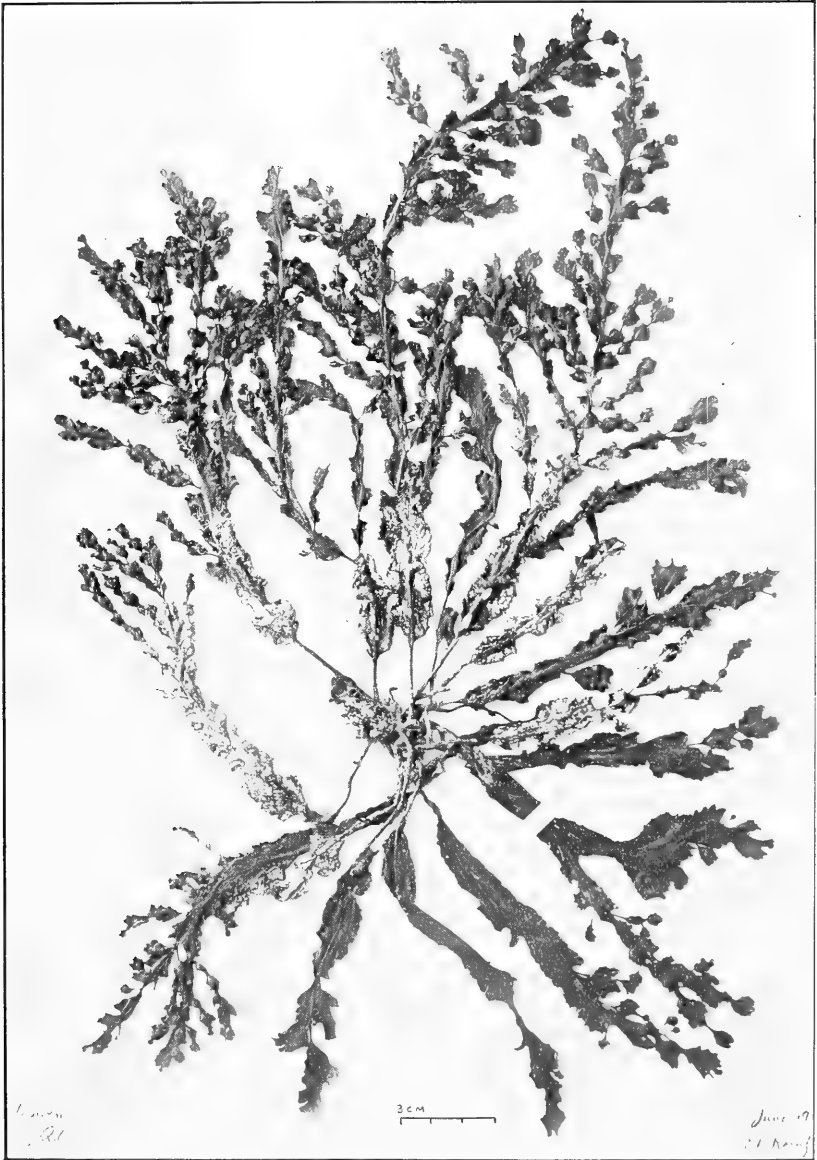


Caulerpa ligulata.

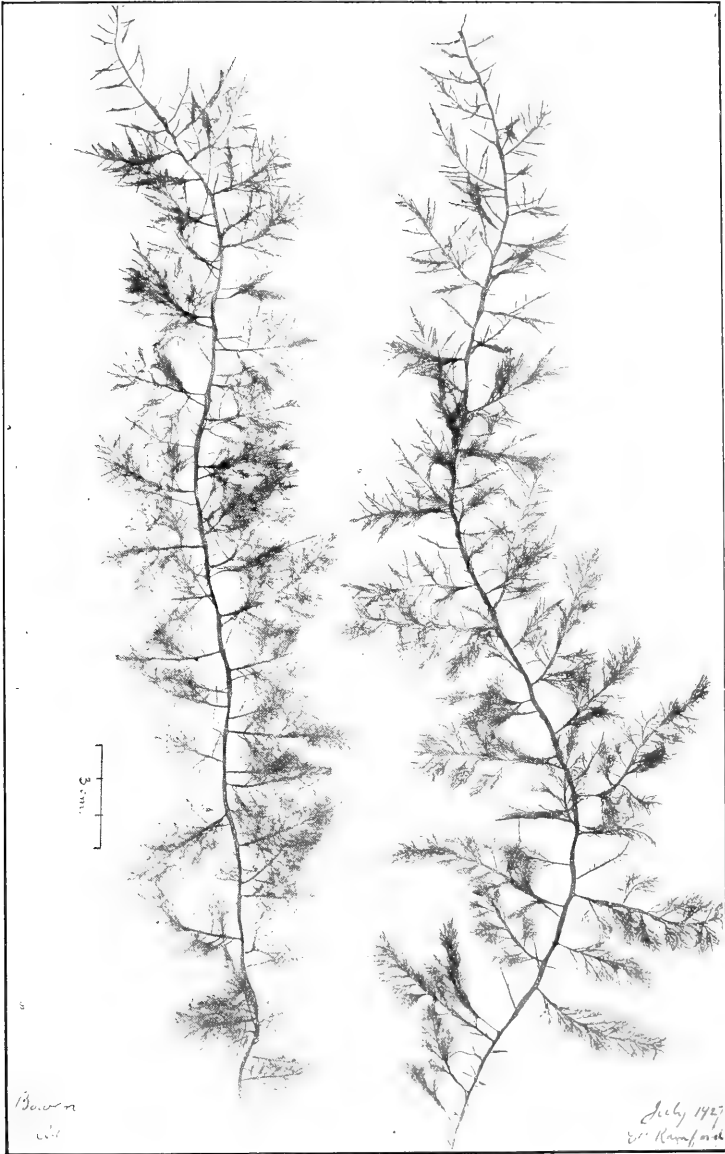


1. *Caulerpa fastigiata*.

2. *Caulerpa Hedleyi*.



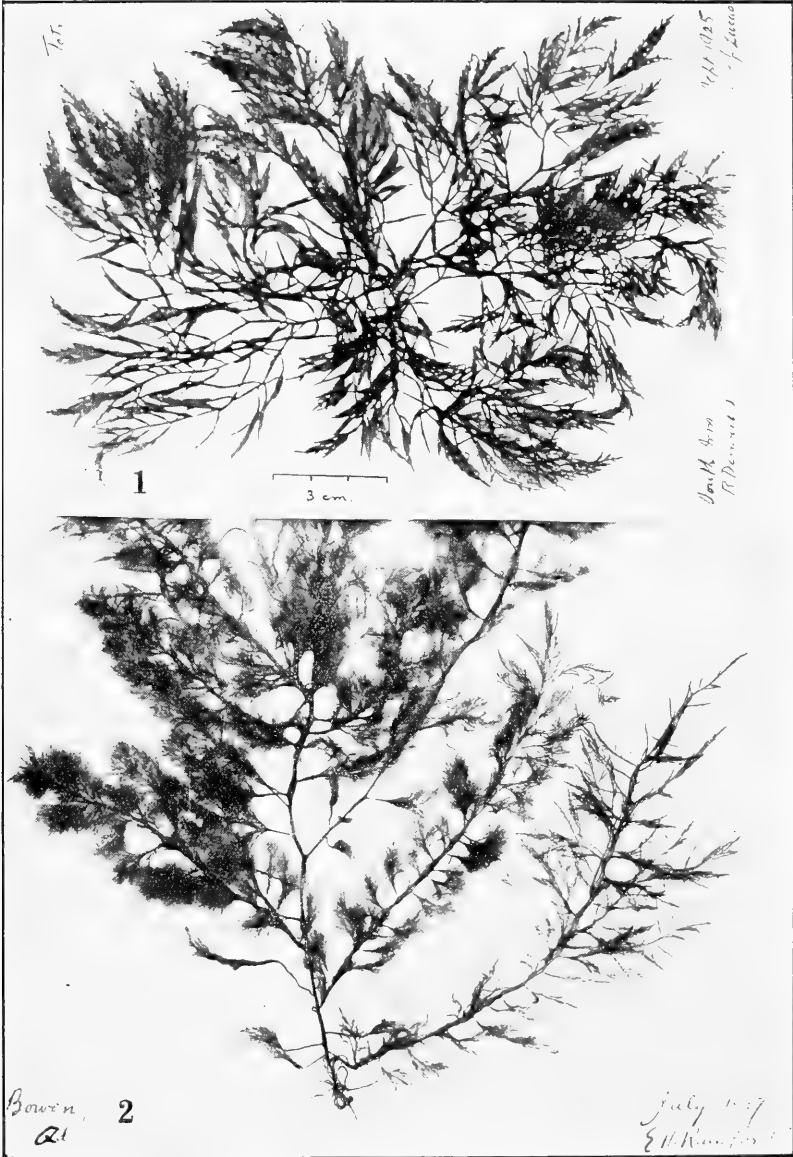
Hormosira articulata.



Chondria Rainfordi, n. sp.



Chondria fusifolia.

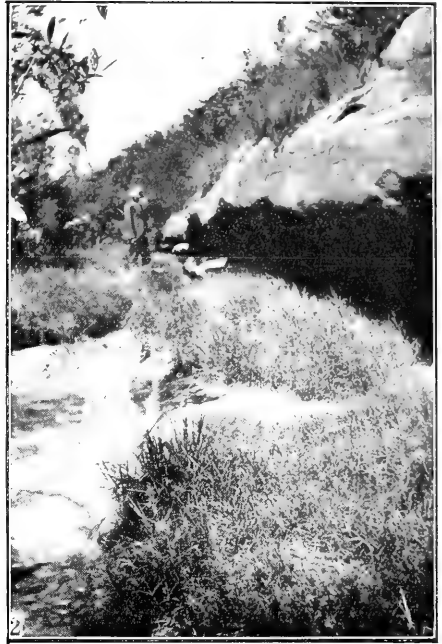


1. *Chondria fusifolia*.

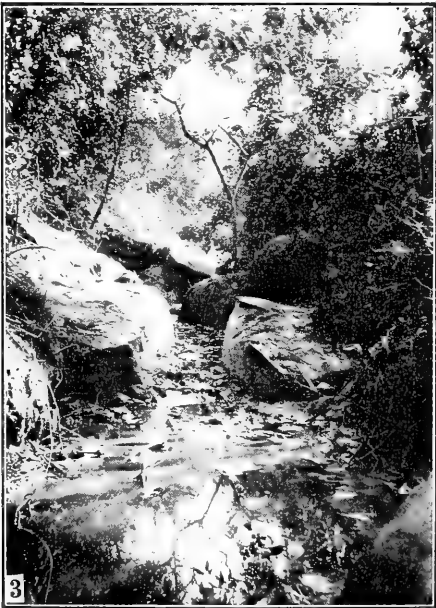
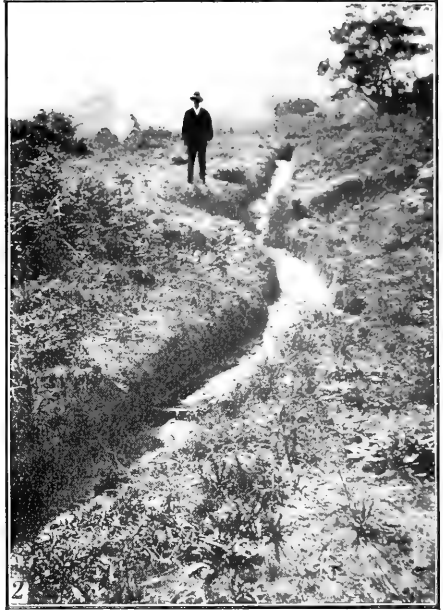
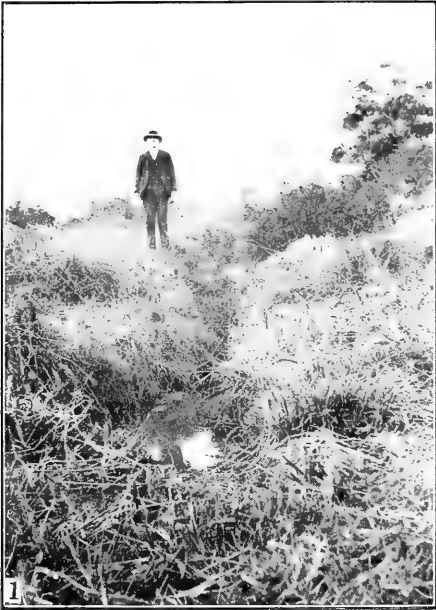
2. *Chondria Rainfordi*, n. sp.



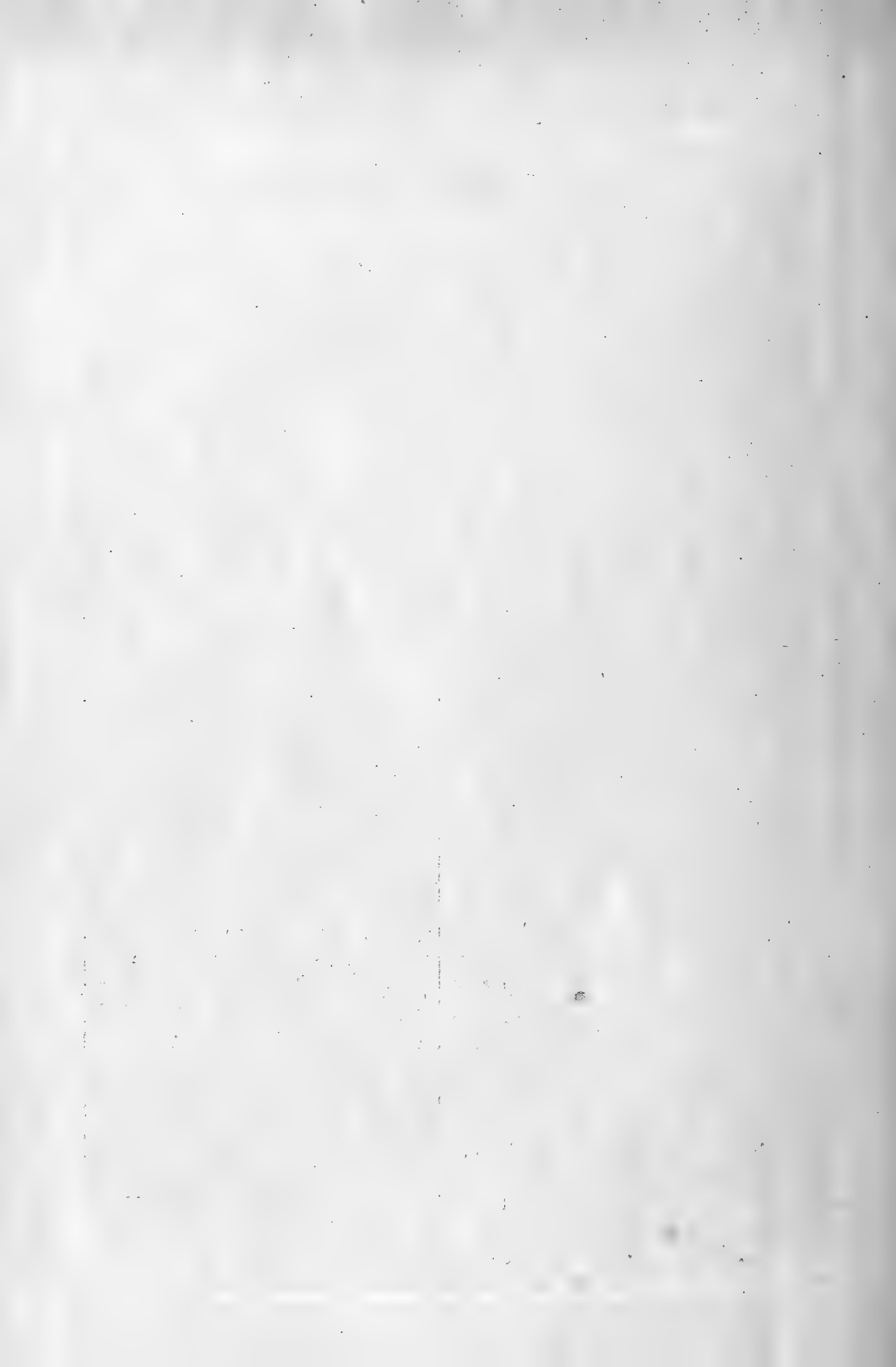
Chondria iridescens, n. sp.



Views taken in the Municipality of Lane Cove.



Views taken in the Municipality of Lane Cove.



(Issued 15th April, 1927.)

Vol. LII.
Part 1.

No. 210.

THE
PROCEEDINGS
OF THE
LINNEAN SOCIETY
OF
NEW SOUTH WALES

FOR THE YEAR

1927.

Part I (Pages i-xxii).

CONTAINING THE PROCEEDINGS OF THE ANNUAL MEETING.

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The Linnean Society of New South Wales

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PROCEEDINGS, 1927, PART 1.

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(Issued 11th July, 1927.)

Vol. LII.
Part 2.

No. 211.

THE
PROCEEDINGS
OF THE
LINNEAN SOCIETY
OF
NEW SOUTH WALES

FOR THE YEAR

1927.

Part II (Pages 1-186.)

CONTAINING PAPERS READ IN MARCH-MAY.

With nine plates.

[Plates i-ix.]

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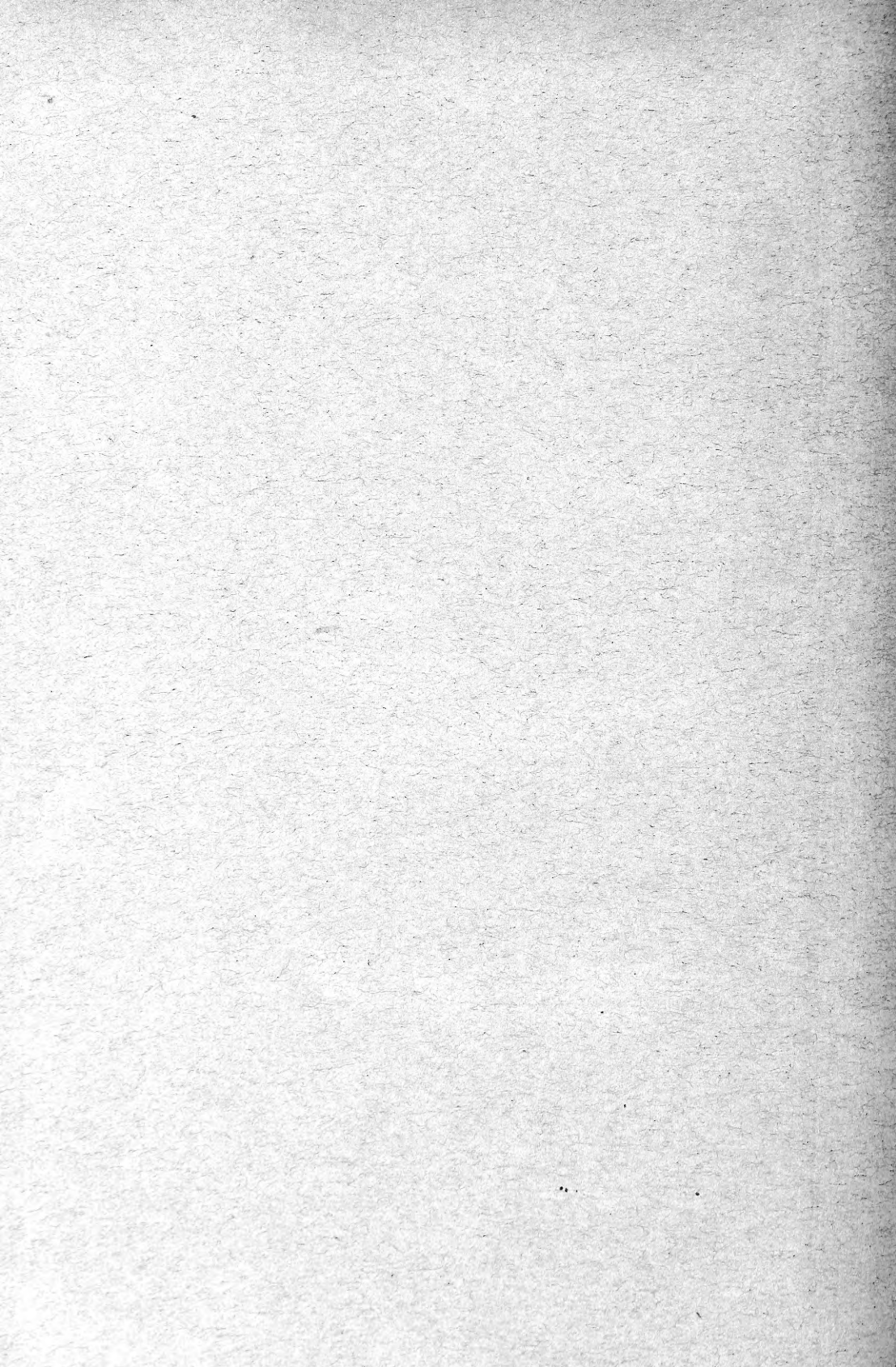
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