

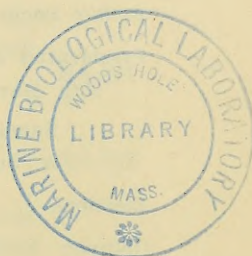
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THE
PROCEEDINGS
OF THE
LINNEAN SOCIETY
OF
NEW SOUTH WALES

FOR THE YEAR

1964

VOL. LXXXIX.



WITH EIGHT PLATES.

180 Text-figures.



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1965

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(Issued 14th October, 1964.)

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ARTHUR BACHE WALKOM, D.Sc.

Dr. Walkom became a member of this Society in 1909 while still an undergraduate of the University of Sydney. He was Linnean Macleay Fellow in Geology in 1912 and resigned the following year to become a Lecturer in the University of Queensland.

On the retirement of Mr. J. J. Fletcher in 1919 he was appointed Secretary of this Society, and he held this office until 1940, when he resigned to become Director of the Australian Museum. He was elected President in 1941 and Vice-President in 1942. Since 1943 he has been Honorary Treasurer and since 1952 Joint Honorary Secretary, with the special duty of editing the Society's Proceedings.

To mark the completion of his 45 years of continuous service in administering the affairs of the Society, and the 75th anniversary of his birth, Council resolved that a photographic portrait of Dr. Walkom, with a biographical note, be published in Part 1 of the Proceedings for 1964, and that a framed enlarged copy of it be hung on the wall of the Meeting Room. This enlargement was unveiled by the retiring President, Mr. G. P. Whitley, at the Annual General Meeting, March 25, 1964.

Dr. Walkom's services in the cause of Science include Honorary Secretaryship and Presidency of the Royal Society of Queensland and Honorary General Secretaryship of the Australian and New Zealand Association for the Advancement of Science for 21 years (1926-1947). He also served as President of the Royal Society of New South Wales, and as President and Vice-President of the Australian and New Zealand Association for the Advancement of Science, and was Honorary Secretary of the Australian National Research Council and first editor of the *Australian Journal of Science*.



a B Walkom

ANNUAL GENERAL MEETING.

25th MARCH, 1964.

The Eighty-ninth Annual General Meeting was held in the Society's Rooms, Science House, Sydney, on Wednesday, 25th March, 1964.

Mr. G. P. Whitley, President, occupied the chair.

The minutes of the Eighty-eighth Annual General Meeting (27th March, 1963) were read and confirmed.

Before reporting on the affairs of the Linnean Society of New South Wales for the year, I wish to thank the Society for the privilege of serving as its President. To members of Council and Committees my thanks are due for their support during the year. The Society is grateful to the Honorary Treasurer and Editor (Dr. A. B. Walkom) and to Dr. W. R. Browne, who shares with Dr. Walkom the important duties of the Honorary Secretaries. Any inclination to take for granted their services, freely afforded for so many years, should be resisted: these gentlemen are assured that we appreciate our deep and cumulative obligation to them. In the business and library sides of the Society's activities, the careful work of the Assistant Secretary, Miss G. L. Allpress, should not pass unnoticed, nor the auditorial services of Mr. S. J. Rayment, F.C.A., to both of whom our thanks are merited.

REPORT ON THE AFFAIRS OF THE SOCIETY FOR THE YEAR.

The Society's Proceedings for 1963, Vol. 88, Parts 1 and 2, were published in 1963 and Part 3 in 1964. Vol. 88 consists of 417 pages, 24 plates and 207 text-figures.

During the year thirteen new members were added to the list, five died, one resigned and two were removed from the list of members. The numerical strength of the Society at 1st March, 1964, was: Ordinary Members, 253; Life Members, 31; Corresponding Member, 1; total 285.

It is with regret that the following deaths during the year are recorded: W. A. Boardman, L. A. Cotton, R. L. Crocker, G. A. M. Heydon, and E. H. Zeck. (See pages 5-7 for obituary notices.)

Lecturettes were given at the following meetings: April, A Recent Expedition to the Subantarctic Auckland Islands, by Dr. J. C. Yaldwyn; June, The Earliest Vertebrates, by Mr. R. Strahan; July, Bio-electricity in Plants, by Mr. G. P. Findlay; October, Account of the Recent (1962) Australian Museum Expedition to Swain Reefs off the Queensland Coast, by Dr. D. F. McMichael. Our appreciation and thanks to the lecturers are expressed. At the September Ordinary Monthly Meeting a symposium on the Myall Lakes, by members of the University of Sydney Biological Society and others, was held. The speakers and subjects were: (1) The proposed Faunal Reserve, by Mr. A. Strom; (2) The Quaternary History, by Dr. A. R. H. Martin; (3) The Soils; and (4) The Vegetation, by fourth year students of the School of Biological Sciences, University of Sydney. The discussions which followed both the lecturettes and the symposium added greatly to the interest of the meetings.

Library accessions from scientific institutions and societies on the exchange list amounted to 2,174, compared with 1,997 and 1,962 in the years 1962 and 1961 respectively. Members and institutions continued to borrow books and periodicals from the library, the total borrowings for the year being 260, members and others also consulting the periodicals in the library. Arrangements have been made with the Fisher Library, University of Sydney, for the copying of articles from old and rare publications desired by organizations and universities. The Australian Medical Association (N.S.W. Branch) presented to the Society's library copies of the *British Medical Journal*, 1931-1962

(imperfect), to help complete the Society's set of that Journal. The following requests for exchange of publications were acceded to during the year: Geological Survey of Sweden, Stockholm; and Institute of Scientific and Technical Information of China, Peking. The Bombay Natural History Society, Bombay, India, and Sociedad Entomologica Argentina, Buenos Aires, Argentina, notified their decisions to discontinue the exchange of their Journal and Revista for the Proceedings and Entomological Reprints respectively, as their publications are now only available by subscription. A complimentary copy of the Society's Proceedings as issued, commencing 1963, is now presented to the Adolf Bassler Library of the Australian Academy of Science, Canberra, A.C.T.

In October, 1963, it was decided that no free reprints be given to non-member authors of papers in the Proceedings. On 24th July, 1963, the Council fixed the prices for Volumes and Parts of the Society's Proceedings as follows: (1) The price of Vols. 1-20 (1875/76-1895) be £5 each volume; (2) the price of Vols. 21-87 (1896-1962) be £4 10s. each volume; (3) the price of each part of a volume from Vol. 1 to Vol. 87 be £2, except that for volumes consisting of 5 or 6 parts the price of the first and last parts be 10s. each; (4) the price of current and future parts of each volume from Vol. 88 (1963) onwards be £1 15s.

Dr. A. K. O'Gower was elected a member of Council during the year in place of Dr. A. R. Woodhill, who had resigned. Miss Elizabeth C. Pope was appointed the Society's representative at the 16th International Congress of Zoology.

A Conversazione was held from 2 to 5.30 p.m. on Saturday, 28th September, 1963, in the Botany Laboratories, Carslaw Building, University of Sydney, when about 130 members and visitors were present. There were displays of research into various branches of Natural Science being conducted by members of the Society.

The total net return from the Society's one-third ownership of Science House for the year ended 31st August, 1963, was £1,174 2s. 8d. The Society's representatives on the Science House Management Committee are Dr. W. R. Browne and Mr. S. J. Copland and Drs. A. B. Walkom and D. T. Anderson, deputies.

As a gesture of goodwill about 100 of each of the Society's five coloured wildflower postcards were offered to the "Muogamarra" Sanctuary Trust for sale to visitors to the Sanctuary and accepted with thanks and much appreciation.

A meeting, at the instance of the Council of the Society, was held in Canberra during the meeting of the Australian and New Zealand Association for the Advancement of Science in January, 1964, of representatives of Australian scientific societies to discuss the promotion of Nature Conservation in the Commonwealth.

Professor H. G. Andrewartha, Department of Zoology, University of Adelaide, has accepted Council's invitation to deliver The Sir William Macleay Memorial Lecture for 1964 on Friday, 21st August, 1964, in the Main Hall of Science House, Sydney. The title of the lecture is "How Animals can live in Dry Places".

Linnean Macleay Fellowships.

In November, 1962, Mr. P. J. Dart, B.Sc.Agr., was appointed to a Linnean Macleay Fellowship of the Society in Plant Physiology tenable for one year from 1st January, 1963.

During the year Mr. Dart followed two main lines of research. A study of the fine structure in molybdenum deficient root nodules was begun (in conjunction with Miss R. Mullens) and a survey of fine structural differences between the nodules of the various host legume-*Rhizobium* cross inoculation groups undertaken.

Molybdenum deficient *Medicago tribuloides* nodules are characterized by an apparently normal meristem with an abnormal development as the host cells become infected. In the young, first-formed nodules, which develop before the deficiency symptoms become acute, a small number of the invaded host cells develop as in normal nodules with the characteristic bacteroid and membrane envelope formation. Fewer cells are invaded in the deficient nodule (cf. normal nodules) resulting in a large

number of parenchyma-like cells in the Mo-deficient nodule. The bacteroid-filled host cells are short lived and breakdown of bacteroid and host fine structure occurs as in the degenerate zone of the base of a normal nodule. Treatment of a Mo-deficient plant with molybdenum results in a "recovery" of the nodules. Already degenerate cells remain as such, but many more differentiating cells adjacent to the meristem are invaded and bacteroid development proceeds as in normal nodules with the mature bacteroid-filled host cells persisting without breakdown, as they do in normal +Mo nodules. Preliminary studies with *Trifolium fragiferum* and *Lotus corniculatus* indicate that a similar pattern prevails in these nodules. A study of Mo-deficient *Stylosanthes gracilis* and *Vigna sinensis* nodules is also in progress.

The other research programme involved a survey of fine structure in the legume-*Rhizobium* cross inoculation groups. Considerable differences exist between the groups. In the cowpea group, *Acacia longifolia*, *Viminaria juncea* and *Vigna sinensis* have several bacteroids enclosed by a single membrane envelope in the red zone of the nodule. The *Rhizobium* cells expand very little during nodule development, retaining the gram-negative rod appearance, and there is no apparent loss of nucleoid fibrillar material. This contrasts with the development in *M. tribuloides*, *Trifolium subterraneum* and *Vicia atropurpurea* where the bacteria expand greatly during development, losing the gram-negative rod appearance. The nucleoid region in these bacteroids is only sparsely filled with fibrillar material and each bacteroid is enclosed by a single membrane envelope. The fine structure of *Lupinus angustifolius* nodules has similarities to both the types mentioned previously. The bacteroids are usually enclosed singly by a membrane envelope and expand noticeably during development, losing the typical gram-negative rod appearance. Occasionally, however, more than one bacteroid appears to be enclosed by a single membrane envelope giving the blue lupin nodule a resemblance to the cowpea type.

Further studies of several other species are in progress including detailed study of soybean and peanut nodule fine structure. A study of the fine structure of *Casuarina glauca* root nodules has also been started.

In November, 1963, Mr. Dart was reappointed to a Fellowship for the year commencing 1st January, 1964. We wish him every success in his work.

Linnean Macleay Lectureship in Microbiology.

Dr. Y. T. Tchan, Linnean Macleay Lecturer in Microbiology, University of Sydney, reported on his work for the year ending 31st December, 1963, as follows: During 1963 progress has been made on the physiology of nitrogen-fixing bacteria. A paper on this subject has been published in the Proceedings of the Society. Other aspects of research on the nitrogen-fixing bacteria have made some progress, particularly on the requirement of Ca by *Azotobacter*. The study of seed inoculation with *Azotobacter* is near its completion. A research programme on the study of pesticides by the algal method has been initiated and should proceed during the coming year.

Dr. Tchan has been appointed by the Senate of the University of Sydney to a Readership in Agricultural Microbiology. His full title is now Reader in Agricultural Microbiology and Linnean Macleay Lecturer in Microbiology.

The Honorary Treasurer (Dr. A. B. Walkom) presented the balance sheets for the year ending 29th February, 1964, duly signed by the Auditor, Mr. S. J. Rayment, F.C.S., and his motion that they be received and adopted was carried unanimously.

Dr. A. B. Walkom.

The President said that Dr. A. B. Walkom, who had recently celebrated his 75th birthday, had completed forty-five years of continuous service to the Society. The Council had resolved to mark the occasion by having a photograph of Dr. Walkom printed in the Proceedings and by having a framed enlargement hung in the meeting room.

The President concluded: "As a token of our appreciation, I now have pleasure in unveiling this photograph of Dr. A. B. Walkom which deservedly takes its place of

honour with the portraits around our walls of other men distinguished for their association with the Linnean Society."

Dr. Walkom thanked the President and members of the Council and expressed his appreciation of the honour conferred on him.

PRESIDENTIAL ADDRESS.

A Survey of Australian Ichthyology.

The Address briefly traces the history and development of the study of Australian Fishes from early historical times to the present. Some indication is given as to how various aspects of the subject have been treated. A modern list of species is appended, with a bibliography. (For full text see pp. 11 et seq.)

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

President: Miss Elizabeth C. Pope, M.Sc., C.M.Z.S.

Members of Council: W. R. Browne, D.Sc., F.A.A.; S. J. Copland, M.Sc.; F. V. Mercer, B.Sc., Ph.D.; A. K. O'Gower, M.Sc., Ph.D.; S. Smith-White, D.Sc.Agr., F.A.A.; H. S. H. Wardlaw, D.Sc., F.R.A.C.I.

Auditor: S. J. Rayment, F.C.A.

The President then installed Miss Elizabeth C. Pope as President.

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

OBITUARY NOTICES.

WILLIAM BOARDMAN.

WILLIAM BOARDMAN, M.Sc., who had been a member of the Society since 1929, died in Victoria on 28th November, 1963. His scientific career began at the Australian Museum, Sydney, as a Cadet in 1922, when he worked in the Department of Lower Invertebrates, specializing in earthworms, about which he wrote several papers. He collected marine life when with the British Great Barrier Reef expedition at Low Isles in 1928. He resigned from the Australian Museum in 1939 to take up a position at the Australian Institute of Anatomy, Canberra. He obtained his M.Sc. degree in 1941, and in 1944 became part-time lecturer at Canberra University College. After a term as Senior Lecturer at the University of Queensland (1945-47), he transferred to Melbourne University, spending 1948-49 at Mildura. He visited England in 1951-52, working at Birmingham, in the Strangeways Laboratory, Cambridge, and at the British Museum. The anatomy of marsupials and the hair tracts of various mammals were the subjects of his researches in the last twenty years. He contributed nine papers to the PROCEEDINGS between 1941 and 1950, most of them dealing with the hair tracts in marsupials.

LEO ARTHUR COTTON.

Emeritus Professor LEO ARTHUR COTTON, M.A., D.Sc., a member of this Society since 1908, died on 12th July, 1963, in his 80th year. Born in the far-west mining township of Nymagee, he received his early education at the old Fort Street Model School, and while employed as a draughtsman in the N.S.W. Department of Lands took an evening course in Arts at the University of Sydney, gaining the B.A. degree with 1st Class Honours in Mathematics. In 1905 he entered the Faculty of Science and graduated with 1st Class Honours in Geology, having also distinguished himself in Physics. At the end of 1908 he accompanied the Shackleton Expedition to the Antarctic, returning early next year. Elected to a Linnean Macleay Fellowship in 1909, he studied the mode of occurrence and genesis of the tin and diamond deposits of western New England, and after two years as Fellow was appointed to a University Lectureship in Geology. During World War I, while Professor David was on service abroad, and later when he was on leave prior to retirement, Cotton acted as head of the Geology Department, but still contrived to interest himself in research. He was awarded the degree of M.A. in 1916 and in 1920 that of D.Sc.; in the same year he was given the title of Assistant Professor. On David's resignation at the end of 1924, he was appointed to the Chair of Geology, which he occupied until his retirement at the end of 1948. Cotton's chief geological interests lay in problems involving the application of mathematical and physical principles, such as polar wanderings, isostasy, orogenesis and the strength of the earth's crust; much of his published work dealt with such topics. During the filling of Burrinjuck Reservoir he examined by means of recording pendulums the crustal response to loading, and for his D.Sc. thesis investigated the relations between earthquakes and tidal stresses. He made a practice of lecturing to students of all years and of leading their field-excursions, and they came into personal contact with him. His department staff recognized in him a just and capable administrator, a sympathetic counsellor and a warm personal friend. The needs of a growing department absorbed most of his attention, but under his supervision research was carried on by members of his staff and by graduates, some of whom afterwards became Linnean Macleay Fellows; indeed, at one time three out of four Fellowships were being held by graduates of the Geology School.

Cotton was for some years Dean of the Faculty of Science in the University, and served as councillor and president of the Royal Society of New South Wales, as chairman of the Australian National Research Council and as a member of the Editorial Committee of *The Australian Journal of Science*. He presided over Section C of the Australian and New Zealand Association for the Advancement of Science in 1932 and was Clarke Lecturer of the Royal Society of New South Wales and Macrossan Lecturer of the University of Queensland. His name is perpetuated in the L. A. Cotton School of Geology in the University of New England.

ROBERT LANGDON CROCKER.

Professor ROBERT LANGDON CROCKER, D.Sc., Professor of Biology, of the Botany Department, University of Sydney, died suddenly on 20th June, 1963. He had been elected to membership of the Society in May, 1955, was elected to Council in June, 1956, and resigned as a Councillor on 29th August, 1962. Professor Crocker was born at Peterborough, South Australia, in July, 1914. His secondary education was received at Scotch College, Adelaide, where, in addition to his scholastic achievements, he became the College's leading athlete. On coming up to the University of Adelaide, his original inclinations were towards Agricultural Science, or Forestry, possibly being influenced by his home background, for he was the son of a farmer in the marginal farming land of South Australia. He became interested in Geology and Botany, and at graduation in 1935 seemed likely to make his career in Geology. His close friendship with the late Professor J. G. Wood, then Professor of Botany at Adelaide, swung the balance in favour of plants. He joined the staff of the Division of Soils, C.S.I.R., in 1936, but later transferred to the Agronomy Department of the Waite Institute. He was a member of the first expedition to cross the Simpson Desert in 1939. During the war years 1940-1943, he was an explosives chemist attached to the Ministry of munitions. In 1947, he was awarded a D.Sc. by the University of Adelaide for his contributions to ecology and soils. He then spent two years in Cambridge and travelled as a Fellow of the Rockefeller Foundation. Upon return to Australia, he was appointed Reader in Grassland Ecology with the University of Adelaide. In 1950 he joined the staff of the University of California at Berkeley as Associate Professor of Soil Morphology, and was made a Full Professor in 1951. He was invited by the University of Sydney to the Chair of Botany in 1954. Professor Crocker published over thirty papers. His work is a major development of the philosophy of the science of soils and plant ecology, especially in their conjuncture. In his chosen field, his achievements made him the spokesman of the times. An account of Professor Crocker's work appears in *The Union Recorder* (published by the Sydney University Union), Vol. XLIII, No. 17, p. 185, August 1, 1963.

GEORGE ALOYSIUS MAKINSON HEYDON.

GEORGE ALOYSIUS MAKINSON HEYDON, M.C., B.A., M.B., Ch.M., D.P.H., D.T.M. & H., F.R.A.C.P., who died in Sydney on 27th April, 1963, at the age of 81, had been a member of the Society since 1930. He was born at Gladesville, New South Wales, in 1881, the son of Mr. Justice Charles Heydon, a judge of the Arbitration Court of New South Wales, who had succeeded Sir Edmund Barton as Attorney-General of New South Wales. He was educated in Sydney and England, returning to Sydney to commence his medical studies. He took his degrees of M.B., Ch.M., in 1908 and was Resident Medical Officer of a number of hospitals in Sydney, later serving in World War I at Gallipoli and in France with the Australian Medical Corps (Australian Imperial Force). He served again in World War II as Consultant Parasitologist to Australian Army Headquarters. He then joined the laboratory service of the Commonwealth Health Department, being appointed to Rabaul, New Guinea, and serving from 1921 to 1925. In 1925 he transferred from New Guinea to the Australian Institute of Tropical Medicine at Townsville. His work was now particularly centred on parasitology, in which he specialized henceforth. In 1930, when the Institute was

incorporated in the newly established School of Public Health and Tropical Medicine at the University of Sydney, Dr. Heydon became Parasitologist to the School and University Lecturer in Medical Parasitology, holding these appointments until his retirement in 1946. (For a full biography see *The Medical Journal of Australia*, 1963, Vol. 2, p. 465, September 14, 1963.)

EMIL HERMAN ZECK.

EMIL HERMAN ZECK, F.R.Z.S., who died in Sydney on 3rd September, 1963, had been a member of the Society since 1936. He contributed, with the late H. J. Carter, two papers to the Society's Proceedings, one in 1937—"A Monograph of the Australian Colydiidae"—and the second in 1941. Mr. Zeck was born in Sydney on 16th November, 1891, and, except for a period of six months spent in Mexico in 1926, lived there until his death. He entered the N.S.W. Public Service in 1908 as a cadet entomological and biological artist, but transferred to the Department of Agriculture in 1923 as an entomologist, from which position he retired in 1956. Mr. Zeck's work in entomology covered a very broad field and a bibliography of his publications exceeds three hundred titles in many journals. He had experience in teaching entomology at Hawkesbury Agricultural College and Sydney Technical College and, during the second World War, lectured to army personnel on the control of insect pests of foodstuffs. He was awarded the Australian Natural History Medallion for 1961 in recognition of his outstanding entomological work which included taxonomic studies. He rendered good service to scientific societies and, apart from filling the position of President of the Naturalists' Society of New South Wales, was also editor of the *Australian Naturalist* for many years. His work as an artist in illustrating articles on insects was outstanding. For more detailed biographical notes see *The Australian Journal of Science*, Vol. 25 (1), p. 432 (1963), and *Victorian Naturalist*, Vol. 80 (5), p. 128 (1963).

GENERAL ACCOUNT. Balance Sheet at 29th February, 1964.

LIABILITIES.			ASSETS.		
Accumulated Funds—			Fixed Assets—		
Amount received from Sir William Macleay during his lifetime ..	£	s. d.	Commonwealth Loans, at cost ..	£	s. d.
Further sum bequeathed by his will ..	14,000	0 0	Debentures: Metropolitan Water, Sewerage and Drainage Board, at cost ..	15,048	10 0
	6,000	0 0	Science House (one-third share), as cost ..	10,844	7 6
Contingencies Reserve ..	20,000	0 0		14,835	4 4
	17,930	11 4			
Current Liabilities—					40,728 1 10
Bookbinding Account ..	946	1 1	Current Assets—		
Income Account ..	4,377	5 7	Cash in hand ..	10	0 0
Suspense ..	8	4 4	Commercial Banking Company of Sydney, Ltd. ..	2,524	0 6
	5,331	11 0			2,534 0 6
					£43,262 2 4

INCOME ACCOUNT. Year Ended 29th February, 1964.

INCOME ACCOUNT. Year Ended 29th February, 1964.			INCOME ACCOUNT. Year Ended 29th February, 1964.		
To Salary ..			By Balance from 1962-63 ..		
" Printing Proceedings ..	£	s. d.	" Subscriptions: ..	£	s. d.
" Printing Reprints ..	1,940	16 5	" 1963-64 ..	430	10 0
" Illustrations ..	813	13 0	" Arrears ..	39	18 0
	325	14 6	" In Advance ..	12	12 0
	3,080	3 11			
" Insurance ..	12	17 2	" Entrance Fees ..	483	0 0
" Postage ..	139	13 4	" Interest ..	11	11 0
" Petty Cash ..	37	4 4	" Science House ..	1,308	3 8
	176	17 8	" Rent ..	1,174	2 8
" Audit ..	16	16 0	" Sales ..	16	15 0
" Printing and Stationery ..	148	3 10	" N.S.W. Government Grant ..	1,587	16 6
" Expenses ..	202	14 11	" Fellowships Account (surplus income at 29th February, 1964, transferred) ..	200	0 0
" Legal Expenses ..	7	7 0	" Bank Expenses ..	1,207	1 2
" Cleaning ..	64	7 0	" Sale of Reprints ..	676	12 4
" Library ..	35	6 1	" Postcard Sales ..	5	5 0
" Conversazione ..	62	18 1			
" Balance to 1964-65 ..	537	12 11			
	4,377	5 7			
					£8,990 17 3

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 29th February, 1964, and certify that the above Balance Sheet and accompanying Income Account are correct, and in accordance therewith, and in my opinion present the true state of the Society's affairs at 29th February, 1964, as shown by the books. Certificates of the investments have been inspected.

S. J. RAYMENT, F.C.A., Chartered Accountant, Auditor.

Registered under the Public Accountants Registration Act, 1945, as amended.

LINNEAN SOCIETY OF NEW SOUTH WALES.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

Balance Sheet at 29th February, 1964.

LIABILITIES.		ASSETS.	
Accumulated Funds—		Fixed Assets—	
	£ s. d.		£ s. d.
Amount bequeathed by Sir William Macleay ..	35,000 0 0	Commonwealth Loans, at cost ..	30,442 15 0
Surplus Income Capitalized ..	22,856 3 4	Debtures:	
		Metropolitan Water, Sewerage and Drainage Board, at cost	16,648 9 9
		Rural Bank of N.S.W., at cost	2,172 15 0
		State Electricity Commission ..	2,500 0 0
		Loan on Mortgage ..	6,035 0 0
			57,798 19 9.
		Current Assets—	
		Commercial Banking Company of Sydney, Ltd. ..	57 3 7
			£57,856 3 4

INCOME ACCOUNT. Year Ended 29th February, 1964.

	£ s. d.		£ s. d.
To Salary of Linnean Macleay Fellow ..	1,500 0 0	By interest ..	2,807 1 2
" Research Expenses ..	87 0 0		
" Capital Account ..	13 0 0		
" Balance, being Surplus Income transferred to General Account ..	1,207 1 2		
	£2,807 1 2		£2,807 1 2

AUDITOR'S REPORT TO MEMBERS.

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S. J. RAYMENT, F.C.A., Chartered Accountant, Auditor.
Registered under the Public Accountants Registration Act, 1945,
as amended.

A. B. WALKOM,
Hon. Treasurer.

Sydney, 9th March, 1964.

2nd March, 1964.

LINNEAN SOCIETY OF NEW SOUTH WALES.

BACTERIOLOGY ACCOUNT:

Balance Sheet at 29th February, 1964.

[illegible]

INCOME ACCOUNT. Year Ended 29th February, 1964.

	£	s.	d.
To University of Sydney (towards salary of Lecturer) ..	925	0	0
Balance to 1964-65 ..	230	11	2
	<hr/>		
	£1,155	11	2
	<hr/>		
By Balance from 1962-63 ..	229	17	8
" Interest ..	925	13	6
	<hr/>		
	£1,155	11	2

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 29th February, 1964, and certify that the above Balance Sheet and accompanying Income Account are correct, and in accordance therewith, and in my opinion present the true state of the Society's affairs at 29th February, 1964, as shown by the books. Certificates of the investments have been inspected.

S. J. RAYMENT, F.C.A., Chartered Accountant, Auditor,
Registered under the Public Accountants Registration Act, 1945,
as amended.

A. B. WALKOM,
Hon. Treasurer.

2nd March, 1964.

Sydney, 9th March, 1964.

PRESIDENTIAL ADDRESS.

A SURVEY OF AUSTRALIAN ICHTHYOLOGY.

By G. P. WHITLEY.

[Delivered 25th March, 1964.]

The word Ichthyology is generally taken to mean the science or study of fishes. A more engaging interpretation, at least to my mind, was supplied as long ago as 1836, when *The British Cyclopaedia of Natural History* ("by authors eminent in their particular departments" and therefore anonymous) stated that Ichthyology "means 'the voice of the fishes' or the account they can give of themselves, not in words, of course, for fishes are remarkable for their silence, but in such facts and relations as human observation can collect concerning them".

Nowadays we know, as our eminent nineteenth-century authors did not, that fishes can make enough noise to confuse the hydrophones of submarine listeners, but our ears do not normally hear them. So, deaf to their protests, I presume to act as their spokesman and shall try briefly to survey the "facts and relations" which have accumulated concerning Australian fishes over the last three and a half centuries.

The earliest documents about Australian fishes are the paintings and rock-engravings of the aborigines whose message now is silent as their subjects. Fish paintings dating back to the third millennium B.C. have been recorded from Baluchistan (Hora, 1956, *Mem. Indian Mus.*, 14 (2): 73, figs), but Australian aboriginal art is much younger, some of it extending into historical and even modern times.

Written records by white men refer back to A.D. 1606, when Prado in Torres Strait mentioned albacore and the floating eggs of fishes. The Dutch sailor, Carstenzoon, noted "sharks, swordfishes and the like unnatural monsters" in the same area and was delighted to find "plenty of delicious fish" in the Gulf of Carpentaria in 1623, but Tasman left no record we can trace of any Australian fish, even though he was the first white man to remark upon the humpback whale migration and he noted mussels in Tasmania.

The Dutch seamen, with Willem de Vlamingh on his visit of 1696-7 to Western Australia, observed a remarkable fish, about two feet long, with a round head and sort of arms and legs, and even something like hands. Perhaps this was an Angler fish.

When Dampier paid his second visit to Australia, in the "Roebuck" 1699, he had aboard an artist who drew fishes and other animals. The engravings from these drawings, published in Dampier's *Voyage to New Holland* in 1703, are the first known published pictures of Australian fishes. Bougainville noted a flying fish from a locality well eastward of the Great Barrier Reef in June, 1768.

Lieutenant James Cook, in the "Endeavour" 1770, noticed various fishes in eastern Australia, and the manuscripts and drawings then made by Banks, Solander and Parkinson are in the British Museum.

Marion du Fresne and François de Saint Allouarn noted some fishes from Tasmania and Western Australia respectively in 1772, the latter observing from Dirk Hartog's Bay, Western Australia, the poisonous toadfishes there. Captain Cook was poisoned by similar toadfishes in New Caledonia in 1774, but happily survived so that on his third voyage, William Anderson and William Ellis were able to describe Tasmanian fishes in a manuscript which is in the British Museum. The earliest description of an Australian flathead dates from this period.

The First Fleet naturalists made paintings, some still in existence, of Sydney fishes, and made known such interesting species as the Port Jackson Shark, the Five-fingers (now Morwong), Watts's Shark (Wobbegong) and Light horsemen (Snapper) and La Perouse's men caught nearly 2,000 "Light horsemen" in one day. The first published pictures of New South Welsh fish appeared in Phillip's *Voyage to Botany Bay*, 1789, soon followed by White's *Journal* and a host of other natural history publications.

The first printed list of Australian fishes was C. P. Thunberg's *Fauna Novae Hollandiae* (Upsala, 1822), but that only specified two sharks. Actually quite a few Australian species were known to science by the end of the 18th century.

In Collins' *Account of the English Colony in New South Wales* we can read of the first fisheries enactments for the new settlement. Any modern visitor to Botany Bay can still see the identical species of fishes mentioned in the journals of Cook, Banks, Phillip and the early French naturalists.

Linnaeus' *Systema Naturae*, the foundation for animal classification, was found insufficient to classify and name the new Australian animals, so Broussonet in 1780, and later Bonnaterre and Gmelin, Meyer, Forster and Latham, each added a few new species.

Shaw and Nodder from 1790 to 1810 published their *Naturalists' Miscellany* with over a thousand plates; in this work a number of fishes from the "Southern" or "Antarctic" seas, "New Holland" or the "Southern Ocean" are clearly recognizable as Queensland or Botany Bay species, evidently from Cook, White and other 18th century Australian collectors.

In 1791 Archibald Menzies described in manuscript new fishes from King George Sound, and George Tobin in 1792 painted and noted Tasmanian animals on Bligh's voyage.

At the beginning of the nineteenth century, Baudin's expedition with the ships "Geographe" and "Naturaliste" thoroughly explored much of our coastlines. The chief zoologist, René Maugé de Cely, was very ill and died in Tasmania in 1802, so the natural history was attended to by François Péron. He noticed that shells, fishes and other marine animals differed in such localities as, for example, Sydney, Tasmania, Kangaroo Island and Sharks Bay, and sought their limits of distribution. He collected and described many hundreds of specimens, many of which were painted by his friend and colleague Charles Alexandre Le Sueur. Their manuscripts and drawings have never been published in full and, having survived the ravages of war, are stored in Le Havre, France. So exquisite was Le Sueur's draughtsmanship that he would hand a visitor a lens so that he might examine the brush-strokes in his paintings in which every hair, feather or scale was truly delineated. He lived from 1778 to 1846. Other phenomenally gifted painters of Australian fishes were Ferdinand Bauer (1760-1826) whose work I have admired in the British Museum (fishes painted during the Flinders Expedition) and James Stuart (1802-1842), a quarantine official whose paintings are a valued possession of the Linnean Society of New South Wales.

Lacépède included in his *Histoire Naturelle des Poissons* from 1798 onwards such Australian fishes as were known to him and in 1804 he described specimens from Baudin's voyages. After the French Revolution, the popular demand for knowledge was so great, that encyclopaedias and dictionaries of natural history were issued in many volumes and, in these, from Bosc (1804) onwards, were incorporated numerous accounts of strange Australian fishes. Fréminville, Cuvier and others in France also published papers on them.

In England, Shaw's *General Zoology*, Turton, Perry's *Arcana* and Bullock's various synopses of the contents of his Museum all contained Australian fishes, as also did Donovan (1823).

In Australia, Thomas Skottowe had compiled by 1817 his manuscript and drawings illustrating the natural history of Newcastle, New South Wales.

Other batches of explorers and naturalists visited our shores: Quoy and Gaimard (1824), P. P. King, R. P. Lesson, Eydoux and Souleyet, until the 1820s culminated in the researches of Cuvier who had published his *Règne Animal* and was producing, with Valenciennes, their classic *Histoire Naturelle des Poissons* in 22 volumes with 650 coloured plates.

As the 1830s passed, the infant Australian Museum in Sydney was being directed by George Bennett.

The overland explorers made known our freshwater fishes. When G. W. Evans crossed the Blue Mountains in 1813, he named the Fish River in which he mentioned the presence of "trout". This is the first reference to the famous Murray Cod, so Evans blazed the trail which led to the discovery of the unique fish-fauna of the vast Murray River system, stretching from South Australia to Queensland. Oxley gave the first detailed account of the Murray Cod. T. L. Mitchell inserted excellent drawings of catfish, cod and silver perch in his journals; and Sturt, Cunningham and even Eyre mentioned the fish they gratefully ate.

In Germany, Müller and Henle were pioneering anatomical and taxonomic work on such primitive creatures as the hagfishes, sharks and rays. Swainson produced his volumes on fishes, amphibians and reptiles, and sought to justify his quinary scheme, one of the systems destined to fall by the wayside when Darwin (who was in Australia in 1836) later promulgated his more acceptable theories. The fishes of Darwin's voyage of the "Beagle" were described by Jenyns. Explorers and collectors of the 1840s were Stokes, Dring, and Emery; Neill, Miles, Gilbert, Gould and Leichhardt.

Perhaps the first native-born Australian ichthyologist was Dr. Edmund Charles Hobson (1814-1848), author of a paper on the Elephant Shark in the first number of the *Tasmanian Journal*, 1842.

Next John Richardson towers over the scene. He wrote *Icones Piscium*, describing the novelties from north-western Australia; he received fishes and drawings (even some from convicts) in Tasmania and compiled for the British Association for the Advancement of Science lists of the fishes of Australia and New Zealand; his account of the fishes in the *Voyage of the "Erebus and Terror"* (1844-1848) is still in constant use in Australian ichthyology.

The Dutch ichthyologist, Peter Bleeker, perhaps of all ichthyologists *facile princeps*, wrote 500 detailed papers apart from his massive *Atlas Ichthyologique*, but only about one per cent of them, unfortunately, were of Australian fishes.

Hombron and Jacquinot (1853) were about the last of the French naturalists who seemed to come to Australia in pairs (Peron and Lesueur, Quoy and Gaimard, Lesson and Garnot come to mind).

The 1860s was the age of Acclimatization Societies, so that many foreign fishes were introduced into our waters, often with dire results in due course. The *Zoological Record* had started its noble task which is still proceeding after a hundred years. Several scientific societies had sprung up in Australian capital cities. Rev. G. J. Bostock was collecting in Western Australia.

Another giant to follow Cuvier, Richardson and Bleeker was Albert Gunther of the British Museum who, in his many papers, but particularly in his eight volume *Catalogue of the Fishes in The British Museum*, made it possible for zoologists all over the world to name their fishes. The appearance of this work between 1859 and 1870 enabled a school of Australian zoologists to emerge. However, at the same time or soon afterwards, continental ichthyologists were describing fishes sent, overseas. Peters in Berlin, Klunzinger in Stuttgart, Steindachner in Vienna and the workers in Paris were all contributing to Australian ichthyology independently so there was some confusion, which I tried to a small extent to disentangle when I visited all those places in 1937 and examined as many of their actual specimens as time allowed. Kaup and Kner also published descriptions of new species.

Johann Ludwig Gerard Krefft (1830-1880) was born in Brunswick, Germany, and came from America to Victoria in 1852 to try for gold. In 1857 he accompanied

Blandowski's now almost forgotten expedition* to the Murray River as naturalist and draughtsman. In 1860 he joined the staff of the Australian Museum and was curator from 1861 to 1874 with residence in the Museum building. Krefft sent a collection of Australian fishes to the International Exhibition in 1862 and helped Gunther, who was writing his monumental *Catalogue*, by sending him Sydney specimens. Krefft himself wrote several papers on Australian freshwater fishes, but his most dramatic discovery was first revealed in a letter he sent on 17th January, 1870, to the *Sydney Morning Herald* announcing the finding of an "amphibious creature inhabiting northern streams and lagoons. . . . I have named this strange creature *Ceratodus Forsteri*"; this was the now world-famous Queensland Lungfish. Teeth of similar animals had been found fossil in various parts of the world, but there was the "living fossil", so much unlike anything that had been imagined that Louis Agassiz wrote to Krefft: "My fossil sharks are sharks no longer." Krefft died at Woolloomooloo, Sydney, just after his fiftieth birthday, on 19th February, 1880.

Another German, Schomburgk, collected in South Australia. Some new Australian fishes resulted from the German "Gazelle" Expedition of 1875 and the British H.M.S. "Alert" in 1881.

Hollard, Duméril, Guérin-Ménéville, Thiollère, Guichenot pursued their individual lines in France and the Italian, Canestrini, described and figured an Australian Boarfish.

In the United States, Theodore Gill brought the light of his accuracy and industry to bear on taxonomic and bibliographical problems, and wrote masterly papers setting the classification of fishes in order and correcting the errors or slipshod work of earlier authors. Cope named some presumably Australian fishes in Philadelphia.

Count Castelnau forsook insects to study fishes when he became French Consul at Melbourne, and McCoy produced his excellent *Prodromus* with many illustrations of Victorian fishes unexcelled to this day.

Allport was interested in what we should now call bionomics of Tasmanian fishes.

Then Sir William Macleay came on the scene: first with a paper as joint author with Dr. Haynes Gibbes Alleyne on the fishes of the "Chevert" expedition to New Guinea; later, as an independent author, he contributed papers and his *Descriptive Catalogue of Australian Fishes* to the pages of our Linnean Society's Proceedings, the *Catalogue* being a definitive work based not only on literature but on his extensive private collections.

But ichthyology never stands still. In the 1880s the results of the great "Challenger" expedition were being made known by Gunther. In Australia, De Vis, Haacke, Zietz, R. M. Johnston, Morton and Ramsay were building up on the foundations laid by Gunther and Macleay.

Interest in the fishing industry was aroused in 1880 by the Royal Commission on the Fisheries of New South Wales which for the first time assembled reliable information from scattered sources. The Rev. J. Tenison-Woods wrote his *Fish and Fisheries of New South Wales*, published in 1882, in readiness for the London International Fisheries Exhibition which called attention to fishes as a world economic proposition. Ramsay was in charge of the Australian exhibit which included a giant sunfish from Sydney named in honour of Ramsay by the Italian zoologist, Giglioli.

In Paris, Thomillot and Sauvage in the 1880s were producing descriptions of new Australian species.

James Douglas Ogilby began in the 1890s his fine series of careful descriptions of Australian fishes: a bibliography of his work appeared in *Records of the Australian Museum*, 15 (2), 1926: 149, with portrait.

Lucas named some Victorian rock-pool fishes encountered during his studies of algae. Regan, of the British Museum, began a series of papers on classification and osteology, and France was represented by Vaillant who described new species. In

* William Blandowski wrote an account of fishes of the Murray River which has not been published because it was held to contain unflattering references to Melbourne notabilities of the time.

passing, we are struck by the world-wide flavour, through the decades of "Australian" ichthyology. Our fishes engage the interest of people in faraway lands as much as of local students. A Russian publication dealing with South Australian fishes now unexpectedly appears, in which Herzenstein (1896) describes new species collected by Schneider.

The trawling activities of the "Thetis" were the subject of *Australian Museum Memoir* 4, 1899-1914. Edgar Ravenswood Waite, in his introduction thereto, gave a valuable history of marine investigations in New South Wales.*

The twentieth century was gently ushered in by the publication in 1900 of Anderson's *Guide to Fishing in Tasmania*. David G. Stead became Naturalist to the Fisheries Department in Sydney and recorded many field notes from all over New South Wales. His voluminous writings included *Fishes of Australia* (1906), *The Edible Fishes of New South Wales* (1908), and the posthumously published *Sharks and Rays of Australian Seas* (1963). An account of his work is given in the *Proceedings of the Royal Zoological Society of New South Wales* for 1956-57 (1958: 8, with portrait). He was manager of the State trawling industry which, while not an outstanding business success, at least produced very many interesting marine specimens. The work of the Fisheries Inspectors in various States should not be forgotten; they have always been helpful to science.

In Queensland, James Tosh studied the eggs and young as well as the adult fishes of Moreton Bay. He later became Professor of Biology at St. Andrews University and was killed in Mesopotamia. Thomas Welsby, also in southern Queensland, left us a good deal of fish lore in his writings, notably his book *Schnappering*.

Garman in the United States compiled his great memoirs on Sharks and Rays. Jordan and Seale issued their *Fishes of Samoa* and H. W. Fowler was producing numerous taxonomic papers. All these American works were of immense value to Australian ichthyologists.

Parker and Haswell used Australasian sharks and fishes as anatomical examples in their now classic *Text-Book of Zoology*.

The Federal Government commissioned the trawler "Endeavour" to explore the continental shelf under the direction of the Norwegian, Harald Dannevig, from 1909 until the tragic loss of the vessel in 1914. Great collections of fishes were made and some groups were reported on by McCulloch, Norman and Raff, but there is still a good deal of material to be identified.

Another Scandinavian was Knut Dahl who explored north-western Australia and the Northern Territory; his fishes were recorded by Rendahl in 1922.

Praise must be given to Edgar R. Waite whose descriptions of our fishes were not only accurate but illustrated by good wash drawings from his own brush. A bibliography of his papers has been furnished by Hale (1928, *Rec. S. Aust. Mus.*, 3 (4): 345, with portrait).

It was Waite who trained A. R. McCulloch and the pupil improved on the master. McCulloch read and card-indexed everything that had been written about Australian fishes, he discovered new species which he described and illustrated so accurately and beautifully that there is little that can be added to his work.

Theodore Roughley, subject of a memorial notice by this Society (*Proc. Linn. Soc. N.S. Wales*, 86, 1962: 265 and portrait), when Economic Zoologist at the Technological Museum, Sydney, published in 1916 his *Fish and Fisheries of New South Wales*, beautifully illustrated in colour as well as black and white. He wrote and lectured extensively about the excellent edible qualities of Australian fish.

Interstate, in the 1910s, W. B. Alexander studied Western Australian species, and Bancroft experimented with the rearing of Queensland Lungfish. Albert Gale championed Australian freshwater fishes as aquarium subjects and recorded the breeding habits of some of the smaller eastern Australian ones.

* Complementary to this is Iredale's list of dredgings from New South Wales to Tasmania in *Rec. Austr. Mus.*, 14, 1925: 243, and map.

Abroad, Weber and de Beaufort in Holland continued their *Fishes of the Indo-Australian Archipelago*; Duncker in Germany brought order into the classification of pipefishes (Syngnathidae) and Cockerell studied scales.

In 1916 appeared the first part of Bashford Dean's monumental *Bibliography of Fishes* which was completed with part three in 1923 and has laid the world of ichthyology under obligation since. An even more colossal undertaking of this period was Sherborn's *Index Animalium*, recording all the scientific names in the animal kingdom proposed between 1758 and 1850. With Dean, Sherborn and the *Zoological Record*, a good deal of ichthyological work was indexed, but there remained a "no man's land" between 1850 and the early 1860s and a good deal of detailed analysis of literature to be done before even a list of Australian fishes could be prepared. McCulloch had his thousands of card-index slips and a name-list in manuscript, so the latter was elaborated upon and published in 1929-30 as a Check-list of the fishes recorded from Australia in *Austr. Mus. Mem.* 5.

The 1920s had been marked by steady work in the post-war years: Norman monographed the flatfishes though he was fated to produce only volume 1. Rendahl wrote on remote north-western Australian freshwater fishes obtained by Dahl; Nichols and Raven on those of the then almost as remote streams of Queensland. Hale was studying pipefishes with Waite; Longman was interested in Queensland fishes, Glauert in those of Western Australia, while Lord and Scott wrote a book about Tasmanian vertebrates. Johannes Schmidt arrived from Denmark to study freshwater eels (*Anguilla*) and to arrange for the visit of the "Dana" expedition, which made notable discoveries in the Tasman Sea.

In 1927 Taronga Zoological Park opened its Aquarium to public view and studies there over the years have yielded information on growth, longevity and variation amongst fish, and thrown light on the reproduction of sharks.

Professor C. Yonge was in charge of the Great Barrier Reef expedition to the Low Isles, Queensland. A naval surgeon, Lieutenant Commander W. E. J. Paradise, made large collections of fishes in the Northern Territory. McCulloch had died, but one may perhaps be pardoned for mentioning that his work was continued and built upon at the Australian Museum, whose collections were expanding, so that many new records of fishes and taxonomic adjustments had to be made over the years.

A milestone in our knowledge was the publication of the "Map of Fisheries" prepared by the Development and Migration Commission for the information of the members of the Australian Fisheries Conference, 1929. Later the work of the Commission was taken over by the Fisheries Division of the Council for Scientific and Industrial Research in its laboratory at the old Fisheries Department hatchery at Cronulla, New South Wales.

In the 1930s sharks were being sought commercially by Norman Caldwell and others and it was noticed that large ones could be quickly diminished in numbers by meshing a particular region. Because of the danger of shark attacks, a Shark Menace Advisory Committee was set up under the chairmanship of Judge (now Sir) Adrian Curlewis.

Big-game fishing, practised for some time by a few enthusiasts, received an impetus from the visit of Zane Grey who wrote books on his angling experiences as well as the novels for which he was famous; fishes of unwieldy size were becoming accessible for study and inevitably it was found that their classification needed revision.

Fraser-Brunner revised the Plectognathi, Chabanaud the soles, Regan and Trewavas the deep-sea fishes from the "Dana", Bertin the leptocephalus larvae of eels and the type-specimens of fishes in the Paris Museum, Tortonese catalogued the fishes of the "Magenta" expedition of the 1860s, Miss Erna Mohr reviewed the "Dana" Centriscidae, and Carl Hubbs listed blind fishes.

Dakin and Colefax investigated at first hand the plankton of the Tasman Sea and the flatheads (Platycephalidae) caught by the trawlers. Dr. H. Leighton Kesteven proposed some new interpretations of the bones of fishes, based on the skulls of local

species. In New Zealand, Phillipps' papers had an Australian bearing. Mack in Victoria, E. O. G. Scott in Tasmania, T. C. Marshall in Queensland, Moorhouse in South Australia were investigating fishes, Walford in the Blue Mountains found that *Galaxias coxii* bred in fresh water; it was generally held before this that *Galaxias* was obliged to descend to the sea to breed. Evans investigated the food of fishes in Tasmania.

Material was collected on the Great Barrier Reef by Iredale, McNeill, and Melbourne Ward.

Japanese vessels visited our tropical waters in the 1930s, but, apart from some exquisite coloured postcards illustrating *Nemipterus* and other genera, I have not traced any ichthyological results from their surveys.

The original scientists associated with the C.S.I.R. Marine Biological Laboratory, Cronulla, New South Wales, were Dr. Harold Thompson, Chief; and Research Officers Stanley Fowler, Serventy, Blackburn, Tubb and others, later joined by Geoffrey Kesteven. The "Warreen" was the first of a number of research vessels employed in field work.

World War II delayed research to some extent, but opened other avenues. Fisheries activities were organized to supply fish for consumption in the Commonwealth, sharks were studied not only as enemies of man, but as sources of vitamin-rich oil; anti-submarine patrols by aeroplanes were sometimes used for fish-spotting as well; poisonous and harmful fishes were studied from the serviceman's point of view. A case of fatal stabbing by a stingray was reported by Wright-Smith.

In 1947, chiefs of interstate Fisheries Departments conferred in Sydney and reached general agreement on the vernacular names (hitherto very confused) to be used for commercial fishes in all States of the Commonwealth.

In the 1940s, Dunbavin Butcher studied the food of freshwater fishes of Victoria; Ian Munro worked on eggs and larvae as well as revising the breams and Spanish mackerels, Geoffrey Kesteven examined the mullet in great detail, Elizabeth Pope demonstrated the anatomy of the Port Jackson Shark, that interesting "living fossil" whose hatching and growth were recorded by Jacups; and Shipway made field observations on freshwater fishes in Queensland and Western Australia. Cleland studied the biology of whiting (*Sillago*) and Stokell, from New Zealand, threw light on our *Galaxias*. Tom Iredale's bibliographical researches may be mentioned here; although primarily dealing with ornithological and conchological subjects, his work is of great value in other branches of zoology and his inspiration to workers in many different branches of natural history should never be overlooked. In 1940, a book on Sharks and Rays was published by the Royal Zoological Society of New South Wales; it was intended as the first of a series of volumes on Australian fishes, but financial stringency prevented further publications.

Overseas, Chabanaud continued on the soles, Ege revised *Chauliodus* (his work was later (1952) elaborated by Haffner) and J. T. Nichols wrote the results of the Archbold Expedition to Cape York.

A joint American and Australian expedition to the Northern Territory spent some time there in 1948, but the results of the fish collecting have not yet come to hand, though a few new records therefrom have strayed into American reviews of various families of fishes.

By the 1950s ichthyologists were becoming more specialized and generally were revising smaller groups of genera and species. In a museum, one has to work on a huge shark one day, a small blenny the next, or sort a collection from some tropic reefs which may contain a hundred species of almost as many genera.

C.S.I.R. had been established as C.S.I.R.O. in 1949 and now produced a handbook *Australian Fisheries* reviewing that subject; this is now a very rare book. In that organization, Blackburn worked on anchovies, pilchards, Tasmanian whitebait, barracouta and fisheries generally. J. P. Robins was making observations at sea on the occurrence of tuna in relation to surface-temperatures. The main taxonomic work on tunas was continued by Serventy. Cowper found a new gadoid from the rich fish-fauna being opened up by line-fishing, in greater depths than before, to the south-east

of Tasmania. Munro studied various families and the eggs and larvae of flying fishes, and in 1956 commenced his Handbook of Australian Fishes in *Fisheries Newsletter*, but this enterprise unfortunately lapsed (at least temporarily) when about one thousand species had been dealt with. J. M. Thompson and G. Kesteven worked on mullets and Kurth on flatfishes. The death of W. S. Fairbridge deprived science of a promising young man who had studied flathead, snapper, "salmon" (*Arripis*) and the effects of over-fishing on the trawling industry.

Dr. (now Sir Victor) Coppleson reviewed cases of shark attacks since 1919 and formulated theories as to times when attacks might be expected, dependent on locality and water-temperatures. Colefax's Presidential Address to the Linnean Society of New South Wales discussed scale structure in fishes.

George Coates, a naturalist and angler who painted accurate representations of tropical fishes, brought out the second edition of his *Fishing on the Barrier Reef*.

E. O. G. Scott continued his Tasmanian ichthyological studies and T. D. Scott commenced some contributions on Western and South Australian fishes.

A fatal case of poisoning through eating toadfish in Tasmania revived interest in ciguatera or ichthyotoxismus (C. Duncan, 1951; Whitley, 1953). Dr. Flecker of Cairns studied Stonefishes.

The Australian Museum produced a list of type-specimens of all the recent fishes in its collections. In 1957, *Australian Science Abstracts* ceased publication; for some twenty-five years these had afforded a detailed, annotated list of zoological papers as they appeared, and so are of value to the future historian of that period. The new *Australian Encyclopaedia* in 1958 contained articles and illustrations of fishes and fisheries.

The Danish "Galathea" expedition, directed by Anton Bruun, worked in Australian waters, but full results of the important catches made have not yet been published. Japanese research ships were again busy and fishermen from Japan exploited the tunas, swordfishes and other species off Australian shores. The lesser fishing activities in our waters by Indonesians were discussed by Serventy (1952).

A voice from the past was heard as H. W. Fowler (1953) catalogued for publication the Australian fishes from the United States Exploring Expedition of 1838 to 1842.

Overseas workers in the 1950s continued: Fraser-Brunner turned his attention to Hammerhead Sharks, mackerels and Chandidae. Koumans's studies on gobies and gudgeons were incorporated in his volume on the order Gobioidae in Weber and Beaufort's *Fishes of the Indo-Australian Archipelago*, 10 (1953), mentioning many Australian types.

Other overseas workers of the 1950s who touched Australian ichthyology were: J. C. Briggs (clingfishes), Kähnsbauer (pipefishes), Randall (surgeon-fishes), Thines (blindfishes), Arnold (Carapidae) and the brilliant Denys Tucker (Trichiuridae); Barton described a new *Siganus* and Meinken figured aquarium fishes. Bertelsen's classic papers on deep-sea (bathypelagic) angler fishes mentioned *inter alia* a number of New South Wales forms newly discovered in Australian waters by the Danish "Dana" Expedition of 1929.

Game-fishermen were becoming interested for purposes of record in the exact identity of their catches, so Lamonte (1955) reviewed the Marlins, a very difficult group, whose final classification has still not been decided on.

The appearance in 1953 of the first of the volumes on fishes from the American "Operations Crossroads", by Schultz and others, was in its way another milestone in the study of our coral reef fishes, for whilst these *Bulletins* of the U.S. National Museum describe and figure fishes primarily from the Marshall and Marianas Islands, numerous Australian species are keyed or their data tabulated, sometimes from fresh sources of information.

The 1960s are still too close for contemplation. This is a period of rapid travel when ichthyologists can come from all over the world to collect or compare specimens.

The use of underwater breathing devices has opened up new vistas in field work and the study of fish behaviour. Modern photographic techniques show us a new, more natural world of fishes, often in colour,* and one is tempted to regret that the technical advantages of today had not been available years ago so that greater progress in this fascinating subject could have been made.

The impression one receives (if anything as clear as an impression emerges) from this review of work on Australian ichthyology is that slowly, perhaps painfully, a great deal of worth-while information has been gathered together, often by devoted, poorly paid souls working in many countries and often under conditions of stress.

We have progressed from the observations of early explorers and natural history collectors, who were astonished by the novelty and strangeness of some of the fishes they found, to the more or less routine description of species by overseas and local zoologists. No definite limits can be set to the periods in which such work was carried out, indeed some is still continuing. The purely systematic approach prevails and ichthyological literature is still cluttered with synonyms and scattalia rather than résumés of information concerning particular fishes. Catalogues and check-lists slowly appeared. Fresh fishing techniques resulted in new captures, especially in the depths of the sea. Anatomical, physiological and skeletal work on Australian fishes is almost an untouched field. As in all branches of science it is important to know where to find the data which are already published. In an attempt to help in this regard, a subject-index, following the lines of that in Dean's *Bibliography of Fishes*, but adapted for modern Australian requirements, is appended to this address.

Australian ichthyological literature is marked by a series of fallen monuments, of many a part 1, or volume 1—never to be followed by subsequent numbers.

Not counting Macleay's *Descriptive Catalogue*, which was complete for its time, valiant efforts by Ogilby, Waite, McCulloch, Munro and others to prepare accounts of all our fishes have lapsed. Nonetheless good accounts of fishes of South Australia (Waite, 1923; T. D. Scott, 1962) and New South Wales (McCulloch, 1922) have appeared, and some success has been achieved by authors attacking piecemeal certain aspects of the whole.

A new trend is to compile a dossier or synopsis on one particular fish: J. M. Thompson (1963) on mullet and J. P. Robins (1962) on tuna are examples.

But work in the future will probably be planned by international committees and at the colloquium or symposium rather than by the individual worker.

There are probably well over 40,000 different species of fishes in the fresh and salt waters of this globe, referable to more than 600 families. At the end of 1883, Sir William Macleay noted the total number of Australian fishes as amounting to 1,291 species. More than eighty years later it is now nearer 2,450. Only 7.5% of the species of Australian fishes inhabit freshwater. Many Australian freshwater fishes are as worthy of conservation as koalas and gumtrees, kangaroos and waratahs, and should be preserved because of their unique interest.

Probably when all the deep-sea fishes are known and when we have identified and catalogued the planktonic larvae, we may find we have up to three or four thousand different kinds of Australian fishes. Even in New South Wales, where some seven hundred different fishes are well classified, it has been found that larvae, apparently plentiful in the plankton off-shore, belong to genera and families so far unrecorded from Australia.

Well may we agree with the poet Spenser:

"Oh! what an endlesse work has he in hand
Who'd count the sea's abundant progeny."

We have advanced a little in our knowledge since the eminent authors of the *British Cyclopaedia* whose quotation began this address, in which such "facts and relations" as human beings have collected concerning Australian fishes have been but

* A beautiful example is Gillett and McNeill's the *Great Barrier Reef*.

sketchily and imperfectly indicated by their spokesman who has been talking long enough; it is now time for him to join the fishes in being remarkable for their silence.

Submitted herewith as appendices* are: (A) An alphabetical subject-index on topics associated with Australian fishes; some ninety main headings lead the student to references on these. (B) A name-list of some 2,450 species; and (C) a bibliography.

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APPENDIX A: SUBJECT INDEX.

As the result of about forty years spent answering questions about fishes as ichthyologist to the Australian Museum, I found it useful to have a Subject Index, on cards, giving notes and references to literature on many different topics associated with fishes. Thousands of cards were accumulated, from which a selection of principal references cogent to Australian ichthyology has been extracted, as below, in the hope that this will be of use to future students.

The main source-books are, from the earliest times to at least the year 1920, Bashford Dean's "A Bibliography of Fishes", the third and final volume of which was published in 1923, and the "Zoological Record" down to recent years. The alphabetical arrangement of Bashford Dean's "Subject Index (Morphological and General Section)" is followed hereunder.

ABORIGINES.

[The association between aborigines and fishes is a very broad subject, at present being studied by F. D. McCarthy. I have scattered references to fishing implements: fish traps, nets, spears, hooks and the things used in their manufacture, sinkers, kierlies, and other devices. The aborigines not only ate fish but used their oil, bones, etc.

Remains of fishes (often groper, snapper and even porcupine fishes) are found in middens and rock shelters. The fish-bones were occasionally used as ornaments.

The aborigines depicted fishes in rock engravings, wood carvings, and bark paintings, many of which are reproduced in artistic and anthropological monographs. Vocabularies of native names for fishes appear in books of voyages and travels.

Old illustrations of aboriginal fishing methods are scattered in historical literature or in unpublished photographs.

Then there are countless legends about fishes, rites to increase fish, charms, dances and songs. Aborigines have been attacked by sharks and injured by other types of fishes. All this material has yet to be collated.]

ACCLIMATIZATION.

Fish-farming: Lake, 1962, *The Fisherman* (State Fisheries N.S.W.), Summer 1962: 1-7, figs. Kesteven, 1960, *Austr. J. Sci.* 23 (4): 125. Thomson, J. M., 1955, *Fisheries Newsletter* 14 (5): 17, illustr.

Introduced Fishes: Whitley, 1958, *Austr. Encycl.* Whitley, *Austr. Mus. Mag.* 10 (6), July 1951: 198. Whitley, *Austr. Mus. Mag.* 10 (7), Sept. 1951: 234. Whitley, *Austr. Mus. Mag.* 11 (11), Sept. 1955: 360. Shipway, 1953, *W.A. Nat.* 3 (8): 173. Stephenson, 1953, *Id. Notes* 2: 37. Seager, 1941, *N.S.W. Rod Fish. Soc. Gazette* 11 (5) and 11 (6): 1 & 5.

AERIAL OBSERVATIONS.

Anon., 1943, *Fisheries Newsletter* 2 (3): 13 and later issues. Ralph, 1942, *Vict. Nat.* 59: 131. Serventy, V., 1952, *Walkabout*, Aug. 1952: 16. Whitley, 1946, *Proc. Roy. Zool. Soc. N.S.W.* 1945/6, p. 17, figs. Julius a.o., 1937, *Eleventh Ann. Rept. C.S.I.R.*: 63 and later C.S.I.R. publications. Fowler, S., 1942, *Pacific Fisherman* 40 (10): 35, figs, and 42 (4), 1944: 39.

* A substantial anonymous donation made it possible to print these appendices.—Ed.

AESTIVATION.

Whitley, 1959, *Monogr. Biol.* 8: 138. Taylor, R., 1855, *Te Ika a Maui*: 652.

AGE.

Dakin, 1939, *Rec. Austr. Mus.* 20: 282 (flathead). Fairbridge, 1951, *Austr. J. Mar. Freshw. Res.* 2 (2): 156 (flathead). Hinton, 1962, *Zoologica* 47 (2): 105 (longevity of fishes). Jacups, 1943, *Proc. Roy. Zool. Soc. N.S. Wales* 1942/3, p. 11 (Port Jackson Shark). Parrott, 1932, *N.Z. J. Sci. Tech.* 14: 101 (trout in Victoria). Smith & Thomson, 1957, *Fisher. Dept. W. Austr. Monthly Service Bull.* 6 (11): 148. Walford (1941), *Austr. Mus. Mag.* 7: 236 (*Galaxias*). Whitley, 1940, *Fish. Austr.* 1: 52 (sharks). Anon., 1959, Eleventh Ann. Rept. C.S.I.R.O., 1958-59: 73 (school shark, 23½ years old).

AIR-BLADDER.

Kesteven, H., 1931, *Rec. Austr. Mus.* 18 (4): 167. Parker & Haswell, *Text-book of Zoology*: 229, fig. 905. Philipps, 1928, *N.Z. J. Sci. Tech.* 10 (4): 220, fig.

ANATOMY.

Parker & Haswell, 1962, *Text-book of Zoology* ed. 7, 2: passim, figs.

BACTERIA and fishes.

Ferguson-Wood, 1939, C.S.I.R. Pamph. 93. Ferguson-Wood, 1953, *Austr. J. Sci.*, Dec. 1953: 87, fig. 1.

BEHAVIOUR. (*See also* Commensalism, Locomotion, Migration, Reproduction, etc.)

Goadby (1959), *Sharks*, passim, photos. (sharks). Graham (1953), *Treasury of N. Zeal. Fishes*, passim. Kesteven, G., 1960, F.A.O. Indo Pacif. *Fisher. Symposium on fish behaviour*. Kondo, 1955, *Copeia* 1955 (3): 236 (bronsonian knot of eel).

There is also much general information in various books about the Great Barrier Reef.

BLIND FISHES.

[There may be blind fishes yet unnamed in Australian caves—certainly there are reports of them and specimens are required. One proved to be a pale *Salmo gairdneri*, however. These should not, of course, be confused with fishes whose eyes are affected by bore water after aestivation. *See also* aestivation and deep-sea fishes.]

Hubbs, 1938, *Carneg. Inst. Wash. Publ.* 491: 261, figs. Whitley, 1945, *Austr. Zool.* 11: 35, fig. 15 (*Milyeringa*). Whitley, 1959, *Monogr. Biol.* 8: 147. Thines, 1955, *Les Poissons Aveugles. Ann. Soc. Roy. Belg.* 86 (1): 1-128, figs 1-36 (includes Australian ones). *See his later papers too.* Wolf, 1934 onwards, *Animalium Cavernarum Catalogus*. Whitley, 1935, *Rec. Austr. Mus.* 19 (4): 244. Gianferrari, 1932, *Atti Soc. Ital. Milano* 71: 217. Norman, 1926, *Ann. Mag. Nat. Hist.* (9) 18: 324.

BLOOD.

Buchanan, 1916, *Proc. Roy. Soc. Vic. (n.s.)* 28 (2): 188, Pl. 18. Dakin, 1931, *Austr. Zool.* 7: 22. Dakin & Edmonds, 1931, *Austr. J. Exper. Biol. Med. Sci.* 8: 169. Molineux, 1885, *Trans. R. Soc. S. Austr.* 7: 82 (exuding of blood by sharks).

CAVE FISHES (*see* Blind fishes).

CENSUS.

Depletion and population studies: Blackburn, 1953, *Austr. J. Sci.* 15 (5): 151. Kesteven, G., 1947, *Nature*, Jan. 4: 10.

Numbers of species: McCulloch, 1914, *Biol. Res. Endeavour* 2 (3): 77. Whitley, 1927, *Austr. Mus. Mag.* 3 (3): 108. Whitley, 1941, *Proc. Roy. Zool. Soc. N.S.W.* 1940/1: 9.

[The present number of Australian species is about 2,450. The Australian Museum houses very approximately 50,000 specimens of fishes from all parts of the world.]

Correlations in rates of diversification: Small, 1952, *Proc. Roy. Soc. Edinburgh (Biol.)* 64 (3): 277.

CLASSIFICATION.

Berg, 1940, *Trav. Inst. Zool. Acad. Sci. U.R.S.S.* 5 (2): 346-517, and later editions. *See also* W. Gosline's 1952 "Unofficial Addendum" to Berg (ronco'd). Jordan, 1923, *Classif. Fishes*. Whitley, 1940, *Fish. Austr.* 1: 67-69. Whitley, 1952, *Austr. Mus. Mag.* 10 (12): 402.

COLORATION.

Albinism: Anon., 1961, *N. Qld. Nat.* 29, June, 1961: 4.

Ambicolorate flatfishes: Norman, 1934, *Monogr. Flatfishes* 1: 22, figs. Benham, 1921, *Ann. Rept. Otago Mus.* 1920: 4. Archey, 1924, *N.Z. Journ.* 6: 342. Cott, 1940, *Adaptive Coloration in Animals*.

General: Whitley, 1958, *Proc. Roy. Zool. Soc. N.S.W.* 1956-7: 36, fig. 7 (conspic. colours of juvenile fishes). Prince, 1949, *Visual Development* 1: 217. Griffiths, 1936, *Proc. Linn. Soc. N.S. Wales* 61: 319, pl. 16 (colour-changes in batoids).

Markings on fishes simulating objects: Whitley, 1941, *Austr. Mus. Mag.* 7 (10): 339, figs.

[*Melanism*: A melanistic *Morwong fuscus* is in the Australian Museum.]

Xanthism: Haysom, 1960, Qld. Fisher. Inform. Bull. 17: 2. Whitley, 1952, *Proc. Roy. Zool. Soc. N.S. Wales* 1950/1: 29. Anon., 1956, *Anglers' Digest & Shooters' Monthly* Oct. 1956: 121 (yellow eel, Victoria). Scott, 1942, *Proc. Roy. Soc. Tas.* 1941: 47 (eel). Kershaw, 1904, *Vict. Nat.* 20: 140 (eel).

[*Xanthic Girella tricuspidata* and *Segutilum sydneyanum* are in the Australian Museum.]

COMMENSALISM.

Anemone fishes: Eibl-Eibesfeldt, 1960, *Zeitschr. Tierpsych.* 17 (1): 1-10, figs. 1-5. Gudger, 1947, *J. Roy. Asiat. Soc. Bengal* 12 (2), 1946: 53 illustr.

Carangids and medusae: Masters, 1879, *Proc. LINN. SOC. N.S. WALES* 3: 413. Macleay, 1884, *Proc. LINN. SOC. N.S. WALES* 7: 533. Whitley, 1931, *Rec. Austr. Mus.* 18: 110. Semon, 1899, *In Austr. Bush*: 485.

Cleaning symbiosis: Limbaugh, 1961, *Scient. American*, Aug. 1961: 4, 27 & 42-49, illustr. Eibl-Eibesfeldt, 1959, *Zeitschr. Tierpsych.* 16: 19-25, illustr. Grobe, 1960, *Natur u. Volk* 90 (5): 152, illustr. Randall, 1958, *Pac. Sci.* 12 (4): 327-347, illustr.

Fishes, sea-urchins and corals: Slack-Smith, 1962, *Mem. Nat. Mus. Melbourne* 25: 9. Bayer & Harry-Rofen, 1957, *Ann. Rept. Smithsonian. Inst.* 1956: 495, illustr. Abel, 1960, *Natur u. Volk* 90: 33, fig. 3. Eibl-Eibesfeldt, 1961, *Zeitschr. Tierpsych.* 18: 56-59. Whitley, 1959, *Proc. Roy. Zool. Soc. N.S. Wales* 1957-8: 16-17. Lachner, 1955, *Copeia* 1955 (1): 53.

Clingfishes and echinoderms: Bayer & Rofen, 1957, *Ann. Rept. Smithsonian. Inst.* 1956: pl. 8, fig. 2. Pfaff, 1942, *Vidensk. Medd. fra Dansk. nat. Foren.* 105: 418.

Portuguese man-o'-war (Physalia) and fishes: Beaglehole, 1962, *Endeavour Journ.* Jos. Banks 1: 174.

Pilot-fish and sharks: Whitley, 1951, *Austr. Mus. Mag.* 10 (5): 151, illustr.

Hydroids on fishes: Hand, 1961, *Trans. Roy. Soc. N. Zeal. Zool.* 1 (5), 91, fig. Gudger, 1928, *Ann. Mag. Nat. Hist.* (10) 1: 17-48, illustr. Zirpolo, 1939, *Ann. Mus. Zool. R. Univ. Napoli* (n.s.) 7 (8): 1, figs.

Association with tunicates: Rathjen, 1960, *Copeia* 1960 (4): 354. Giglioli, 1912, *Ann. Agric. (Roma) Stud. Talass.* 29. Giglioli, 1887, *Nature* 34: 313. Firth, 1933, *Bull. Boston Soc. Nat. Hist.* 69: 3.

Carapus and echinoderms: Strasburg, 1961, *Copeia* 1961 (4): 479, fig. Schultz a.o., 1960, *U.S. Nat. Mus. Bull.* 202: 394.

Fishes and molluscs, eggs in shells, etc.: Munro, 1955, *Austr. J. Mar. Freshw. Res.* 6 (1): 30, figs 1-2.

Barnacles on fishes: Bouxin & Legendre, 1952, *Bull. Soc. Zool. France* 77: 119. Nilsson-Cantell, 1939, *Discov. Rept.* 18: 236, and fig.

Worms and lancelets: Whitley, 1927, *Rec. Austr. Mus.* 16: 3.

CONSERVATION.

Allen, 1962, *N. Zeal. Ecol. Soc. Proc.* 9: 39-43, fig. 1. Whitley, 1955, *Austr. Mus. Mag.* 11: 359-364. Myers, 1953, *Proc. 7th Pacif. Sci. Congr. Auckland* 4, *Zool.*: 691. Symposium on dams and migratory fishes, 1940, *Stanford Ichth. Bull.* 1 (6).

[As early as 1824, Lesson predicted diminution of numbers of aborigines and indigenous Australian animals—Whittell, 1954, *Lit. Aust. Birds*: 81.]

DEEP-SEA FISHES.

Bruun, 1953, *Geogr. Mag (London)* 26 (5): 247, and reports of "Galathea" Exped. Bruun, 1953, *Galatheas Jordomsejling*: 306, pp., illustr. Grey, 1956, *Fieldiana, Zool.* 36 (2): 73-337. Hargraves, 1923, *Austr. Mus. Mag.* 1 (7): 213. Nybelin, 1957, *Rept. Swedish Deep-Sea Exped.* 2, *Zool.* 20: 250-345, pls 1-7. Roughley & Whitley, 1930, *Austr. Mus. Mag.* 4: 1. Wolff, 1961, *Nature*, April 15: 283 (deepest recorded fishes).

[Live animals were trawled from 400 faths. as early as the "Erebus" and "Terror" Voyage in the Tasman Sea, well east of Australia.—L. Huxley, 1918, *Life and Lett.* Hooker 1: 122.]

DENTITION.

Colefax, 1952, *Proc. LINN. SOC. N.S. WALES* 77: pp. viii et seq., figs 1-28. Gudger, 1937, *Bull. Amer. Mus. Nat. Hist.* 73 (2): 249-280, figs (sharks). Kerr, 1960, *Proc. Zool. Soc. London* 133 (3): 401, illustr. Moy-Thomas, 1934, *Q. J. Micros. Soc.* 76: 481, illustr. Nicholls, 1909, *Teeth of Australian Animals (Austr. J. Dentistry)*. Whitley, 1930, *Austr. Mus. Mag.* 4 (3): 92, illustr. Whitley, 1940, *Fish. Austr.* 1: passim. Anon., 1928, *Otago Univ. Mus. Ann. Rept.* 1927: 4.

DIGESTION-RATE in sharks.

Coppleson, 1951, *Med. J. Austr.* 1951 (1): 633-635. Coppleson, 1958, *Shark Attack*: 20 et seq. and 107. Whitley, 1951, *W. Austr. Nat.* 2 (8): 190. Beauvalet, 1933, *Comptes Rendus Acad. Sci. Paris* 196 (19): 1437-9. Cook, 1941, *Nature*, March 29: 388, fig.

DISEASES in man caused by fishes.

Cleland, 1925, *Med. J. Austr.*, Oct. 4, 1924. Wheeler, 1931, *Calif. Fish. Bull.* 36: 110 (sardines). Brazier, 1880, *Proc. LINN. SOC. N.S. WALES* 5: 629 (*Filaria* from herrings).

DISTRIBUTION.

Freshwater: Gill, 1875, *Ann. Mag. Nat. Hist.* (4) 15: 251, and *Nat. Acad. Sci. Wash.* 6: 108. Iredale and Whitley, 1938, *South Austr. Nat.* 18: 64-68, map. Myers, 1953, *Proc. 7th Pac. Sci. Congr.* 1949, iv, *Zool.*: 38-48. Whitley, 1959, *Monogr. Biol.* 8, passim. Whitley, 1960, *Freshwater Fishes* (Brisbane: Jacaranda Press).

Marine: Bartholomew, 1911, *Physical Atlas*, vol. 5, zoogeography. Endean, 1957, *Aust. J. Mar. Freshw. Res.* 8 (3): 233, maps, etc. Endean, 1961, *Univ. Qld. Pap. Dept. Zool.* 1 (13): 297 (Dampierian-Banksian). Hubbs, 1952, *Proc. 7th Pacif. Sci. Congr.* (N. Zeal.) 3: 324-329 (bipolarity). Iredale & Hull, 1929, *Austr. Zool.* 5 (4): 311. Iredale, 1938, *Aust. J. Sci.* 1 (3): 102-103. Kloss, 1929, *Bull. Raffles Mus.* 2: 1, maps. Kott, 1952, *Aust. J. Mar. Freshw. Res.* 3 (3): 205-333 (Baudinian region). Tortonese, 1938, *Boll. Mus. Torino* 46: 279-311. Whitley, 1932, *Aust. Nat.* 8 (8): 166 and map. Whitley, 1937, *Aust. Zool.* 8 (4): 199, 268, and Iredale, *ibid.*: 287, 289 and maps.

ECOLOGY.

Beadle & Costin, 1952, *PROC. LINN. SOC. N.S.W.* 77: 61. Bennett & Pope, 1953, *Austr. J. Mar. Freshw. Res.* 4 (1): 105-159, pls 1-6, figs 1-5. Guiler, 1950, *Proc. Roy. Soc. Tas.* 1949: 135-201, illustr.; *ibid.* 1952-3: 86, passim & 87-93. Hedley, 1915, *Proc. Roy. Soc. N.S.W.* 49: 1-77, pls 1-7 and 38 text-figures. Knox, 1960, *Proc. Roy. Soc. Lond.* (B) 949, *Biol. Sci.* 152: 577, illustr. Tenison-Woods, 1880, *PROC. LINN. SOC. N.S. WALES* 5: 106-131.

ELECTRIC FISHES.

Berrill, 1953, *Natural History* (N.Y.), Dec. 1953: 450, illustr. Keynes, 1956, *Endeavour* 15 (60): 215, figs 1-7. Whitley, 1940, *Fish. Austr.* 1: 160-166.

ELECTRICITY used in Fishing.

Burnet, 1952, *Aust. J. Mar. Freshw. Res.* 3 (2): 111-125, illustr. Burnet, 1961, *N.Z. J. Sci.* 4: 151, figs. Meyer-Waarden, 1958, *Electrical Fishing* (F.A.O.)—reviewed in *Fisheries Newsletter*, Oct. 1958: 11. Whitley, 1940, *Fish. Austr.* 1: 26.

ENEMIES OF FISHES.

Mammals: Anon., 1960, *Fisheries Newsletter*, Dec. 1960: 15 (seals). Barrett, 1941, *Austr. J. Sci.* 4 (2): 59-60 (seals). Coonan, 1950, *Fisheries Newsletter* 9 (11): 7, fig. (whale). Goadby, 1959, *Sharks*: 93, 97 (cetacea). Harney, 1951, *Walkabout*, July 1: 37 (dingo). Hull, 1927, *Aust. Zool.* 4 (6): 338 (seals). Le Souef, 1925, *Austr. Zool.* 4 (2): 112 (seals). Ride, 1957, *Fisher. Dept. W. Austr. Monthly Service Bull.* 6 (11): 156 (sperm whale). Troughton, 1941, *Furred Anim. Austr.*: 43 (native cat); 247 (seals); 264 (water rat) & 399 (bats). Whitley, 1940, *Fish. Austr.* 1: 26, 59 & 199 (seals).

Birds (other than cormorants) eating fishes: Barrett, 1941, *Nature*, 22 Nov.: 630. Cleland, 1937, *Emu* 36: 297. Gudger, 1927, *Nat. Hist.* (New York), Sept.-Oct., 1927, 27 (5): 485, figs. Harvey, 1943, *Mankind* 3 (4): 108, map. Lea & Gray, 1936, *Emu* 35: 342, nos. 97, 117 & 188. Le Souef, 1926, *Emu* 26: 79. Ramsay, 1883, *Cat. Exhib. N.S.W. Court.*: 48. Rau, 1938, *S. Austr. Ornith.*, April 1: 174. Salter, 1954, *Vict. Nat.* 71 (6): 99. Selby, 1952, *Emu* 52: 146, pl. xv. Serventy, D. L., 1939, *Emu* 38: 363 and 510. Serventy, D. L., & Whittell, 1948, *Birds W. Austr.*, passim. Serventy, V. N., 1957, *W.A. Nat.* 5 (8): 233. Sutton, 1933, *S. Austr. Ornith.* 12, pl. opp. p. 19. Whitley, 1940, *Fish. Austr.* 1: 62 & 127. Whittell, 1954, *Lit. Austr. Birds*: 451.

Cormorants and fishes.

[There is much discussion in newspapers, angling and other journals as to whether cormorants are damaging to fisheries. Examination of their stomach-contents by scientists discloses that they are not as destructive as fishermen think. Shags occasionally eat valuable fishes, but most often their stomachs contain small fish of no importance. See *Ann. Repts. Fisheries N.S.W.* 1906 onwards.]

Anon., 1909, *Fisheries Inquiry Board. Rept. & Minutes of Evidence*, Victoria. Anon., 1962, *The Fisherman*, Autumn 1962: 8, figs. Barrett, 1941, *Austr. J. Sci.* 4: 59. Bryant, 1958, *Emu* 58: 156. Dickison, 1951, *Emu* 51: 224. Everitt, 1938, *Emu Index to vols. 1-37*: 16. Kesteven, 1941, *Austr. J. Sci.*, Aug. 1941: 13, and Oct. 1941: 59. Lea & Grey, 1935, *Emu*, 35: 275. McKeown, 1944, *Emu* 43, 259. McNally, 1957, *Vic. Fish & Game Dept. Fauna Contrib.* 6: 1-36, plates and figures. McNally, 1958, *Wildlife Circular* 8, *Fisher. Game Victoria*: 12 pp., graphs. Mack, 1941, *Mem. Nat. Mus. Melb.* 12: 95, figs 1-15. Mattingley, 1931, *Emu* 31: 148. Morris, 1942, *Vict. Nat.* 59: 23. *Report Roy. Comm. Vict. Fisheries* 1919: 13-14, 26 & 47. Serventy, 1938, *Emu* 38: 293 and 362, diagrams. Serventy, 1958, *Austr. Encycl.* 3: 63 and 4: 87. Serventy & Whittell, 1948, *Birds W. Austr.*: iii. Stead, 1954, *Aust. Wild Life* 2 (4): 40, figs. White, 1917, *S.A. Ornith.* July 1917: 75. Whittell, 1954, *Lit. Austr. Birds* (refs. to Buckland, Cole, Forster, Gregory, Morris, Prendergast, Ross, Rudall *a.o.*).

Snakes: Whitley, 1939, *Austr. Mus. Mag.* 6 (12): 432 and 7, 1940: 89. Worrell, 1954, *Outdoors & Fishing*, Oct. 1954: 30, fig.

Eels as enemies of trout: Cairns, 1942, *N. Zeal. J. Sci. Tech.* (B) 23: 132B.

Spiders: McKeown, 1935, *Austr. Mus. Mag.* 5 (12): 431, figs. McKeown, 1936, *Spider Wonders of Australia*, figs. McKeown, 1943, *Proc. Roy. Zool. Soc. N.S.W.* 1942-3: 26, figs. McKeown, 1952, *Austr. Spiders*: 166. Wadey, 1935, *S. Austr. Nat.* 16 (3): 32, pl. i.

Insects: Anon., 1887, Town & Country Journal (Sydney), 29 Oct.: 916, fig. Campbell, 1927, *Austr. Mus. Mag.* 3 (3): 93. McKeown, 1933, *Austr. Mus. Mag.* 5: 14, figs. Roughley, 1933, Cult of the Goldfish, chap. ix. Tillyard, 1917, Biol. Dragonflies: 329.

Echinoderms: Serventy, 1958, *W.A. Nat.* 6 (5): 128 (seastars). Frey, 1951, *Copeia*, 1951: 175 (sea-cucumbers poisoning fish).

Molluscs: Lane, 1957, Kingdom of the Octopus: 36-38, 47, 76 & 148, illustr. Norris, 1931, *Austr. Nat.* 8 (5): 93 (snails). Wright, 1963, *Austr. Newsletter Malac. Soc. Austr.* 11 (40): 8 (cone-shell).

FISHERIES.

Annual Reports of various State Fisheries Departments and the Sea Fisheries Board of Tasmania. C.S.I.R.O. Annual Reports. Commonwealth of Australia Official Year Books, 1927 onwards. Official Year-Book of New South Wales, 1906 onwards. Fisheries Newsletter 1, 1941, to date. Development and Migration Commission, 1st Ann. Rept., 1927. Rivett, 1939, *Nature* Aug. 19: 312, 2 figs. Roughley, 1935, *Proc. Roy. Zool. Soc. N.S.W.* 1934-5: 9-20. Roughley, 1939, *Proc. Linn. Soc. N.S.W.* 64: vi. Griffith Taylor, 1947, *Australia*: 367.

[Some of the first Australian fisheries were mostly concerned with whaling and sealing. Commerce in edible fish commenced about 1827 (Shaw, 1952, *J. Roy. Austr. Histor. Soc.* 35: 314; Hartwell, 1956, *J. Roy. Austr. Histor. Soc.* 42 (2): 57). Early fisheries conditions were noted in Collins's Account of the English Colony of N.S.W. The works of Tenison-Woods, Stead, G. Kesteven, H. Thompson, Dakin, Dannevig, Colefax, R. M. Johnston, Saville-Kent, the Australian Encyclopaedia, and the Reports of Royal Commissions (1880, 1883 & 1896) should be consulted. The manuscript *Returns of the Colony of New South Wales* are important.

Much of the early literature is of archival interest only. See also Haydn's 1910 Dictionary of Dates: 530. A list of the more important papers issued before 1927 was prepared by me but published in roneo'd form under the name of W. T. Wells (1927, Rept. Austr. Fisher. Conf., Govt. Printer, Melbourne, Appendix 7: 1-4).

Waite (1899) gave a history of trawling and the F.I.V. "Endeavour" conducted extensive trawling experiments before her loss in 1914. The annual catch, by species, has been analysed by Kearns (1953, Fisheries Newsletter 12 (3): 9 and in each ensuing year.)

FISHES AND FLOWERS.

[Natives used to time the appearance of certain fishes with the seasons when flowers bloomed.]

Tuioi, 1955, *Tuatara* 5 (3): 82. Whitley, 1934, *Aust. Mus. Mag.* 5 (7): 223. Whitley, 1959, *Aust. Mus. Mag.* 13 (2): 56.

FISHES OUT OF WATER.

E. Scott, 1934, *Proc. Roy. Soc. Tas.* 1933: 36, 41-44.

FISHING METHODS.

"Australian Fisheries" (Sydney: Halstead Press), 1950: 1-104, pls i-vi. "Fisheries Newsletter", passim. Blackburn & Fairbridge, 1946, *Journ. C.S.I.R.* 19 (4): 404, figs (Danish seine trials). Domeny de Rienzi, 1855, *Oceania* 3, pl. 255 (aboriginal fishing, Jervis Bay). Gudger, 1950, *Aust. Mus. Mag.* 10: 61, fig. (fishing with the hand). Caldwell, 1938, Titans of the Barrier Reef: 56 & 120, pl. (shark-nets). McCarthy, 1940, *Mankind* 2 (9): 303, 305 (nets and traps). Roughley, 1916, *Fish. Aust. Technol.* (Tech. Educ. series no. 21). Serventy, 1952, *Austr. Geographer* 6 (1): 13-16, map and bibliography (Indonesian fishing activities in Australian seas).

FOOD AND FEEDING HABITS.

Baker, 1956, *Vict. Nat.* 73: 87 (swallowing stones). Butcher, 1945, *Vict. Fisher. Pamphlet* 2: 1-48 & suppl. pp. 1-4. Butcher, 1946, *Freshw. Fish. Victoria*. Colefax, 1938, *Proc. Linn. Soc. N.S. WALES* 63: 56 (flathead) and 58 (*Apogonops*). Cotton, 1942, *Trans. Roy. Soc. S. Austr.* 66 (1): 83 (cephalopoda). Dakin, 1931, *Austr. Zool.* 7: 26, fig. 3 (food-chain of flathead). Evans, 1939, *Parl. Tasm. Salmon & Freshw. Fisher. Comm. Rept.* 46: 3-37. Graham, 1939, *Trans. Roy. Soc. N. Zeal.* 68: 421. Jenkins, 1952, *W.A. Nat.* 3 (6): 139. La Monte, 1955, *Bull. Amer. Mus. Nat. Hist.* 107 (3): 329 (marlins). McKeown, 1934-55, *Rec. Aust. Mus.* 19: 141, 184, 397; 21: 38 and 23 (5): 273. Philipps, 1926, *Trans. N. Zeal. Inst.* 56: 525-529. Rayment, 1952, *Aust. Mus. Mag.* 10 (12): 408. Stephenson & McNeill, 1955, *Rec. Aust. Mus.* 23 (5): 240 (stomatopods). G. Thomson, 1931, *Rept. Fisher. N. Zeal.* 1931: 30-32. J. Thomson, 1957, *W.A. Fisher. Dept. Bull.* 7 (food of W. Aust. estuarine fishes). Tillyard, 1934, *Proc. Roy. Soc. Tas.* 1933: 1 (trout). Whitley, 1940, *Fish. Austr.* 1: passim.

FOREIGN BODIES.

Gudger, 1922, *Nat. Hist. (N. York)* 22: 452, figs. Whitley, 1935, *Aust. Mus. Mag.* 5 (10): 341 (ringed fishes). Whitley, 1941, *Aust. Mus. Mag.* 7 (10): 341 (ringed fishes). Whitley, 1955, *Aust. Mus. Mag.* 11 (9): 294 (marlin bill).

FRESHWATER FISHES.

Bodenheimer, 1959, *Monogr. Biol.* 8: 136, figs 1-3. Butcher, 1946, *Freshw. Fish. Vict. & their food*. Gill, 1884, *Smithson. Rept.* 1882: 44. Iredale & Whitley, 1938, *S.A. Nat.* 18: 64-68 (map of fluvifaunulae). Lake, 1959, *Fisher. N.S.W. Res. Bull.* 5 (freshw. fish. N.S. Wales).

Mees, 1962, *J. Roy. Soc. W. Austr.* 45: 24. Myers, 1951, *Stanford Ichth. Bull.* 4 (1): 11. Whitley, 1947, *W.A. Nat.* 1: 49, map (fluvifaunulae). Whitley, 1955, *Austr. Mus. Mag.* 11: 359-364, 10 figs. Whitley, 1956, *Australasian Aqua Life* 1, onwards (serial articles). Whitley, 1956, *Proc. Roy. Zool. Soc. N.S. Wales* 1954-5: 39 (list of Aust. species). Whitley, 1960, *Freshw. Fish.* (Brisbane: Jacaranda Press).

GROWTH. (See also Age and Size.)

Garrick, 1960, *Trans. Roy. Soc. N. Zeal.* 88, passim (sharks). Jacups, 1943, *Proc. Roy. Zool. Soc. N.S. Wales* 1942-3: 11 (Port Jackson Shark). Rudel, 1960, *Finchat*, Dec. 1960: 19 & 21 (*Neoceratodus*). Shapiro, 1938, *Amer. Mus. Novit.* 995: 1-20 (marlins). Thomson & Anderton, 1921, *Bull. N. Zeal. Board Sci. Art* 2: 77 (parrot fish).

HERMAPHRODITES.

Cleland, 1919, *Abstr. Proc. Linn. Soc. N.S. Wales* p. ii (mullet). Stead, 1936, *Austr. Nat.* 9 (7): 158 (snapper & bream).

HYBRID (trout).

Phillipps, 1922, *N. Zeal. J. Sci. Tech.* 5 (2): 98. Stokell, 1949, *Rec. Canterb. Mus.* 5 (4): 209.

ICONOGRAPHY.

Old illustrations.

[30,000-year-old drawing of fishes in Aurignacian Cave reproduced in *Illustr.* London News, May 25, 1935, pl. 923, fig. Early Australian drawings listed by Whitley, 1938, *Austr. Mus. Mag.* 6: 301. The first illustrations of Australian fishes were made by Dampier's artists.]

Figuring fishes: Olsen & Morrow, 1959, *Bull. Bingham Oc. Coll.* 17: 147, illustr.

Plaster casts: Mackay, 1957, *Austr. Mus. Mag.* 12 (5): 153, figs.

Beautiful illustrations.

[Bauer, James Stuart, McCulloch and others have made beautiful paintings of Australian fishes.]

Nissen, 1951, *Schöne Fischbücher*, passim. Roughley, 1916, *Fish. Austr. Tech.*: 238-254, pls & figs (fishes in applied art).

Photography.

[The first photograph of a living fish was taken at London Aquavivarium by Count Montigon (Brightwell, 1936, *The Zoo You Knew?*, p. 80). Mobsby's methods of photographing live fishes were discussed by Hamlyn-Harris, 1929, *Proc. Roy. Soc. Qld.* 41 (3), pls i et seq. Modern methods are given by Randall, 1961, *Copeia* 1961 (2): 241. Early cinematography was practised by McCulloch (1924, *Austr. Mus. Mag.* 2 (3): 103, frontispiece & figs). Colour transparencies are now popular in the 1960s.]

INTEGUMENT.

[A swimming-belt made partly of a fish's skin was amongst the relics of Capt. Cook (papers re Cook Relics ii, Cat. Colon. Ind. Exhib. 1886: 6).

For notes on development and variation of sharks' skins, see Garrick's papers.

Budker and associates have discussed pit-organs and "dents jumelées".]

Ecdysis: Hirosaki, 1957, *J. Fac. Sci. Hokkaido Univ.* (vi) Zool. 13, Jubilee of Uchida: 178-9.

Artificial pearls from fishes' scales: *Illustr.* Sydney News, April 17, 1871, p. 55.

Scales: Butcher, 1948, Victor. Fisher. Pamph. 4: 1, illustr. (scale-reading). Cockerell, various papers, esp. 1915, *Mem. Qld. Mus.* 2 & 3. Colefax, 1952, *Proc. Linn. Soc. N.S.W.* 77, pp. viii et seq., figs 1-28. Dakin, 1931, *Austr. Zool.* 7: 30, pl. 2. Kerr, 1955, *Proc. Zool. Soc. Lond.* 125 (2): 335, illustr. (*Neoceratodus*). Kesteven & Proctor, 1941, *J.C.S.I.R.* 14 (1): 57, pls 3 & 4 (apparatus for scale-reading). Parrott, 1934, *Trans. Proc. N. Zeal. Inst.* 63: 497, pl. 52 and figs (trout). E. Scott, 1953, *Proc. Roy. Soc. Tas.* 1952: 165, fig. 4 (*Brachionichthys*). Stokell, 1955, *Freshw. Fish. N. Zeal.* 81, pls (scale-reading). Tubb & Proctor, 1941, *J.C.S.I.R.* 14 (3), pls i-ii (apparatus).

ISINGLASS.

Woods, 1888, *Proc. Linn. Soc. N.S.W.* (2) 3: 194-202.

LARVAE. (See Planktonic Ova and Larvae.)

LATERAL LINE.

E. S. Hills, 1941, *Rec. Austr. Mus.* 21: 48, figs.

LOCOMOTION.

Magnan, 1930, *Ann. Sci. Nat. Zool.* (10) 13 (3): 404, pls & figs. Rauther, 1933, *Kl. Ord. Tierreichs* (Bronn) 6 (1) 2, echte Fische, 4 Lief: 494, figs. Salier, 1929, *J. Proc. Roy. Austr. Hist. Soc.* 15 (3): 153.

Speed: Gudger, 1940, *Mem. Roy. Asiat. Soc. Bengal* 12 (2): 285. Whitley, 1958, *Austr. Mus. Handbook* 1957: 77.

LOGOTYPES.

Whitley, 1935, *Austr. Zool.* 8 (2): 136-139. Whitley, 1936, *Austr. Zool.* 8 (3): 189-192. Whitley, 1939, *Austr. Zool.* 9 (3): 222-226.

MIGRATIONS.

[The movements of sharks, game and commercial fishes around Australia are incompletely known, but tagging operations, especially over the last 20 years or so, have yielded some interesting results. Reports of Fisheries Departments, notably the *W. Austr. Monthly Service Bulletin* of the 1950s, record data, as well as *Fisheries Newsletter*, of post-World War II years.

The first records of marked fishes recaptured after migration were probably mediterranean tunnies (see "A Marked Tuna", Whitley, 1950, *Austr. Mus. Mag.* 10 (3): 75), though Aristotle and Rondelet mention marking experiments by cutting dolphins' tails (Cole, 1944, *Hist. Compar. Anat.*: 71). Sir Francis Bacon was perhaps the first to tag freshwater fishes by tying a riband to them, according to Isaac Walton, 1653. In New South Wales, marking experiments on freshwater fishes were performed by the Fisheries Dept. in 1909 and later years, but reports on fish movements by Inspectors go back to 1905 in Annual Reports of the State Fisheries Dept. Snapper were tagged in Port Phillip by 1914 by the Victorian Piscatorial Council; mullet at Port Hacking, N.S.W., in 1938 and Brisbane in 1935. The present writer was the first (1942) to tag sharks in Australia. In other seas, albacore have been noted as migrating 4,724 miles in 324 days (Kreider, 1961, *Field & Stream* 66 (6): 48). Latterly, tattooing of fish has been practised (Dunn & Coker, 1951, *Copeia* 1951 (1): 28, fig.).

Fishes may still attempt ancient passages now blocked by land-masses (Smith, 1956, *Ichth. Bull. Rhodes Univ.* 2: 29); for example, kingfish (*Regificola*) seem to try to enter Sydney Harbour where now blocked by the isthmus of Manly Beach. Hall (1936, *Vict. Nat.* 53: 42) refers to Faunal Corridors.]

Butcher & Ling, 1962, *Vict. Nat.* 78 (9): 256-264, figs 1-4 (tagging bream). Kesteven, 1946, *Fisheries Newsletter* 5 (4): 10, figs. Lissmann, 1954, *The Advancement of Science* 11 (41): 69 (direction-finding). Malcolm, 1954, *Fisher. Dept. W. Austr. Monthly Ser. Bull.* 3 (1): 4. Moorhouse, 1953, *Fisher. Newsletter* 12 (7): 17 (Ruff). Olsen, 1953, *Austr. J. Mar. freshw. Res.* 4: 95, pls i-v. Olsen, 1959, *J. Mar. Freshw. Res.* 10 (2): 169. Robins, 1960, *Fisher. Newsletter* 19 (7): 11, maps (tuna tagging). Teesey, 1936, *N.S.W. Rodfishers' Gazette* 4 (9): 12 (trout, Barrington Tops). J. M. Thomson, 1955, *Fisher. Newsletter* 14 (2): 17 (leather-jacket recoveries). J. M. Thomson, 1960, *Austr. Mus. Mag.* 13 (5): 158-162, 4 figs. J. M. Thomson, 1962, *C.S.I.R.O. Div. Fisher. Oc. Tech. Pap.* 13: 1-39, figs 1-7 (tagging of marine animals in Australia). Whitley, 1934, *Daily Telegraph newspaper*, May 25, leading article (Fish on Tour).

MIMICRY.

[That some fishes imitate their surroundings has long been realized, but it is only in recent years that proof has been forthcoming that certain kinds mimic other fishes. Some fishes, especially when young, bear remarkable resemblance to algae, floating leaves, jellyfishes, and may adopt special postures to heighten the resemblance. There are fantastic implications in the mimicry of the Cleaner Fish (*Labroides*) by a Blenny (*Aspidontus*) involving mimesis, the imitation of behaviour patterns as well as coloration. Snake Eels mimic sea snakes or even other snake eels. The Leafy Sea Dragon, *Phycodurus*, is a classic case of a syngnathid fish resembling kelp.]

Breder, 1946, *Bull. Bingh. Oc. Coll.* 10 (2): 1. Dunn, 1897, 64th Ann. Rept. Cornwall Polytechn. Soc.: 56-59. Randall, 1958, *Pacif. Sci.* 12 (4): 330 et *ibid.* 1960, 14 (3): 269-270. J. & H. Randall, 1960, *Bull. Mar. Sci. Gulf & Carib.* 10: 444-480 (with bibliography). Smith, 1958, *Ann. Mag. Nat. Hist.* (13) 1: 62 (*Canthigaster & Paraluteres*). Whitley, 1935, *Rec. S. Austr. Mus.* 5 (3): 348 (mimicry of coral fishes). Whitley, 1940, *Fish. Austr.* 1: 248 & 250 (worm imitating lancelet). Wickler, 1961, *Natur u. Volk* 91 (11): 417. Wickler, 1963, *Zeit. Tierpsychol.* 20 (6): 657-679, figs 1-10.

MORTALITY.

Marine: Anon., 1953, *Fisher. Dept. W. Austr. Monthly Serv. Bull.* 2 (6): pl. opp. p. 148. Arden, 1950, *Walkabout*, March 1, 1950: 39 & figs. Dunstan, 1955, *Fisheries Newsletter* 14 (5): 15. Dunstan, 1959, *C.S.I.R.O. Div. Fisher. Tech. Pap.* 5: 9. Kesteven, 1962, *Fisher. Newsletter* 21 (2): 17, photo. on cover. Middleton, 1955, *Fisher. Dept. W. Austr. Monthly Serv. Bull.* 4 (5): 69 and 4 (8): 133-142, figs. E. Scott, 1960, *Proc. Roy. Soc. Tas.* 94: 99 (Tasmanian leatherjackets). J. M. Thomson, 1963, *Austr. J. Sci.* 25 (9): 414-415, fig. (fish in fly ash suspension). Young, 1938, *Qld. Nat.* 10 (4): 78.

Freshwater: *Agric. Gazette N.S. Wales* 1947, 58 (12): 637, fig. (effects of D.D.T.). Hamlyn-Harris, 1930, *Mem. Qld. Mus.* 10: 51, pl. ii (goldfish, Queensland). Johnston, 1917, *Proc. Roy. Soc. Qld.* 29 (11): 125. Johnston & Bancroft, 1921, *Proc. Roy. Soc. Qld.* 33 (10): 174-210. Johnston & Hitchcock, 1923, *Trans. Roy. Soc. S. Austr.* 47: 157-161 (bacterial disease, Queensland). Lamond, 1961, *N. Qld. Register*, Dec. 9, 1961: 30 (1916 mortality, C. Australia). Sandars, 1948, *Qld. Nat.* 13: 89-90.

MOSQUITO-DESTROYING FISHES.

Cooling, 1913, *Ann. Rept. Comm. Publ. Health Qld.* 1913: 61. Cooling, 1923, 1927, *Health (Melbourne)*, April 1923, 94-98 and 5: 12, 1927. Hamlyn-Harris, 1929, *Proc. Roy. Soc. Qld.* 41 (3): 23-38, pls 1-8. Laird, 1956, *Roy. Soc. N. Zeal. Bull.* 6: 97. Phillipps, 1930, *N. Zeal. J. Sci. Tech.* 12 (1): 19-20. Stead, 1907, *Agric. Gazette N.S.W.* Miscel. Publ. 1111: 1-3. *et ibid.* 18, 1907: 762.

MUSIC.

Ackland, 1929, "Animals in Orchestration", *Nat. Hist. (N.Y.)* 29: 519.

MYOLOGY.

Lightoller, 1940, *PROC. LINN. SOC. N.S. WALES* 65: 355.

NERVOUS SYSTEM.

Johnston, 1938, *Trans. Proc. Roy. Soc. N. Zeal.* 68: 47, pl. 8. (*Physiculus*). Pope, 1938, *PROC. LINN. SOC. N.S. WALES* 63: 412, 12 figs. (*Heterodontus*.)

OIL.

Blackburn, 1941, *C.S.I.R. Bull.* 138: 44. Cunningham *a.o.*, 1944, *N. Zeal. J. Sci. Tech.* 26 (B) 1: 21-27, fig. Cunningham *a.o.*, 1949, *N. Zeal. J. Sci. Tech.*, Jan. 1949: 214, figs. Denz & Shorland, 1934, *N. Zeal. J. Sci. Tech.* 15 (5): 327. Julius *a.o.*, 1937, Eleventh *Ann. Rept. C.S.I.R.*: 64, and later reports. Shorland, 1937, *Nature* 140: 223-224. Shorland, 1950, *N.Z. J. Sci. Tech.* (B) 32 (2): 30. Stead, 1906, *Fish. Austr.*: 251. Whitley, 1940, *Fish. Austr.* 1: 55-57, etc. (see index).

OSMOSIS.

DAKIN, 1935, *PROC. LINN. SOC. N.S. WALES* 60: vii-xxxii.

OTOLITHS.

Dakin, 1939, *Rec. Aust. Mus.* 20: 282-292, pls. 27-30 & fig. 1. Frost, 1924, *Trans. Roy. Soc. N. Zeal.* 55: 605-616 *et ibid.* 1928, 59: 91 *et ibid.* 63: 133, pls. Longman, 1931, *Proc. Roy. Soc. Qld.* 42, p. ix. Stinton, 1953, *Trans. Roy. Soc. S. Austr.* 76: 66-69, figs 1-12. Stinton, 1957, *Trans. Roy. Soc. N. Zeal.* 84 (3): 513. Stinton, 1958, *Proc. Roy. Soc. Vict.* 70: 81, pl. (for other papers—see *Zool. Rec.* 1953 onwards). Weiler, 1950, *Senckenbergiana* 31: 209, illustr. (with bibliography).

OVA. (See Planktonic Ova and Larvae.)

PATHOLOGY. (See also Mortality and Teratology.)

Hamlyn-Harris and Duhig, 1930, *Mem. Qld. Mus.* 10: 51-54, pl. 2. Mellen, 1928, *Zoopathologica* 2: 1 (treatment of fish diseases). Roughley, 1932, *Bull. Tech. Mus. Syd.* 18: 22.

[For references to Salmon disease (*Saprolegnia*) see Greig-Smith's papers in *PROC. LINN. SOC. N.S.W.*]

PELVIS.

Gregory, 1935, *Amer. Nat.* 69: 193, figs. Tyler, 1962, *Proc. Acad. Nat. Sci. Philad.* 114: 207-250, figs 1-55.

PHILATELY.

[The Australian Museum has the Dovey Collection of zoological stamps, over 200 of which have fish motifs. The first mention of an aquarium on a postage stamp was on the New Caledonia March 1959 issue.]

Renouf, n.d., *The Stamp Zoo* 2: 45, figs (Stanphil Stamp Books, no. 5). Way & Standen, 1952, *Zoology in Postage Stamps* (London: Harvey & Blythe).

PINEAL ORGAN.

Holmgren, 1958, *Breviora* (Mus. Comp. Zool., Harvard) 100: 1, figs. 1-2 (tuna).

PISCICULTURE. (See also Acclimatization.)

Fish pond farming: Anderson, 1918, *Aust. Zool.* 1 (6): 157, figs 1-2. Anon., 1933, *Nature* Feb. 4: 177 (historical). Anon., 1959, *Fisheries Circ.* 4, *Fish & Game Dept.*, Melbourne: 1-4. Anon., 1959a, *Pond Culture of Fish in Queensland*: 1-12, figs 1-13. Butcher & Thompson, 1947, *Vict. Fisher. Pamph.* 3. Hora, 1948, *J. Roy. Asiat. Soc. Bengal* 14: 8 (prehistoric fish-culture). Nichols, 1953, *J. Soil Conserv. Service N.S.W.* 9 (2): 53, figs. 1-6, with bibliography. O'Connor, 1887, 1898, *Proc. Roy. Soc. Qld.* 3, 4 & 12 and *Qld. Agric. J.*, 1 & 2. Weatherley, 1958, *C.S.I.R.O. Divn. Fisher. Tech. Pap.* 4: 1-24, figs 1-12. Dannevig, 1903, *Rept. Fisher. N.S.W.* 1902, 2: 5 (introduced flatfishes).

PITUITARY.

Atz, 1962, *Anim. Kingdom* (New York) 65 (3): 83, figs. Atz & Pickford, 1959, *Endeavour* 18 (71): 125, illustr. Griffiths, 1938, *PROC. LINN. SOC. N.S. WALES* 63: 82, pl. v & figs. Pickford & Atz, 1957, *Physiol. Pituit. Gland Fishes* (N.Y. Zool. Soc.).

PLANKTONIC OVA & LARVAE. (See also Reproduction.)

Eggs of elasmobranchs: Gudgey, 1940, Bashford Dean Memor. Vol. 7: 531 (various sharks: largest eggs in the animal kingdom are of Isuridae). Hale, 1935, *Rec. S. Austr. Mus.* 5 (3): 367, fig. 1. Kershaw, 1958, *Vict. Nat.* 75 (7): 115, fig. Phillipps, 1946, *Domin. Mus. Rec. Zool.* 1 (2): 17, fig. 6. Smith, 1942, Bashford Dean Memor. Vol. 8: 705, illustr. Whitley, 1938, *Austr. Mus. Mag.* 6 (11): 372, figs. Whitley, 1940, *Fish. Austr.* 1: 37 et seq., figs. Whitley, 1943, *PROC. LINN. SOC. N.S. WALES* 58: 128. Whitley, 1944, *Austr. Mus. Mag.* 8 (8): 260, figs.

Eggs of Fishes: Graham, 1953, Treasury of N. Zeal. Fishes, passim, figs. Kesteven & Serventy, *Austr. J. Sci.* 3 (6): 171 (breem). Whitley, 1947, *Aust. Mus. Mag.* 9 (4): 115, fig. (raft of fish eggs). Gunther, 1889, "Challenger" Rept. Zool. 31. Haswell, 1890, Rept. 2nd meet. Austr. Assn. Adv. Sci.: 482 (shore eel). Tosh, 1903, Parl. Rept. Mar. Dept. Qld. 1902-3. Thomson, 1906, *Trans. N.Z. Inst.* 38: 557, illustr. Anderton, 1907, *Trans. N.Z. Inst.* 39: 477, illustr. (also later vols.). Stead, 1907, Eggs and Breeding Habits of Fishes. Dannevig, 1909, Fisheries Inquiry Board Rept. & Minutes—Victoria: 106, et seq. Regan, 1916, Brit. Antarctic "Terra Nova" Exped. 1910, Nat. Hist. Rept. Zool. 1, 4. Thomson & Anderton, 1921, *Bull. N.Z. Board Sci. Art.* 2: 82, et seq., figs. Dakin & Colefax, 1934, *Rec. Austr. Mus.* 19: 139 (pilchard). See also *PROC. LINN. SOC. N.S.W.* 58, 1933: 212. Colefax, 1938, *PROC. LINN. SOC. N.S. WALES* 63: 60. Kesteven, 1938, State Fisheries N.S.W. Research Bull. 1 (Murray Cod). Graham, 1939, *Trans. Roy. Soc. N. Zeal.* 69: 361 et seq., figs. Dakin & Colefax, 1940, Univ. Syd. Zool. Monogr. 1: 201 et seq., figs. Rapson, 1940, N.Z. Mar. Dept. Fish. Bull. 7: 7 et seq., figs. Schadwinkel, 1963, *Zool. Anzeiger* 171: 456-459, figs 1-8. Whitley, 1938, *Rec. Austr. Mus.* 20: 195, fig. 1 (eel). Blackburn, 1941, C.S.I.R. Bull. 138. Whitley, 1941, *Austr. Zool.* 10: 1 et seq., figs. Kesteven, 1941, *Austr. J. Sci.* 3 (6): 171. Munro, 1942, *Proc. Roy. Soc. Qld.* 54: 33, pls 2-4 (*Scomberomorus*). Dakin, 1933, *J.C.S.I.R.* 6: 211-212 (pilchard). Whitley, 1945, *Aust. Mus. Mag.* 8: 426, fig. (*Regalecus*).

[The first reference to Australian fish eggs was that of de Prado, 1606, see Stevens, 1930, *New Light Discov. Austr.*: 167.]

Delayed metamorphosis: Berry, 1958, *Copeia* 1958 (2): 124. Tucker, 1959, *Nature* Oct. 24: 1281.

Juvenile stages defined: Hubbs, 1958, *Copeia* 1958 (4): 282. Whitley, 1940, *Rec. Austr. Mus.* 20 (5): 326.

Post-larval Australian fishes: Munro, 1945, *Mem. Qld. Mus.* 12 (3): 136-153, figs 1-8. Whitley & Colefax, 1938, *PROC. LINN. SOC. N.S. WALES* 63: 293, 395.

PLURAL.

[When speaking of fish as a commercial product, as, for example, in the markets or fish-shops, one uses the plural *fish*. When speaking of them as animals or individuals or as different species, the plural is *fishes*.]

Anon., 1932, *Copeia* 1932 (4): 185. Emmison, 1954, *The Times* (London), Jan. 11. Innes, 1936, *Aquarium* 5 (7): 148. Mellen, 1925, *N. York Zool. Soc. Bull.* 28 (3): 57.

POISONOUS FISHES.

Fishes poisonous as food: Brock, 1956, *Copeia* 1956 (3): 195 (boxfish exudation). Halstead, 1959, *Dangerous Marine Animals*. Whitley & Halstead, 1955, *Rec. Austr. Mus.* 23 (5): 211-227 (annotated bibliography, q.v.).

Poisoning agents. (See also Pollution.): Carr, 1947, *N. Qld. Nat.* 15 (84): 3. Fawcett, 1900, *Proc. Linn. Soc. London*: 86. MacPherson, 1933-1935, *Mankind* 1 (7): 157 & 1 (12): 9. Maiden, 1894, *Agric. Gazette N.S.W.* 5 (7): 470-472. Mitchell, 1848, *Trop. Austr.*: 372. Roth, 1901, *N. Qld. Ethnol. Bull.* 3: 19. Schultz, 1948, *Copeia* 1948 (2): 94 (rotenone). Shirley, 1895, *Proc. Roy. Soc. Qld.* 11: 88-90. Smithsonian Inst. Anthropol. Papers 38, 1953: 243 (with bibliography).

POLLUTION. (See also Mortality.)

[Possibly the first record of fish pollution in Australia was that reported from Victoria in 1841 by Hopton, 1951, in *J. Proc. Roy. Aust. Hist. Soc.* 36 (5): 243-244.]

Anon., 1947, *Agric. Gazette N.S. Wales* Dec. 1947: 637. P. Dickinson, 1952, *N. Zeal. Engineering* 7: 43-47. Entom. Branch, 1948, *Agric. Gazette N.S. Wales* 59 (3): 152 (effect of D.D.T.). Hindwood, 1953, *Emu* 53: 90. Mansfield, 1956, *Australas. Aqua Life* 1 (11): 13-14, figs. Marshall, 1924, Council Munic. Mosman Rept. 1922-23: 35. J. M. Thomson, 1963, *Austr. J. Sci.* 25 (9): 414-415, fig. 1.

Oil-pollution: Anon., 1955, Fisher. Dept. W. Aust. Monthly Serv. Bull. 4 (6): 94-97. Dickison, 1951, *Emu* 51: 238. Mayo, 1933, *Emu* 32: 328 and 35: 310 (see also *Emu Index* 1938: 49). Morris, 1929, *Vict. Nat.* 46: 170.

PREDATORY FISHES. (See also Venomous Fishes.)

Bartlett, 1954, Pearl Seekers: 146, 231 et seq. Boddeke, 1963, *Nature* Feb. 16: 714-715. Whitley, 1963, Internat. Convention Life Saving Tech. 1960 (B), passim. pls A-B (bibliography. 62-63, q.v.).

RAINS OF FISHES.

Gudger, 1929, *Ann. Mag. Nat. Hist.* (10): 3: 13. Haysom, 1959, *Qld. Fisher. Info. Bull.* 16: 1. McCulloch, 1925, *Aust. Mus. Mag.* 2 (6): 217-218. Ogilby, 1906, *Proc. Roy. Soc. Qld.* 20: 28 et *ibid.* 21, 1908: 12. Palmer, 1902, *Proc. Linn. Soc. N.S. Wales* 26: 515. Shipway, 1947, *N. Qld. Nat.* 15 (85): 10 and *W.A. Nat.* 1 (2), 1947: 47. Stewart, 1959, *Finchat*, May 1959: 29. Whitley, 1954, *Aust. Mus. Mag.* 11 (5): 154-155. Whitley, 1961, *Aust. Mus. Mag.* 13: 333-334.

[There are many accounts in newspapers, yet to be assembled.]

REPRODUCTION. (*See also* Hermaphroditism, Planktonic ova and larvae, and Sex Dimorphism.)

Fecundity: Blackburn, 1941, *C.S.I.R. Bull.* 138: 16 (maturity scale). Smith & Thomson, 1957, *Fisher. Dept. W. Austr. Monthly Serv. Bull.* 6 (11): 150. Stead, 1936, *Aust. Nat.* 9 (7): 157 (maturity in snapper).

[The reports of fisheries inspectors in various State departmental Annual Reports and in New Zealand are notable.]

Storage of milt: Butcher, 1944, *Aust. J. Sci.* 7 (1): 23-25.

Larval fishes.

[Information on *Neoceratodus*, sharks, rays and various fishes is scattered through literature. Following are some general treatises. As many as 2,170 embryos have been found in a *Cristiceps*.]

Graham, 1927, *Pairing, Courtship and Parental Care among three New Zealand Fishes*. Graham, 1939, *Trans. Roy. Soc. N. Zeal.* 69: 369, pls 45-46. Haswell, 1890, *Rept. 2nd Meet. Aust. Assn. Adv. Sci.*: 482 (shore eel). Munro, 1954, *Aust. J. Mar. freshw. Res.* 5: 64, pl. 1 (flying fish). Regan, 1916, *Brit. Antarctic Exp., Zool.* 1 (4): 125-152. Thomson & Bennett, 1953, *Aust. J. Mar. freshw. Res.* 4 (2): 227-233, figs 1-3 (blenny). Whitley, 1950, *Proc. Roy. Zool. Soc. N.S. Wales* 1948-9: 28 (Port Jackson Shark). Whitley & Allan, 1958, *Seahorse & Relatives*: 16 et seq. (Syngnathidae).

Nests: Hamilton, 1891, *Syd. Quarterly Mag.* 8 (4): 318-320 (catfish). T. Mitchell, 1848, *J. Exped. Trop. Austr.*: 371 (catfish). Semon, 1899, *In Aust. Bush*: 197, etc. (catfish).

Buccal incubation: Fowler & Bean, 1930, *Bull. U.S. Nat. Mus.* 100 (10): 4, figs. Hale, 1947, *S. Aust. Nat.* 24 (3): 1, figs. Ogilby, 1889, *Proc. Linn. Soc. N.S.W.* (2) 3 (4): 1559. Stead, 1934, *Abstr. Proc. Linn. Soc. N.S. Wales* 470: 2. Tryon, 1934, *Qld. Nat.* 9: 30.

RESPIRATION.

Hora, 1933, *J. Bombay Nat. Hist. Soc.* 36: 538, figs.

SEX DIMORPHISM.

Bertelsen, 1951, *Dana Rept.* 39: 14, figs (Ceratioidea). Blackburn, 1950, *Aust. J. Mar. freshw. Res.* 1 (2): 157, 182, etc. Fraser-Brunner, 1940, *Ann. Mag. Nat. Hist.* (11) 6: 390 (boxfishes). Graham, 1939, *Trans. Roy. Soc. N. Zeal.* 69: 370 (clingfish). McCann, 1953, *Rec. Dom. Mus.* 2 (1): 1, figs. McCulloch, 1914, *Aust. Zool.* 1 (1): 29-31, 4 figs (pipefishes). Troschel, 1870, *Arch. Naturg.* 36 (4): 276. Whitley, 1940, *Fish. Austr.* 1: 48 & 180 (sharks and skates).

[It is not possible to distinguish male from female fishes externally in the great majority of cases. It is necessary to open the body-cavity and see if there are eggs in the roe of the female or hard roe (milt) in the male. Sharks and rays have "claspers", long appendages next to the ventral fins in the males. The females are without these. The jaws and teeth of many sharks and skates are different in shape in males and females.

In the breeding season, the females of ordinary bony fishes may be distended by roe, or, in the case of aquarium fishes, a female may be chased by more than one male, which is often smaller and slenderer. Usually the differences are so slight that they cannot be described, but males of some fishes are more brilliantly coloured in the nuptial season. The colours of many parrot fishes are so different according to sex that males and females have been considered to belong to separate species. Carp often have small pearly dots on the head (the "pearl organs") in the male fish. Dorsal fin-rays may be lengthened in male Western Australian "Jewfish" (*Glaucosoma*) and the tail-corners pointed in female Angel Fishes.

The structure of the fins and proportion of the bodies vary subtly in the sexes in certain leatherjackets, boxfishes, blennies, the Tasmanian troutlet and clingfishes. The male salmon often develops hooked jaws with age and the males of certain gobies and blennies have lengthened jawbones. In Pipefishes and Seahorses the males have a brood-pouch for carrying the eggs, laid therein by the female. Some catfishes have differently shaped ventral fins in the two sexes. Pigmy Garfish and certain live-bearers are characterized by the lengthened rays in the anal fins of the males and there is a well-developed "genital cage" in brotulid fishes. The distance between the eyes differs in the sexes of some flounders and these may have much lengthened fin-rays in males. Unicorn fishes show sex-dimorphism in the shape of the head. Some deep-sea angler fishes have degenerate parasitic males.]

SEX RATIO.

Kesteven, 1942, *C.S.I.R. Bull.* 157: 62 & 135 (mullet). Whitley, 1945, *Austr. Zool.* 11: 11 (sharks).

SIZE.

[Maximum sizes are given under species in general works by McCulloch, Munro, Whitley and others. Record game fishes are recorded annually by the International Game Fish Association at the American Museum of Natural History, New York.

Minimum legal lengths at which fish may be caught are stipulated by State Fisheries Depts.]

Bancroft, 1933, *Proc. Linn. Soc. N.S. Wales* 58: 468 (lungfish). Bruun, 1940, *Dana Rept.* 21: 10 (lightest fish is *Schindleria*). Hemmingsen, 1934, *Vidensk. Medd. fra Dansk. naturh. Foren* 98: 125-160, pls 7-19. Schultz, 1938, *Journ. Mammal.* 19 (4): 480 (formulae for large sharks, whales, etc.). Smith & Thomson, 1957, *Fisher. Dept. W. Austr. Monthly Serv. Bull.* 6 (11): 148-150 (minimum sizes of fishes at maturity). Whitley, 1955, *Aust. Mus. Mag.* 11 (10): 329, figs (largest and smallest).

SKELETON.

Chabanaud, 1933, *Mem. Soc. Sci. Nat. Maroc* 35, and his other papers (flatfishes). Gosline, 1961, *Smithson. Misc. Coll.* 142 (3): 1, figs. *Jap. J. Ichth.* 4, 1955: 162. Romeo & Mansueti, 1962, *Chesapeake Science* 3 (4): 257-263, figs (esp. *Euthynnus*). Waite, 1902, *Rec. Aust. Mus.* 4: 292, pls 45-46 (*Luvarus*). Weitzman, 1962, *Stanford Ichth. Bull.* 8 (1): 1-78, figs 1-21.

Locking-mechanism of fin-spines: Monod, 1958, *Bull. Mus. nat. Hist. Nat. (Paris)* (2) 30: 498, figs 3-4.

Green and blue bones of certain fishes.

[According to Cole, 1944, *Hist. Compar. Anat.*: 379, Borch in 1673 was apparently the first to observe green bones in *Belone*, followed by Willughby, 1686, and others. There may be mention of this colouring matter in general works on the skeleton, but the following deal specifically with the subject: Krukenberg, C. F., 1882, *Vergl. Physiol. Studien*, Heidelberg, ii, 3, Abth.: 139-143. Wagenaar, M., 1939, *Arch. neerl. Zool.* 4: 103-105. Fontaine, M., 1941, *Bull. Inst. Oceanogr. Monaco* 793: 1-3.]

SKULL.

Gregory, 1933, *Trans. Amer. Philos. Soc.* 23: 1-481, figs 1-302. Harrington, 1955, *Copeia* 1955 (4): 267, figs (synonymy of skull bones). Haswell, 1884, *Proc. Linn. Soc. N.S. Wales* 9: 71, figs (elasmobranchs). H. Kesteven, 1926, *Rec. Aust. Mus.* 15: 132-140, 8 figs. H. Kesteven, 1942, *Aust. Mus. Mem.* 8. Whitley, 1941, *Aust. Mus. Mag.* 7 (9): 307, fig. ("crucifix" in catfish skull).

SLEEP.

Graham, 1953, *Treasury N. Zeal. Fish.*: 273. Qasim, 1955, *Nature* 175: 217, fig. (larval fishes). Weber, 1961, *Zeitschr. Tierpsych.* 18 (5): 517, figs. Winn, 1955, *Zoologica* 40 (3): 145, pl. i (mucous envelope of sleeping parrot fishes). Zahl, 1952, *Nat. Geogr. Mag.* 101 (2): 200, fig. and plate on p. 206 (trigger fishes).

SOUND-PRODUCTION.

Bernstein, 1956, *Natural History (New York)*, April 1956: 192, figs. Coppleson, 1958, *Shark Attack*: 34 et seq., 54, 133, 164-5, 170, 171 & 177. Hardenberg, 1934, *Zool. Anzeiger* 108: 224-227, fig. 1. Kellogg, 1953, *Amer. Mus. Novit.* 1611: 1-5 (bibliography). E. Scott, 1955, *Proc. Roy. Soc. Tas.* 89: 136 (pipefish). Wilimovsky, 1954, *Copeia* 1954 (2): 161 (further refs on those given by Kellogg, *loc. cit.*).

SPEED. (See Locomotion.)

TELEVISION.

[The dissection of a Stingray by the late Alan Colefax was televised at the A.N.Z.A.A.S. Science Congress at the University of Sydney in August, 1952.]

Anon., 1953, *Fisheries Newsletter* 12 (4): 24, 3 figs (television in fish research).

TEMPERATURE.

Sea-temperatures.

[Sea-temperatures and water-movements, knowledge of which is so important when dealing with migratory fish, are still incompletely understood in Australasia. Aourousseau (1959, *J. Proc. Roy. Soc. N.S. Wales* 92: 104-114) recorded surface temperatures of Australian seas, but had no data for much of northern Australia. From the Northern Territory to Thursday Island, Queensland, in October, 1949, I noted sea-temperatures of 26.8 to 28.6°C. In July, 1949, in the same region Serventy (MS) read 24.5 to 25.6°C. At the Abrolhos Islands, Western Australia, in December, 1945, the surface temperature ranged from 21 to 23°C. Australian sea-surface temperatures in relation to shark attacks were shown in Coppleson (1958, *Shark Attack*: 114-115). A chart of sea temperatures was prepared by the Royal Dutch Meteorological Institute at De Bilt, Ref. No. 124, and one of ocean currents by the United States Navy Hydrographic Office, Publ. no. 568. Work is continuing by scientists of the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, New South Wales, some indication of the measures being adopted having been published in *Fisheries Newsletter*, Nov., 1961: 19-22, figs 1-3.]

Aurousseau, 1959, *J. Proc. Roy. Soc. N.S. Wales* 92: 104-114, illustr. Coppleson, 1962, *Shark Attack*, ed. 2: 43-163 (a table which appeared in the first edition, pp. 114 & 115, is not reproduced). Dakin, 1952, *Aust. Seashores*.

Technique of shipping fishes alive in ice: Amsnaes, 1954, *Natural History* (New York), Nov. 1954: 405-407, photos.

Hot springs, etc.; freshwater temperatures: R. Miller, 1949, *Aquar. Journ.* 20 (11): 286. Whitley, 1960, *Freshw. Fish. Aust.*: 9-11 and under species.

TERATOLOGY. (See also Coloration and Pathology.)

Fin-abnormalities: Catala, 1949, *Bull. Soc. Zool. France* 74: 108-111, pl. i (aberrant spinous dorsal in *Hemiochus*). Iredale & Whitley, 1929, *Aust. Mus. Mag.* 3 (12): 423, figs (leather-jackets). Myers, 1946, *Copeia* 1946, 1: 41 (fishes lacking ventral fins). E. Pope, 1945, *Aust. Mus. Mag.* 8 (11): 383, fig. (leatherjacket). Whitley, 1940, *Fish. Aust.* 1: 173-174 & 181 (pectorals). Whitley, 1943, *Aust. Zool.* 10 (2): 177 (*Euleptorhamphus* without ventrals).

Heterosomata: Chabanaud, 1936, *Bull. Mus. Nat. Hist. Nat. Paris* (2) 8: 394, figs. Chabanaud, 1939, *Arch. Mus. Hist. Nat. Lyons* 15: 1, figs 1-3. Gudger, 1935-37, *Amer. Mus. Novit.* 768, 811, 885, 896, 897, 925 and 959. Gudger, 1935a, *Journ. Morph.* 58: 1. Gudger, 1941, *Copeia* 1941 (1): 28. Gudger, 1945, *Science* 102: 672. Norman, 1934, *Monogr. Flatfishes* 1: 22-29, figs 16-19. Whitley, 1949, *Aust. Mus. Mag.* 9 (11): 381.

Pug-headed fishes: Ogilby, 1893, *Ed. Fish. N.S. Wales*: 126. Whitley, 1944, *Aust. Mus. Mag.* 8: 200, figs. Young, 1929, *Trans. N. Zeal. Inst.* 60: 147, pl. 17, fig. B.

Two-headed sharks and fishes: Anon., 1838, *Hobart Town Courier*, March 9: 3 (shark). Arudpragasam, 1960, *Ceylon J. Sci. (Biol. Sci.)* 3 (2): 167, pls 1-4 (anatomy of two-headed shark). Cox, 1892, *PROC. LINN. SOC. N.S. WALES* 7: 41 (shark). Gemmill, 1895, *Proc. Zool. Soc.* 423 & 1903, *ibid.*, 2: 4-23, pl. (fishes, &c.). B. G. Smith, 1942, *Bashford Dean Mem.* Vol. 8: 750, pl. 5, fig. 62 (*Heterodontus*). Whitley, 1937, *Aust. Mus. Mag.* 6 (5): 154, figs (fishes & sharks). Whitley, 1939, *Aust. Mus. Mag.* 6 (12): 432 (sharks). Whitley, 1940, *Fish. Aust.* 1: 60, figs (sharks).

Various abnormalities: Breder, 1934, *Bull. N.Y. Zool. Soc.* 37 (5): 141, illustr. Chabanaud, 1927, *Arch. Mus. Hist. Nat. Paris* (6) 2: 35, plates (Sciaenoids). D'Ombraïn, 1957, *Game Fishing Aust.*, pl. opp. p. 63 (twin-beaked marlin). Graham, 1953, *Treasury N. Zeal. Fishes, passim*. Gudger, 1930, *Amer. Mus. Novit.* 444: 1-7, figs. Gudger, 1936, *Sci. Monthly* 43: 252-261 (earliest records). Morrow, 1951, *Copeia* 1951 (4): 303, fig. 1 (marlin without spear). Pope, 1936, *PROC. LINN. SOC. N.S. WALES* 41: p. xlvii (snapper). Schaperclaus, 1941, *Fischkrankheiten*. Whitley, 1929, *Proc. Roy. Soc. Tas.* 1928: 55, pl. 4, fig. 5. Whitley, 1940, *Aust. Mus. Mag.* 7 (5): 179-180, 2 figs (two-mouthed fishes). Whitley, 1943, *PROC. LINN. SOC. N.S.W.* 58: 126, fig. 6 (*Rhinobatus*). Whitley, 1952, *Proc. Roy. Zool. Soc. N.S. Wales* 1950-51: 30, fig. 4. Whitley, 1961, *Aust. Mus. Mag.* 13 (9): 298-301, 4 figs (freaks).

TERRITORIALITY.

Bayer & Rofen, 1957, *Ann. Rept. Smithson. Inst.* 1956: 495. Forseluis, 1957, *Zool. Bidrag Uppsala* 32: 159 et seq., 422 et seq., etc., figures. Gerking, 1959, *Biol. Rev. Cambr. Philos. Soc.* 34 (2): 221. Hass, 1958, *We Come from the Sea*: 160, pl. opp. p. 129 (attacking mirror reflections). Herald, 1956, *Copeia* 1956 (3): 195. Randall, 1958, *Pacific Science* 12 (4): 327-347. Robins & Phillips, 1959, *Zoologica* 44 (2): 77, pls 1-3, & fig.

TIME.

[The angle of the light of the sun or moon and the rise and fall of the tides affect fishes, but it seems that they also have a "time-sense", so far little understood by man. The spawning of the Grunion (*Leuresthes*) in California and Whitebait (*Austrocobitis*) in New Zealand must occur within an extremely limited period to be successful.]

Blanco, 1958, *Phil. J. Fisher.* 4: 33. Brain, 1951, *Mind, Perception & Science*: 44 et seq. Gamulin & Hure, 1956, *Nature Jan.* 28: 193, fig. (evening spawning of sardine). Hass, 1952, *Under the Red Sea*: 142. J. Randall, 1945, *Proc. Hawaiian Acad. Sci.* 1954-5 (unpaged). L. E. Russell, 1951, *Let's Go Fly Fishing*: 129.

TYPES (See also Logotypes.)

Lists of types in Museums containing Australasian species: Anon., 1961, *W. Aust. Mus. Ann. Rept.* 1959-60: 28. Bauchot & Blanc, 1961, *Bull. Mus. Nat. Hist. Paris* 33 (4): 369. Bauchot a.o., 1960, *Bull. Mus. Nat. Hist. Paris* (2) 32: 290. Klausewitz, 1960, *Senckenb. Biol.* 41: 289, pls & figs. Ladiges, Wahlert & Mohr, 1958, *Mitt. Hamburg Mus.* 56: 155, 169-171. Le Danois, 1961, *Bull. Mus. Nat. Hist. Nat., Paris* (2) 32: 513-527 and (2) 33: 276-281 and 462-478. Powell, 1941, *Rec. Auckland Inst.* 2: 239 and 3: 403 (Pisces, pp. 258-259). Ramsay, 1885, *Aust. Mus. Ann. Rept.* 1884: 42-46 and 1885: 5 (Day's types in Australian Museum). Tortonese, 1961, *Ann. Mus. Civico Stor. Nat. Giac. Doria, Genova*, 72: 179-191. Wahlert, 1955, *Veröff. Übersee Mus. Bremen*, A, 2 (5): 323-326, figs 1-2. Whitley, 1957, *List of Type-Specimens of Recent Fishes in The Australian Museum, Sydney*. Roneoed: 1-40.

VELUM MAXILLARE.

Gudger, 1935, *J. Morph.* 57: 91, figs. Müller & Henle, 1837, *Ber. Verh. K. Prus. Akad. Wiss. Berlin*: 111.

VENOMOUS FISHES. (See also Predatory Fishes.)

Gillis, 1961, *N. Qld. Nat.* 29 (130): 3-5, figs 1-4 (stonefish). Steinitz, 1959, *Copeia* 1959 (2): 158-160 (*Pterois*). Whitley, 1963, Suppl. to Bull. Post-Graduate Ctee. in Medicine, Univ. Syd. 18 (12): 41-63 (with bibliography, q.v.), pls A-B. Whitley & Halstead, 1955, *Rec. Aust. Mus.* 23 (5): 211-227 (q.v. for annotated bibliography).

VERTEBRAE. (See also Skeleton.)

Clothier, 1950, Calif. Fish. Bull. 79, illustr. Springer & Bullis, 1960, *Bull. Mar. Sci. Gulf & Caribbean* 10: 241, fig. 2 (*Pristiophoridae*). Stokell, 1941, *Rec. Canterb. Mus.* 4 (7): 364 (*Retropinna*). Stokell, 1945, *Trans. Roy. Soc. N. Zeal.* 75: 127. Stokely, 1952, *Copeia* 1952 (4): 255, figs. Whitley, 1945, *Austr. Zool.* 11: 8, fig. 5a (sharks).

VISCERA.

Barnstock, 1957, *Nature* 4600, Dec. 28, 1957: 1491, figs 1-2 (observed through "window").

VISION.

Beach, 1941, *Natural History* (New York) 48 (2); Sept. 1941: 66 & 127 (fishes not colourblind). Hora, 1938, *J. Bombay Nat. Hist. Soc.* 40 (1): 62, figs (aerial vision). Pincher, 1947, *Discovery* 8 (7): 209-215, figs 1-7.

VITAMINS.

Anon., 1947, *Fisheries Newsletter* 6 (2): 19 (bibliography available). Cunningham, 1935, *N. Zeal. J. Sci. Tech.* 17 (3): 563-567. Cunningham, 1939, *Austr. J. exper. Biol. Med. Sci.* (Adelaide) 17: 457-464. Denz & Shorland, 1934, *N. Zeal. J. Sci. Tech.* 15 (5): 327. Ferguson Wood & Kuchel, 1941, *J.C.S.I.R.* 14 (1): 47-57. Jowett & Davies, 1938, C.S.I.R. Pamphlet 85. Julius a.o., 1937, Eleventh Ann. Rept. C.S.I.R.: 64, and later annual reports. Malcolm, 1927, *Trans. N. Zeal. Inst.* 57: 879-880.

WEATHER AND WINDS. (See also Time.)

Dannevig, 1907, On some peculiarities in our coastal winds and their influence upon the abundance of fish in inshore waters, *Proc. Roy. Soc. N.S. Wales* 41: 27-45, diagrams A-H. G. Kesteven, 1946, *Fisheries Newsletter*, Oct. 1946. Serventy, 1947, *Journ. Counc. Sci. Industr. Res.* 20 (1): 15-16 (weather and tuna fishing). Tosh, 1903, Marine Biologist's Report (Parliament. Rept. Queensland Marine Dept. 1902-3), appendix 7: 2 (weather affecting movements of mullet). Whitley, 1940, *Fishes of Australia* 1: 14, 18-20, and 266-268 (weather and sharks).

X-RAYS.

Abbie, 1959, *Bull. Post-Graduate Ctee. Med. Univ. Syd.* 15 (3): 115, 118. Bonham & Baycliff, 1953, *Copeia* 1953 (3): 150, pl. i. Gosline, 1948, *Copeia* 1948 (1): 58. Nissen, 1951, *Schöne Fischbüchers* 36. R. Miller, 1953, *X-ray News* (G.E.C., Milwaukee) Dec. 1953: 6, figs. R. Miller, 1957, *Syst. Zool.* 6 (1): 29, illustr. Sherrard, 1896, *Illustr. Handbk. Aquar.* Melbourne.

ZODIACAL FISHES.

Blavatsky, 1925, *Secret Doctrine*, i, ii, *passim*. Singer, 1943, *A Short History of Science*: 118, fig. 50. Singer, 1958, *From Magic to Science*: 85, etc., figs.

APPENDIX B: NAME-LIST OF THE FISHES RECORDED FROM AUSTRALIA.

My late mentor in ichthyology, Allan R. McCulloch, compiled a manuscript list of the genera and species of Australian fishes which was published, with some modifications, after his death, as the fifth Memoir of the Australian Museum in 1929 and 1930. This "Check-list of the Fishes recorded from Australia" embraced some two thousand nominal species. In the last thirty years and more, many additions have been made as the result of collecting in deeper water or in remoter localities than were accessible in McCulloch's days and some species have been shown to be synonyms so that an up-to-date list is overdue.

The list now presented does not include synonyms or nomina nuda and some obviously non-Australian species in McCulloch's list have been omitted. References to most of the genera and species will be found in McCulloch (1929) or in later papers listed in the bibliography hereunder. This new list follows the same order as McCulloch's 1929 Check-list, which may be consulted for names of classes, orders and families. At the present time 2456* nominal species are known, as follows:

- | | |
|---|--|
| 1. <i>Branchiostoma</i> (<i>Amphipleurichthys</i>)
<i>minucauda</i> Whitley, 1932. | 4. <i>Paramphioxus</i> <i>bassanus</i> (Gunther,
1884). |
| 2. <i>Bathyamphioxus</i> <i>franzi</i> Whitley, 1932. | 5. <i>Epigonichthys</i> <i>cultellus</i> Peters, 1877. |
| 3. <i>Bathyamphioxus</i> <i>australis</i> (Raff,
1912). | 6. <i>Merscalpellus</i> <i>hedleyi</i> (Haswell,
1908). |

* Excluding such new species and records as may be in the newly announced Australian-American Arnhem Land Expedition's Report, not yet to hand at time of proof-reading (June, 1964).

7. *Notasymmetron caudatum* (Wille, 1896).
8. *Geotria australis* Gray, 1851.
9. *Mordacia mordax* (Richardson, 1846).
- 9a. *Hexanchus griseus* (Bonnaterre, 1788).
10. *Heptranchias dakini* Whitley, 1931.
11. *Notorynchus cepedianus* (Peron, 1807).
12. *Heterodontus portusjacksoni* (Meyer, 1793).
13. *Molochophrys galeatus* (Gunther, 1870).
14. *Hemiscyllium freycineti* (Quoy & Gaimard, 1824).
15. *Hemiscyllium ocellatum* (Bonnaterre, 1788).
16. *Hemiscyllium trispeculare* (Richardson, 1843).
17. *Chiloscyllium punctatum* Muller & Henle, 1838.
18. *Parascyllium collare* Ramsay & Ogilby, 1888.
19. *Parascyllium ferrugineum* McCulloch, 1911.
20. *Parascyllium variolatum* (Dumeril, 1853).
21. *Parascyllium* (*Neoparascyllium*) *multimaculatum* Scott, 1935.
22. *Brachaelurus waddi* (Bloch & Schneider, 1801).
23. *Orectolobus ornatus* (De Vis, 1883).
24. *Orectolobus maculatus* (Bonnaterre, 1788).
25. *Orectolobus wardi* Whitley, 1939.
26. *Eucrossorhinus ogilbyi* (Regan, 1909).
27. *Sutorectus tentaculatus* (Peters, 1864).
28. *Stegostoma tigrinum* (Pennant, 1769).
29. *Nebrodes concolor ogilbyi* Whitley, 1934.
30. *Heteroscyllium colcloughi* (Ogilby, 1908).
31. *Rhincodon typus* Smith, 1829.
32. *Asymbolus analis* (Ogilby, 1885).
33. *Juncus vincenti* (Zietz, 1908).
34. *Aulohalaelurus labiosus* (Waite, 1905).
35. *Figaro boardmani* (Whitley, 1928).
36. *Figaro boardmani socius* Whitley, 1939.
37. *Cephaloscyllium isabella laticeps* Dumeril, 1853.
38. *Cephaloscyllium isabella laticeps nascione* Whitley, 1932.
39. *Atemomycteris macleayi* Whitley, 1939.
40. *Gillisqualus amblyrhynchoides* Whitley, 1934.
41. *Platypodon coatesi* Whitley, 1939.
42. *Platypodon gangeticus* Muller & Henle, 1839.
43. *Platypodon menisorrah* Muller & Henle, 1839.
44. *Galeolamna coongoola* Whitley, 1964.
45. *Galeolamna dorsalis* Whitley, 1944.
46. *Galeolamna greyi* Owen, 1853.
47. *Galeolamna isobel* Whitley, 1947.
48. *Galeolamna pleurotaenia tilstoni* Whitley, 1950.
49. *Galeolamna ahenea* (Stead, 1938).
50. *Galeolamna eblis* Whitley, 1944.
51. *Galeolamna macrurus* (Ramsay & Ogilby, 1887).
52. *Galeolamna mckaili* Whitley, 1945.
53. *Galeolamna cauta* Whitley, 1945.
54. *Galeolamna fowleri* Whitley, 1944.
55. *Galeolamna* (*Lamnarius*) *spenceri* (Ogilby, 1911).
56. *Galeolamna* (*Ogilamia*) *stevensi* (Ogilby, 1911).
57. *Galeolamna* (*Urogymnops*) *fitzroyensis* Whitley, 1943.
58. *Galeolamna* (*Bogimba*) *bogimba* Whitley, 1943.
59. *Mapolamia spallanzani* (Le Sueur, 1822).
60. *Carcharhinus mackiei* (Phillipps, 1935).
61. *Uranga nasuta* Whitley, 1943.
62. *Longmania brevipinna* (Muller & Henle, 1839).
63. *Longmania calamaria* Whitley, 1944.
64. *Negogaleus microstoma* (Bleeker, 1852).
65. *Triaenodon apicalis* Whitley, 1939.
66. *Mystidens innominatus* Whitley, 1944.
67. *Hypoprion hemiodon* (Muller & Henle, 1839).
68. *Hypoprion macloiti* (Muller & Henle, 1839).
69. *Scoliodon jordani* Ogilby, 1908.
70. *Protozygaena longmani* (Ogilby, 1912).
71. *Negaprion queenslandicus* (Whitley, 1939).
72. *Galeocerdo cuvier* (Le Sueur, 1822).
73. *Furgaleus macki* (Whitley, 1943).
74. *Furgaleus ventralis* (Whitley, 1943).
75. *Notogaleus rhinophanes* (Peron, 1807).
76. *Emissola antarctica* (Gunther, 1870).
77. *Emissola maugeana* Whitley, 1939.
78. *Emissola ganearum* Whitley, 1945.
79. *Rhizoprionodon crenidens* (Klunzinger, 1879).
80. *Physodon mulleri* (Muller & Henle, 1839).
81. *Sphyrna lewini* (Griffith, 1834).
82. *Sphyrna ligo* Fraser-Brunner, 1950.
83. *Lamna whitleyi* Phillipps, 1935.
84. *Isuropsis mako* Whitley, 1929.
85. *Carcharodon albigors* Whitley, 1939.
86. *Odontaspis herbsti* Whitley, 1950.
87. *Carcharias arenarius* Ogilby, 1911.
88. *Carcharias tricuspidatus* Day, 1878.
89. *Alopias caudatus* Phillipps, 1932.
90. *Alopias greyi* Whitley, 1937.
91. *Mitsukurina owstoni* Jordan, 1898 (? Australian).
92. *Halsiudrus maccoyi* (Barrett, 1933).
93. *Koinga lebruni* (Vaillant, 1888).
94. *Koinga whitleyi* (Phillipps, 1931).
95. *Flakeus tasmaniensis* (Rivero, 1936).
96. *Flakeus megalops* (Macleay, 1881).
97. *Oxynotus brunensis* (Ogilby, 1893).
98. *Centrophorus* (*Gaboa*) *harrissoni* McCulloch, 1915.
99. *Centrophorus* (*Proscymnodon*) *plunketi* Waite, 1910.
100. *Centrophorus scalpratus* McCulloch, 1915.

101. *Centrophorus (Somnispinax) nilsoni* Thompson, 1930.
102. *Deania kaikourae* (Whitley, 1934).
103. *Deaniops quadrispinosus* (McCulloch, 1915).
104. *Euprotomicros bispinatus* (Quoy & Gaimard, 1824).
105. *Acanthidium mollerii* Whitley, 1939.
106. *Scimnus philippii* (Whitley, 1931).
107. *Echinorhinus (Rubusqualus) mccoysi* Whitley, 1931.
108. *Leius ferox* Kner, 1865.
109. *Squatina australis* Regan, 1906.
110. *Squatina tergocellata* McCulloch, 1914.
111. *Pristiophorus cirratus* (Latham, 1794).
112. *Pristiophorus nudipinnis* Gunther, 1870.
113. *Pristis clavata* Garman, 1906.
114. *Pristis zijsron* Bleeker, 1851.
115. *Pristiopsis leichhardti* Whitley, 1945.
116. *Rhinobatos batillum* Whitley, 1939.
117. *Aptychotrema bogaivillii* (Muller & Henle, 1841).
118. *Aptychotrema rostrata* (Shaw & Nodder, 1794).
119. *Aptychotrema vincentiana* (Haacke, 1885).
120. *Rhynchobatus djiddensis* (Bonnaterre, 1788).
121. *Trygonorrhina fasciata* Muller & Henle, 1841.
122. *Trygonorrhina fasciata guanerius* Whitley, 1932.
123. *Trygonorrhina melaleuca* T. D. Scott, 1954.
124. *Rhina ancylostomus* Bloch & Schneider, 1801.
125. *Raja cerva* Whitley, 1939.
126. *Raja australis* Macleay, 1884.
127. *Raja (Dentiraja) dentata* Klunzinger, 1872.
128. *Raja lemprieri* Richardson, 1845.
129. *Zearaja nasuta* (Muller & Henle, 1841).
130. *Zearaja gudgeri* Whitley, 1940.
131. *Pavoraja nitida* (Gunther, 1880).
132. *Pavoraja (Argoraja) polyommata* (Ogilby, 1910).
133. *Spiniraja whitleyi* (Iredale, 1938).
134. *Irolita waitii* (McCulloch, 1911).
135. *Notastrape macneilli* Whitley, 1932.
136. *Narcinops tasmaniensis* (Richardson, 1842).
137. *Hypnos monopterygium* (Shaw & Nodder, 1795).
138. *Bathytoshia thetidis* (Waite, 1899).
139. *Bathytoshia brevicaudata* (Hutton, 1875).
140. *Toshia fluviorum* (Ogilby, 1908).
141. *Neotrygon kuhlii* (Muller & Henle, 1841).
142. *Urogymnus asperimus solanderi* Whitley, 1939.
143. *Urolophus sufflavus* Whitley, 1929.
144. *Urolophus bucculentus* Macleay, 1884.
145. *Urolophus cruciatus* (Lacepede, 1804).
146. *Urolophus expansus* McCulloch, 1916.
147. *Urolophus testaceus* (Muller & Henle, 1841).
148. *Urolophus mucosus* Whitley, 1939.
149. *Urolophus viridis* McCulloch, 1916.
150. *Urolophus gigas* T. D. Scott, 1954.
151. *Gymnura australis* (Ramsay & Ogilby, 1886).
152. *Taeniura lymnia* (Bonnaterre, 1788).
153. *Taeniura meyeri* Muller & Henle, 1841.
154. *Pastinachus sephen ater* (Macleay, 1883).
155. *Himantura toshi* Whitley, 1939.
156. *Himantura granulata* (Macleay, 1883).
157. *Aetobatus australis* (Macleay, 1881).
158. *Aetobatus hamlyni* (Ogilby, 1911).
159. *Stoasodon punctatus* (Miklouho-Maclay & Macleay, 1886).
160. *Stoasodon ocellatus* (Kuhl, 1823).
161. *Rhenoptera neglecta* Ogilby, 1912.
162. *Mobula diabolus* (Shaw, 1804).
163. *Daemomanta alfredi* (Kreff, 1868).
164. *Psychichthys ogilbyi* (Waite, 1898).
165. *Psychichthys waitei* (Fowler, 1908).
166. *Phasmichthys lemures* Whitley, 1939.
167. *Callorhynchus milii* Bory, 1823.
168. *Neoceratodus forsteri* (Kreff, 1870).
169. *Saccopharynx schmidtii* Bertin, 1934.
170. *Elops (Gularus) australis* Regan, 1909.
171. *Megalops cyprinoides* (Broussonet, 1782).
172. *Albula neoguinaica* Cuvier & Valenciennes, 1846.
173. *Scleropages leichhardti* Gunther, 1864.
174. *Scleropages leichhardti jardinii* Saville-Kent, 1892.
175. *Chirocentrus dorab* (Bonnaterre, 1788).
176. *Dussumieria hasseltii* Bleeker, 1851.
177. *Etrumeus jacksonensis* Macleay, 1878.
178. *Stolephorus gracilis* (Temminck & Schlegel, 1846).
179. *Stolephorus robustus* (Ogilby, 1897).
180. *Stolephorus delicatulus macassariensis* Bleeker, 1849.
181. *Fiscina postera* (Whitley, 1931).
182. *Maugeclupea novaehollandiae* (Cuvier & Valenciennes, 1847).
183. *Escualosa macrolepis* (Steindachner, 1879).
184. *Escualosa abbreviata* (Cuvier & Valenciennes, 1847).
185. *Escualosa macrura* (Cuvier, 1829).
186. *Fimbriclupea dactylolepis* Whitley, 1940.
187. *Chupalosa bulan* (Bleeker, 1849).
188. *Chupalosa lipa* (Whitley, 1931).
189. *Macrura maccullochi* (Whitley, 1931).
190. *Macrura blackburni* Whitley, 1948.
191. *Macrura kanagurta* (Bleeker, 1852).
192. *Harengula koningsbergeri* (Weber & De Beaufort, 1912).
193. *Harengula punctata stereolepis* Ogilby, 1898.
194. *Harengula schlegelii* (Castelnau, 1873).
195. *Sardinops neopilchardus* (Steindachner, 1879).
196. *Sardinops (Fusiclupea) dakini* Whitley, 1937.

197. *Potamalosa richmondia* (Macleay, 1879).
198. *Hyperlophus vittatus* (Castelnau, 1875).
199. *Hyalosprattus translucidus* (McCulloch, 1917).
200. *Neosteus ditchela* (Cuvier & Valenciennes, 1847).
201. *Nematalosa come* (Richardson, 1846).
202. *Nematalosa erebi* (Gunther, 1868).
203. *Fluvialosa richardsoni* (Castelnau, 1873).
204. *Fluvialosa horni* (Zietz, 1896).
205. *Fluvialosa elongata* (Macleay, 1883).
206. *Fluvialosa vlaminghi* Munro, 1956.
207. *Fluvialosa paracome* Whitley, 1948.
208. *Fluvialosa bulleri* Whitley, 1948.
209. *Chanos chanos* (Bonnaterre, 1788).
210. *Austranchovia australis* (White, 1790).
211. *Scutengraulis hamiltoni* (Gray, 1830).
212. *Scutengraulis mystax* (Bloch & Schneider, 1801).
213. *Amentum devisi* Whitley, 1940.
214. *Amentum carpentariae* (De Vis, 1882).
215. *Thrissina nasuta* (Castelnau, 1878).
216. *Thrissina aestuaria* (Ogilby, 1910).
217. *Anchoviella indica* (Van Hasselt, 1823).
218. *Thrissocles setirostris* (Broussonet, 1782).
219. *Thrissocles dussumieri* (Cuvier & Valenciennes, 1848).
220. *Argentina elongata australiae* Cohen, 1958.
221. *Bathylagus argyrogaster* Norman, 1930.
222. *Bathylagus* (*Bathylagoides*) *antarcticus* Gunther, 1878.
223. *Salmo eriox* Linné, 1758. Introduced.
224. *Salmo salar* Linné, 1758. Introduced.
225. *Salmo gairdnerii* Richardson, 1836. Introduced.
226. *Salmo levenensis* Walker, 1808. Introduced.
227. *Salmo sebago* Girard, 1853. Introduced.
228. *Salmo gilberti* Jordan, 1894. Introduced.
229. *Oncorhynchus narka* (Bloch & Schneider, 1801). Introduced.
230. *Oncorhynchus tshawytscha* (Donndorff, 1798). Introduced.
231. *Salvelinus fontinalis* (Mitchell, 1814). Introduced.
232. *Retropinna semoni* (Weber, 1895).
233. *Retropinna victoriae* Stokell, 1941.
234. *Retropinna tasmanica* McCulloch, 1920.
235. *Brachygalaxias pusillus* (Mack, 1936).
236. *Brachygalaxias nigrostriatus* (Shipway, 1953).
237. *Lepidogalaxias salamandroides* Mees, 1961.
238. *Austrocobitis attenuatus* scribe (Cuvier & Valenciennes, 1846).
239. *Galaxias occidentalis* Ogilby, 1899.
240. *Galaxias weedoni* Johnston, 1883.
241. *Galaxias atkinsoni* Johnston, 1883.
242. *Galaxias parkeri* Scott, 1936.
243. *Galaxias fuscus* Mack, 1936.
244. *Galaxias rostratus* Klunzinger, 1872.
245. *Galaxias truttaceus* (Cuvier, 1816).
246. *Galaxias truttaceus hesperius* Whitley, 1944.
247. *Galaxias auratus* Johnston, 1883.
248. *Galaxias corii* Macleay, 1880.
249. *Galaxias nigothoruk* Lucas, 1892.
250. *Galaxias affinis* Regan, 1906.
251. *Galaxias ornatus* Castelnau, 1873.
252. *Galaxias kayi* Ramsay & Ogilby, 1886.
253. *Galaxias scopus* Scott, 1936.
254. *Galaxias johnstoni* Scott, 1936.
255. *Galaxias findlayi* Macleay, 1882.
256. *Galaxias bongbong* Macleay, 1881.
257. *Galaxias schomburgkii* Peters, 1869.
258. *Galaxias planiceps* Macleay, 1881.
259. *Galaxias planiceps waitii* Regan, 1906.
260. *Galaxias upcheri* Scott, 1942.
261. *Saxilaga cleaveri* (Scott, 1934).
262. *Saxilaga anguilliformis* Scott, 1936.
263. *Paragalaxias dissimilis* (Regan, 1906).
264. *Halaphya elongata* Gunther, 1889.
265. *Searsia koefoedi primicrops* Parr, 1960.
266. *Prototroctes maraena* Gunther, 1864.
267. *Lovettia sealii* (Johnston, 1883).
268. *Rouleina eucla* Whitley, 1940.
269. *Ericara* (*Whitleyidea*) *nigra* (Gunther, 1878).
270. *Chauliodus dannevigii* McCulloch, 1916.
271. *Narooma benefica* Whitley, 1935.
272. *Mauroliscus muelleri* (Gmelin, 1789).
273. *Cyclothone microdon* Gunther, 1878.
274. *Gonostoma elongatum* Gunther, 1878.
275. *Polymetme illustris* McCulloch, 1926.
276. *Argyripnus iridescent* McCulloch, 1926.
277. *Diplophos taenia* Gunther, 1873.
278. *Sternoptyx diaphana* Hermann, 1781.
279. *Polyipnus tridentifer* McCulloch, 1914.
280. *Argyropelecus hemigymnus* (Cocco, 1829).
281. *Argyropelecus amabilis* (Ogilby, 1888).
282. *Pachystomias microdon* (Gunther, 1878).
283. *Stomias affinis* Gunther, 1887.
284. *Stomias gracilis* Garman, 1899.
285. *Opotomias micripnus* (Gunther, 1878).
286. *Idiacanthus fasciola* Peters, 1877.
287. *Astronesthes* (*Warreenula*) *lupina* Whitley, 1941.
288. *Gonorynchus greyi* (Richardson, 1845).
289. *Carassius auratus* (Linné, 1758). Introduced.
290. *Carassius carassius* Linné, 1758. Introduced.
291. *Neocarassius ventricosus* Castelnau, 1872.
292. *Leuciscus rutilus* (Linné, 1758). Introduced.
293. *Idus idus* (Linné, 1758). Introduced.
294. *Tinca tinca* (Linné, 1758). Introduced.
295. *Cyprinus carpio* Linné, 1758. Introduced.
296. *Plotosus anguillaris* (Bloch, 1794).
297. *Paraplotosus albilabris* (Cuvier & Valenciennes, 1840).

298. *Porochilus obbesi* Weber, 1913.
299. *Tandanus tandanus* (Mitchell, 1838).
300. *Tandanus bostocki* Whitley, 1944.
301. *Tandanus rendahli* (Whitley, 1928).
302. *Neosilurus robustus* Ogilby, 1908.
303. *Neosilurus hyrtlui* Steindachner, 1867.
304. *Neosilurus argenteus* (Zietz, 1896).
305. *Neosilurus mortoni* Whitley, 1941.
306. *Neosilurus brevidorsalis* (Gunther, 1867).
307. *Neosilurus glencoensis* (Rendahl, 1922).
308. *Lambertichthys ater* (Perugia, 1894).
309. *Anodontiglanis dahli* Rendahl, 1922.
310. *Cnidoglanis macrocephalus* (Cuvier & Valenciennes, 1840).
311. *Euristhmus elongatus* (Castelnau, 1878).
312. *Euristhmus lepturus* (Gunther, 1864).
313. *Exilichthys nudiceps* (Gunther, 1880).
314. *Pararius proximus* (Ogilby, 1898).
315. *Pararius berneyi* (Whitley, 1941).
316. *Pararius godfreyi* (Whitley, 1941).
317. *Pararius graeffei* (Kner & Steindachner, 1867).
318. *Tachysurus mastersi* (Ogilby, 1898).
319. *Tachysurus broadbenti* Ogilby, 1908.
320. *Tachysurus leiotocephalus* (Bleeker, 1846).
321. *Netuma thalassina jacksoniensis* Whitley, 1941.
322. *Netuma venatica* (Richardson, 1845).
323. *Netuma vertagus* (Richardson, 1845).
324. *Neoarius australis* (Gunther, 1867).
325. *Nemapteryx stirlingi* (Ogilby, 1898).
326. *Cochlefelis colcloughi* (Ogilby, 1910).
327. *Anommatophasma candidum* Mees, 1962.
328. *Synbranchus bengalensis gutturalis* Richardson, 1845.
329. *Amphipnous cuchia* (Hamilton-Buchanan, 1822).
330. *Alabes rufus* (Macleay, 1881).
331. *Alabes dorsalis* (Richardson, 1845).
332. *Alabes cuvieri* Vaillant, 1905.
333. *Alabes parvulus* (McCulloch, 1909).
334. *Fluta alba* (Zuiew, 1793). Introduced.
335. *Anguilla bicolor* McClelland, 1844.
336. *Anguilla obscura* Gunther, 1872.
337. *Anguilla australis* Richardson, 1841.
338. *Anguilla reinhardtii* Steindachner, 1867.
339. *Diastobranchus danae* (Bruun, 1937).
340. *Nessorhamphus ingolfianus* (Schmidt, 1912).
341. *Cyema atrum* Gunther, 1878.
342. *Nemichthys scolopaceus* Richardson, 1848.
343. *Serrivomer bertini* Bauchot, 1959.
344. *Leptocephalus verreauxi* (Kaup, 1856).
345. *Leptocephalus wilsoni* (Bloch & Schneider, 1801).
346. *Leptocephalus wilsoni hesperius* Whitley, 1944.
347. *Leptocephalus labiatus* (Castelnau, 1879).
348. *Forskaliichthys cinereus* (Ruppell, 1831).
349. *Anago anago* (Temminck & Schlegel, 1846).
350. *Scalanago lateralis* Whitley, 1935.
351. *Gnathophis habenatus habenatus* (Richardson, 1848).
352. *Gnathophis habenatus longicauda* (Ramsay & Ogilby, 1888).
353. *Gnathophis incognitus* Castle, 1963.
354. *Fimbriceps umbrellabia* Whitley, 1946.
355. *Bassanago bulbiceps* Whitley, 1948.
- 355a. *Ariosoma mauritianum* (Pappenheim, 1914).
- 355b. *Ariosoma scheelei* (Stromman, 1896).
356. *Muroenesox arabicus* (Bloch & Schneider, 1801).
357. *Saurencichthys finitimus* (Whitley, 1935).
358. *Myrophis australis* Castelnau, 1879.
359. *Scolecenchelys tasmaniensis* (McCulloch, 1911).
360. *Scolecenchelys tasmaniensis smithi* Whitley, 1944.
361. *Scolecenchelys australis* (Macleay, 1881).
362. *Muraenichthys breviceps* Gunther, 1876.
363. *Muraenichthys laticaudata godeffroyi* Regan, 1909.
364. *Muraenichthys iredalei* Whitley, 1927.
365. *Muraenichthys devisi* Fowler, 1908.
366. *Muraenichthys ogilbyi* Fowler, 1908.
367. *Muraenichthys gymnotus* Bleeker, 1857.
368. *Muraenichthys macropterus* Bleeker, 1857.
369. *Leptognathus novaezealandiae* (Hector, 1870).
370. *Stethopterus semicinctus* (Lay & Bennett, 1839).
371. *Yirrkala chaselingi* Whitley, 1940.
372. *Calamuraena calamus* (Gunther, 1870).
373. *Zonophichthys marginatus* (Bleeker, 1803).
374. *Malvoliophis (Malvoliophis) pinguis* (Gunther, 1873).
375. *Malvoliophis (Cyclophichthys) cyclo-rhinus* (Fraser-Brunner, 1934).
376. *Chlevastes colubrinus* (Boddaert, 1781).
377. *Chlevastes elapsoides* (Castelnau, 1878).
- 377a. *Myrichthys maculosus* (Cuvier, 1816).
378. *Ophichthys episcopus* Castelnau, 1878.
379. *Ophichthys derbyensis* Whitley, 1941.
380. *Ophichthys versicolor* (Richardson, 1848).
381. *Pisodonophis cancrivorus* (Richardson, 1848).
382. *Callechelys marmoratus* (Bleeker, 1853).
383. *Rataboura intermedia* (Ogilby, 1907).
384. *Rataboura javanica* (Kaup, 1856).
385. *Anarchias insuetus* Whitley, 1932.
386. *Notorabula callorhyncha* (Gunther, 1870).
387. *Fimbrinares mosaica* Whitley, 1948.
388. *Muraena australiae* Richardson, 1848.
389. *Siderea picta* (Thunberg, 1789).
390. *Verdithorax prasinus* (Richardson, 1848).
391. *Lycodontis boschii* (Bleeker, 1853).

392. *Lycodontis petelli* (Bleeker, 1856).
393. *Lycodontis elegantissimus* (Kaup, 1856).
394. *Lycodontis meleagris* (Shaw & Nodder, 1795).
395. *Lycodontis punctatus* (Bloch & Schneider, 1801).
396. *Lycodontis thyrsoideus* (Richardson, 1845).
397. *Lycodontis flavimarginatus annasona* Whitley, 1937.
398. *Lycodontis longinquus* Whitley, 1948.
399. *Lycodontis rhodocephalus* (Bleeker, 1865).
400. *Lycodontis scriptus* (Bloch & Schneider, 1801).
401. *Lycodontis stellatus* (Lacepede, 1803).
402. *Lycodontis pseudothyrsoides* (Bleeker, 1852).
403. *Lycodontis undulatus* (Lacepede, 1803).
404. *Lycodontis cribroris* (Whitley, 1932).
405. *Lycodontis chilospilus* (Bleeker, 1865).
406. *Lycodontis melanospilos* (Bleeker, 1855).
407. *Lycodontis makassariensis* (Bleeker, 1863).
408. *Lycodontis margaritiphorus* (Bleeker, 1865).
409. *Lycodontis woodwardi* (McCulloch, 1912).
410. *Serranguilla prionodon* (Ogilby, 1895).
411. *Thaerodontis favagineus* (Bloch & Schneider, 1801).
412. *Evenchelys macrurus* (Bleeker, 1854).
413. *Echidna nebulosa* (Thunberg, 1789).
414. *Arndha zebra* (Shaw & Nodder, 1797).
415. *Leihala polyzona* (Richardson, 1845).
416. *Uropterygius concolor* (Ruppell, 1838).
417. *Uropterygius marmoratus* (Lacepede, 1803).
418. *Uropterygius obesus* Whitley, 1932.
419. *Pseudechidna brummeri* (Bleeker, 1859).
420. "Leptocephalus" — larvae of various eels, including *Leptocephalus cera-mensis* Bleeker, 1865.
- 420a. *Leptocephalus geminus* Castle, 1964.
- 420b. *Leptocephalus trilineatus* Castle, 1964.
421. *Latropiscis purpurissatus* (Richardson, 1843).
422. *Latropiscis milesii* (Cuvier & Valenciennes, 1849).
423. *Harpadon translucens* Saville-Kent, 1889.
424. *Saurida tumbil* (Bloch, 1795).
425. *Saurida undosquamis* Richardson, 1844.
426. *Saurida gracilis* (Quoy & Gaimard, 1824).
427. *Saurida filamentosa* Ogilby, 1910.
428. *Synodus* (*Newtonscottia*) *houlti* McCulloch, 1921.
429. *Austrotirus similis* (McCulloch, 1921).
430. *Xystodus sageneus* (Waite, 1905).
431. *Trachinocephalus myops hypozona* (Ogilby, 1897).
432. *Chlorophthalmus nigripinnis* Gunther, 1878.
433. *Paralepis prionosa* Roßen, 1963.
434. *Paralepis rissoi* Bonaparte, 1841.
435. *Lestidium pseudosphraenoides danae* (Ege, 1930).
436. *Lestidium indopacificum* Ege, 1953.
437. *Lestidium atlanticum* Borodin, 1928.
438. *Macroparalepis macrurus* Ege, 1933.
439. *Macroparalepis elegans* Ege, 1933.
440. *Collettia perspicillata* (Ogilby, 1898).
441. *Dasyscopelus asper* (Richardson, 1845).
442. *Scopelus hookeri* Whitley, 1953.
443. *Gonichthys barnesi* Whitley, 1943.
444. *Elampadena subaspera* (Gunther, 1864).
445. *Ctenoscopelus phengodes* (Lutken, 1892).
446. *Lepidophanes guntheri* (Goode & Bean, 1895).
447. *Serpa australis* (Taning, 1932).
448. *Myctophum cuvieri* (Castelnau, 1873).
449. *Neoscopelus bruuni* Whitley, 1931.
450. *Diaphus danae* Taning, 1932.
451. *Electrona risso salubris* Whitley, 1933.
452. *Electrona carlsbergi* (Taning, 1932).
453. *Electrona antarctica* (Gunther, 1878).
454. *Alepisaurus richardsonii* Bleeker, 1855.
455. *Notocanthus sexspinis* Richardson, 1846.
456. *Halosaurus pectoralis* McCulloch, 1926.
457. *Aulostomus chinensis waitei* Whitley, 1940.
458. *Fistularia immaculata* Cuvier, 1816.
459. *Fistularia villosa* Klunzinger, 1871.
460. *Macroramphosus elevatus* Waite, 1899.
461. *Orthichthys mollerii* (Whitley, 1930).
462. *Orthichthys velitaris* (Pallas, 1770).
463. *Centriscoops obliquus* Waite, 1911.
464. *Centriscoops humerosus* (Richardson, 1846).
465. *Notopogon lilliei* Regan, 1914.
466. *Notopogon endeavouri* Mohr, 1937.
467. *Aeoliscus strigatus* (Gunther, 1861).
468. *Centriscus cristatus* (De Vis, 1885).
469. *Centriscus scutatus* Linné, 1758.
470. *Solenichthys cyanopterus* (Bleeker, 1855).
471. *Solenichthys leptosomus* (Tanaka, 1908).
472. *Solenichthys raceki* Whitley, 1955.
473. *Tigricampus tigris* (Castelnau, 1879).
474. *Pugnaso curtirostris* (Castelnau, 1872).
475. *Pugnaso caretta* (Klunzinger, 1879).
476. *Filicampus superciliaris* (Gunther, 1880).
477. *Mitotichthys tuckeri* (Scott, 1942).
478. *Leptonotus semistriatus* Kaup, 1856.
479. *Leptonotus* (*Kaupus*) *costatus* Waite & Hale, 1921.
480. *Parasyngnathus altirostris* (Ogilby, 1890).
481. *Parasyngnathus wardi* Whitley, 1948.
482. *Parasyngnathus sawagei* (Whitley, 1929).
483. *Parasyngnathus phillipi* (Lucas, 1891).

484. *Parasyngnathus margaritifer* (Peters, 1868).
485. *Parasyngnathus poecilolaemus* (Peters, 1869).
486. *Parasyngnathus gazella* (Whitley, 1947).
487. *Parasyngnathus (Vanacampus) vercoi* (Waite & Hale, 1921).
488. *Parasyngnathus (Vanacampus) fin- dersi* (T. D. Scott, 1957).
489. *Novacampus mollisoni* (E. O. Scott, 1955).
490. *Oxyleyana parviceps* (Ramsay & Ogilby, 1886).
491. *Maroubra perserrata* Whitley, 1948.
492. *Bhanotichthys haematopterus* (Bleeker, 1851).
493. *Halicampus grayi* Kaup, 1856.
494. *Micrognathus nitidus* (Gunther, 1873).
495. *Micrognathus brevirostris spini- caudatus* Ogilby, 1908.
496. *Micrognathus annulatus* (Macleay, 1878).
497. *Festucalex scalaris* (Gunther, 1870).
498. *Festucalex galei* (Duncker, 1909).
499. *Festucalex cinctus* (Ramsay, 1882).
500. *Campichthys tryoni* (Ogilby, 1890).
501. *Larvicampus runa* (Whitley, 1931).
502. *Larvicampus fatiloquus* (Whitley, 1943).
503. *Yozia bicoarctata brevicauda* (Castel- nau, 1875).
504. *Yozia campitalis* Whitley, 1950.
505. *Stipecampus cristatus* (McCulloch & Waite, 1918).
506. *Choeroichthys serialis* (Gunther, 1884).
507. *Choeroichthys suillus* Whitley, 1951.
508. *Choeroichthys suillus malus* Whitley, 1954.
509. *Microphis stictorhynchus* (Ogilby, 1912).
510. *Doryrhamphus melanopleura* (Bleeker, 1858).
511. *Nannocampus ruber* Ramsay & Ogilby, 1886.
512. *Nannocampus subosseus* Gunther, 1870.
513. *Lissocampus caudalis* Waite & Hale, 1921.
514. *Lissocampus affinis* Whitley, 1944.
515. *Urocampus carinirostris* Castelnau, 1872.
516. *Leptoichthys fistularius* Kaup, 1853.
517. *Hypselognathus rostratus* (Waite & Hale, 1921).
518. *Histiogamphelus maculatus* Hale, 1939.
519. *Histiogamphelus maculatus robensis* Whitley, 1948.
520. *Histiogamphelus cristatus* (Macleay, 1881).
521. *Histiogamphelus briggsii* McCulloch, 1914.
522. *Histiogamphelus briggsii orae* Whitley, 1950.
523. *Histiogamphelus meraculus* Whitley, 1948.
524. *Histiogamphelus gallinaceus* Hale, 1941.
525. *Stigmatopora argus* (Richardson, 1840).
526. *Stigmatopora unicolor* Castelnau, 1875.
527. *Nigracus nigra* (Kaup, 1856).
528. *Syngnathoides biaculeatus* (Bloch, 1785).
529. *Solegnathus guntheri* Duncker, 1915.
530. *Solegnathus spinosissimus* Gunther, 1870.
531. *Solegnathus fasciatus* Gunther, 1880.
532. *Solegnathus robustus* McCulloch, 1911.
533. *Solegnathus (Runcinatus) dunckeri* Whitley, 1927.
534. *Halichthys taeniophora* Gray, 1859.
535. *Phyllopteryx taeniolatus* (Lacepede, 1804).
536. *Phyllopteryx lucasi* Whitley, 1931.
537. *Phycodurus eques* (Gunther, 1865).
538. *Phycodurus glauerti* Whitley, 1939.
539. *Farlapiscis breviceps* (Peters, 1870).
540. *Hippocampus angustus* Gunther, 1870.
541. *Hippocampus whitei* Bleeker, 1855.
542. *Hippocampus tristis* Castelnau, 1872.
543. *Hippocampus kuda* Bleeker, 1852.
544. *Hippocampus zebra* Whitley, 1964.
545. *Hippocampus planifrons* Peters, 1877.
546. *Hippohystrix spinosissimus* (Weber, 1913).
547. *Macleayina abdominalis* (Lesson, 1827).
548. *Acentronura australe* Waite & Hale, 1921.
549. *Acentronura breviperula* Fraser- Brunner & Whitley, 1949.
550. *Pegasus volitans* Linné, 1758.
551. *Eurypegasus draconis* (Linné, 1766).
552. *Acanthopegasus lancifer* (Kaup, 1861).
553. *Scomberesox forsteri* Cuvier & Valenciennes, 1846.
554. *Strongylura incisa* (Cuvier & Valenciennes, 1846).
555. *Strongylura strongylura* (Van Hasselt, 1823).
556. *Lhotskia macleayana* (Ogilby, 1886).
557. *Djulongius gavioloides* (Castelnau, 1873).
558. *Djulongius melanotus* (Bleeker, 1851).
559. *Stenocaulis krefftii* (Gunther, 1866).
560. *Tylosurus marisrubri* (Bloch & Schneider, 1801).
561. *Lewinichthys ciconia* (Richardson, 1846).
562. *Belone platyura* Bennett, 1832.
563. *Athlennes caeruleofasciatus* (Stead, 1908).
564. *Thalassosteus appendiculatus* (Klun- zinger, 1871).
565. *Reporhamphus ardelio* Whitley, 1931.
566. *Reporhamphus australis* Steindachner, 1866.
567. *Reporhamphus melanochir* Cuvier & Valenciennes, 1847.
568. *Reporhamphus regularis* Gunther, 1866.
569. *Reporhamphus caudalis* Whitley, 1951.
570. *Hyporhamphus dussumieri* (Cuvier & Valenciennes, 1847).

571. *Hyporhamphus quoyi* (Cuvier & Valenciennes, 1847).
572. *Ardeaspiscis welsbyi* (Ogilby, 1908).
573. *Farhians commersonii* (Cuvier, 1829).
574. *Rhynchorhamphus georgii* (Cuvier & Valenciennes, 1847).
575. *Hemiramphus argenteus* Bennett, 1840.
576. *Hemiramphus robustus* Gunther, 1866.
577. *Hemiramphus gaimardi* Cuvier & Valenciennes, 1847.
578. *Euleptorhamphus longirostris* (Cuvier, 1829).
579. *Loligorhamphus normani* Whitley, 1931.
580. *Zenarchopterus dispar* (Cuvier & Valenciennes, 1847).
581. *Zenarchopterus buffonis* (Cuvier & Valenciennes, 1847).
582. *Zenarchopterus amblyurus* (Bleeker, 1849).
583. *Arrhamphus sclerolepis* Gunther, 1866.
584. *Eoocoetus volitans vagabundus* Whitley, 1937.
585. *Parezoceetus brachypterus* (Richardson, 1846).
586. *Cypsilurus exsiliens* (Linné, 1771).
587. *Cypsilurus heterurus* (Rafinesque, 1810).
588. *Cypsilurus arcticeps* (Gunther, 1866).
589. *Cypsilurus bahiensis* (Ranzani, 1842).
590. *Cypsilurus poecilopterus* (Cuvier & Valenciennes, 1847).
591. *Cypsilurus spilopterus* (Cuvier & Valenciennes, 1847).
592. *Cypsilurus melanocercus* (Ogilby, 1885).
593. *Econoantes katoptron* (Bleeker, 1865).
594. *Danichthys cribrus* (Kner, 1867).
595. *Hirundichthys speculiger praecox* Whitley, 1937.
596. *Hirundichthys oxycephalus* (Bleeker, 1852).
597. *Oxyporhamphus micropterus* (Cuvier & Valenciennes, 1847).
598. *Hypoatherina usila* (Jordan & Seale, 1906).
599. *Hypoatherina lacunosa* (Bloch & Schneider, 1801).
600. *Taeniomembras tropicalis* (Whitley, 1948).
601. *Taeniomembras hepsetoides* (Richardson, 1843).
602. *Taeniomembras elongata* (Klunzinger, 1879).
603. *Taeniomembras tamarensis* (Johnston, 1883).
604. *Atherina presbyteroides* Richardson, 1843.
605. *Allanetta punctata* (De Vis, 1885).
606. *Atherinosoma vorax* Castelnau, 1872.
607. *Atherinosoma rockinghamensis* Whitley, 1943.
608. *Atherinosoma microstoma* (Gunther, 1861).
609. *Atherinosoma microstoma lincolniensis* Whitley, 1941.
610. *Pranesella endorae* Whitley, 1934.
611. *Pranesus capricornensis* Woodland, 1961.
612. *Pranesus endrachtensis* (Quoy & Gaimard, 1825).
613. *Pranesus ogilbyi* Whitley, 1930.
614. *Atherinason dannevigii* (McCulloch, 1911).
615. *Atherinason dannevigii verae* Whitley, 1951.
616. *Craterocephalus edelensis* (Castelnau, 1873).
617. *Craterocephalus capreoli* Rendahl, 1922.
618. *Craterocephalus eyresii* (Steindachner, 1884).
619. *Craterocephalus marjoriae* Whitley, 1948.
620. *Craterocephalus worrelli* Whitley, 1948.
621. *Craterocephalus anticanus* Whitley, 1955.
622. *Craterocephalus cuneiceps* Whitley, 1944.
623. *Craterocephalus fluviatilis* McCulloch, 1913.
624. *Craterocephalus stercusmuscarum* (Gunther, 1867).
625. *Craterocephalus pauciradiatus* (Gunther, 1861).
626. *Stenatherina esox* (Klunzinger, 1872).
627. *Stenatherina honoriae* (Ogilby, 1912).
628. *Atherion maccullochi* Jordan & Hubbs, 1919.
629. *Iso rhotophilus* (Ogilby, 1895).
630. *Quirichthys stramineus* (Whitley, 1950).
631. *Pseudomugil signifer* Kner, 1866.
632. *Pseudomugil signatus* Gunther, 1867.
633. *Pseudomugil gertrudae* Weber, 1911.
634. *Pseudomugil affinis* Whitley, 1935.
635. *Rhadinocentrus ornatus* Regan, 1914.
636. *Rhadinocentrus rhombosomoides* Nichols & Raven, 1928.
637. *Melanotaenia nigrans* Richardson, 1843.
638. *Nematocentris splendida* Peters, 1867.
639. *Nematocentris fluviatilis* (Castelnau, 1878).
640. *Nematocentris australis* (Castelnau, 1875).
641. *Nematocentris maccullochi* (Ogilby, 1915).
642. *Anneris rubrostriata* (Ramsay & Ogilby, 1886).
643. *Aidaprora carteri* Whitley, 1935.
644. *Ellochelon vaigiensis* (Quoy & Gaimard, 1825).
645. *Moolgarda delicata* (Alleyne & Macleay, 1877).
646. *Moolgarda argentea* (Quoy & Gaimard, 1825).
647. *Moolgarda compressa* (Gunther, 1861).
648. *Moolgarda pura* Whitley, 1945.
649. *Moolgarda (Planiliza) ordensis* Whitley, 1945.
650. *Liza planiceps* (Cuvier & Valenciennes, 1836).
651. *Liza subviridis* (Cuvier & Valenciennes, 1836).
652. *Mugil dobula* Gunther, 1861.

653. *Mugil dussumieri* Cuvier & Valenciennes, 1836.
654. *Mugil georgii* Ogilby, 1897.
655. *Mugil cunnesius* Cuvier & Valenciennes, 1836.
656. *Mugil strongylocephalus* Richardson, 1846.
657. *Mugil australis* Steindachner, 1879.
658. *Mugil tade* Gmelin, 1789.
659. *Mugil tadopsis* Ogilby, 1908.
660. *Oxymugil acutus* (Cuvier & Valenciennes, 1836).
661. *Gracilimugil ramsayi* (Macleay, 1883).
662. *Oedalechilus kesteveni* Whitley, 1943.
663. *Oedalechilus cirrhostomus* (Bloch & Schneider, 1801).
664. *Oedalechilus papillosus* (Macleay, 1883).
665. *Crenimugil labiosus* (Cuvier & Valenciennes, 1836).
666. *Valamugil buehanani* (Bleeker, 1853).
667. *Squalomugil nasutus* (De Vis, 1883).
668. *Trachystoma petardi* (Castelnau, 1875).
669. *Myzus elongatus* Gunther, 1861.
670. *Aldrichetta forsteri* (Bloch & Schneider, 1801).
671. *Polydactylus indicus* (Shaw, 1804).
672. *Polydactylus plebeius* (Broussonet, 1782).
673. *Polydactylus sheridani* (Macleay, 1884).
674. *Polydactylus heptadactylus* (Cuvier & Valenciennes, 1829).
675. *Polydactylus specularis* (De Vis, 1883).
676. *Polydactylus macrochir* (Gunther, 1867).
677. *Polydactylus multiradiatus* (Gunther, 1860).
678. *Polynemus verekeri* Saville-Kent, 1889.
679. *Eleutheronema tetradactylus* (Shaw, 1804).
680. *Indosphyraena waitii* (Ogilby, 1908).
681. *Agrioposphyraena microps* (Marshall, 1953).
682. *Agrioposphyraena akerstromi* (Whitley, 1947).
683. *Australuzza novaehollandiae* (Gunther, 1860).
684. *Sphyraenella obtusata* (Cuvier & Valenciennes, 1829).
685. *Sphyraenella grandisquamis* (Steindachner, 1866).
686. *Sphyraenella langsar* (Bleeker, 1854).
687. *Sphyraena forsteri* Cuvier & Valenciennes, 1829.
688. *Sphyraena jello altipinnis* Ogilby, 1910.
689. *Tetragonurus cuvieri* Risso, 1810.
690. *Centrolophus maoricus* Ogilby, 1893.
691. *Tubbia tasmanica* Whitley, 1943.
692. *Mupus imperialis* Cocco, 1833.
693. *Psenopsis humerosus* Munro, 1958.
694. *Nomeus dyscritus* Whitley, 1931.
695. *Psenes whiteleggii* Waite, 1894.
696. *Psenes hillii* Ogilby, 1915.
697. *Psenes cyanophrys* Cuvier & Valenciennes, 1833.
698. *Cubiceps baxteri* McCulloch, 1923.
699. *Seriotelella brama* (Gunther, 1860).
700. *Seriotelella maculata* (Forster, 1794).
701. *Seriotelella noel* Whitley, 1958.
702. *Hoplocoryphus physalium* Whitley, 1933.
703. *Hyperoglyphe porosa* (Richardson, 1845).
704. *Malacocephalus laevis* (Lowe, 1843).
705. *Nezumia nigromaculata* (McCulloch, 1907).
706. *Paramacrurus australis* (Richardson, 1839).
707. *Paramacrurus innotabilis* (McCulloch, 1907).
708. *Garichthys fasciatus* (Gunther, 1878).
709. *Garichthys mirus* (McCulloch, 1926).
710. *Nematonurus armatus* (Hector, 1875).
711. *Lepidorhynchus denticulatus* Richardson, 1846.
712. *Macruronus novaezealandiae* (Hector, 1871).
713. *Tripterothycis intermedius* Whitley, 1948.
714. *Lotella callarias* Gunther, 1863.
715. *Lotella fuliginosa* Gunther, 1862.
716. *Physiculus barbatus* (Gunther, 1863).
717. *Physiculus bachus* (Bloch & Schneider, 1801).
718. *Austrophycis megalops* Ogilby, 1897.
719. *Euclichthys polynemus* McCulloch, 1926.
720. *Antimora rostrata* (Gunther, 1878).
721. *Gaidropsarus novaezealandiae* (Hector, 1874).
722. *Lepidion microcephalus* Cowper, 1956.
723. *Mora dannevigii* Whitley, 1948.
724. *Bregmaceros nectabanus* Whitley, 1941.
725. *Bregmaceros maclellandi* Thompson, 1840.
726. *Bregmaceros japonicus* Tanaka, 1908.
727. *Beryx splendens* Lowe, 1834.
728. *Beryx decadactylus* Cuvier and Valenciennes, 1829.
729. *Centroberyx lineatus* (Cuvier & Valenciennes, 1829).
730. *Centroberyx affinis* (Gunther, 1859).
731. *Centroberyx gerrardi* (Gunther, 1887).
732. *Diretmus aureus* (Campbell, 1879).
733. *Paradiretmus circularis* Whitley, 1948.
734. *Gephyroberyx darwini* (Johnson, 1866).
735. *Optivus elongatus* (Gunther, 1859).
736. *Hoplostethus intermedius* (Hector, 1875).
737. *Hoplostethus gigas* McCulloch, 1914.
738. *Hoplostethus latus* McCulloch, 1914.
739. *Paratrachichthys trailii* (Hutton, 1875).
740. *Sorosichthys ananassa* Whitley, 1945.
741. *Trachichthys australis* Shaw & Nodder, 1799.
742. *Cleidopus gloriamaris* De Vis, 1882.
743. *Cleidopus gloriamaris occidentalis* Whitley, 1931.
744. *Scopeloberyx microlepis* (Norman, 1937).
745. *Melamphaes suborbitalis* (Gill, 1883).
746. *Sio nordskjoldii* (Lonnberg, 1905).

747. *Scopelogadus beanii* (Gunther, 1887).
748. *Holocenthrus diadema* (Lacepede, 1802).
749. *Holocenthrus cornutus* Bleeker, 1853.
750. *Holocenthrus cornutus melanospilos* Bleeker, 1858.
751. *Holocenthrus prasin* (Lacepede, 1802).
752. *Holocenthrus violaceus* Bleeker, 1853.
753. *Holocenthrus dimidicauda* Marshall, 1953.
754. *Sargocentron spinifer* (Bonnaterre, 1788).
755. *Ostichthys australis* (Castelnau, 1875).
756. *Neomyrpristis amaenus* Castelnau, 1873.
757. *Neoniphon armatus* Castelnau, 1875.
758. *Holotrachys oligolepis* Whitley, 1941.
759. *Holotrachys major* Whitley, 1950.
760. *Neoniphon hasta* De Vis, 1884.
761. *Myrpristis murdjan* (Bonnaterre, 1788).
762. *Cyttus australis* (Richardson, 1843).
763. *Cyttus maccullochi* Whitley, 1947.
764. *Cyttus novaezelandiae* (Arthur, 1885).
765. *Cyttosoma boops* Gilchrist, 1904.
766. *Oreosoma atlanticum waitei* Whitley, 1929.
767. *Allocyttus propinquus* McCulloch, 1914.
768. *Neocyttus gibbosus* McCulloch, 1914.
769. *Zeus australis* Richardson, 1845.
770. *Zenopsis nebulosus* (Temminck & Schlegel, 1845).
771. *Antigonia rhomboidea* McCulloch, 1915.
772. *Antigonia rubicunda* Ogilby, 1910.
773. *Lampris regius* (Bonnaterre, 1788).
774. *Velifer hypselopterus* Bleeker, 1879.
775. *Metavelifer multiradiatus* (Regan, 1907).
776. *Metavelifer multiradiatus multi-spinosus* Smith, 1951.
777. *Regalecus pacificus* Haast, 1878.
778. *Desmodema arawatae* (Clarke, 1881).
779. *Agrostichthys benhami* E. O. Scott, 1934.
780. *Lophotes guntheri* Johnston, 1883.
781. *Diploprion bifasciatum* Cuvier & Valenciennes, 1828.
782. *Percalates colonorum* (Gunther, 1863).
783. *Percalates colonorum novemaculeatus* (Steindachner, 1866).
784. *Plectroplites ambiguus* (Richardson, 1845).
785. *Macquaria australasica* Cuvier & Valenciennes, 1830.
786. *Bostockia porosa* Castelnau, 1873.
787. *Acanthistius serratus* Cuvier & Valenciennes, 1828.
788. *Centrogenys vaigiensis* (Quoy & Gaimard, 1824).
789. *Polyprionum* (Hectoria) *oxygeneios* (Bloch & Schneider, 1801).
790. *Plectropomus maculatus* (Bloch, 1790).
791. *Plectropomus variegatus* Castelnau, 1875.
792. *Trachypoma macracanthus* Gunther, 1859.
793. *Anyperodon leucogrammicus* Cuvier & Valenciennes, 1828.
794. *Epinephelus mysticalis* (De Vis, 1884).
795. *Epinephelus areolatus* (Gmelin, 1789).
796. *Epinephelus amblycephalus* (Bleeker, 1857).
797. *Epinephelus morrhua* (Cuvier & Valenciennes, 1833).
798. *Epinephelus summana hostiaretis* Whitley, 1954.
799. *Epinephelus fario* (Thunberg, 1793).
800. *Epinephelus viridipinnis* (De Vis, 1885).
801. *Epinephelus megachir* (Richardson, 1846).
802. *Epinephelus australis* (Castelnau, 1875).
803. *Epinephelus raymondi* Ogilby, 1908.
804. *Epinephelus gilberti* (Richardson, 1842).
805. *Epinephelus* (*Cynichthys*) *flavocaeeruleus* (Lacepede, 1802).
806. *Epinephelus hoedtii* (Bleeker, 1855).
807. *Epinephelus damelii* (Gunther, 1876).
808. *Epinephelus undulatostratus* (Peters, 1867).
809. *Epinephelus* (*Schistorus*) *ergastularius* Whitley, 1930.
810. *Epinephelus chlorostigma* (Cuvier & Valenciennes, 1828).
811. *Epinephelus corallicola* (Cuvier & Valenciennes, 1828).
812. *Epinephelus marginalis* (Bloch, 1793).
813. *Epinephelus homosinensis* Whitley, 1944.
814. *Epinephelus rankini* Whitley, 1945.
815. *Epinephelus spiramen* Whitley, 1945.
816. *Epinephelus slacksmithi* Whitley, 1959.
817. *Epinephelus merra* (Bloch, 1793).
818. *Epinephelus forsythi* Whitley, 1937.
819. *Epinephelus thompsoni* Whitley, 1948.
820. *Epinephelus* (*Homalagrystes*) *tauvina* (Bonnaterre, 1788).
821. *Epinephelus* (*Homalagrystes*) *malabaricus* (Bloch & Schneider, 1801).
822. *Epinephelus sexfasciatus* (Cuvier & Valenciennes, 1828).
823. *Epinephelus hoevenii* (Bleeker, 1849).
- 823a. *Epinephelus tukula* Morgans, 1959.
824. *Promicrops lanceolatus* (Bloch, 1790).
825. *Altiserranus jayakari* (Boulenger, 1889).
826. *Altiserranus woorei* Whitley, 1951.
827. *Cephalopholis urodetus mars* (De Vis, 1884).
828. *Cephalopholis cyanostigma* (Cuvier & Valenciennes, 1828).
829. *Cephalopholis pachycentron* (Cuvier & Valenciennes, 1828).
830. *Cephalopholis nigripinnis* (Cuvier & Valenciennes, 1828).
831. *Cephalopholis boenack* (Bloch, 1790).
832. *Cephalopholis miniatus formosanus* Tanaka, 1911.
833. *Cephalopholis argus* (Bloch & Schneider, 1801).
834. *Cephalopholis coatesi* Whitley, 1937.
835. *Aethaloperca rogaa* (Bonnaterre, 1788).

836. *Enneacentrus sonnerati* (Cuvier & Valenciennes, 1828).
837. *Enneacentrus aurantius* (Cuvier & Valenciennes, 1828).
838. *Enneacentrus leopardus* (Lacepede, 1802).
839. *Chromileptes altivelis* (Cuvier & Valenciennes, 1828).
840. *Grammistes sexlineatus* (Thunberg, 1792).
841. *Maccullochella macquariensis* (Lesson, 1828).
842. *Maccullochella macquariensis peelii* (Mitchell, 1838).
843. *Rainfordia opercularis* McCulloch, 1923.
844. *Ellerkeldia annulata* (Gunther, 1859).
845. *Ellerkeldia maccullochi* Whitley, 1929.
846. *Ellerkeldia jamesoni* (Ogilby, 1908).
847. *Hypoplectrodes nigrorubrum* (Cuvier & Valenciennes, 1828).
848. *Epinephelides armatus* (Castelnau, 1875).
849. *Othos dentex* (Cuvier & Valenciennes, 1828).
850. *Fraudella carassiope* Whitley, 1935.
851. *Caprodon longimanus* (Gunther, 1859).
852. *Caesioperca lepidoptera* (Bloch & Schneider, 1801).
853. *Caesioperca raso* (Richardson, 1839).
854. *Anthias pleurotaenia* Bleeker, 1857.
855. *Anthias pulchellus* Waite, 1899.
856. *Variola louti* (Bonnaterre, 1788).
857. *Lepidoperca tasmanica* Norman, 1937.
858. *Lepidoperca occidentalis* Whitley, 1951.
859. *Callanthias allporti* Gunther, 1876.
860. *Nannoperca australis* Gunther, 1861.
861. *Nannoperca ozaleana* Whitley, 1940.
862. *Nannoperca obscura* (Klunzinger, 1872).
863. *Edelia vittata* Castelnau, 1873.
864. *Oustonia maccullochi* Whitley, 1934.
865. *Klunzingerina novaehollandiae* (Steindachner, 1879).
866. *Pseudochromis (Assiculus) punctatus* (Richardson, 1846).
867. *Pseudochromis cyaneotaenia* Bleeker, 1857.
868. *Pseudochromis fuscus* Muller & Troschel, 1849.
869. *Pseudochromis maccullochi perpulcher* Whitley, 1959.
870. *Leptochromis tapeinosoma* (Bleeker, 1853).
871. *Devisina aurea* (Seale, 1909).
872. *Devisina wilsoni* (Whitley, 1929).
873. *Devisina quinquedentata* (McCulloch, 1926).
874. *Stigmatonotus australis* Peters, 1877.
875. *Dampiera ignita* T. Scott, 1959.
876. *Dampiera lineata* Castelnau, 1875.
877. *Ogilbyina longipinnis* (Ogilby, 1908).
878. *Pelates quadrilineatus* (Bloch, 1790).
879. *Pelates sexlineatus* (Quoy & Gaimard, 1824).
880. *Leiopotherapon (Archerichthys) suavis* Whitley, 1948.
881. *Eutherapon theraps* (Cuvier & Valenciennes, 1829).
882. *Terapon servus* (Bloch, 1790).
883. *Terapon (Austisthes) puta* Cuvier & Valenciennes, 1829.
884. *Amniataba percoides* (Gunther, 1864).
885. *Amniataba percoides burnettensis* Whitley, 1943.
886. *Amniataba percoides yorkensis* (Nichols, 1949).
887. *Amphitherapon caudavittatus* (Richardson, 1845).
888. *Madigania unicolor* (Gunther, 1859).
889. *Bidyanus bidyanus* (Mitchell, 1838).
890. *Pelsartia humeralis* (Ogilby, 1899).
891. *Mesopristes argenteus* (Cuvier & Valenciennes, 1829).
892. *Mesopristes aheneus* (Mees, 1963).
893. *Mesopristes alligatoris* (Rendahl, 1922).
894. *Hephaestus carbo* (Ogilby & McCulloch, 1916).
895. *Hephaestus bancrofti* (Ogilby & McCulloch, 1916).
896. *Hephaestus fuliginosus* (Macleay, 1883).
897. *Hephaestus welchi* (McCulloch & Waite, 1917).
898. *Papuservus trimaculatus* (Macleay, 1883).
899. *Scortum hillii* (Castelnau, 1878).
900. *Scortum parviceps* (Macleay, 1883).
901. *Scortum barcoo* (McCulloch & Waite, 1917).
902. *Scortum ogilbyi* Whitley, 1951.
903. *Pingalla gilberti* Whitley, 1955.
904. *Helotes sexlineatus* (Quoy & Gaimard, 1825).
905. *Helotes profundior* De Vis, 1884.
906. *Helotes scotus* Haacke, 1885.
907. *Assessor macneilli* Whitley, 1935.
908. *Paraplesiops bleekeri* (Gunther, 1861).
909. *Paraplesiops gigas* (Steindachner, 1884).
910. *Paraplesiops meleagris* (Peters, 1870).
911. *Paraplesiops jolliffei* Ogilby, 1916.
912. *Paraplesiops (Liopelichthys) poweri* Ogilby, 1908.
913. *Trachinops taeniatus* Gunther, 1861.
914. *Trachinops caudimaculatus* McCoy, 1890.
915. *Pseudoplesiops typus* Bleeker, 1858.
916. *Plesiops nigricans* (Ruppell, 1828).
917. *Plesiops melas* Bleeker, 1849.
918. *Belonepterygion fasciolatum* (Ogilby, 1889).
919. *Dules rupestris haswelli* (Macleay, 1881).
920. *Herops munda* (De Vis, 1884).
921. *Moronopsis taeniurus* (Cuvier & Valenciennes, 1829).
922. *Nannatherina balstoni* Regan, 1906.
923. *Priacanthus macracanthus* (Cuvier & Valenciennes, 1829).
924. *Priacanthus tayenus* Richardson, 1846.
925. *Priacanthus cruentatus* (Lacepede, 1802).
926. *Cookeolus velabundus* (McCulloch, 1915).
927. *Perca fluviatilis* Linné, 1758. Introduced.

928. *Kurandapogon blanchardi* Whitley, 1939.
929. *Aspiscis savayensis* (Gunther, 1871).
930. *Apogon cardinalis* (Seale, 1909).
931. *Apogon margaritophorus* Bleeker 1854.
932. *Apogon nigrocinctus* (Radcliffe, 1912).
933. *Apogon chrysurus* Ogilby, 1889.
934. *Apogon doryssa* Jordan & Seale, 1906.
935. *Apogon trimaculatus* Cuvier & Valenciennes, 1828.
936. *Apogon simplex* De Vis, 1884.
937. *Apogon rudis* De Vis, 1884.
938. *Apogon australis* Steindachner, 1867.
939. *Apogon atripes* (Ogilby, 1911).
940. *Apogon aureus* (Lacepede, 1802).
941. *Apogon ruppellii* Gunther, 1859.
942. *Lovamia fasciata* (White, 1790).
943. *Lovamia cookii* (Macleay, 1881).
944. *Lovamia novemfasciata* (Cuvier & Valenciennes, 1828).
945. *Lovamia aroubiensis* (Jacquinot & Guichenot, 1853).
946. *Lovamia endekataenia* (Bleeker, 1852).
947. *Lovamia monogramma* (Gunther, 1880).
948. *Lovamia septemstriata* (Gunther, 1880).
949. *Lovamia aterrima* (Gunther, 1867).
950. *Jaydia eliotti* (Day, 1876).
951. *Vincentia novaeollandiae* (Valenciennes, 1832).
952. *Yarica hyalosoma* (Bleeker, 1852).
953. *Pristiapogon darnleyensis* (Alleyne & Macleay, 1877).
954. *Pristiapogon fraenatus* Valenciennes, 1832.
955. *Pristiapogon victoriae* (Gunther, 1859).
956. *Neamia octospina* Radcliffe, 1912.
957. *Nectamia fusca* (Quoy & Gaimard, 1825).
958. *Zoramia leptacanthus* (Bleeker, 1851).
959. *Foa vaiulae* Jordan & Seale, 1906.
960. *Foa fo* Jordan & Seale, 1906.
961. *Fowleria aurita* (Cuvier & Valenciennes, 1831).
962. *Fodifoa guttulata* (Alleyne & Macleay, 1877).
963. *Fodifoa fistulosa* (Weber, 1909).
964. *Apogonichthys coggeri* Whitley, 1964.
965. *Apogonichthys nebulosus* Ogilby, 1908.
966. *Apogonichthys isostigma* Jordan & Seale, 1906.
967. *Apogonichthys longicauda* De Vis, 1884.
968. *Apogonichthys ocellatus* (Weber, 1913).
969. *Apogonichthys ramsayi* (Fowler, 1908).
970. *Apogonichthys poecilopterus* (Cuvier & Valenciennes, 1828).
971. *Apogonichthys ahimsa* Whitley, 1959.
972. *Adenapogon roseigaster* (Ogilby, 1886).
973. *Adenapogon (Scopelapogon) cephalotes* (Castelnau, 1875).
974. *Siphamia cuneiceps* Whitley, 1941.
975. *Siphamia zaribae* Whitley, 1959.
976. *Glossamia aprion* (Richardson, 1842).
977. *Glossamia gillii* (Steindachner, 1867).
978. *Archamia melasma* Lachner & Taylor, 1960.
979. *Scepterias lenimen* Whitley, 1935.
980. *Paramia quinquelineata* (Cuvier & Valenciennes, 1828).
981. *Cheilodipterus macrodon* (Lacepede, 1802).
982. *Dinolestes lewini* (Griffith, 1834).
983. *Apogonops anomalus* Ogilby, 1896.
984. *Gymnapogon annonus* (Whitley, 1936).
985. *Sillago schomburgkii* Peters, 1865.
986. *Sillago maculata* (Quoy & Gaimard, 1824).
987. *Sillago bassensis* (Cuvier & Valenciennes, 1829).
988. *Sillago robusta* Stead, 1908.
989. *Sillago ciliata* Cuvier & Valenciennes, 1829.
990. *Sillago sihama* (Bonnaterre, 1788).
991. *Sillago analis* Whitley, 1943.
992. *Sillaginodes punctatus* (Cuvier & Valenciennes, 1829).
993. *Malacanthus hoedti* Bleeker, 1859.
994. *Lactarius lactarius* (Bloch & Schneider, 1801).
995. *Pomatomus pedica* Whitley, 1931.
996. *Rachycentron pondicerianum* (Cuvier & Valenciennes, 1832).
997. *Scomberoides sanctipetri* (Cuvier & Valenciennes, 1832).
998. *Scomberoides tolooparah* (Ruppell, 1829).
999. *Scomberoides tolooo* (Cuvier & Valenciennes, 1832).
1000. *Chorinemus lysan* (Bonnaterre, 1788).
1001. *Chorinemus tol* Cuvier & Valenciennes, 1831.
1002. *Eleria tala* (Cuvier & Valenciennes, 1832).
1003. *Naucrates angeli* Whitley, 1931.
1004. *Regificola grandis* (Castelnau, 1872).
1005. *Regificola simplex* (Ramsay & Ogilby, 1886).
1006. *Naucratopsis hippos* Gunther, 1876.
1007. *Naucratopsis excusabilis* McCulloch, 1929.
1008. *Zonichthys nigrofasciatus* (Ruppell, 1829).
1009. *Elagatis bipinnulatus* (Quoy & Gaimard, 1825).
1010. *Megalaspis cordyla* (Linné, 1758).
1011. *Decapterus leptosomus* Ogilby, 1898.
1012. *Decapterus macrosoma* Bleeker, 1851.
1013. *Decapterus russelli* (Ruppell, 1831).
1014. *Trachurus mccullochi* Nichols, 1921.
1015. *Trachurus novaezelandiae* Richardson, 1843.
1016. *Alepes mate* (Cuvier & Valenciennes, 1833).
1017. *Alepes kalla queenstandiae* (De Vis, 1884).
1018. *Gnathanodon speciosus* (Bonnaterre, 1788).
1019. *Caranx bucculentus* Alleyne & Macleay, 1877.
1020. *Caranx melampygus* Cuvier & Valenciennes, 1833.
1021. *Caranx chrysophrys* Cuvier & Valenciennes, 1833.

1022. *Caranx ignobilis* (Bonnaterre, 1788).
1023. *Caranx malabaricus* Bloch & Schneider, 1801.
1024. *Caranx humerosus* McCulloch, 1915.
1025. *Caranx sexfasciatus* Quoy & Gaimard, 1825.
1026. *Caranx forsteri* Cuvier & Valenciennes, 1833.
1027. *Caranx papuensis* Alleyne & Macleay, 1877.
1028. *Citula aurochs* (Ogilby, 1915).
1029. *Citula oblonga* (Cuvier & Valenciennes, 1833).
1030. *Citula diversa* Whitley, 1940.
1031. *Pantolabus parasitus* (Garman, 1903).
1032. *Uraspis uraspis* (Gunther, 1860).
1033. *Ferdauia jordani* (Nichols, 1922).
1034. *Ferdauia claeszooni* Whitley, 1947.
1035. *Ferdauia claeszooni prestonensis* Whitley, 1947.
1036. *Ferdauia lindemanensis* Whitley, 1951.
1037. *Carangoides gymnostethoides* Bleeker, 1851.
1038. *Usacaranx platessa* (Cuvier & Valenciennes, 1833).
1039. *Usacaranx georgianus* (Cuvier & Valenciennes, 1833).
1040. *Usacaranx nobilis* (Macleay, 1881).
1041. *Selaroides leptolepis* (Cuvier & Valenciennes, 1833).
1042. *Olistus hedlandensis* Whitley, 1934.
1043. *Absalom radiatus* (Macleay, 1881).
1044. *Turram emburyi* Whitley, 1932.
1045. *Ulua mandibularis* (Macleay, 1882).
1046. *Atule affinis* (Ruppell, 1836).
1047. *Selar malam* Bleeker, 1851).
1048. *Selar boops* (Cuvier & Valenciennes, 1833).
1049. *Selar crumenophthalmus* (Bloch, 1793).
1050. *Alectis indica* (Ruppell, 1831).
1051. *Alectis ciliaris* (Bloch, 1787).
1052. *Caesiomorus botla* (Shaw, 1803).
1053. *Caesiomorus baillonii* (Lacepede, 1802).
1054. *Trachinotus blochi* (Lacepede, 1802).
1055. *Trachinotus anak* Ogilby, 1909.
1056. *Parastromateus niger* (Bloch, 1795).
1057. *Mene maculata* (Bloch & Schneider, 1801).
1058. *Pteraclis velifer australiae* Whitley, 1935.
1059. *Lepidotus squamosus* (Hutton, 1876).
1060. *Taractes miltonis* Whitley, 1938.
1061. *Coryphaena hippurus* Linné, 1758.
1062. *Ambassis miops* Gunther, 1871.
1063. *Ambassis commersoni papuensis* Alleyne & Macleay, 1877.
1064. *Ambassis ambassis* (Lacepede, 1802).
1065. *Ambassis nigripinnis* (De Vis, 1884).
1066. *Austrochanda pallida* (De Vis, 1884).
1067. *Austrochanda macleayi* (Castelnau, 1878).
1068. *Blandowskiella agassizii* (Steindachner, 1867).
1069. *Blandowskiella agrammus* (Gunther, 1867).
1070. *Blandowskiella reticulata* (Weber, 1913).
1071. *Blandowskiella castelnaui* (Macleay, 1881).
1072. *Velambassis jacksoniensis* (Macleay, 1881).
1073. *Acanthopercra gulliveri* Castelnau, 1878.
1074. *Priopis gymnocephalus* (Lacepede, 1802).
1075. *Priopidichthys marianus* (Gunther, 1880).
1076. *Priopidichthys dussumieri telkara* (Whitley, 1935).
1077. *Konopickia mulleri* (Klunzinger, 1879).
1078. *Denariusa bandata* Whitley, 1948.
1079. *Glaucosoma scapulare* Macleay, 1881.
1080. *Glaucosoma hebraicum* Richardson, 1845.
1081. *Glaucosoma magnificum* (Ogilby, 1915).
1082. *Lates calcarifer* (Bloch, 1790).
1083. *Psammoperca waigiensis* (Cuvier & Valenciennes, 1828).
1084. *Hypopterus macropterus* (Gunther, 1859).
1085. *Arripis trutta* (Bloch & Schneider, 1801).
1086. *Arripis trutta esper* Whitley, 1951.
1087. *Arripis georgianus* (Cuvier & Valenciennes, 1831).
1088. *Emmelichthys nitidus* Richardson, 1845.
1089. *Plagiogeneion rubiginosus* (Hutton, 1876).
1090. *Plagiogeneion macrolepis* McCulloch, 1914.
1091. *Symphorus nematophorus* (Bleeker, 1860).
1092. *Paracaesio pedleyi* McCulloch & Waite, 1916.
1093. *Caesiocorpiis theagenes* Whitley, 1945.
1094. *Caesio digramma* Bleeker, 1865.
1095. *Caesio lunaris* Cuvier & Valenciennes, 1830.
1096. *Caesio caeruleaureus* Lacepede, 1802.
1097. *Caesio erythrogaster* Cuvier & Valenciennes, 1830.
1098. *Caesio chrysozonus translimitanus* Whitley, 1933.
1099. *Aprion virescens placidus* Whitley, 1937.
1100. *Aprion microlepis* Bleeker, 1873.
1101. *Etelis carbunculus* Cuvier & Valenciennes, 1828.
1102. *Aphareus rutilans* Cuvier & Valenciennes, 1830.
1103. *Lutjanus coatesi* Whitley, 1934.
1104. *Lutjanus argentimaculatus* (Bonnaterre, 1788).
1105. *Lutjanus russellii* (Bleeker, 1849).
1106. *Lutjanus sanguineus* (Cuvier & Valenciennes, 1828).
1107. *Lutjanus fulviflamma* (Bonnaterre, 1788).
1108. *Lutjanus malabaricus* (Bloch & Schneider, 1801).
1109. *Lutjanus rivulatus* (Cuvier & Valenciennes, 1828).
1110. *Lutjanus nigricauda* (De Vis, 1884).
1111. *Lutjanus (Evoplites) kasmira* Bonnaterre, 1788.

1112. *Lutjanus macleayanus* (Ramsay, 1883).
1113. *Lutjanus castelnaui* Whitley, 1928.
1114. *Lutjanus longmani* Whitley, 1937.
1115. *Lutjanus janthinuropterus* (Bleeker, 1852).
1116. *Lutjanus amabilis* (De Vis, 1885).
1117. *Lutjanus notatus* (Cuvier & Valenciennes, 1828).
1118. *Lutjanus notatus sublineatus* (De Vis, 1884).
1119. *Lutjanus (Raizero) johnii* (Bloch, 1792).
1120. *Lutjanus gibbus* (Bonnaterre, 1788).
1121. *Lutjanus chrysotaenia* (Bleeker, 1851).
1122. *Lutjanus vitta* (Quoy & Gaimard, 1824).
1123. *Lutjanus carponotatus* (Richardson, 1842).
1124. *Lutjanus vaigiensis* (Quoy & Gaimard, 1824).
1125. *Lutjanus superbus* (Castelnau, 1878).
1126. *Diacope sebae* (Cuvier, 1816).
1127. *Loxolutjanus erythropterus* (Bloch, 1790).
1128. *Neomesoprion unicolor* Castelnau, 1875.
1129. *Lunicauda emeryi* (Richardson, 1843).
1130. *Nemipterus theodori* Ogilby, 1916.
1131. *Nemipterus upeneoides* (Bleeker, 1852).
1132. *Nemipterus samsonensis* T. D. Scott, 1959.
1133. *Nemipterus aurifilum* (Ogilby, 1910).
1134. *Nemipterus robustus* Ogilby, 1916.
1135. *Nemipterus hexodon* (Quoy & Gaimard, 1824).
1136. *Nemipterus sundanensis* (Bleeker, 1873).
1137. *Nemipterus tolu* (Cuvier & Valenciennes, 1830).
1138. *Scolopsis plebaeus* De Vis, 1884.
1139. *Scolopsis margaritifera* (Cuvier & Valenciennes, 1830).
1140. *Scolopsis longulus* Richardson, 1842.
1141. *Scolopsis bilineatus* (Bloch, 1793).
1142. *Scolopsis cancellatus* (Cuvier & Valenciennes, 1830).
1143. *Scolopsis personatus* (Cuvier & Valenciennes, 1830).
1144. *Scolopsis specularis* De Vis, 1882.
1145. *Scolopsis affinis* Peters, 1877.
1146. *Scolopsis bimaculatus* Ruppell, 1828.
1147. *Scolopsis regina* Whitley, 1937.
1148. *Lobotes surinamensis* (Bloch, 1790).
1149. *Gazza minuta* (Bloch, 1797).
1150. *Equula equula* (Bonnaterre, 1788).
1151. *Equulites novaehollandiae* (Steindachner, 1879).
1152. *Equulites hastatus* (Ogilby, 1884).
1153. *Equulites moretoniensis* (Ogilby, 1912).
1154. *Equulites bindus* (Cuvier & Valenciennes, 1835).
1155. *Aurigequula longispinis* (Cuvier & Valenciennes, 1835).
1156. *Secutor profundus* (De Vis, 1884).
1157. *Eubleekeria ovalis* (De Vis, 1884).
1158. *Eubleekeria (Nuchequula) nuchalis* (Temminck & Schlegel, 1845).
1159. *Pentaprion longimanus* (Cantor, 1850).
1160. *Gerres argyreus* (Bloch & Schneider, 1801).
1161. *Gerres longicaudus* Alleyne & Macleay, 1877.
1162. *Gerres oblongus carinatus* Alleyne & Macleay, 1877.
1163. *Gerres subfasciatus* Cuvier & Valenciennes, 1830.
1164. *Gerres australis* Castelnau, 1875.
1165. *Gerres splendens* De Vis, 1884.
1166. *Gerres philippinus* Gunther, 1862.
1167. *Parochus abbreviatus* (Bleeker, 1850).
1168. *Parochus cheverti* (Alleyne & Macleay, 1877).
1169. *Victor filamentosus* (Cuvier, 1829).
1170. *Parequula melbournensis* (Castelnau, 1872).
1171. *Gerreomorpha rostrata* Alleyne & Macleay, 1877.
1172. *Plectorhinchus schotaf* (Bloch & Schneider, 1801).
1173. *Plectorhinchus chaetodonoides* (Lacepede, 1802).
1174. *Plectorhinchus ordinalis* T. D. Scott, 1959.
1175. *Plectorhinchus sordidus* (Klunzinger, 1870).
1176. *Plectorhinchus polytaenia* (Bleeker, 1852).
1177. *Plectorhinchus goldmanni multivittatus* Macleay, 1878.
1178. *Plectorhinchus roughleyi* Whitley, 1930.
1179. *Plectorhinchus nitidus* (Gunther, 1859).
1180. *Plectorhinchus punctatissimus* (Playfair, 1868).
1181. *Plectorhinchus chrysotaenia* (Bleeker, 1855).
1182. *Plectorhinchus celebicus* Bleeker, 1873.
1183. *Spilotichthys pictus* (Thunberg, 1787).
1184. *Euelatichthys niger* (Cuvier & Valenciennes, 1830).
1185. *Pomadasys hasta* (Bloch, 1790).
1186. *Pomadasys maculatum* (Bloch, 1793).
1187. *Pomadasys commersonnii* (Lacepede, 1802).
1188. *Pomadasys argyreum* (Cuvier & Valenciennes, 1833).
1189. *Pomadasys (Pristipomus) auritum* (Cuvier & Valenciennes, 1830).
1190. *Sciaena antarctica* Castelnau, 1872.
1191. *Sciaena antarctica rex* Whitley, 1945.
1192. *Sciaena albida* Cuvier & Valenciennes, 1830.
1193. *Johnius soldado mulleri* (Steindachner, 1879).
1194. *Johnius australis* (Gunther, 1880).
1195. *Johnius carutta* Bloch, 1793.
1196. *Johnius novaehollandiae* (Steindachner, 1866).
1197. *Dendrophysa dussumieri* (Cuvier & Valenciennes, 1833).
1198. *Pseudosciaena diacanthus* (Lacepede, 1802).
1199. *Zeluco atelodus* (Gunther, 1867).

1200. *Otolithes argenteus* Cuvier & Valenciennes, 1830.
1201. *Mulloidichthys auriflamma* (Bonnaterre, 1788).
1202. *Mulloidichthys samoensis armatus* De Vis, 1884.
1203. *Pseudupeneus rubriniger* (De Vis, 1884).
1204. *Pseudupeneus* (Hogbinia) *barberinus* (Lacepede, 1802).
1205. *Caprupeneus jeffi* (Ogilby, 1908).
1206. *Barbupeneus signatus* (Gunther, 1867).
1207. *Parupeneus sufflavus* Whitley, 1941.
1208. *Parupeneus luteus* (Cuvier & Valenciennes, 1831).
1209. *Parupeneus indicus* (Shaw, 1803).
1210. *Upeneus vittatus* (Bonnaterre, 1788).
1211. *Upeneus sundaicus* Bleeker, 1855.
1212. *Upeneus sulphureus* Cuvier & Valenciennes, 1829.
1213. *Upeneus roseus* (Castelnau, 1875).
1214. *Upeneus malabaricus* Cuvier & Valenciennes, 1829.
1215. *Upeneus taeniopterus* Cuvier & Valenciennes, 1829.
1216. *Pennon filifer* (Ogilby, 1910).
1217. *Pennon armatoides* Whitley, 1955.
1218. *Upeneichthys porosus* (Cuvier & Valenciennes, 1829).
1219. *Upeneichthys lineatus* (Bloch & Schneider, 1801).
1220. *Monotaxis affinis* Whitley, 1943.
1221. *Monotaxis grandoculis* (Bonnaterre, 1788).
1222. *Lethrinella miniata* (Bloch & Schneider, 1801).
1223. *Lethrinichthys nematacanthus* (Bleeker, 1854).
1224. *Lethrinus imperialis* De Vis, 1884.
1225. *Lethrinus chrysostomus* Richardson, 1848.
1226. *Lethrinus glyphodon* Gunther, 1859.
1227. *Lethrinus fusciceps* Macleay, 1878.
1228. *Lethrinus kallopterus* Bleeker, 1856.
1229. *Lethrinus rhodopterus* Bleeker, 1852.
1230. *Lethrinus reticulatus* Cuvier & Valenciennes, 1830.
1231. *Lethrinus nebulosus* (Bonnaterre, 1788).
1232. *Lethrinus perselectus* Whitley, 1933.
1233. *Lethrinus fletus* Whitley, 1943.
1234. *Lethrinus laticaudus* Alleyne & Macleay, 1877.
1235. *Lethrinus punctulatus* Macleay, 1878.
1236. *Lethrinus harak papuensis* Alleyne & Macleay, 1877.
1237. *Lethrinus fasciatus* Cuvier & Valenciennes, 1830.
1238. *Lethrinus variegatus* Cuvier & Valenciennes, 1830.
1239. *Lethrinus hypslepterus* Bleeker, 1873.
1240. *Lethrinus viridis* Whitley, 1932.
1241. *Lethrinus mahsena* (Bonnaterre, 1788).
1242. *Lethrinus nebulosus devisianus* Whitley, 1929.
1243. *Lethrinus cinnabarinus* Richardson, 1843.
1244. *Lethrinus cyanoxanthus* Richardson, 1843.
1245. *Lethrinus mahsenoides* Cuvier & Valenciennes, 1830.
1246. *Neolethrinus similis* Castelnau, 1875.
1247. *Scaevius milii* (Bory, 1823).
1248. *Pentapodus microdon* (Bleeker, 1853).
1249. *Pentapodus setosus* (Cuvier & Valenciennes, 1830).
1250. *Pentapodus dubius* (Bory, 1823).
1251. *Allotauis spariformis* (Ogilby, 1910).
1252. *Chrysophrys unicolor* Quoy & Gaimard, 1824.
1253. *Chrysophrys guttulatus* (Cuvier & Valenciennes, 1830).
1254. *Argyrops spinifer* (Bonnaterre, 1788).
1255. *Rhabdosargus sarba tarachine* Whitley, 1931.
1256. *Acanthopagrus australis* (Owen, 1853).
1257. *Acanthopagrus palmaris* (Whitley, 1935).
1258. *Acanthopagrus berda* (Gmelin, 1789).
1259. *Acanthopagrus butcheri* (Munro, 1949).
1260. *Acanthopagrus latus* (Houttuyn, 1782).
1261. *Paradentex bitorquatus* (Cockerell, 1916).
1262. *Paradentex marshalli* Whitley, 1936.
1263. *Monodactylus argenteus* (Linné, 1758).
1264. *Branchiostegus wardi* Whitley, 1932.
1265. *Schuettea scalaripinnis* Steindachner, 1866.
1266. *Schuettea woodwardi* (Waite, 1905).
1267. *Pempheris compressa* (White, 1790).
1268. *Pempheris klunzingeri* McCulloch, 1911.
1269. *Liopempheris multiradiata* (Klunzinger, 1879).
1270. *Liopempheris affinis* (McCulloch, 1911).
1271. *Parapriacanthus elongatus* (McCulloch, 1911).
1272. *Parapriacanthus unwini* (Ogilby, 1889).
1273. *Leptobrama muelleri* Steindachner, 1879.
1274. *Toxotes dorsalis* Whitley, 1950.
1275. *Toxotes carpentariensis* Castelnau, 1878.
1276. *Toxotes jaculator* (Bonnaterre, 1788).
1277. *Toxotes ulysses* Whitley, 1950.
1278. *Protoxotes lorentzi* (Weber, 1911).
1279. *Kurtus gulliveri* Castelnau, 1878.
1280. *Atypichthys strigatus* (Gunther, 1860).
1281. *Atypichthys mado* Whitley, 1931.
1282. *Scorpis lineolatus* Kner, 1865.
1283. *Scorpis georgianus* Cuvier & Valenciennes, 1832.
1284. *Scorpis aequipinnis* Richardson, 1848.
1285. *Scorpis violaceus* (Hutton, 1873).
1286. *Scorpis oblungus* Canestrini, 1869.
1287. *Neatypus obliquus* Waite, 1905.
1288. *Microcanthus vittatus* (Castelnau, 1873).
1289. *Microcanthus joyceae* Whitley, 1931.
1290. *Segutilum klunzingeri* Whitley, 1931.
1291. *Segutilum cornelli* Whitley, 1944.

1292. *Segutilum sydneyanum* (Günther, 1886).
1293. *Opisthistius squamosus* (Alleyne & Macleay, 1877).
1294. *Kyphosus vaigiensis* (Quoy & Gaimard, 1825).
1295. *Leptokyphosus gibsoni* (Ogilby, 1912).
1296. *Girella tricuspidata* (Quoy & Gaimard, 1824).
1297. *Iredalella cyanea* (Macleay, 1881).
1298. *Girellipiscis elevatus* (Macleay, 1881).
1299. *Tephraeops tephraeops* (Richardson, 1846).
1300. *Melambaphes zebra* (Richardson, 1846).
1301. *Selenotoca multifasciata* (Richardson, 1846).
1302. *Selenotoca altermans* (Castelnau, 1878).
1303. *Scatophagus argus* (Linné, 1766).
1304. *Scatophagus ornatus* Cuvier & Valenciennes, 1831.
1305. *Platax pinnatus* (Linné, 1758).
1306. *Platax batavianus* Cuvier & Valenciennes, 1831.
1307. *Platax orbicularis* (Bonnaterre, 1788).
1308. *Zabidius novemaculeatus* (McCulloch, 1916).
1309. *Drepanichthys punctatus* (Linné, 1758).
1310. *Chaetodon semeion* Bleeker, 1855.
1311. *Chaetodon assarius* Ogilby, 1905.
1312. *Chaetodon aureofasciatus* Macleay, 1878.
1313. *Chaetodon setifer* Bloch, 1795.
1314. *Chaetodon aphrodite* Ogilby, 1889.
1315. *Chaetodon citrinellus nigripes* De Vis, 1884.
1316. *Chaetodon lunula* (Lacepede, 1802).
1317. *Chaetodon rainfordi* McCulloch, 1923.
1318. *Chaetodon aurora* De Vis, 1884.
1319. *Chaetodon guntheri* Ahl, 1923.
1320. *Chaetodon vitulus* Whitley, 1957.
1321. *Chaetodon germanus* De Vis, 1884.
1322. *Chaetodon flavirostris* Günther, 1873.
1323. *Chaetodon octofasciatus* Bloch, 1787.
1324. *Chaetodon kleinii* Bloch, 1790.
1325. *Chaetodon vagabundus* Linné, 1758.
1326. *Chaetodon melannotus* Bloch & Schneider, 1801.
1327. *Chaetodon (Rabdophorus) ephippium* Cuvier & Valenciennes, 1831.
1328. *Chaetodon (Rabdophorus) speculum* Cuvier & Valenciennes, 1831.
1329. *Chaetodon (Rabdophorus) trifasciatus* Park, 1797.
1330. *Chaetodon (Rabdophorus) bennetti* (Cuvier & Valenciennes, 1831).
1331. *Anisochaetodon lineolatus* (Cuvier & Valenciennes, 1831).
1332. *Gonochaetodon triangulus* (Cuvier & Valenciennes, 1831).
1333. *Megaprotodon strigangulus* (Gmelin, 1789).
1334. *Megaprotodon maculiceps* Ogilby, 1910.
1335. *Tetrachaetodon plebeius* (Cuvier & Valenciennes, 1831).
1336. *Coradion altivelis* McCulloch, 1916.
1337. *Coradion chrysozonus* (Cuvier & Valenciennes, 1831).
1338. *Parachaetodon ocellatus* (Cuvier & Valenciennes, 1831).
1339. *Parachaetodon townleyi* (De Vis, 1884).
1340. *Vinculum sexfasciatum* (Richardson, 1842).
1341. *Vinculum ocellipinnis* (Macleay, 1878).
1342. *Vinculum kershawi* Whitley, 1931.
1343. *Chelmon rostratus mulleri* Klunzinger, 1879.
1344. *Chelmon rostratus marginalis* Richardson, 1842.
1345. *Forcipiger lol* (Montrouzier, 1856).
1346. *Chelmonops truncatus* (Kner, 1859).
1347. *Heniochus acuminatus* (Linné, 1758).
1348. *Heniochus varius* (Cuvier & Valenciennes, 1831).
1349. *Heniochus permutatus* Cuvier & Valenciennes, 1831).
1350. *Euxhipops sexstriatus* (Cuvier & Valenciennes, 1831).
1351. *Centropyge bicolor* (Bloch, 1787).
1352. *Centropyge nox* (Bleeker, 1853).
1353. *Centropyge vroliki* (Bleeker, 1853).
1354. *Holacanthus flavissimus* Cuvier & Valenciennes, 1831.
1355. *Holacanthus imperator* (Bloch, 1787).
1356. *Holacanthus tricolor* (Bloch, 1795).
1357. *Pygopites diacanthus* (Boddaert, 1772).
1358. *Pomacanthops semicirculatus* (Cuvier & Valenciennes, 1831).
1359. *Chaetodontoplus melanosoma* (Bleeker, 1853).
1360. *Chaetodontoplus duboulayi* (Günther, 1867).
1361. *Chaetodontoplus personifer* (McCulloch, 1914).
1362. *Chaetodontoplus conspicillatus* (Waite, 1900).
1363. *Chaetodontoplus ballinae* Whitley, 1959.
1364. *Enoplosus armatus* (White, 1790).
1365. *Paristiopterus labiosus* (Günther, 1871).
1366. *Paristiopterus (Glauertichthys) gal-lipavo* Whitley, 1944.
1367. *Zanclistius elevatus* (Ramsay & Ogilby, 1888).
1368. *Pentaceropterus recurvirostris* (Richardson, 1845).
1369. *Undecimus hendecacanthus* (McCulloch, 1915).
1370. *Ostorhinchus conwaii* (Richardson, 1840).
1371. *Cepola australis* Ogilby, 1899.
1372. *Acanthocephala abbreviata* (Cuvier & Valenciennes, 1835).
1373. *Cirrhitichthys aprinus* (Cuvier & Valenciennes, 1829).
1374. *Neocirrhitichthys armatus* Castelnau, 1873.
1375. *Cyprinocirrhites polyactis* (Bleeker, 1875).
1376. *Chironemus georgianus* Cuvier & Valenciennes, 1829.
1377. *Chironemus aboriginalis* Whitley, 1931.

1378. *Chironemus marmoratus* Gunther, 1860.
1379. *Threpterus maculosus* Richardson, 1850.
1380. *Threpterus chalcus* T. D. Scott, 1954.
1381. *Dactylosargus meandratus* (Richardson, 1842).
1382. *Dactylosargus arctidens* (Richardson, 1839).
1383. *Crinodus lophodon* (Gunther, 1859).
1384. *Crinodus marmoratus* (Thomiot, 1883).
1385. *Nemadactylus concinnus* Richardson, 1839.
1386. *Nemadactylus carponemus* (Cuvier & Valenciennes, 1830).
1387. *Nemadactylus douglasii* (Hector, 1875).
1388. *Nemadactylus valenciennesi* (Whitley, 1937).
1389. *Nemadactylus macropterus* (Bloch & Schneider, 1801).
1390. *Morwong fuscus* (Castelnau, 1879).
1391. *Cheilodactylus spectabilis* Hutton, 1872.
1392. *Cheilodactylus nigripes* Richardson, 1850.
1393. *Goniistius gibbosus* (Richardson, 1841).
1394. *Goniistius vizonarius* (Saville-Kent, 1887).
1395. *Psilocranium nigricans* (Richardson, 1850).
1396. *Latris mortonii* Saville-Kent, 1886.
1397. *Latris lineata* (Bloch & Schneider, 1801).
1398. *Latridopsis ciliaris* (Bloch & Schneider, 1801).
1399. *Latridopsis forsteri* (Castelnau, 1872).
1400. *Mendosoma allporti* Johnston, 1881.
1401. *Schindleria praematura* (Schindler, 1930).
1402. *Pneumatophorus australasicus* (Cuvier & Valenciennes, 1832).
1403. *Rastrelliger canagurta serventyi* Whitley, 1944.
1404. *Auxis thazard* (Lacepede, 1801).
1405. *Auxis thynnoides* Bleeker, 1855.
1406. *Gymnosarda unicolor* (Ruppell, 1836).
1407. *Katsuwonus pelamis* (Linné, 1758).
1408. *Euthynnus wallisi* (Whitley, 1937).
1409. *Kishinoella tonggol* (Bleeker, 1851).
1410. *Allothunnus fallai* Serventy, 1948.
1411. *Neothunnus macropterus* (Temminck & Schlegel, 1844).
1412. *Parathunnus argentivittatus* (Cuvier & Valenciennes, 1832).
1413. *Thynnus maccoyii* (Castelnau, 1872).
1414. *Germo germon steadi* Whitley, 1933.
1415. *Grammatorycnus bicarinatus* (Quoy & Gaimard, 1825).
1416. *Sarda australis* (Macleay, 1881).
1417. *Sarda orientalis serventyi* Whitley, 1945.
1418. *Cybiosarda elegans* (Whitley, 1935).
1419. *Cybbium commerson* (Lacepede, 1800).
1420. *Cybbium queenslandicum* (Munro, 1943).
1421. *Savara nipponia* (Cuvier & Valenciennes, 1832).
1422. *Indocybbium semifasciatum* (Macleay, 1883).
1423. *Acanthocybbium solandri* (Cuvier & Valenciennes, 1832).
1424. *Gasterochisma melampus* Richardson, 1845.
1425. *Luvarus imperialis* Rafinesque, 1810.
1426. *Ruvettus tydemani* Weber, 1913.
1427. *Xiphias estara* Phillipps, 1932.
1428. *Makaira mazara howardi* (Whitley, 1954).
1429. *Istiompax dombraini* Whitley, 1954.
1430. *Istiompax indicus* (Cuvier & Valenciennes, 1832).
1431. *Tetrapturus brevirostris* (Playfair, 1866).
1432. *Istiophorus ludibundus* Whitley, 1933.
1433. *Marlina audax zelandica* (Jordan & Evermann, 1926).
1434. *Benthodesmus elongatus* (Clarke, 1879).
1435. *Lepidopus lex* Phillipps, 1932.
1436. *Assurger alexanderi* Whitley, 1933.
1437. *Trichiurus coxii* Ogilby, 1887.
1438. *Trichiurus haumela* (Bonnaterre, 1788).
1439. *Lepturacanthus savala* (Cuvier, 1829).
1440. *Leionura atun* (Euphrasen, 1791).
1441. *Rexea solandri* (Cuvier & Valenciennes, 1832).
1442. *Lepidocybbium flavobrunneum* (Smith, 1843).
1443. *Amphacanthus lineatus* (Cuvier & Valenciennes, 1835).
1444. *Amphacanthus javus* (Linné, 1766).
1445. *Amphacanthus vermiculatus* Cuvier & Valenciennes, 1835.
1446. *Amphacanthus tumifrons* Cuvier & Valenciennes, 1835.
1447. *Amphacanthus notostictus* Richardson, 1853.
1448. *Amphacanthus doliatus* (Griffith, 1834).
1449. *Amphacanthus oramin* Bloch & Schneider, 1801.
1450. *Amphacanthus fuscescens* (Houttuyn, 1732).
1451. *Amphacanthus chrysospilos* Bleeker, 1852.
1452. *Amphacanthus nebulosus* Quoy & Gaimard, 1824.
1453. *Amphacanthus corallinus* Cuvier & Valenciennes, 1835.
1454. *Amphacanthus hexacanthus* (Barton, 1950).
1455. *Amphacanthus teuthopsis* (De Vis, 1884).
1456. *Amphacanthus gibbosus* (De Vis, 1884).
1457. *Amphacanthus capricornensis* (Whitley, 1926).
1458. *Amphacanthus concavocephalus* (Paradice, 1927).
1459. *Amphacanthus hexagonatus* Bleeker, 1854.
1460. *Amphacanthus virgatus* Cuvier & Valenciennes, 1835.
1461. *Lo vulpinus* (Schlegel & Muller, 1844).
1462. *Buro brunneus* Lacepede, 1803.
1463. *Rhombotides triostegus* (Linné, 1758).
1464. *Teuthis nigrofuscus* (Gmelin, 1789).

1465. *Teuthis nigroris* (Cuvier & Valenciennes, 1835).
1466. *Teuthis spinifrons* Whitley, 1953.
1467. *Teuthis dussumieri* (Cuvier & Valenciennes, 1835).
1468. *Teuthis fuliginosus* (Lesson, 1831).
1469. *Teuthis glaucopareius* (Cuvier, 1829).
1470. *Teuthis formosus* (Castelnau, 1873).
1471. *Teuthis gahm* (Gmelin, 1789).
1472. *Teuthis lineatus* (Linné, 1758).
1473. *Teuthis olivaceus* (Bloch & Schneider, 1801).
1474. *Ctenochaetus strigosus* (Bennett, 1828).
1475. *Zebrasoma hypselopterum* (Bleeker, 1854).
1476. *Laepichthys rostratus* (Gunther, 1875).
1477. *Prionurus microlepidotus* Lacepede, 1804.
1478. *Burobulla maculata* (Ogilby, 1887).
1479. *Naso unicornis* (Bonnaterre, 1788).
1480. *Naso lituratus* (Bloch & Schneider, 1801).
1481. *Priodon annulatus* Quoy & Gaimard, 1824.
1482. *Cyphomycter tuberosus* (Lacepede, 1802).
1483. *Zanclus canescens* (Linné, 1758).
1484. *Psettodes erumei* (Bloch & Schneider, 1801).
1485. *Scaops grandisquama spiniceps* (Macleay, 1881).
1486. *Engyprosonon bleekeri* (Macleay, 1881).
1487. *Bothus pantherinus* (Ruppell, 1831).
1488. *Grammatobothus polyophthalmus* (Bleeker, 1866).
1489. *Grammatobothus pennatus* (Ogilby, 1913).
1490. *Arnoglossus tenuis* Gunther, 1880.
1491. *Arnoglossus andrewsi* Kurth, 1954.
1492. *Arnoglossus fisoni* Ogilby, 1898.
1493. *Arnoglossus waitei* Norman, 1926.
1494. *Arnoglossus muelleri* (Klunzinger, 1872).
1495. *Arnoglossus bassensis* Norman, 1926.
1496. *Arnoglossus intermedius* (Bleeker, 1866).
1497. *Arnoglossus aspiros praeteritus* Whitley, 1950.
1498. *Lophonectes gallus* Gunther, 1880.
1499. *Istiorhombus spinosus* (McCulloch, 1914).
1500. *Istiorhombus spinosus normani* Whitley, 1931.
1501. *Pseudorhombus duplici-cellatus* Regan, 1905.
1502. *Pseudorhombus argus* Weber, 1913.
1503. *Pseudorhombus jenynsii* Bleeker, 1855.
1504. *Pseudorhombus dubius* Norman, 1934.
1505. *Pseudorhombus arsius* (Hamilton-Buchanan, 1822).
1506. *Pseudorhombus tenuirostrum* (Waite, 1899).
1507. *Pseudorhombus anomalus* Ogilby, 1912.
1508. *Pseudorhombus elevatus* Ogilby, 1912.
1509. *Pseudorhombus moorei* Thomiot, 1880.
1510. *Pseudorhombus diplospilus* Norman, 1926.
1511. *Azygopus pinnifasciatus* Norman, 1926.
1512. *Samaris cacatuæ* (Ogilby, 1910).
1513. *Ammotretis rostratus* Gunther, 1862.
1514. *Ammotretis elongatus* McCulloch, 1914.
1515. *Ammotretis tudori* McCulloch, 1914.
1516. *Ammotretis macrolepis* McCulloch, 1914.
1517. *Ammotretis brevipinnis* Norman, 1926.
1518. *Ammotretis lituratus* (Richardson, 1843).
1519. *Rhombosolea tapirina* Gunther, 1862.
1520. *Neorhombus unicolor* Castelnau, 1875.
1521. *Microbuglossus ovatus* (Richardson, 1846).
1522. *Liachirus klunzingeri* (Weber, 1908).
1523. *Liachirus whitleyi* Chabanaud, 1950.
1524. *Soleichthys lineatus* (Ramsay, 1883).
1525. *Æsopia microcephala* (Gunther, 1862).
1526. *Æsopia heterorhinos* (Bleeker, 1856).
1527. *Aseraggodes haackeanus* (Steindachner, 1883).
1528. *Aseraggodes haackeanus ramsaii* Ogilby, 1889.
1529. *Synclidopus normani* (Chabanaud, 1930).
1530. *Synclidopus macleayanus* (Ramsay, 1881).
1531. *Rendahlia jaubertensis* (Rendahl, 1921).
1532. *Pardachirus pavoninus* (Lacepede, 1802).
1533. *Pardachirus hedleyi* Ogilby, 1916.
1534. *Normanetta rautheri* (Chabanaud, 1931).
1535. *Achlyopa nigra* (Macleay, 1880).
1536. *Trichobrachirus salinarum* (Ogilby, 1910).
1537. *Trichobrachirus selheimi* (Macleay, 1882).
1538. *Trichobrachirus breviceps* (Ogilby, 1910).
1539. *Heterobuglossus aspiros* (Bleeker, 1852).
1540. *Strabozebias cancellatus* (McCulloch, 1916).
1541. *Strabozebias craticulus* (McCulloch, 1916).
1542. *Haplozebias fasciatus* (Macleay, 1882).
1543. *Dezillus* (Strandichthys) *muelleri* (Steindachner, 1879).
1544. *Paradicula setifer* (Paradice, 1927).
1545. *Phyllichthys sclerolepis* (Macleay, 1878).
1546. *Phyllichthys punctatus* McCulloch, 1916.
1547. *Phyllichthys sejunctus* Whitley, 1935.
1548. *Nematozebias quagga* (Kaup, 1858).
1549. *Symphurus australis* McCulloch, 1907.
1550. *Symphurus holothuriae* Chabanaud, 1948.
1551. *Paraplagusia acuminata* (Castelnau, 1875).
1552. *Paraplagusia unicolor* (Macleay, 1881).
1553. *Rhinoplagusia guttata* (Macleay, 1878).

1554. *Rhinoplagusia australis* Rendahl, 1922.
1555. *Cynoglossus ogilbyi* Norman, 1926.
1556. *Cynoglossus macrophthalmus* Norman, 1926.
1557. *Cynoglossus maccullochi* Norman, 1926.
1558. *Cynoglossus broadhursti* Waite, 1905.
1559. *Cynoglossus sindensis* Day, 1877.
1560. *Cynoglossus maculipinnis* Rendahl, 1921.
1561. *Cynoglossus bilineatus* (Bloch, 1787).
1562. *Amphiprion verweyi* Whitley, 1933.
1563. *Amphiprion polymnus* (Linné, 1758).
1564. *Amphiprion melanopus* Bleeker, 1852.
1565. *Amphiprion tricolor* Gunther, 1862.
1566. *Amphiprion bicinctus* Ruppell, 1831.
1567. *Amphiprion unimaculatus* (Meuschen, 1781).
1568. *Amphiprion chrysogaster* Cuvier & Valenciennes, 1830.
1569. *Amphiprion melanostolus* Richardson, 1842.
1570. *Amphiprion rubrocinctus* Richardson, 1842.
1571. *Amphiprion papuensis* Macleay, 1883.
1572. *Amphiprion clarkii* (Bennett, 1830).
1573. *Amphiprion perideraion* Bleeker, 1855.
1574. *Actinicola percula* (Lacepede, 1802).
1575. *Actinicola bicolor* (Castelnau, 1873).
1576. *Premnas biaculeatus* (Bloch, 1790).
1577. *Premnas gibbosus* Castelnau, 1875.
1578. *Pomacentrus ovooides* Cartier, 1874.
1579. *Pomacentrus obreptus* Whitley, 1948.
1580. *Pomacentrus taeniurus* Bleeker, 1856.
1581. *Pomacentrus violescens* (Bleeker, 1848).
1582. *Dischistodus fasciatus* (Cuvier & Valenciennes, 1830).
1583. *Dischistodus prosopotaenia* (Bleeker, 1852).
1584. *Dischistodus perspicillatus* (Cuvier & Valenciennes, 1830).
1585. *Dischistodus notophthalmus* (Bleeker, 1853).
1586. *Pseudopomacentrus rainfordi* Whitley, 1935.
1587. *Pseudopomacentrus littoralis* (Cuvier & Valenciennes, 1830).
1588. *Pseudopomacentrus wardi macleayi* (Whitley, 1928).
1589. *Pseudopomacentrus wardi wardi* (Whitley, 1927).
1590. *Pseudopomacentrus bilineatus* (Castelnau, 1873).
1591. *Pseudopomacentrus modestus* (Castelnau, 1875).
1592. *Pseudopomacentrus flavicauda* Whitley, 1928).
1593. *Pseudopomacentrus fasciatus* (Macleay, 1878).
1594. *Pseudopomacentrus sufflavus* (Whitley, 1927).
1595. *Pseudopomacentrus amboinensis* (Bleeker, 1868).
1596. *Pseudopomacentrus apicalis* (De Vis, 1885).
1597. *Pseudopomacentrus bankanensis* (Bleeker, 1856).
1598. *Brachypomacentrus albifasciatus* (Schlegel & Muller, 1844).
1599. *Eupomacentrus subniger* (De Vis, 1885).
1600. *Eupomacentrus lividus* (Bloch & Schneider, 1801).
1601. *Eupomacentrus profundus* (De Vis, 1885).
1602. *Daya jerdoni* (Day, 1873).
1603. *Parapomacentrus bankieri* (Richardson, 1846).
1604. *Cheiloprion labiatus* (Day, 1877).
1605. *Glyphisodon coelestinus* Cuvier & Valenciennes, 1830.
1606. *Glyphisodon palmeri* Cockerell, 1913.
1607. *Glyphisodon seafasciatus* (Lacepede, 1802).
1608. *Glyphisodon saxatilis vaigiensis* Quoy & Gaimard, 1825.
1609. *Glyphisodon septemfasciatus* Cuvier & Valenciennes, 1830.
1610. *Glyphisodon sordidus* (Bonnaterre, 1788).
1611. *Glyphisodon leucogaster* Bleeker, 1846.
1612. *Glyphisodon expansus* De Vis, 1885.
1613. *Glyphisodon luteocaudatus* Saville-Kent, 1893.
1614. *Glyphisodon hemicyaneus* (Weber, 1913).
1615. *Amblyglyphidodon curacao* (Bloch, 1787).
1616. *Negostegastes leucozona* (Bleeker, 1859).
1617. *Paraglyphidodon melas* (Cuvier & Valenciennes, 1830).
1618. *Paraglyphidodon melanopus* (Bleeker, 1856).
1619. *Glyphidodontops biocellatus* (Quoy & Gaimard, 1825).
1620. *Glyphidodontops amabilis* (De Vis, 1884).
1621. *Glyphidodontops unimaculatus* (Cuvier & Valenciennes, 1830).
1622. *Glyphidodontops zonatus* (Cuvier & Valenciennes, 1830).
1623. *Iredaleichthys hedleyi* (Whitley, 1927).
1624. *Iredaleichthys glaucus* (Cuvier & Valenciennes, 1830).
1625. *Iredaleichthys uniozellatus* (Quoy & Gaimard, 1825).
1626. *Actinochromis victoriae* (Gunther, 1863).
1627. *Parma microlepis* Gunther, 1862.
1628. *Parma oligolepis* Whitley, 1929.
1629. *Parma viola* Whitley, 1929.
1630. *Parma mccullochi* Whitley, 1929.
1631. *Mecaenichthys immaculatus* (Ogilby, 1885).
1632. *Chromis humbug* Whitley, 1954.
1633. *Chromis bitaeniatus* Fowler & Bean, 1928.
1634. *Chromis nitidus* (Whitley, 1928).
1635. *Chromis hypsilepis* (Gunther, 1867).
1636. *Chromis klunzingeri* Whitley, 1929.
1637. *Chromis scotochilopterus* Fowler, 1918.
1638. *Chromis cinerascens* (Cuvier & Valenciennes, 1830).
1639. *Hoplochromis caeruleus* (Cuvier & Valenciennes, 1830).
1640. *Dascyllus aruanus* (Linné, 1758).

1641. *Peltochromis xanthosoma* (Bleeker, 1851).
1642. *Peltochromis trimaculatus* (Ruppell, 1829).
1643. *Acanthochromis* (*Heptadecanthus*) *longicaudis* (Alleyne & Macleay, 1877).
1644. *Acanthochromis* (*Heptadecanthus*) *maculosus* (De Vis, 1885).
1645. *Acanthochromis* (*Heptadecanthus*) *brevipinnis* (De Vis, 1885).
1646. *Cheilio inermis* (Bonnaterre, 1788).
1647. *Duymaeria flagellifera* (Cuvier & Valenciennes, 1839).
1648. *Coris aygula cyanea* Macleay, 1883.
1649. *Coris auricularis* (Cuvier & Valenciennes, 1838).
1650. *Coris dorsomaculata* Fowler, 1908.
1651. *Coris gaimard* (Quoy & Gaimard, 1824).
1652. *Hemicoris variegata* (Ruppell, 1835).
1653. *Hemicoris pallida* (Macleay, 1881).
1654. *Ctenocorissa picta* (Bloch & Schneider, 1801).
1655. *Tiricoris sandeyeri rex* (Ramsay & Ogilby, 1885).
1656. *Ophthalmolepis lineolatus* (Cuvier & Valenciennes, 1838).
1657. *Eupetrichthys angustipes* Ramsay & Ogilby, 1888.
1658. *Pictilabrus laticlavus* (Richardson, 1839).
1659. *Austrolabrus maculatus* (Macleay, 1881).
1660. *Pseudolabrus luculentus* (Richardson, 1848).
1661. *Pseudolabrus convexus* (Castelnau, 1875).
1662. *Pseudolabrus cyprinaceus* (White, 1790).
1663. *Pseudolabrus guntheri* Bleeker, 1862.
1664. *Pseudolabrus fucicola* (Richardson, 1840).
1665. *Pseudolabrus bostockii* (Castelnau, 1873).
1666. *Pseudolabrus tetricus* (Richardson, 1840).
1667. *Pseudolabrus cuvieri* (Castelnau, 1873).
1668. *Pseudolabrus bleekeri* (Castelnau, 1872).
1669. *Pseudolabrus gymnogenis* (Gunther, 1862).
1670. *Pseudolabrus parilis* (Richardson, 1850).
1671. *Pseudolabrus punctulatus* (Gunther, 1862).
1672. *Pseudolabrus unicolor* (Castelnau, 1875).
1673. *Pseudolabrus macleayi* (Herzenstein, 1896).
1674. *Pseudolabrus bleasdalei* (Castelnau, 1875).
1675. *Lunolabrus miles* (Bloch & Schneider, 1801).
1676. *Lunolabrus celidotus botryocosmus* (Richardson, 1846).
1677. *Dotalabrus aurantiacus* (Castelnau, 1872).
1678. *Hemigymnus fasciatus* (Bloch, 1792).
1679. *Hemigymnus* (*Cheilolabrus*) *melapterus* (Bloch, 1791).
1680. *PlatyGLOSSUS amabilis* De Vis, 1885.
1681. *PlatyGLOSSUS equinus* De Vis, 1885.
1682. *PlatyGLOSSUS punctatus* De Vis, 1885.
1683. *PlatyGLOSSUS dussumieri* (Cuvier & Valenciennes, 1838).
1684. *PlatyGLOSSUS immaculatus* Macleay, 1878.
1685. *PlatyGLOSSUS notopsis* (Cuvier & Valenciennes, 1838).
1686. *Halichores nebulosus* (Cuvier & Valenciennes, 1838).
1687. *Halichores argus* (Bloch & Schneider, 1801).
1688. *Halichores poecilus* (Lay & Bennett, 1839).
1689. *Halichores melanurus* (Bleeker, 1851).
1690. *Halichores hoevenii* (Bleeker, 1851).
1691. *Halichores hartzfeldii* (Bleeker, 1852).
1692. *Choerojulius gymnocephalus* (Bloch & Schneider, 1801).
1693. *Choerojulius brownfieldi* Whitley, 1945.
1694. *Octocynodon miniatus* (Cuvier & Valenciennes, 1838).
1695. *Octocynodon margaritaceus* (Cuvier & Valenciennes, 1839).
1696. *Halimnoides leucostigma* (Fowler & Bean, 1928).
1697. *Guntheria devisi* Whitley, 1941.
1698. *Guntheria ziczac* (De Vis, 1885).
1699. *Guntheria trimaculata* (Griffith, 1834).
1700. *Guntheria vestalis* Whitley, 1958.
1701. *Hemitautoga centiquadrus* (Lacepede, 1802).
1702. *Labroides auropinna* Saville-Kent, 1893.
1703. *Labroides bicinctus* Saville-Kent, 1893.
1704. *Labroides dimidiatus* (Cuvier & Valenciennes, 1839).
1705. *Labrichthys cyaneotaenia* Bleeker, 1854.
1706. *Gomphosus varius* Lacepede, 1802.
1707. *Gomphosus caeruleus* Lacepede, 1802.
1708. *Pseudojulius murrayensis* De Vis, 1885.
1709. *Pseudojulius maculifer* Castelnau, 1875.
1710. *Pseudojulops trifasciatus* (Weber, 1913).
1711. *Stethojulis strigiventer* (Bennett, 1833).
1712. *Stethojulis renardi* (Bleeker, 1851).
1713. *Stethojulis kalosoma* (Bleeker, 1852).
1714. *Stethojulis casturi* Gunther, 1881.
1715. *Stethojulis rubromacula* T. D. Scott, 1959.
1716. *Hinalea axillaris* (Quoy & Gaimard, 1824).
1717. *Thalassoma lunare* (Linné, 1758).
1718. *Thalassoma lutescens* (Lay & Bennett, 1839).
1719. *Thalassoma ventrale* (De Vis, 1885).
1720. *Thalassoma cyanoventor* (Saville-Kent, 1893).
1721. *Thalassoma semilunatum* (Lacepede, 1804).
1722. *Thalassoma septemfasciatum* T. D. Scott, 1959.
1723. *Thalassoma hardwicke* (Bennett, 1829).
1724. *Thalassoma janseni* (Bleeker, 1856).

1725. *Thalassoma dorsale* (Quoy & Gaimard, 1825).
1726. *Julichthys inornatus* De Vis, 1885.
1727. *Novaculichthys jacksonensis* (Ramsay, 1881).
1728. *Novaculichthys taeniourus* (Lacepede, 1802).
1729. *Cheilinus oxyrhynchus* Bleeker, 1862.
1730. *Cheilinus fasciatus* (Bloch, 1791).
1731. *Cheilinus bimaculatus* Cuvier & Valenciennes, 1839.
1732. *Cheilinus digrammus* (Lacepede, 1802).
1733. *Cheilinus undulatus* Ruppell, 1835.
1734. *Thalichthys chlorourus* (Bloch, 1791).
1735. *Epibulus insidiator* (Pallas, 1770).
1736. *Anampses pterophthalmus* Bleeker, 1857.
1737. *Anampses lennardi* T. D. Scott, 1959.
1738. *Anampses geographicus* Cuvier & Valenciennes, 1839.
1739. *Choerodon venustus* (De Vis, 1884).
1740. *Choerodon paynei* Whitley, 1945.
1741. *Choerodon cyanostolus* (Richardson, 1846).
1742. *Choerodon australis* (Castelnau, 1875).
1743. *Choerodon lineatus* (De Vis, 1885).
1744. *Choerodon schoenleinii* (Cuvier & Valenciennes, 1839).
1745. *Choerodon cyanodus* (Richardson, 1843).
1746. *Choerodon albigena* (De Vis, 1885).
1747. *Choerodon cephalotes* (Castelnau, 1875).
1748. *Choerodon macleayi* (Ramsay & Ogilby, 1887).
1749. *Choerodon rubescens* (Gunther, 1862).
1750. *Choerodon crassus* (Castelnau, 1875).
1751. *Choerodon anchorago* (Bloch, 1791).
1752. *Choerodon transversalis* Whitley, 1956.
1753. *Choerodon rubidus* T. D. Scott, 1959.
1754. *Choerodon vitta* Ogilby, 1910.
1755. *Choerodon frenatus* Ogilby, 1910.
1756. *Choerodon monostigma* Ogilby, 1910.
1757. *Lienardella fasciata* (Gunther, 1867).
1758. *Xiphocheilus quadrimaculatus* Gunther, 1880.
1759. *Achoerodus gouldii* (Richardson, 1843).
1760. *Lepidaplois vulpinus* (Richardson, 1850).
1761. *Lepidaplois richardsoni* Fowler, 1908.
1762. *Lepidaplois perditio* (Quoy & Gaimard, 1835).
1763. *Lepidaplois mesothorax* (Bloch & Schneider, 1801).
1764. *Lepidaplois latro* (De Vis, 1885).
1765. *Trochocopus sanguinolentus* De Vis, 1883.
1766. *Verreo bellis* (Ramsay & Ogilby, 1887).
1767. *Verreo unimaculatus* (Gunther, 1862).
1768. *Haletta semifasciata* (Cuvier & Valenciennes, 1840).
1769. *Neoodax balteatus* (Cuvier & Valenciennes, 1839).
1770. *Neoodax (Sheardichthys) radiatus* (Quoy & Gaimard, 1835).
1771. *Neoodax frenatus* (Gunther, 1862).
1772. *Neoodax attenuatus* (Ogilby, 1897).
1773. *Coriododax pullus* (Bloch & Schneider, 1801).
1774. *Olisthops cyanomelas* Richardson, 1850.
1775. *Siphonognathus argyrophanes* Richardson, 1858.
1776. *Siphonognathus beddomei* (Johnston, 1885).
1777. *Heteroscarus acroptilus* (Richardson, 1846).
1778. *Callyodon toshi* (Whitley, 1933).
1779. *Callyodon formosus* (Cuvier & Valenciennes, 1840).
1780. *Callyodon frenatus* (Lacepede, 1802).
1781. *Callyodon ghobban* (Bonnaterre, 1788).
1782. *Callyodon sordidus* (Bonnaterre, 1788).
1783. *Callyodon strigipinnis* (De Vis, 1885).
1784. *Callyodon fuscus* (De Vis, 1885).
1785. *Callyodon fasciatus* (Cuvier & Valenciennes, 1840).
1786. *Callyodon dubius* (E. Bennett, 1828).
1787. *Callyodon globiceps* (Cuvier & Valenciennes, 1840).
1788. *Callyodon microrrhinos* (Bleeker, 1854).
1789. *Callyodon flavipinnis* (De Vis, 1885).
1790. *Callyodon flavolineatus* (Alleyne & Macleay, 1877).
1791. *Callyodon nudirostris* (Alleyne & Macleay, 1877).
1792. *Callyodon obscurus* (Castelnau, 1875).
1793. *Callyodon modestus* (Castelnau, 1875).
1794. *Callyodon dumerilii* (Castelnau, 1875).
1795. *Callyodon richardsonii* (Castelnau, 1875).
1796. *Callyodon viridescens* (Castelnau, 1875), not *Searus* (*Calliodon*) *viridescens* Ruppell.
1797. *Callyodon forsteri* (Cuvier & Valenciennes, 1839).
1798. *Xanothon cyanotaenia* (Bleeker, 1861).
1799. *Chlorurus (Cetoscarus) bicolor* (Ruppell, 1829).
1800. *Cryptotomus spinidens* (Quoy & Gaimard, 1824).
1801. *Leptoscarus vaigiensis* (Quoy & Gaimard, 1824).
1802. *Gadopsis marmoratus* Richardson, 1848.
1803. *Ammodytoides vagus* (McCulloch & Waite, 1916).
1804. *Champsodon nudivittis* (Ogilby, 1895).
1805. *Tandya latitabunda* Whitley, 1937.
1806. *Tandya papuensis* (Bleeker, 1868).
1807. *Tandya darwiniensis* (Macleay, 1878).
1808. *Tandya inornata* (Ramsay & Ogilby, 1887).
1809. *Merogymnus eximius* Ogilby, 1908.
1810. *Merogymnus jacksoniensis* (Macleay, 1881).
1811. *Parapercis cylindrica* (Bloch, 1792).
1812. *Parapercis haackei* (Steindachner, 1884).
1813. *Parapercis (Neosillago) nebulosa* (Quoy & Gaimard, 1825).
1814. *Parapercis (Neosillago) stricticeps* (De Vis, 1884).
1815. *Parapercis (Neosillago) hexophthalma* (Cuvier & Valenciennes, 1829).

1816. *Parapercis* (*Neosillago*) *xanthozona* (Bleeker, 1849).
1817. *Neopercis* *ramsayi* (Steindachner, 1884).
1818. *Neopercis* *allporti* (Gunther, 1876).
1819. *Neopercis* *binivirgata* Waite, 1904.
1820. *Neopercis* *naevosa* (Serventy, 1937).
1821. *Enigmapercis* *reducta* Whitley, 1936.
1822. *Lesueurina* *platycephala* Fowler, 1908.
1823. *Trichonotus* *blochii* Castelnau, 1875.
1824. *Trichonotus* *setiger* Bloch & Schneider, 1801.
1825. *Kraemeria* *samoensis* *merensis* Whitley, 1935.
1826. *Parkraemeria* *ornata* Whitley, 1951.
1827. *Creedia* *haswelli* (Ramsay, 1881).
1828. *Squamieredia* *obtusa* Rendahl, 1921.
1829. *Limnichthys* *fasciatus* Waite, 1904.
1830. *Limnichthys* *fasciatus* *major* Whitley, 1945.
1831. *Schizochirus* *insolens* Waite, 1904.
1832. *Crapatalus* *arenarius* McCulloch, 1915.
1833. *Leptoscopus* *macropygus* (Richardson, 1846).
1834. *Uranoscopus* *cognatus* Cantor, 1850.
1835. *Uranoscopus* *terraereginae* Ogilby, 1910.
1836. *Kathetostoma* *laeve* (Bloch & Schneider, 1801).
1837. *Kathetostoma* *nigrofasciatum* Waite & McCulloch, 1915.
1838. *Gnathagnoides* *innotabilis* (Waite, 1904).
1839. *Ichthyoscopus* *spinosus* Mees, 1960.
1840. *Ichthyoscopus* *barbatus* Mees, 1960.
1841. *Ichthyoscopus* *insperatus* Mees, 1960.
1842. *Ichthyoscopus* *fasciatus* Haysom, 1957.
1843. *Ichthyoscopus* *sannio* Whitley, 1936.
1844. *Genyagnus* *monopterygius* (Bloch & Schneider, 1801).
1845. *Bovichtus* *variegatus* Richardson, 1846.
1846. *Bovichtus* *angustifrons* Regan, 1913.
1847. *Pseudaphritis* *bursinus* (Cuvier & Valenciennes, 1830).
1848. *Dactylopus* *dactylopus* (Cuvier & Valenciennes, 1837).
1849. *Diplogrammus* *goramensis* (Bleeker, 1858).
1850. *Synchiropus* *splendidus* (Herre, 1927).
1851. *Synchiropus* *microps* (Gunther, 1877).
1852. *Foetorepus* *calauropomus* (Richardson, 1844).
1853. *Foetorepus* *achates* (De Vis, 1883).
1854. *Foetorepus* *papilio* (Gunther, 1864).
1855. *Callimucenus* *macdonaldi* (Ogilby, 1911).
1856. *Repomucenus* *calcaratus* (Macleay, 1881).
1857. *Yerutius* *phasis* (Gunther, 1880).
1858. *Yerutius* *apricus* (McCulloch, 1926).
1859. *Calliurichthys* *grossi* (Ogilby, 1910).
1860. *Calliurichthys* *japonicus* (Houttuyn, 1782).
1861. *Calliurichthys* *goodladi* Whitley, 1944.
1862. *Calliurichthys* *nasutus* (McCulloch, 1926).
1863. *Calliurichthys* *belcheri* (Richardson, 1844).
1864. *Orbonymus* *rameus* (McCulloch, 1926).
1865. *Callionymus* *calliste* Jordan & Fowler, 1903.
1866. *Callionymus* *ocelligena* McCulloch, 1926.
1867. *Velesionymus* *limiceps* *limiceps* (Ogilby, 1908).
1868. *Velesionymus* *limiceps* *sublaevis* (McCulloch, 1926).
1869. *Macrurrhynchus* *maroubrae* Ogilby, 1896.
1870. *Aspidontus* *taeniatus* Quoy & Gaimard, 1835.
1871. *Runula* *tapeinosoma* (Bleeker, 1857).
1872. *Xiphasia* *setifer* Swainson, 1839.
1873. *Petrosirtes* *helenae* (De Vis, 1884).
1874. *Petrosirtes* *mitratus* Ruppell, 1830.
1875. *Petrosirtes* *fasciolatus* Macleay, 1881.
1876. *Petrosirtes* *soloensis* Bleeker, 1853.
1877. *Petrosirtes* *cyprinoides* (Cuvier & Valenciennes, 1836).
1878. *Cyneichthys* *anolius* (Cuvier & Valenciennes, 1836).
1879. *Enchelyurus* *kraussi* (Klunzinger, 1871).
1880. *Enchelyurus* *flavipes* (Peters, 1869).
1881. *Enchelyurus* *caeruleopunctatus* Herre, 1939.
1882. *Dasson* *eretes* (Jordan & Seale, 1905).
1883. *Dasson* *temmincki* (Bleeker, 1851).
1884. *Dasson* *dasson* (Jordan and Snyder, 1902).
1885. *Dasson* *steadii* Whitley, 1930.
1886. *Dasson* *lupus* (De Vis, 1886).
1887. *Dasson* *viperidens* (De Vis, 1884).
1888. *Dasson* *duperreyi* Whitley, 1945.
1889. *Graviceps* *decipiens* (De Vis, 1884).*
1890. *Graviceps* *alexanderi* Whitley, 1945.
1891. *Graviceps* *punctatus* *hyena* Whitley, 1953.
1892. *Graviceps* *furcatus* (De Vis, 1884).*
1893. *Graviceps* *angelus* Whitley, 1959.
1894. *Graviceps* *darcini* Whitley, 1958.
1895. *Graviceps* (*Pauloscirtes*) *obliquus* (Garman, 1903).
1896. *Graviceps* (*Pauloscirtes*) *kallosoma* (Bleeker, 1858).
1897. *Graviceps* (*Pauloscirtes*) *elongatus* (Peters, 1855).
1898. *Meiacanthus* *grammistes* (Cuvier & Valenciennes, 1836).
1899. *Atrosalarias* *fuscus* (Ruppell, 1838).
1900. *Istiblennius* *edentulus* (Bloch & Schneider, 1801).
1901. *Istiblennius* *mulleri* (Klunzinger, 1879).
1902. *Istiblennius* *spaldingi* (Macleay, 1878).
1903. *Salarias* *chrysospilos* *belemnites* De Vis, 1884.
1904. *Salarias* *fasciatus* Bloch, 1786.
1905. *Salarias* *dussumieri* *geminatus* Alleyne & Macleay, 1877.
1906. *Crenalticus* *lineatus* (Cuvier & Valenciennes, 1836).
1907. *Crenalticus* *pallidus* (Whitley, 1926).
1908. *Crenalticus* *meleagris* (Cuvier & Valenciennes, 1836).
1909. *Negoscirtes* *guttatus* (Cuvier & Valenciennes, 1836).

* New combination, these species formerly in *Petrosirtes*.

1910. *Entomacrodus decussatus* (Bleeker, 1858).
1911. *Cirripectus filamentosus* (Alleyne & Macleay, 1877).
1912. *Cirripectus sebae* (Cuvier & Valenciennes, 1836).
1913. *Pescadorichthys frontalis* (Cuvier & Valenciennes, 1836).
1914. *Ecsenius mandibularis* McCulloch, 1923.
1915. *Pictiblennius iredalei* Whitley, 1931.
1916. *Pictiblennius intermedius* (Ogilby, 1915).
1917. *Pictiblennius tasmanianus* (Richardson, 1839).
1918. *Blennius pardalis* Castelnau, 1875.
1919. *Blennius victoriorae* Fowler, 1908.
1920. *Queriblennius gaudichaudi* Whitley, 1933.
1921. *Verconectes bucephalus* (McCulloch & Waite, 1918).
1922. *Brachynectes fasciatus* T. D. Scott, 1957.
1923. *Helcogramma decurrens* McCulloch & Waite, 1918.
1924. *Vauchusella atrogularis* (Günther, 1873).
1925. *Vauchusella annulata* (Ramsay & Ogilby, 1887).
- 1925a. *Vauchusella acanthops* Whitley, 1964.
1926. *Norfolkia striaticeps* (Ramsay & Ogilby, 1888).
1927. *Norfolkia clarkei* (Morton, 1888).
1928. *Norfolkia squamiceps* (McCulloch & Waite, 1916).
1929. *Norfolkia macleayana* (Lucas, 1891).
1930. *Norfolkia thomasi* Whitley, 1964.
1931. *Lepidoblennius haplodactylus* Steindachner, 1867).
1932. *Lepidoblennius marmoratus* Macleay, 1878.
1933. *Heteroclinus adelaidae* Castelnau, 1872.
1934. *Clinus perspicillatus* Cuvier & Valenciennes, 1836.
1935. *Clinus tristis* (Klunzinger, 1872).
1936. *Clinus puellarum* E. Scott, 1955.
1937. *Petraites johnstoni* (Saville-Kent, 1886).
1938. *Petraites heptaeolus* Ogilby, 1885.
1939. *Petraites multifenestratus* (Castelnau, 1872).
1940. *Petraites antinectes* (Günther, 1861).
1941. *Petraites roseus* (Günther, 1861).
1942. *Petraites sellularius* Whitley, 1931.
1943. *Petraites nasutus* (Günther, 1861).
1944. *Petraites equiradiatus* Milward, 1960.
1945. *Petraites forsteri* (Castelnau, 1872).
1946. *Cristiceps australis* Cuvier & Valenciennes, 1836.
1947. *Cristiceps aurantiacus* Castelnau, 1879.
1948. *Cristiceps argyroleura* Kner, 1865.
1949. *Cristiceps pataecoides* Whitley, 1959.
1950. *Cristiceps amaenus* Castelnau, 1873.
1951. *Neoblennius fasciatus* Castelnau, 1875.
1952. *Peronedys anguillaris* Steindachner, 1883.
1953. *Sticharium greeni* (E. Scott, 1936).
1954. *Sticharium antarcticum* (Castelnau, 1872).
1955. *Sticharium dorsale* Günther, 1867.
1956. *Sticharium varium* (McCulloch & Waite, 1918).
1957. *Sticharium gabrieli* (Waite, 1906).
1958. *Sticharium aethiops* (McCulloch & Waite, 1918).
1959. *Ophichthys pardalis* (McCulloch & Waite, 1918).
1960. *Scleropteryx devisi* (Ogilby, 1894).
1961. *Stenophus marmoratus* Castelnau, 1875.
1962. *Stenophus obscurus* Castelnau, 1875.
1963. *Gunellichthys pleurotaenia* Bleeker, 1858.
1964. *Notograptus livingstonei* Whitley, 1931.
1965. *Notograptus guttatus* Günther, 1867.
1966. *Notograptus gregoryi* Whitley, 1941.
1967. *Echiodon rendahli* (Whitley, 1941).
1968. *Encheliophis vermicularis* Müller, 1842.
1969. *Carapus homei* (Richardson, 1846).
1970. *Carapus houlti* (Ogilby, 1922).
1971. *Carapus (Onuxodon) margaritiferae* (Rendahl, 1921).
1972. *Brotula multibarbata* (Temminck & Schlegel, 1846).
1973. *Aphyonius gelatinosus* Günther, 1878.
1974. *Dinematichthys ilucoeteoides* Bleeker, 1855.
1975. *Dinematichthys mizolepis* Günther, 1867.
1976. *Dermatopsis macrodon* Ogilby, 1896.
1977. *Dermatopsis multiradiatus* McCulloch & Waite, 1918.
1978. *Sirembo everriculi* Whitley, 1936.
1979. *Monothrix polylepis* Ogilby, 1897.
1980. *Dipulus caecus* Waite, 1905.
1981. *Typhlonus nasus* Günther, 1878.
1982. *Blennodesmus scapularis* Günther, 1872.
1983. *Congrogadoides malayanus* (Weber, 1909).
1984. *Congrogadoides spinifer* Borodin, 1933.
1985. *Congrogadus subducens* (Richardson, 1842).
1986. *Dannevigia tusca* Whitley, 1941.
1987. *Genypterus blacodes* (Bloch & Schneider, 1801).
1988. *Genypterus microstomus* Regan, 1903.
1989. *Batrachomoeus dubius* (White, 1790).
1990. *Batrachomoeus striatus* (Castelnau, 1875).
1991. *Batrachomoeus broadbenti* (Ogilby, 1908).
1992. *Batrachomoeus dahli* (Rendahl, 1922).
1993. *Halophryne diemensis* (Le Sueur, 1824).
1994. *Cochleocephalus spatula* (Günther, 1861).
1995. *Aspasmogaster tasmaniensis* (Günther, 1861).
1996. *Aspasmogaster liorhynchus* Briggs, 1955.
1997. *Aspasmogaster interorbitalis* (Whitley, 1943).
1998. *Creocele cardinalis* (Ramsay, 1882).
1999. *Parvicrepis parvipinnis* (Waite, 1906).
2000. *Lepadichthys frenatus* Waite, 1904.
2001. *Lepadichthys sandaracatus* Whitley, 1943.

2002. *Culius fuscus* (Bloch & Schneider, 1801).
2003. *Culius robustus* (De Vis, 1884).
2004. *Bostrichthys sinensis* (Lacepede, 1802).
2005. *Eleotris planiceps* Castelnau, 1878.
2006. *Eleotris sulcaticollis* Castelnau, 1878.
2007. *Bunaka gyrynooides* (Bleeker, 1853).
2008. *Bunaka herwerdenii* (Weber, 1910).
2009. *Odonteleotris macrodon* (Bleeker, 1853).
2010. *Oxyeleotris lineolata* (Steindachner, 1867).
2011. *Gobiomorphus coxii* (Krefft, 1864).
2012. *Mogurnda mogurnda* (Richardson, 1844).
2013. *Mogurnda australis* (Krefft, 1862).
2014. *Mogurnda striata* (Steindachner, 1866).
2015. *Phillypnodon grandiceps* (Krefft, 1864).
2016. *Shipwayia aurea* (Shipway, 1950).
2017. *Carassiops klunzingeri* Ogilby, 1898.
2018. *Carassiops galii* Ogilby, 1898.
2019. *Carassiops compressus* (Krefft, 1864).
2020. *Parioglossus rainfordi* McCulloch, 1921.
2021. *Lindemanella iota* Whitley, 1935.
2022. *Asterropterix semipunctatus quisqualis* Whitley, 1932.
2023. *Butis amboinensis* (Bleeker, 1853).
2024. *Butis butis* (Hamilton-Buchanan, 1822).
2025. *Prionobutis microps* (Weber, 1908).
2026. *Prionobutis (Themistocles) wardi* Whitley, 1939.
2027. *Ophieleotris aporos* (Bleeker, 1854).
2028. *Ophiocara macrolepidotus* (Bloch, 1792).
2029. *Meuschenula darwiniensis* (Macleay, 1878).
2030. *Calleleotris strigata* (Broussonet, 1782).
2031. *Gergobius muralis* (Cuvier & Valenciennes, 1837).
2032. *Gergobius taeniura* (Macleay, 1881).
2033. *Herreolus formosus* (H. M. Smith, 1931).
2034. *Ptereleotris microlepis* (Bleeker, 1856).
2035. *Amblygobius bynoensis* (Richardson, 1844).
2036. *Amblygobius phalaena* (Cuvier & Valenciennes, 1837).
2037. *Eviota distigma* Jordan & Seale, 1906.
2038. *Eviota viridis queenslandica* Whitley, 1932.
2039. *Eviota viridis inutilis* Whitley, 1943.
2040. *Milyeringa veritas* Whitley, 1945.
2041. *Koumansetta rainfordi* Whitley, 1940.
2042. *Austrolethops wardi* Whitley, 1935.
2043. *Munrogonobius semivestitus* (Munro, 1949).
2044. *Nesogobius hinsbyi* (McCulloch & Ogilby, 1919).
2045. *Nesogobius pulchellus* (Castelnau, 1872).
2046. *Istigobius stephensoni* (Whitley, 1932).
2047. *Istigobius interstinctus* (Richardson, 1844).
2048. *Parvigobius immeritus* Whitley, 1930.
2049. *Mars strigilliceps* Jordan & Seale, 1906.
2050. *Cryptocentroides bulbiceps* Whitley, 1953.
2051. *Gobius pauper* De Vis, 1884.
2052. *Gobius princeps* De Vis, 1884.
2053. *Gobius haackei* Steindachner, 1884.
2054. *Gobius microlepidotus* Castelnau, 1875.
2055. *Gobius platystoma* Gunther, 1872.
2056. *Arenigobius tamarensis* (Johnston, 1883).
2057. *Arenigobius bifrenatus* (Kner, 1865).
2058. *Arenigobius frenatus* (Gunther, 1861).
2059. *Arenigobius castelnaui* (Macleay, 1881).
2060. *Favonigobius obliquus* (McCulloch & Ogilby, 1919).
2061. *Favonigobius lateralis* (Macleay, 1881).
2062. *Favonigobius exquisitus* Whitley, 1950.
2063. *Fusigobius neophytus* (Gunther, 1877).
2064. *Innoculus nigroocellatus* (Gunther, 1873).
2065. *Oplopomus caninoides* (Bleeker, 1852).
2066. *Batman insignitus* Whitley, 1956.
2067. *Gnatholepis inconsequens* Whitley, 1958.
2068. *Ctenogobius (Yoga) pyrops* Whitley, 1954.
2069. *Ctenogobius (Aurigobius) auriga* Whitley, 1959.
2070. *Acentrogobius scrutarius* Whitley, 1955.
2071. *Acentrogobius balteatus* (Herre, 1935).
2072. *Drombus halei* Whitley, 1935.
2073. *Drombus halei lepidothorax* Whitley, 1945.
2074. *Chlamydogobius eremius* (Zietz, 1896).
2075. *Ostreogobius macrostoma* (Gunther, 1861).
2076. *Berovra lidwilli* (McCulloch, 1917).
2077. *Gunnamatta insolita* Whitley, 1928.
2078. *Etyrias puntang* (Bleeker, 1851).
2079. *Glossogobius suppositus* (Sauvage, 1880).
2080. *Glossogobius biocellatus* (Cuvier & Valenciennes, 1837).
2081. *Glossogobius gutum* (Hamilton-Buchanan, 1822).
2082. *Tasmanogobius lordi* E. O. Scott, 1935.
2083. *Obtortiphagus koumansii* Whitley, 1933.
2084. *Stenogobius genivittatus* (Cuvier & Valenciennes, 1837).
2085. *Bathygobius fuscus* (Ruppell, 1831).
2086. *Bathygobius watkinsoni* (De Vis, 1884).
2087. *Bathygobius krefftii* (Steindachner, 1866).
2088. *Yongeichthys criniger* (Cuvier & Valenciennes, 1837).
2089. *Yongeichthys leftwichii* (Ogilby, 1910).
2090. *Cryptocentrus cristatus* (Macleay, 1881).
2091. *Cryptocentrus russus* (Cantor, 1850).

2092. *Priolepis nuchifasciatus* (Gunther, 1874).
 2093. *Priolepis necopinus* Whitley, 1959.
 2094. *Quisquilius macrophthalmus* Weber, 1909.
 2095. *Lizagobius olorum* (Sauvage, 1880).
 2096. *Waitea maxillaris* (Macleay, 1878).
 2097. *Cremornea francoisi* Whitley, 1962.
 2098. *Parachaeturichthys polynema* (Bleeker, 1853).
 2099. *Mucogobius gobiosoma* Whitley, 1931.
 2100. *Callogobius hasseltii* (Bleeker, 1851).
 2101. *Callogobius (Crossogobius) mucosus* (Gunther, 1872).
 2102. *Metagobius sclateri* (Steindachner, 1880).
 2103. *Waiteopsis paludis* Whitley, 1930.
 2104. *Waiteopsis stigmaticus* (De Vis, 1884).
 2105. *Stigmatogobius johnstoniensis* (Koumans, 1940).
 2106. *Gobiichthys papuensis* (Cuvier & Valenciennes, 1837).
 2107. *Gobiichthys cornutus* (McCulloch & Waite, 1918).
 2108. *Gobiichthys microlepis* (Bleeker, 1849).
 2109. *Trichopharynx crassilabris* (Gunther, 1861).
 2110. *Paragobiodon echinocephalus* (Ruppell, 1831).
 2111. *Gobiodon citrinus* (Ruppell, 1838).
 2112. *Gobiodon quinquestrigatus* (Cuvier & Valenciennes, 1837).
 2113. *Gobiodon unicolor* (Castelnau, 1873).
 2114. *Leme mordax* De Vis, 1883.
 2115. *Leme purpurascens* De Vis, 1884.
 2116. *Trypauchen wakae* Jordan & Snyder, 1901.
 2117. *Ctenotrypauchen microcephalus* (Bleeker, 1860).
 2118. *Brachyamblyopus rubrilineatus* (Saville-Kent, 1889).
 2119. *Boleophthalmus caeruleomaculatus* McCulloch & Waite, 1917.
 2120. *Scartelaos macrophthalmus* (Castelnau, 1873).
 2121. *Periophthalmus expeditionium* Whitley, 1953.
 2122. *Euchoristopus kalolo* (Lesson, 1831).
 2123. *Euchoristopus kalolo regius* Whitley, 1931.
 2124. *Periophthalmodon australis* (Castelnau, 1875).
 2125. *Remora remora* (Linné, 1758).
 2126. *Phtheichthys lineatus* (Menzies, 1791).
 2127. *Remoropsis brachyptera* (Lowe, 1839).
 2128. *Remoropsis pallidus* (Temminck & Schlegel, 1850).
 2129. *Remilegia australis* (Bennett, 1840).
 2130. *Rhombochirus osteochir* (Cuvier, 1829).
 2131. *Remorina albenscens* (Temminck & Schlegel, 1850).
 2132. *Echeneis naucrates* Linné, 1758.
 2133. *Caracanthus maculatus* (Gray, 1831).
 2134. *Rhinopias godfreyi* Whitley, 1954.
 2135. *Ruboralga jacksoniensis* (Steindachner, 1866).
 2136. *Ruboralga ergastulorum* (Richardson, 1842).
 2137. *Ruboralga bellicosa* (Castelnau, 1875).
 2138. *Ruboralga sumptuosa* (Castelnau, 1875).
 2139. *Parascorpaena aurita grandisquamis* (Ogilby, 1910).
 2140. *Oligoscorpaena bandanensis* (Bleeker, 1851).
 2141. *Scorpaena stokesii* Richardson, 1846.
 2142. *Scorpaena burra* Richardson, 1842.
 2143. *Scorpaena armata* Sauvage, 1873.
 2144. *Scorpaena moultoni* Whitley, 1961.
 2145. *Sebastapistes strongia* (Cuvier & Valenciennes, 1829).
 2146. *Sebastapistes bynoensis* (Richardson, 1845).
 2147. *Scorpaenopsis diabolus* (Cuvier & Valenciennes, 1829).
 2148. *Scorpaenopsis macrochir* Ogilby, 1910.
 2149. *Scorpaenopsis palmeri* Ogilby, 1910.
 2150. *Scorpaenopsis palmeri furneauxi* Whitley, 1959.
 2151. *Helicolenus papillosum* (Bloch & Schneider, 1801).
 2152. *Neosebastes scorpaenoides* Guichenot, 1867.
 2153. *Neosebastes pandus* (Richardson, 1842).
 2154. *Neosebastes incisipinnis* Ogilby, 1910.
 2155. *Neosebastes thetidis* (Waite, 1899).
 2156. *Neosebastes nigropunctatus* McCulloch, 1915.
 2157. *Neosebastes panticus* McCulloch & Waite, 1918.
 2158. *Macrilocosta scabriceps* Whitley, 1935.
 2159. *Scorpaenodes scaber* (Ramsay & Ogilby, 1886).
 2160. *Scorpaenodes guamensis* (Quoy & Gaimard, 1825).
 2161. *Notesthes robusta* (Gunther, 1860).
 2162. *Centropogon australis* (White, 1790).
 2163. *Centropogon marmoratus* Gunther, 1863.
 2164. *Centropogon latifrons* Mees, 1962.
 2165. *Paracentropogon vespa* Ogilby, 1910.
 2166. *Paracentropogon vespa livingstonei* Whitley, 1933.
 2167. *Gymnapistes marmoratus* (Cuvier & Valenciennes, 1829).
 2168. *Hypodytes carinatus macrolepidotus* (Ogilby, 1910).
 2169. *Hypodytes balnearum* (Ogilby, 1910).
 2170. *Apistops caloundra* (De Vis, 1886).
 2171. *Liocranium praepositum* Ogilby, 1903.
 2172. *Vadesuma scorpio* (Ogilby, 1910).
 2173. *Amblyapistes (Parocosia) slacksmithi* Whitley, 1958.
 2174. *Richardsonichthys leucogaster* (Richardson, 1848).
 2175. *Pterois volitans* (Linné, 1758).
 2176. *Pterois volitans castus* Whitley, 1951.
 2177. *Pterois (Macrochyrus) lunulata* Temminck & Schlegel, 1843.
 2178. *Pterois (Pteroleptus) russelli* (Bennett, 1831).
 2179. *Pteropterus antennatus* (Bloch, 1787).

2180. *Brachirus zebra* (Quoy & Gaimard, 1825).
2181. *Glyptauchen panduratus* (Richardson, 1850).
2182. *Glyptauchen panduratus deruptus* Whitley, 1931.
2183. *Glyptauchen insidiator* Whitley, 1931.
2184. *Glyptauchen insidiator mirandus* Whitley, 1931.
2185. *Minous versicolor* Ogilby, 1910.
2186. *Inimicus barbatus* (De Vis, 1884).
- 2186a. *Inimicus cirrhosus* McKay, 1964.
2187. *Dampierosa daruma* Whitley, 1932.
2188. *Erosa fratrum* Ogilby, 1910.
2189. *Peristrominus dolosus* Whitley, 1952.
2190. *Synanceja trachynis* (Richardson, 1842).
2191. *Synanceichthys verrucosus* (Bloch & Schneider, 1801).
2192. *Pterygotrigla polyommata* (Richardson, 1839).
2193. *Pterygotrigla andertoni* Waite, 1910.
2194. *Dixipichthys ferculum* Whitley, 1952.
2195. *Currupiscis volucer* Whitley, 1931.
2196. *Lepidotrigla phalaena* (Cuvier & Valenciennes, 1829).
2197. *Lepidotrigla sphinx* (Cuvier & Valenciennes, 1829).
2198. *Lepidotrigla modesta* Waite, 1899.
2199. *Lepidotrigla alata* (Houttuyn, 1782).
2200. *Lepidotrigla argus* Ogilby, 1910.
2201. *Lepidotrigla spiloptera* Gunther, 1880.
2202. *Lepidotrigla calodactyla* Ogilby, 1910.
2203. *Hatha mulhalli* (Macleay, 1884).
2204. *Paratrigla papilio* (Cuvier & Valenciennes, 1829).
2205. *Paratrigla umbrosa* (Ogilby, 1910).
2206. *Paratrigla (Aoyagichthys) vanessa* (Richardson, 1839).
2207. *Panichthys picturatus* (McCulloch, 1926).
2208. *Panichthys lingi* Whitley, 1933.
2209. *Ebisinus procne* Ogilby, 1910.
2210. *Dactyloptena orientalis* (Cuvier & Valenciennes, 1829).
2211. *Dactyloptena papilio* Ogilby, 1910.
2212. *Kanekonia queenslandica* Whitley, 1952.
2213. *Adventor elongatus* (Whitley, 1952).
2214. *Aploactisoma milesii* (Richardson, 1850).
2215. *Aploactisoma milesii horrenda* Whitley, 1933.
2216. *Paraploactis trachyderma* Bleeker, 1865.
2217. *Bathyploactis curtisensis* Whitley, 1933.
2218. *Bathyploactis curtisensis ornatus* Whitley, 1933.
2219. *Gnathanacanthus goetzei* Bleeker, 1855.
2220. *Pataecus fronto* Richardson, 1844.
2221. *Aetopus armatus* (Johnston, 1891).
2222. *Aetopus vincenti* (Steindachner, 1883).
2223. *Aetopus maculatus* (Gunther, 1861).
2224. *Neopataecus waterhousii* (Castelnau, 1872).
2225. *Neophrynichthys marcidus* McCulloch, 1926.
2226. *Platycephalus indicus* (Linné, 1758).
2227. *Platycephalus mortoni* Macleay, 1883.
2228. *Cumbel haackei* (Steindachner, 1883).
2229. *Cumbel semermis* (De Vis, 1883).
2230. *Planiprora castelnaui* (Macleay, 1881).
2231. *Planiprora mulleri* (Klunzinger, 1879).
2232. *Planiprora fusca* (Cuvier & Valenciennes, 1829).
2233. *Planiprora cinerea* (Gunther, 1872).
2234. *Planiprora marmorata* (Stead, 1908).
2235. *Neoplatycephalus speculator* (Klunzinger, 1872).
2236. *Neoplatycephalus richardsoni* (Castelnau, 1872).
2237. *Trudis arenarius* (Ramsay & Ogilby, 1886).
2238. *Trudis bassensis* (Cuvier & Valenciennes, 1829).
2239. *Trudis bassensis westraliae* Whitley, 1938.
2240. *Trudis caeruleopunctatus* (McCulloch, 1922).
2241. *Laeviprora proxima* (Castelnau, 1872).
2242. *Laeviprora inops* (Jenyns, 1840).
2243. *Laeviprora laevigata* (Cuvier & Valenciennes, 1829).
2244. *Longitrudis longispinis* (Macleay, 1884).
2245. *Thysanophrys cirronasus* (Richardson, 1848).
2246. *Suggrundus bosschei* (Bleeker, 1860).
2247. *Suggrundus malayanus* (Bleeker, 1853).
2248. *Suggrundus tuberculatus suggrundus* Whitley, 1933.
2249. *Suggrundus jugosus* (McCulloch, 1914).
2250. *Suggrundus harrisii* (McCulloch, 1914).
2251. *Suggrundus staigeri* (Castelnau, 1875).
2252. *Suggrundus diversidens* (McCulloch, 1914).
2253. *Cymbacephalus nematophthalmus* (Gunther, 1860).
2254. *Repotrudis macracanthus* (Bleeker, 1869).
2255. *Rogadius pristiger* (Cuvier & Valenciennes, 1829).
2256. *Levanaora isacanthus* (Cuvier & Valenciennes, 1829).
2257. *Wakiyus spinosus* (Temminck & Schlegel, 1843).
2258. *Elates thompsoni* (Jordan & Seale, 1907).
2259. *Rhinkoplichthys haswelli* (McCulloch, 1907).
2260. *Oplichthys ogilbyi* McCulloch, 1914.
2261. *Congiopodus leucopaecilus* (Richardson, 1846).
2262. *Perryena leucometopon* (Waite, 1922).
2263. *Lophiomus laticeps* (Ogilby, 1910).
2264. *Tathicarpus subrotundatus* (Castelnau, 1875).
2265. *Tetrabrachium ocellatum* Gunther, 1880.
2266. *Rhycherus filamentosus* (Castelnau, 1872).
2267. *Pterophrynoides histrio* (Linné, 1758).

2268. *Phrynelox striatus* (Shaw & Nodder, 1794).
2269. *Phrynelox pinniceps* (Cuvier & Valenciennes, 1837).
2270. *Batrachopus insidiator* Whitley, 1934.
2271. *Lophiocharon broomensis* Whitley, 1933.
2272. *Lophiocharon goramensis* (Bleeker, 1864).
2273. *Antennarius urophthalmus* Bleeker, 1851.
2274. *Antennarius trisignatus* (Richardson, 1844).
2275. *Antennarius nummifer* (Cuvier, 1817).
2276. *Antennarius stigmaticus* Ogilby, 1912.
2277. *Antennarius tuberosus* Cuvier, 1817.
2278. *Antennarius pictus* (Shaw & Nodder, 1794).
2279. *Antennarius glauerti* Whitley, 1957.
2280. *Antennarius phymatodes* Bleeker, 1857.
2281. *Plumantennatus asper* (Macleay, 1881).
2282. *Echinophryne glauerti* Whitley, 1944.
2283. *Echinophryne crassipina* McCulloch & Waite, 1918.
2284. *Trichophryne mitchelli* (Morton, 1897).
2285. *Histiophryne bougainvilli* (Cuvier & Valenciennes, 1837).
2286. *Histiophryne scortea* McCulloch & Waite, 1918.
2287. *Histiophryne scortea inconstans* McCulloch & Waite, 1918.
2288. *Caulophryne jordani* Goode & Bean, 1896.
2289. *Melanocetus murrayi* Gunther, 1887.
2290. *Melanocetus johnsoni* Gunther, 1864.
2291. *Himantolophus groenlandicus* Reinhardt, 1838.
2292. *Ceratias holboellii* Kroyer, 1844.
2293. *Cryptopsaras pennifer* Regan & Trewavas, 1932.
2294. *Gigantactis* sp. (larva, type A. of Bertelsen, 1951).
2295. *Edriolychnus schmidti* Regan, 1925.
2296. *Linophryne arborifera* Regan, 1925.
2297. *Aceratias indicus* Brauer, 1902.
2298. *Brachionichthys hirsutus* (Lacepede, 1804).
2299. *Brachionichthys politus* (Richardson, 1849).
2300. *Sympterichthys unipennis* (Cuvier, 1817).
2301. *Sympterichthys verrucosus* McCulloch & Waite, 1918.
2302. *Chaunax endeavouri* Whitley, 1929.
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2315. *Rhinecanthus echarpe* (Anonymous, 1798).
2316. *Rhinecanthus aculeatus* (Linné, 1758).
2317. *Balistapus brevissimus* (Hollard, 1854).
2318. *Balistapus undulatus* (Park, 1797).
2319. *Balistoides conspicillum* (Bloch & Schneider, 1801).
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 2387. *Rhinesomus gibbosus* (Linné, 1758).
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 2422. *Gastrophysus glaber* (Fremerville, 1813).
 2423. *Gastrophysus perlevis* (Ogilby, 1908).
 2424. *Gastrophysus pleurostictus* (Günther, 1872).
 2425. *Takifugu oblongus* (Bloch, 1786).
 2426. *Contusus richei* (Fremerville, 1813).
 2427. *Torquigener tuberculiferus* (Ogilby, 1912).
 2428. *Torquigener tuberculifens vicinus* Whitley, 1930.
 2429. *Torquigener piosae* Whitley, 1955.
 2430. *Chelonodon dapsilis* Whitley, 1943.
 2431. *Liosaccus aerobaticus* Whitley, 1928.
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 2433. *Canthigaster bennetti* (Bleeker, 1854).
 2434. *Canthigaster callisternus* (Ogilby, 1889).
 2435. *Canthigaster axiologus* Whitley, 1931.
 2436. *Canthigaster janthinopterus* (Bleeker, 1855).
 2437. *Dicotylichthys myersi* Ogilby, 1910.
 2438. *Atopomycterus nictemerus* (Cuvier, 1818).
 2439. *Allomycterus pilatus* Whitley, 1931.
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 2442. *Diodon armillatus* Whitley, 1933.
 2443. *Diodon holocanthus* Linné, 1758.
 2444. *Diodon bleekeri* Günther, 1910.
 2445. *Mola ramsayi* (Giglioli, 1883).
 2446. *Triurus laevis* (Pennant, 1776).
 2447. *Masturus lanceolatus* (Lienard, 1840).

NEW SYNONYMS.

When certain generic groups are better understood, a number of nominal species in the Australian list will no doubt prove to be synonyms of others. There is still a "hard core" of unrecognized "*Eleotris*" spp. and "*Gobius*" spp., still to be rediscovered in Australia and placed in their correct genera, and the family Aleuteridae is badly in need of revision. Meanwhile, the new synonyms listed below are noteworthy. References to literature will mostly be found in McCulloch (1929) at the page-numbers listed on the left. The final name in each equation is regarded as being the correct modern one.

112. *Rhombosoma trifasciata* Rendahl, 1922 = *Melanotaenia nigrans* Richardson, 1843.
291. *Amphiprion xanthurus* Cuvier & Valenciennes, 1830 = *Sparus milii* Bory, 1831 = *Amphiprion melanostolus* Richardson, 1842 = *Amphiprion clarkii* (Bennett, 1830).
324. *Neodax waterhousii* Castelnau, 1875 = *Odax obscurus* Castelnau, 1872 = *Neodax balteatus* (Cuvier & Valenciennes, 1839).
326. *Heteroscarus macleayi* McCoy, 1888 = *Heteroscarus acroptilus* (Richardson, 1846).
347. *Vauchusella calva* Whitley, 1944 = *Helcogramma decurrens* McCulloch & Waite, 1918.
364. *Eleotris nudiceps* Castelnau, 1872 = *Philypnodon grandiceps* (Krefft, 1864).
365. *Eleotris simplex* Castelnau, 1878, and *E. modesta* Castelnau, 1873 = *Carassioops compressus* (Krefft, 1864).
- 405 & 407. *Tathicarpus muscosus* and *T. butleri* Ogilby, 1907, and *T. appeli* Ogilby, 1922 = *Tathicarpus subrotundatus* (Castelnau, 1875).
407. *Phrynelox* (*Triantennatus*) *zebrinus* Schultz, 1957 = *Phrynelox striatus* (Shaw & Nodder, 1794).
407. *Phrynelox atra* Schultz, 1957 = *Batrachopus insidiator* Whitley, 1934.
434. *Dicotylichthys myersi* still stands. Le Danois (1959) made the specific name a synonym of "*diversispinis* Verreaux, 1847", but Verreaux's name was only in unpublished manuscript, so cannot be dated back to 1847. Other species are ascribed by Le Danois to much "earlier" names, some pre-Linnean and others seventeenth-century, but such synonymizing is not permissible nowadays.

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DESCRIPTION OF TWO NEW SPECIES OF AUSTRALIAN BUPRESTIDAE OF
THE GENUS STIGMODERA.

By C. M. DEUQUET.

(Two Text-figures.)

[Read 25th March, 1964.]

Synopsis.

The following are described as new: *Stigmodera* (*Castiarina*) *vallisii*, *Stigmodera* (*Themognatha*) *macqueeni*.

STIGMODERA (CASTIARINA) VALLISII, n. sp. (Text-fig. 1.)

Oblong, ovate. Head and prothorax: bright bronzy-green. Antennae, scutellum and legs dark-green. Elytra yellow with bluish-green markings as follows: a narrow sutural stem surrounding the scutellum, two fasciae, neither of them reaching the external margins, and an apical mark narrowly connected along the suture with the second fascia; the first fascia connected with the base by a narrow sutural stem branching at basal fourth on each side of the elytra into two semi-triangular roundish spots suggesting the upper wings of a butterfly, the second, postmedian, nearly twice the size of the first one, branching similarly into two pear-shaped parts, one on each elytron, the pear stalk directed more or less obliquely upwards.

Head fairly deeply excavated with an impressed line between the eyes and regularly punctate. *Thorax*: sides rounded, anterior margin nearly straight, posterior angles acute, the base only slightly sinuate, with a shallow medial fovea, surface covered with close deep punctures, deeper at sides, smaller in the basal part of the medial dorsal line which is terminated in a small fovea, the sides much widened near the base and obliquely narrowed to apex. Near each posterior angle is a small angular impression. *Elytra* little widened behind shoulders and middle, punctate-striate, the punctation being very close and the intervals much impressed. Sides sinuate above the middle, apical border minutely serrated, apices largely rounded, not spinose.

Underside dull green, abdomen minutely punctate, the sternum covered with a cinereous pubescence.

Dimensions: 15 × 7 mm.

Habitat: Mt. Speck, Northern Queensland (Close Vallis).

Two examples, both ♀, of this pretty and very distinct species discovered by Mr. C. Vallis, a prominent Queensland naturalist to whom it is dedicated.

It is superficially, although a much smaller insect, somewhat of the *S. secularis* type, but its size and pattern alone are sufficient to distinguish it from other previously described species.

Type in Mr. Vallis's collection. Paratype in the author's collection.

STIGMODERA (THEMOGNATHA) MACQUEENI, n. sp. (Text-fig. 2.)

Ovate, subcylindric. Head and antennae bronzy-green, the former with bright-green reflections on apex and coppery hue on base. Pronotum bronzy-green with bright-

green tinge on the side margins. Legs green, scutellum bright-coppery. Elytra yellow with the arcuate apical mark and the narrow post-median suture green.

Head only slightly excavated, densely and finely rugose, punctate. *Pronotum* strongly convex, smooth, finely and evenly punctate, apex almost straight, base slightly sinuate, anterior side margins strongly raised and channelled, the latter especially much widened and rounded behind middle. Surface smooth and moderately punctured except at sides where punctation is deeper, with a smooth medial dorsal line faintly indicated on basal half met at the base with a small faint impression. *Scutellum* small, subcordate, concave. *Elytra* much rounded, strongly attenuated behind, each elytron rather widely subtruncate and rounded, not spinose, the sutural points feebly produced and divergent, with a wide oblique excision at extremity. Striate-punctate; intervals flat or nearly so throughout, distinctly but sparsely punctate. Underside finely punctate, covered with short white pubescence.

Dimensions: ♀, 17 × 8 mm.; ♂, 14½ × 7 mm.

Habitat: Southern Queensland: Milmerran (J. Macqueen). Three specimens examined, 1 ♀, 2 ♂. All are identical in colour and markings. This new species is undoubtedly fairly closely related to *S. saundersi* Waterh., their morphological charac-

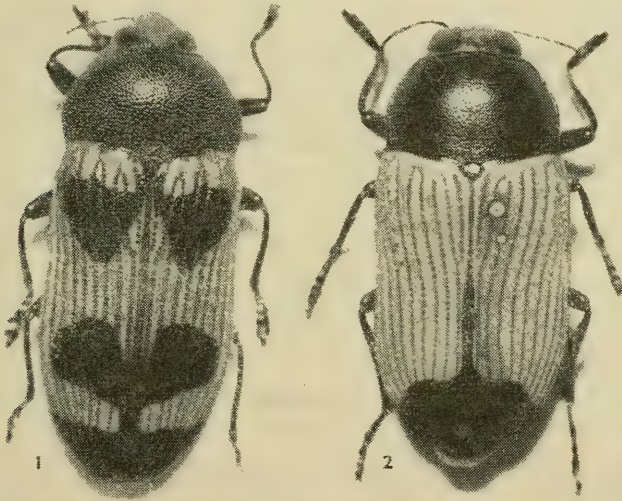


Fig. 1. *Stigmodera* (*Castiarina*) *vallisii*, n. sp. (×4.)

Fig. 2. *Stigmodera* (*Themognatha*) *macqueeni*, n. sp. (×4.)

teristics being somewhat similar, and it could possibly be regarded as a subspecies of *S. saundersi*. The differences between the two are, however, numerous and important: 1, *S. saundersi* is a consistently larger, broader and more globular insect; 2, The elytral patterns of the two species are entirely different: all elytral markings of *S. saundersi* with the exception of the arcuate apical mark are absent in the new species; 3, The vivid red colour so conspicuous in *S. saundersi* is not to be seen in the new species, while yellow, the dominant elytral colour of the new species, is quite absent in *saundersi*; 4, The apical forms of the two differ, the margins being more raised and channelled in the new species and the arcuate excision being wider and more obliquely pronounced.

Mr. Macqueen informs me that he has two examples showing traces of a median fascia, one in the form of a very thin line, the second only slightly indicated by a tiny round dot on each elytron, not reaching sides or suture in either case.

I feel a real pleasure in naming this new species after its captor, Mr. J. Macqueen, who has been for years a most experienced student and lover of the insect fauna of Australia.

Type in Coll. Macqueen: 1 paratype each in the Australian Museum, Sydney, and the author's collection.

NOTES ON THE SUBGENUS *CHAETOCRUIOMYIA* THEOBALD
(DIPTERA: CULICIDAE).

By ELIZABETH N. MARKS, National Mosquito Control Committee, Department of
Entomology, University of Queensland.

(Four Text-figures.)

[Read 25th March, 1964.]

Synopsis.

This paper supplements a previous revision of the subgenus *Chaetocruiomyia* Theobald (Marks, 1963). Descriptions and figures are given of both sexes of *Aedes macmillani*, n. sp., male, larva and pupa of *Aedes elchoensis* Taylor, males of *Aedes calabyi* Marks and *Aedes wattensis* Taylor, and egg of *Aedes spinosipes* Edwards. Taxonomy, biology, and distribution of species of the subgenus are discussed and a distribution map is provided.

Mosquitoes of the subgenus *Chaetocruiomyia* Theobald of genus *Aedes* Meigen are known only from Australia. The subgenus was revised by Marks (1963) who recognized 2 species groups, with 7 named species and 2 unnamed forms, viz.:

Group A (*Spinosipes*-group: *Chaetocruiomyia* s. str.). *A. calabyi* Marks, *A. humeralis* Edwards, *A. moloensis* Taylor, *A. spinosipes* Edwards, *A. tulliae* Taylor, *A. wattensis* Taylor, "species A", "species B".

Group B (*Elchoensis*-group). *A. elchoensis* Taylor.

"Species B" was represented by a single female; no further specimens have been taken and its specific status remains uncertain. "Species A", a well-defined species first collected by Dr. Bruce McMillan, was left unnamed in the belief that it was to be described elsewhere; it is now described at the request of Dr. McMillan, who has made available his original series of both sexes, and it is named *Aedes macmillani*, n. sp., in appreciation of his valuable field work on the mosquitoes of Australia and New Guinea.

Since the revision (which included the first description of male terminalia, larva, and pupa of a species of the subgenus—*tulliae*), a series of *Chaetocruiomyia* including males of *calabyi* and *elchoensis*, from the collections of the School of Public Health and Tropical Medicine, University of Sydney, has been received for study through the kindness of Mr. D. J. Lee; Mr. Alan Dyce has recently collected and generously made available males of *wattensis*; and the larva and pupa of *elchoensis* and egg of *spinosipes* have been discovered.

From the foregoing collections, descriptive, biological, and distributional notes are here provided on all species of the subgenus except *moloensis* and "species B"; the species are treated in alphabetical order. Descriptions here omit subgeneric and species-group characters given in Marks (1963), including the specialized scales or bristles on the thorax and its appendages which are characteristic of species of Group A. The nomenclature used here for larval and pupal setae is the same as in the previous paper.

Unless otherwise stated the specimens examined are in the School of Public Health and Tropical Medicine, Sydney (S.P.H. & T.M.); those recorded in U.Q. are in University of Queensland collection.

AËDES (CHAETOCRUIOMYIA) CALABYI Marks.

Female.

Nine ♀♀ have wing length 1.7–2.0 mm. and agree with the original description except as follows: 1 ♀, Hd. Pendleton, has all scutellar scales dark, hind femur dark ventrally, another has scutal integument dark brown and basal white dorsal patch $1/5$ – $1/4$ length of hind tarsal segment IV; 1 ♀, Hd. Senior, has median white scales on head extending from patch at nape in a double row to vertex, one row complete, one interrupted by a couple of dark scales.

Male (Fig. 1, a-c).

Two ♂♂, one headless, differ from ♀♀ as follows: Wing length 1.9–2.0 mm. *Head*.—Antenna as in *macmillani*. Palp scarcely longer than proboscis (excluding labella), black scaled, 2 distal segments down-turned (partly rubbed—setation may be incomplete); a stout dark bristle dorsally at apex of III; IV with 1 long, 1 shorter ventral bristle, a dorsolateral row of about 8 strong dark bristles, and dorsally a double row of shorter square-tipped or forked bristles or narrow scales (about as long as width of segment); V with dark bristles dorsolaterally and at apex. Proboscis 1.5 times length of fore femur. *Thorax*.—Pale scales of scutum whiter than in ♀; long *stp* bristle blunt-tipped, not distinctly forked. Hind femur dark ventrally and posteriorly (except base and apex); tibial bristles rubbed, but apparently as in *macmillani*; mid and hind tibiae dark except for basal pale patch; basal white bands on fore tarsal segments $1/6$ I, $1/4$ II; on mid tarsal segments $1/8$ I, $1/5$ – $1/4$ II, a couple of white scales or patch $1/4$ III; on hind tarsal segments $1/4$ – $1/3$ I, $2/5$ II and III, $1/3$ – $2/5$ IV; fore and mid tarsal segments IV and V, and tarsal claws as in *macmillani*. Wing partly denuded, C dark at base; broad squame scales on Sc, R_1 , and base of Cu in one specimen, on Sc, R_1 , M, and one at base of An in the other; cell R_2 1.6–1.7 times length of its stem; cell M_1 0.6–0.8 times length of its stem. *Abdomen*.—Tergites II–VII with fairly large median basal white patches, which may touch base only in mid line, III–VII with sublateral subbasal white patches; true tergite VIII dark scaled with white lateral basal patches; sternites I–VII dark scaled with white diagonal patches extending from mid length laterally towards base mesially; coxites inconspicuous, scarcely extending beyond true sternite VIII which is large, with large lateral basal white patches narrowly separated mesially; segments VII and VIII not obviously laterally compressed. *Terminalia*.—Generally similar to *macmillani*; basal lobe extending $3/4$ length of coxite, its distal attachment to coxite approximately right-angled; along distal margin of lobe there is a long, strong seta at angle between lobe and coxite, followed by about 4 broad striated setae, and at apex of lobe and extending along distal $2/3$ mesially are setae with very broad curved flattened tips, those at apex longest; on inner tergal margin of membranous area on distal $1/4$ are 4–5 moderately long setae; sternally coxite bears scattered fine setae on basal half, and mesially towards apex, and a group of about 6 small setae distally on inner sternal margin of membranous area. Style almost $1/2$ length of coxite, non-pilose, without setae, slightly swollen on proximal $2/5$, slender distally; appendage a little more than $1/2$ length of style. Harpago about $1/5$ length of coxite, with 2 fine setae near base; appendage $2\frac{1}{2}$ times length of harpago and 4 times as long as its own greatest width, curved and broadly expanded on distal half, with pointed tip. Paraproct with 4–5 fine setae. Lobes of tergite IX small with 2–3 setae; sternite IX bilobed with 1 long and 2–4 short setae to each lobe.

Specimens Examined: SOUTH AUSTRALIA: 1 ♂, 1 ♀ pinned to one mount, Hundred of Pendleton, 28.ii.1952, E. J. Waterhouse; a second ♂ and ♀ pinned to one mount, and 1 ♀, same data; 3 ♀♀ Shinner's Soakage, Hundred of Senior, 11.iii.1952, E. J. Waterhouse; 1 ♀ Hundred of Petherick, 23.ii.1952, E. J. Waterhouse. WESTERN AUSTRALIA: 1 ♀ near Lake King, 24.iii.1955, biting 0630 hrs, E. J. Britten; 1 ♀ near Newdegate, 24.iii.1955, biting 1500 hrs in shade, E. J. Britten.

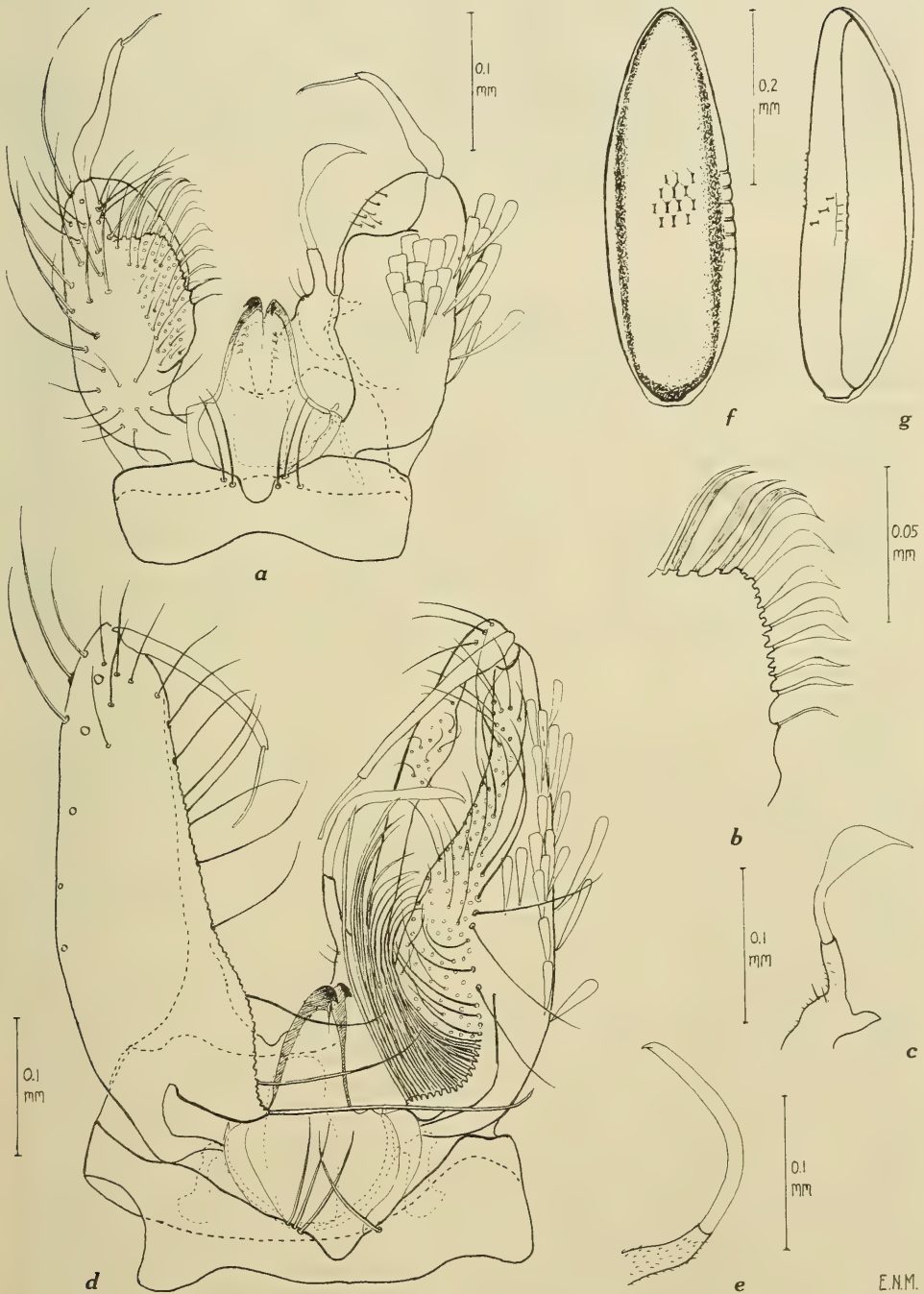


Fig. 1.—*a-c*, *Aedes calabyi* Marks, ♂ terminalia—*a*, tergal aspect; *b*, basal lobe of left coxite, tergal aspect to indicate only shape and extent of specialized setae; *c*, right harpago, inner lateral aspect. *d-e*, *Aedes elchoensis* Taylor, ♂ terminalia—*d*, tergal aspect; *e*, left harpago, inner lateral aspect. *f-g*, *Aedes spinosipes* Edwards, egg (details of surface pattern indicated only at mid length)—*f*, upper aspect; *g*, ventrolateral aspect.

Biology: Waterhouse (1959) describes the area which includes Hundred of Petherick as swampy flats, mostly very saline, and mentions only one tree, red-gum (*Eucalyptus camaldulensis*), in the less saline areas; Hundred of Pendleton is in an area of mallee, heath, broom, and teatree associations.

Comment: The specimens examined from South Australia were recorded by Waterhouse (1959) as "*Aedes* (*Chaetocruiomyia*) undescribed sp.", and the Western Australian specimens are those recorded as *Aedes spinosipes* from the Lake Grace area by Britten (1958); my suggestion (Marks, 1963) that these records were probably referable to *calabyi* is now confirmed.

AÈDES (*CHAETOCRUIOMYIA*) *ELCHOENSIS* Taylor.

Female.

Fifteen ♀♀ have wing length 1.7–2.4 mm. and show the following differences from my previous description (Marks, 1963). Upper lateral white patch on head reaching eye margin; a few small pale or dark scales mesially on torus; palp 1/2 length of proboscis excluding labella (distal segment 1/2 length of palp). Scutal integument black; *ppn* with 1 or 2 flat or curved white scales below; subspiracular patch of 2–13 broad scales, all but 1 or 2 may be dark; 6 ♀♀ have 1–8 broad scales among the post-spiracular bristles, usually white, but may be 1 or 2 black. Fore femur with antero-ventral streak of white scales and with posterior broad white streak extending almost to base and apex; mid femur posteriorly with a couple of white scales; hind femur with anterior white streak on distal 2/3; mid tibia with dorsal streak of pale scales on distal 3/5; basal white bands on mid tarsal segments 1/4 I, 1/2 II and III, a couple of white scales on IV and V, or V dark, but not black; basal white bands on hind tarsal segments 1/2 III, 3/5 IV. Tergite VII with paired submedian basal patches of 2 white scales; sternite II white scaled, III, or III–IV with basal white band, IV–VII with small basal lateral white patches, dark scaling as dark as on tergites.

Male (Fig. 1, *d-e*).

One ♂ differs from ♀♀ as follows: Wing length 1.9 mm. Torus large, dark; verticillate hairs dense, dark, lying mainly in a vertical plane. Palp 1 1/5 length of proboscis (excluding labella), black scaled, 2 distal segments slightly down-turned; at apex of segments III and IV a very stout, long, black bristle dorsally, with shorter, finer bristle mesial to it; numerous fine appressed bristles about as long as width of segment mesially along IV and V, 1 long, and 1 shorter moderately strong bristle at apex of V. Proboscis 1 1/4 times length of fore femur, black scaled. Mid lobe of scutellum rubbed, but apparently with some curved white scales; on one side a postspiracular patch of 3 broad white scales. Legs: Fore tibia with 4 rows of about 6 or 7 bristles, of which 2 on basal half of anterior row are strongest, and about 1–1 1/2 times width of tibia. Mid tibia also with 4 rows of bristles, about 10 in anterior row. Hind tibia with dorsal and ventral rows of about 6 strong bristles, the 2 or 3 longest twice width of tibia, an anterior row of 8–9 shorter strong bristles and a row of shorter bristles posteriorly; elongate narrow scales posteriorly along apical 2/3 of hind tibia and base of first tarsal segment; hind tarsal segment III with 1 white scale at apex. Tarsal segment IV on fore leg 1/2 length of V, on mid leg 2/3 length of V; claws of fore and mid legs unequal, anterior long with slender tooth near base, posterior shorter, simple; hind claws equal, simple. *Terminalia* (described and figured from a slightly flattened and twisted mount).—Coxite about 3 1/2 times as long as broad with membranous area along mesial aspect, tergal to which is a densely setose area extending from base almost to apex of coxite, bearing moderately long setae in about 8 longitudinal rows, the more tergal and proximal setae the longest; this setose area merges on basal 1/4 of coxite with a prominent basal lobe, apparently shelf-like, which bears long dense setae, about 3 of which at apex of lobe are stouter, non-striated, 3/5 length of coxite, of uniform width, tapering only at tip. Dense dark scales laterally and sternally on coxite, which also bears scattered long and moderately long setae laterally and near

apex tergally, several mesially directed rows of setae along inner sternal aspect, finer at base, long and strong near apex, and a preapical group of about 10 fine setae on inner sternal margin. Style almost $2/5$ length of coxite, slender, very slightly curved and tapering, non-pilose, without setae; appendage terminal, $1/2$ length of style, slender, with curved, blunt tip. Harpago slender, $1/6$ length of coxite, with 2 fine setae at base; appendage twice length of harpago, and scarcely more slender than it, of even width, strongly curved and finely striated, with short, curved, pointed tip. Paraproct with 1-2 teeth (setae, if present, obscured). Phallosome simple, slightly narrower on distal half, with flattened apex. Lobes of tergite IX scarcely differentiated, bearing 1-3 stout setae; sternite IX with slightly concave distal margin, and 7 setae.

Larva (Fig. 2, *a-h*).

Colour pale, head light brown, siphon and saddle brown; length about 6 mm. Long setae of thorax and abdomen finely plumose. *Head*.—Almost as long as broad, none of the setae very long. Antenna brown, $1/3$ length of head, 9 times as long as broad, cylindrical, non-spiculate; seta 1 arising at mid length, short, single; 2-6 arising close together at tip, 2 the longest. Head seta 1 a moderately stout, curved, bluntly pointed spine $1/3$ length of antenna; 4 and 6 arising close to front of head, 4 slightly anterior to 6; 5 backwardly directed, arising slightly lateral to 6 and posterior to 7 which arises level with base of antenna; 4 short, 11-12-branched; 5 single, frayed; 6 and 7 2-branched; 8, 10, 13, 14, 15 single (10 duplicated on one side); 11 with 1 strong and 1 weak branch; 12 2-3-branched. Mentum with strong median tooth and 10 large lateral teeth. *Thorax*.—The following setae are long, strong: 5, 6-P, 5, 7, 10, 12-M, 10-T single; 7-P 2-branched; 1-P 2-3-branched; 9-T 3-4-branched; 6-M 4-branched; 9-M 4-5-branched; 8-M 5-branched; 7-T 6-7-branched. The following setae are fairly short and fine: 2, 9, 10 11, 12-P, 2, 3, 11-M, 2, 5, 6, 11, 12-T single; 3, 8, 14-P, 1-M, 3-T 2-branched; 4-P, 4-M 2-3-branched; 4-T 3-branched; 0-P, 1-T 3-4-branched; 8, 13-T 4-branched; 13-M 4-5-branched; 14-M 5-6-branched. 2-P is longer than 3-P. The long lateral setae arise from sclerotized basal tubercles; basal tubercles of 5, 6-P and of 6, 7-M are fused; basal tubercle of 9-12-M and 9-12-T each bears a very strong spine. *Abdomen*.—Segments I-VII: The following setae are long, strong: 6-V-VI, 7-I, 13 III-IV single, 6-III-IV 2-branched; 6-I-II 3-branched. The following setae are of short to medium length: 2-II-VII, 3-III-IV, VI, 4-II-III, V, 5-V-VII, 7-II-VII, 8-IV-V, 9-II, VII, 10-II-VII, 11-I-VII, 12-II-VII single; 4-VII, 5-II, IV, 9-VI, 13-V, VII 1-2-branched; 8-III 1-3-branched; 1-III-VII, 2-I, 3-I, 4-IV, VI, 5-III, 6-VII, 8-I-II, VII, 9-IV 2-branched; 3-V, VII, 5-I, 8-VI, 9-I, III, V, 13-I 2-3-branched; 13-VI 2-4-branched; 1-I-II, 3-II 3-branched; 4-I, 13-II 3-4-branched. Segment VIII: Setae 1, 2, 4 single, 3 3-4-branched, 5 3-branched; 1, 3 and 5 strong, frayed; 1 arising from sclerotized base of comb; 3 arising from separate sclerotized tubercle. Lateral comb of 4 stout, dark, simple, blunt spines arising from a sclerotized plate, the distal margin of which is slightly indented between the spines; in some spines the heavy sclerotization ends abruptly, leaving a pale tip; longest spines (excluding base) $1/4$ length of saddle. Siphon: Tapering, index 2.2; with a distinct complete dark basal collar and well-developed acus. Pecten extending over basal $1/3$ - $3/8$ length of siphon, of 13-14 fairly even, close set teeth; on one side the proximal tooth arises from the acus; each tooth is coarsely fringed with denticles apically and ventrally; the more basal teeth also have a few denticles dorsally. Seta 1 single, long, strong, frayed, arising at mid length of siphon; valve setae short, seta 8 2-branched. Anal segment: Saddle covering dorsal $1/2$, with distinct sclerotized basal collar, and with several rows of fine spicules along distal margin; the lower distal angle is slightly produced and seta 1 arises from its apex; seta 1 moderately long, single, finely frayed; setae 2-4 long, strong, simple; 2 4-branched; 3 single; 4 (ventral brush) consisting of 10 2-branched setae arising from an incompletely sclerotized grid; anal papillae about $2\frac{2}{3}$ length of saddle, equal, with rounded tips.

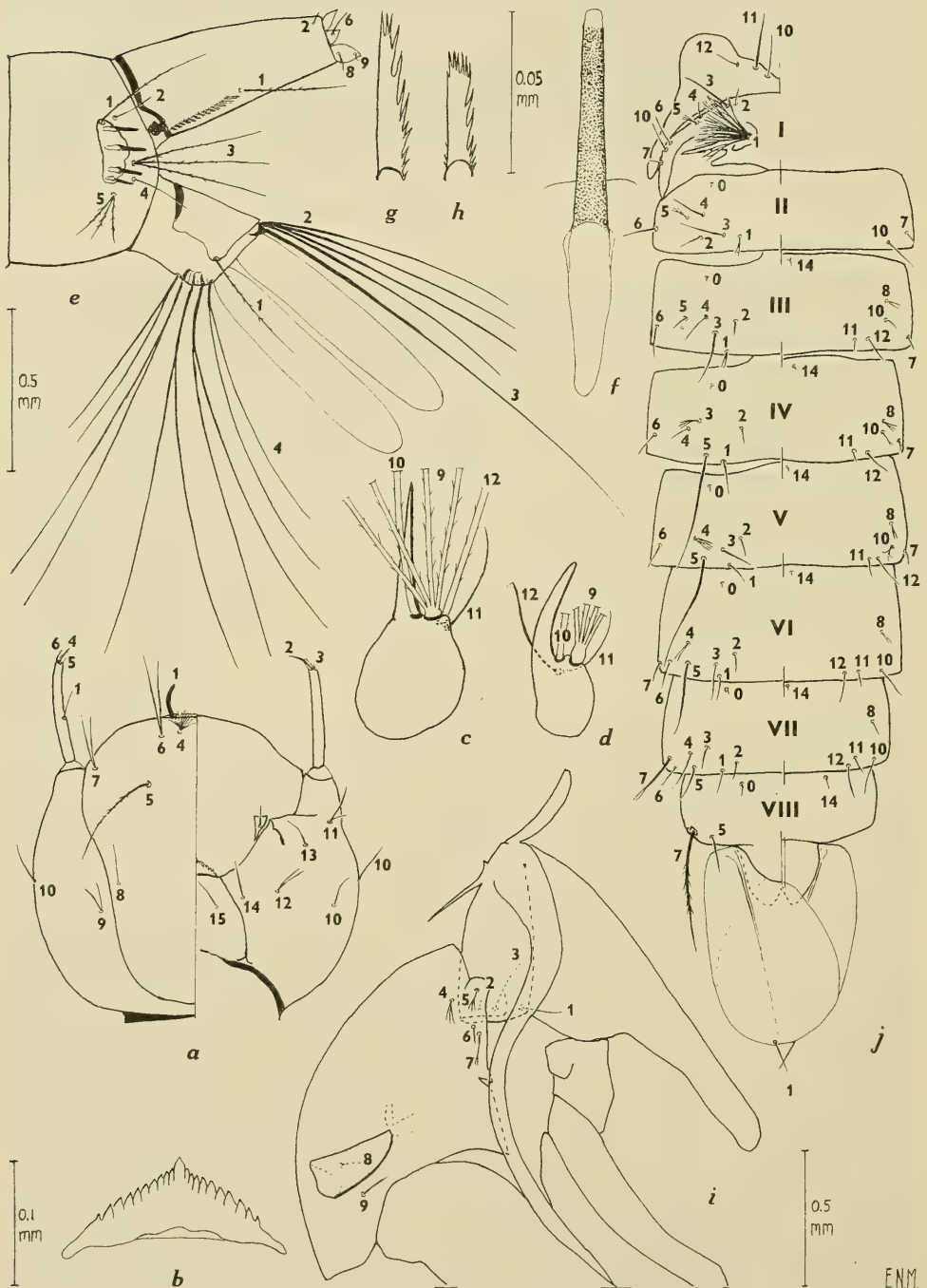


Fig. 2.—*Aedes elchoensis* Taylor: a-h, larva—a, head; b, mentum; c, base of mesothoracic pleural setae; d, base of metathoracic pleural setae (c and d to same magnification as b); e, terminal segments; f, lateral comb tooth; g, distal pecten tooth; h, tooth from middle of pecten. i-j, pupa—i, cephalothorax; j, metanotum and abdomen.

Pupa (Fig. 2, i-j).

Colour pale. The longest setae may be finely frayed. *Cephalothorax*.—Proboscis sheath short (extending little more than half-way to lower margin). Trumpet brown, lighter at base and apex, about $2\frac{2}{5}$ times as long as greatest width, with slightly oblique opening and shallow apical notch; ratio of meatus to whole 1:1.3. Setae short, simple; setae 1-3, 6, 8-11 single (11 simple or sparsely frayed); seta 4 2-3-branched; seta 5 3-4-branched; seta 7 2-3-branched; seta 12 single or bifid near tip (seta 2 is duplicated on one side). *Abdomen*.—Setae 0-II-VII, 14-III-VII minute, single; 0-VIII, 14-VIII slightly longer, single; 2, 6-I-VII single; 7-I-VI small, single; 11, 12-III-VII single. *Segment I*. Seta 1 strongly developed, dendritic, branches arising from broad fused base; setae 3, 4, 10 single; seta 5 3-4-branched. *Segment II*. Seta 1 2-branched; setae 3, 4, 10 single; seta 5 1-3-branched. *Segment III*. Seta 1 2-branched; setae 3 and 4 single; seta 5 1-2-branched; seta 8 2-3-branched; seta 10 1-3-branched. *Segment IV*. Setae 1, 5 single; seta 3 3-4-branched; seta 4 1-2-branched; seta 8 3-branched; seta 10 2-3-branched. *Segment V*. Setae 1, 3, 5 single; seta 4 4-branched; seta 8 1-2-branched; seta 10 3-branched. *Segment VI*. Setae 1, 3, 5, 10 single; seta 4 2-3-branched; seta 8 2-branched. *Segment VII*. Setae 1, 3, 4, 5, 8, 10 single; seta 7 about half length of segment VIII, stout, bifid at tip. *Segment VIII*. Seta 5 single; seta 7 $\frac{3}{5}$ length of paddle, stout, plumose. *Paddles* oval, with minute sparse spicules on apical margin; midrib slender, distinct on basal $\frac{2}{3}$ only; buttress undeveloped; index 1.6-1.7; seta 1 single, $\frac{1}{5}$ length of paddle.

Specimens Examined: NORTHERN TERRITORY: 11 ♀♀, 1 ♂, Darwin, 1 ♀, 1.iii.1953, 2000 hrs, 10 ♀♀, 1 ♂, 3.iii.1953, 2100 hrs, A. K. O'Gower; 3 ♀♀ 8 miles S. Adelaide River, on N.-S. road, 23.ii.1943, A. R. Woodhill. QUEENSLAND: 1 ♀ (P.2836) with correlated larval and pupal skins, Mt. Molloy, 28.x.1962, E. N. Marks and G. Barrow (U.Q.).

Biology: The localities from which *elchoensis* has been collected all lie between the 40-inch and 60-inch isohyets. All females for which time of biting is recorded were taken at night.

At Mt. Molloy (alt. 1300 ft.) the collecting site was in open forest with numerous small trees, principally *Eucalyptus alba* and *Melaleuca* spp. A dry hollow, $\frac{1}{2}$ inch \times $\frac{3}{4}$ inch across, 8 inches deep, and 1 foot above ground level, in a small *E. alba* was filled with water at approximately 1700 hours on 27th Oct. From a collection made from it 24 hours later 3 larvae were reared, 2 *Aedes tremulus* (Theobald) and 1 *elchoensis*; the latter pupated on 8th Nov. and the adult emerged on 13th Nov. *Chaetocruiomyia* adults (*moloiensis* also occurs here) may be fairly common in the Mt. Molloy area during the wet season, for residents who spend much time in the bush, when asked about local mosquitoes, gave special mention to the little mosquitoes with white backs which are vicious biters.

Dr. O'Gower informs me that the site at Darwin where he collected 11 specimens on 3.iii.1953 was on the edge of the town at Berry Springs, a series of swimming pools in a limited area of wet sclerophyll eucalypt forest with some *Pandanus*; the trees had been thinned to make the pools more accessible; light intensity was low and humidity high.

Comment: The larva and pupa of *elchoensis* key to subgenus *Macleaya* in Mattingly's (1959) keys. The larva closely resembles those of species of *Macleaya* in the placing of head seta 12 mesial to seta 13, and in the form of lateral comb; it differs in having very large spines on bases of both meso- and metathoracic pleural setae (some species of *Macleaya* have a fairly large spine on base of the mesothoracic group, but none have more than a short spine on the metathoracic) and a well-developed acus on the siphon. The larva resembles that of *tulliae* in having abdominal seta 13 very long on segments III and IV; it differs in the form of lateral comb, base of siphon, and pecten; moreover *tulliae* has head seta 12 arising lateral to seta 13, thoracic seta 1-M very long; and bases of meso- and metathoracic pleural setae without large spines. The pupa shows no distinct differences from pupae of *Macleaya* species,

which, however, have not yet been studied in detail; it differs from the pupa of *tulliae* in having seta 7 not strongly developed on segments III–VI, and paddle seta 1 short.

Male terminalia of *elchoensis* show affinities with some or all species of *Macleaya* (several of which are undescribed) in the shape of tergite IX, sternite IX, and appendage of harpago, and in the basal lobe and setose area of coxite; they appear to differ in the shape of apex of phallosome; they differ from other species of *Chaetocruiomyia* in all these characters. The male palp also resembles *Macleaya* species rather than other species of *Chaetocruiomyia*.

Except in adult scale pattern, *elchoensis* appears to be nearer to *Macleaya* than to Group A of *Chaetocruiomyia*, but any reconsideration of its subgeneric position seems best left until the subgenus *Macleaya* has been revised.

AËDES (CHAETOCRUIOMYIA) HUMERALIS Edwards.

Female.

Eight ♀♀ have wing length 1.7–2.2 mm. and show the following differences from my previous description (Marks, 1963): Head extensively pale scaled, lateral dark scale patch not reaching nape; no narrow curved scales at nape; torus with numerous pale scales mesially. Scutum with golden brown scaling extending forward as a broad median stripe only to level of scutal angle, merging anteriorly with creamy scales which are darker than the white scaling of fossae; 4 specimens have 1–3 narrow curved or broad scales on postspiracular area, and though all 4 are damaged to some extent, on 3 the broad scales at least appear to be *in situ*. Tergite I entirely dark scaled mesially.

Specimens Examined: QUEENSLAND: 5 ♀♀ Eidsvold, T. L. Bancroft, 2 of which are labelled “Aedes (Chaeto.) humeralis Edw. Paratype id. by G. F. Hill” and are presumably part of the original series of 5 ♀♀ described by Edwards; 3 ♀♀ without locality data, one of which is labelled in Bancroft’s hand “No. 3 New Stegomyia”. These do not appear to include any of the 4 Eidsvold ♀♀ on which I made notes at S.P.H. & T.M. in 1945.

Comment: Presence of postspiracular scales had not previously been observed in *Chaetocruiomyia*; their absence can no longer be considered a reliable subgeneric character.

AËDES (CHAETOCRUIOMYIA) MACMILLANI, n. sp.

Aedes (*Chaetocruiomyia*) “Species A” of Marks (1963).

Female (Fig. 3, a).

Subgeneric characters and those common to species of Group A listed by Marks (1963) are omitted from the following description. Wing length 2.7–2.8 mm. (2.7 mm. in holotype). *Head*.—Flat white scales at nape mesially, not extending in a continuous triangle to vertex, but sometimes reaching eye margin sublaterally (as in holotype), separated by a broad sublateral area of black scales from lateral pale scaling; a continuous band of flat black scales dorsally behind eyes, often with mottling along its junction with posterior pale scaling; small creamy scales along eye margin, narrow curved, with sometimes some flat at vertex; some narrow curved pale scales at nape; upright forked scales dark; clypeus brown. *Thorax*.—Integument reddish-brown. Scutum clothed with creamy scales anteriorly, deeper creamy between acrostichal and dorsocentral bristles; posterior margin of pale scaling follows posterior margin of fossa, and is slightly indented at dorsocentral and extended at acrostichal bristles; posterior scutal scaling brown, with golden scales round prescutellar bare area, and in double line lateral to prescutellar bristles; a few golden scales above wing root; short creamy and longer dark forked bristles in front of wing root. Scutellum with narrow curved creamy scales only on all lobes (as in holotype), or with 2–3 flat pale or dark scales mesially on mid lobe; 4–5 strong bristles to each

lobe. *Apn* with narrow curved creamy scales above and below a patch of flat dark scales. *Ppn* with narrow curved dark scales only, or with some flat dark and with a few narrow curved creamy above or below. Subspiracular scale patch small, of about 5-8 white scales, usually all flat, sometimes a few narrow. Legs: Fore femur anteriorly with short pale streak or extensive pale scaling on basal half, posteriorly with large pale patch on middle 1/3, mottling beyond it, and large apical patch, or mainly pale on apical 2/3 and mottled on basal 1/3. Mid femur anteriorly dark; ventrally with pale scaling almost continuous from base to apex, merging at mid length with a large posterior pale patch which extends as a streak, sometimes with associated mottling, towards base and apex; a small complete preapical dark ring and small posterior apical pale patch. Hind femur dark with ventrally a few scattered pale scales or mottled streak, and sometimes posteriorly a few pale scales at mid length. Fore tibia posteriorly with some scattered pale scales, or extensively pale on basal 2/3 with pale patch at apex. Mid tibia dark or with extensive mottling of pale scales dorsally and some posteriorly. Hind tibia dark. Basal white bands on fore tarsal segments 1/6-1/5 I, 1/3-2/5 II; on mid tarsal segments 1/7-1/5 I, 1/3-2/5 II; on hind tarsal segments 1/4 I, 1/3-2/5 II, 2/5-1/2 III, IV all dark, V all white, or with a few dark scales at apex (as in holotype). Wing: Pale scales in small patch at base of C, with 1 or 2 beyond it; cell R_2 2.3-2.9 times length of its stem; cell M_1 0.8-1.2 times length of its stem. *Abdomen*.—Tergite I dark scaled mesially; II-VII with fairly large median basal creamy patches; VIII in holotype with basal band not reaching lateral margin (retracted in most specimens).

Described from holotype and 3 paratype females.

The following differences were observed among specimens from other localities: 4 ♀♀, Colo Vale—wing length 2.6-2.7 mm.; scutellar scales all golden, narrow curved, or broad curved, or the two mixed, or with 1-2 dark curved or flat mesially on mid lobe; subspiracular scale patch short, irregular, of 5-12 white scales; 7 upper *stp* bristles; mid tibia with continuous pale dorsal streak not reaching base and apex; a white scale at base of fore tarsal segment V; basal band 1/4 mid tarsal segment III; base of C dark or with a couple of pale scales; cell R_2 3 times length of its stem; terminalia of 1 ♀ examined, similar to *spinipes*. 1 ♀, Kangaroo Valley—wing length 2.9 mm. 7 ♀♀, Victorian localities—wing length 2.5-2.9 mm.; mid lobe of scutellum with broad curved creamy scales, those in mid line darker; *ppn* scales mainly flat black; basal white band 1/2 fore tarsal segment II, a few white scales at base of III; a patch at base of mid tarsal segment III; band 1/2 length of hind tarsal segment III; 1-2 pale scales mesially at base of tergite I. The foregoing are all from south of the type locality and the following from north of it. 1 ♀, Guyra—wing length 3.1 mm. 2 ♀♀, Point Lookout—wing length 2.6-3.1 mm.; scutal integument dark brown; median patches on tergites white. 2 ♀♀, Ben Lomond—wing length 3.0-3.1 mm.; scutal integument dark brown; mid femur anteriorly with a few white scales at mid length; basal white bands half fore tarsal segment II, quarter mid tarsal segment III; otherwise these 2 ♀♀ agree with the type series, more particularly they have anterior scutal scaling deep creamy, scutellar scales all pale curved, or mid lobe with some flat black in mid line, *apn* with narrow curved creamy scales above, subspiracular scale patch small, white, and some pale scales at base of C. 5 ♀♀, Ben Lomond—wing length 2.5-2.8 mm.; scutal integument medium to dark brown (reddish-brown under strong light); all pale scaling of scutum and scutellum white, or at least fossae white, rest very pale creamy; sparse pale scales round prescutellar bare area; mid lobe of scutellum clothed mainly with flat dark scales, with a few narrow curved dark or pale laterally, lateral lobe with narrow curved dark and pale scales, or scutellar scales all narrow curved, a few dark mesially on mid lobe, rest pale; *apn* mainly dark scaled, without pale scales above, or with only a couple of narrow curved white or creamy, and with narrow curved and sometimes flat white scales below; subspiracular scale patch of 7-12 scales, sometimes divided into a lower patch of broad scales and upper patch of 2-4 narrow elongate scales, all scales white in 2 ♀♀, mainly white with

a few dark in 2 ♀♀, all dark in 1 ♀; fore tarsal segment III with 1-2 white scales at base; mid tarsus with basal band 1/4 segment II, basal white patch on III; hind tarsus with white band 1/2 segment III; base of C dark; tergite I with 1 white scale mesially at base in 2 ♀♀; mesial patches on tergites white in 4 ♀♀, pale creamy in 1 ♀.

Male (Fig. 3, b-d).

Allotype and 2 paratype ♂♂ differ from ♀♀ as follows: Wing length 2.8-3.3 mm. *Head*.—Torus large, dark, with fine hairs mesially; verticillate hairs long, dense, dark brown, lying mainly in a vertical plane. Palp 1.1 times length of proboscis (excluding labella), black scaled, the 2 distal segments slightly down-turned; segment III at apex with 2 stout dark bristles dorsally, the mesial one shorter, and 4 long fine bristles ventrally; segment IV with numerous long bristles dorsolaterally, a stout apical bristle mesially, a ventral row of about 10 long bristles, and a few short unmodified bristles dorsally; segment V with numerous moderately long bristles dorso-laterally, ventrally and at apex. Proboscis 1.5 times length of fore femur. *Thorax*.—Integument dull medium brown (reddish in strong light); anterior scutal scaling pale creamy, posterior light brown, golden and creamy. Scutellum with curved creamy scales; some flat black in middle of mid lobe. *Apn* with a couple of narrow curved creamy scales above, elongate and flat dark mesially, narrow curved and flat white below. *Ppn* with a few narrow curved or elongate flat white scales below dark scaling. Subspiracular scale patch of 7-15 white scales, mainly broad, 2-3 narrow above. One paratergite of allotype bears a single broad curved white scale, which may be displaced from group in front of wing root. Legs: Fore tibia with about 6 well separated bristles anteriorly, posteriorly, dorsally and ventrally, the 2 longest anteriorly about $2\frac{1}{2}$ times width of tibia. Mid tibia with anterior row of about 15 long bristles, the 2 or 3 longest about $2\frac{1}{2}$ times width of tibia, dorsal and ventral rows of about 6 bristles, and a row of fine short bristles posteriorly. Hind tibia with rows of 3-4 very long, and some shorter strong bristles dorsally and ventrally (the longest 3 times width of tibia), anterior and postero-dorsal rows of about 18-20 moderately long bristles; some long narrow scales posteriorly along tibia and at base of tarsal segment I. Basal bands on fore tarsal segments 2/5-1/2 II, sometimes a patch at base of III; on mid tarsal segments 1/7-1/6 I, 1/4-1/3 II, sometimes a white scale at base of III; on hind tarsal segments 1/5-1/4 I, 1/4-1/3 II, 2/5 III, IV dark or with a white scale at base, V may have numerous dark scales on distal half; fore and mid tarsal segments IV and V approximately equal, not obviously modified, with unequal claws, anterior long with a slender tooth near base, posterior simple; hind claws equal, simple. C dark at base. *Abdomen*.—Tergites with numerous long hairs laterally and apically; tergite I mesially dark or with small white basal patch; II-VII with large median basal white patches; sublateral white patches distinctly subbasal on III-VI; true tergite VIII dark scaled; true sternite VIII with sublateral white patches, coxites scarcely projecting beyond it, small, dark scaled. *Terminalia* (described from 2 paratypes).—Coxite about $2\frac{1}{3}$ times as long as greatest width, with membranous area along mesial aspect, tergal to which is an elongate basal lobe extending $\frac{2}{3}$ length of coxite, its distal attachment to coxite approximately right-angled. Dense scales laterally on coxite, extending onto sternal aspect and onto middle third tergally. Basal lobe densely clothed with moderately long setae, fewer and finer on mesial basal portion; on distal margin of lobe there are 2-4 long, strong setae at angle between lobe and coxite, followed by 2-4 broad striated setae, and at apex of lobe and extending along distal $\frac{1}{3}$ mesially are setae with curved, flattened tips, those at apex the longest. On inner tergal margin of membranous area on distal $\frac{1}{3}$ are 4-5 moderately long setae. Coxite bears numerous long setae laterally, and on distal $\frac{1}{3}$ sternally (the longest as long as coxite); a group of about 10 moderately long setae tergally at base; scattered fine setae on middle third sternally and extending mesially towards apex, those on inner sternal margin not forming a distinct group. Style $\frac{1}{2}$ length of coxite, pilose on basal $\frac{1}{6}$, with 2 fine preapical setae, or without setae; fairly straight, slender, slightly tapering; appendage terminal,

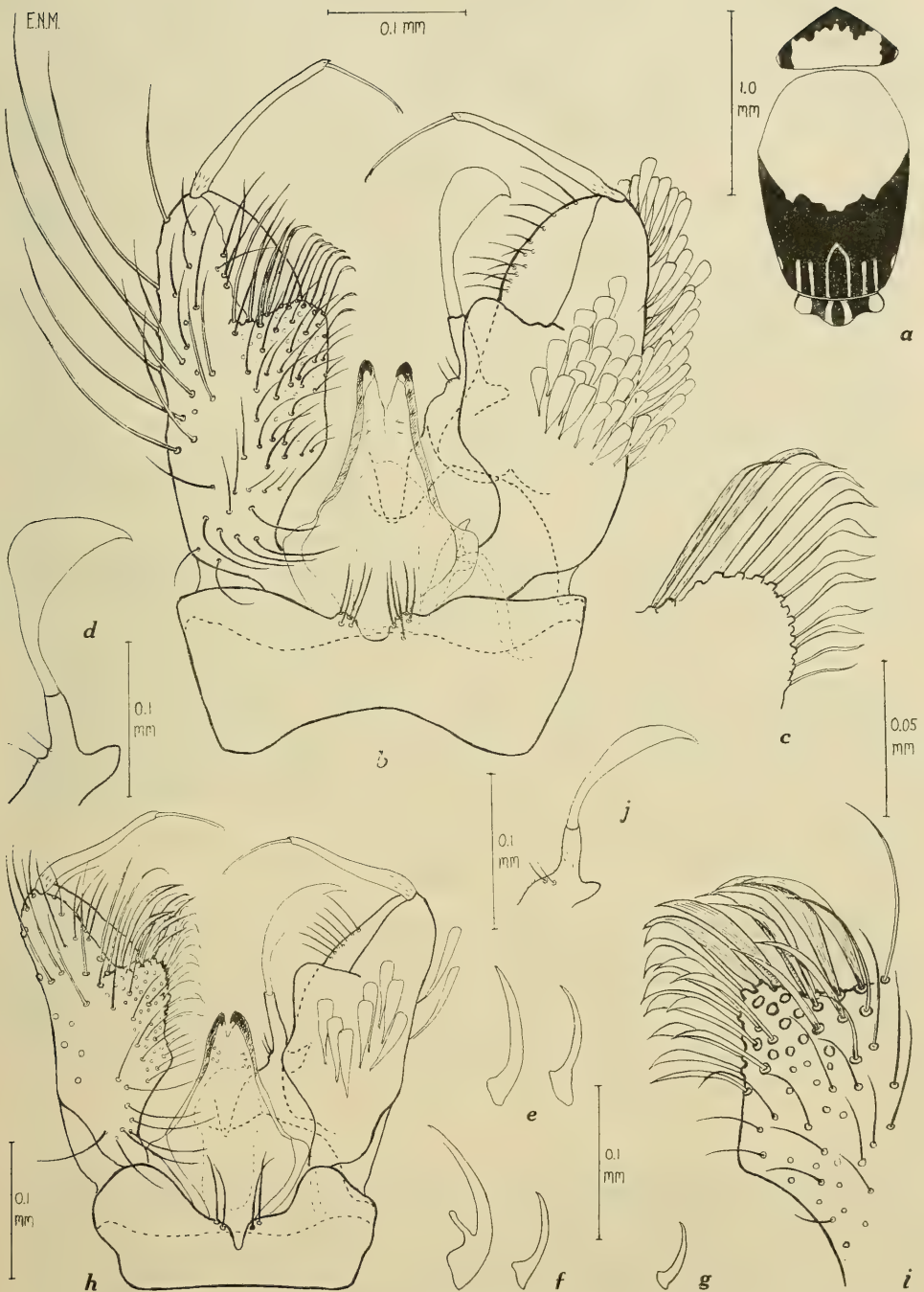


Fig. 3.—*a-d*, *Aedes macmillani*, n. sp.: *a*, ♀ head and scutal pattern; *b-d*, ♂ terminalia—*b*, tergal aspect; *c*, distal portion of basal lobe of left coxite, tergal aspect, to indicate only shape and extent of specialized setae; *d*, right harpago, inner lateral aspect. *e-j*, *Aedes wattensis* Taylor: *e-g*, ♂ tarsal claws—*e*, fore (untoothed anterior claw is abnormal); *f*, mid; *g*, hind; *h-j*, ♂ terminalia—*h*, tergal aspect; *i*, basal lobe of right coxite, inner lateral aspect; *j*, right harpago, inner lateral aspect.

almost $3/5$ length of style, slightly curved, with unfurled grooved tip. Harpago $1/5-1/4$ length of coxite, with 2 fine setae near base; appendage about twice length of harpago, and 3 times as long as its own greatest width, lightly sclerotized, curved and broadly expanded on distal $2/3$, with short pointed tip. Paraproct with a single tooth and 2-3 fine setae. Phallosome simple, straight sided basally, widening beyond mid length, with rounded apex. Lobes of tergite IX small, with 3-5 setae; sternite IX bilobed with 1-2 long and 2 short setae to each lobe.

Types: Holotype ♀, Barrington area (Gummi Plain), N.W. Dungog, New South Wales, 3800 ft., 3.iii.1951, biting, B. McMillan; allotype ♂, 3 ♀♀, 2 ♂♂ paratypes, same locality, 1 ♀, 1 ♂ same date, allotype and 2 ♀♀, 1 ♂, 2.iii.1951. Holotype, allotype, and 4 paratypes in S.P.H. & T.M., 1 ♂ paratype in U.Q. The allotype is the only practically perfect and undissected male *Chaetocruiomyia* in known collections.

Specimens Examined: The type series; 4 ♀♀, Ben Lomond, off dog, E. J. Waterhouse, 3 ♀♀, 3.iii.1956, one 0530-35 hrs, one 0540-45 hrs, one 0602 hrs; 1 ♀, 15.iii.1956, 0645 hrs. Detailed notes on specimens previously listed (Marks, 1963) have also been used in descriptions.

Distribution (details in Marks, 1963): NEW SOUTH WALES: Ben Lomond, Guyra, Point Lookout, Barrington Area, Colo Vale, Upper Kangaroo Valley. VICTORIA: Orbost, Sherbrooke Forest, Lyonville, Tidal River. Dr. N. V. Dobrotworsky (personal communication) has taken *macmillani* on Flinders I., Bass Strait.

Biology: No further details can be added to the previous account (Marks, 1963), except to note the early morning biting at Ben Lomond. This is the *Chaetocruiomyia* species of the wetter and cooler areas of south-east Australia, and its distribution is not known to overlap that of any other species of the subgenus.

Comment: Although Ben Lomond specimens show a good deal of variation, there is a gradation in some variations and some are represented in specimens from other localities; different characters also are affected in different specimens. There seems no reason to suppose more than the one species, *macmillani*, is represented in this series. Perhaps greater variability may be associated with specimens from the northern limits of its range, but most localities are represented by too few specimens to indicate local variation.

AÈDES (CHAETOCRUIOMYIA) SPINOSIPES Edwards.

Female.

Thirty-one ♀♀ have wing length 1.8-2.4 mm. and show the following differences from my previous description (Marks, 1963). Flat scales of head almost all white, dark patches reduced to a few scales; some creamy scales mesial to and lateral to prescutellar bristles, on mid lobe of scutellum laterally, and on lateral lobe; 8 upper *stp* bristles; pale scales on C usually extending to level of tip of scale tuft, sometimes twice that distance, often some also on Sc beyond tip of scale tuft; tergite IX with submedian groups of 2-3 setae; insula with 10 setae.

Egg (Fig. 1, f-g).

Described and figured from darkened eggs dissected from adults. Length 0.475 mm., greatest width 0.15 mm.; elongate oval in upper view, the micropylar end the more rounded. The lower surface (width about $1/3$ circumference of egg) is flattened and lightly sclerotized, apparently smooth with a fine reticulate structure. The upper surface is more heavily sclerotized, the sclerotization continuous below round each end, and the lateral junction with the lower surface sharply defined, and appearing as a scalloped border. The upper surface appears when immersed to be marked with a series of fairly regularly spaced, elongate sclerotizations, each like a "capital I", the upper ones lying mainly parallel to, and the lateral ones at right angles to long axis of egg. These sclerotizations form the sides of hexagonal reticulations which cover the upper surface, the diagonal lines joining them being usually more lightly sclerotized,

and not obvious at low magnifications. When the egg is dried, the surface appears rugose, the tuberosities being at each end of each "capital I".

Specimens Examined: QUEENSLAND: 1 ♀ Palm I., G. F. Hill; 1 ♀ Palm I., xi.1920, A. Breinl; 1 ♀ Eungella, 50 miles W. Mackay, alt. 2300 ft., F. H. Taylor; 4 ♀♀ labelled "Loc. doubtful ? Palm Is."; 2 ♀♀ unlabelled; 22 ♀♀ Noosa, 13.iii.1963, E. N. Marks and G. Monteith. Noosa specimens in U.Q. (some will be distributed to other institutions), remainder in S.P.H. & T.M. Palm I. specimens are not those on which I had previously made notes. Eungella is a new locality record.

Biology: Eungella has extensive rainforests and an average annual rainfall of 68 inches.

A small rainforest area at Noosa where *spinosipes* had been collected twice previously was visited after rains in March, 1963, with the object of trying to locate its breeding places and of collecting adults. Collections from small tree cavities at heights of 2 feet to 35 feet above ground did not yield larvae of this species, and no adults were taken in two New Jersey light traps, one run 1800 hrs (dusk)–2200 hrs and one dusk-dawn. Between 0830 and 1245 hrs on 13th March, in overcast, humid, damp and sometimes showery conditions, 22 ♀♀ were taken biting in this rainforest, one at 30 feet above ground, but most at ground level attacking the collectors' feet and ankles.

Most of these adults were held in a small cage, some in vials, and all were transferred about 2000 hrs to a 9 inch × 9 inch × 9 inch cage in the laboratory, where they were kept thereafter at room temperature, and in fairly high but variable humidity. A porous flower-pot with base immersed in water, a Petri dish with moist cotton wadding, and two narrow glass vials with moist filter paper (one moistened with tree-hole water, and darkened by wrapping it externally) were provided as oviposition sites, but no eggs were found in them.

An arm was inserted in the cage twice on 14th March, 1200–1210 hrs and 1330–1345 hrs, about 8 engorged; once on 15th, 4 or 5 fed; twice on 18th, none fed; on 21st at 0945 hrs, 1 fed; on 22nd and 25th, none fed. Fruit, sugar solution, and water were also available; on 22nd specimens were feeding on apple and on 25th some specimens appeared engorged with liquid.

Dead adults were removed from the cage when observed—14th, 2; 15th, 2; 18th, 3; 19th, 3; 21st, none dead in morning, 1 in afternoon; 25th, 1; 26th, 2; 27th, in morning 4 dead, 1 moribund, in afternoon, 1 dead, 1 moribund, and the single survivor was killed.

Spermathecae of the specimen moribund on morning of 27th were examined and appeared to contain non-motile sperm. Two drowned specimens, preserved in alcohol, were subsequently found to contain respectively 22 and 25 well-developed eggs. Their abdomens were not obviously distended with eggs and it is probable that some of the specimens pinned were also gravid. It seems clear from the structure of the eggs that they would normally be laid where they would adhere to a firm surface.

AÈDES (CHAETOCRUIOMYIA) TULLIAE Taylor.

Larva.

Four specimens in U.Q. show the following differences from my previous description (Marks, 1963): Length 7.5–8.5 mm.; seta 1-P 2–3-branched; 13-I stout or fine in specimens from same site; upper anal papillae twice length of saddle.

Specimens Examined: QUEENSLAND: Silver Plains, Port Stewart, 1 larva, 1 larval skin, tree hole 23 ft. above ground in bloodwood tree, clean water, 24.iv.1963; 1 larva, 1 larval skin, treehole in big bloodwood tree, dirty water, 26.iv.1963, J. L. Wassell.

Distribution: Known only from north Queensland localities previously recorded (Marks, 1963), with over 40-inch annual rainfall. O'Gower's (1958) record of *tulliae* from Northern Territory was based on specimens now identified as *wattensis* and discussed under that species.

AÈDES (CHAETOCRUIOMYIA) WATTENSIS Taylor.

Female.

Ten ♀♀ have wing length 1.4–1.9 mm. and show the following differences from my previous description (Marks, 1963): Pale scales on posterior half of scutum reduced to a short line lateral to prescutellar bristles; mid femur posteriorly with only a few scattered white scales near middle; hind femur dark ventrally; white basal bands on mid tarsal segments 1/2 II–III, on hind 2/5 I; no pale scales mesially on tergite I.

Male (Fig. 3, e–j).

Two ♂♂, one pinned, one on slide, are too denuded for a close comparison with characteristic head and thoracic scaling of ♀♀; most observable characters agree with *wattensis* and differences are similar to those between sexes in other species; their identification is, however, based principally on association—the two sexes were taken at the same site on the same or consecutive days, and no other species of *Chaetocruiomyia* are known from this locality. They differ from ♀♀ as follows: Antenna as in *macmillani*; palp black scaled, segments I–IV equal in length to proboscis (excluding labella), V lost, remaining bristles on III and IV as in *macmillani*, apparently no square-tipped bristles dorsally on IV; proboscis (excluding labella) 1.6 times length of fore femur; head scaling denuded, but 1 ♂ has flat black scales mesially at vertex. Legs: Bristles partly denuded; hind tibia with anterior row of about 15 and posterodorsal row of 12 moderately strong bristles, possibly very long bristles dorsally and ventrally have been lost but their bases are not apparent; white basal bands on fore tarsal segments 1/8 I, 1/4 II, on mid tarsal segments 1/8 I, 1/4 II, a patch on III, 1 white scale on IV, on hind tarsal segments 1/4 I, 1/3 II, 2/5 III, 1/3 IV; fore and mid tarsal segments IV and V and tarsal claws as in *macmillani*, but in 1 ♂ anterior claw on one fore leg lacks a basal tooth. Wings: Cell R_2 1.5–1.6 times length of its stem, cell M_1 0.6–0.7 times length of its stem. *Terminalia*.—Generally similar to *macmillani*; coxites extending straight beyond segment VIII; basal lobe extending 2/3 length of coxite, its distal attachment to coxite approximately right-angled; along distal margin of lobe there are 1–2 long setae at angle between lobe and coxite followed by a row of 5–6 broad striated scale-like setae (appearing dark in uncleared specimen) with curved pointed tips, and a further 5–6 smaller striated setae in the two rows proximal to these; at apex of lobe and along distal 1/2–2/3 mesially the striated setae are succeeded by setae with very broad, curved, flattened tips, and setae in 1–2 rows lateral to these have narrower flattened tips; bases of all these modified setae lie in a triangle with its apex at apex of lobe; on inner tergal aspect of membranous area on distal 1/3 are 4–5 moderately long setae; sternally coxite bears scattered fine setae on basal half, and mesially towards apex, with an ill-defined group of 7–10 setae pre-apically on inner sternal margin of membranous area. Style almost half length of coxite, pilose on basal 1/6, without setae, slightly curved and tapering; appendage about 3/5 length of style. Harpago 1/5 length of coxite with 1–3 fine setae near base; appendage 2½ times length of harpago and 6 times as long as its own greatest width, curved and expanded on distal 2/3, with pointed tip. Paraproct with 4–5 fine setae. Lobes of tergite IX with 2 setae; sternite IX bilobed with 1–2 long and 2 short setae to each lobe.

Specimens Examined: NORTHERN TERRITORY: 2 ♀♀ Roper River Mission, biting in house, one 0630 12.xi.1956, one 16.xi.1956, A. K. O'Gower. QUEENSLAND: 1 ♀ Lawn Hill, 90 miles S.W. Burketown, Saville Plain, 14.v.1931, T. G. Campbell; 2 ♀♀ Acton Station, 20 miles N. Richmond, biting indoors, one 1840 hrs, 5.xi.1962, one 1800 hrs, 6.xi.1962, E. N. Marks; 1 ♀ Goondiwindi, 16.iv.1951, F. N. Ratcliffe; 2 ♀♀, 2 ♂♂ Noondoo, ♂♂ light trap, one 25.ii.1963, one 26.ii.1963, 1 ♀ to man, sunrise, 1 ♀ biting man 0800 hrs, 26.ii.1963, A. L. Dyce. NEW SOUTH WALES: 1 ♀, Cobarr; 1 ♀, Lake Urana, rabbit warren, 1730 hrs, 10.iii.1954, A. L. Dyce. With the exception of Noondoo and Lake Urana, these are new distribution records. Noondoo ♂♂ in Australian National Insect Collection, Canberra, ♀♀ returned to A. L. Dyce; Richmond specimens in U.Q.; remainder in S.P.H. & T.M.

Biology: Average annual rainfall is 28 inches at Roper River Mission, 20 inches at Lawn Hill, 18 inches at Richmond, 24 inches at Goondiwindi and 12½ inches at Cobar.

Richmond specimens were taken on hot, dry, sunny afternoons, in a room with louvres open to a garden containing large trees, close to a dry watercourse fringed by numerous large coolibah (*Eucalyptus microtheca*) and boree (*Acacia cana*) trees, beyond which was savannah; all treeholes examined were dry; some of those experimentally filled with water later yielded *Aedes* (*Macleaya*) spp. larvae, but many small holes were inaccessible; no adults of *wattensis* were taken in a light trap run from dusk to dawn close to the collecting site.

Noondoo males are the first specimens of *Chaetocruiomyia* known to be taken in a light trap, and Dyce (*in litt.*) gives the following notes on the locality: The plant association was dominated by bimbie box (*Eucalyptus populnea*) and wilga (*Geijera parviflora*) with some false sandalwood (*Eremophila mitchellii*) but no conspicuous *Acacia* component. He also comments that Urana has no mallee that he saw; Myers' study sites, where timbered, carried open pine (*Callitris columellaris*) and eucalypts, around the lake margin *Eucalyptus camaldulensis*, and further back *E. populnea*. The Urana record from a rabbit warren is the first indication of resting places of *wattensis*.

Comment: In 1957 I identified a Roper River specimen as "*A tulliae*?" and, as a result, O'Gower (1958) recorded *tulliae* from Northern Territory. Re-examination of this and a second specimen shows that they are not *tulliae* but *wattensis*, which was not previously known from Northern Territory. One of the males described above differs from females in having dark scales at vertex, but this is not considered significant, as a similar difference occurs between the sexes in *tulliae* (Marks, 1963); this male would not run to *wattensis* in my key to adults, but any revision of the key must await less damaged specimens.

DISCUSSION.

Males. Males of four species of Group A are now known and terminalia characters provide further evidence of the close relationship between species of this group. The differences between species lie mainly in the shape of the appendage of the harpago, and the shape and extent of specialized setae on the basal lobe of the coxite; there may be differences in the shape of the style, and in the angle of attachment of the basal lobe to the coxite; but the appearance of this angle might be affected by the degree to which the mount has been flattened. The specialized setae of the basal lobe are best seen in an inner lateral view of the coxite after the terminalia are bisected, but it has been possible to examine only one specimen thus. There are apparent differences on the bristles of the palp between *calabyi* and other species, but these need checking on a larger series.

Subgeneric Characters. The subgeneric characters previously given (Marks, 1963, p. 191) now need modification. For the adult ♀, "postspiracular area unscaled" should be deleted, since postspiracular scales are sometimes present in *elchoensis* and *humeralis*. For the adult ♂, substitute "broad squame scales may be absent from Cu and An" for "no very broad squame scales on Cu and An"; and substitute for the terminalia characters (which are those of Group A) "Coxite with well developed basal lobe; style with terminal appendage; appendage of harpago of uniform width or with broad blade; phallosome simple".

It does not now appear practicable to find larval and pupal characters common to both subgroups of *Chaetocruiomyia* which will distinguish the subgenus from *Macleaya*. The subgeneric characters previously given apply to a larva and pupa of Group A ("seta 12 of III-V very long" should read "seta 13 . . .").

Species Group Characters. The following may be added to those previously listed (Marks, 1963, p. 193).

Group A. ♂: Palp with a row of long bristles dorsolaterally on segment IV; fore and mid tarsal segments IV and V approximately equal; coxite with elongate basal lobe extending more than half length of coxite; appendage of harpago broadened, blade-like; phallosome broadest on distal half, apex rounded. Larva: Head seta 12 arising lateral to 13; lateral comb a patch of fringed scales.

Group B. ♂: Palp without long bristles dorsolaterally on segment IV; fore and mid tarsal segment IV distinctly shorter than V; coxite with shelf-like basal lobe on basal



Fig. 4.—Distribution of *Chaetocruiomyia* species (capital letter indicates type locality): B, "species B"; C, *calabyi*; E, *elchoensis*; H, *humeralis*; L, *moloienensis*; M, *macmillani*; S, *spinosipes*; T, *tulliae*; W, *wattensis*.

quarter; appendage of harpago of uniform width; phallosome broadest on basal half, apex flattened. Larva: Head seta 12 arising mesial to 13; lateral comb a row of simple spines arising from a sclerotized plate.

Biology. In summary, the following is known of the biology of *Chaetocruiomyia* species: Breeding places are narrow treeholes, 1 inch or less in diameter, 1 ft. (*elchoensis*) to 30 ft. (*tulliae*) above ground. Eggs probably adhere to the sides of these holes. Larvae may be obtained by filling a dry breeding place with water and siphoning it out 24 hours later (*elchoensis*). *A. elchoensis* is mainly a night-biting mosquito; species of Group A usually bite by day, occasionally at night (*tulliae*), from ground level to 30 ft. above ground (*spinosipes*), and will enter houses; they have been taken biting man, dog (*macmillani*) and horse (*tulliae*), resting on a tree trunk (*macmillani*) and in a rabbit warren (*wattensis*). Wild caught females can survive up to two weeks in a laboratory cage (*spinosipes*), feed in captivity on blood and on fruit, and develop mature eggs, but have not been induced to oviposit. Males

have been taken flying with females (*calabyi*, *macmillani*) and in a light trap (*wattensis*).

Distribution (Fig. 4). From the increasing number of records of *Chaetocruiomyia* a distribution pattern begins to emerge, though there are as yet few records from Northern Territory and none from the north of Western Australia.

A. elchoensis is a species of open forests in tropical areas with over 40-inch annual rainfall, and may be sympatric with species of Group A, *tulliae* and *molojiensis*. The evidence suggests, however, that species of Group A may be largely isolated from one another geographically and/or ecologically.

A. calabyi and *wattensis* inhabit areas of less than 30-inch (mostly less than 20-inch) annual rainfall, *calabyi* in the south-west, *wattensis* in the north and east of the continent; they are apparently allopatric, but their ranges approach one another in south-east South Australia and north-west Victoria.

A. macmillani, *molojiensis* and *tulliae* inhabit eucalypt forests of eastern Australia with over 30-inch (mostly over 40-inch) annual rainfall. *A. macmillani* is a cool climate species of the south-east, extending to northern New South Wales only at higher altitudes. *A. molojiensis* ranges from south-east Queensland to the Cairns hinterland; in the south it approaches the range of *wattensis* in the Warwick-Gooniwindi area, and is apparently sympatric with *humeralis* at Eidsvold (*humeralis* may, however, be a monsoon forest species and ecologically isolated); possibly in the north it may be sympatric with *tulliae*, but records of *tulliae* in the Tully-Cairns area are from the coast with over 80-inch rainfall, whereas *molojiensis* is from a locality at higher altitude and with under 60-inch rainfall (some other species of mosquitoes found in south Queensland are known in north Queensland only from the Atherton-Mt. Molloy area). *A. tulliae* occurs in tropical coastal areas from Tully north, and in mountain country on Cape York Peninsula.

Geographically the range of *spinosipes* overlaps that of *tulliae* and *molojiensis*, but *spinosipes* is a rainforest species and ecologically isolated. Nothing is known of the distribution or ecology of "species B".

Acknowledgements.

I am grateful to Dr. B. McMillan and Messrs. D. J. Lee and A. L. Dyce for the loan of specimens and to Messrs. G. Barrow and G. Monteith for assistance in the field.

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OBSERVATIONS ON SOME AUSTRALIAN FOREST INSECTS.

17. TWO NEW SPECIES OF GLYCASPIS (HOMOPTERA: PSYLLIDAE) AND A NOTE ON GLYCASPIS OCCIDENTALIS (SOLOMON).

By K. M. MOORE, Forestry Commission of New South Wales.

(Five Text-figures.)

[Read 25th March, 1964.]

Synopsis.

Two species of *Glycaspis* (*Alloglycaspis*) from South Australia are described and figured. A lectotype male of *Glycaspis occidentalis* (Solomon) is selected, the claspers and aedeagus are figured and label data on all specimens of the type series of this species are given. The host associations and the evolutionary position of the species examined are discussed.

GLYCASPIS (ALLOGLYCASPIS) WANBIENSIS, sp. nov.

The name refers to the type locality of this species: Wanbi Experiment Station, Loxton, South Australia.

General colour: (Dried specimens) pale yellow to yellow, with or without pale brown to brown markings, sometimes with red or green suffusion; abdomen may be suffused pale blue.

Male: Head: width 0.59 mm., yellow, sometimes suffused red; vertex: along suture 0.24 mm., width 0.34 mm.; posterior border with variable brown markings, suture sometimes pale brown; genal processes: length 0.22 mm., deep cream; antennae: length 0.95 mm., segs. 1 to 3 cream, segs. 4 to 7 suffused pale brown, segs. 8 and 9 darker brown, seg. 10 almost black. Pronotum: width 0.49 mm., yellow, with depressions at bases of prominences each side sometimes brown. Prescutum, scutum, scutellum, metascutellum and area between, yellow. Metanotum and post-metanotum, yellow. Abdomen: sometimes with transverse variable brown marking on some segments. Genitalia: yellow suffused pale brown, claspers and aedeagus as in Text-figure 3. Length of aedeagus (13 specimens): Extremes 0.180 mm. to 0.207 mm. Forewing: (Text-fig. 1) length 1.71 mm., width 0.61 mm., venation cream suffused pale brown on the anterior half of wing. Hindwing: Cu_1 as in Text-figure 2. Ventral: pale yellow.

Female: General colour as for the male, but brown markings sometimes darker and more extensive.

Host-plant: *Eucalyptus transcontinentalis* Maiden (morrel).

Type locality: Wanbi Experiment Station, Loxton, South Australia.

Types: Holotype male on slide labelled "Loxton, S.A., 15 iii 1961, N. Stewart. *E. transcontinentalis*", to The Australian Museum, Sydney. Paratypes: 4 slides labelled as above to the Waite Agricultural Research Institute, Adelaide, South Australia, and 2 slides with the same label data to The Australian Museum. Dried specimens: 2 males and 1 female to the Waite Institute, and 1 male and 1 female to The Australian Museum.

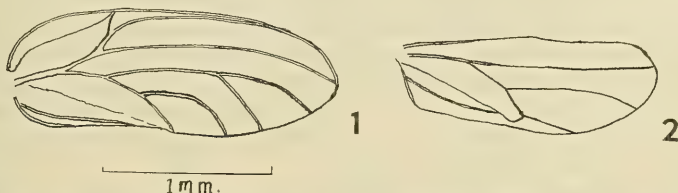
This species is nearest to *G. occidentalis* and can be separated by the claspers and aedeagus of the male.

GLYCASPIS (ALLOGLYCASPIS) REPENTINA, sp. nov.

L. repentinus = giving surprise. Referring to the unexpected occurrence of this species, intermingling with *G. wanbiensis*.

General colour: (Dried specimens) dark brown, or yellow marked with variable amounts of brown. Intergradation in coloration with specimens of *G. wanbiensis* occurs, and the two species usually are not separable on coloration alone.

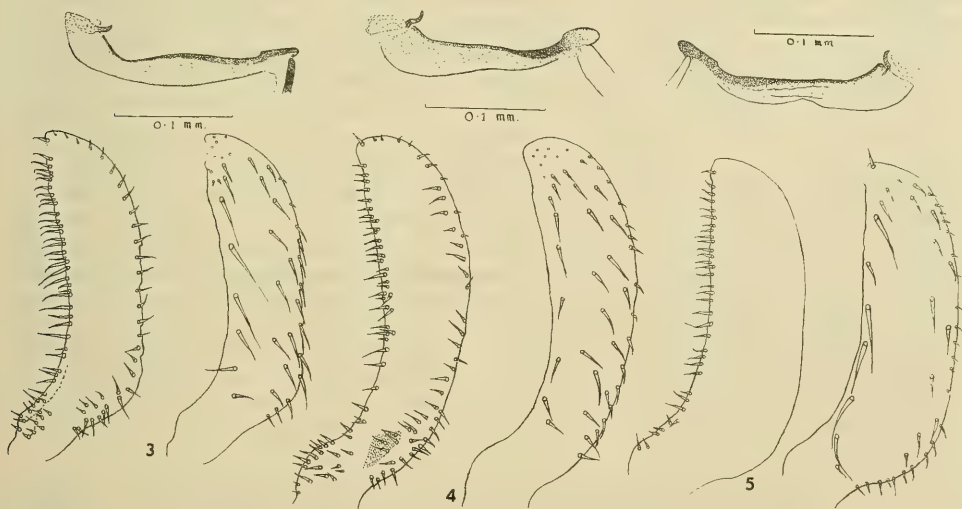
Male: Head: width 0.63 mm., dark brown or yellow suffused pale brown; vertex: along suture 0.27 mm., width 0.39 mm., dark brown, or yellow suffused brown; genal



Text-fig. 1.—Forewing of *Glycaspis (Alloglycaspis) wanbiensis*, sp. nov.

Text-fig. 2.—Hindwing of *Glycaspis (Alloglycaspis) wanbiensis*, sp. nov.

processes: length 0.24 mm., yellow sometimes suffused red, or suffused dark brown with tips paler; antennae: length 1.10 mm., pale to dark brown, with distal segs. darkest. Pronotum: width 0.49 mm., yellow to dark brown. Prescutum: yellow to dark brown. Scutum: yellow suffused brown, sometimes with two brown longitudinal lateral marks each side, or may be all dark brown. Scutellum, metascutellum, metanotum and post-metanotum, yellow suffused pale to dark brown. Abdomen: variable brown transverse marks on most segments. Genitalia: yellow suffused pale



Text-figs 3-5.—Aedeagus and claspers of (3) *Glycaspis (Alloglycaspis) wanbiensis*, sp. nov., (4) *Glycaspis (Alloglycaspis) repentina*, sp. nov., and (5) *Glycaspis (Alloglycaspis) occidentalis* (Solomon). (As claspers overlap and specimens were not cleared during processing, setae on the internal face were not sufficiently distinct to include in Text-fig. 5.)

brown, claspers and aedeagus as in Text-figure 4. Length of aedeagus (15 specimens): Extremes 0.164 mm. to 0.187 mm. Forewing: as in Text-figure 1, length 2.04 mm., width 0.73 mm., venation suffused pale to dark brown. Hindwing: Cu_1 as in Text-figure 2. Ventral: pale yellow suffused pale to dark brown.

Female: General colour as for the male.

Host-plant: *E. transcontinentalis*.

Type locality: Wanbi Experiment Station, Loxton, South Australia.

Types: Holotype male on slide labelled "Loxton, S.A., 15 iii 1961, N. Stewart. *E. transcontinentalis*", to The Australian Museum. Paratypes: 4 slides labelled as above to the Waite Institute, and 2 slides labelled as above to The Australian Museum. Dried specimens: 1 male and 1 female to the Waite Institute.

GLYCASPIS (ALLOGLYCASPIS) OCCIDENTALIS (Solomon).

The type-series of this species was placed in the collection of The Australian Museum, Sydney, during 1938 (personal communication, Solomon, 1961), but this information is not given in the original description of the species. The series consists of 7 microscope slide mounts of 1 male, 2 females, and several nymphs of instars 1 to 5. Two slides (one of a male and one of a female) were labelled "Co-type" and the other female was labelled "Subsidiary Type".

The male specimen has been selected and is here designated as the lectotype. The slide is labelled accordingly, and the remaining slides are each labelled "Paralectotype". The following data are now relevant to the various slides bearing the specimens:

Lectotype: 1 slide labelled "Lectotype. *Glycaspis occidentalis* (Solomon), ♂ (coll. in cop.). (Euparal.) Host—*Eucalyptus gomphocephala*. Perth, W. Aust. Dec. 1935. M. E. Solomon. Australian Museum Register Number, K67767".

Paralectotypes: (a) 1 slide labelled "Paralectotype. *Glycaspis occidentalis* (Solomon), ♀ (coll. in cop.). (Euparal.) Host—*Eucalyptus gomphocephala*. Perth, W. Aust., Dec. 1935. M. E. Solomon. Australian Museum Register Number K67768". (b) 1 slide labelled "Paralectotype. *Glycaspis occidentalis* (Solomon), ♀—used for drawing of leg (right post. leg). (Euparal.) Host—*Eucalyptus gomphocephala*. Perth, W. Aust. Dec. 1935, M. E. Solomon. Australian Museum Register Number K67769". (c) 1 slide labelled "Paralectotype. *Glycaspis occidentalis* (Solomon). Used for published drawing. Young nymphs before secn. of new test. Berlese's fluid. 27 Nov. '35. Australian Museum Register Number K67762". (d) 1 slide labelled "Paralectotype. *Glycaspis occidentalis* (Solomon). Used for published drawing. 2nd instar. Berlese's fluid. 27 Nov. '35. Australian Museum Register Number K67763". (e) 1 slide labelled "Paralectotype. *Glycaspis occidentalis* (Solomon). Used for published drawing. 3rd and 4th instars. Berlese's fluid. 27 Nov. '35. Australian Museum Register Number K67764, K67765". (f) 1 slide labelled "Paralectotype. *Glycaspis occidentalis* (Solomon). 5th instar. Used for published drawing. (Berlese's fluid.) Crawley, W. Aust. 12 Dec. '35. Australian Museum Register Number K67766".

All of the above specimens are in the collection of The Australian Museum, Sydney.

According to data given in the original description of *G. occidentalis*, the series was obtained from four colonies on *E. gomphocephala* A. DC (tuart) in the grounds of the Department of Biology, University, Crawley, Western Australia, here designated the Type-locality.

The claspers and aedeagus of *G. occidentalis* are shown in Text-figure 5. Length of aedeagus (1 specimen), 0.207 mm. Hindwings with Cu, as in Text-figure 2. Other features of the morphology and biology of this species are given by Solomon.

The similarity in coloration of *G. wanbiensis*, *G. repentina* and *G. occidentalis* necessitated the location and examination of existing specimens of Solomon's species. It is now evident that coloration, most morphological features, and even the host associations of some species, are but arbitrary means of separating species within the genus *Glycaspis*, so that a detailed study of the claspers and aedeagus of the males is essential. *G. wanbiensis* and *G. repentina* intermingle on the one plant, and it is assumed that the lectotype and paralectotypes of *G. occidentalis* represent the one species, as only a single male specimen is available. The assumption is probably correct as the lectotype ♂ and paralectotype ♀ are labelled by Solomon as being "collected in cop.", but there must necessarily remain a doubt concerning the other specimens.

DISCUSSION.

From the information supplied by Mr. N. Stewart concerning the habits of *G. wanbiensis* and *G. repentina*, and from their coloration and morphological characteristics, they are closely related to *G. occidentalis*. These three species apparently belong to a separate evolutionary group within the subgenus *Alloglycaspis* and are the only species of the genus at present known to construct lerps on the stems and leaf petioles of their host plant. In future references they will be referred to collectively as the *occidentalis* group of species. The lerps are round in shape, as are those of *G. occidentalis*, and the shape of vein Cu₁ of the hindwing venation of the three species is the same.

When considering the host associations of previously described species of *Glycaspis* (Moore, 1961), it is of interest to note that *E. gomphocephala*, the host plant of *G. occidentalis*, is placed in Section A, Macrantherae, Series viii (Cornutae), and *E. transcontinentalis*, which is the host plant of *G. wanbiensis* and *G. repentina*, in Section H, Platyantherae, Series xliii (subulate), by Blakely (1955).

As the number of rhinaria on the antennal segments of previously described species of *Glycaspis* broadly indicated their evolutionary sequence, the rhinaria of this group were also examined. In the most primitive group (i.e. gall-formers) rhinaria occur on antennal segments 4 to 9; in the intermediate group (i.e. species constructing flat, round or oval lerps) rhinaria occur on segments 4 to 6, 8 and 9; in the most recent group (i.e. species constructing rectangular lerps) rhinaria occur on segments 4, 6, 8 and 9.

Rhinaria on the antennae of the *occidentalis* group of species occur on segments 4 to 6, 8 and 9, but that on segment 5 is atrophied. From the antennal rhinaria, the feeding habits of the species and the shapes of their lerps, the group is regarded as having diverged, probably at an early stage of the evolutionary sequence within the genus, from the intermediate group of species within the subgenus *Alloglycaspis*.

Acknowledgements.

The writer is grateful to Dr. J. W. Evans, Director, and Mr. C. N. Smithers, Curator of Insects, of The Australian Museum, Sydney, for the loan of the type series of *G. occidentalis*, and to Mr. M. E. Solomon of the Agricultural Research Council, Slough, Bucks., England, for information concerning the location of the specimens. Thanks are also expressed to Mr. N. Stewart of the Waite Agricultural Research Institute, Adelaide, and Mr. K. L. Taylor of the C.S.I.R.O. Tasmanian Regional Laboratory, for providing the material of the two new species together with information on their habits.

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CONTRIBUTIONS ON PALAEOZOIC FLORAS. 1.

ON THE IDENTIFICATION OF GLOSSOPTERIS CORDATA DANA.

By J. F. RIGBY, Geology Department, Newcastle University College,
Tighe's Hill, N.S.W.

(Plate i.)

[Read 25th March, 1964.]

Synopsis.

A neotype for *Glossopteris cordata* Dana has been selected. *Glossopteris feistmantelii*, nom. nov., is proposed to describe specimens of *G. cordata* Feistmantel *non* Dana described from India and South Africa.

GLOSSOPTERIS CORDATA Dana.

1849. *Glossopteris* ? *cordata* Dana in Wilkes' U.S. Exploring Expedition, vol. 10, p. 718, Pl. 13, fig. 5.
 1880. *Glossopteris cordata* in Feistmantel, *J. roy. Soc. N.S.W.*, 14: 115, 107.
 1883. *Glossopteris cordata* in Tenison-Woods, *PROC. LINN. Soc. N.S.W.*, 8 (1): 124 and footnote.
 1890. *Glossopteris cordata* in Feistmantel, *Mem. geol. Surv. N.S.W.*, Pal. 3: 124.
 1904. *Glossopteris nephroidicus* Etheridge, *Rec. geol. Surv. N.S.W.*, 7 (4): 315-316, Pl. lviii, lix, fig. 1, 2.

Not Recognized as belonging to this Species.

1882. *Glossopteris cordata* Feistmantel, *Flora. gondw. Syst.*, 4 (1): 35, Pl. XXA, fig. 1.
 1932. *Glossopteris cordata* in du Toit, *Ann. Sth. Afr. Mus.*, 28 (4): 378-381, text-fig. 1A-D.

The type specimen of Dana, originally housed in the U.S. National Museum, Washington, has been lost (du Toit, 1932, and confirmed by Mamay, pers. comm.). The locality was given as "District of Illawarra".

The type specimens of *Glossopteris nephroidicus* Etheridge are housed in the Mines Department Museum, Sydney, N.S.W., and bear the numbers 2878 and 2883 (with its counterpart 2884). These specimens came from the foot of Mount Kembla. They have been relabelled *Glossopteris cordata* Dana, possibly by Dun.

It is impossible to determine the exact position of either locality, but specimens attributable to this species are common in and below the Unanderra Seam near Mount Kembla and Mount Keira. It is suggested that Dana's specimen was an imperfect specimen of the same species as Etheridge described as *Glossopteris nephroidicus*. It is proposed that one of these specimens should now become the neotype for the species, viz., No. 2883. This specimen was illustrated by Etheridge (1904) as Plate lviii. Plate i shows the counterpart, No. 2884, of the leaf selected. The venation is clear on this photograph, but was not clear in Etheridge's photographs. This venation differs from that of his Plate lix, fig. 2. The specimen he illustrated as Plate lix, fig. 1, bears the number 2878.

Amended diagnosis.

Broadly elliptical leaf, obtuse to broadly rounded apex, margin entire, possibly slightly thickened and recurved, base cordate, auriculate lobes overlap petiole when

the leaf is fully expanded. Midrib stout at base, virtually indistinguishable from secondary venation at apex, longitudinally ribbed, fibres of midrib anastomosing. Secondary venation dichotomous, anastomosing with meshes approximately four times as long as broad. Secondary venation curves away from the midrib over a distance of 1 or 2 meshes, then runs straight to margin. Angle venation makes with margin 90° towards apex, decreasing to 80° at base of auriculate lobes, between base of lobes and petiole angle decreases rapidly to 20° and veins become arcuate. Petiole broad with decurrent blade, particularly in smaller specimens. Cuticle could not be prepared.

Description.

Counterpart, Pl. 1. ($\times \frac{3}{4}$.) No. 2884, Mines Dept. Mus., Syd., N.S.W. Length along midrib 98 mm. Length including auricles 112 mm. Maximum breadth 80 mm. half-way along midrib. Width of midrib at base of blade 3.5 mm. Density of secondary venation 1 cm. from midrib, and away from the apex: 10 per cm. Density of secondary venation at margin, but not along lobes: 20 per cm. Length of areoles at 1 cm. from midrib 4–5 mm. Length of areoles at 1 areole removed from margin 1.5–2 mm.

The venation of this leaf is identical with that described from the specimen of Dana where they were “nearly 4 to a line in breadth”. His other characters (Dana, 1849, p. 718) also accurately describe the specimen illustrated below. His figure appears to be more diagrammatic than accurate as the measurement given above does not coincide with that measured from the figure (Dana, 1849, Pl. 13, fig. 5). He thought that “the frond was probably quite broad for its length”. His locality was given as “District of Illawarra”.

Arber (1905) included *Glossopteris cordata* Dana in *Glossopteris ampla* Dana. He described Dana's specimen as “simply a basal portion of a frond of (*G. ampla*)”. This is not admissible as the base of *Glossopteris ampla* is tapering (see Dana, 1849, Pl. xiii, fig. 1a).

Etheridge (1904) described a number of leaves from the foot of Mount Kembla, Illawarra district, as *Glossopteris nephroëidicus*. He justified its separation from *Glossopteris cordata* Dana in these words: “In Dana's figure the basal margin does appear to be incurved on each side (of) the mid-rib, but a little consideration will convince the observer that this is simply a fractured edge”, even though Dana (1849, p. 718) had considered and discounted this.

In 1882 Feistmantel (p. 34, Pl. XXA, fig. 1) described *Glossopteris cordata*, sp. nov. I consider that it is quite clear from his description that he had forgotten that the trivial epithet was occupied. I propose that this species be re-named *Glossopteris feistmantelii*, nom. nov., in his honour. His description as given should stand as the description of *Glossopteris feistmantelii*.

Arber (1905, p. 49) listed ? *G. cordata* Feistmantel (*non* Dana) in the synonymy of *Glossopteris browniana* Brongniart. Arber (1905, pp. 52–53) stated: “In any case Feistmantel's specific name is inadmissible, since it had previously been used by Dana.”

du Toit (1932) discussed the inclusion of some specimens from near the Inhluzani Mountain, Natal, in *Glossopteris cordata* Feistmantel *non* Dana. He was inclined to regard *Glossopteris nephroëidicus* Etheridge and *Glossopteris cordata* Feistmantel “as most probably stages in the development of the same species or at most as mere varieties thereof”. On page 38, du Toit thought that in the Natal leaves “the auriculation is essentially a juvenile character and that it becomes less prominent with age, being accompanied by corresponding changes in the outline of the frond and also in the course of the venation”. This is clearly illustrated in his Text-fig 1, A–D (p. 379), and Plate XXA, fig. 1, of Feistmantel (1882).

This differs markedly from the development of the auriculation in *Glossopteris cordata* Dana (syn. *nephroëidicus* Etheridge) where it becomes stronger with age. The leaf shape in *Glossopteris cordata* becomes increasingly broadly elliptical whereas in *Glossopteris feistmantelii* it becomes oblong.

GLOSSOPTERIS FEISTMANTELI, *nom. nov.*

1882. *Glossopteris cordata* Feistmantel, *Palaeont. indica. Flora gondw. Syst.*, 4 (1): 35, Pl. XXA, fig. 1.

1932. *Glossopteris cordata* in du Toit, *Ann. Sth. Afr. Mus.*, 28 (4): 378-381, text-fig. 1, A-D.

Type specimen. Geological Survey of India Museum, Calcutta.

Diagnosis. As given by Feistmantel (1882, p. 35).

Distribution. Raniganj group of South Rewah (Feistmantel, 1882), Lower Beaufort beds of Natal (du Toit, 1932).

Acknowledgements.

Grateful acknowledgement is made to Mr. H. Whitworth, Curator, Mining Museum, Sydney, for the loan of specimen No. 2884. Mr. F. Zabrana, Newcastle University College, photographed the specimen. Dr. Beryl Nashar, Newcastle University College, read the manuscript and made suggestions for its improvement.

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EXPLANATION OF PLATE I.

Glossopteris cordata Dana; the entire leaf on the upper right is the counterpart of the neotype. $\times \frac{1}{2}$.

THE *ULYSSES* SPECIES-GROUP, GENUS *HAEMOLAE LAP S*
(ACARINA, LAELAPIDAE).

By ROBERT DOMROW, Queensland Institute of Medical Research, Brisbane.

(Fifteen Text-figures.)

[Read 29th April, 1964.]

Synopsis.

The following stages of a complex of three species of *Haemolaelaps* parasitic on Australian marsupials are described—the female of *H. penelope*, n. sp., from *Trichosurus caninus* (Phalangeridae); the female, male and deutonymph of *H. ulysse s* Domrow from *Pseudocheirus laniginosus* and *Schoinobates volans* (Phalangeridae); and the female, male and deutonymph of *H. telemachus*, n. sp., from *Antechinus flavipes* and *A. stuarti* (Dasyuridae).

Since Strandtmann's fine work (1949) on the American species of *Haemolaelaps* Berlese, three important keys to the Laelapinae have been published: Strandtmann and Wharton (1958), Tipton (1960) and Zumpt and Till (in Zumpt *ed.*, 1961). The three species discussed below key out to *Haemolaelaps* in all of them. Further, they fit Till's later (1963) and broader concept of *Androlaelaps* Berlese (including *Haemolaelaps*) in all aspects, even to the typical formulae given for the pedal and palpal setation.

From Till's key, since femora II in the female have only simple setae on their ventral surface, the present species would fall in *Haemolaelaps* s.s., the type species of which—*H. marsupialis* Berlese, 1910, from an Australian marsupial bandicoot (Peramelidae)—has been well redescribed by Keegan (1956) with *camera lucida* figures from the Berlese collection in Florence. Womersley (1955, 1958) and Domrow (1961, 1963) have since described a further four species in the *marsupialis* species-group, all except one of which are parasites of Australian marsupials.

The characters which might exclude the present species from *Haemolaelaps* s.s. are fourfold. Firstly, seta s3 on the dorsal shield is regularly absent. Secondly, the anterior seta on coxae II and III is expanded and hyaline in two of them (yet normal in the third). Thirdly, the femora and trochanters of the legs may bear one or two apically notched setae. Fourthly, one of the palpal trochanteral setae is foliate (as, incidentally, in *Andreacarus petersi* Radford, see Clifford and Keegan, 1963). However, Till (1963) lists many setal types for *Androlaelaps* s.l., and it therefore still seems preferable, at this stage, to place the following three species in *Haemolaelaps*. They may be assigned to the *ulysses* species-group.

Key to species of ulysse s species-group (genus Haemolaelaps).

- | | |
|--|----------------------------|
| 1. Adults | 2. |
| Deutonymphs | 6. |
| 2. Females | 3. |
| Males | 5. |
| 3. Anterior seta on coxae II and III normal, filiform. On <i>Trichosurus caninus</i> .. | <i>penelope</i> , n. sp. |
| Anterior seta on coxae II and III expanded, hyaline | 4. |
| 4. Larger species, idiosoma 810-850 μ long in type series, and about 900 μ in series from <i>S. volans</i> . Anal shield only slightly wider than long. Anterodorsal seta on trochanter IV apically notched. First taken from <i>Pseudocheirus laniginosus</i> , and three times since on <i>Schoinobates volans</i> | <i>ulysses</i> Domrow. |
| Smaller species, idiosoma 660-700 μ long. Anal shield decidedly wider than long. Anterodorsal seta on trochanter IV normal. Many records from <i>Antechinus</i> | <i>telemachus</i> , n. sp. |

5. Dorsal shield with distinct lateral bands of longitudinal striae. Holoventral shield with four pairs of usurped ventral setae; sternal, metasternal and genital setae reaching far beyond insertions of subsequent pair. Terminal body setae far exceeding outline of body *ulysses* Domrow.
Dorsal shield without definite lateral bands of longitudinal striae. Holoventral shield with three pairs of usurped ventral setae; sternal, metasternal and genital setae not reaching beyond insertions of subsequent pair. Terminal body setae scarcely exceeding outline of body *telemachus*, n. sp.
6. Anterior half of dorsal shield with 15 or 16 pairs, and posterior half with 20 pairs of setae. Metasternal setae on sternal shield. Anal shield as wide as long *ulysses* Domrow.
Anterior half of dorsal shield with 21 pairs, and posterior half with 16 or 17 pairs of setae. Metasternal setae off sternal shield. Anal shield wider than long *telemachus*, n. sp.

HAEMOLAE LAP S PENELOPE, n. sp. (Figs 1-3).

Type Material.—Holotype female and three paratype females from the mountain brush-tailed possum, *Trichosurus caninus* (Ogilby) (Phalangeridae), rainforest 2000', Mt. Glorious, S.E. Queensland, 7.xi, 13.xi and 6.xii.1962, I. D. Fanning and R.D. Holotype in National Insect Collection, CSIRO, Canberra; paratypes in School of Public Health and Tropical Medicine, Sydney, and QIMR.

Female.—Idiosoma 775-825 μ long, almost entirely covered by dorsal shield. Posterior half of shield, as well as anterolateral margins, reticulate, but anterior half of disc virtually textureless. Forty pairs of short setae and numerous paired pores (including one very strong posterolateral pair) present. Marginal cuticle without setae.

Sternal shield preceded by striate cuticle; surface generally with stippled punctae, but few weak striations in anterolateral corners beyond SI. Three pairs of short subequal setae and two pairs of pores on shield. Metasternal setae and pores free in cuticle. Genital shield expanded behind coxae IV, with anterolateral margins sinuous and posterior margin ever so slightly concave. Surface marked with striae as figured. Genital setae on shield, and three pairs of ventral setae very near (occasionally touching) lateral margins (pattern of setae on right hand side typical). Anal shield wider than long, marked anterolaterally, and with anus slightly in front of centre. Adanal setae set near centre of anus, rather weaker than postanal seta. Crigrum present. Metapodal shields elongate, bean-shaped, with minute sclerotization in from anterior angle. Ventral cuticle with about 40 pairs of setae, the posterior ones quite spinose. Peritremes reaching forward almost to anterior margin of coxae I. Peritremal shield not extended posteriorly far behind stigmata, nor fused to exopodal shield IV.

Legs. Coxal formula 2.2.2.1, all setae slender and unexpanded. Anterodorsal margin of coxa II with weak process. Bifurcate setae present dorsally on same segments as in *ulysses* except trochanter IV, where all setae are simple.

Gnathosoma essentially as in *ulysses*.

HAEMOLAE LAP S ULYSSES Domrow (Figs 6-10).

Haemolaelaps ulysses Domrow, 1961, PROC. LINN. SOC. N.S.W., 86: 63, figs 3-5.

Material Examined.—From the greater glider-possum, *Schoinobates volans* (Kerr) (Phalangeridae), twenty-one females, Brindabella Range, Australian Capital Territory, xi.1961, J. H. Calaby; nine females, Glenaladale, 23 m. W Bairnsdale, Victoria, 7.ix.1962, R. M. Warneke; eighteen females, thirteen males and one deutonymph, Cumberland, E of Marysville, Vic., 25.ix.1963, R.M.W. (The type series is from another phalangerid, the ring-tailed possum, *Pseudocheirus laniginosus*,* Victoria.)

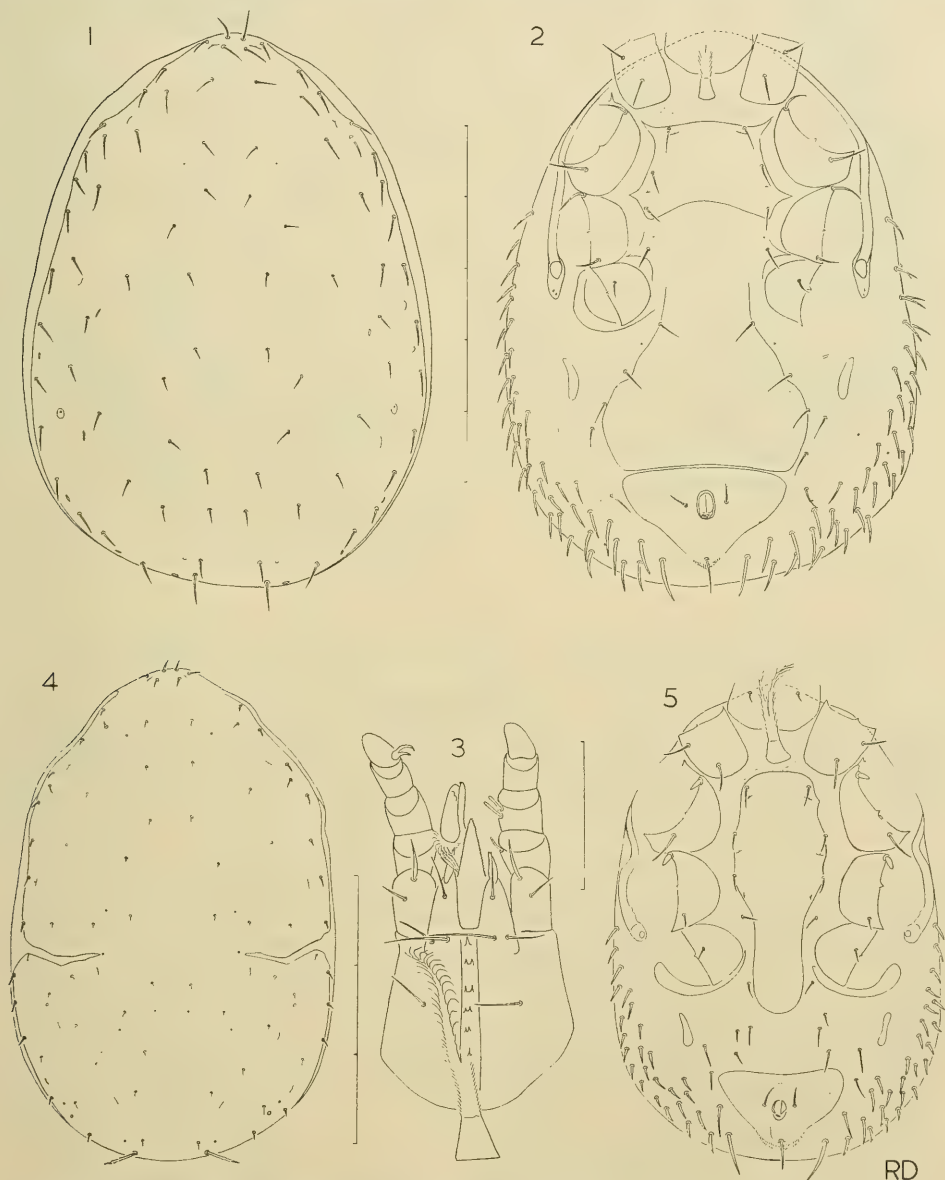
Female.—Strip of dorsal shield between marginal and submarginal setae (i.e. about one-sixth of total width on each side) reticulate, but not closely and longitudinally striate as in male; markings stronger from vertex to shoulders, weaker laterally, but

* This latter possum is also the type host of *Trichosuroaelaps striatus* Domrow, 1958, eight females of which were likewise present on the specimen of *S. volans* from Cumberland. Similar double infestations have been noted on two *S. volans* at Esk, Qld., 8.ii.1964, R.D., I.D.F. and J. S. Welch.

extending back almost to subterminal pair of setae. Disc virtually textureless. Distinct pore present posterolaterally in position shown for male.

Sternal shield with weak reticulation anterolaterally between pores I and margin. Two zones of long curved striae between sternal shield and tritosternal base. Palpal femur with truncate, distally hyaline seta similar to pair shown on inner face of genu.

My original statement "femora I & II without elongate setae dorsally" is misleading—two such setae are present on each of these segments, but they are also apically bifurcate and therefore treated later in the same paragraph. Femur III and



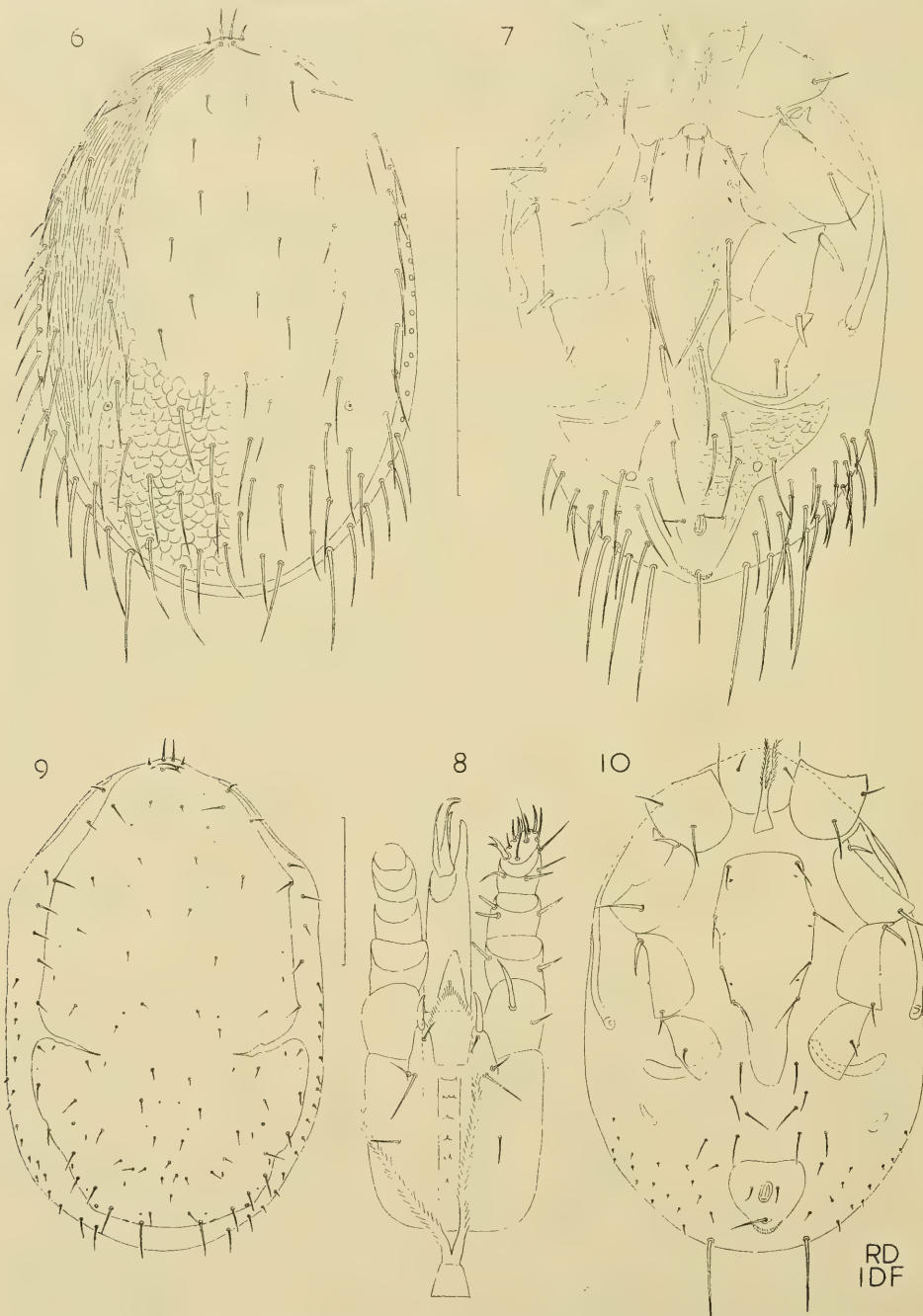
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Text-figs 1-3.—*Haemolaelaps penelope*, n. sp. Female.—1 and 2, Dorsal and ventral surfaces of idiosoma; 3, Ventral surface of gnathosoma.

Text-figs 4-5.—*Haemolaelaps telemachus*, n. sp. Deutonymph.—Dorsal and ventral surfaces of idiosoma. (Each division on the scales = 100 μ .)

trochanter IV each bear one, and femur IV two such setae dorsally. The remainder of the leg setation, apart from the anterior seta on coxae II and III, is normal.

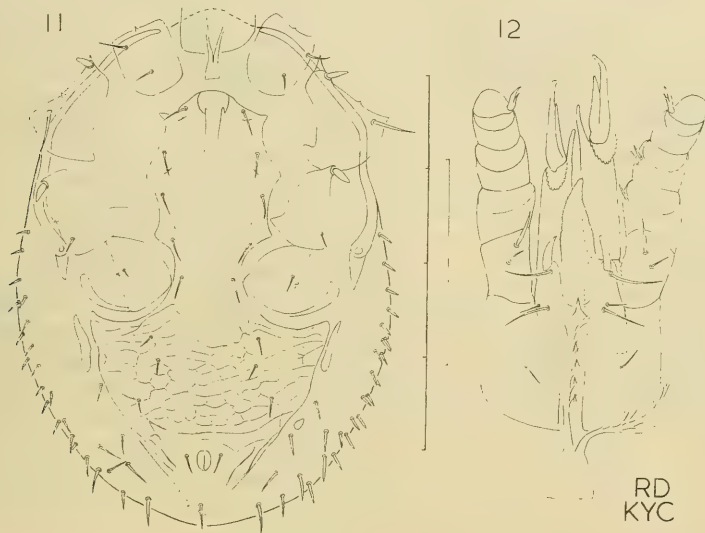
Male.—Idiosoma of nine specimens 759–825, av. 790 μ long. Dorsal shield with areas of three differing textures—anterolateral band closely and longitudinally striate; mid-



Text-figs 6-10.—*Haemolaelaps ulysses* Domrow. 6-8, Male; 9-10, Deutonymph.—6 and 7, Dorsal and ventral surfaces of idiosoma; 8, Ventral surface of gnathosoma; 9 and 10, Dorsal and ventral surfaces of idiosoma. (Each division on the scales = 100 μ .)

anterior virtually textureless; mid-posterior with reticulate striae. Very strong pore posterolaterally, and many weaker ones elsewhere. Dorsal setae arranged in 40 pairs, much stronger than in female, especially posteriorly. Dorsal marginal cuticle with about sixteen pairs of setae increasing in length posteriorly.

Holovenral shield with reticulate striae as figured. Genital aperture just in front of SI, preceded by zone of striate cuticle. Sternal, metasternal and genital setae very much stronger than in female, with SI barely half as long as remainder. Three pairs of sternal and metasternal pores present. Ventral area expanded behind coxae IV, with slender usurped setae arranged 4·4 (4·3 in one specimen). An unpaired fenestration appears posterolaterally in ventral area of one mite, and two paired ones (as



Text-figs 11-12.—*Haemolaelaps telemachus*, n. sp. Male.—11, Ventral surface of idiosoma; 12, Ventral surface of gnathosoma. (Each division on the scales = 100 μ .)

figured) in another. Anal area much as in female. Metapodal shields absent. Peritremes extending forward almost to anterior margin of coxae I. Peritremal shields very weak, not at all extended posteriorly to meet exopodal shields IV, which latter in some specimens appear to fuse with holovenral shield between coxae IV. Ventral cuticle with about 20 pairs of slender setae, posterior pairs particularly long.

Leg setation, including bifurcate setae, essentially as in female.

Gnathosoma also essentially as in female. Basal segment of chelicerae about one-third of total length. Central segment with virtually edentate fixed digit and trace of corona. Third segment comprising weak movable digit, which is virtually obscured by longer, seemingly tubular spermatophore-carrier.

Deutonymph.—Idiosoma 714 μ long. Dorsal shield virtually textureless, incised midlaterally. Anterior half with fifteen setae on one side and sixteen on other; posterior half with 20 pairs of setae, posterior discals being unevenly arranged. System of paired pores present. Marginal cuticle with about 20 pairs of setae. Peritremes as in female.

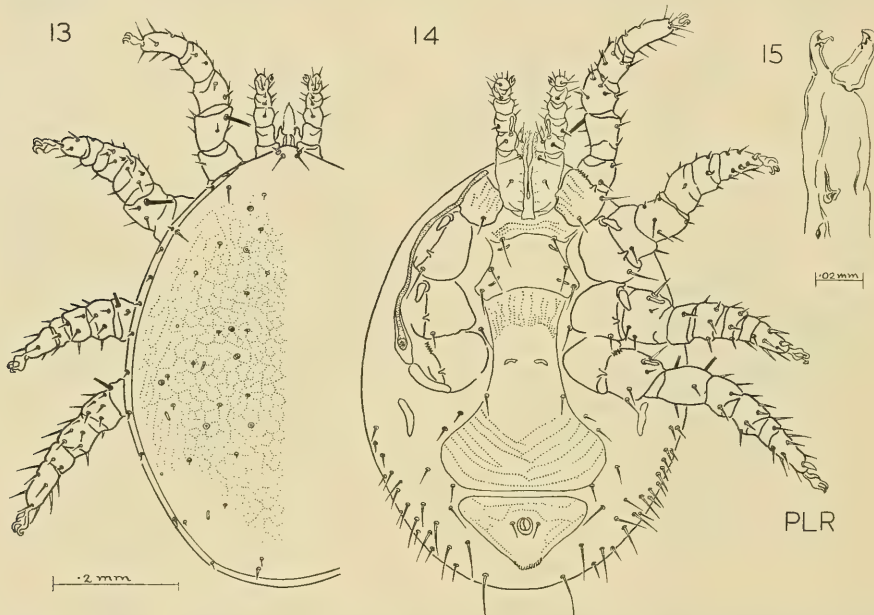
Sternal shield extending from anterior margin of coxae II to posterior margin of coxae IV; narrower, ligulate in posterior third; faintly striate. Four pairs of slender setae and three pairs of pores (sternal and metasternal series) present on shield. Future genital pair free in cuticle between coxae IV, and followed by two rows of four similar setae. Anal shield rather more rounded, but much as in female. Meta-

podal shields present. Ventral cuticle with about fifteen pairs of small setae, and one pair of very strong setae posteriorly.

Legs and gnathosoma essentially as in female.

HAEMOLAEALAPS TELEMACHUS, n. sp. (Figs 4, 5, 11-15).

Type Material.—Holotype female, allotype male, four paratype females, three paratype males and one morphotype nymph, Glenlofty, Victoria, 15.vii.1962, R. M. Warneke, from the yellow-footed marsupial mouse, *Antechinus flavipes* (Waterhouse) (Dasyuridae).



Text-figs 13-15.—*Haemolaelaps telemachus*, n. sp. Female.—13 and 14, Dorsal and ventral surfaces; 15, Chelicera in lateral view. (Scales as indicated.) (Except for one point, I have not retouched these figures in any way. The dorsal shield actually takes in all the setae shown on the marginal cuticle. Three pairs of vertical setae are present as is usual, and an additional two pairs, whose bases I have indicated by circles, are normally present in the submarginal series. The metasternal and anal complexes are detailed in the text. Coxa II with process on anterodorsal margin. Outer posterior hypostomal setae present.)

Also four paratype females, Ben Nevis, Vic., 20.iii.1962, A. L. Streefkeek; two paratype females, 8 m. from Buchan, Buchan-Bruthen Road, Vic., 11.iv.1962, R.M.W.; thirteen paratype females and three paratype males, Tommy's Bend, 6 m. E Marysville, Vic., 20.v.1962, R.M.W.; one paratype female, Cathedral Range, Vic., 17.vi.1962, R.M.W.; seven paratype females, Timbarra, Vic., 15.iv.1963, R.M.W.; and one paratype female, Murrumbateman, N.S.W., 26.v.1962, R.M.W., all from *A. stuarti* Macleay.

Holotype and allotype NIC; paratypes British Museum (Natural History), U.S. National Museum, SPHTM and QIMR.

Female.—Idiosoma 660-700 μ long, almost entirely covered by dorsal shield. Shield striate anterolaterally, but disc marked with punctae in distinct hexagonal pattern; also with regularly arranged system of pores. Thirty-eight pairs of setae normally present on shield; discals extremely weak.

Sternal shield preceded by biconvex striations, virtually textureless except for striae in extreme anterolateral angles. Anterior margin convex, posterior margin concave; with usual six setae and four pores. Metasternal complex represented by

seta, pore and shieldlet. Genital shield greatly expanded behind coxae IV, rectilinear posteriorly; with one pair of genital setae and striations in characteristic chevron arrangement. Anal shield wider than long, striate except behind anus; cribrum present. Anus centrally placed, flanked by adanal setae, and followed by postanal seta twice as strong as adanals. Elongate metapodal shields present. In addition to three pairs closely flanking genital shield, ventral cuticle with about 22 pairs of setae, which are more spinose than figured. Peritremes reaching forward to anterior margin of coxae I; peritremal shield not fused to exopodal shield IV.

Legs. Coxal formula 2.2.2.1, anterior seta on coxae II and III expanded and hyaline, as is one seta on trochanters III and IV. Coxa II with small spinose process on anterodorsal margin. Femora I-IV with one, and femur IV with two apically notched setae dorsally. Seta on anterodorsal face of trochanter IV normal. Other leg setation undistinguished except for one or two stronger setae on tarsi II-IV.

Male.—Idiosoma 528–550 μ long. Dorsum as in female. Holovenral shield striate only on expanded ventral area behind coxae IV. Intercoxal area with usual five pairs of setae and three pairs of pores. Ventral area with three pairs of usurped setae. Anal area as in female, but postanal seta relatively weaker. Ventral cuticle with about 26 pairs of spinose setae.

Legs and gnathosoma essentially as in female. Deutosternum with five single denticles. Fixed digit of chelicerae obsolescent. Spermatophore-carrier slightly curved distally, somewhat longer than movable digit.

Deutonymph.—Idiosoma 550 μ long. Dorsal shield of same texture as adult, but incised unilaterally. Anterior half with 21 pairs of setae; posterior half with 16–17 pairs, terminal pair strongest.

Sternal shield textureless. Anterior half wider, bearing six setae and six pores; posterior half evenly ligulate, flanked by four setae. Ventral cuticle with about 32 pairs of spinose setae.

Otherwise essentially as in female.

Acknowledgements.

I am most grateful to Dr. Winifred M. Till for her comments, to Dr. Phyllis L. Robertson for Figs 13–15, and to Messrs. I. D. Fanning and Koong Yue Cheong for their assistance with some of the others. Figs 11 and 12 were prepared while I was on leave at the Institute for Medical Research, Kuala Lumpur, supported by U.S. Public Health Service Research Grant AI-03793-03 (formerly E3793) from the National Institute of Allergy and Infectious Diseases. Mrs. J. W. Phillips and Miss B. Nolan have typed my manuscript with their usual care.

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Corrigenda.

I am grateful to Mr. R. M. Warneke, who is working on the genus *Antechinus*, for allocating many animals previously assigned to *A. flavipes* to their proper place. The following corrections to mite hosts are necessary in three earlier papers in these PROCEEDINGS. Throughout Vol. 80, Part 3, pp. 201-6 (1956), read *A. stuarti* for *A. flavipes*. In Vols. 86, Part 1, p. 71 (1961) and 88, Part 2, p. 214 (1963), the marsupial mice from Nambour, Mt. Glorious, Pearl Beach, Picton, Tuggolo, Gelantipy, Mt. Clay, Ben Nevis, Buchan and Cathedral Range are all *A. stuarti*, not *A. flavipes*.

OBSERVATIONS ON SOME AUSTRALIAN FOREST INSECTS.

18. FOUR NEW SPECIES OF GLYCASPIS (HOMOPTERA: PSYLLIDAE) FROM QUEENSLAND.

By K. M. MOORE, Forestry Commission of New South Wales.

(Eight Text-figures.)

[Read 29th April, 1964.]

Synopsis.

Specimens of the genus *Glycaspis* in the collections of the Department of Primary Industries, Brisbane, the Queensland Museum, Brisbane, and the Bernice P. Bishop Museum, Honolulu, Hawaii, were examined, and four new species are described.

The preparation of specimens, the procedure for the descriptions and the scale of drawings are the same as for previous specimens (Moore, 1961). Setae are drawn to scale, and the following descriptions are based on dried specimens.

GLYCASPIS (ALLOGLYCASPIS) BRIMBLECOMBEI, sp. nov.

Named after Dr. A. R. Brimblecombe of the Department of Primary Industries, Brisbane, who collected the type specimen.

General Colour: Variable; yellow, pale yellow or lemon yellow and either with or without brown and black markings and red suffusion.

Male: Head: width 0.68 mm.; vertex: along suture 0.32 mm., width 0.37 mm., cream, with red anteriorly and laterally, foveae pale brown, suture and posterior aspect

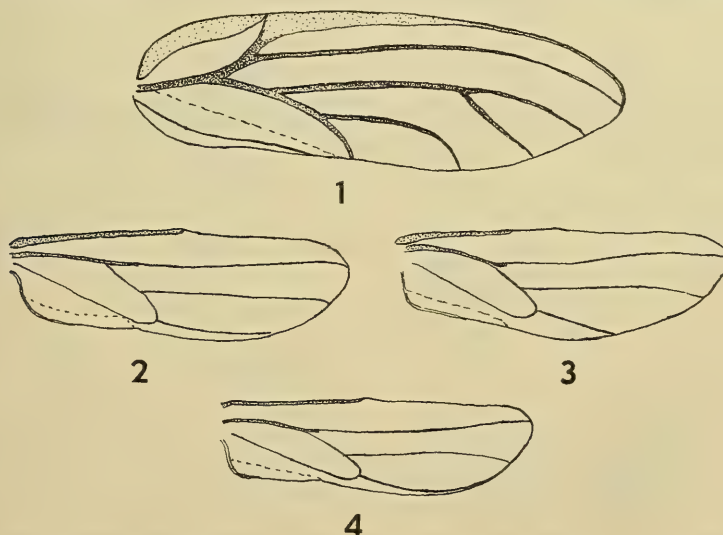
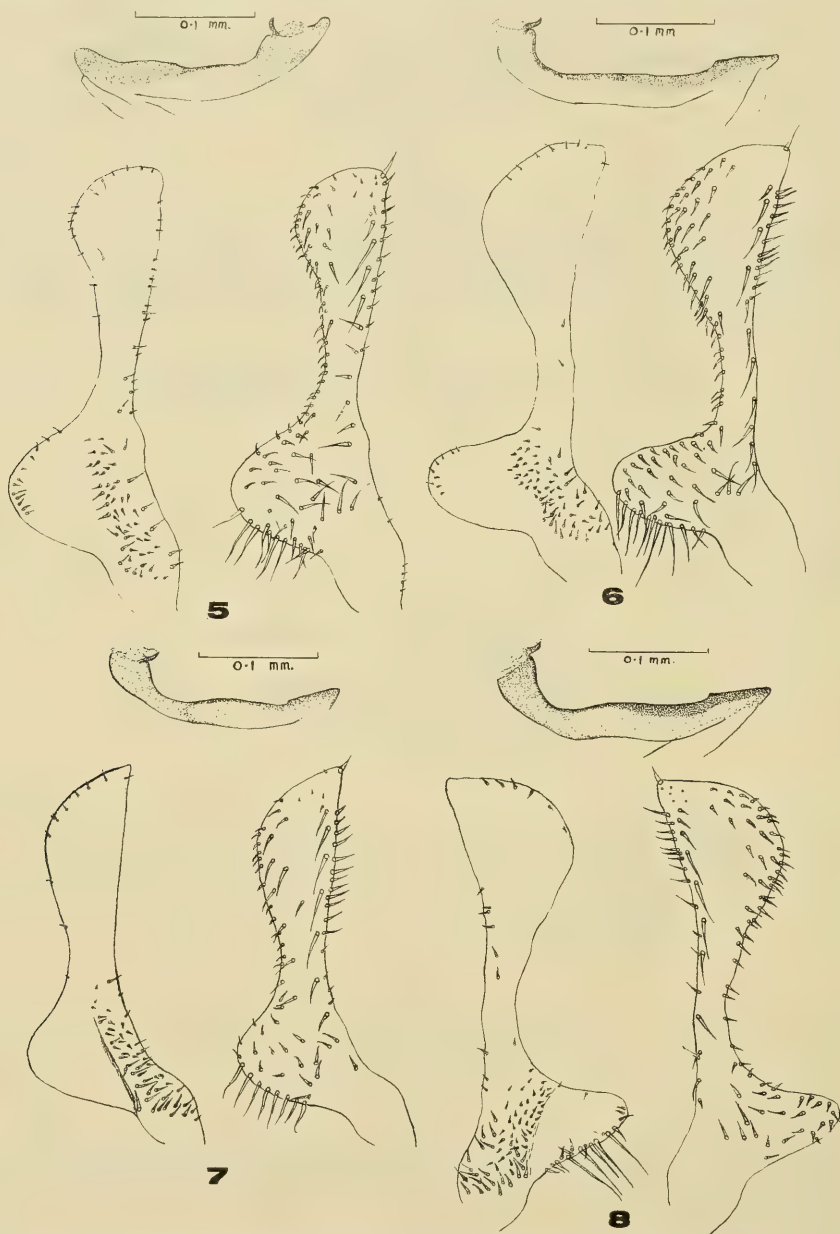


Fig. 1.—Typical forewing venation of *Glycaspis* (*Alloglycaspis*) spp.

Figs 2, 3 and 4.—Typical hindwing venation of *Glycaspis* (*Alloglycaspis*) spp. showing variation in shape of Cu_1 .

of head brown or black; genal processes: length (from tips to anterior edge of antennal foveae) 0.34 mm., widely divergent, cream suffused red dorsally; antennae: length 1.51 mm., segs. 1 to 3 cream, segs. 4 to 8 darkening from pale brown to dark brown, segs. 9 and 10 black. Pronotum: width 0.54 mm., cream with foveae pale brown, depressions at bases of lateral prominences black, median suture pale brown.

Prescutum: suffused brown. Scutum: median longitudinal area whitish, remainder pale yellow. Scutellum: pale cream. Metanotum: pale brown laterally. Post-metanotum: yellow, with a dark brown area each side toward anterior border.



Figs 5-8.—Aedeagus and claspers of (5) *Glycaspis brimblecombei*, sp. nov., (6) *Glycaspis ochros*, sp. nov., (7) *Glycaspis hackeri*, sp. nov., (8) *Glycaspis mesicola*, sp. nov.

Abdomen: yellow, with a transverse central pale brown stripe on each of segs. 1 to 4; other segments cream. Legs cream. Genitalia: claspers and aedeagus as in Text-figure 5. Length of aedeagus (3 specimens): Extremes 0.214 mm. to 0.225 mm. Forewing: length 2.80 mm., width 0.85 mm., venation pale yellow with darker yellowish suffusion toward posterior one-third. Hindwing: Cu₁ as in Text-figure 2.

Female: General colour as for the male, but dark marks more intense and extensive, and often suffused red; anal aperture bordered black at outer posterior angles.

Host-plant: *Eucalyptus* sp. (blue gum).

Type Locality: Brisbane, Queensland.

Types: Holotype male on slide labelled "Brisbane, 25 v 1936, A. R. Brimblecombe. Host, blue gum", deposited with the Queensland Museum, Brisbane. Paratypes: 1 slide labelled as above, to the Queensland Museum; 1 slide labelled "Brisbane, 21 x 1925, Host, blue gum", to The Australian Museum, Sydney. Dried specimens: 3 females to the Queensland Museum, 1 female to The Australian Museum.

This species appears to be nearest to *G. (A.) baileyi*, but is separable by the colouring, and the male claspers and aedeagus.

GLYCASPIS (ALLOGLYCASPIS) OCHROS, sp. nov.

Gr. ochros = pale.

General Colour: Pale yellow; black markings absent.

Male: Head: width 0.68 mm.; vertex: along suture 0.32 mm., width 0.39 mm., pale yellow; genal processes: length 0.34 mm., cream; antennae: length 1.68 mm., segs. 1 to 4 pale cream, segs. 5 to 8 suffused pale brown, segs. 9 and 10 dark brown. Pronotum: width 0.49 mm., pale yellow. Prescutum and scutum yellow. Scutellum and metascutellum cream. Metanotum and post-metanotum, yellow. Abdomen: pale yellow suffused pale blue-green. Legs cream. Genitalia: claspers and aedeagus as in Text-figure 6. Length of aedeagus (4 specimens): Extremes 0.232 mm. to 0.248 mm. Forewing: length 2.41 mm., width 0.78 mm., venation cream suffused pale brown. Hindwing: Cu_1 as in Text-figure 4.

Host-plant: Not known.

Type Locality: Brisbane, Queensland.

Types: Holotype male and allotype female on slide labelled "K. Grove, Em. 10 x 1908", deposited with the Queensland Museum, Brisbane. Paratypes: 1 slide labelled as above to The Australian Museum, Sydney.

This species appears to be nearest to *G. (A.) australoraria*, but is separable by the male claspers and aedeagus.

GLYCASPIS (ALLOGLYCASPIS) HACKERI, sp. nov.

Named after the collector of these specimens, Mr. H. Hacker.

General Colour: Pale greenish-yellow.

Male: Head: width 0.66 mm.; vertex: along suture 0.32 mm., width 0.37 mm.; genal processes: length 0.32 mm.; antennae: length 1.68 mm., segs. 1 and 2 greenish-yellow, segs. 3 to 8 darkening from pale brown to dark brown, segs. 9 and 10 black. Pronotum: Width 0.49 mm. Prescutum, scutum, scutellum, meta-scutellum, metanotum, post-metanotum, abdomen and legs pale greenish-yellow. Genitalia: Claspers and aedeagus as in Text-figure 7. Length of aedeagus (3 specimens): Extremes 0.198 mm. to 0.203 mm. Forewing: length 2.59 mm., width 0.76 mm. Hindwing: Cu_1 as in Text-figure 4.

Host-plant: Not known.

Type Locality: Brisbane, Queensland.

Types: Holotype male and co-type male on slide labelled "Brisbane, 4 x 1939. H. Hacker", deposited with the Queensland Museum, Brisbane. Paratypes: 1 slide labelled as above, to The Australian Museum, Sydney.

This species appears to be nearest to *G. (A.) lactea*, but is separable by the shape of the male claspers and aedeagus, and Cu_1 of hindwing.

GLYCASPIS (ALLOGLYCASPIS) MESICOLA, sp. nov.

L. mesa = between; *-icola* = dwelling. Referring to the occurrence of the species in the border area of New South Wales and Queensland.

General Colour: Variable; cream suffused red, lightly marked with black; similar to *G. brimblecombei*.

Male: Head: width 0.66 mm.; vertex: along suture 0.32 mm., width 0.37 mm., posterior border and posterior three-quarters of suture lightly marked with black; genal processes: length 0.34 mm.; antennae: length 1.78 mm.; segs. 1 to 3 cream, segs. 4 to 8 progressively darkening to dark brown, segs. 9 and 10 black. Pronotum: bases of lateral prominences and depressions at two-thirds, brown. Prescutum: lateral edges lightly marked with brown. Scutum: a broad median area cream, lateral areas rose-red. Scutellum: cream. Metanotum: red. Post-metanotum: yellow. Abdomen: yellow with pale transverse lines on some segments. Genitalia: suffused red; claspers and aedeagus as in Text-figure 8. Length of aedeagus (two specimens): 0.230 mm., 0.239 mm. Forewing: length 2.59 mm. Hindwing: Cu_1 as in Text-figure 4.

Host-plant: Not known.

Type Locality: Brisbane, Queensland.

Types: Holotype male, allotype female on slide labelled "Brisbane, Queensland, 4 x 1939, H. Hacker", deposited with the Queensland Museum, Brisbane. Paratype: 1 slide labelled "Coolangatta, Queensland. Coll. F. Muir, viii 1919", to the Bernice P. Bishop Museum, Hawaii.

This species appears to be nearest to *G. (A.) ignea*, but is separable on the male claspers and aedeagus, and Cu_1 of hindwing.

Acknowledgements.

The writer is grateful to Dr. A. R. Brimblecombe, Deputy Government Entomologist of the Department of Primary Industries, Brisbane; the late Mr. G. Mack, past Director of the Queensland Museum, Brisbane; and Dr. J. L. Gressitt, Director of the B. P. Bishop Museum, Honolulu, Hawaii, for the loan of specimens in the collections of those Institutions.

Reference.

MOORE, K. M., 1961.—PROC. LINN. SOC. N.S.W., 86 (1): 128-167.

CONTRIBUTIONS ON PALAEOZOIC FLORAS. 2.

AN UNUSUAL FOSSIL TREE FROM WOLLAR, NEW SOUTH WALES.

By J. F. RIGBY, Geology Department, Newcastle University College,

Tighe's Hill, N.S.W.

(Five Text-figures.)

[Read 29th April, 1964.]

Synopsis.

A small tree *in situ*, of Permian age, is described. Insufficient evidence is available to classify the tree, although there is some information regarding its habit (all growth of woody parts occurred in a vertical direction) and environment.

This fossil tree showed so many unusual features from the point of view of Permian trees that a preliminary note concerning it is of interest. It should be noted that little information of diagnostic value is available. Mr. R. Helby of the N.S.W. Mines Department found it, then kindly took me to the site and assisted in its collection. It was exposed by digging operations in the cutting at the western end of Wollar Tunnel on the Sandy Hollow to Gulgong railway formation, 80 miles WNW of Newcastle, New South Wales. It was preserved as a limonitic impregnation following silicification.

The tree was *in situ*. The lower axis (see Fig. 1) was vertical, but the upper axis had been broken and was lying at an angle of 30° to the horizontal pointing in a westerly direction.

The tree appeared to have lived under unfortunate conditions. Two ground levels formed during its growth. The lower 1' 10", termed the "lower axis" (see Fig. 1), was buried in a layer, now a blue-grey, fine-grained, argillaceous sandstone, then growth continued above the new ground level. A large bole developed at the second ground level. From this bole a second trunk grew, termed the "upper axis". The upper axis was knocked over and apparently killed during the deposition of a second bed of the same sandstone as the first deposit.

TABLE 1.

Radial Measurements to Edge of Bark, and to Prominent Growth Rings in Cross-section of Lower Axis of Permian Tree from Wollar, N.S.W. Measurements are in millimetres.
Diameter of pith : 25 mm.

Section line	..	..	..	A.	B.	C.	D.	E.	F.
Distance to edge of bark	..	..	..	40.8	39.0	30.2	28.8	27.3	35.6
Distance to prominent growth ring 1	..	..	..	3.1	3.2	3.0	2.1	2.0	2.9
Distance to prominent growth ring 2	..	..	..	8.0	8.1	9.3	—	—	8.1
Distance to prominent growth ring 3	..	..	..	24.9	31.6	23.8	20.5	19.6	31.0

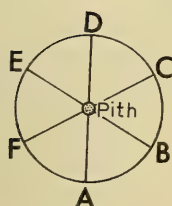


Figure A.—Orientation of measured section lines listed in Table 1.

Roots developed below the first ground level. Unfortunately these were preserved only as carbonaceous ribbons up to 1 cm. wide. The root system was irregularly dichotomously branching. It occurred in the top few inches of the first ground level. No tap root, nor any structure similar to even a vestigial tap root, could be found. The root system seemed reminiscent of the system found in the Bambuseae, but to be rather sparse. The roots extended at least one foot from the trunk. No adventitious roots were found beneath the second ground level.

Litter occurred at both ground levels. The first ground level litter contained many recognizable leaves of *Glossopteris browniana* of all sizes, and fragments of *Phyllothea australis*, both stems and leaves. Twigs were absent. Litter from the second ground level formed a structureless, very thin carbonaceous layer.

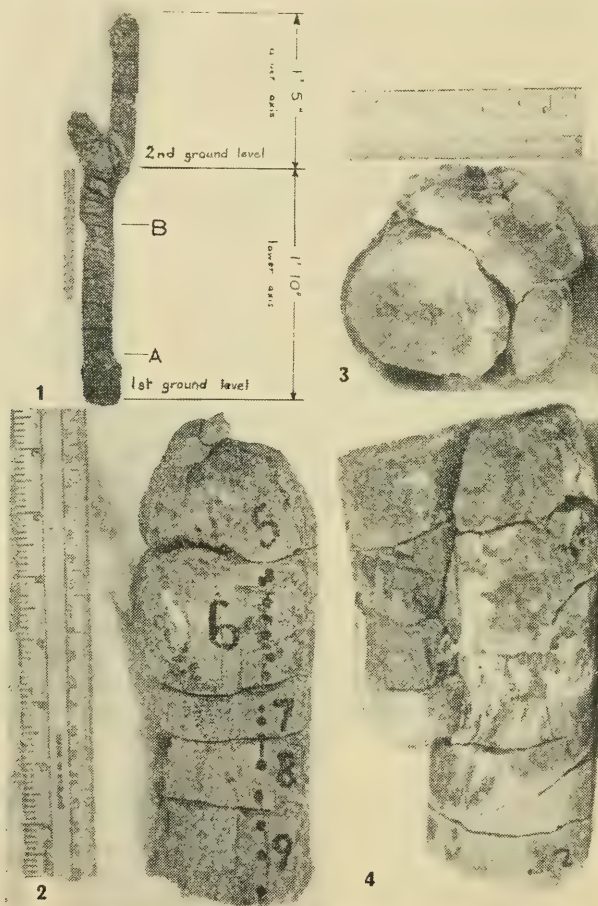


Fig. 1.—Fossil Tree from Wollar, N.S.W. Fragments of fossil reassembled into position of growth. Explanation as to the significance of the annotations is described in the text. Ruler is one foot long. $\times 1/18$.

Fig. 2.—Detail of Fossil Tree from Wollar, N.S.W. Upper part of Upper Axis. Budding of branches may be seen as large, scale-like attachments. The numbers and dots were placed on the specimen to assist in reassembly in the laboratory. $\times \frac{1}{2}$.

Figs 3, 4.—Details of Fossil Tree from Wollar, N.S.W. Development of a new branch. 3, view from above of top of portion shown in Fig. 4; 4, side elevation. $\times \frac{1}{2}$.

The stem itself was endarch with a very narrow pith. The pith was generally eccentrically placed. In a cross-section at approximately half-way up the lower axis the measurements in Table 1 were made (all in mm.). Measurements were made along radial lines spaced at 60° from one another. Measurements were made to the edge of the bark and to prominent growth rings from the edge of the pith.

The section line A pointed towards the north. This eccentricity is not due to heliophyllism or to any tropism, as branching occurs on the side where growth had been a minimum. The unfortunate mode of preservation precluded detailed examination

of the mechanism of branching. Where a branch occurred the pith did not appear to branch, but a new pith formed at the base of the new branch. All growth was entirely negatively geotropic, i.e., occurred in a vertical direction. The branch grew in contact with the main trunk, and in time replaced the original main trunk as the principal axis. Two such branchings may be seen clearly on Figure 1. One starts at B, and has become the main axis by the second ground level. Details of this branching are shown on Figures 3 and 4.

TABLE 2.

*Showing Number of Cells and Width of Growth Rings of a Fossil Tree from Wollar, N.S.W.
Measurements are in microns.*

Growth Ring.	Width of Ring (in Microns).	Number of Cells across Width.	Cell Size. (Radial measurement given first.)
Pith (diameter)	2000 approx.	Cell size uniform	
	1710	71	12-33 × 12-29
1	1100	41	20-29 × 25-83
	At 60° to right of this section line this ring is subdivided by the insertion of two extra rings, viz.:		
	1720	25, 22, 24	
2	1160	49	As 1-2
3	975	51	20-41 × 29-41
4	1400	46	As 3-4
5	1880	60	
	Includes 4 minor rings spaced at 11/10/9/5/25		
6	1400	51	
7	580	24	
8	3050	87	
9	6000	156	
	Tendency for diagonal compression of the cells rather as if the bark were rotated slightly relative to the pith during growth		
10	3730	98	
	Insignificant growth ring		
	2280	76	
11	1010	28	
	Minor rings at 5/13/10		
12	650	26	
13	1040	28	
14	1290	37	
Cambium			
Bark, fibrous	2400-3200		

Other branchings are indistinctly visible on Figure 1. The main trunk of the lower axis grew from behind two other branches at ground level. The front branch appeared to be the main axis from which roots grew. This extended to slightly above the bottom of the ruler, as shown by eccentricity of the trunk, but has been preserved only as high as A.

The left arm at the second ground level appeared to consist of nothing but a very large mass of buds, or better, scales, of the type shown in Figure 2. A section cut through one of these scales showed that it was coherent with the parent stem throughout. Scale budding was frequent over the lower four inches of the upper axis and on and above fragment 6 (see Figure 2). The scale on the left of fragment 5 (from which it appeared to branch) would probably have developed into the main trunk, eventually superseding the main axis at that point as it was growing faster. The tip was hemispherical and ribbed.

As this tip was growing more rapidly than its parent trunk, it would develop a circular cross-section in preference to the trunk when both branch and trunk were in contact. This has happened to the trunk and branch shown by Figures 3 and 4.

The branching shown by Figures 3 and 4 emphasizes the way in which a branch assumes dominance during growth. The circular section in Figure 3 is of the branch.

The original trunk occupies the upper right portion of the section. The small lunate-shaped portion, apparently part of the original trunk, shown in Figure 3 is a second branch that never assumed dominance. It appeared to branch at the level of the lowest remaining portion of the left hand branch. It appears out of focus on the front of the vertical section shown on Figure 4. Strong longitudinal ribbing is always found on both branch and trunk where they abut.

As growth was very slow, evident from the height of the tree, and the number of growth rings, the rate of photosynthesis must have been slow also. With such a plant one can only postulate a radiating crown of leaves as is found in modern cycads, and that these leaves were non-filiclean in nature. When budding or "scale formation" occurred at the apex, the available space for the attachment of leaves must have been severely reduced. The consequent reduction in photosynthetic activity might have accounted for narrower growth rings (see below).

Narrow medullary rays 4 to 5 cells in height appeared to occur sporadically. No thickening nor pitting of tracheids could be seen on any polished section, or transfer. Identification is impossible without these features. Tracheids were up to 50μ long. Radial air gaps were present in the secondary wood. They appeared to develop most often where the distance between growth rings was a maximum, i.e., where rate of growth had been a maximum whether or not growth rings indicated a seasonal growth.

Cell sizes and numbers of cells between each growth ring were measured on a transverse section cut in fragment 10 of the upper axis at the base of the part of the specimen shown in Figure 2. All measurements are in microns.

From these figures it is apparent that the factors controlling development of narrow, thicker-walled cells as growth rings were irregularly applied. The lower axis had 32 rings equally irregular in width, but with irregularities that bore no relationship to the irregularities in the upper axis. This would be consistent with cessation of growth of the lower axis at the time of the first flood, followed by commencement of growth of the upper axis.

It is quite possible that growth of the upper axis did not occur immediately, but that budding continued on the left-hand arm until a second inundation caused further damage. Following the second flood the present upper axis grew.

The size of growth rings may have reflected the quantity of water available, rather than the seasons, as the tree must have grown near a stream. This is shown by the presence of *Phyllothea* in the litter. This is an alternative to reduction of growth owing to reduction in photosynthetic activity, or to normal seasonal cycles.

This tree can only be classified as a woody plant, hence seed bearing. It does not conform to the usual Cordaitalean pattern as it has a narrow pith. The only narrow pith endarch woods with homogeneous pith cells listed by Kräusel *et al.* (1962) from the Gondwanaland area are *Dadoxylon porosum* Kräusel and *D. rangei* Kräusel, both from South-west Africa. My tree may or may not be one of these. Final identification will depend on the finding of more suitable material.

I would like to thank Prof. Dr. R. Kräusel of Frankfurt a.M. for examining a small fragment of the wood, although he was not able to reach any conclusion as to its identity.

Reference

- KRÄUSEL, R., MAITHY, P. K., and MAHESHWARI, HARI K., 1962.—Gymnospermous woods with primary structures from Gondwana Rocks—A Review. *Palaeobotanist*, 10: 97-107.



Glossopteris cordata Dana.

EDAPHIC CONTROL OF VEGETATIONAL PATTERN IN EAST COAST FORESTS.

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(Five Text-figures.)

[Read 27th May, 1964.]

Synopsis.

This study attempts to place in exploratory perspective some of the edaphic factors responsible for the complex vegetational pattern in east coast forests. Relationships between forest communities characterized by the presence of blackbutt (*Eucalyptus pilularis* Sm.) and white mahogany (*E. acmenioides*, *E. umbra*), and the relationship of each to rainforest have been examined, and the following tentative conclusions reached:

(i) Distribution of blackbutt is limited by physical properties of the soil which restrict aeration, moisture permeability or penetration of roots to depth; these soil properties vary with the mineralogical composition of the parent material, its geological history, and the landscape pattern.

(ii) Narrow ranges of available moisture associated with some rainforest soils suggest that where other factors are not limiting, soil moisture availability could be a critical factor in distribution of rainforest in east coast forests.

(iii) Soil fertility status is not a determining factor in the delimitation of blackbutt and white mahogany communities, but within each community a gradient of increasing soil fertility is largely responsible for the vegetational gradient from dry sclerophyll forest to rainforest; along this fertility gradient the vegetation, and particularly the occurrence of rainforest, may be restricted by limiting physical properties of the soil and the soil moisture availability.

(iv) The influence of eucalypts on their own sites may be a factor contributing to the marked sensitivity of eucalypt communities to minor habitat variations.

The eucalypt-rainforest relationship is discussed in terms of the concept that both the sclerophyllous dominants and the rainforest element stratum change sensitively and predictably along environmental gradients.

INTRODUCTION.

The coastal forests of south-eastern Australia may be characterized by a mosaic of eucalypt species associations and a complex relationship of eucalypt sclerophyll and rainforest (Fig. 1). There have been a number of ecological studies in these forests (Fraser and Vickery, 1937, 38, 39; Pidgeon, 1942; Burges and Johnston, 1953), but until more recent years (Beadle, 1954, 62; Webb, 1956, 59; Baur, 1957) there has been little emphasis on the analysis of vegetation-environment relationships.

This current study is complementary to an analysis of vegetation pattern in east coast forests (Florence, 1963), and attempts to place in exploratory perspective some of the environmental factors responsible for the vegetational mosaic.

I. THE VEGETATION PATTERN.

Partly because of their obvious complexity, there has been little attention directed towards an understanding of eucalypt species and species association relationships. A given species, for example, may exhibit an apparent sensitivity to minor habitat variation within any one situation, but nevertheless it may occur over wide geographic and habitat ranges. Development of concepts concerning ecological-genetic relationships within *Eucalyptus* (Pryor, 1953, 1959) has provided some initial perspective of species relationships; these concepts include (i) that *Eucalyptus* may be subdivided into four principal groups (subgenera) which are reproductively isolated from one another; (ii) that interbreeding eucalypt species occupy distinctly different ecological situations;

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(iii) that many reproductively isolated eucalypt species occur together in pairs which are ecologically co-extensive for a major portion of their ranges, though usually separated at the extremes.

With the exception of blackbutt (*Eucalyptus pilularis* Sm.) the pattern of distribution of members of the interbreeding group Renantherae in east coast forests would be in substantial agreement with the principle that interbreeding species occupy distinctly different habitats. Distribution of blackbutt is best illustrated as one superimposed on the distinctive habitat situations of each of the other Renantherae and.



Fig. 1.—Air Photo.

Fig. 1. Complex vegetational pattern on part of Mount Boss State Forest No. 910; scale averages slightly more than 20 chains to inch. Symbols are: *Rm*, rainforest characterized by presence of *Ceratopetalum*; *Ry*, rainforest characterized by presence of *Argyrodendron*; *Rs*, depauperate rainforest, *Myrtus* sp. usually dominant; *Mb*, *Tristania conferta*, *Syncarpia glomulifera*, *E. microcorys*, *E. saligna* dominating a well-developed rainforest element stratum; *Mm*, *E. microcorys*, *E. saligna* dominant with *T. conferta*, *S. glomulifera*, *E. acmenioides* and rainforest element associated; *Bp*, *E. pilularis* dominant with *E. microcorys*, *E. saligna*, *E. gummiifera* associated, some rainforest element; *Bh*, *E. acmenioides*, *E. microcorys*, *E. gummiifera*, *E. pilularis*; *Dm*, *E. umbra*, *E. globosidea*, *E. tereticornis*, little or no rainforest element; *Cr*, rock outcrops.

Acknowledgement is made to the Forestry Commission of New South Wales for provision of the Air Photo, and for the interpretation of the vegetational pattern.

although they are largely separate, there may be a considerable degree of cohabitation of interbreeding species within each situation (Florence, 1963).

In this study, environmental relationships between forest communities characterized by the presence of blackbutt and white mahogany (*E. acmenioides* Schau., or *E. umbra**), both members of the Renantherae, and the relationship of each to rain-forest are examined. Throughout their common range (Fig. 2), blackbutt and white mahogany communities are often sharply delineated, but alternatively, in other situations there may be a wide co-occurrence. Within its community blackbutt reaches

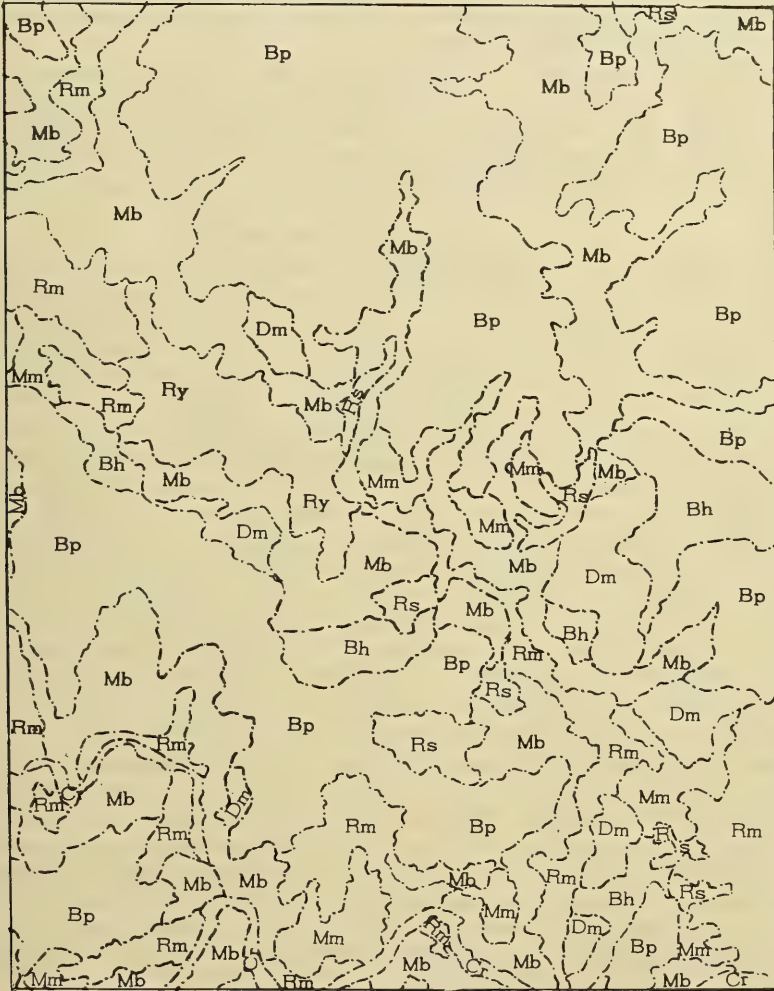


Fig. 1.—Vegetational Pattern.

* Blake (*Proc. Roy. Soc. Qld.*, 69: 86) synonymized *E. umbra* R. T. Bak. and *E. carnea* R. T. Bak. in 1958, and in this and the previous paper relating to vegetational pattern in east coast forests (Florence, 1963), the terminology *E. umbra* has been used in Blake's sense. However, Johnson (*Contrib. N.S.W. Nat. Herbarium*, 3: 103) has subsequently recognized two subspecies, *E. umbra* ssp. *umbra* and *E. umbra* ssp. *carnea*. Along the vegetational gradient from rainforest to the more depauperate dry sclerophyll, *E. umbra* ssp. *carnea* might be regarded as ecologically intermediate between *E. acmenioides* and *E. umbra* ssp. *umbra*. For the most part, *E. umbra* referred to in this and the preceding paper is *E. umbra* ssp. *carnea*, although much intermediacy between the two ssp. was observed.

very high levels of ecological "importance", and may in fact be the only dominant present. From this situation blackbutt's vegetational gradient may be regarded as moving in two directions, towards dry sclerophyll forest and towards rainforest. Along the latter gradient a characteristic assemblage of rainforest element species may form a secondary stratum to the dominants—blackbutt, Sydney blue gum (*E. saligna* Sm.), tallowwood (*E. microcorys* F.v.M.), turpentine (*Syncarpia glomulifera* Sm.—Niedenzu), brush box (*Tristania conferta* R.Br.), and others. Nevertheless along this vegetational gradient towards rainforest, the upper limit of blackbutt's environmental tolerance is apparently well short of that necessary for rainforest¹ formation, so that a mixed sclerophyll-rainforest element community without blackbutt is frequently interposed between blackbutt forest and rainforest.

White mahogany occupies a total vegetational gradient largely parallel to that of blackbutt, but in contrast to blackbutt, *E. acmenioides* will occur in situations directly marginal to rainforest. Along the white mahogany gradient from rainforest to dry sclerophyll forest, *E. umbra* is considered to replace *E. acmenioides* in the more open sclerophyllous situations and the gradient continue to quite depauperate dry sclerophyll.

II. THE CLIMATIC ENVIRONMENT.

Vegetational and environmental studies were carried out within the coastal region extending from Batemans Bay to Fraser Island (Fig. 2). In this zone the climate is characterized by a predominantly summer rainfall, a mean monthly rainfall less than 200 points for no more than one month of the year and the Australian maxima for rainfall "effectiveness" and "reliability" (Leeper, 1949). An adaptation from Swain's Climatic Index for Australia (de Beuzeville, 1943) illustrates the essential climatic data for this zone (Fig. 3). In view of the probable influence of more or less annual and sometimes extended spring and summer droughts on the Australian vegetation, Swain's Index is based on the continuity or otherwise of rainfall throughout the year, and has mean annual rainfall (MAR) as a subordinate factor. Other factors included in the Index are the mean temperature of the coldest month (MTCM) and the temperature range as expressed by the mean temperature of the hottest month (MTHM) in relation to (MTCM). The index defines with some precision the geographic limits of the vegetation studied. For example, the blackbutt range is entirely associated with the coastal zone demarcated by the numeral "1". North of Fraser Island the zone with initial numeral "3" has increasing duration of drought, and just beyond the southern extremity of the coastline illustrated, zone "1" is replaced by zone "2", indicating the change from summer to winter dominant rainfall.

Within the coastal zone of optimum rainfall and rainfall uniformity in Australia, variation in MAR from as low as 40" and up to 100" per annum is related largely to elevation and distance from the coast of the sinuous mountain system that extends along the whole of Australia's east coast. For example, the increasing drought in zone "3" north of Gympie (Qld.) is related in part to the westward swing of this mountain system. Although elevation, through its effect on rainfall and temperature, has an apparent influence on vegetation, it is nevertheless clear that macroclimatic factors cannot explain the often sharp discontinuities in blackbutt, white mahogany and rainforest distribution that characterize much of their common range.

III. THE GEOLOGICAL FACTOR IN THE VEGETATION PATTERN.

While the geological mosaic along the east coast of New South Wales and southern Queensland is clearly responsible for some major features of the vegetational pattern, the parent material-vegetation relationship is by no means a simple one, particularly in respect to the nature and distribution of rainforests.

¹In this paper, the term "rainforest" refers specifically to a closed community forming a deep densely interlacing canopy, and from which a sclerophyllous overstorey is absent; species occurring in mixture with sclerophyll dominants are referred to as a "rainforest element".

Delineation of Blackbutt and White Mahogany.

Although blackbutt extends from the New South Wales/Victorian border to Fraser Island in Queensland its most continuous and extensive occurrences are in the middle of its range and associated with (1) the Lorne Triassic Basin (north of Taree) and (2) Silurian schists and shales (Coffs Harbour District).

Sedimentary depositions within the Lorne Basin include basal beds of massive conglomerate, ferruginous grits, sandstones, shales and soft clay shales. The vegetational structure of the blackbutt forest may be correlated with gradation in depositions; conglomerates and coarse sandstone-derived soils support blackbutt communities

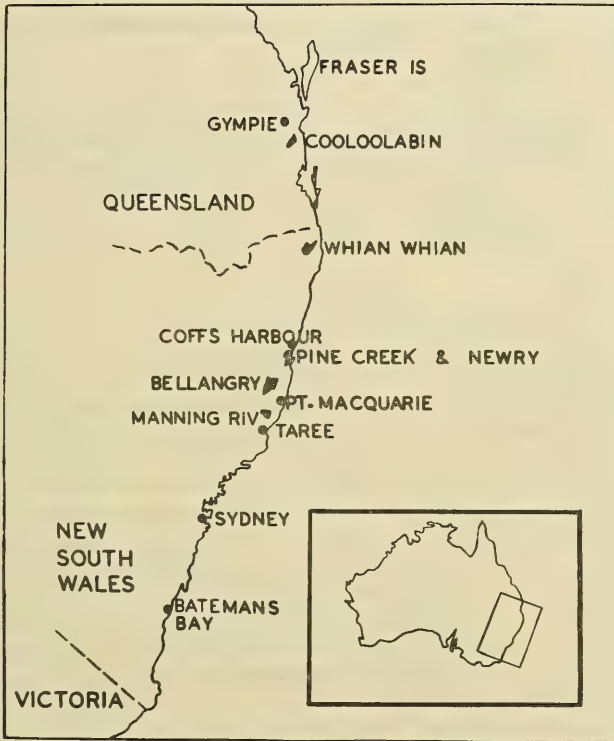


Fig. 2. Part of the east coast of southern Australia showing place names referred to in text.

Blackbutt (*Eucalyptus pilularis*) has a distribution from the Victoria-New South Wales border to Fraser Island, and the common range of blackbutt and white mahogany (*E. acmenioides*, *E. umbra*) extends from about Sydney to Fraser Is.

characteristic of its vegetational gradient towards dry sclerophyll forest, red-brown finer sandstones support near optimum blackbutt stands, and fine sandstones and shales support stands characteristic of the vegetational gradient towards rainforest.

Within the Lorne Basin discontinuity in blackbutt distribution is correlated with outcrops of the underlying Carboniferous formation, with "alkaline intrusives" (Voisey, 1939), and with fine felspathic sandstone and siltstone.

On the mid-north coast of New South Wales blackbutt has a relatively continuous distribution on the extensive schist and shale soils. On the schist soil of Pine Creek and Newry State Forests, discontinuity of blackbutt and white mahogany forest is associated with variation in the bedding of the rock and in the consequent nature of the rock-soil relationship. Apart from this differentiation, the alignment of blackbutt forest on ridges, rainforest in gullies, and with white mahogany forest interposed, is

common through a large part of this formation. This pattern has presented one of the most complex problems in understanding the environmental relationships involved (Section VII).

Together, the Permian and Carboniferous formations provide one of the major barriers to a more widespread occurrence of blackbutt forest. A great diversity of

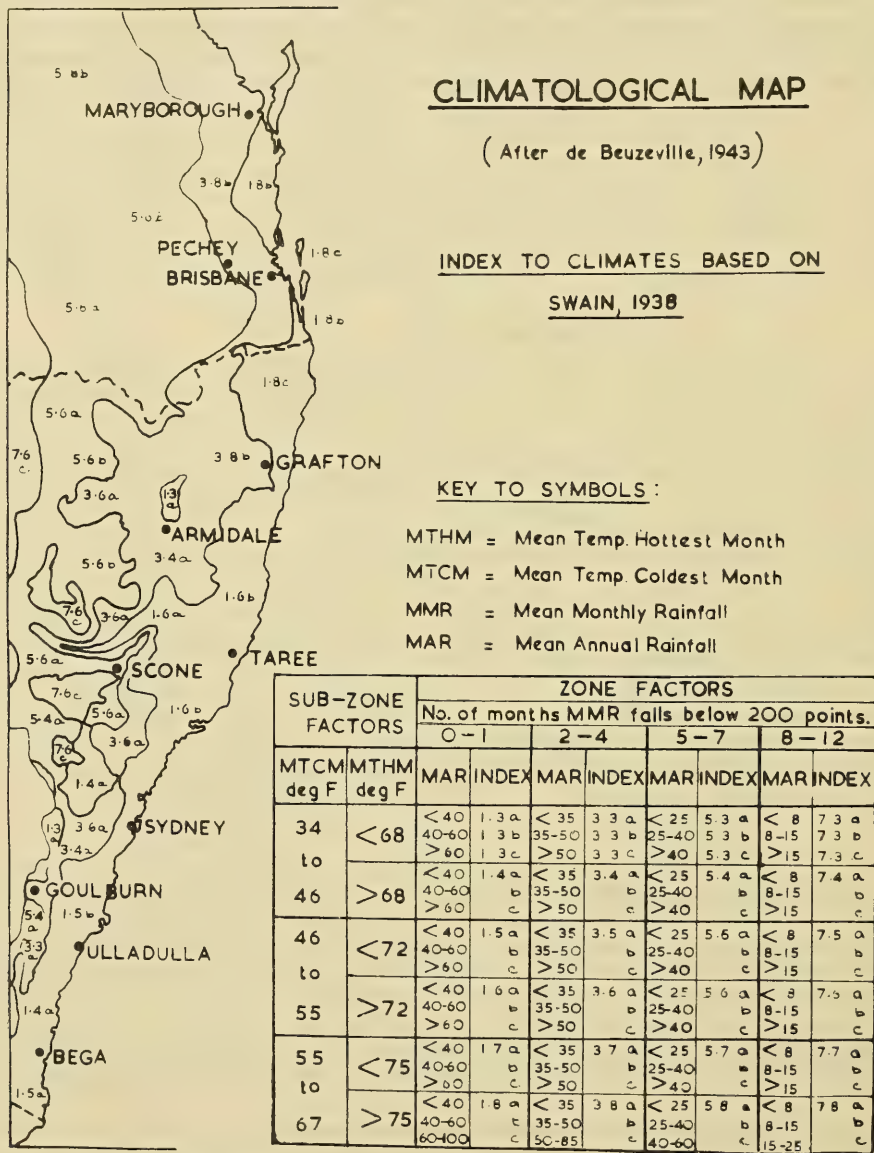


Fig. 3. Illustration of principal climatological data in south-eastern Australia. White mahogany, blackbutt and rainforest communities have a common distribution restricted to zones indicated by the initial numeral "1" in the climatic index.

vegetation is associated with these formations and includes woodland, dry sclerophyll, "mixed forest" (*Eucalyptus*, *Syncarpia*, *Tristania*, dominating a rainforest element stratum) and rainforest. West of Port Macquarie the Carboniferous formation rises to over 4000'. On a part of this area blackbutt forest is developed on greywacke, as is

white mahogany forest, Sydney blue gum-brush box forest, and rainforest including Antarctic beech (*Nothofagus moorei*) around 4000' elevation. It will be demonstrated that variation in greywacke mineralogy may be primarily responsible for some of the vegetation pattern in this area.

Blackbutt has extensive occurrence on coastal deposits of Recent origin, for example Fraser Island, and the Myall Lakes area (Osborn and Robertson, 1939). The association of blackbutt with Recent deposits is restricted to coastal sands; the species rarely occurs on Recent alluvium associated with coastal streams, which frequently carried rainforest.

Rocks of volcanic origin are widespread along the Australian east coast. These range from basic fine-grained basalts to highly acid granites. They vary in occurrence from extensive flows occupying thousands of square miles to localized outcrops of granite interbedded with other strata. Within the Lorne Basin intrusions of both granite and "alkaline intrusive" (dolerite) have uplifted part of the Basin; white mahogany forest occupies the dolerite and blackbutt the granite. In northern New South Wales on Whian Whian State Forest, Baur (1957) has recorded a belt of blackbutt forest on acid rock (rhyolite) "sandwiched" between upper and lower rainforest on basalt, and in southern Queensland the mosaic of blackbutt and white mahogany forest is largely related to the mosaic of rhyolite and trachyte respectively, forming the acid phase of the Triassic "North Arm Volcanics".

Delineation of Rainforest and Eucalypt Sclerophyll.

The most extensive and continuous occurrences of rainforest in New South Wales and southern Queensland are associated with basic volcanic rocks, notably basalts, but only where red loams rather than black earths have developed on them. In a detailed study of lithology in relation to rainforest in southern Queensland, Webb (1956) concluded that subtropical rainforests are not generally supported by sedentary soils from acid rocks, i.e. with silica much in excess of 50%. Where rainforests appeared to be developed on such soils some form of basic enrichment could usually be evidenced. For example, Webb has suggested that polygenetic soils are responsible for rainforest on highly siliceous phyllite. Recent exposure of phyllites by partial erosion of a basalt capping has occurred, but the closed nutrient cycle in rainforest has retarded soil impoverishment even under intense leaching conditions.

The existence of numerous patches of rainforest developed as a function of topography within eucalypt-sclerophyll suggests the possibility that soils formed from some parent materials, though limiting in certain properties for rainforest formation, may be capable of supporting rainforest with colluvial concentration of nutrients or with higher levels of soil moisture. Because of the superimposition of a complexity of such factors on the parent material-vegetation relationship, precise determination of vegetation in relation to lithology will probably not be possible.

Vegetational Delineation in Relation to Parent Rock Mineralogy.

The distribution of blackbutt and white mahogany in relation to the mosaic of geological strata suggested that an examination of the mineralogy of a range of parent materials might reveal some features that would characterize the presence of the respective communities. Micro-sectioning of some 20 rocks was carried out in the Department of Geology, and the results are examined for a number of localities.

1. *Lorne Triassic Basin.* All soils associated with these depositions carry blackbutt, and all have a high quartz content. Conglomerates and coarse-textured sandstones are associated with blackbutt's vegetational gradient towards dry sclerophyll, and depositions with a more complex mineralogical composition with the gradient towards rainforest. For example, a blackbutt-Sydney blue gum-tallowwood forest with some rainforest element is developed on a fine sandstone, with 50% detrital quartz grains, 10% feldspar and a considerable amount of epidote.

Within an area of apparently homogeneous rock, contrasts in mineralogical composition may have a considerable influence on the vegetational composition. For

example, on a section of the Lorne Basin, the occurrence of a community with blackbutt, flooded gum, brush box and a rich rainforest element stratum might have been assumed to result from topographic influences on the soil derived from the epidote-rich sandstone just described, were it not for puzzling inconsistencies in this pattern. Mineralogical analysis of the apparently similar underlying rock showed that it had no epidote, but had a large amount of clay minerals, particularly chlorite; this parent material difference may well be the primary cause of the vegetational pattern.

Discontinuity of blackbutt within the limits of the Lorne Basin is associated with various exposed Carboniferous strata, and with intrusions of basic plutonic rock. All carry white mahogany. A Carboniferous shale had a small component of very fine quartz (15%), feldspar, white mica and abundant muscovite; a fine felspathic sandstone had 10–15% quartz with potash feldspar as small grains with a matrix of mica and indeterminate material, and the basic plutonic rock (dolerite) was low in quartz but contained lime-rich feldspar, augite, hornblende and magnetite.

2. *Bellangry Forest.* (Carboniferous strata.) Four rocks from contrasted communities were examined. All were greywacke and were indistinguishable on ocular inspection. However, they varied as follows:

(a) *Blackbutt forest, little rainforest element:* angular quartz grains 30%, fine grained biotite 30%, remainder fine grained and possibly weathered to kaolin.

(b) *Blackbutt, Sydney blue gum and rainforest element understorey:* quartz 10%, biotite 40–50%, small quantity of muscovite, and remainder potash feldspar.

(c) *Sydney blue gum, brush box, with *Argyrodendron* rainforest in gully:* biotite 50–60%, and quartz as occasional larger grains forming 5–10% of the total.

(d) *White mahogany:* mineralogically distinct from above, particularly low quartz content, and a high component of fine-grained chlorite minerals.

With respect to the first three communities (a-c), a vegetational gradient from blackbutt-sclerophyll forest to rainforest is associated with a gradient in the quartz-biotite relationship; a rock relatively high in quartz content supports almost "pure" blackbutt forest, and on the other extreme, a rock relatively high in biotite and low in quartz supports *Argyrodendron* rainforest. It is possible that this quartz-biotite relationship reflects a gradient from acid to basic rock, in which case the vegetational expression would be in agreement with Webb's (1956) conclusions concerning rainforest distribution and the nature of the parent material.

3. *Cooloolabin Forest.* (Acid and intermediate volcanic rocks.) Several rock specimens from each of blackbutt and white mahogany forest respectively were examined.

(a) *Blackbutt forest:* (i) *some turpentine component, no brush box;* rhyolite, phenocrysts of quartz in a ground mass of fine potash feldspar, and a small percentage of chlorite. (ii) *as (i);* acid rhyolitic lava, large phenocrysts quartz forming a high percentage of total, in fine ground mass feldspar and plagioclase. (iii) *high brush box and turpentine component;* altered trachyte, microcrystalline, feldspar about 95% of rock, extremely altered, secondary minerals, zeolite and chlorite; quartz veins 5% of rock.

(b) *White mahogany forest:* (i) trachyte, quartz nil, dominant minerals potash-feldspar and plagioclase. (ii) trachyte, no quartz, texturally different from (i).

Within the acid phase of the North Arm Volcanics of Cooloolabin Forest, there is apparently a gradient in rock mineralogy from the acid rhyolites to the intermediate trachytes. Blackbutt forest that is characteristic of the vegetational gradient towards dry sclerophyll forest is associated with the rhyolites, and all white mahogany forest examined has been developed on trachytes. However, apart from these extremes, there is apparently no precise definition of the forest community in terms of the rock mineralogy; for example, in a more detailed study of the vegetation pattern of Cooloolabin Forest to be presented elsewhere it will be shown that blackbutt and white mahogany forest may occur mosaically on the one parent material.

In summary it is apparent that in many areas the distribution of blackbutt is primarily related to the mineralogy of the parent material. While the mineralogical examinations have been too limited to characterize with any certainty a type of parent material on which blackbutt forest is developed, if indeed this is at all possible, it is clear that in many cases blackbutt is associated with a rock high in quartz content, and absent from fine grained rocks low in quartz, and with high percentages of such minerals as chlorite, mica and magnetite.

In what way the parent material may be primarily responsible for vegetational differentiation is examined in succeeding sections.

IV. THE PHYSICAL SOIL FACTOR IN THE VEGETATIONAL PATTERN.

The role of mineralogical composition of the parent rock in the soil-forming process cannot be defined directly. Under one climatic environment identical soils are commonly derived from contrasted rock types. Nevertheless the mineralogical composition, texture, and hardness of the underlying rock, and its general habit and direction of cleavage are properties which have an important bearing on pedogenesis.

Physical Properties of Blackbutt and White Mahogany Soils.

1. *Rock-Soil Relations*: Through the region studied it is evident that the mineralogy of the parent rock has been a principal controlling factor in the nature of the soil profile formed. Weathering of many rocks with a high or moderate quartz content has been rapid and relatively deep mature soils have formed on them, or alternatively the rock has fractured to depth and an undulating soil/rock boundary formed. In contrast, many of the rocks that have a low quartz content, particularly those with a fine-grained ground-mass of chlorite and mica minerals, have weathered more slowly, producing in many cases immature soils over massive parent rock. On the other hand, deep soils formed on rocks with nil or low quartz carry blackbutt forest, or blackbutt may be developed on parts of the one parent material where formation of deeper soils has occurred, for example, as a function of topography. It is apparent that the nature of the soil profile formed rather than the mineralogy of the rock *per se* is the determining factor in blackbutt-white mahogany differentiation, and that many examples of the correlation between forest community and rock mineralogy can be extended to a correlation between forest community and the nature of the rock-soil relationship. Some examples are given (Table 1).

Generally a striking variation in the rock-soil relationship is associated with a lithological change. However, in a number of instances blackbutt and white mahogany are sharply delineated on the same rock type, and in similar topographic situations, as a result of variation in the structural characteristics of the rock. For example, in Pine Creek State Forest (Table 1) blackbutt occurs where the schist has been tilted to 45° and fractured, facilitating much deeper weathering through moisture infiltration of the laminated rock structure; where the rock is undisturbed and horizontally bedded, and the soil is relatively shallow, white mahogany forest is developed. Again, in Myall River Forest, white mahogany forest occurs on a shallow immature soil overlying massive and very hard dacite. On one part of the forest, blackbutt is found on a deeply weathered soil derived from the same parent material; in this latter case it is possible that the part of the magma had shattered during cooling and deep weathering was facilitated.

2. *Texture and Structure of the Soil*: Although discontinuity of blackbutt and white mahogany can be correlated with the nature of the rock/soil relationship in a large number of cases, there are, alternatively, many examples where variation in the physical properties of the soil itself appears to be a causal factor in the differentiation. For all profiles examined, texture, the nature of soil aggregates and bulk density were recorded. Texture and structure of the soil may affect plant distribution and growth indirectly by their influence on aeration, water movement, water retention and root ramification. For comparable soil textures, bulk density may be regarded as a useful comparative measure of soil aeration and root penetration potential. For example,

Veihmeyer and Hendrickson (1948) suggest that compacted soil layers whose bulk density exceeds 1.75 for sand and from 1.46 to 1.63 for clays may prevent the penetration of roots. In Table 2 a number of examples are given of contrast in the physical properties of profiles carrying sharply delimited blackbutt and white mahogany forest respectively.

From this set of data it seems that blackbutt discontinuity might also be correlated with soils of heavy texture, where soil structure is such that aeration and root ramification might be restricted. Blackbutt is certainly not restricted on heavy textured soil, but may occur only where the soil is well aggregated and bulk densities are moderate.

TABLE 1.

The Rock-Soil Relationship in Adjacent Blackbutt and White Mahogany Forests.

Blackbutt.		White Mahogany.	
(i) Parent Rock.	Profile.	(i) Parent Rock.	Profile.
(ii) Soil Group.		(ii) Soil Group.	
<i>Bateman's Bay.</i>			
(i) Chert.	To 40" light clay with pieces of quartz and angular chert. Below 40", chert fragments increasingly compact.	(i) Schist.	12" of light clay with copious parent material fragments over decomposing but compact schist in original laminations.
(ii) Podzol.		(ii) Prairie soil.	
<i>Manning River (Lorne Basin).</i>			
(i) Fine sandstone.	Very deep porous soil.	(i) Shale.	Angular shale fragments throughout profile becoming dense and compact at about 15". At 30" mainly shale.
(ii) Krasnozëm.		(ii) Immature.	
<i>Bellangry.</i>			
(i) Greywacke (30% quartz)	Deep porous profile; some bands of weathered rock present, but no barrier to moisture on roots.	(i) Greywacke (low quartz-high chlorite).	Angular rock fragments and soil of light texture to 15", below 15" rock increasingly massive.
(ii) Krasnozëm.		(ii) Immature.	
<i>Pine Creek.</i>			
(i) Schist.	Loam and clay loam over shattered schist in parts deeply weathered.	(i) Schist.	Variable shallow soil to 24" over massive horizontally bedded schist.
(ii) Yellow podzolic.		(ii) Immature.	
<i>Cooloolabin.</i>			
(i) Trachyte.	Grey brown clay loam over a yellow brown clay and heavy clay; deep profile.	(i) Trachyte.	Grey brown loam to 15", yellow brown clay to 30", over a massive parent rock.
(i i) Yellow podzolic.		(ii) Brown podzolic.	

The evidence presented this far would suggest that the distribution of blackbutt is limited by any physical properties of the soil profile which restrict aeration, moisture permeability or penetration of roots to depth, such soil properties varying with the mineralogy of the parent material, its geological history and the landscape pattern. Blackbutt, however, does not occur on all soils which are apparently adequate in physical properties, and the plant-soil relationships involved in representative cases are discussed later in this paper.

Physical Properties of Rainforest Soils.

Webb (1956) has shown that a suitable range of available moisture and macroporosity are apparently necessary for rainforest formation, but he has stressed that structure in rainforest soils could not be dissociated from the effects of rainforest themselves and so claimed to be causative. Soils which are permeable and well aerated in virgin rainforest may become compacted and waterlogged after removal of the forest, and cultivation. A possible example of the critical nature of soil structure for rainforest formation is seen on soils developed from Carboniferous shale in Cooperbrook Forest. Normally the moist gully habitats support a typical mixed sclerophyll and rainforest element. The soils are heavy textured and notably subject to waterlogging. However, an isolated patch of rainforest has formed in a small alluvial fan at the

base of a gully formed along the junction of the shale and a relatively sterile Triassic sandstone. The presence of the rainforest might be attributed to the simultaneous build up of clay colluvium and sandstone fragments, resulting in the formation of a clay loam with well-developed structure and a particular low bulk density: at 3", 0.96; at 15", 0.90; and at 33", 0.86. In the absence of the ameliorating sandstone influence, the mixed forest may represent an "edaphic climax", restricted by deficiencies in the soil structure.

TABLE 2.

Physical Properties of Soils Associated with adjacent Blackbutt and White Mahogany Forests.

(i) Parent Rock. (ii) Soil Group.	Profile.	Depth.	Density	Notes.
<i>Manning River State Forest.</i>				
(a) <i>Blackbutt.</i>				
(i) Sandstone.	Clay loam over light clay; coarse	3"	0.80	Deep, permeable with good aeration characteristics.
(ii) Krasnozern.	granular structure.	18"	1.24	
		33"	1.34	
(b) <i>White Mahogany.</i>				
(i) Felspar-sandstone.	Fine granular sandy loam to 6" over red and yellow mottled stiff sandy	3"	1.27	Even at the surface B.D. is high, and at 33" root penetration aeration may be impeded.
(ii) Yellow-red podzolic.	clay, fine blocky structure.	15"	1.44	
		33"	1.56	
<i>Manning River State Forest.</i>				
(a) <i>Blackbutt.</i>				
(i) Sandstone.	Loam to 10" where sharp transition	3"	0.93	Both of these communities are part of a mosaic on what is a marginal blackbutt site. The white mahogany (<i>E. umbra</i>) is present throughout the blackbutt forest but also occurs in depauperate patches; the very compact clay horizon in these latter situations may be limiting for blackbutt.
(ii) Podzol.	to red brown stiff clay, and gradual change to pale grey sandy clay streaked with yellow, red, brown; in B horizon coarse blocky structure.	15"	1.30	
		33"	1.50	
(b) <i>White Mahogany.</i>				
(i) Sandstone.	Sandy loam to 8" where sharp transition to yellow brown sandy clay changing to heavy clay at 27", the latter granular and exceptionally compacted.	3"	1.27	
(ii) Podzol.		15"	1.44	
		27"	1.77	
<i>Queens Lake State Forest.</i>				
(a) <i>Blackbutt.</i>				
(i) Sandstone.	0-5" sandy loam, 5-15" yellow brown light clay.	3"	1.19	In spite of heavy textured subsoil, the good structural characteristics and moderate bulk density indicate reasonable aeration, moisture and root penetration potential.
(ii) Yellow-red podzolic.	15-36" red brown heavy clay, coarse blocky structure breaking to fine blocky.	15"	1.35	
		33"	1.33	
(b) <i>White Mahogany.</i>				
(i) Basic conglomerate.	Variable depth over rock, but where relatively deep, a granular sandy clay.	3"	1.07	Combination of rock habit, texture, lack of particle aggregation, and high bulk density would restrict aeration and permeability.
(ii) Podzolic.		15"	1.45	
		33"	1.62	

V. SOIL MOISTURE AND THE VEGETATION PATTERN.

Although the many difficulties inherent in an adequate examination of the soil moisture factor in community differentiation were well appreciated, it was felt that a comparative study of soil moisture availability patterns would provide some initial information on forest community-soil moisture relationships that could lead to a later, more critical evaluation of the soil moisture factor in the vegetational mosaic.

During the period April, 1959, to August, 1960, soils were sampled for moisture determination at six-week intervals in three blackbutt, three white mahogany and three rainforest and marginal rainforest communities. In each community samples from three borings were taken at 4" and 40"; these were dried at 105° C for 48 hours and moisture content expressed as a percentage of oven-dry weight. For each soil and depth, determinations in triplicate were made of Wilting Point and Field Capacity,

using pressure membrane apparatus under a tension of 15 atmospheres for five days and $\frac{1}{2}$ atmosphere for two days respectively.

Unfortunately for a study of this nature, most of the experimental period was characterized by atypically high rainfall. Normally the months of greatest potential moisture stress are August to November, but in 1959 more than double the mean rainfall was recorded for this period. However, dry conditions prevailed from July, 1960, to October, 1960, with less than one-third normal rainfall, and the pattern of drying for the various soils has been demonstrated.

The pattern of change in soil moisture in relation to Wilting Point and Field Capacity is shown for each of four adjacent communities in Bellangry State Forest (Fig. 4). Three communities are developed on krasnozemic profiles, namely (i) blackbutt with little rainforest element; (ii) Sydney blue gum-brush box-tallowwood, grading downslope into (iii); subsequently referred to as "marginal rainforest"; (iii) rainforest characterized by presence of *Argyrodendron trifoliatum*. The fourth community, white mahogany, is on a brown podzolic.

The blackbutt forest had clearly the most favourable soil moisture characteristics, a wide range of available moisture, and a soil moisture level consistently approaching Field Capacity. In both the rainforest and marginal rainforest soils, ranges of available moisture were comparatively restricted, and at 4" the soil moisture had fallen below Wilting Point before the final sampling in October, 1960. At 40" the blackbutt soil was consistently above the Wilting Point until the August, 1960, sampling. In contrast, the marginal rainforest soil was particularly droughty, being above Wilting Point in only three samplings at 40"; inside the rainforest itself, at the base of the slope, soil moisture was more readily available at this depth.

At Coopernook the position was much the same. At 4" a blackbutt forest soil (a krasnozem) had a wide range of available moisture and a moisture content generally in the upper part of that range. The rainforest soil developed on the alluvial fan (Section IV) was surprisingly droughty, mainly because of the high Wilting Point. At 40" the rainforest soil fluctuated close to Wilting Point, but the blackbutt soil was consistently above that level. Two white mahogany soils at Coopernook showed rapid soil moisture fluctuation at 4", but at 40" soil moisture was much more stable.

One of the striking features of the data obtained is that unless rainforest species which draw their moisture supply principally from the 0-40" depth range are able to obtain moisture at levels below the permanent wilting percentage, then these species must be subject to moisture stress in most years and severe moisture stress in periodic drought years.

The comparative status of soil moisture availability in the eucalypt-sclerophyll and gully rainforest is surprising. Undoubtedly it may be related in part to the greater moisture usage under rainforest, but in addition the question arises as to whether rainforest, by virtue of its own effect on soil pore characteristics (through the nature of its litter and organic matter), effectively limits the availability of soil moisture to itself. This is suggested by the range in available moisture for four krasnozem profiles, as follows.

		Field Capacity. (% Soil Moisture.)	Permanent Wilting Percentage. (% Soil Moisture.)	Range of Available Moisture.
Blackbutt Forest, Coopernook	.. ..	54	27	27
Blackbutt Forest, Bellangry	.. ..	50	24	26
Marginal Rainforest, Bellangry	.. ..	49	32	17
Rainforest, Bellangry	.. ..	57	41	16

Webb (1956) has also commented on the narrow range of available moisture found in many rainforest soils; he found there was a high percentage of small pores in the soil and Wilting Points were typically high. For this reason, he stated, rainforest required climates which were relatively moist during the year. It seems, therefore,

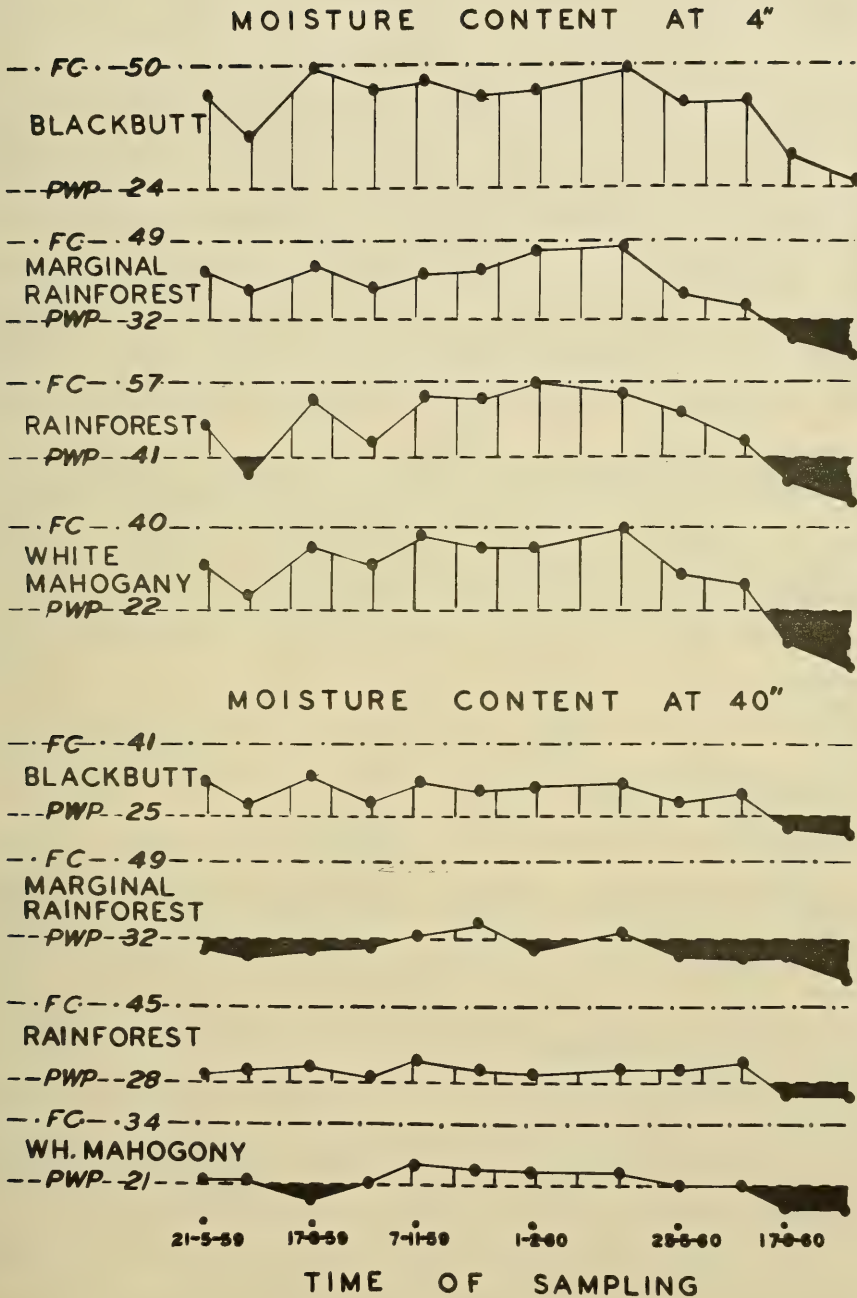


Fig. 4. Patterns of change in soil moisture at 4" and 40" in four forest communities at Bellangry. Soil moisture content was expressed as a percentage of oven-dry weight, and for each community has been plotted between the soil's Field Capacity (FC) and the Permanent Wilting Percentage (PWP). Vertically hatched and darkened sections illustrate available moisture and possible soil drought respectively.

that under conditions where other soil properties are not limiting for rainforest, soil moisture availability would be a critical factor in its distribution. At lower elevation, or in steep topography, rainforest might be restricted to gully habitats, but if the same soil were at higher elevations, or in more gently underlying relief, rainforest could be the dominant vegetation.

VI. THE NUTRIENT FACTOR IN THE VEGETATION PATTERN.

The total amount of nutrient available to a plant in a given soil is primarily a function of the lithology of the parent material and the weathering to which it has been subjected. It is also a function of the vegetation present through its effect on (i) differential use or accumulation of various elements, (ii) distribution of total nutrients through the soil-plant ecosystem, (iii) rate of nutrient mineralization from the organic matter, and (iv) the nature of plant-microbiological interactions.

It is apparent then that in ecological studies the use of the pot-nutrient technique for determination of the soil-nutrient factor in plant distribution may have certain limitations. This was well illustrated in this study. It had been planned to examine the possibility that a soil-nutrient factor might be responsible for the ecological differentiation of blackbutt and white mahogany by nutrient studies with blackbutt seedlings in a number of white mahogany soils, and with white mahogany seedlings

TABLE 3.
Yield of Blackbutt in White Mahogany Soils. Mean Leaf Area Production per Pot—Sq. Inches.

No Addition.	Minus ¹ P.	Minus N.	Minus K.	Minus Ca.	Minus Tr. ²	Complete Nutrient.
<i>E. acmenioides</i> Soil (I). 64.2**	99.2*	75.1**	118.4	118.8	117.5	117.5
<i>E. acmenioides</i> Soil (II). 78.7**	86.9**	115.7**	140.0	141.1	—	143.1
<i>E. umbra</i> Soil (III). 9.3**	14.3**	46.4**	80.1**	82.4**	91.7	89.7
<i>E. umbra</i> Soil (IV). 39.8**	79.1	52.9**	91.6	88.9	—	90.0

¹ Complete nutrient addition minus P . . . (etc.).

² Trace elements.

For each soil, differences from "complete nutrient". * Significant at 5% level; ** significant at 1% level.

in a number of blackbutt soils. Following the demonstration of the severe inhibition of blackbutt and other plants in a blackbutt soil (Florence and Crocker, 1962) this approach seemed hardly justified. However, blackbutt seedlings did not develop symptoms of inhibition in *E. acmenioides* soil, and the use of the pot-nutrient technique has made possible some conclusions concerning (i) the nutrient status of white mahogany soils for growth of blackbutt and (ii) relative fertility status of *E. acmenioides* and *E. umbra* soils.

Soils were sampled from the surface 6" in two *E. acmenioides* forests and two *E. umbra* forests; they were coarse-sieved, and for each soil equal amounts by weight were placed in 8" diameter pots. The "omission method" for exploratory examination of nutrient deficiencies was used in each case, and the "complete nutrient addition" consisted of NaH_2PO_4 at 4 cwt/acre, NH_4NO_3 at 1 cwt/acre, KCl at 1 cwt/acre, CaCO_3 at 2 cwt/acre, MgSO_4 at 1 cwt/acre, and a mixed trace element solution containing Fe, Bo, Mn, Zn, Cu and Mo. All nutrients except Ca were added in solution. Summarized yields (leaf area production per pot) are presented in Table 3.

Although lower yields were obtained in the absence of either N or P in *E. acmenioides* soils, blackbutt seedlings developed well without nutrient addition. In *E. acmenioides* soil No. I, the main response was to N with a smaller response to P. In this same soil under field conditions excellent growth of cotyledonary transplants was obtained, though seedlings were a pale green throughout. In *E. acmenioides* soil

No. II all seedlings were a dark healthy green including those without nutrient addition, but nevertheless a response to both N and P was obtained. In view of blackbutt's response to N and P on a high site quality blackbutt soil, especially after air-dry storage or mild heat treatment (Florence and Crocker, 1962), there seems little basis for suggesting that responses to these nutrients in this case indicate a critical deficiency in the soil limiting blackbutt's occurrence on the soil.

The yield pattern on *E. umbra* soils suggests the possibility that N and P deficiencies could be limiting for blackbutt. The failure of seedlings on the unaltered *E. umbra* soil No. III might not be attributed to microbiological inhibition, as the seedlings exhibited neither leaf purpling nor severely restricted root development. *E. umbra* soil No. IV was obtained from a depauperate community marginal to blackbutt forest on sandstone (Table 2). The soil was a pale sand, and in view of the nature of the vegetation, some marked deficiencies were expected. However, absence of added P had no, or possibly a very slight effect on yield, but absence of added N had a depressive effect. Even with complete nutrient leaves were slightly chlorotic, and it appears that level of N added was inadequate, particularly in the presence of added P.

From the lithological, soil profile and nutrient study, some tentative conclusions concerning differentiation of blackbutt and white mahogany are now possible.

(i) Blackbutt is not necessarily restricted by a soil nutrient deficiency from *E. acmenioides* sites, a conclusion supported both by glasshouse and field studies.

(ii) The relationship between blackbutt nutrient requirement and *E. umbra* soils is not clear. Their frequent co-occurrence indicates a considerable overlap in their physiological tolerances. The adequate soil P in the depauperate *E. umbra* community (Soil No. IV) suggests a blackbutt tolerance of soils of particularly low fertility status.

(iii) By and large, therefore, it seems that the delimitation of these interbreeding species is related to the physical characteristics of the soil rather than to its nutritional status.

TABLE 4.
Exchangeable Cations and Phosphorus in Soils from a Range of Vegetational Types.
(From Baur, 1957.)

	Exch. Cations. (m.eq/100 gr.)	Exch. Ca.	Exch. K.	Total PO ₄ p.p.m.
Rainforests with <i>Argyrodendron</i> ..	15.8-62.0	10.5-47.2	0.8-2.8	2940-7620
Rainforests with <i>Ceratopetalum</i> ..	2.3-11.3	1.1- 3.5	0.6-1.0	520-1090
Wet sclerophyll	6.8-10.2	2.3- 5.9	0.5-0.7	480-1710
Dry sclerophyll	0.9- 4.5	0.4- 3.2	0.1-0.9	110- 226

The Nutrient Factor in the Vegetational Gradient to Rainforest.

Within both blackbutt and white mahogany communities, the largely parallel gradients from xeromorphic to mesomorphic vegetation (Florence, 1963) are undoubtedly associated with gradients in soil fertility status. In agricultural development in eastern Australia, the rainforest areas of reasonable relief were the first to be settled, although subsequent deterioration in nutrient status of many of these soils has been rapid. The association of rainforest with basic parent materials, or with soils enriched with basic materials, points to a high fertility requirement, and in fact Beadle (1954, 1962) has shown that an increase in phosphorus content of parent materials and soils in the Sydney district is associated with vegetational gradient from dry sclerophyll to rainforest. Data presented by Baur (1957) show that soils of the most highly developed rainforest type in New South Wales (characterized by the presence of *Argyrodendron* sp.) are particularly high in exchangeable cations and phosphorus (Table 4). On the other hand Baur's data show that certain "wet-sclerophyll" communities, and rainforest communities characterized by the presence of *Ceratopetalum*, are associated with much the same range of values for soil phosphorus

and exchangeable cations. While this suggests that *Ceratopetalum* and *Argyrodendron* rainforests may be delineated by soil fertility status, studies of the total nutrient content within the "wet sclerophyll" and *Ceratopetalum* rainforest ecosystems would be necessary to determine their nutrient relationships. Rainforests may have much greater amounts of nutrients immobilized in the dense crown layers, and these are probably circulated through the plant-root system at a much faster rate than in eucalypt forests. It may be that "wet-sclerophyll" forests with soil nutrients at the upper limit of the given range may be limiting in soil moisture for *Ceratopetalum* rainforest development and, alternatively, *Ceratopetalum* rainforest soils with nutrients at the lower limit of the given range may have a very favourable and compensating soil moisture regime. Alternatively some superimposed factor such as the fire history of the forest could tip the balance between sclerophyll forest near the upper limit of the vegetation gradient towards rainforest, and *Ceratopetalum* rainforest.

VII. THE COMMUNITY-SITE INTERACTION AS A FACTOR IN THE VEGETATION PATTERN.

Florence and Crocker (1962) have suggested that the nature of the interaction of a plant community with its environment can be a critical factor in determination of vegetational relationships. This was based on their investigations into the severe inhibition of blackbutt seedling growth in blackbutt forest soil, and the finding that some component of the soil microflora was directly antagonistic to blackbutt seedling roots. A tentative hypothesis suggested that the development of a blackbutt forest might depend on a considerable degree of fluctuation in the microbiological environment and that, along gradients of decreasing potential for that fluctuation, the interaction of blackbutt with its site would be increasingly adverse, resulting in modification to the blackbutt community, and eventually to its complete replacement.

The possible application of such an hypothesis to explain some otherwise puzzling aspects of blackbutt's vegetational relationships is examined for two typical situations.

(i) *Possible Mechanism Restricting Blackbutt along a Gradient of Increasing Permanence in Soil Moisture Status.*

A widespread vegetational pattern on Silurian schists and shales of the Coffs Harbour area is the occurrence of blackbutt forest on ridges, with rainforest in gullies and with a variable strip of white mahogany forest interposed between the two. Soil profiles were examined along several road cuttings in Newry and Orara Forests, but no marked differences in physical properties were found. It was noted, however, that the soil exposed in cuttings on lower slopes (carrying white mahogany forest) was apparently moister than on upper sections of the slopes (carrying blackbutt forest). This probably resulted from the tilt and low permeability of the schist rock with consequent movement of moisture downslope rather than to depth. If the development of a blackbutt forest, on some soils at least, is partly dependent on fluctuation in the microbiological environment as hypothesized, then this may be achieved to a large degree through fluctuation in soil moisture and through the resultant cumulative effect of the drying and wetting cycles on stimulation of microbiological activity and organic carbon and nutrient mineralization (Birch, 1958). Under conditions where level of soil moisture may be relatively stabilized by slow moisture infiltration, the microbiological condition created through incorporation of blackbutt litter could well interact adversely against this species, and an alternative species so enabled to gain dominance. In this respect it is possibly significant that the properties of *E. acmenioides* litter are such that no apparent inhibition was found in several *E. acmenioides* soils.

(ii) *Possible Mechanism Restricting Blackbutt along a Gradient of Increasing Soil Fertility.*

On part of Bellangry Forest a quite striking vegetational pattern consists of an alternating occurrence of sharply delimited blackbutt and marginal rainforest communities (Sydney blue gum, brush box, tallowwood). Both extend from ridge to gully habitats, the former having little rainforest element and the latter a low rainforest element on slopes and *Argyrodendron* rainforest in a broad fan at the base of the slope.

These contrasted communities are both developed on krasnozems profiles similar in general appearance; both have clearly had a history of fairly severe fires before protection. What then is the reason for their sharp delimitation?

The blackbutt forest soil is associated with a parent material with a higher quartz and lower biotite content than the marginal rainforest soil (Section III). Both the blackbutt parent material and soil are more weathered, the blackbutt soil being a clay and the marginal rainforest soil a loam. In view of the variation in rock mineralogy, the weathering status of rock and soil, and the lower slope occurrence of *Argyrodendron* rainforest on the marginal rainforest soil, it can be indirectly inferred that this latter soil has a considerably higher fertility status. The question becomes one of suggesting how a soil that is probably not limiting in other directions can, by virtue of a high fertility status, sharply restrict the presence of blackbutt. Both of these soils were shown to inhibit severely blackbutt seedling development (Florence and Crocker, 1962), but seedlings in the marginal rainforest soil were strikingly chlorotic in contrast to the typical purpling of inhibited seedlings in a blackbutt forest soil. Although blackbutt seedling growth is restricted in an undisturbed blackbutt forest soil, it is possible that blackbutt seedlings could be even more sensitive to the various influences of certain other species on soils of high fertility status, and in this way there could be an effective barrier to blackbutt seedling establishment and survival on those soils.

In the example described, the blackbutt forest was sharply delimited from the marginal rainforest along an edaphic boundary. But frequently the same accumulation of dominants (Sydney blue gum, tallwood, brush box) dominating a rainforest element stratum is interposed between blackbutt forest and rainforest along a uniform environmental gradient. In such cases an increasing fertility status through colluvial enrichment, or increasing permanence in soil moisture status, or both, may well create conditions with which blackbutt would interact unfavourably, and so result in a gradual displacement of blackbutt from the community.

DISCUSSION.

The main conclusions from the study of edaphic relationships in east coast vegetation can be summarized as follows:

(i) The interbreeding species blackbutt and white mahogany occupy largely distinctive habitats, characterized by differences in physical properties of soils and expressed through variation in potential for soil aeration and root penetration to depth.

(ii) Blackbutt and white mahogany communities occupy largely parallel gradients from open sclerophyllous conditions to mixed sclerophyll-rainforest, and rainforest, respectively. Vegetation gradients may be correlated with gradients of increasing soil fertility status, or to some extent with gradients of increasing soil moisture. Where soil nutrients are particularly limiting, improvement in soil moisture may have little or no effect on the vegetation, and alternatively, where soil nutrient status is high the vegetational gradient may be restricted through soil moisture deficiencies. Irrespective of nutrient or moisture status, vegetation gradients to rainforest may be restricted by limiting physical soil conditions.

(iii) The upper limit of blackbutt's environmental tolerance along gradients of increasing soil fertility, soil moisture, or both, may be determined in part by the nature of its own interaction with its environment. On the other hand, white mahogany may extend along environmental gradients and be marginal to rainforest.

The relationship between the broader edaphic criteria and vegetation can be expressed diagrammatically by illustrating the alignment of vegetation along gradients in physical and chemical soil properties (Fig. 5). The model assumes a geographic location in the centre of the common blackbutt-white mahogany-rainforest range, a low elevation with rainfall around 60" per annum and a flat topography. The influence of slope on vegetation would vary from point to point on the model, and a key is included showing slope effects for a number of representative situations.

In the foregoing an attempt has been made to show how the complexities of the vegetational pattern in east coast forests composed of blackbutt, white mahogany and rainforest communities may be closely related to variation in physical, chemical and biological properties of the soil. This, however, is probably not a static relationship, even over the geographic range common to all three species; it has been suggested, for example, that brush box and turpentine may have a wider edaphic tolerance in southern Queensland than along the central coast of New South Wales (Florence, 1963). That the relationship between the nature of the vegetation and the parent

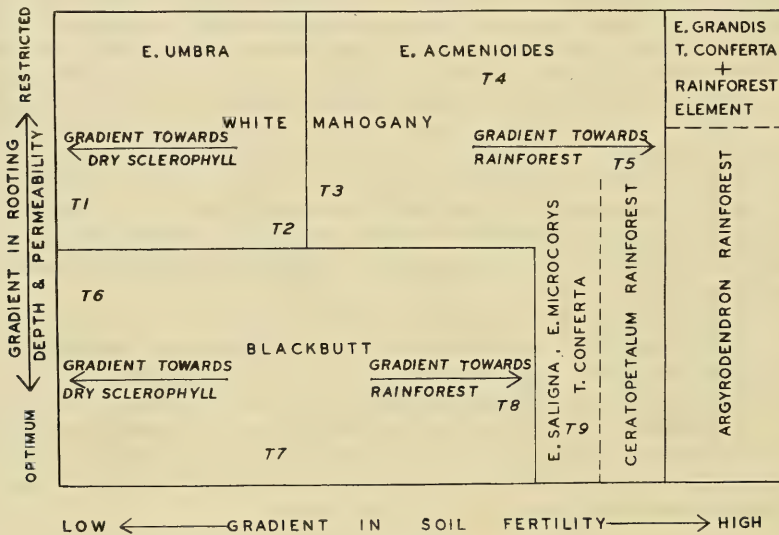


Fig. 5. Diagrammatic illustration of the relationships between vegetation and the broader edaphic criteria. The model assumes low elevation with rainfall around 60" per annum and a flat topography.

- Key to the influence of slope on vegetation at a number of points (T_1 , T_2 . . . T_9) follows:
- T_1 No changes in dominant strata, slight changes in understorey.
 - T_2 Some *E. grandis* in broader colluvial situations with a limited shrubby mesophytic element understorey.
 - T_3 Mixed forest (with *T. conferta*) or *Ceratopetalum* type rainforest.
 - T_4 Where colluvial material is of good structure—rainforest, but otherwise mixed forest—i.e. *E. grandis*, and *T. conferta* emergent over rainforest.
 - T_5 Through increasing *T. conferta* to highly developed *Argyrodendron* rainforest.
 - T_6 On gentler slopes *E. pilularis* decreases and *E. resinifera* and *E. umbra* increase, with some development of mesophytic shrubs. In deeper alluvial situations, a *T. conferta*-*E. grandis* mixed forest.
 - T_7 Steep topography is unlikely on this soil. On moderate slopes, scattered mesophytic shrubs develop with some *E. grandis* and *Acmena* and *Eugenia* species along watercourses.
 - T_8 On slopes, *E. pilularis* decreases and *E. microcorys* and *E. saligna* increase; composition of understorey becomes richer in rainforest element species. On long slopes, *E. pilularis* may cut out, and a *E. saligna*-*E. microcorys*-*T. conferta* community may be interposed between the blackbutt and pure rainforest.
 - T_9 *Argyrodendron* or *Ceratopetalum* rainforest.

material and soil does alter is evident from the occurrence of rainforests in North Queensland on soils derived from some types of parent material from which they would certainly be absent in the south.

Although the actual pattern in Nature may be very complex (Fig. 1), particularly where there is variability in the parent material and where the topography is steep and uneven, it is apparent that the total plant community in a given ecological niche can be regarded as a single unit that is the resultant expression of a number of environmental pressures; and, further, the total community changes sensitively and predictably with changes in edaphic environment. In an earlier paper (Florence,

1963) the concept was advanced that the eucalypt-rainforest relationship can be characterized as a continuum; in terms of environment this concept envisages a gradual change in the composition of both the dominants and the associated rainforest element species along gradients of increasing soil fertility and/or permanence in soil moisture status. In the virgin forests before the advent of man, the expression of the continuum may have been restricted, possibly because of the nature of the eucalypt influence on its own site, and certainly by the superimposed influence of periodic wildfires, resulting in sharp discontinuities in the eucalypt-sclerophyll relationship. Consequent to the advent of man, widespread habitat disturbance followed by complete protection may have led to the so-called rainforest "advance", but this may represent a more complete expression of the continuum through less restricted development of species according to their respective amplitudes.

The concept that the vegetation in a given ecological niche is the sensitive expression of largely the edaphic environment, conflicts with the widely held view that fire incidence is the major factor determining the vegetation pattern, a view summarized by Cremer (1960) in these terms: ". . . From the point of view of the rainforest the eucalypts are but a transient fire weed . . . the mixed forest is then a fire sere in the succession towards the rainforest climax." While it is well recognized that eucalypts, and such other species as turpentine and brush box, will not regenerate within a well-developed rainforest element understorey, it is, on the other hand, open to serious doubt whether the factors of the environment would be adequate to enable a rapid and widespread development of a self-perpetuating rainforest following senescence and death of the dominant stratum in much of the "mixed" forest in eastern Australia. Perhaps at an advanced stage along the environmental and vegetational gradient towards rainforest, the rainforest element stratum could maintain itself as such (e.g., a coachwood community understorey to tallowwood and brush box), but it seems inconceivable that even the most highly developed rainforest element stratum under blackbutt, for example, could maintain itself indefinitely if, as postulated, that element is by necessity composed of species with less demanding edaphic requirements. Although it is accepted that perpetuation of most "mixed" forests may in fact have resulted directly from periodic wildfires or other major disturbances (e.g., cyclones), it is nevertheless suggested that a rainforest-element stratum which is not capable of self-perpetuation following senescence of the dominants would itself decline in time, leading directly to regeneration of the dominants, or creating the vegetational condition conducive to its own destruction by fire.

Ultimately, a real understanding of the complexities of the eucalypt-rainforest relationship must depend on a much more intimate understanding of the various ecosystems, e.g., the total nutrient store, its distribution and re-circulation, the moisture balance, the influence of species and species mixtures on the physical, chemical and biological properties of the soil, and their contribution to the overall biological system. Again, it seems necessary that ecological thought must be directed to the principles contained within Watt's (1947) classic perspective on the dynamics of the plant community. Watt demonstrated, for a wide range of communities, that many dynamic situations may be cyclic, and not, as would appear at a point in time, seral; a species or group of species in a community may undergo a regular series of upgrade and downgrade phases in which there is a continual change in ecological structure. If, in east coast forests, a community of sclerophyllous dominants and rainforest element species form a vegetational unit sensitively in equilibrium with the environment, then in terms of Watt's concept, a downgrade phase (or senescence) of overmature sclerophyll dominants could be associated with an upgrade phase of the rainforest element and, in time, the downgrade phase of the rainforest element with an upgrade phase of the sclerophyll. Long-term analysis of vegetational dynamics in these mixed communities would be necessary to substantiate or reject such an hypothesis, an analysis that would be complicated by the impact of broader (e.g., macroclimatic) changes on the habit-sensitive communities.

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CHROMOSOME NUMBERS AND RELATIONSHIPS IN *CHARA LEPTOPITYS* A. BR.¹

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(Plate ii; three Text-figures.)

[Read 27th May, 1964.]

Synopsis.

Chara leptopitys A. Br. First chromosome counts in this species from Western Australia and South Australia show 14 chromosomes, an expected number in the haplostephanae. The numbers 21 and 42 were also found in dividing antheridial filament cells in certain enlarged antheridia produced by otherwise normal plants with 14 chromosomes. The possible significance of this endopolyploid condition is discussed in relation to the initiation of polyploidy by means of a multiplication of genomes in gametes in the charophytes.

In a collection of *Chara leptopitys* A. Br. from Western Australia there were found within single individuals two or three distinct chromosome numbers revealing a striking instance of endopolyploidy in these plants. A multiplication of genomes in dividing or extra large nuclei has been observed in occasional antheridial filament cells of naturally occurring, untreated *Chara contraria* (Hotchkiss, 1958), and *Nitella furcata* (Imahori and Kato, 1961). Endopolyploidy in *Chara leptopitys*, however, involves the cells of entire antheridial filaments and entire antheridia dividing in synchronous mitoses.

MATERIALS AND METHODS.

Material of *Chara leptopitys* used in this study was from the extensive collections of charophytes made by Prof. R. D. Wood as reported by Wood (1962b, 1963, and in press) and Hotchkiss (1963, and in press). Among these collections from the Australasian area was a series of specimens fixed in the field for cytological examination and sent to the present author for study. The data recorded by Wood for the two collections used here are as follows:

1. R. D. Wood 60-10-11-1-B. In 2-4" of water, muck bottom. Pool, W side of road 12 miles N of Katanning, Western Australia. Abundant; cold water.
2. R. D. Wood and von der Borsch 60-9-22-3. Sept. 22, 1960. In 3-5" of water; fresh water pool on W side of road. C. 10 mi. SE of Salt Creek, Coorong Region, South Australia.

For fixation, fertile young stem tips, or "heads", were selected in the field and placed in freshly prepared acetic-alcohol in the usual manner. These were later transferred to 70% alcohol and after shipping were stored under refrigeration until examined in aceto-orcein squash preparations.

OBSERVATIONS.

Macroscopic Features. The material of *Chara leptopitys* from Western Australia consisted of seven separate heads or stem tips (Heads 1, 2, etc.) each containing 3-5 whorls of branchlets. It is not known whether these heads were from the same or different plants. In the process of study much of the material was utilized and reduced to small fragments, but the following general description, which agrees well with the description provided by Nordstedt (1891), was made before dissection. *Stem cortication* diplostichous; *stipulodes* haplostephanous, apparently alternating with the branchlets (opposite according to Nordstedt, 1891), long, slender, with acute tips, stipulodes well developed at nodes bearing few basal gametangia but few or lacking at nodes with many

¹ Contribution No. 76 (New Series) from the Department of Biology, University of Louisville. This study was supported in part by the National Science Foundation, Washington.

basal gametangia which appear to replace them; *branchlets* 5-7 per whorl, with 3-4 branchlet nodes including the terminal one, the lower two branchlet nodes fertile; *gametangia* dioecious (only male plants seen), *antheridia* aggregate at the base of the branchlets where they extend outside and below the branchlets, geminate or up to four per node at the two branchlet nodes (above the base) or occasionally solitary at the uppermost fertile node, antheridia 950μ in diameter, often with the plates as outwardly bulging protuberances.

The heads were examined in detail and their structures noted separately as follows. *Head 1* appeared abnormal in that there were many antheridia of different sizes clustered together at the base of the older whorls of branchlets. Besides a considerable range in antheridial size from small to large, surface protuberances were conspicuous on the larger antheridia. *Head 2* contained more antheridia, but the range in antheridial size was not much greater than normally seen within and between whorls of branchlets on the same plant. There were no extremely large, bulbous-looking antheridia. *Heads 3-7* bore normal appearing antheridia and generally resembled head 2.

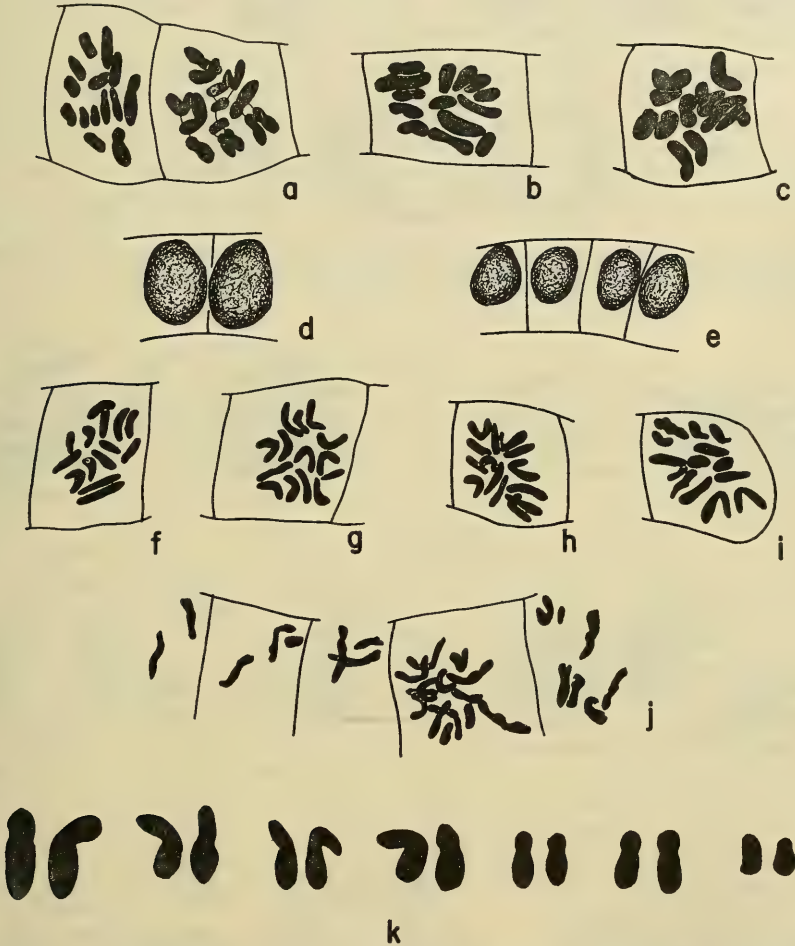
The material of *Chara leptopitys* from South Australia was still more limited and consisted of but three heads with 4-5 whorls of branchlets bearing antheridia all of normal appearance. The stipulodes were longer, but in other respects this material resembled the Western Australian plants; the gametangia were in the same arrangement.

TABLE 1.
Dimensions of Antheridial Filament Cells of Chara leptopitys, Western Australia.

Chromosome Number.	Length and Breadth in Microns.			
	Resting Cell.	Dividing Cell.	Last Telophase Before Presperm.	Presperm Cell.
14	27-21	27-23	8-27	7-22
21	27-27	32-27	12-27	—
42	34-27	40-27	16-27	8-22

Chromosome Numbers and Cytological Observations. Because of the unusual appearance of the antheridia in one of the heads from Western Australia, this was examined first. All of the extraordinary chromosome numbers were observed in heads 1 and 2. The first preparation from head 1 was made with a selection of antheridia from the youngest apical whorl down through the third and oldest whorl of branchlets in order to sample the various stages of antheridial development. Antheridia in the first whorl appeared normal, were small, contained short, immature antheridial filaments with cells of a small diameter of 21μ (Table 1). Cells in mitotic division showed counts of 14 chromosomes only (Text-fig. 1; Plate ii, A). Antheridia from the second and third whorls ranged in size from small to large, the smaller antheridia had dividing filaments with 14 chromosome counts, and presperm cells and sperm of normal size. Some very large, bulbous, protuberant antheridia were entirely polyploid with all the dividing cells in all filaments with 42 chromosomes (Text-fig. 3; Plate ii, C). These cells were about 27μ broad by 38μ long when in division and somewhat shorter in interphase. The presperm and nearly mature sperm cells were all correspondingly large (Table 1). From the large number of adjacent synchronous stages of mitosis (up to 30-40 cells at metaphase and anaphase), the cells in 42-chromosome filaments appeared to be quite stable. At the same time, there were instances of irregularity in mitosis as seen in a tripolar spindle shown in Text-figure 3, *d*, which was bounded on either side by dividing cells in regular anaphase, and in other antheridial filament cells with either lobulate nuclei or with a multinucleate condition (Text-fig. 3, *e-f*).

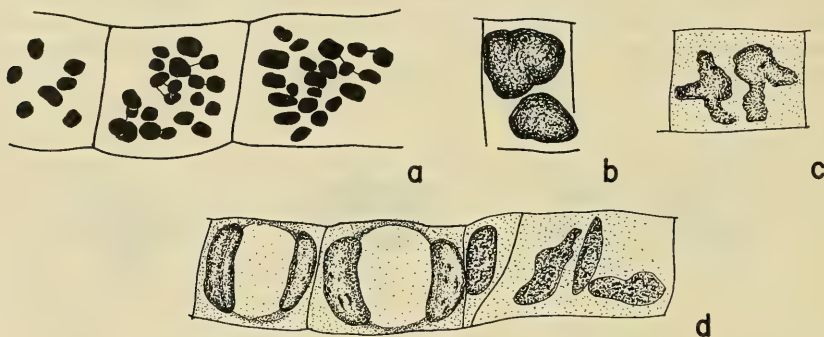
Alerted to the variability in the material, and with more antheridia available than in the first head, a second head was studied whorl by whorl in a series of five preparations. The first, from eight minute antheridia all from the youngest whorl, contained short, immature filaments in which all dividing cells displayed 14 chromosomes; no presperm or sperm cells were yet present. A second preparation from the second whorl of branchlets contained nine antheridia all normal in size and appearance. All but two of these showed normal presperm cells only; the remaining two antheridia had filament cells in division showing 14-chromosome counts only.



Text-figure 1.—Mitosis in *Chara leptopitys*, $n = 14$. *a-c*, Metaphase, showing somatic pairing in *a*. *d*, Last telophase preceding presperm stage. *e*, Telophase in presperm cells. *f-j*, Metaphase, showing knob-like projections in *j*. *k*, Paired arrangement of karyotype from Text-figure 1, *a*. *a-e*, Western Australia. *f-j*, South Australia. *a-j*, $\times 650$. *k*, $\times 1300$.

A third preparation from the third whorl of branchlets contained six antheridia, five of which were of the size normal for mature antheridia; the sixth one was slightly larger but not conspicuously bulbous. Four of the five antheridia showed normal presperm cells, the fifth one contained several filaments of normal size and with 14 chromosomes, but most filaments were made up of larger cells with 21 chromosomes in the dividing cells (Text-fig. 2; Plate ii, B). As many as 10 cells in synchronous, adjacent metaphase were seen, but usually only two adjacent cells were in metaphase. Presperm of both normal size and a larger size corresponding to the larger cells with

21 chromosomes were present, but no mature sperm were found in this antheridium. The sixth antheridium had all cells either as larger presperm or with 21-chromosome divisions. Antheridia in other preparations from whorl three were all of normal appearance and without divisions.



Text-figure 2.—Mitosis in *Chara leptopytis*, Western Australia, $n = 21$. *a*, Metaphase. *b-d*, Aberrant mitoses in terminal divisions, somatic reduction. All $\times 650$.



Text-figure 3.—Mitosis in *Chara leptopytis*, Western Australia, $n = 42$. *a*, Prophase. *b*, Metaphase. *c*, Normal anaphase and telophase. *d*, Anaphase with tripolar spindle between normal anaphase figures. *e-f*, Telophase figures following aberrant mitoses, somatic reduction. All $\times 650$.

In heads 3-7 from Western Australia and in the three heads of material from South Australia no unusual chromosome numbers were found. All heads were normal in both external and internal appearance and samplings of all revealed antheridial filaments with 14 chromosomes only.

The complement of 14 chromosomes (Text-fig. 1), found exclusively in the plants from South Australia and in the great majority of cases in the Western Australian plants, had no great range in size and under this treatment all chromosomes appeared to be relatively short and thick at metaphase. There was seen here, as reported in other species (Hotchkiss, in press), a notable degree of pairing between chromosomes of similar size and form (Text-fig. 1, *a*). Other pairs of similar chromosomes can be found in the metaphase grouping and the entire 14-chromosome complement can be arranged in pairs of at least approximately congruent chromosomes. The paired and unpaired chromosomes from Text-fig. 1, *a*, are thus arranged in seven pairs of similar chromosomes in Text-fig. 1, *k*. The occasional fine strands connecting chromosomes at metaphase were not confined to connections between chromosomes of the same size and form. The morphology of the chromosomes in *Chara leptopitys* from South Australia was somewhat different (Text-fig. 1, *f-j*) from those from Western Australia. In the former the overall diameter was smaller and there were present knob-like projections which may represent early anaphase separation of chromatids in the region of the centromere (Text-fig. 1, *j*). There was no evident ploidy, but in one of the heads some mature antheridia contained filaments with persistently dividing cells where only sperm or presperm cells would be expected.

Individual chromosomes in the 21- and 42-chromosome complements appeared to be equivalent to those in the 14-chromosome nuclei. These numbers suggest a multiplication of the genomes found in the 14-chromosome nucleus.

DISCUSSION.

Chromosome Numbers. The haplontic life cycle in the Characeae consists of gametophyte plants comparable with the gametophyte phase of the bryophytes but, as in many of the algae, alternating with a one-celled sporophyte phase consisting of only the zygote. After a period of dormancy the first divisions of the zygote are meiotic and result in the growth of a new gametophyte phase, green and bearing gametangia at maturity. Following a series of mitotic divisions, the cells of the antheridial filaments are transformed directly into male gametes. Any chromosomal aberrations or variations developing and persisting in the maturation of the antheridial filaments are thus potentially carried by the gametes into the next generation. An alteration in chromosome number at this point in the life cycle may be the basis of one of the possible methods for the development of polyploidy.

Extensive polyploidy is now known to occur in the charophytes as a whole and has been reported by Telezynski (1929), Hotchkiss (1958, 1963, in press), Gillet (1959), Guerlesquin (1961), Imahori and Kato (1961), Tindall and Sawa (in press) and others. In addition, our unpublished data show an even greater importance of ploidy in the *Chara zeylanica* complex and in other species of *Chara* and *Nitella* than has been reported thus far. A degree of polyploidy induced by radiation and radiomimetic chemicals has been reported by Moutschen and Dahmen (1956) and Moutschen, Dahmen and Gillet (1956) in a series of experiments which we have repeated in part with the use of X-radiation.

In the genus *Chara* the series of polyploid gametic numbers 14, 28, 56 is found in some diplostephanous species groups and appears to be a sequence resulting from simple doubling of chromosome numbers. The number 14, probably derived from an ancestral 7, is the lowest number found in the extant species of *Chara*; no 7-chromosome species has been reported in this genus and probably none now exists. In the absence of detailed studies of meiosis, the best evidence for regarding the 7-chromosome genome as basic is found in studies revealing the common multiples of 7 in the polyploid species of *Chara*. Additional evidence may be found in several 14-chromosome forms in which there is a considerable degree of somatic pairing between chromosomes from two closely similar and presumably sometime homologous genomes of 7. A similar degree of somatic pairing can be seen in other species of *Chara* with higher chromosome number and in other genera as well. The denoting of 7 as ancestrally basic in *Chara* thus seems justified and to be useful in the interpretation

of speciation and evolutionary development in the genus. A theoretical basic 7 in *Chara* is comparable to the well-known low chromosome number of 6 in *Nitella*. At the same time it would appear that a diploidized 14 ($2n = 28$) may be the presently effective number in *Chara*. Polyploid numbers which are not multiples of 14 are extremely rare in species of *Chara* enumerated thus far.

Species with 21 chromosomes have not been reported in *Chara*, but the number 42 is found rather frequently in such groups as the *Chara zeylanica* complex. The theoretical number series 21 and 42 can be based on 7, and these numbers would represent triploid and hexaploid levels in the gametophyte respectively. One explanation of the origin of a 42-chromosome complement in *Chara* follows the pattern often suggested for triploids in higher plants, that is, resulting from a cross between two polyploid parents. In *Chara* this process would require parents at the 28 and 56 chromosome levels for a direct production of the hexaploid gametophyte with 42 chromosomes. Such parents do exist in some species groups and this possibility has been suggested (V. Proctor, personal communication) for certain forms in the *Chara zeylanica* complex. It may be possible also that the 42-chromosome level could be attained by a cross between parents with 14 and 28 chromosomes followed by a chromosome doubling or failure of reduction at germination of the zygote. From chromosome number relationships, such a possibility was suggested by Tindall and Sawa (in press) for *Chara aspera*, *Chara globularis* and *Chara delicatula* with 14, 28 and 42 chromosomes respectively. Since no 21-chromosome species is known to occur, the 21 is probably unbalanced genetically, whereas the 42-chromosome forms are stable and able to reproduce.

In *Chara leptoptysis* the presence of 14 chromosomes in the great majority of antheridial filaments, and particularly in the younger antheridia of plants showing a partial polyploid condition in older stages, indicates that 14 is the present normal number for this species as it is for related species. The polyploid condition appears to be limited to certain antheridia; there is no reason to suppose that the apical portion of the plant as a whole, its meristem, or its separate vegetative parts are involved in the development of polyploid cells which appear in older regions only. Although the normal chromosome complement in *Chara leptoptysis* is not at a high polyploid level, interest here lies in the suggestion of another possible site for the initiation of polyploidy. In the charophytes there thus seem to be two principal locations where multiplication of genomes may most readily occur. At meiosis a failure in reduction resulting in a simple doubling of chromosomes is probably much the more common method and directly produces the polyploid condition. More indirectly, polyploidy originating in a multiplication of genomes in mitoses leading to the maturation of gametes depends upon the union of a polyploid gamete with another ploided or unploided gamete. The resulting possibilities would include triploidy, tetraploidy and hexaploidy. In either case there is an opportunity for hybridization and the results may be allopolyploid or autopolyploid.

A potential for the initiation of polyploidy through the multiplication of genomes in antheridial filament development thus appears to be present in *Chara leptoptysis*. This assumption is supported by the production of gametes in apparently polyploid filaments. It may be presumed that some of these gametes, especially those with 42 chromosomes, are viable and capable of fertilization and that here, as in the other species with occasional polyploid antheridial cells, mentioned earlier, there is seen a mechanism for the effective multiplication of genomes in gametes. A puzzling feature of the process in *Chara leptoptysis*, however, is the apparent lack of a simple doubling of chromosomes and the consequent lack of any 28-chromosome complements in the antheridial filaments examined. Furthermore, the direct production within an originally diploid gametophyte of the triploid-hexaploid levels in a chromosome number series of 14-21-42 involves something other than a simple doubling. For this phenomenon an explanation based on observations of the entire mechanism involved would be desirable but unfortunately is not available at present.

Of the two higher numbers it may be assumed that the 42 results from a doubling of the 21. This is the simplest explanation and is in accord with the positioning of the 42-chromosome cells in the older antheridia. Thus in a series leading from 14 through 21 to 42 chromosomes, only the origin of the 21 would require a special explanation. Assuming a basic genome of seven chromosomes, one might speculate on a mechanism whereby in a 14-chromosome complement the two closely similar but not necessarily identical genomes are capable of a differential response resulting in a division of one but not the other. It is tempting to recall here the work of Hughes-Schrader (1948) on the males of two probably polyploid species of coccids in which single genomes act independently and aberrantly through meiosis I and II and finally disintegrate. Although in each case there is no resultant increase in chromosome number in the coccids, such as seems to be found in *Chara leptopitys*, this may be an interesting parallel in differential genome reaction.

Of the various numbers seen in antheridial filaments of *Chara leptopitys* the 14 and 42 appear to be most stable. The 21 was seen in but a few filaments each with only a few cells at metaphase in which the number could be determined. The scanty 21-chromosome filaments were scattered in antheridia otherwise made up of 14-chromosome filaments. The low incidence of 21s seems to indicate a low rate of initiation for this number. Once established, the 21 may rather quickly double into the more stable 42-chromosome level or disintegrate after a short series of progressively more aberrant nuclear divisions. The great stability of the 42-chromosome nuclei is attested by the presence in the larger antheridia of numerous filaments of regularly dividing cells at all stages of mitosis. Although rare, there was a degree of irregularity in cell division in the antheridia with 42 chromosomes. The lobulate nuclei, the tripolar spindle and multinucleate cells bespeak a type of somatic reduction which may be able to proceed through several successive divisions but which will not produce functional sperm. The lobulate nuclei seen here somewhat resemble internodal nuclei (Gillet, 1961), but their form appears to be related more to the polyploid nature of these cells than to the physiological requirements of internodal cells described by Gillet. Whatever the immediate results of the unusual cytological behaviour seen in this limited sampling of *Chara leptopitys*, it is concluded to be of considerable theoretical importance in the general survey of the cytotaxonomy of the charophytes.

Relationships. *Chara leptopitys* Braun, 1882, was reported by Nordstedt (1891) as being found in Victoria and Tasmania and also, as *C. leptopitys* subsp. *ebracteata* Nords., in Western Australia and Victoria. Wood and Imahori (1959) listed this species as occasional in Australia. This species was placed by Nordstedt (1891) between *Chara braunii* and *Chara scoparia*, and in the revision of Wood (1962a) much the same position was accorded it in Subgenus Charopsis, Section Agardhia, Subsection Agardhia along with *Chara fibrosa*, *C. pseudohdropitys*, *C. ecklonii* and *C. submollusca*.

It is clear that *Chara leptopitys* occupies an important position in the systematics of the group of species with basal gametangia. If these species can be considered a group, and this group is interpreted as a reductional series (based on considerations not elaborated here) leading to a gradual elimination of the cortex on branchlets and stems, *Chara leptopitys* remains as the member of the group primitively possessing cortication in any degree, and pointing to origins for the group among the corticated forms. Chromosome numbers greater than 14 are unusual among the haplostephanae and none has yet been reported among those species with basal gametangia. Despite the extraordinary polyploidy described in this study, the normal chromosome complement in *Chara leptopitys* is 14. Such a low number might be expected in this dioecious (heterothallic) species in accord with the observations (Hotchkiss, 1958) that in the Characeae dioecious species tend to have lower chromosome numbers while corresponding monoecious (homothallic) species have higher numbers. An assessment of the significance of the monoecious-dioecious states and their relationship to degree of polyploidy will be developed in future studies in the cytotaxonomy of the corticate and ecorticate haplostephanae, and will be based in part on the hypothesis of the derived nature of the dioecious state in the charophytes.

Acknowledgements.

I am grateful to Dr. R. D. Wood, University of Rhode Island, for the collections of *Chara leptoptitys* from Australia. Acknowledgements are due to my wife, Dr. Doreen Hotchkiss, for continuing aid in counting chromosomes, and to Mr. T. Sawa for aid in making the illustrations, Plate ii.

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EXPLANATION OF PLATE II.

Mitosis in *Chara leptoptitys* A. Br. from Western Australia. A. Metaphase, $n = 14$. B, focal levels b-1 and b-2, Metaphase, $n = 21$. C, focal levels c-1, c-2, c-3, Metaphase, $n = 42$.

AUSTRALIAN FOSSIL CRINOIDS.

II. TRIBRACHIOCRINUS CLARKEI MCCOY.

By G. M. PHILIP, Geology Department, University of New England.

(Plate iii; one Text-figure.)

[Read 24th June, 1964.]

Synopsis.

The holotype of the Permian crinoid *Tribrachiocrinus clarkei* McCoy, type species of *Tribrachiocrinus* McCoy 1847, is re-described and figured. The morphology and affinities of *Tribrachiocrinus* are discussed and it is concluded that the genus is best included in the inadunate crinoid family Sundacrinidae Moore and Laudon 1943.

The first Australian fossil crinoid to be named was *Tribrachiocrinus clarkei* McCoy, type species of *Tribrachiocrinus* McCoy 1847. Subsequently four other species of *Tribrachiocrinus* have been diagnosed from the Permian of eastern Australia. However, no little confusion exists as to the nature of the genus.

Although McCoy originally gave what prove to be reasonably accurate figures of the type species, different interpretations were subsequently given by de Koninck (1877), Wachsmuth and Springer (1886), Bather (1890, 1900) and Etheridge (1892). Wachsmuth and Springer inferred that seven rami arose from the calyx, whereas Bather depicted three of the radials as compound. Perhaps because of this confusion Wright (1936) included a Scottish Carboniferous species in *Tribrachiocrinus*, although later (1952) he proposed a new genus for this form.

Not only have details of the morphology of *Tribrachiocrinus* long remained obscure, but also doubts have been raised recently as to the broader affinities of the genus. *Tribrachiocrinus* was regarded as a dicyclic inadunate crinoid by the authorities of the last century. Strimple (1951, p. 200), however, has observed that "In the study of an entirely different problem, Dr. R. C. Moore and the author concluded that *Tribrachiocrinus* probably belongs to the Flexibilia rather than the Inadunata". Wright (1952, p. 138) comments that "There is justification for this view . . . chiefly on account of the tripartite IB circlet and possibly also on the character of the R facets".

In order to establish the nature of *Tribrachiocrinus* it was necessary to study the holotype of *T. clarkei*. The specimen was included in the material sent to Adam Sedgwick by W. B. Clarke in 1844, and is now lodged in the Sedgwick Museum, Cambridge, where it is catalogued as E10564. Opportunity to study the specimen was found during the tenure of a Commonwealth Scientific and Industrial Research Organization Overseas Studentship at the Sedgwick Museum. I am most obliged to Mr. A. G. Brighton, Curator of the Sedgwick Museum, for his assistance. An account of other species of *Tribrachiocrinus* will be given at a later date.

TRIBRACHIOCRINUS CLARKEI MCCOY. (Text-figure 1; Pl. iii.)

Tribrachyocrinus Clarkii McCoy, 1847, *Ann. Mag. nat. Hist.* 20, p. 288, Pl. 12, fig. 2;

McCoy, 1851, *Proc. roy Soc. V.D. Land* 1, p. 315, Pl. 12, fig. 2.

Tribrachyocrinus Clarkei McCoy, de Koninck, 1877, *Mém. Soc. Sci. Liège* 6, p. 161, Pl. 6, figs 5, 5a-d.

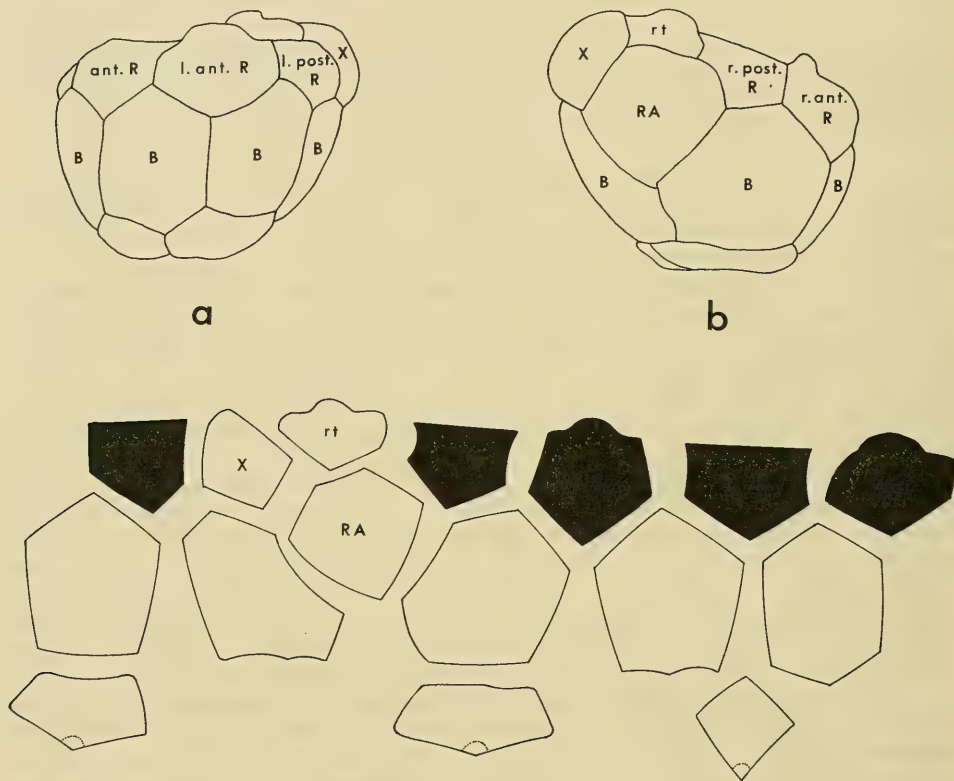
Tribrachiocrinus Clarkei McCoy, Wachsmuth and Springer, Revision of the Palaeocrinoidea III, p. 175; Etheridge, 1892, *Pal. Mem. geol. Surv. N.S.W.* 5 (2), p. 90, Pl. 13, figs 2-4, Pl. 14, fig. 3, Pl. 17, figs 2-4.

Description: Holotype large, hemispherical and somewhat flattened so that X and rt (= right proximal tube plate) have slipped over the l. post. R, and the RA under the

post. B. Plates thick (post. B c. 3 mm. thick) and sutures deeply incised. Surface generally smooth (? worn), but RA and post. B are dimpled with the ridges between the depressions arrayed roughly at right angles to the sutures. Stem cicatrix sunken and small, with portion of a rounded columnal 3 mm. in diameter adhering to the calyx.

IB circlet tripartite with IBB extending well up the side of the calyx. Lateral IBB approximately twice the size of the ant. IB, apparently consisting respectively of fused r. ant. and r. post. IBB, and l. ant. and l. post. IBB.

BB large and generally irregularly hexagonal, except the post. which is heptagonal and the l. post. which is pentagonal.



Text-fig. 1. *Tribrachiocrinus clarkei* McCoy. (a) Anterior, (b) Posterior views of holotype, (c) Plating analysis of holotype. $\times 4/5$.

RR smaller and incurved, so that the dorsal margin of the cup is constricted; r. and l. post. and ant. RR possessing wide and shallow brachial facets with elongate dorsal ligament pits and obscure fulcral ridges. Brachial facets lacking on r. and l. ant. RR, which, together with rt, possess rounded protuberant rims which rise above the level of the cup as defined by the other RR.

Three anal plates present within the cup, comprising a large pentagonal RA surmounted to the left by a pentagonal X and to the right by a small quadrangular rt. Whether or not anal X contributes in the rim of the cup, or rt. and the l. post. R actually meet, cannot be decided due to displacement of plates.

Measurements: Maximum height: 42.5 mm.; maximum width: 53 mm.; minimum width: 34 mm. Dimensions of individual plates may be obtained from Text-figure 1c.

Locality: McCoy gives his specimen as derived from "the soft gray shale of Darlington, N.S. Wales".

Remarks: The holotype establishes beyond doubt that in *Tribrachiocrinus* the r. and l. ant. RR did not bear brachials. The flattened inner surfaces of the peculiar protuberances of the dorsal margins of these RR, together with that of the rt., probably supported plates of the tegmen.

Affinities: From the above description it can be seen that, in all aspects of its morphology, *Tribrachiocrinus* is manifestly inadunate. Concerning Strimple's (1951) suggestion that it is a flexible crinoid the following points should be noted:

1. Although the IB circle is tripartite, this cannot be taken as indicating any affinity with the Flexibilia. In this group the small IB is that of the r. post., whereas in *Tribrachiocrinus* it is in the ant. Moreover, in the Upper Palaeozoic Flexibilia the IB circle is greatly diminished in size, so that it is often concealed entirely by the stem.

2. The arrangement of large anal plates (RA, X, rt) within the cup is fully typical of many inadunate crinoid groups, but I know of no similar arrangements within the Flexibilia, even in the family Lecanocrinidae.

3. Although the distal articulating faces of the radials are neither well preserved nor wide, the deep transverse ligament pit is suggestive of inadunate rather than flexible crinoid affinities. Indeed, Wachsmuth and Springer (1886, p. 200) have observed that "the mode of articulation is similar to that of all late Poteriocrinidae".

Among dicyclic inadunate crinoids *Tribrachiocrinus* finds its closest relative in *Sundacrinus*, a fact originally pointed to by Wanner (1916, p. 220; 1923, p. 193). In common with *Tribrachiocrinus*, *Sundacrinus* lacks arms in the r. and l. ant. radii, although it differs in possessing five IBB. *Indocrinus* Wanner 1916, also from the Permian of Timor, has plating more similar to that of *Tribrachiocrinus*, although the form of the calyx is markedly different. Other genera which appear to be related to this group are *Parindocrinus* Wanner 1937, *Hemiindocrinus* Jakovlev 1926 and *Tetrabrachiocrinus* Jakovlev 1934. These forms may be conveniently placed together in the family Sundacrinidae Moore and Laudon 1943, which is therefore confined to the Permian of Australia, Timor and Russia. Among other features, the group is characterized by high IBB, and a marked inequality of the size of the RR which leads to atrophy of one or more rays. The Scottish Lower Carboniferous species *Hosiecrinus caledonicus* (Wright), originally referred to *Tribrachiocrinus*, lacks these two features which suggests that it represents an earlier independent development of atrophied rays in dicyclic inadunate crinoids. The suppression of rays is seen in other Inadunata, e.g., late members of the Codiocrinidae and the Erisocrinidae.

Concerning the general asymmetry of the Sundacrinidae, A. H. Clark (1914) has shown that outside an optimum temperature range (12.7–18.3° C.) living comulatids tend to become malformed during growth. Radials may be atrophied, and the number of arms increased or reduced. This has led Wanner (1949) to suggest that the great number of irregular types of crinoids present in the Permian of Timor may have been caused by sea temperatures above the optimum.

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EXPLANATION OF PLATE III.

Tribrachiocrinus clarkei McCoy.

Figs 1, 2, 3, 4. Posterior, ventral, dorsal and anterior views of holotype. $\times 1.5$. Fig. 5. Oblique dorsal view of calyx, showing radial facets. $\times 2$.

THE STRATIGRAPHY AND STRUCTURE OF THE UPPER PALAEOZOIC SEDIMENTS OF THE SOMERTON-ATTUNGA DISTRICT, N.S.W.

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(Three Text-figures.)

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Synopsis.

Revision of the stratigraphy of the Upper Palaeozoic marine succession in the Somerton-Attunga district, west of Tamworth, N.S.W., has been necessitated by the recognition of two angular unconformities and two regionally persistent marker beds. These are the Bective and Onus Creek unconformities, the Keepit Conglomerate and the Tulcumba Sandstone. Because of the presence of the unconformities in the sequence in the Somerton-Attunga district, use of the Parry Group and the Goonoo Goonoo Mudstone (Crook, 1961) and the Manilla Group (Voisey, 1958) as units has been discontinued. Two new lithological units, the Keepit Conglomerate and the Tangaratta Formation, have been described. An attempt has been made to deduce the sedimentation of the lithologies in the succession, and it is concluded that there is a transition from turbidite and slump deposits in the lower part of the sequence to traction current deposits at the top. New structural elements, the Appleby Syncline, the Appleby Fault and the Clay Gully Fault, are described. The Devonian-Carboniferous boundary, which occurs in the Tangaratta Formation, remains to be accurately positioned.

INTRODUCTION.

The area with which this paper is concerned lies to the south of Manilla and to the west of Tamworth in New South Wales, and adjoins those mapped by Carey (1937), Crook (1961), Chappell (1961), and Voisey and Williams (in press). The rocks are Upper Palaeozoic sediments which lie in the Western Belt of Folds and Thrusts (Voisey, 1959).

W. N. Benson was first to map the much larger region which includes the Somerton-Attunga district, and described it under the heading of the Great Serpentine Belt of N.S.W. (see Benson, 1913). Since then problems have arisen regarding the detailed division of the stratigraphical sequence as explained by Carey and Browne (1938), Crook (1961) and Chappell (1961). In 1912 Cotton and Walkom noted the apparent Devonian-Carboniferous boundary at Carroll Gap, and on their map marked an approximate position of this boundary from Carroll Gap towards Tamworth. This boundary has never been properly defined. More recently differences of opinion have arisen regarding the actual stratigraphical division. Considerable thicknesses of mudstone, besides other rock units, are contained in the Baldwin, Barraba and Burindi portions of Benson's sequence and in some successions difficulty has been experienced in separating them. Crook (1961), because of apparent similarities in the mudstones, even included all the Barraba and Burindi in the formation which he called the Goonoo Goonoo Mudstone which, with the Baldwin Formation, was included in a new unit, the Parry Group. Working in the Keepit Dam area, Voisey and Williams (in press) found a distinct break at the base of the Tulcumba Sandstone which they took to be the base of the Carboniferous sequence and which marked a change in the character of the sedimentation from turbidite to traction current type. Hence, they retained the Baldwin Formation and Barraba Mudstone in the Manilla Group (Voisey, 1958).

However, the difficulties of reconciling the sequence below the Tulcumba with that observed elsewhere (Voisey, 1958; Crook, 1961) led to the view that there was an unconformity below the Tulcumba Sandstone, and this view was expressed by T. B. H. Jenkins (pers. comm.) and Campbell and Engel (1963, p. 57). It was realized that

the Somerton-Attunga district was critical as it adjoined the other areas where the various workers had obtained conflicting results, so work was commenced here on the suggestion of Professor A. H. Voisey, early in 1962.

R. Leslie recently conducted geological work in the area from Gravesend to Murrurundi and was able to recognize certain stratigraphic units and marker horizons throughout. The writer is indebted to him for certain useful suggestions, particularly relating to the unconformities which have become apparent in the area which he too was mapping during this period.

As different rock units were used in the areas adjoining the one mapped and Mr. Leslie's interpretation was not available, it was difficult to determine which nomenclature should be followed in this publication. An attempt has been made to retain as many older names as possible, so only the new terms Tangaratta Formation and Keepit Conglomerate, which are necessary in the revised interpretation, have been introduced. The use of the Parry Group and Goonoo Goonoo Formation (Crook, 1961) and the Manilla Group (Voisey, 1958) has been discontinued because unconformities are present in these units in the Somerton-Attunga district. The Mandowa Mudstone (Chappell, 1961) has been kept as a useful name to cover the Barraba Mudstone, much reduced from the original sequence described by Benson. The nomenclature has been summarized in Table 1. A definite transition from turbidites to traction current deposits is present in this part of the sequence.

The naming of the unconformities is thought to be a useful procedure, as reference is now being frequently made to one or other of them by those at present working in north-eastern New South Wales.

The classification of sediments used herein is that of Pettijohn (1957), supplemented by the descriptive classification of interbeds of laminated sediments proposed by Lombard (1963).

An attempt has been made to deduce the conditions of sedimentation through the sequence, on the basis of sedimentary structures and associations of sediments.

New structural elements described herein are the Appleby Syncline, the Appleby Fault and the Clay Gully Fault.

STRATIGRAPHY.

The stratigraphic rock units employed here are:

Namoi Formation.

Tulcumba Sandstone.

Onus Creek Unconformity.

Tangaratta Formation.

Gowrie Sandstone Member.

Garoo Conglomerate Member.

Mandowa Mudstone.

Kiah Limestone Member.

Keepit Conglomerate.

Bective Unconformity.

Baldwin Formation.

Rock Units.

The Baldwin Formation: The Baldwin Formation (Voisey, 1958) consists of greywackes, conglomerates, breccias and argillites. It conformably overlies the Tamworth Group and is unconformably overlain by the Keepit Conglomerate. The sediments below the Hyde Greywacke and above the Tamworth Group, as described by Crook (1961), are equivalent to the Baldwin Formation here defined. The Baldwin Formation contains two main lithologies. These are: (i) Fine silts and argillites interbedded with fine laminae of feldspathic arenite—Laminites II (Lombard, 1963); (ii) Coarse-grained labile greywackes which are green when fresh, buff to brown when weathered. Minor developments of calcilutites may be associated with the greywackes. In the Somerton-Attunga district argillites constitute the bulk of the Baldwin Formation.

(i) Laminites II: The argillites are medium to dark grey in colour, and occur in laminae 0.5 mm. to 1 cm. thick. The laminae are usually graded, and the grading is distinct because the silt sized particles tend to be lighter in colour than the finer clays. The argillite laminae may also show fine current ripple laminations and current bedding on a minute scale. Convolute bedding of closed cast type is common in the argillites.

The fine non-graded feldspathic arenite laminae, interbedded with the argillites, have scoured and filled them on a small scale. The arenites are well sorted, lack graded bedding, and sometimes show small scale boudinage, full-aparts, and small load casts. The argillites may contain small chips of argillite and arenite of Baldwin lithology. They usually occur in structureless bands of argillite 2-5 cm. thick. The feldspathic arenite laminae vary in thickness from the finest visible partings (which still remain prominent because of their pale colour) to 2 cm. thick.

(ii) Greywackes: The greywackes of the Baldwin Formation are poorly sorted sediments largely composed of andesitic detritus. When fresh they form outcrops of very hard grey-green rock. Argillite fragments oriented parallel to the bedding planes are a common feature of the coarser greywackes. A thick breccia bed, with a coarse greywacke matrix containing contorted slabs of banded argillite, is present in the formation (Map ref. 107 E., 322 N.). In the same locality a coarse feldspatholithic arenite, containing polymictic conglomerate lenses and large scale current bed foresets, is present beneath the breccia bed. Typical banded argillites occur above and below these sediments. Individual greywacke beds vary in thickness from a few inches to 30 feet. The Baldwin sediments have been described petrographically in detail by Chappell (1961) and Crook (1960).

Leptophloeum australe is present in the upper parts of the Baldwin Formation, and at Map ref. 095 E., 251 N. poorly preserved goniatites have been found.

The Keepit Conglomerate: The Keepit Conglomerate unconformably overlies the Baldwin Formation, and underlies the Mandowa Mudstone. Because of its competency, the Keepit Conglomerate outcrops more prominently than most sediments in this district, particularly at "Klori" trig. station. The type section of the Keepit Conglomerate is exposed on the southern flank of Klori hill (Map ref. 084 E., 267 N.) where the unit attains a total thickness of 345 feet. Table 2 describes the type section in detail. Leslie (pers. comm.) has correlated this unit with the Keepit Conglomerate which occupies a similar stratigraphic position at Keepit (Voisey and Williams, in press).

The base of the Keepit Conglomerate is variable. Where there is angular unconformity between the conglomerate and the Baldwin Formation, a coarse polymictic conglomerate with a discontinuous framework forms the basal phase. However, north of the Somerton-Manilla road (Map ref. 067 E., 262 N.), where the conglomerate overlies the Baldwin Formation with apparent conformity, the basal lithology is a coarse-grained greywacke containing large disoriented slabs of Baldwin argillite.

The Mandowa Mudstone: The Mandowa Mudstone (Chappell, 1961) conformably overlies the Keepit Conglomerate. It is overlain by the basal conglomerate of the Tangaratta Formation where this formation is present, and where the Tangaratta Formation is not present the top of the Mandowa Mudstone is marked by the base of the Tulcumba Sandstone.

The Mandowa Mudstone is a sequence of laminites II with thin sparse laminites I. The mudstones in the unit are less indurated and contain less silty material and noticeably more plant debris than the Baldwin argillites. They are often without sedimentary structures, but are sometimes finely laminated with oriented fine macerated carbonaceous plant debris. Small scale current bedding foresets and current ripple laminations are common in the mudstone, while graded bedding is rare.

Interbedded with the mudstone laminae are feldspathic arenite laminae. Prominent in these are small scale current bedding foresets and, at the tops of beds, current ripple laminations. They contain abundant fine plant debris and lack graded bedding. The

mudstone and feldspathic arenite laminites II (0.2 mm. to 2 cm. thick) show minute vertical displacements, boudinage, and load casts. Contacts between the argillite and arenite bands are sharply defined. Single beds of coarse sediment thicker than 6 cm. (laminites I) have not been observed in the Mandowa Mudstone. Towards the top of the unit the arenite bands become thinner and less frequent and the argillite bands may comprise 85% of the sediment. *Leptophloeum australe* is common in the Mandowa Mudstone.

The Kiah Limestone Member: The Kiah Limestone member (Crook, 1961) is a very fine grained lithographic limestone that is sometimes present in the Mandowa Mudstone, a short distance (20–100 feet) above the top of the Keepit Conglomerate. The top and base of the unit are marked by the sharp change in lithology from lithographic lime-

TABLE 2.
Type Section of the Keepit Conglomerate, 400 Yards East of Klori Trig. Station.

Lithology.	Thickness. Top
Laminites I of the Mandowa Mudstone, containing <i>Leptophloeum</i> .	
Polymictic orthoconglomerate, with a notably discontinuous framework. Contains 25% pebbles, 75% tuffaceous coarse greywacke matrix. Pebbles are of greywacke and andesite lithology, are sub-rounded to subangular, very rarely rounded. Angular mudstone chips are common. Average pebble size, $\frac{1}{2}$ "– $\frac{3}{4}$ " in diameter.	230 ft.
Buff-coloured coarse feldspathic arenite.	15 ft.
Coarse polymictic conglomerate, pebbles and boulders comprise 40% of the rock. Pebbles and boulders are rounded to subrounded, largest boulder 9" in diameter, average pebble size $\frac{1}{2}$ " diameter, grey-wacke pebbles most common.	10 ft.
Very coarse greywacke with flat mudstone chips and isolated pebbles.	16 ft.
Polymictic conglomerate with greywacke and rare andesite pebbles occurring in two size-ranges, $\frac{1}{4}$ "– $\frac{1}{2}$ " and 4"–10". Largest boulder 12" in diameter. Pebbles and boulders comprise 60% of rock.	3 ft.
Fine conglomerate with rounded chert pebbles and continuous framework, largest boulder 4" in diameter, average pebble diameter $\frac{1}{2}$ "– $1\frac{1}{4}$ ".	4 ft.
Fine gravelly conglomerate with rounded pebbles, some siliceous mudstone chips and gravel matrix.	15 ft.
Coarse boulder bed with granite, acid volcanic and coarse and fine greywacke boulders 2'–5' in diameter, with a discontinuous framework. Matrix of many smaller pebbles and greywacke bands.	30 ft.
Fine conglomerate with rounded pebbles of chert and greywacke composition.	6 ft.
Coarse conglomerate with rounded greywacke boulders up to 2' in diameter.	3 ft.
Fine pebbly and gritty conglomerate with some small rounded boulders and some mudstone chips.	20 ft.
Total thickness	352 ft.
Laminites of Baldwin Formation.	Bottom

stone to mudstone laminae of the Mandowa Mudstone. In the Somerton–Attunga district it often lacks the pseudomorphous calcite crystals that are characteristic of the limestone elsewhere. Weathered specimens exhibit beds $\frac{1}{8}$ " to 1" thick. The beds are finely laminated and show low angle current bedding foresets and current ripple marks. This is the limestone noted by Cotton and Walkom (1912) at a number of points on the Tamworth–Attunga road (see Fig. 1). Pelagic fossils have not been found in the Kiah Limestone in this district, although Pickett (1960) found *Cymacilmenia borahensis*, a high Devonian ammonite, in the Kiah Limestone near Manila. Crook (1961) found petioles of *Kalymma* Unger 1856 in *Leptophloeum australe* preserved in the Kiah Limestone. Crook found that the *Kalymma* Unger 1856 was a new species, but it showed affinities to those species found at the Devonian–Carboniferous boundary in the New Albany Shale of central Kentucky (Read, 1937). Crook placed the Devonian–Carboniferous boundary at the level of the Kiah Limestone horizon, which

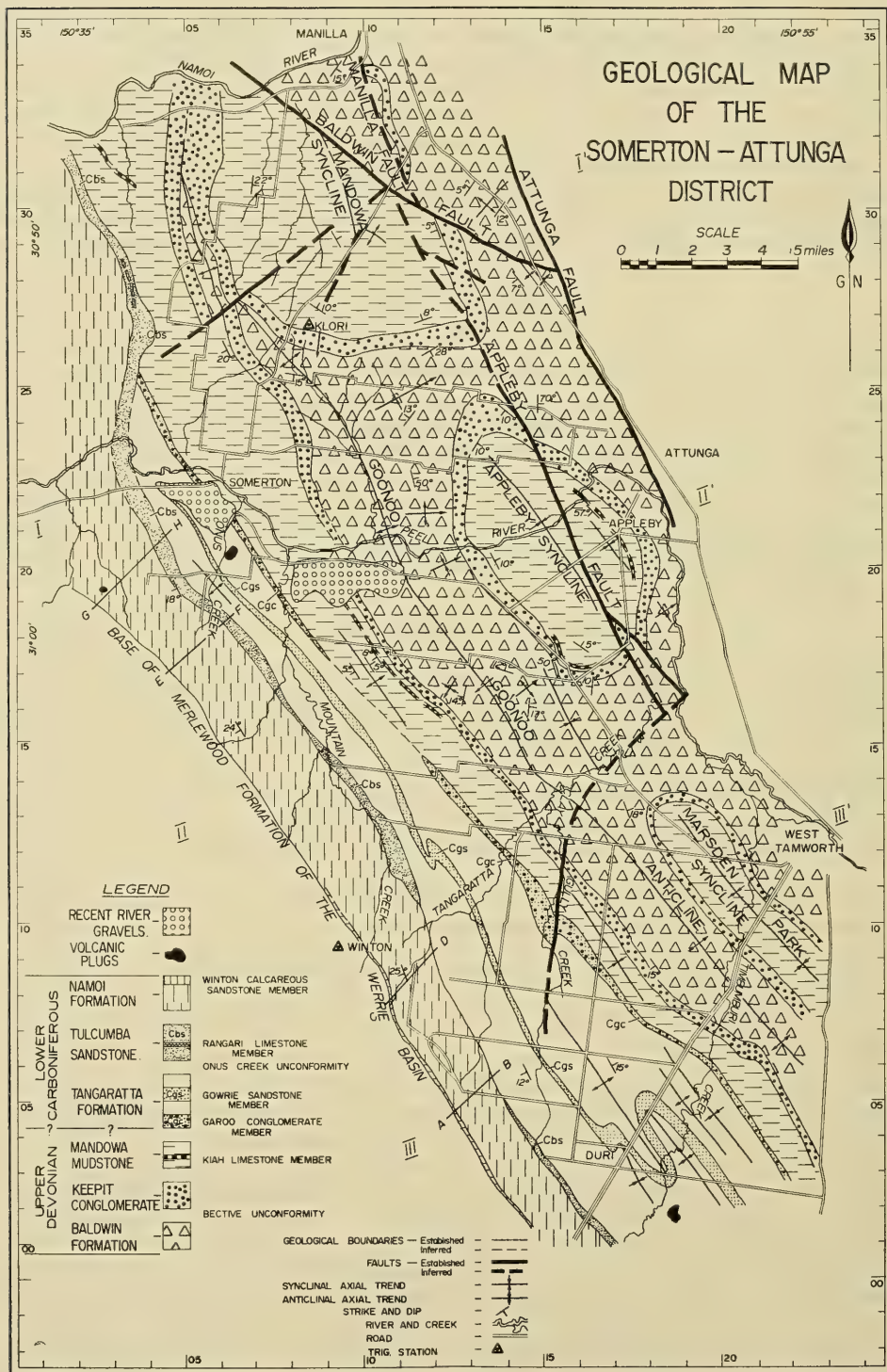


Figure 1.

he stated marked the upper limit of *Leptophloeum australe*, but the author has since found *Leptophloeum australe* in the Mandowa Mudstone just below the base of the Tangaratta Formation in a road section (Map ref. 155 E., 103 N.). The author feels that until palaeontological work is done on the Tangaratta Formation there is insufficient evidence to place the Devonian-Carboniferous boundary accurately in this part of the sequence.

The Tangaratta Formation: The Tangaratta Formation overlies the Mandowa Mudstone and is unconformably overlain by the Tulcumba Sandstone. The formation has not previously been recognized as a separate entity. The name derives from Tangaratta Creek where the unit is best exposed in the Somerton-Attunga district. The thickness of the Tangaratta Formation varies from 0 to 2,000 feet, and it thickens towards the south-east. The base of the unit in the Somerton-Attunga district is the base of the Garoo Conglomerate member, and the top of the unit is marked by the base of the Tulcumba Sandstone. The Tangaratta Formation is correlated with the central and part of the upper Goonoo Goonoo Mudstone described by Crook (1961). The Garoo Conglomerate and Gowrie Sandstone members (Crook, 1961) have been traced from the district mapped by Crook through the western part of the Somerton-Attunga district.

The Tangaratta formation is composed largely of interbeds of mudstone and arenite (laminites I and II). The laminites I and II are most distinct in the lower part of the Tangaratta Formation, where the three lithologies present are medium-grained and fine-grained feldspatholithic arenites and fine grey mudstone. Beds of medium-grained feldspathic arenite 2"-15" thick (laminites I) are separated by similar thicknesses of laminites II—thin interbeds of fine feldspatholithic arenite and grey mudstone. Laminations present in each lithology are fine bedding laminations, current bedding foresets and current ripple laminations. Scour and fill is usually preserved at the top of the laminites II by the medium-coarse grained arenite beds, and truncated ripple marks are often present in these. Some groove casts and load casts have been observed at the top of mudstone beds. The ripple marks and current bed foresets indicate currents flowing most commonly from the south, but also sometimes from the opposite direction. Minute macerated plant remains are present in each lithology in great abundance, and long axes of the plant shreds show a preferred orientation about 350°-10°. Plant remains define fine bedding laminations in each lithology. The laminites I contain thin beds $\frac{1}{4}$ "- $\frac{1}{2}$ " thick that are graded, although grading is not a feature of the whole bed. Grading is usually rare in the formation.

The laminites I and II become less distinct towards the top of the Tangaratta Formation where the characteristic lithology changes to buff-coloured mudstone. Beds of mudstone 3-10 feet thick are interbedded with $\frac{1}{2}$ " thick bands of separate feldspar crystals interspersed in a mudstone matrix, and beds of tuffaceous feldspathic arenite 2"-18" thick. The tuffaceous arenites are distinctly graded and they have scoured and filled the underlying mudstone beds. Scour and fill is also present within the mudstone beds which are laminated, the laminations being defined by fine carbonaceous plant debris. Graded bedding has also been observed in these mudstones. There is not, however, the distinct fine bedding that is common in the mudstones lower in the sequence.

The Garoo Conglomerate Member: The Garoo Conglomerate member (Crook, 1961) occurs at the base of the Tangaratta Formation in the Somerton-Attunga district. The unit conformably overlies the Mandowa Mudstone and is overlain by laminites I and II of the Tangaratta Formation. The base and top of the member are marked by the change in lithology from conglomerate and greywacke to mudstone and arenite laminites. In the Somerton-Attunga district the unit outcrops poorly. The typical lithologies of the member are basal coarse polymictic conglomerates overlain by fine greywacke and conglomerate lenses. The pebbles in the conglomerate are dominantly of andesitic, intermediate volcanic and greywacke lithology. Crook states that the Garoo Conglomerate reaches a thickness of 250 feet in the type section.

The Gowrie Sandstone Member: The Gowrie Sandstone member (Crook, 1961) is a coarse-grained arenite and conglomerate unit present in the upper part of the Tangaratta Formation. It is underlain and overlain by laminites I and II of the formation. Coarse-grained feldspatholithic arenite, and polymictic conglomerate lenses, in which the pebbles are usually no more than 6" in diameter, are the typical lithologies of the unit. Large scale current bedding foresets have been observed in the thin arenite beds near the top of the member. Interbeds of laminites I and II mark the top of the member.

The Tulcumba Sandstone: The Tulcumba Sandstone (Voisey and Williams, in press) unconformably overlies the Tangaratta Formation, or the Mandowa Mudstone where the former unit is not present, and is overlain by the Namoi Formation. The top of the Tulcumba Sandstone is the top of the highest arenite bed in the unit. It has been found that the Boiling Down Sandstone (Crook, 1961) is the southern extension of the Tulcumba Sandstone. Leslie (pers. comm.) has demonstrated the regional persistence of the unit above the Onus Creek Unconformity.

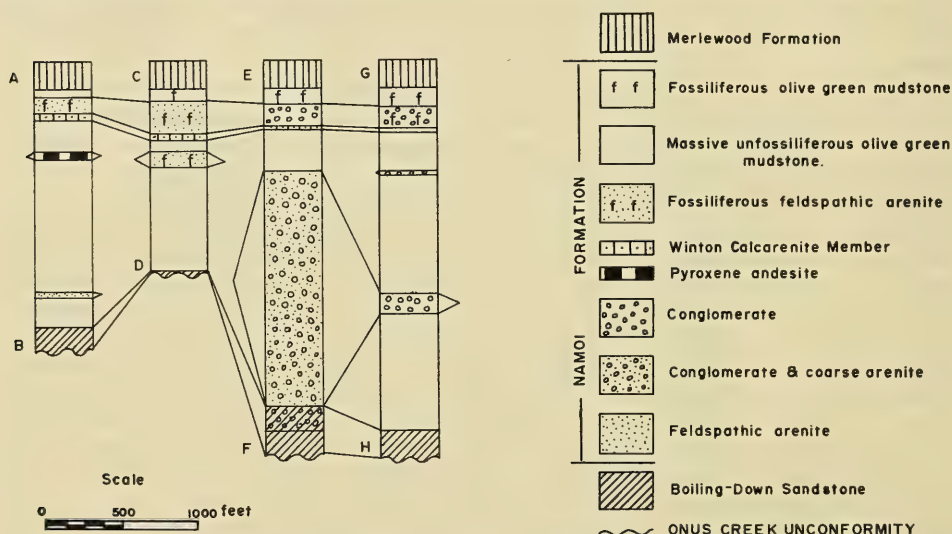


Fig. 2. Correlation of sections A-B, C-D, E-F, and G-H through the Namoi Formation and the Boiling-down Sandstone.

The Tulcumba Sandstone is a coarse to fine grained feldspatholithic arenite with some development of polymictic conglomerate, usually at the base of the unit, and some quartzo-feldspathic arenite. Marine and plant fossils are present in the unit. It is well bedded and large scale cross bedding foresets are common in the beds. A maximum thickness of approximately 150 feet has been observed in the Somerton-Attunga district. Large scale current bedding and calcareous feldspathic arenites at the top of the unit serve to distinguish it from underlying arenites.

The Rangari Limestone (Voisey and Williams, in press) is present in the Tulcumba Sandstone in the north-west part of the Somerton-Attunga district. This limestone member is one of the distinguishing features of the Tulcumba Sandstone. It is an oolitic limestone containing detrital fragments of brachiopods and crinoid stems.

The Namoi Formation: The Namoi Formation (Voisey and Williams, in press) is a sequence of mudstones containing minor calcarenites that lies conformably on the Tulcumba Sandstone and is overlain by the Merlewood Formation. The top of the Namoi Formation is marked by the base of the first conglomerate or arenite of the Merlewood Formation.

The Namoi Formation is the only unit in the district that outcrops well, and Figure 2 shows the representation of columnar sections measured in several places

through the formation. The unit is correlated with the lower Burindi Series described by Carey and Browne (1938) and the uppermost part of the Goonoo Goonoo Mudstone (Crook, 1961).

The lower part of the unit is laminated mudstone containing discontinuous calcareous concretions and some interbeds of thin feldspathic arenite. Above this laminated mudstone is a thickness of fine-grained massive olive-green mudstone that breaks into small elongate fragments and is barren of fossils. There is a great abundance of brachiopods, crinoid stems and solitary horn corals in the mudstone in the upper part of the formation.

A notable feature of the middle Namoi Formation in the Somerton-Attunga district is the very local development of conglomerate and arenite lenses. The conglomerates are coarse and polymictic with boulders varying in diameter from coarse gravel size to 2 feet. Acid plutonics, intermediate and basic volcanics and greywacke boulders are present in the conglomerates which have a matrix of coarse sand. The arenites are coarse, cross bedded and fossiliferous.

The Winton Limestone Member: The Winton Limestone member, within the upper part of the fossiliferous mudstone of the Namoi Formation, is a persistent, cross bedded, sometimes fossiliferous calcarenite varying in thickness from 20 feet to 80 feet. The type section of this member is in Mountain Creek east of Winton Trig. (whence it derives its name) at map ref. 100 E., 093 N. The unit is oolitic in places, and crinoid stems are an abundant constituent of the rock.

Above the Winton Limestone member is a thickness of mudstone that is unfossiliferous and characteristically very pale green or yellow and contains in places "red bed" lenses. The top of the mudstone marks the top of the Namoi Formation.

UNCONFORMITIES.

Two angular unconformities have been noted in the sequence in the Somerton-Attunga district. Their regional persistence, as demonstrated by Leslie, has an important bearing on the interpretation of the tectonic history and stratigraphy of these sediments. It is proposed to name these unconformities the Bective Unconformity and the Onus Creek Unconformity.

The Bective Unconformity: The Bective Unconformity is the angular unconformity between the Baldwin Formation and the Keepit Conglomerate. The angle of unconformity between the two units is variable and may be as much as 90°.

Evidence for the unconformity: (1) The structural trends of the Baldwin and overlying sediments in places differ markedly. The Baldwin Formation is distinctly cross folded, while cross folding is only expressed by the formation of large scale domes and basins in the overlying sediments; (2) Strong angular unconformity between the two units has been observed at widely separated localities in the Somerton-Attunga district (e.g., at Map ref. 118 E., 263 N.; Map ref. 153 E., 169 N.; Map ref. 106 E., 250 N.); (3) Angular unconformities between the Baldwin Formation and the Keepit Conglomerate have been observed in exposures of the contact of the two units in the southern, central and northern parts of this belt of sediments by the writer and by R. Leslie (Leslie, pers. comm.).

The Baldwin Formation and the Keepit Conglomerate appear to be turbidite deposits. Crook (1959) suggested that paraconformities (Dunbar and Rogers, 1957) could be formed in turbidite sequences when turbidites were scoured by turbidity currents. There is no evidence, such as weathering, to suggest that the upper layers of the Baldwin Formation were subaerially eroded. Thus the erosion may have been accomplished by a mechanism such as postulated by Crook (1959), that is, scouring of the sediments by turbidity currents, or by deep sea traction currents, such as reported by Heezen (1959a, b).

An unconformity, in places as much as 90°, and a marked difference in structural trends between the two units, indicate that the Baldwin Formation was folded during or prior to the erosion of the upper part of the unit. A time break of some length is thus inferred.

The Onus Creek Unconformity: The Onus Creek unconformity is the angular unconformity at the base of the Tulcumba Sandstone.

Evidence for the unconformity: (1) The Tangaratta Formation is missing north-west of Somerton, where the Tulcumba Sandstone changes strike suddenly to form the eastern limb of the Belvue Basin (Voisey and Williams, in press) and directly overlies the Mandowa Mudstone. The Tangaratta Formation is a widespread unit elsewhere in this belt of sediments (Leslie, pers. comm.) and is therefore not merely a local sedimentary unit. The total absence of the unit indicates that at least 1,500 feet of sediment has been removed; (2) The strikes of the Gowrie Sandstone and the Garoo Conglomerate converge with the strike of the Tulcumba Sandstone (see fig. 1); (3) The Tangaratta Formation is folded into a series of gentle north-west trending folds, whereas the Tulcumba Sandstone and the Namoi Formation dip uniformly west, under the Werrie Basin—indicating that the Tangaratta Formation was folded prior to deposition of the Tulcumba Sandstone. The sudden change in facies also indicates that there was a time break following the folding; (4) Angular unconformity has been observed between the Tulcumba Sandstone and the Tangaratta Formation, for example, in Onus Creek (Map ref. 062 E., 193 N.) and at Keepit where an angular unconformity has been found between the basal Tulcumba Sandstone and the Mondowo Mudstone (Jenkins, pers. comm.). Here apparently all the Tangaratta Formation and part of the Mandowa Mudstone have been removed.

SEDIMENTATION.

In recent studies of some sediments and reviews of the literature dealing with marine sedimentation, Murphy and Schlanger (1962) and Dott (1963) have concluded that the single valid criterion distinguishing turbidites is the repeated occurrence of graded bedding. The presence of large scale current bedding foresets is the most widely accepted criterion for identifying a traction current deposit. Using these criteria, turbidites and traction current deposits have been identified in the Somerton-Attunga district. Subaqueous slide breccias, mudstones lacking in current structures, and tuffs are also present in the sequence. However, the mode of deposition of much of the sediment of the Mandowa Mudstone and the lower part of the Tangaratta Formation is not immediately apparent. These sediments contain abundant sedimentary structures which are listed in two groups, viz.: (i) those that have been found associated with well documented turbidites, and (ii) those that are normally believed to have been formed by the movement of sediment by traction.

(i) From Kuenen and Migliorini (1950), Kuenen (1953), Kuenen and Sanders (1956), and Dott (1963), the attributes of turbidites that are also features of the above-mentioned sediments include graded bedding; abruptly alternating coarse and fine beds; absence of wave ripple marks; channel scour; frequent "slump" structures; scarcity of benthonic life; load casting, convolute bedding; conglomerate interbedded with greywacke and lacking cross bedding; angular mudstone chips in greywacke or siltstone matrix; slumped boulder beds; worm trails preserved; flute and groove casts; shallow water organisms in a reworked condition when present.

(ii) Structures indicating the movement of sediment by traction are small scale current bed foresets; current ripple marks; oriented plant debris.

The structures listed under (i) may be found in sediments other than turbidites, as pointed out by Dott (1963), but when all or most of them occur in a sediment it is reasonable to conclude that it is a turbidite. In the Mandowa Mudstone and the lower part of the Tangaratta Formation, when these features are common in the sediment, repeated graded bedding does not occur, but there are occasional graded beds. This suggests that these sediments have been deposited by turbidity currents.

When the structures listed under (ii) are common, traction of sediment is evident. However, the structures may have been formed by the action of traction currents or by the winnowing of fine material at the tops of beds by turbidity currents. When

they are common in sediments inter-bedded with sandstones that contain large scale current bed foresets, and the structures listed under (i) are minor, such sediments are probably traction current deposits.

The Baldwin Formation is a sequence of greywackes and repeatedly graded argillite units which alternate abruptly. Load casts, convolute bedding, conglomerate lacking current bedding foresets and interbedded with greywackes, angular mudstone chips in siltstone beds, scarcity of benthonic life and absence of wave ripple marks characterize the sediment of the Baldwin Formation and indicate that the greywackes and argillites are turbidites.

An exception is the thick feldspathic arenite which occurs towards the middle of the formation. This contains large scale current bedding foresets and orthoconglomerate lenses, and so indicates a distinct change in the sedimentation of the Baldwin Formation, for it suggests traction current deposition.

The rock overlying this arenite may be subaqueous slide deposit, as it consists of large angular disoriented blocks of argillite in a greywacke matrix. The overlying rocks represent a return to the normal condition of sedimentation of the formation.

The rare current ripple laminations in the argillites of the Baldwin Formation may be explained as the result of winnowing of fine material at the top of beds by turbidity currents.

The Keepit Conglomerate: This unit is mostly polymictic paraconglomerate and coarse gravel. These lithologies contain angular and sub-rounded as well as rounded boulders and pebbles, sparse reworked shallow water fossil remains, and large angular mudstone blocks. There is an excess of matrix over boulders in the conglomerate. These features are strongly suggestive of a turbidite deposit (Pettijohn, 1957). Minor lithologies which are sometimes present are a basal greywacke containing large slabs of argillite, and a very coarse boulder bed (present in the type section). These probably represent subaqueous slide deposits.

The Mandowa Mudstone and the Tangaratta Formation: These units are discussed together because they contain features indicating similar modes of sedimentation. Current ripple marks, fine laminations and abundant plant debris are common in the mudstones, and silty layers and graded beds are rare. These latter contain load casts, convolute bedding and groove casts. They thus contain sedimentary structures associated with turbidites and it is possible that they do in fact represent turbidites. The remaining mudstone beds are thin, laminated, and lacking in any current structures and seemingly have been deposited as a result of slow settling of mud.

The thin arenites of these units contain abundant current ripple laminations, small scale current bed foresets, groove casts, load casts and truncated ripple marks, and are well sorted, of wide lateral extent, and constant thickness. Thus the sedimentary structures are definitive neither of turbidity current nor of traction current deposition. Grading could be absent because of pre-sorting of the sediment and its absence is therefore not a criterion for traction current deposition. Because of the lack of any large scale current bedding and because of the presence of some thin fine-grained sediments which do show grading, it is possible that these arenites are also turbidites and that the current structures are due to reworking by turbidity currents. Gorsline and Emery (1959) found that similar laminites were formed when turbidity currents moved sediments, already sorted by wave action in shallow water, down through submarine canyons into basins where they spread out and deposited thin beds of non-graded arenite.

The upper Tangaratta Formation consists of thick mudstone beds interbedded with thin tuffaceous feldspathic arenites of a different character from the arenites discussed above. The distinct grading in these arenites may have been produced by subaerial grading of tuffaceous material, as the tuffs show little reworking and do not contain current structures of any kind. Moreover they contain unbroken shards. The mudstones are similar to the thin nongraded mudstone beds lower in the sequence, except the beds are much thicker. They probably represent long periods of quiet sedimentation.

The coarse-grained members of the Tangaratta Formation, the Garoo Conglomerate and the Gowrie Sandstone were deposited under different conditions of sedimentation. The Garoo Conglomerate is a greywacke with coarse conglomerate lenses, current bedding, angular mudstone chips and broken shallow water fossil remains. On the other hand, the Gowrie Sandstone is a fairly well sorted feldspathic arenite containing large scale current bedding foresets, and so represents a traction current deposit. The Garoo Conglomerate is the youngest coarse turbidite of the sequence in the Somerton-Attunga district.

The Tulcumba Sandstone: This unit has a basal orthoconglomerate overlain by a feldspathic and quartzo-feldspathic arenite which contains abundant calcite cement. Large scale current bedding foresets and ripple marks are the most common sedimentary structures in the sandstone, and hence the unit appears to be a traction current deposit. The appearance of abundant neritic fossils and the presence of a cross-bedded oolitic limestone within the formation, the Rangari Limestone (Voisey and Williams, in press), indicate a shallow water environment for the deposition of the Tulcumba Sandstone.

The Namoi Formation: In general the mudstones of this unit are massive, although some are laminated near its base. The sandstone lenses in the unit contain large scale current bed foresets and ripple marks and are well sorted. The absence of sedimentary structures in the mudstones suggests that they were deposited in a quiet environment as slowly settling muds. The arenites clearly are traction current deposits. The presence of abundant neritic fossils in the mudstones of the upper part of the formation indicates shallow water deposition. A local influx of coarse sediment has resulted in sandstone and conglomerate lenses which are present in the Namoi Formation, south of Somerton (see Fig. 2). Such local, coarse, round-stone conglomerates and arenites could have been deposited at the mouth of a river.

Thus, from the Baldwin Formation to the top of the Namoi Formation there is a transition from turbidites to traction current deposits. The Baldwin Formation is a sequence of turbidites in which coarse greywackes are abundant. The Mandowa Mudstone and the Tangaratta Formation contain much less frequent fine and coarse grained turbidites and more sediments reworked after deposition. The laminites I in these units were possibly presorted before being transported to their present position. Going up the sequence, muds deposited in a quiet, gradually shallowing environment become more and more abundant and turbidites give way to traction deposits. The Namoi Formation contains only muds and traction current deposits laid down in shallow water.

STRUCTURE.

The Somerton-Attunga district lies in the structural division called the "Western Belt of Folds and Thrusts" (Voisey, 1959). Structures defined by Voisey (1958), Chappell (1961) and Crook (1961) have been recognized and extended to this district. Folding of the sediments has been followed by the development of normal and trans-current faults, low angle thrusts, and wrench faults. The structures are illustrated in the cross sections in Figure 3.

Folding: Folding commenced at or before the end of the deposition of the Baldwin sediments, which were eroded and overlain unconformably by the Keepit Conglomerate. The folding continued (or commenced again) before the deposition of the Tulcumba Sandstone, as indicated by the unconformity at the top of the Tangaratta Formation, and the final folding included the remaining sediments in the sequence. The folding was never intense and the regional axial trend of the major folds is north-north-west. Axial traces of gentle cross folds on the limbs of the major fold in the Baldwin Formation trend north eastwards, at about 80° to the major fold trend.

The Major Folds: The Goonoo Goonoo Anticline (Crook, 1961) is correlated with the Klori Anticline (Chappell, 1961), in the northern part of the district. The Marsden Park Syncline (Crook, 1961), the Appleby Syncline and the Mandowa Syncline (Chappell, 1961) lie along an axis of depression, east of the Goonoo Goonoo Anticline.

The northern continuation of this axis of depression is the Manilla Syncline (Voisey, 1958). Low amplitude north-north-west trending folds occur in the Tangaratta Formation north of Duri. The upper Tangaratta Formation and overlying sediments form the eastern limb of the Werrie Basin (Carey, 1937).

The Goonoo Goonoo Anticline is the major structural feature of the district and is flanked in most places by low hills of the Keepit Conglomerate. Cross-folded Baldwin sediments in the anticline may dip as much as 80° , but the Keepit Conglomerate and younger sediments do not dip more than 25° on the limbs of the anticline.

The Mandowa Syncline (Chappell, 1961) is a very gentle north-plunging structure that has been disrupted by the Baldwin Fault (Benson, 1917; Voisey, 1958) and the Appleby Fault. The Appleby Syncline, to the south of the Mandowa Syncline and on the same axis of depression, is an asymmetrical structure with dips of 55° on the

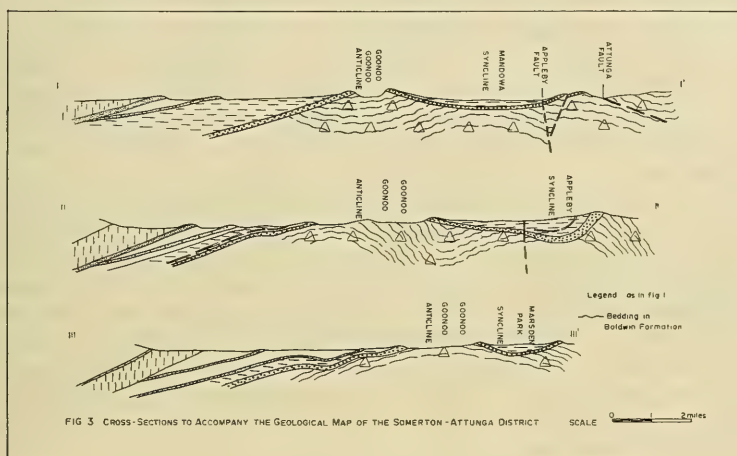


Figure 3.

eastern limb and 5° on the western limb. It is disrupted by the Appleby Fault and there is some complex small-scale folding near the south-east closure of the syncline, where the Appleby Fault bifurcates. Still further south along this axis of depression is the Marsden Park Syncline which is flanked by the gently dipping Keepit Conglomerate.

To the west of the Goonoo Goonoo Anticline the Tangaratta Formation shows ill-defined low amplitude folds which do not appear in the overlying sediments. The upper part of the Tangaratta Formation and the overlying units dip at about 25° south-west and form the lower sediments of the eastern limb of the Werrie Basin (Carey, 1937).

The folds with axes trending north-east are subordinate to the regional north-west folds. The genetic relationships of the two axial trends have not been established, but the "cross folds" are most conspicuous in the Baldwin sediments. The younger rocks are not noticeably "cross folded", but the common fold style developed in the sediments in this region is open non-cylindroidal folding, i.e., domes and basins.

Faulting: Three types of faults occur in the district. These are, in order of formation, the Manilla Fault (Voisey, 1958), the Appleby Fault, the Attunga Fault (Chappell, 1961), the Baldwin Fault, and the Clay Gully Fault and similar minor wrench faults. The Appleby and Manilla Faults are normal faults with a strike component along the axial trend of the Appleby and Mandowa Synclines. The eastern blocks of sediment have moved up along the faults. These faults are offset by the Baldwin and the Attunga Faults which are low angle thrust planes on which the sediment has been thrust towards the west. The Baldwin Fault appears to die out on meeting the Attunga Fault. The Appleby Fault bifurcates near Appleby and has not been traced further

south than the Clay Gully Fault. This fault, together with the minor wrench fault that offsets the Goonoo Goonoo Anticline north-west of Klori Trig. station, represents the last major fault movement in the district, and they are not affected by the other faults.

CONCLUSIONS.

1. Interpretation of the stratigraphy in the Somerton-Attunga district has been greatly influenced by the recognition of (a) Persistent marker beds in the sequence, of which the Tulcumba Sandstone and the Keepit Conglomerate are the most important because of their regional continuity; (b) The presence of two angular unconformities in the sequence; (c) The change in sedimentation, from turbidite deposition at the base to traction current deposition at the top of the sequence.

2. New light has been thrown on the tectonic history of the district by the recognition of the Bective and Onus Creek unconformities.

3. Carey (1937) and Voisey and Williams (in press) studied the western outcrops of this belt of sediments. Here, because the Tulcumba Sandstone unconformably overlies the Mandowa Mudstone (and the Tangaratta Formation is absent), they had no difficulty in establishing that the Tulcumba Sandstone was the lowest Carboniferous unit in the sequence and the top of the Mandowa Mudstone present here was the uppermost Devonian unit.

However, in the east, the junction between the Carboniferous rocks and the Devonian rocks is not so well defined. Here the Tangaratta Formation has been recognized as a unit which thickens towards the east, overlies the *Leptophloeum*-bearing Mandowa Mudstones and is unconformably overlain by the Tulcumba Sandstone. The unit itself contains marine shelly fossils and does not appear to contain *Leptophloeum australe* remains even though it has been mapped as a rock unit. The problem is then posed of where in this unit, in which the actual transition from turbidite to traction current deposit can be most closely pinpointed, does the Carboniferous-Devonian boundary occur? This problem can now only be solved by palaeontological investigations.

Acknowledgements

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A NEW GENUS AND SPECIES OF PALLOPTERIDAE (DIPTERA, SCHIZOPHORA) FROM PAPUA.

By DAVID K. MCALPINE, The Australian Museum, Sydney.

(Three Text-figures.)

[Read 27th May, 1964.]

Synopsis.

Hypsomyia goilala, a new species representing a new genus of the family Pallopteridae, is described from the mountains of Papua. The genus is remote geographically and morphologically from any previously known pallopterid genus. Some notes on its habitat are given.

Genus HYPSONYIA nov.

Occiput convex; face with a prominent median carina for its full length; fronto-orbitals present; outer vertical not distinguished from post-ocular setulae. Thorax with one pair of dorsocentrals, prescutellar acrostichals, mesopleural, and one sternopleural; no presutural; scutellum not haired. Legs with preapical dorsal bristle on middle tibia only. Wing with Sc and vein 1 strongly diverging distally; vein 1 setulose above distally from level of end of Sc; vein 6 reaching to margin but weak distally.

Type species: *Hypsomyia goilala* nov.

HYPSONYIA GOILALA, sp. nov.

♂♀. Head deep reddish-brown; upper half of occiput black; face, anterior part of cheeks and parafacials whitish-pruinose, the pruinoscence extending narrowly up the anterior lateral margins of frons; upper part of third antennal segment and arista blackish; hairs and bristles black. Thorax brown-black; pleura largely grey pruinose; mesoscutum with a complete grey-dusted median band and a pair of irregular lateral bands interrupted at suture and just behind humeral callus. Legs brown-black; the coxae reddish-brown. Wings brownish-hyaline with blackish markings as follows: a small spot on base of M_{3+4} (vein separating discal and second basal cells); a larger spot just beyond fork of veins 2 and 3; a spot at end of vein 1, extending to vein 2; a more diffuse spot at end of vein 2, extending over vein 3; a mark surrounding anterior crossvein and another surrounding posterior crossvein. Halteres brown-black. Abdomen black.

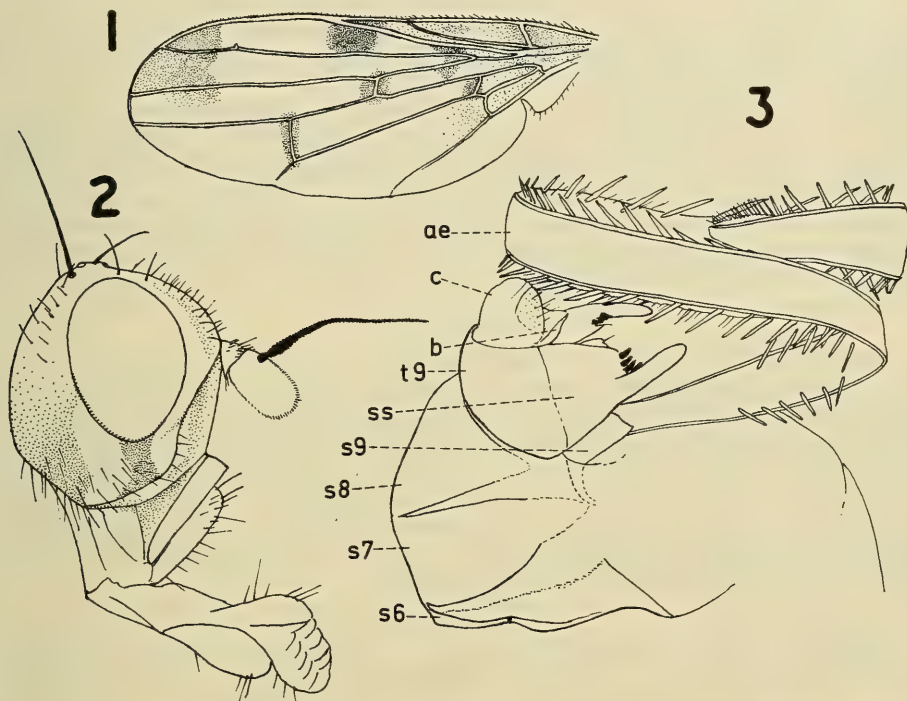
Cheek nearly half as high as eye; a distinct but shallow antennal groove on each side of the facial carina; two fronto-orbitals, rather short, especially the anterior one, sloping outwards, the posterior one also reclinate; ocellars as long as posterior fronto-orbital; postverticals shorter, curved forwards; frons with numerous scattered setulae; a series of fine anterior cheek setulae, extending round vibrissal angle and a number of longer posterior cheek setulae. Third antennal segment about one and a half times as long as wide, broadly rounded distally; arista but slightly longer than rest of antennae, finely pubescent, somewhat thickened basally. Palpi rather slender, setulose.

Mesoscutum setulose, the intradorsocentral setulae in about four irregular series; mesopleuron with rather numerous long setulae, one or two often approaching mesopleural bristle in size; sternopleuron with few, scattered fine setulae; prosternum broad, setulose laterally, without precoxal bridges; the following thoracic bristles present: one pair of posterior dorsocentrals, prescutellar acrostichals, humeral, two notopleurals, two supra-alars, posterior intra-alar, a rather fine propleural, long mesopleural, one sternopleural, two subequal scutellars. Front femur with numerous long

bristles on posterior surface including about four posteroventral bristles; hind femur with a weak preapical dorsal bristle. Costa without bristles or major spines on any part, a series of minute black spinules on anterior surface terminating just beyond end of vein 2; costal index 3.3-3.8; fourth vein index 1.5-1.6.

Abdomen broad; preabdomen of five segments, the first two tergites fused; spiracles situated at junction of tergites with pleural membrane.

Male postabdomen with sixth tergite obsolete; sixth sternite ventral, asymmetrical, joined to seventh and eighth sternites on left side; ninth sternite smaller than eighth; surstyli broad basally, narrowed into an obtuse finger-like process distally, with three or four black spines posteriorly at base of process; ninth sternite produced into a



Figures 1-3. *Hypsomyia goilala*, sp. nov. 1, wing of holotype. 2, head of holotype. 3, postabdomen of paratype ♂, ventral aspect (hypopygium twisted to right through reversal of circumversion during clearing). *ae*, aedeagus. *b*, bacilliform sclerite. *c*, cercus. *s6-s9*, sternites 6-9. *ss*, surstylus. *t9*, tergite 9.

short, broad process on each side of base of aedeagus; aedeagus strap-like, coiled, with a pigmented strip along each margin and with two series of spines which become coarser distally; cerci short, haired.

Female postabdomen of the usual lonchaeid type, with sheath-like seventh segment and fused cerci.

Dimensions: Total length, ♂ 3.2-4.1 mm.; ♀ 3.4-3.5 mm.; length of thorax, ♂ 1.4-1.7 mm.; ♀ 1.5-1.8 mm.; length of wing, ♂ 4.0-4.6 mm.; ♀ 4.1-4.8 mm.

Distribution: Highlands of the Central District, Papua.

Material Examined: Sidibamul, Murray Pass, Wharton Range, 10,000 ft., Oct. 14, 1963 (holotype ♂, paratypes 2 ♂, 1 ♀), Oct. 15, 1963 (paratypes 4 ♂, 2 ♀), coll. D. K. McAlpine.

Location of Types: Australian Museum. Through the courtesy of the Trustees of the Australian Museum a paratype will be lodged in the British Museum (Natural History), one in the United States National Museum, and one in the Entomology collection, Department of Agriculture, Stock, and Fisheries, Konedobu, T.P.N.G.

RELATIONSHIPS AND ORIGIN.

Though there are few characters that are unique among the Pallopteridae, the combination of characters in *Hypsomyia* suggests that it is not closely related to any other known genus. The absence of the outer vertical bristles and the presence of setulae on vein 1 do appear to differentiate it from all other pallopterid genera. It further differs from all other genera except the European *Eurygnathomyia* in the presence of preapical bristles on the middle tibia, and from all except the Nearctic *Omomyia* in possessing a prominent median facial carina. It is distinguished from *Eurygnathomyia* further by the non-spinose costa and possession of only one dorso-central, and from *Omomyia* by the short scutellum and distinct fronto-orbitals.

Geographically the nearest genus is *Neomaorina* from New Zealand, but this differs in having two dorsocentrals, a presutural, three sternopleurals, no mesopleural, narrow subcostal cell, vein 6 incomplete, and in other details. Clearly *Neomaorina* is very distantly related to *Hypsomyia*.

Hypsomyia is the first pallopterid to be recorded from the tropics.* The absence of any records of Pallopteridae from Australia or the Oriental Region further prevents any deduction as to its geographical origin. As fairly extensive collecting of Diptera in alpine country in Australia has been carried out, it is probable that Pallopteridae are absent there. On the other hand they may well be present on high mountains of Indonesia and South East Asia, and it is here that one may expect forms related to *Hypsomyia* to be found in the future.

NOTES ON HABITAT.

Sidibamul is not an actual settlement, but consists only of a mission-owned rest house used by travelling missionaries for overnight shelter. The vegetation consists of low alpine shrubs and herbs with scattered tree-ferns, and patches of sphagnum. Nearby are areas of high moss forest. The open country has been produced, or at least increased, by the natives' habit of setting fire to the vegetation whenever visiting the locality. All the specimens of *Hypsomyia* were taken in the open country by sweeping the vegetation. At this altitude (about 10,000 ft.) the sky is usually overcast; light rain and mists at ground level are frequent. Temperatures are never high, but no frost was experienced during the author's visit.

Acknowledgements.

Thanks are due to the Trustees and Director of the Australian Museum for making possible the author's field work in Papua-New Guinea. The C.S.I.R.O. Science and Industry Endowment Fund contributed generously towards the financing of this trip. Dr. J. J. H. Szent-Ivany and Mr. Ian Pendergast, both of the Department of Agriculture, Stock and Fisheries, arranged the visit to Murray Pass.

Reference.

HENNIG, W., 1952.—Die Larvenformen der Dipteren, 3: VII + 628 pp.

* Dr. Hennig has kindly informed the author in correspondence that his reference to certain pallopterid genera as "chilenisch-papuanisch" (Hennig, 1952) is an error for "chilenisch-patagonisch".

OBSERVATIONS ON SOME AUSTRALIAN FOREST INSECTS.

19. ADDITIONAL INFORMATION ON THE GENUS GLYCASPIS (Homoptera: Psyllidae);
ERECTION OF A NEW SUBGENUS AND DESCRIPTIONS OF SIX NEW SPECIES.

By K. M. MOORE, Forestry Commission of New South Wales.

(Twenty-seven Text-figures.)

[Read 24th June, 1964.]

Synopsis.

The subgenus *Boreioglycaspis* nov. is erected within the genus *Glycaspis* Taylor 1960 to receive those species with morphological characteristics indicative of a more recent evolutionary sequence than that of specimens in the subgenera *Glycaspis* and *Alloglycaspis*.

Six new species from New South Wales, Queensland, Penang Id. and North Borneo are described, and their apparent evolutionary sequence within the genus is discussed. *Epipsylla forcipata* Crawford 1917 from the Philippine Is. is placed in the new subgenus, and a male specimen of the type series is designated as lectotype.

The genus *Glycaspis* apparently originated in Australia with the leaf-gall formers of the subgenus *Glycaspis* occurring on those *Eucalyptus* spp. placed in the Renantherae by Blakely (1955), and the specimens examined and described in this paper are considered to represent a northern evolutionary extension of the genus. The species of *Boreioglycaspis* apparently diverged from the subgenus *Alloglycaspis* (species of which occur on *Eucalyptus* spp. other than Renantherae) to a *Melaleuca* sp. host-association.

No lerp-forming habits are recorded for any of the species in the new subgenus.

INTRODUCTION.

The genus *Glycaspis* was discussed in a previous paper (Moore, 1961a) and, sequential to the publication of that paper, several psyllid specimens which were in the collections of the Bernice P. Bishop Museum, Hawaii, and the United States National Museum, Washington, and which appeared similar to species of *Glycaspis*, were made available for examination.

Among the specimens received from the B. P. Bishop Museum was one which bore label data corresponding to data on labels of specimens in the type series of *Epipsylla forcipata* in the U.S. National Museum and yet agreeing in certain morphological characteristics with those previously given for species of the genus *Glycaspis*. Specimens of the type series of *E. forcipata* were then examined and compared with specimens received from the B. P. Bishop Museum.

The Genus GLYCASPIS Taylor 1960.

Subgenus ALLOGLYCASPIS Moore 1961.

Synonymy: *Psylla* Dobson 1851; *Spondylia* Schwarz 1898; *Spondylia* Froggatt 1900; *Epipsylla* Crawford 1917; *Spondylia* Tuthill & Taylor 1955.

Subgenus BOREIOGLYCASPIS, nov.

(Greek: *voreia* = northern.)

Type species: Glycaspis (Boreioglycaspis) melaleucae, sp. nov. (here designated).

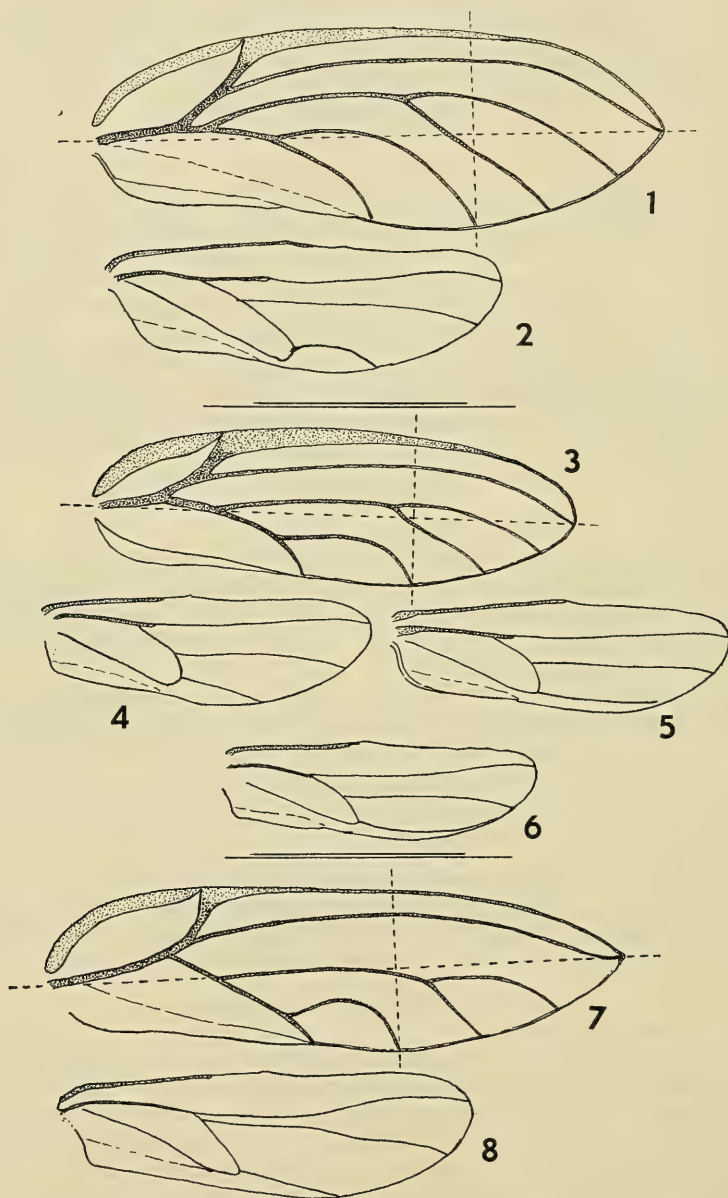
Type locality: 12½ miles along the Gwydir Highway west of Grafton, N.S.W.

Species within the subgenus *Boreioglycaspis* may be separated from species in the subgenera *Glycaspis* and *Alloglycaspis* by the following morphological characteristics:

1. Proximal angle of cell M of forewing commencing beyond the projected termination of Cu₁ at the posterior border of the wing* (Text-figs 7, 15–20, 23).

* The commencement of the proximal angle of cell M in relation to the termination of Cu₁ at the posterior wing border has been determined by the short axis of the wing projected through the terminal point of Cu₁ and described at 90° to the long axis, the latter passing through the proximal point of the combined basal venation and the distal terminal point of vein Rs at apex of wing (Text-figs 1, 3, 7).

2. Points of origin of veins M and Rs of hindwing close together (Text-figs 8, 21, 24).
3. Meta-tarsal pad usually smaller, approx. $\frac{1}{4}$ to $\frac{1}{3}$ the length of tibia (Text-fig. 10).
4. Tibia approx. $\frac{2}{3}$ of, to equal in length with, femur† (Text-fig. 10).



Figs 1-8. Wings typical of (1, 2) *Glycaspis* (*Glycaspis*) spp., (3-6) *Glycaspis* (*Alloglycaspis*) spp., and (7, 8) *Glycaspis* (*Boreioglycaspis*) spp.

† Taylor (1960), when defining the principal morphological characters for the genus *Glycaspis*, stated "metatibia shorter than femur" although Tuthill & Taylor (1955) stated "metatibia shorter than or about equal to femur". Considering the species now placed in *Glycaspis* (*Boreioglycaspis*), the definition of this particular characteristic by Tuthill & Taylor is therefore the interpretation which should be followed.

5. Metatibia slightly enlarged apically, the black distal spurs not emanating from a lateral protuberance as in the other subgenera (Text-figs 9, 10).

6. Male aedeagus two-jointed (Text-figs 25, 26).

7. Distal segment of male proctiger about equal in length to proximal segment (Text-figs 13, 14).

8. Claspers with dark strong prominent pegs on the internal faces (Text-figs 25, 26).

9. The pointed upper and lower plates of the female genitalia each terminating in a small distal prominence bearing numerous setae (Text-fig. 11).

Genal processes may be longer or shorter than width of the vertex, and ocular sclerites may be reduced or very prominent.

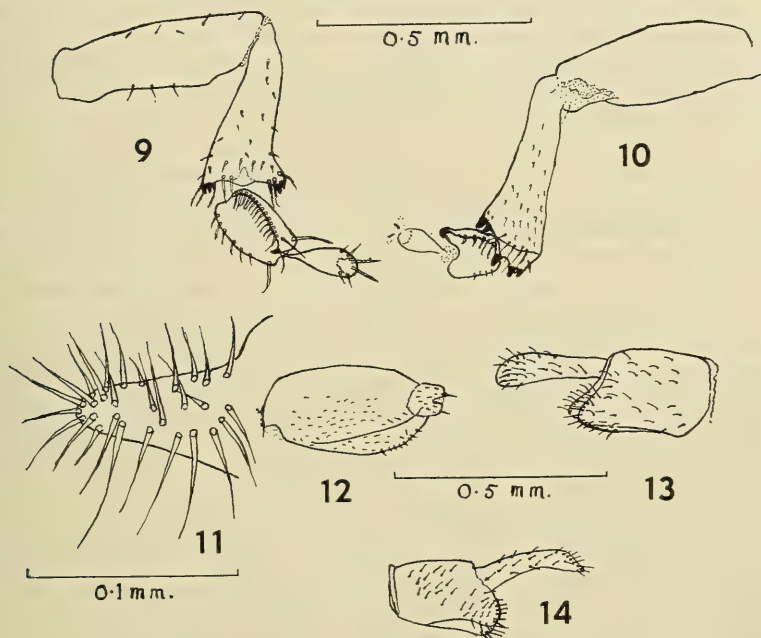


Fig. 9. Meta-femur, tibia and tarsus typical of *Glycaspis* and *Alloglycaspis* spp.

Fig. 10. Meta-femur, tibia and tarsus of *Glycaspis* (*Boreioglycaspis*) *australiensis*, sp. nov.

Fig. 11. Apical tip of female upper genital plate of *G. (B.) australiensis*, sp. nov. (setae to scale).

Fig. 12. Male proctiger typical of species in subgenera *Glycaspis* and *Alloglycaspis*.

Figs 13, 14. Male proctiger of (13) lectotype, (*G. (B.) forcipata* (Crawford)); (14) *G. (B.) melaleucae*, sp. nov.

DESCRIPTIONS.

GLYCASPIS (BOREIOGLYCASPIS) MELALEUCAE, sp. nov.

General colour (in alcohol): Pale yellow sometimes suffused red, with grey and black markings.

Male: Head: width 0.61 mm.; vertex: along suture 0.22 mm., width 0.29 mm., yellow, with posterior and anterior border black, palest on anterior edge; genal processes: length 0.24 mm., cream, with small lateral area near tips suffused pale grey; ventral border of antennal foveae black; antennae: length 0.85 mm., segs. 1 to 3 suffused pale grey, segs. 4 to 9 with distal one-quarter grey and darkest on seg. 9, seg. 10 black. Pronotum: width 0.46 mm., pale yellow, lateral prominences narrowly bordered black posteriorly. Prescutum: pale yellow, antero-lateral edges below pronotum and median and lateral portions of posterior edge, pale grey. Scutum: pale yellow, with posterior edge narrowly marked pale grey. Scutellum and metascutellum: pale yellow. Metanotum: pale yellow, with pale grey suffusion each side of meta-

scutellum. Post-metanotum: pale yellow, with small dark grey lateral wedge-shaped area produced posteriorly. Abdomen: pale yellow, suffused grey laterally, with a dark grey spot surrounding each spiracle, segs. 2 to 5 with a wide anterior transverse pale grey stripe; claspers and aedeagus as in Text-figure 25, pale yellow, distal segment of proctiger slightly longer than proximal seg. (Text-fig. 14). Length of 2-jointed aedeagus (16 specimens): extremes of distal portion 0.050 mm. to 0.063 mm.; of proximal portion 0.182 mm. to 0.209 mm.; of total length 0.232 mm. to 0.270 mm. Forewing: length 2.15 mm., width 0.63 mm., venation pale yellow brown (Text-fig. 15). Hindwings: venation similar to Text-figure 21. Legs: anterior femora marked with black along inner surface near distal joint, anterior and median tibiae with dark grey spot near proximal joint, metatibia shorter than femur, proximal seg. of metatarsus approx. $\frac{1}{3}$ length of tibia. The black pegs on the internal face of each clasper are variable in number in *G. melaleuca*.

Female: General colour as for the male, but dark markings more intense. Anal aperture bordered black anteriorly and postero-laterally, upper and lower plates of genital seg. pointed, and upper plate projecting beyond lower plate.

Host-plant: *Melaleuca quinquenervia* (Cav.) S. T. Blake.

Type locality: Grafton, N.S.W., 12 $\frac{1}{2}$ miles west along Gwydir Highway.

Types: Holotype ♂ and allotype ♀ on slides labelled "Grafton, N.S.W., 11 i 1964, K. M. Moore. On *Melaleuca quinquenervia*", in the collection of The Australian Museum, Sydney, New South Wales. Paratypes: (on slides) 3 ♂♂ labelled as above, to The Australian Museum; 1 ♂ and 1 ♀ labelled as above to the United States National Museum, Washington, D.C., and 1 ♂ to the B. P. Bishop Museum, Honolulu, Hawaii. 1 ♂ labelled "Forster, N.S.W., 15 i 1964, K. M. Moore. (1 to 2 miles south of town). On *M. quinquenervia*"; 6 ♂♂ labelled "Palm Beach, Queensland, 12 i 1964, K. M. Moore. (100 yards west of Pacific Highway). On *Melaleuca quinquenervia*"; 3 ♂♂ and 1 ♀ labelled "Budgewoi, N.S.W., 27 xii 1963, K. M. Moore. ($\frac{1}{2}$ mile east of town). On *Melaleuca quinquenervia*"; all to The Australian Museum. (In alcohol) 7 ♂♂ and 20 ♀♀ and nymphs labelled "Grafton, N.S.W., 11 i 1964, K. M. Moore. On *Melaleuca quinquenervia*"; 1 ♂, 1 ♀ labelled "Budgewoi, N.S.W., 27 xii 1963, K. M. Moore. On *Melaleuca quinquenervia*"; 1 ♀ labelled "Tacoma, N.S.W., 14 ii 1964, K. M. Moore. On *Melaleuca quinquenervia*"; 1 ♀ labelled "Woodburn, N.S.W., 11 i 1964, K. M. Moore. (4 miles south along Pacific Highway). On *Melaleuca quinquenervia*"; 3 ♀♀ labelled "Budgewoi, N.S.W., 15 i 1964, K. M. Moore. On *Melaleuca quinquenervia*"; 11 ♀♀ labelled "Palm Beach, Queensland, 12 i 1964, K. M. Moore. On *Melaleuca quinquenervia*"; all to The Australian Museum.

Notes: Nymphs and adults of this species feed among the foliage of young tips of the host plant, and there was no evidence of lerp formation by nymphs. Known distribution of this species is from Tacoma (Tuggerah Lakes), N.S.W., to Palm Beach, Queensland.

GLYCASPIS (BOREIOGLYCASPIS) PALUDIS, sp. nov.

(*L. paludis* = of a marsh. Referring to the collection locality.)

General colour (in alcohol): Yellow with grey and black markings. Dark markings between venation at posterior edge of forewings.

Female: Head: width 0.63 mm.; vertex: along suture 0.24 mm., width 0.34 mm., yellow suffused red, with posterior border black continuing to behind eyes, lateral borders lightly marked black, and a small grey spot in each discal depression; genal processes: length 0.24 mm., suffused dark grey to black, ventral border of antennal foveae and adjoining area black; antennae: length 0.76 mm., segs. 1 to 8 pale cream, seg. 9 suffused dark grey, seg. 10 black, segs. 4, 6 and 8 suffused grey distally. Pronotum: width 0.57 mm., yellow suffused red, prominences pale cream, a pale grey longitudinal mark each side at half the distance from median area to lateral edges. Prescutum: yellow suffused red with lateral edges suffused grey. Scutum: yellow with postero-lateral edges suffused dark grey, two orange longitudinal stripes each side for the length of scutum. Scutellum and meta-scutellum: pale yellow. Metanotum:

yellow with edges suffused grey, a grey area at each postero-lateral angle of scutellum, and a larger grey area on each postero-lateral edge. Post-metanotum: yellow with small dark grey lateral wedge-shaped area produced posteriorly. Abdomen: yellow, seg. 1 with yellow suffused red central rectangular area surrounded with grey which is produced at posterior angles on to the anterior edge of seg. 2; seg. 2 with anterior edge pale grey and segs. 2 to 5 each with a broad dorsal transverse grey stripe; a dark grey spot surrounding each spiracle. Anal aperture bordered black except posteriorly. Upper plate of genital seg. yellow and projecting beyond lower plate which is black. A prominent black lateral stripe extends from below the lateral prominence of pronotum to the antero-lateral edge of post-metanotum. Forewing (Text-fig. 16): length 2.56 mm., width 0.73 mm., a narrow area between venation along posterior edge suffused grey, venation pale yellow suffused brown. Hindwings: venation similar to Text-figure 8. Ventral. Legs: anterior femora marked grey along inner surface, anterior and median femora pale grey near proximal joint, meta-coxae with a grey area near each postero-lateral angle. Abdomen: seg. 1 with a dark grey area each side on the anterior edge, segs. 2 to 4 each with a dark grey spot near anterior edge and diffused laterally toward spiracle.

Host-plant: Melaleuca quinquenervia.

Type locality: Palm Beach, Queensland, 100 yards west of Pacific Highway.

Types: Holotype ♀ on slide labelled "Palm Beach, Queensland, 12 i 1964, K. M. Moore. On Melaleuca quinquenervia"; paratype: 1 ♀ in alcohol, labelled as above; both to The Australian Museum.

GLYCASPIS (BOREIOGLYCASPIS) AUSTRALIENSIS, sp. nov.

General colour (dried specimen): pale brown suffused red.

Female. Head: width 0.73 mm.; vertex: along suture 0.34 mm., width 0.39 mm., red-brown; discal depressions pronounced; genal processes: length 0.39 mm., red, slightly divergent from $\frac{1}{4}$ of their length from base; antennae: length 1.63 mm., segs. 1 and 2 red, seg. 3 pale brown suffused pink, segs. 4 to 8 pale brown darkening distally to seg. 8 which is dark brown, segs. 9 and 10 black. Pronotum: width 0.57 mm., median area pale brown, lateral areas red. Prescutum: pale brown, median area palest, and lateral ridges suffused black; two anterior median darker brown marks produced to below pronotum. Scutum: wide median longitudinal area creamy brown, lateral areas brown suffused red. Scutellum and meta-scutellum: pale brown with area between brown; a black area each side of meta-scutellum, remainder brown suffused red. Post-metanotum: red-brown marked laterally with black. Abdomen: red, with a wide black transverse band on segs. 1 to 3 and black lateral areas on seg. 4; anal aperture surrounded with black, but narrowest posteriorly; upper genital plate brown. Legs: metatibia and femur equal in length; proximal seg. of meta-tarsus approx. $\frac{1}{4}$ length of tibia. Forewing (Text-fig. 17) with brown areas, length 3.41 mm., width 1.00 mm. Hindwing: venation as in Text-figure 8. Ventral: pale brown.

Host-plant: Not known.

Type locality: Coolangatta, on the New South Wales-Queensland border.

Types: Holotype female (dried specimen) labelled "Coolangata, Queensland, Coll. F. Muir, viii 1919", deposited in the collection of the Bernice P. Bishop Museum, Hawaii. Paratypes: 1 ♀ on slide, with same label data, in the collection of the B. P. Bishop Museum; 1 ♀ (dried specimen) with same label data, in the collection of The Australian Museum.

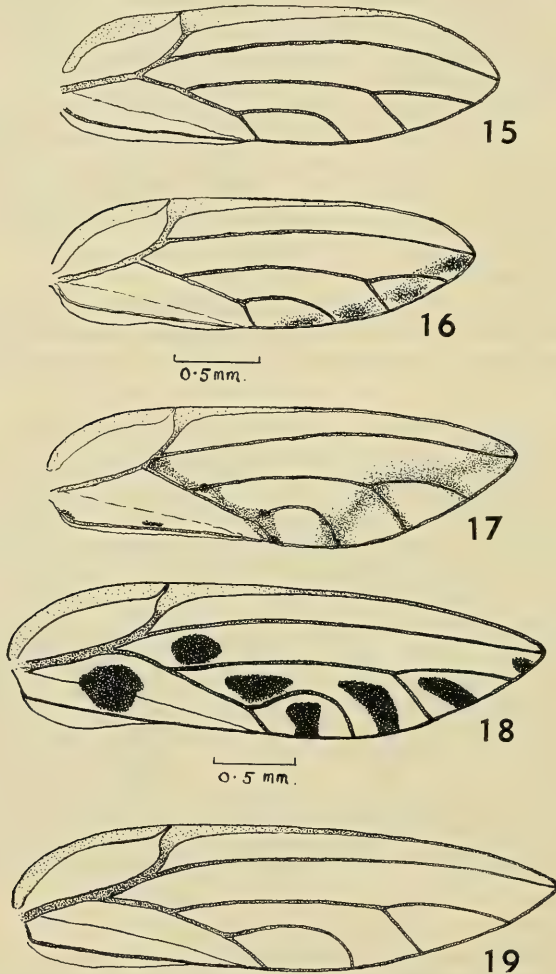
GLYCASPIS (BOREIOGLYCASPIS) POLYMELASMA, sp. nov.

(Gr. *poly-* = many; *melasma* = a black spot. Referring to the coloration of the species.)

General colour (dried specimen): Yellow with black areas.

Female. Head: width 0.73 mm., eyes black; vertex: along suture 0.32 mm., width 0.39 mm., shiny black, discal depressions moderately pronounced, ocular sclerites narrow and very pronounced, yellow; genal processes: length 0.51 mm., dark brown,

paler distally and with a yellow dorsal area from bases to half their length; antennae: length 1.54 mm., segs. 1 and 2 yellow, segs. 3 to 8 pale brown, segs. 9 and 10 black. Pronotum: width 0.61 mm., yellow. Prescutum: yellow with mesopleura black. Scutum: bordered yellow, widest on the anterior border; remainder dark brown, to almost black laterally. Meta-pleura black. Scutellum, meta-scutellum and meta-notum yellow. Post-metanotum: yellow with a large dark brown dorso-lateral spot each side. Abdomen: segs. 1 and 2 yellow, seg. 3 with a small dark brown lateral spot each side, segs. 4 and 5



Figs 15-19. Forewing of (15) *G. (B.) melaleucae*, sp. nov.; (16) *G. (B.) paludis*, sp. nov.; (17) *G. (B.) australiensis*, sp. nov.; (18) *G. (B.) polymelasma*, sp. nov.; (19) *G. (B.) borneensis*, sp. nov.

dark brown, anal aperture bordered black anteriorly and extending laterally, genital segs. yellow, suffused brown dorsally, lower plate tipped black; legs yellow. Forewing: length 3.39 mm., width 0.90 mm., venation pale yellow, black areas as in Text-figure 18. Hindwing: venation similar to that in Text-figure 8.

Host-plant: Not known.

Type locality: Tenompok, 1460m. Jesselton, 30 mi. E., British North Borneo.

Type: Holotype ♀ on slide labelled "British N. Borneo, Tenompok, 1460m. Jesselton, 30 mi. E., ii 10-19 1959, T. C. Maa, Collector, BISHOP"; in the collection of the B. P. Bishop Museum, Hawaii.

GLYCASPIS (BOREIOGLYCASPIS) BORNEENSIS, sp. nov.

General colour (dried specimen): yellow.

Female. Head: width 0.68 mm.; vertex: along suture 0.29 mm., width 0.34 mm., yellow; genal processes: length 0.44 mm., yellow; ocular sclerites pronounced; antennae: length 1.20 mm., segs. 1 to 6 yellow, segs. 7 and 8 suffused pale brown, seg. 9 dark brown, seg. 10 black. Pronotum: width 0.59 mm., yellow. Prescutum and scutum: yellow. Scutellum: yellow, with anterior edge slightly convex anteriorly. Meta-scutellum, metanotum and post-metanotum: yellow. Abdomen: yellow; genital seg. yellow. Forewing: length 3.17 mm., width 0.88 mm. (Text-fig. 19), venation pale yellow, wing with yellow suffusion posterior to vein M. Hindwing: venation similar to that in Text-figure 8.

Host-plant: Not known.

Type locality: Tenompok, 1460m. Jesselton, 30 mi. E., British North Borneo.

Type: Holotype female on slide labelled "British N. Borneo, Tenompok, 1460m. Jesselton, 30 mi. E., ii 2-4, 1959, T. C. Maa, Collector, BISHOP"; in the collection of the B. P. Bishop Museum, Hawaii.

GLYCASPIS (BOREIOGLYCASPIS) PENANGENSIS, sp. nov.

General colour (dried specimen): Yellow, with abdomen brown and blue.

Female. Head: width 0.88 mm.; vertex: along suture 0.37 mm., width 0.49 mm., yellow; ocular sclerites not pronounced; genal processes: length 0.44 mm., yellow, slightly paler than vertex; antennae: length 2.10 mm., segs. 1 and 2 yellow, segs. 3 to 6 suffused pale brown with each seg. darker distally, segs. 7 to 9 slightly darker with seg. 9 brown, seg. 10 almost black. Pronotum: width 0.68 mm., yellow. Prescutum and scutum: yellow. Scutellum: yellow, with anterior edge prominently convex anteriorly (Text-fig. 22). Meta-scutellum: yellow. Metanotum: yellow suffused pale blue. Post-metanotum: pale yellow. Abdomen: seg. 1 yellow, remainder brown dorsally with posterior edge of each seg. suffused pale blue; anterior edge of anal aperture black, genital seg. yellow. Forewing: length 3.20 mm., width 1.17 mm. (Text-fig. 20), suffused honey-colour, darker toward posterior edge; venation yellow. Hindwing: venation as in Text-figure 21.

Host-plant: Not known.

Type locality: Island of Penang.

Type: Holotype ♀ on slide labelled "Island of Penang, Baker"; in the collection of the B. P. Bishop Museum, Hawaii.

This species is distinguishable from *G. (B.) forcipata* by the distinctively convex edge of the scutellum.

GLYCASPIS (BOREIOGLYCASPIS) FORCIPATA (Crawford), comb. nov.

(= *Epipsylla forcipata* Crawford 1917, p. 167, fig. 2.)

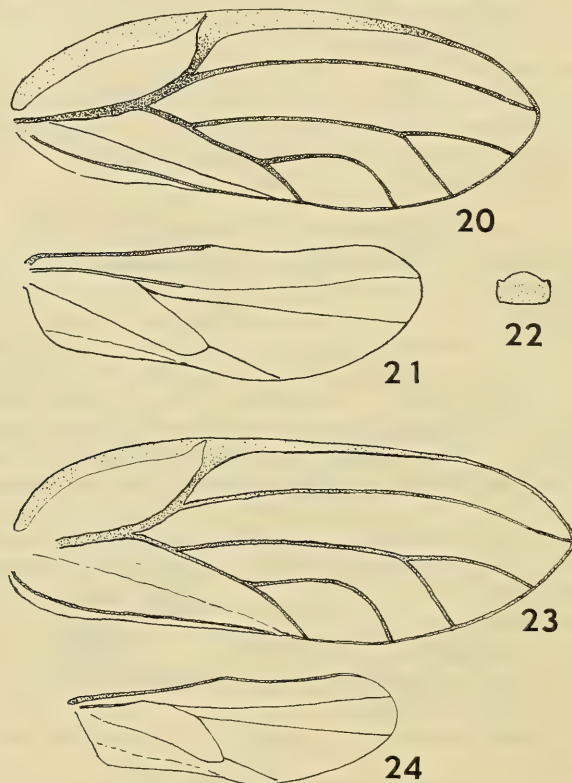
The type series of this species was placed in the collection of the United States National Museum during the 1940s (personal communication, D. L. Crawford, 1963).

In the original description of the species, Crawford gives the data: "Palawan, Puerto Princesa (Baker) 3 males & 5 females". The 1 ♀ and 2 ♂♂ from this series of eight specimens, forwarded on loan, are apparently of the eight that were before Crawford when he wrote the description, and of that eight, three are males and five females as Crawford indicated. These specimens are apparently the co-type series, and each bears an additional label with the data "1943 Colln., D. L. Crawford".

There are 30 additional specimens with the same collection data as the co-types of *forcipata*, but with a "C. F. Baker collection, 1927" label instead of the "1943 Colln., D. L. Crawford" label. Of this series of specimens, 2 ♂♂ and 2 ♀♀ were forwarded for study.

From an examination of the aedeagus and claspers of each male specimen from each of the above label-data series, it has been determined that both groups are *Glycaspis forcipata*.

From the original description (in German) of the genus *Epipsylla* Kuwayama 1908 in which it is stated "pterostigma fehlt" (i.e., pterostigma absent) it is clear that this species does not belong in that genus, and it is here placed in the genus *Glycaspis*. A description is given to include morphological features of the species not given in the original description by Crawford, and because of the poor condition of the type series specimens, this must necessarily be a composite description based on the lectotype ♂, the paralectotype ♂ and the paralectotype ♀ which were forwarded for study, and which were stated to be the better specimens.



Figs 20, 21. Wings of *G. (B.) penangensis*, sp. nov.

Fig. 22. Scutellum of *G. (B.) penangensis*, sp. nov.

Fig. 23. Forewing of female, *G. forcipata*.

Fig. 24. Hindwing of male, *G. forcipata*.

Lectotype male (here designated). Head: pale orange; width 0.81 mm.; vertex: along suture 0.29 mm., width 0.42 mm.; genal processes: length 0.46 mm., slightly divergent for more than half their length; ocular sclerites not pronounced; antennae: length 2.04 mm. Pronotum: width 0.57 mm., pale orange. Prescutum and scutum: pale orange. Scutellum: pale orange, anterior edge almost straight. Meta-scutellum, metanotum and post-metanotum: pale orange. Abdomen: pale orange, segs. 2 and 3 with a small dark brown medio-dorsal mark; claspers and aedeagus (Text-fig. 26) pale orange with a variable number of black pegs on internal face of each clasper. Length of 2-jointed aedeagus: (lectotype) distal portion 0.110 mm., proximal portion 0.205 mm., total length 0.315 mm., (paralectotype) distal portion 0.119 mm., proximal portion 0.212 mm., total length 0.331 mm.; distal segment of proctiger as long as proximal seg. (Text-fig. 13). Forewing: venation as in Text-figure 23. Hindwing: venation as in Text-figure 24.

The black pegs on the internal faces of the claspers are variable in number (8 to 12) in *G. forcipata*.

Paralectotype female. Head: width 0.85 mm., pale orange; vertex: along suture 0.34 mm., width 0.49 mm.; genal processes: length 0.49 mm., contiguous except at distal tips; antennae: length 2.07 mm., segs. 1 to 9 yellow, with distal tips of segs. 5 to 9 pale brown, seg. 10 black. Pronotum: width 0.71 mm., pale orange. Prescutum and scutum: pale orange. Scutellum, meta-scutellum and area between: pale orange; anterior edge of scutellum almost straight. Metanotum and post-metanotum: pale orange. Abdomen: pale orange, segs. 2 and 3 with a small pale brown medio-dorsal mark; genital segment pale orange. Forewing: length 3.37 mm., width 1.20 mm. (Text-fig. 23).

Host-plant: Not known.

Type locality: Puerto Princesa, Palawan Id., Philippine Is.

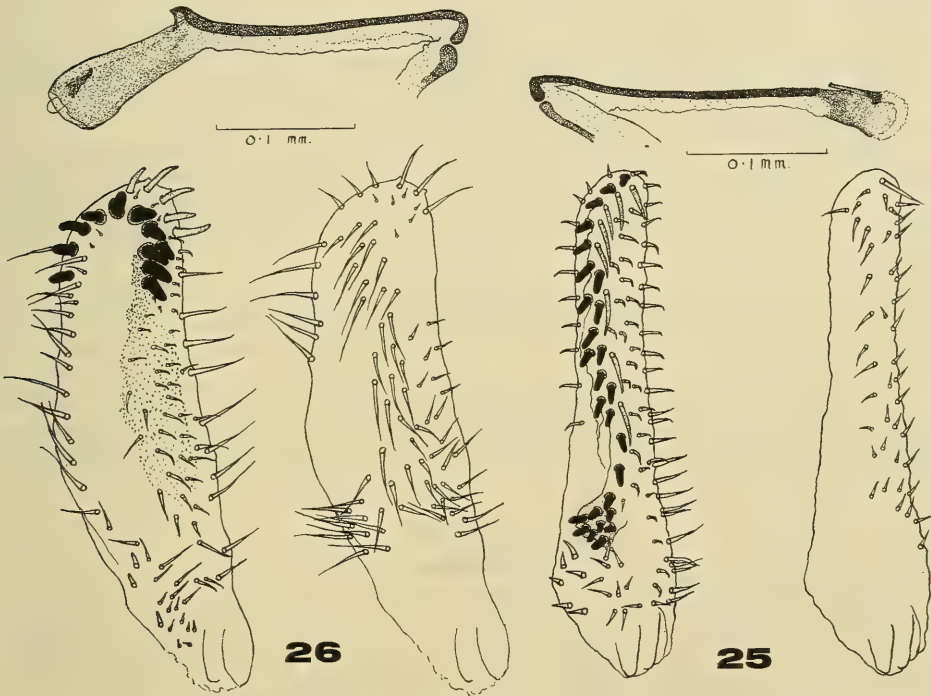


Fig. 25. Male aedeagus and claspers of *G. (B.) melaleuca*, sp. nov. Inner surface (left) and outer surface (right) of claspers.

Fig. 26. Aedeagus and claspers of lectotype male, *G. forcipata*.

Types: (a) Lectotype ♂ on slide labelled "P. Princesa, Palawan, Baker, 1943 Colln. D. L. Crawford", in the collection of the U.S. National Museum, Washington, D.C., U.S.A. (b) Paralectotype ♂ on slide labelled "P. Princesa, Palawan, Baker, 1943 Colln. D. L. Crawford", in the U.S.N.M. (c) Paralectotype ♀ on slide labelled "P. Princesa, Palawan, Baker, 4009, 1943 Colln., D. L. Crawford", in the U.S.N.M. (d) There are an additional five paralectotypes (1 ♂, 4 ♀♀), all presumably of the original type series, 1 ♂ and 3 ♀♀, with the label data "P. Princesa, Palawan, Baker, 1943 Colln. D. L. Crawford", and 1 ♀ with label data "C. F. Baker collection 1927, 4009, *Epipsylla forcipata* Crawf." in the U.S. National Museum, but which were not examined by the writer.

The lectotype ♂, 1 paralectotype ♂ and 1 paralectotype ♀ examined have been labelled as such by the writer, and Miss L. Russell, who is in charge of the psyllids

in the U.S. Department of Agriculture, Washington, D.C., has labelled as paralectotypes the remaining type-series dried specimens (i.e., 1 ♂, 4 ♀♀).

Other specimens examined: A female (dried specimen) labelled "P. Princesa, Palawan, Baker", in the collection of the B. P. Bishop Museum, appears to be *G. forcipata*. Coloration of specimens in the other subgenera of *Glycaspis* is not a reliable characteristic on which the species may be differentiated. This specimen, with considerable brown coloration, bears a brown area on the anterior edge of the prescutum each side of the median area, the marks being continued anteriorly to beneath the pronotum; the scutum bears a narrow brown medio-dorsal longitudinal stripe, and a diffused narrow brown stripe each side diverging posteriorly. These three stripes continue for the total length of the scutum. Lateral to these stripes and separated from them by a narrow golden-yellow area is a paler, more diffused and broader brown longitudinal stripe for the length of the scutum. The scutellum, meta-scutellum and area between are suffused pale brown. From the specimens examined, coloration of this species appears to be variable.

Two ♂♂ on slides and 3 ♀♀ (dried specimens) labelled "Philippines, Pasig, Balabac Id., Mar. 4, 1957, Yoshio Kondo, Collector" have been examined, and 1 ♂ on slide and 3 ♀♀ (dried spec.) are in the collection of the B. P. Bishop Museum. One ♂ on slide, labelled as above, has been placed in The Australian Museum, Sydney.

From the U.S.N.M. collection, 1 ♂ on slide, and 1 ♂, 2 ♀♀ (dried specimens) all labelled "P. Princesa, Palawan, Baker, C. F. Baker 1927 collection" have been examined, and 1 ♂ mounted on a slide and 1 ♀ (dried specimen) are deposited with The Australian Museum. The remaining dried specimens (5 ♂♂, 23 ♀♀) are in the U.S. National Museum.

One ♀ dried specimen of similar colour and characteristics to *G. forcipata* and labelled "British N. Borneo, Tawau Residency, Tawau, xi 19, 1958, T. C. Maa, Collector, BISHOP" has been examined, but at present it is undecided as to which species this specimen represents.

In his "Key to Genera", Crawford (1919) mentions under *E. forcipata* that the species occurs also in the Malay Archipelago, but it is presumed that he examined the specimen now known as *G. penangensis* and that he regarded the specimen to be conspecific with *G. forcipata*.

DISCUSSION.

(a) Species-groups in *Glycaspis* (*Boreioglycaspis*).

There appear to be two groups of species within the subgenus.

Group (i). Species with proximal angle of cell M of forewing commencing just beyond the projection of termination of vein Cu_1 in the posterior border of the wing; forewing wide in proportion to length; apex of wing rounded; tarsal pad approx. $\frac{1}{3}$ the length of tibia; rhinaria on antennal segs. 4 to 6, 8 and 9, with that on seg. 5 atrophied. Species in this Group are *G. penangensis* and *G. forcipata*.

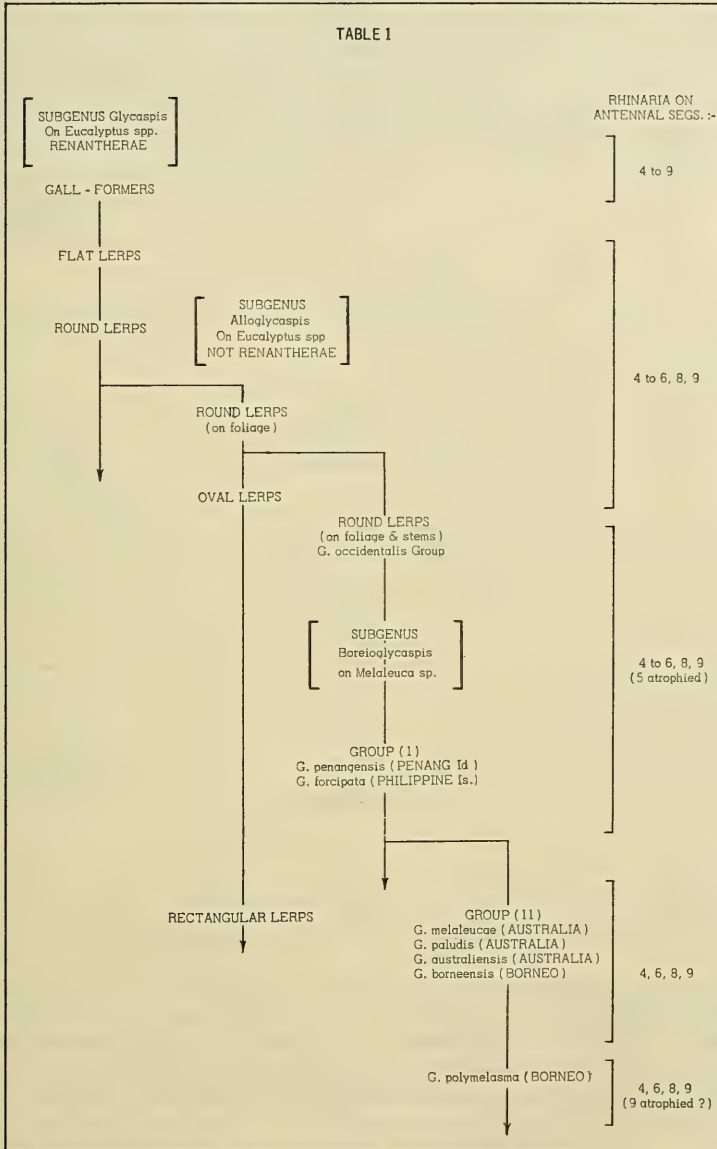
Group (ii). Species with proximal angle of cell M of forewing commencing well beyond the projection of termination of Cu_1 in the posterior border of the wing; wing narrow in proportion to length; apex acutely angular; tarsal pad approx. $\frac{1}{4}$ the length of tibia; rhinaria on antennal segs. 4, 6, 8 and 9 (those on seg. 9 of *G. polymelasma* appear to be atrophied). Species in this Group are *G. melaleucæ*, *G. paludis*, *G. australiensis*, *G. polymelasma* and *G. borneensis*, and are considered to be the most recent and specialized in the genus *Glycaspis*.

The ocular sclerites on *G. polymelasma* and *G. borneensis* are narrow and protrude considerably, while those on the other species in the subgenus may be normal or reduced.

(b) Host-plant Associations and Lerps.

It was considered previously (Moore, 1961a, 1961b) that species of the genus *Glycaspis* were confined to *Eucalyptus* spp. hosts.

From extensive preliminary enquiries concerning the possible occurrence of *Eucalyptus* spp. in Borneo, no species of that plant genus are known to be indigenous to that area (Browne, 1955; publications of the British Information Services, Sydney; and personal communication, L. A. S. Johnson of the National Herbarium, Sydney), so that species of *Glycaspis* (*Boreioglycaspis*) occurring on that island apparently do



not require a host association with *Eucalyptus* spp. Two of the Australian species of the subgenus *Boreioglycaspis* were subsequently determined by the writer to breed on *Melaleuca quinquenervia*, but whether all species in this subgenus utilize *Melaleuca* spp. as their host-plant is still in doubt.

Melaleuca spp. also occur in New Caledonia, New Guinea, the Malay Peninsula, Borneo and possibly many other islands to the north of Australia.

There has been no indication that species of *Boreioglycaspis* possess gall-forming or lerp-forming habits as do the species in the other subgenera.

(c) Distribution and Evolutionary Sequence.

No *Glycaspis* spp. were previously known to occur beyond the Australian mainland and Tasmania.

Three species of *Boreioglycaspis* are now known from the eastern coastal region of Australia, one from Penang Island, two from Borneo and one from the Philippine Islands, so that a comparatively recent dispersal of species of the genus northwards from Australia is indicated. No specimens of *Glycaspis* are known from New Guinea (personal communications, 1963, K. L. Taylor of the C.S.I.R.O., and Y. Miyatake of Kyushu University, Japan) although considerable collecting of psyllids has been carried out in that area.



Fig. 27. Distribution of *Glycaspis* (*Boreioglycaspis*) spp.

The number of rhinaria occurring on the antennal segments is regarded as an indication of the comparative evolutionary age of groups of the species concerned (Moore, 1961a). *Glycaspis* spp. constructing foliage galls, and regarded as the most primitive group within the genus, bear a single rhinarium at the apex of each antennal segment 4 to 9 inclusive; those constructing flat, round or oval lerps bear a rhinarium on segs. 4 to 6, 8 and 9, except those species in the *occidentalis* group in which the rhinaria on seg. 5 are atrophied; those constructing rectangular lerps, and regarded as the most recent and specialized group prior to the erection of the new subgenus, bear a rhinarium on segs. 4, 6, 8 and 9; those species in *Glycaspis* (*Boreioglycaspis*) Group (i) bear a rhinarium on segs. 4, 5 (atrophied), 6, 8 and 9, while those species in Group (ii) bear a rhinarium on segs. 4, 6, 8 and 9.

The number of rhinaria occurring on the antennal segments of species in Group (i) thus corresponds with the number occurring on species in the *occidentalis* group of *Glycaspis* (*Alloglycaspis*) (Moore, 1964a). This characteristic, together with the

general shape of the forewing, suggests affinity with them. The number of rhinaria occurring on species in Group (ii) corresponds to the number occurring on specimens constructing rectangular lerps, and they also are of comparatively recent origin. On examination of further specimens of *G. polymelasma*, if the rhinaria on antennal segs. 9 are shown to be consistently atrophied, it would suggest that this species is of the most recent origin of all the known *Glycaspis* spp.

From the host associations of, and the number of antennal rhinaria on, the various species of *Glycaspis*, this psyllid genus is regarded as having originated in Australia with the gall-forming species in *G. (Glycaspis)* which occur on *Eucalyptus* host species contained in the group *Renantherae* of Blakely (1955), as the basic genetic stock, diverging through *G. (Alloglycaspis)* species which occur on *Eucalyptus* host species not contained in the *Renantherae*, to *G. (Boreioglycaspis)* occurring on *Melaleuca* spp. (Table 1), and dispersing northwards at least to the Philippine Islands of Palawan and Balabac (Text-fig. 27).

TABLE 2.
Length of Genal Processes Compared with Vertex Width.

Subgenus.				Range in mm.		Longer.	Equal.	Shorter.
				Genal Processes.	Vertex Width.			
<i>Glycaspis</i>	Galls	..	..	0.27-0.34	0.42-0.59	—	—	5
	Flat lerps	..	..	0.29-0.32	0.34-0.39	—	—	2
	Round lerps	..	..	0.27-0.32	0.32-0.46	—	—	8
Total	..	..	..	..	..	—	—	15
<i>Alloglycaspis</i>	Round lerps	..	..	0.20-0.34	0.34-0.39	—	—	11
	Oval lerps	..	..	0.29-0.37	0.32-0.39	—	1	6
	Rectangular lerps	..	..	0.34-0.39	0.34-0.39	1	2	—
Total	..	..	..	..	..	1	3	17
<i>Boreioglycaspis</i>	No lerps							
	(Australia)	..	..	0.24-0.39	0.29-0.39	—	1	2
	(Penang)	..	..	0.44	0.49	—	—	1
	(Borneo)	..	..	0.44-0.51	0.34-0.39	2	—	—
	(Philippines)	..	..	0.46	0.42	1	—	—
Total	..	..	..	..	..	3	1	3

Such a dispersal of these insect species northwards from Australia is in contradistinction to the suggested direction of migration of man and other mammals, from the north, southwards into Australia.

The morphological characters of species in the subgenus (*Boreioglycaspis*) which suggest a divergence from *Alloglycaspis* rather than from *Glycaspis* are: (a) The number of antennal rhinaria. (b) Absence of a small spine on each metacoxa (present in *Glycaspis (Glycaspis)* only). (c) Cell Cu of forewing smallest of the three subgenera, with that in *G. (Glycaspis)* the largest. (d) Stem of M+Cu of forewing in *Alloglycaspis* and *Boreioglycaspis* about equal in length in proportion to M and Cu. (e) General wing venation, and particularly the shape of Cu₁ of hindwings. (f) Proportional length of genal processes to vertex width (see Table 2).

CONCLUSION.

It is often impossible to assign the correct female to a male of the same species of *Glycaspis* unless detailed biological observations are made, and then often only on a visual correlation of males and females in copulation. Such observations were particularly important during the initial taxonomic investigations on these species,

for it was not uncommon to find that two species of very similar, if not identical, habits and/or coloration occurred on the one host plant, and males of certain species were separable only on a study of the male claspers and aedeagus mounted on slides. Morphological characters of females, of sufficient reliability to separate the various species, often are not readily recognizable.

One male specimen of *G. (Alloglycaspis)* received on loan from the B. P. Bishop Museum is dealt with in another paper (Moore, 1964b).

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The Department of Entomology, University of Hokkaido, Sapporo City, Hokkaido, Japan, kindly provided a photocopy of the original description of the genus *Epipsylla* Kuwayama, and much time and assistance was given in the translation of that paper by Mr. W. Stahl, of the Forestry and Timber Bureau, Canberra, A.C.T., for which the writer is most grateful.

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Appreciation is expressed to Dr. Barbara Briggs of the National Herbarium, Sydney, N.S.W., who kindly identified the *Melaleuca* sp.; and to Miss M. Conwell, of the Forestry Commission of N.S.W., for the preparation of Text-figure 27 and Table 1.

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TAXONOMIC AND NOMENCLATURAL NOTES ON THE GENUS
WAHLENBERGIA IN AUSTRALIA.

By R. C. CAROLIN, University of Sydney.

[Read 24th June, 1964.]

Synopsis.

A statement of nomenclatural changes made necessary by the provisions of the International Code of Botanical Nomenclature and typification of some other species. *W. stricta* Sweet must replace *W. trichogyna* Stearn and *W. consimilis* Lothian. A new name (*W. communis*, sp. nov.) is provided to replace the misapplied or invalid name *W. bicolor* Lothian, and one species (*W. graniticola*) is described as new.

The genus *Wahlenbergia* is a critical one in Australia from both the biological and nomenclatural aspects. The author has been examining the variation within it for some time, but these researches will take some years to complete. There are, however, some nomenclatural changes which are necessary and at least one, clearly marked, new species. These are reported below. References to Articles of the International Botanical Code of Nomenclature are to the 1961 edition.

1. *W. STRICTA* Sweet, *Hort. Brit.*, ed. 2, 593 (1830).

Absolute Synonyms: *Campanula gracilis* (var.) β *stricta* R.Br., *Prodr.*, 561 (1810); Roem. et Schult., *Syst. Nat.*, 5: 97 (1819); *W. gracilis* (var.) β *stricta* (R.Br.) A.DC., *Monogr. Camp.*, 142 (1830) et *Prodr.*, 7: 432 (1839); *Campanula erecta* Sweet, *Hort. Brit.*, ed. 2, 326 (1830); *W. bicolor* Lothian in *Proc. Linn. Soc. N.S.W.*, 71: 230 (1947).

Taxonomic Synonyms (but see discussion): *W. consimilis* Lothian in *Proc. Linn. Soc. N.S.W.*, 71: 223 (1947); Melville in *Bot. Mag.*, 172 t. 343 (1959); *W. vinciflora* (Vent.) Decne. f. *ericalyx* Domin in *Bibl. Bot.*, 89: 638 (1929); *W. trichogyna* W. T. Stearn in *Gard. Chron.*, 130: 169 (1951); Robertson in Black, *Fl. S. Austr.*, ed. 2, 4: 810 (1957); *W. marginata* var. *grandiflora* Tuyn in *Fl. Males.*, Ser. I, 6: 118 (1960) nom. invalid., pro parte; *W. marginata* var. *grandiflora* sub-var. *trichogyna* (Stearn) Tuyn, loc. cit.

Misapplied illegitimate names: *Campanula vinciflora* Vent., *Jard. Malm.* t. 12 (1803) (as "*vincaeflora*") \equiv *W. vinciflora* (Vent.) Decne., *Rev. Hort.*, 3: 41 (1849); Black in *Trans. Roy. Soc. S. Austr.*, 58: 183 (1934); Domin in *Bibl. Bot.*, 89: 638 (1929); N. E. Brown in *Gard. Chron.*, 54: 355 (1913) pro parte (as "*vincaeflora*") ; Lothian in *Proc. Linn. Soc. N.S.W.*, 71: 220 (1947) (as "*vincaeflora*") \equiv *Campanula gracilis* (var.) α *vinciflora* (Vent.) R.Br., *Prodr.*, 561 (1810) pro parte (as "*vincaeflora*") \equiv *W. gracilis* var. *vinciflora* (Vent.) Hook. f., *Fl. Tasm.*, 1: 239 (1856) pro parte (as "*vincaeflora*").

Typification: *W. stricta* Sweet—holotype—an illustration with dissections, Smith, *Exotic Botany*, t. 45 (1805); this is also the holotype of *Campanula erecta* Sweet. Smith's plate and description are labelled "*C. gracilis* Forst.", not "*C. stricta*" as Sweet says; the specific epithet '*stricta*' was not used at any time, in a published form, by Smith in this connection; it thus dates from Sweet. There is no doubt from Smith's plate and description that he was dealing with the species at present under discussion, despite his equating it with *W. gracilis*. It has not been possible to trace the original specimen used for the plate, but material in Smith's herbarium (LINN) collected by White and labelled by Smith as *W. gracilis* shows that his conception of *W. gracilis* was erroneous; this material also belongs to the species at present under discussion.

It is clear that Sweet recognized Smith's identification to be wrong and that he was supplying a name for this new species when he named it *C. erecta*, which therefore cannot be regarded as a superfluous name; the citation of "*C. stricta* Sm. non L." is either a mistake or the citation of a name conveyed to him personally; the citation of Smith's plate is quite clear. In the addendum Sweet transfers this species to *Wahlenbergia* as *W. stricta* with full citation; the addendum runs on continuously from the main part of the book, there is no difference in date and it was issued at the same time; therefore neither specific epithet has priority over the other. *W. stricta* is the earliest legitimate name available. The epithet "*erecta*" is not now available in *Wahlenbergia* as it is preoccupied by *W. erecta* (Roth ex Roem. et Schult.) Tuyn in *Fl. Males.*, Ser. I, 6: 113 (1960).

Campanula vinciflora Vent. As Stearn (*loc. cit.*) has pointed out this name was superfluous when first published as it included, as a synonym, *C. gracilis* Forst. f., Art. 63. Under Art. 7, note 4, its type is that of *C. gracilis*. It is therefore illegitimate, but has frequently been misapplied to this species. The spelling "*vinciflora*" should be adopted under Rec. 73G (d) and Art. 73, note 2.

W. consimilis Lothian—lectotype—Warby Ranges, N.E. Victoria, N. Lothian, 20th Sept. 1942 (MEL). The punctuation in the original citation makes it impossible to decide whether this or "Aust. Felix, F. Muell., Dec. 1848" was intended as the type. The former specimen is actually marked "Type" (although not in Lothian's handwriting) and it agrees fairly well with the description. It is therefore taken as the lectotype. The description seems to indicate that elements of *W. graniticola* may have been included, notably the type has no collar on the style at all, still less "two prominent collars. . ."

W. bicolor Lothian. There seems little doubt that Lothian intended this to replace *C. gracilis* β *stricta* R.Br. He writes "Although originally described as *Campanula gracilis* var. *stricta* R.Br. . . ." indicating this, as does his inclusion of this variety, without further comment under synonymy. Therefore, it must be based upon the same type. Lothian's "lectotype" of his new species has little bearing here, since it should have been chosen from material referred to by Brown, Art. 7, note 3, i.e., material from Port Jackson, not from Port Phillip, the locality of the so-called "lectotype". On the other hand, it could be accepted that Lothian is providing a new name for R. Brown's specimens, which are not conspecific with the plate cited by Brown and not in complete agreement with his description. Lothian's "lectotype" might then be taken as a type of a newly described taxon. This would leave the epithet invalid, since there is no Latin description accompanying it and no reference to a previous valid Latin description (Art. 36).

The most satisfactory type for *C. gracilis* β *stricta* R.Br. seems to be the holotype of *W. stricta* Sweet. *W. bicolor* Lothian can be interpreted as a synonym of *C. gracilis stricta* R.Br. and therefore of *W. stricta* Sweet or, rather less plausibly, as an invalid name based on Brown's misidentifications. The former argument is accepted here (see also the typification of *C. gracilis* β *stricta* R.Br. and under *W. communis*, n. sp.).

W. trichogyna W. T. Stearn—holotype—New South Wales, Ingleburn, F. M. Hilton, No. 448 (MEL).

C. gracilis (var.) β *stricta* R.Br.—lectotype—the plate Smith, *Exotic Botany*, t. 45 (1805). It is clear that Brown intended to base his variety primarily on Smith's plate, misidentified as *W. gracilis*; the citation of the unpublished epithet "*C. stricta*" for this plate indicates that this was so. The short description agrees better with the plate than with the Port Jackson specimens also cited by Brown. The plate then is the type. The specimens referred by Brown to this variety, moreover, are not conspecific with the plate; they are misidentifications of specimens of *W. communis*. Brown referred some of these specimens to the manuscript name "*W. bicolor*". This bears no relationship whatsoever to *W. bicolor* Lothian (see above), the "lectotype" of which latter was labelled "*W. gracilis a*" (i.e., a *vinciflora* R.Br.) by Brown.

W. vinciflora f. *ericalyx* Domin—holotype—In silvis permixtis apud flumen Logan River in arenosis, III, 1910, Domin no. 8739 (PR): isotype 8738 (PR). These appear to be the same collection. No number is cited by Domin.

W. marginata var. *grandiflora* Tuyn. The author of this variety includes both *W. consimilis* Lothian and *W. gloriosa* Lothian as synonyms. No specimens are cited and neither of the synonyms is clearly indicated as the type of the new variety, which must therefore be rejected as invalid (Arts. 33, 37). The two species in question are quite distinct.

DISCUSSION: This species has had a very chequered nomenclatural history. It is fairly widespread in open forest communities throughout the south and eastern temperate areas of Australia, but not in very dry conditions, probably also in Western Australia in similar communities, extending into Tasmania and New Zealand. Lothian separated the specimens with hirsute capsules as "*W. vincaeflora*" and those with glabrous capsules as *W. consimilis*. No other character difference is consistently correlated with the glabrous capsule and both capsule forms have frequently been found growing side by side. There seems no justification for separating them at the specific level. The type of *W. stricta* shows a hirsute capsule.

2. *W. BILLARDIERI* Lothian in PROC. LINN. SOC. N.S.W., 71: 226 (1947).

Absolute Synonyms: *Campanula littoralis* Labill., *Nov. Holl. Pl. Sp.*, 49, t. 70 (1805); Poir., *Encycl. Meth.*, Suppl. 2: 56 (1811) = *C. gracilis* (var.) γ *littoralis* (Labill.) R.Br., *Prodr.*, 561 (1810) = *W. gracilis* (var.) γ *littoralis* (Labill.), A.D.C., *Monogr. Camp.*, 142 (1830) et *Prodr.*, 7: 433 (1839) = *W. vinciflora* (Vent.) Decne. var. *littoralis* (Labill.) N. E. Brown in *Gard. Chron.*, 54: 355 (1913) = *W. marginata* (Thunb.) A.D.C. var. *littoralis* (Labill.) Hochr. in *Candollea*, 5: 29 (1934) (non *W. littoralis* Schlechter et Brehmer in *Bot. Jahrb.*, 53: 127 (1915)).

Typification: *Campanula littoralis* Labill.—lectotype—Nouvelle Hollande, Herb. Labillardière ex Herb. M. E. Moricand (GEN). There is little doubt that Labillardière's original collection contained two distinct elements, both of which appear to have been used in drawing up his diagnosis. Thus the description states that a thickened style is present, whilst the plate shows no such character. Moreover, the majority of Labillardière's specimens examined have scattered leaves whilst the plate and description show them as being opposite. Both elements are represented on sheets at Geneva. Two of these sheets have "Hb. Delessert" labels and are apparently specimens of the *W. multicaulis* Benth. group of species which have a distinct styler swelling. This element is also represented at BM, P, & FI. A third, donated by the executor of Herb. M. E. Moricand in 1908, and clearly labelled "Herb. Labillardière", corresponds very well with the original plate.

W. billardieri Lothian was intended as a transfer of *C. littoralis* to *Wahlenbergia*. The specific epithet "*littoralis*" was not available and a new one was provided. It is quite clear that Lothian intended *W. billardieri* as nomenclatorially equivalent to *C. littoralis* Labill. Despite this, nowhere does he consider authentic type material. Instead, he considers a Gaudichaud collection at Geneva, which is irrelevant to the typification. As this is inadequate he selects a neotype from amongst Robert Brown's material. This neotype must be rejected as Labillardière's material is extant.

DISCUSSION: This species, in fact, may prove not to be distinct from *W. stricta*. The typification was so involved, however, that this discussion has been included here.

3. *W. COMMUNIS*, sp. nov.

Plantae multicaules erectae plerumque ad basin ramosissimae. Folia alterna vel opposita, plerumque linearia, non undulata. Sepala linearia vel lineari-deltoida, acuta. Corolla coerulea externe interdum plus minusve aurea, campanulata vel fere cylindrica. Stamina filamenta trapezi-formia, humeris acutis. Stylus haud vel obscure contractus, glandulas 6-9 ferens, 3-fidus. Fructus elongato-obconicus vel subglobularis, glabratus.

Taxonomic Synonyms: *Campanula gracilis* (var.) δ *capillaris* R.Br., Prodr., 561 (1810) \equiv *W. gracilis* (var.) δ *capillaris* (R.Br.) A.DC., Monogr. Camp., 142 (1830) et Prodr., 7: 433 (1839); Hook. f., Fl. N. Zeal., 1: 159 (1852) et Handbook N. Zeal. Fl., 170 (1864); *W. multicaulis* var. *dispar* N. E. Brown in Gard. Chron., 14: 338 (1913).

Misapplied Names: *C. gracilis* Forst. f. (var.) β *stricta* (non R.Br.) R.Br., Prodr., 561 (1810); *W. gracilis* (Forst. f.) DC. (var.) β *stricta* (non (R.Br.) A.DC.) A.DC., Monogr. Camp., 142 (1830) et Prodr., 7: 433 (1839); *W. gracilis* (var.) *a vinciflora* (non (Vent.) R.Br.) R.Br., Prodr., 561 (1810) nom. illegit., pro parte; *W. multicaulis* (non Benth.) N. E. Brown in Gard. Chron., 14: 337 (1913) pro parte; *W. bicolor* (non Lothian) Lothian in PROC. LINN. Soc. N.S.W., 71: 230 (1947); Robertson in Black, Fl. S. Austr., 4: 810 (1957).

Perennial herbs with thick fleshy tap-roots and frequently erect white rhizomes. *Stems* numerous, erect, usually much branching at or near the base, glabrous or with scattered stiff scabrous white hairs, basally terete or ridged by the decurrent leaf margins 20–40 cm. tall, 2 mm. wide (or less) at the base. *Leaves* scattered, or opposite, linear or rarely narrow-lanceolate, 10–35 mm. long, 2–3 (4) mm. wide, acute or \pm obtuse, scarcely tapering towards the base and usually quite sessile, glabrous or with stiff scattered white hairs: margins often thickened and cartilaginous, remotely callous-dentate, not usually undulate, flat or \pm recurved. *Flowers* arranged in irregular loose cymes on elongated glabrous naked pedicels, the lower ones subtended by linear bracts c. 10 mm. long or shorter. *Sepals* 5, rarely more, linear to linear-deltoid, 4–6 mm. long, c. 0.5 mm. wide, acute, glabrous. *Corolla* blue, sometimes \pm golden-yellow outside, narrow-campanulate to almost cylindrical; tube 5–8 mm. long, 4–6 mm. wide in the throat; lobes 5 (very rarely more) narrow to broad-elliptic or ovate, 6–8 mm. long, 3–5 mm. wide, generally acute, as long as or longer than the tube, \pm ascending. *Stamens* 5: filaments trapezial with acute shoulders, ciliate on upper margins, c. 1.5 mm. long with an awn about equally as long: anthers oblong, 3–4 mm. long: pollen white or pale yellow. *Ovary* 3-locular; style unconstricted or with an indistinct constriction low down, pubescent in the upper two-thirds with 6 or 9 glands, 9 mm. long: stigmatic branches 3, \pm flat, 2–3 mm. long. *Fruit* elongate-obconic, 3–10 mm. long, 3–4 mm. wide, glabrous, prominently ribbed and crowned by the persistent sepals with a valvular cone c. 1 mm. high: valves 3, suborbicular, obtuse, \pm exserted. *Seeds* oblong to ellipsoidal, c. 1 mm. long, pale-brown or yellow, shining, smooth.

Typification: *W. communis* sp. nov.—holotype—Glen Innes N.S.W., On roadsides—disturbed soils in pastoral country. R. Carolin No. 2095, 1.1961. (NSW).

C. gracilis (var.) δ *capillaris* R.Br.—lectotype—"New South Wales; Botany Bay, Bustard Bay, Bay of Inlets"—Banks and Solander (BM). R. Brown does not indicate by 'v.v.' or 'v.s.' whether he observed this taxon alive or preserved. There are no specimens of R. Brown's at BM labelled as 'var. δ ' or 'capillaris' except this lectotype which is labelled "*Campanula juncea*" and "*C. gracilis* Forst. capillaris" in a hand which is not Brown's. This specimen also bears a "TYPE" label, probably affixed by N. E. Brown. It seems likely that R. Brown drew upon this specimen for his description, with which it more or less agrees. It is a specimen of *W. communis* with \pm globular fruits.

Campanula capillaris Lodd., Bot. Cab., 15: 1406 (1828), was published in a nurseryman's catalogue and neither the illustration nor inadequate description is such that the original plant can be identified. There is no reference to any previously published epithet, specific or varietal. It has not been possible to trace any material appertaining to this description. Indeed, the description is scarcely one at all, but was intended as a guide to gardeners who wanted to grow the particular plants supplied by Loddiges' nursery, not as a diagnosis. The illustration is at variance with the description. The binomial is herewith treated as a *nomen nudum* and therefore invalid.

W. multicaulis var. *dispar* N. E. Brown—lectotype—Fraser Range, W.A., R. Helms, Elder Exploring Expedition, 29.10.1891. No specimens are cited in the original description, but there are three specimens at Kew labelled "TYPE" by N. E. Brown.

One, Guildford and Claremont near Perth (W.A.) Ex. Herb. Cecil Andrews, 1st Coll. No. 591, does not agree with the type description and is, in fact, a specimen of the *W. multicaulis* group. The other two agree very well. *W. multicaulis* is distinct from the species at present under discussion in having a more open campanulate to sub-rotate corolla and a style which is definitely constricted just below the stigmatic lobes; in fact, it is closely related to, if not conspecific with, *W. tadgellii* Lothian.

DISCUSSION: Apparently a very widespread species in open forest and grass land communities which is extremely variable. It may be possible to recognize intra-specific taxa eventually. Specimens of it have usually been referred to *W. bicolor* Lothian, but this name is a synonym of *W. stricta* Sweet, q.v.

4. *W. GRANITICOLA*, sp. nov.

Caulis pauci stricti vel ascendentes ad basin hirsuti pilis albis. Folia alterna sessilia ad basin plus minusve attenuata. Flores solitarii vel pauci. Sepala anguste deltoidea, 2.5–5 mm. longa. Corolla campanulata late 6 mm. lata in fauci, lobis obovatis vel ellipticis 9–12 mm. longis. Stamina filamentis acuminatim trapezi-formibus. Stylus tumidus ad medium glandulas 6 vel 9 ferens. Lobi stigmatis 3. Fructus obconicus vel subglobularis glaber vel hispidus, conum valvularem brevissimum ferens.

Perennial herbs with thick fleshy roots. Stems usually few, erect or ascending, hirsute at least towards the base with stiff white hairs, ridged with the decurrent leaf margins, 20–50 cm. tall, 1–1.5 mm. wide at the base. Leaves alternate, linear to lanceolate, usually with scattered white hairs especially on the mid-rib, \pm acute; margin thickened, subcartilaginous, slightly recurved, remotely callous-dentate, often \pm undulate; lower leaves 1.5–5.0 cm. long, 3–9 mm. wide, \pm tapering towards the base but scarcely petiolate. Flowers solitary or few on each stem. Sepals 5, usually narrow-deltoid, 2.5–5 mm. long, up to 1 mm. wide, glabrous. Corolla blue, paler in the tube, spreading campanulate: tube 2–4 mm. long, c. 6 mm. wide in the throat, usually as long as or slightly longer than the sepals; lobes 5, obovate to elliptic, 9–12 mm. long, 5–8 mm. wide, \pm obtuse or with a short awn, c. 2 mm. wide and 2 mm. long and with short acute shoulders, ciliate: anthers oblong, c. 3 mm. long; pollen white. Ovary 3-locular: style 5–7 mm. long with a constriction about midway, pubescent from this point upwards, with 6 or 9 glands; stigmatic lobes 3, c. 1.5 mm. long. Fruit shortly obconic to subglobular, 4–7 mm. long, 3–4 mm. wide, glabrous or hispid, prominently ribbed and crowned by persistent sepals and with a very short valvular cone: valves 3, broad-deltoid, scarcely exerted. Seeds oblong, brown, smooth, shining.

Typification: Holotype—Lithgow to Mt. Victoria 6 miles, open forest on granite, R. Carolin No. W 106, 11.1956 (NSW).

DISCUSSION: The description which Lothian gives for *V. consimilis*, and specimens cited under that species, indicate that he included the present species within it. It differs, however, from *W. consimilis* (i.e., *W. stricta* Sweet, q.v.) in the wide-campanulate corolla, the broader corolla lobes, the swollen style and alternate leaves. It also resembles *W. tadgellii* Lothian, differing from it in the less rotate corolla, the much lower swelling of the style, and the filament shape. Its distribution, as known at present for certain, is the central and southern tablelands and western slopes of New South Wales from the Blue Mountains southwards to the Australian Capital Territory.

5. *W. FLUMINALIS* (J. M. Black) Wimmer ex Hj. Eichler in *Taxon*, 12: 297 (1963).

Absolute Synonym: *Cephalostigma fluminale* J. M. Black in *Trans. Roy. Soc. S. Austr.*, 58: 184 (1934); Robertson in Black, *Fl. S. Austr.*, ed. 2, 4: 809 (1957).

Typification: Holotype—Murray River, Capt. S. A. White, Dec. 1913 (AD).

DISCUSSION: Recently Tuyn (*Fl. Males.*, Ser. 1, 6 (1961)) has reduced the genera *Lightfootia* and *Cephalostigma* to *Wahlenbergia*. The first is not concerned in the present discussion. De Candolle first described *Cephalostigma* (1830) as having "La corolle divisée profondément en 5 lanières étroites comme dans *Lightfootia*. . .

Le stigmate est en tête." It has been indicated by most subsequent authors that the latter statement is incorrect due to De Candolle having examined the style, which is swollen at the top, before the stigmatic lobes had separated.

The species at present under discussion shows little in common with *Cephalostigma* as defined by De Candolle and subsequent South African authors. In particular the corolla-lobes do not widen towards the base, the filaments are not deltoid or 2-lobed, there is no strongly developed valvular-cone, and the habit is much less branched. The only character held in common is the swollen upper part of the style. Other species (e.g., *W. graniticola* and some forms of *W. communis*) show intermediate conditions between that of *W. fluminalis* and the unswollen style (e.g., *W. stricta*) both in position of the constriction and its prominence. Brehmer indicates that the same gradations exist in the South African species (*Bot. Jahrb.*, 53).

It seems clear, then, that the Australian species showing the "cephalostigmatous" stylar form belong to *Wahlenbergia*. It also seems clear that they are not closely related to *Cephalostigma* in De Candolle's sense. Thus, whereas Tuyn may have been a little precipitate in combining these genera, his action has no relevance to the Australian species.

6. *W. GYMNOCLADA* Lothian in PROC. LINN. SOC. N.S.W., 71: 227 (1947).

Typification: Holotype—Gorae West, near Portland, Victoria, C. Beaglehole. (MEL).

DISCUSSION: There is no doubt about the holotype, but the description supplied by Lothian is at variance with it in the particularly important character of stylar shape. He writes: "... style simple, napiform", which can only be interpreted as meaning a swelling high on a style with unopened lobes ("cephalostigmatous") similar to the *W. multicaulis* group and *W. fluminalis*. The type shows an unswollen style. The description may have been constructed using elements of *W. tadgellii* Lothian. Lothian includes four varieties as synonyms. They are, in fact, misapplications of the names involved.

7. *W. GRACILIS* (Forst. f.) Schrad.

W. marginata (Thunb.) A.DC. var. *neocaledonica* Lothian in PROC. LINN. SOC. N.S.W., 71: 214 (1947) (as "neo-caledonica").

Typification: Lectotype—*C. gracilis*—Forster GÖTT).

DISCUSSION: The type, at Kew, which Lothian cites, is derived from J. R. Forster's herbarium (Carolin, PROC. LINN. SOC. N.S.W., 88). There is, in fact, no real evidence that this specimen was collected in New Caledonia. There appears to be no difference between this specimen and all the other Forster specimens of *W. gracilis* scattered throughout Europe (BM. K. GOTT. KIEL) and they may all be part of the same gathering. It seems that Lothian based var. *neocaledonica* on an isotype of *W. gracilis* (Forst. f.) Schrad. The Göttingen specimen has usually been accepted as the type without having any real claim to first consideration (see Carolin, PROC. LINN. SOC. N.S.W., 88); it is herewith taken as the lectotype. Lothian's confusion seems to have been complete as he cites the collection of W. Anderson, made in New Caledonia and housed in the British Museum, under both the "typical *W. gracilis*" (which he considers to be part of *W. marginata*) and *W. marginata* var. *neocaledonica*. The present author does not consider that *W. gracilis* (Forst. f.) DC. and *W. marginata* (Thunb.) are conspecific.

Acknowledgements.

I should like to thank the Director and the Keeper of the Herbarium of the Royal Botanic Gardens, Kew, and the Keeper of the Herbarium at the British Museum for placing the facilities of their institutes at my disposal, and to Mr. A. A. Bullock, Mr. H. K. Airy-Shaw, Dr. R. Melville, Dr. W. T. Stearn and Mr. L. A. S. Johnson for many helpful discussions. A grant from Science and Industry Fund of C.S.I.R.O. made possible the completion of this work.

A NEW GENUS OF AUSTRALIAN CLAVICORN COLEOPTERA, PROBABLY OF A NEW FAMILY.

By R. A. Crowson, University of Glasgow.

(Communicated by Dr. P. B. Carne.)

(Seventeen Text-figures.)

[Read 29th July, 1964.]

Synopsis.

A new genus, *Cavognatha*, is described for a new species, *C. pullivora*, both larva and adults being described. The beetles probably represent a hitherto undefined family of Cucujoidea; possible adaptive significances of some of their characters are briefly mentioned.

A year or two ago Dr. P. B. Carne of the Division of Entomology, C.S.I.R.O., Canberra, sent me for identification a series of coleopterous larvae together with three adults reared from similar larvae, all the larvae collected from nestlings of a native bird at Gungahlin, A.C.T., on October 28, 1958, by Dr. R. Carrick; subsequently I received a fairly long series of adults of the same species, also from Gungahlin, collected by W. J. M. Vestjens. The characters of both adults and larvae proved to be unusual and interesting, the species apparently representing a hitherto undescribed genus. Both larval and adult characters are unmistakably of Cucujoidea-Clavicornia, but in neither stage are the Gungahlin insects satisfactorily assignable to any Clavicorn family hitherto described. In the circumstances it seemed best to me to postpone serious study of the species until I began a projected major revisional study of Cucujoidea. However, as it is now desired to refer to this species in ecological publications, the opportunity is taken to publish generic and specific diagnoses of it.

By adult characters, the Gungahlin insects would trace to couplet 12 in my previously published key to families of Clavicornia (Crowson, 1955, pp. 91-98), but they cannot be attributed to either of the two families (Cucujidae and Silvanidae) in that couplet. At least three other clavicorn genera from Australia appear to belong to the same family as the Gungahlin species; before the family can be characterized it will, however, be necessary to study these genera more fully than I have yet been able to.

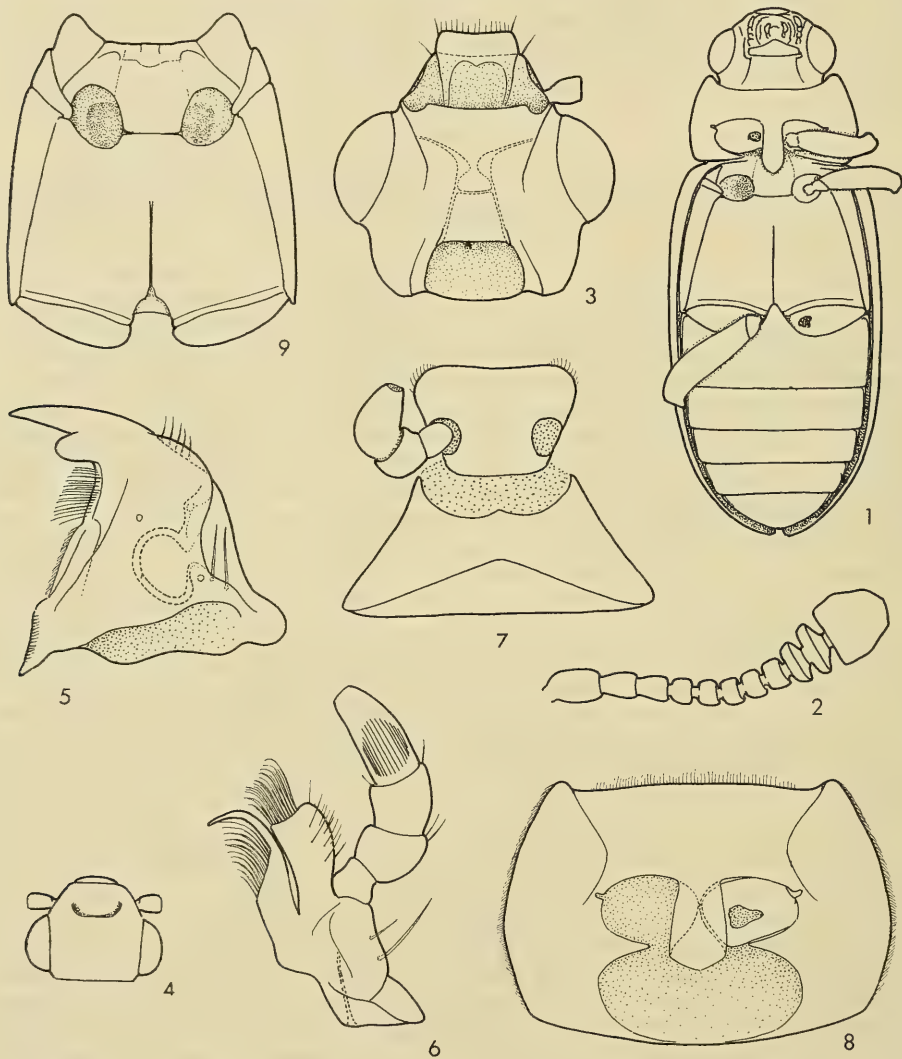
CAVOGNATHA, gen. nov.

Type species: *Cavognatha pullivora*, sp. nov. (The Latin-Greek generic name refers to the adult mandibles.)

With the general characters of Polyphaga-Cucujoidea-Clavicornia.

Adult: General form (Fig. 1) elongate and sub-parallel sided, only slightly depressed. Tarsal formula 5-5-5 in both sexes, segments 1-4 of nearly equal length but progressively narrower, none of them lobed below, segment 5 about as long as 2-4 together; claws simple, empodium inconspicuous. Antennae (Fig. 2) relatively short and thick, 11-segmented with 3-segmented club, segment 11 polygonal and longer than 9 and 10 together. Front coxae transverse, their cavities (Fig. 8) with narrow angular external prolongations in which the trochantins are partly exposed, coxal cavities partly closed behind by hypomerical processes; prosternal intercoxal process unusually broad, apically prolonged and received in the slightly hollowed median part of the mesosternum. Middle coxal cavities (Fig. 9) rather widely separated, the mesepimera broadly reaching them, trochantins partially exposed, meso- and metasterna meeting in a rather long nearly straight line. Hind coxae not quite as widely separated as middle ones, extending laterally a little beyond outer edges of metasternum

but not meeting elytral epipleura. Metasternum with strong median impressed line in posterior $\frac{3}{4}$, the hind margin rather deeply, broadly and angularly excavate between the coxae, receiving the angular process of the first ventrite; metepisterna exposed, narrow posteriorly and much broadened in front, their inner apical angles prolonged. Ventrites 5 in both sexes, the first longest, 2 slightly shorter, 3-5 of equal length and shorter than 2, all of them with distinct raised lateral margins.



Text-figs 1-9. *Cavognatha pullivora*, n. sp. 1, whole insect, ventrally, antennae and parts of legs removed; 2, antenna; 3, head capsule, mouth-parts removed, tentorium dotted; 4, head, dorsal view; 5, right mandible, dorsal view; 6, right maxilla (without cardo), dorsal view; 7, labium, ventral view; 8, prothorax, ventral view, right coxa removed; 9, meso- and meta-thorax, ventrally, middle coxae removed.

Head (Fig. 3) markedly constricted just behind the entire moderately convex eyes, antennal insertions lateral, just in front of eyes; fronto-clypeal suture not distinct; labrum very short, transverse, its front margin arcuately emarginate; genae, between eyes and maxillae, channelled so as to receive retracted bases of antennae; gular sutures short, widely separated, labium borne on a short peduncle under the sides of

which the cardines are partly hidden. Mandibles (Fig. 5) with a sharp apical tooth, a blunt pre-apical one, a prosthecal tuft of long stiff setae, and a less sclerotized setose tract between it and the molar area, the latter only slightly protuberant, oblique, finely asperate, and basally prolonged; basal part of outer face of mandible deeply channelled and opening by a narrow passage into a large ovate internal cavity. Maxillae (Fig. 6) with 4-segmented palpi, segment 4 about as long as 2 and 3 together, slightly narrowed to its apex, its dorsal face with a number of parallel longitudinal impressed lines; galea short, 1-segmented, with a dense apical tuft of slightly curved setae; lacinia narrower, with a strong apical hook and a tract of slightly curved setae behind it. Labium (Fig. 7) with trapezoidal mentum whose sides are strongly convergent and distal edge is strongly emarginate; prementum slightly transverse, its front margin corneous and nearly straight; palpi 3-segmented, apical segment strongly curved, much widened in its basal part and strongly narrowed to apex. Tentorium (Fig. 8) of normal clavicorn type.

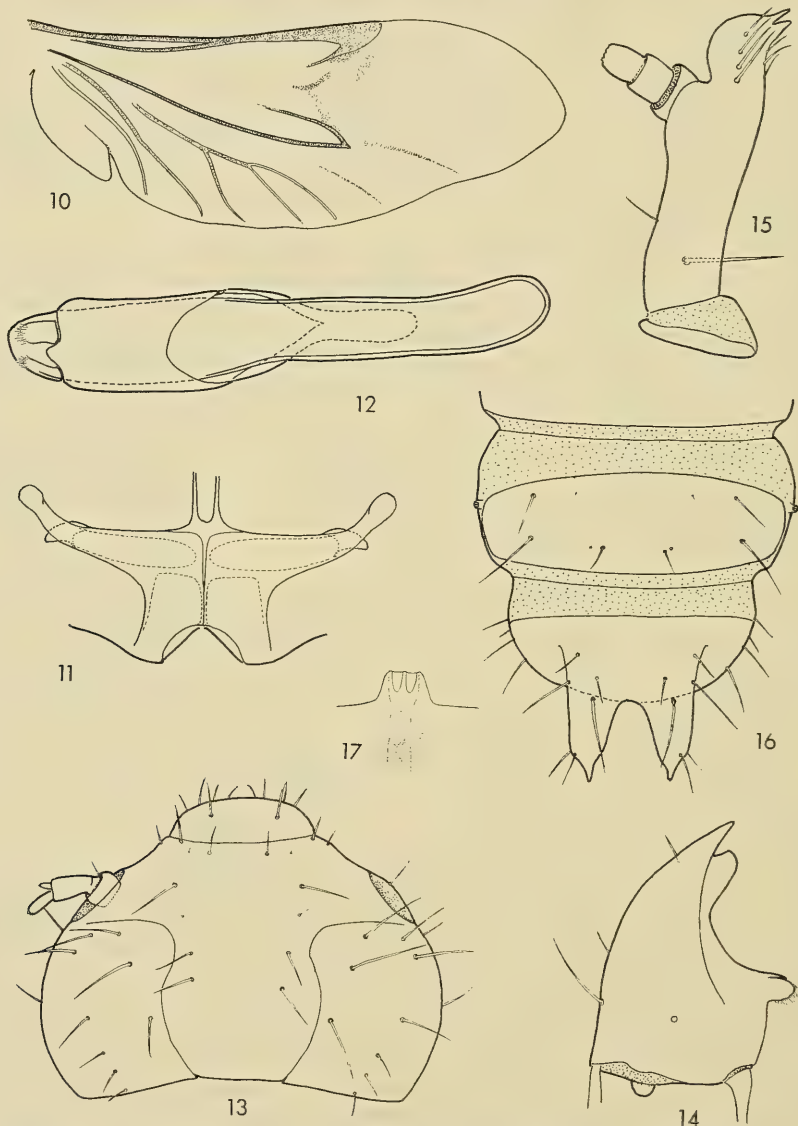
Pronotum more or less uniformly convex, without marked impressions, its side margins complete, running into front and hind margins without marked angles; sternopleural sutures of prothorax rather deeply recessed along outer edges posteriorly. Elytra unusually elongate, side margins slightly curved, upper surface fairly evenly convex, entire and fully covering the abdomen; epipleura oblique, more or less distinct almost to apex, their outer edges obtuse as in *Cryptophagidae*. Scutellum very transverse. Wings (Fig. 10) with five Anal veins in main group, no distinct Anal cell, Radial cell open, r-m cross-vein indistinct and without a spur. Metendosternite (Fig. 11) resembling those of other primitive Clavicornia (e.g., *Sphindus*). Legs with trochanters neither elongate nor heteromeroid, femora moderately thickened in middle, tibiae with rounded outer edges, without keels or denticles, apical margins with a circle of spines, two normal spurs on all legs.

Abdominal tergite 8 normally hidden in both sexes, tergites 1-7 all dark coloured and more or less sclerotized, 2-6 each with a well-marked paratergite on each side, 5-7 with progressively larger paired posterior rubbing areas, spiracles of 7 in edge of tergite, those of 2-6 just outside paratergites. Male with tergite 8 not at all hooded, sternite 8 small and weakly sclerotized, sternite in female nearly as large as tergite, in both sexes with long spiculum gastrale. Aedeagus (Fig. 12) of inverted cucujoid type with short articulated parameres, resembling those of some Cucujidae. Ovipositor short, baculi less than $1\frac{1}{2}$ times as long as 8th tergite, valvifers large, rectangular, slightly transverse, coxites slightly elongate, styli about as long as and half as wide as coxites.

Larva: Form elongate, slightly depressed, of practically even width from prothorax to abdominal segment 7, head very slightly narrower than prothorax, abdominal segment 8 slightly narrower than 7, 9 about $\frac{2}{3}$ as wide as 8, pygopod (segment 10) situated ventrally, about half as wide as 9. Thoracic and abdominal segments all with dark sclerotized tergites, those of thorax each with a pale median line. Protergite about three times as wide as its median length, tergites of next 10 segments each about five times as wide as long, separated from each other by relatively wide pale areas. Pigmented area of protergite with a long seta at each anterior angle, and a few small scattered setae, succeeding tergites each with an anterior and a posterior transverse line of various sized setae. Abdominal tergite 9 as figured (Fig. 16) with a pair of stout, nearly straight, slightly divergent pointed urogomphi, pygopod with well sclerotized tergite. No evident sclerotizations in sternal region of abdomen.

Head capsule (Fig. 13) short and broad, rounded at sides, frontal sutures of typical cucujoid form, no median epicranial suture or endocarina, fronto-clypeal suture indistinct. Labrum free, short and transverse with evenly rounded front margin, the middle of its under surface (epipharynx) with six short seta-like processes in an irregular transverse row. Distinct short hypostomal rods diverging backwards from outer basal angles of maxillae. Six ocelli on each side, an anterior vertical row of 4, posterior row of 2 parallel to top 2 of front row. Antennae 3-segmented, segment 1

short and transverse, 2 elongate and tapered to its base, its broad apical surface bearing posteriorly the small elongate 3rd segment and anteriorly a pale conical sensory appendage. Mandibles (Fig. 14) as figured, with a sharp apical and blunt pre-apical tooth, no distinct prostheca, the molar area represented by a weakly sclerotized pointed process and a setose lobe. Maxillae (Fig. 15) with short 3-segmented palpi,



Text-figs 10-17. *Cavognatha pullivora*, n. sp. 10, wing; 11, metendosternite, dorsal view; 12, aedeagus, ventral view; 13, head capsule of larva, dorsal view; 14, left mandible of larva, dorsal view; 15, left maxilla of larva, dorsal view; 16, end of abdomen of larva, dorsal view; 17, larval spiracle.

mala with outer apical margin strongly rounded, a pair of stout teeth at inner apical angles, dorsal surface with a row of fairly stout setae. Stipes very long, cardo rather small, articulating area of moderate size. Labium with short 2-segmented palpi, hypopharyngeal sclerome simple and rather weakly sclerotized, supported by a well-marked hypopharyngeal bracon.

Spiracles (Fig. 17) small and biforous, situated on short tubular projections, the anterior pair between prothorax and mesothorax, the eight abdominal ones situated somewhat dorsally and near the middle of the segments.

Front coxae separated by about their own width, middle and hind coxae by about twice their own width; prosternum with four long setae, meso- and meta-sterna each with six. Legs relatively short, femora and tibiae each about twice as long as its width and bearing a small number of setae but no specialized spines; tarsungulus claw-like, strongly sclerotized, its two ventral setae in longitudinal succession.

CAVOGNATHA PULLIVERA, sp. nov. (Figs 1-17.)

General body surface more or less uniformly brownish and with recumbent pubescence. Dorsal surface of head (Fig. 4) with a rather deep characteristic impression between bases of antennae, moderately closely punctured, the pubescence directed backwards and in posterior part somewhat medially. Pronotum about $2\frac{1}{2}$ times as wide as its median length, front $\frac{2}{3}$ of side margins gently curved and convergent, hind $\frac{1}{3}$ rather more sharply contracted to base (Fig. 8); dorsal surface moderately strongly, closely and uniformly punctured, the long recumbent pubescence directed posteriorly along the median tract, postero-medially along front $\frac{2}{3}$ of lateral parts, antero-medially in hind $\frac{1}{3}$ of them. Elytral punctures rather smaller than, and not quite as close as, those of pronotum, with no tendency to be arranged in rows, pubescence nearly as long as that of pronotum and directed posteriorly; suture slightly raised and marked off by a groove in posterior $\frac{1}{3}$; elytral surface with faint traces of striae in some specimens. Puncturation and pubescence of under surface distinctly less conspicuous than those of upper side. Male with segments 1-3 of front tarsi wider, and with denser setal brushes, than in female.

Holotype and paratypes from Gungahlin, A.C.T., 13 Dec. 1959; paratypes from nestlings of *Gymnorhina tibicen*, Gungahlin, 28 Oct. 1958. All type material in Australian National Insect Collection, Canberra.

Perhaps the most distinctive feature of *Cavognatha* is the mandibular cavities which have suggested the generic name. The mouth-parts of *C. pullivora* show similarities to those of various carrion-eating Coleoptera, for example, the maxillae are much like those of *Dermestes* spp. and, except for the cavities, the mandibles resemble those of such Nitidulidae as *Nitidula* and *Omosita*. Cavities opening on the dorsal (not the lateral) face of the mandibles are present in Sphindidae—in a specimen of *Sphindus grandis* these cavities contain evident spores, their function in Sphindids may well be the transport of spores of the Mycetozoa on which the insects feed. Possibly *Cavognatha* adults may transport bacterial spores or cultures in the cavities of their mandibles.

Reference.

Crowson, R. A., 1955.—"The Natural Classification of the Families of Coleoptera." Nathaniel Lloyd, London.

THREE NEW SPECIES OF SCOLYTIDAE FROM AUSTRALIA, AND SOME INTRODUCED COLEOPTERA.

224. CONTRIBUTION TO THE MORPHOLOGY AND TAXONOMY OF THE SCOLYTOIDEA.

By KARL E. SCHEDL, Lienz, Osttirol, Austria.

(Communicated by K. M. Moore.)

[Read 29th July, 1964.]

Synopsis.

The Forestry Commission of New South Wales submitted for identification a number of Coleoptera introduced from various countries, and two from New South Wales. There were about an equal number of specimens of the Scolytidae and Platypodidae and two specimens of the Bostrychidae.

Scolytid adults represented in the collection, like the platypodids, are ambrosia beetles which drill entrance holes into wood, make galleries of various designs, deposit eggs freely in the tunnels, and the larvae live on the ambrosia fungus cultivated within the galleries by the parent beetles.

While some of the species concerned were introduced from countries with quite different climatic conditions, other species like *Platypus hintzi* Schauf. may find the climate of New South Wales quite suitable for reproduction so that their possible establishment should be considered. Therefore it seems advisable to record the species introduced, noting at the same time the range of their natural distribution.

Descriptions of two new species of the Scolytidae originating from other sources, and one new species submitted by the Forestry Commission of New South Wales, are also given.

DESCRIPTIONS OF NEW SPECIES.

XYLEBORUS EXACTUS, n. sp.

Female. Ferruginous, 2.4 mm. long, 2.9 times as long as wide. Closely allied to *Xyleborus tereticollis* Schedl but somewhat larger, the striae on the truncate elytral declivity more strongly impressed, the striae punctures much coarser and the circular margin more elevated. *Front* subopaque, broadly convex, minutely punctulate, with a few scattered small punctures and with some longer hairs along the epistomal margin. *Pronotum* longer than wide (32 : 25), cylindrical, postero-lateral angles rounded, sides parallel on the basal three-fifths, apex broadly rounded, a subapical constriction difficult to recognize, apical margin with some very low asperities; summit well before the centre, feebly depressed behind, apical area densely and finely asperate, posterior area subshining, somewhat finely shagreened, with rather remotely placed fine punctures and the median line elevated, pubescence very short, inconspicuous. *Scutellum* of moderate size, shining. *Elytra* as wide as, and 1.25 times as long as the pronotum, of the same general shape as in *X. tereticollis*, cylindrical, steeply truncate, declivital face shining, striate-punctate, the striae impressed, the striae punctures large and densely placed, the interstices flat, each one with a median row of very small punctures bearing minute inclined hairs, suture elevated toward the apex, the punctures replaced by minute granules.

Holotype: In the collection of Schedl.

Locality: Cairns, Queensland.

CARCHESIOPYGUS DENTIPENNIS, n. sp.

Male. Fusco-rufous, 3.6 mm. long, four times as long as wide. A rather peculiar species of doubtful position provisionally placed in the genus *Carchesiopygus* Schedl. *Front* flat, subopaque, shallowly areolate-punctate, the punctures bearing fine erect

hairs, not separated from the vertex by an acute angle. *Pronotum* longer than wide (31 : 26), widest at the posterior angles of the rather shallow femoral emarginations, surface subshining, extremely densely covered with punctures of varying size, median sulcus long and fine, pubescence absent except for a few hairs along the anterior margin. *Elytra* feebly wider (27 : 26) and twice as long as the pronotum, widest shortly before the declivity, the sides nearly straight, surface opaque, the interstices indicated by raised lines being more distinct toward the declivity and on the alternate interstices, the sulci situated between these ridge-like structures shallow and minutely reticulate-punctulate, the elytra but feebly thickened behind so that the subperpendicular declivity is rather low; at the apex of the horizontal elytra the interstices 1, 3, 5, 7 and 9 dentate, interstices 2, 4 and 6 feebly elevated and ceasing before the apical margin, the short triangular teeth of interstices 1 and 6 of equal length, the teeth of interstices 3 and 5 much longer and of the same slender shape, beneath tooth of interstice 5 another still longer slender tooth originating on the apical margin of the elytra, the tooth on the extreme side in prolongation of the 9th interstices about as long as the lower tooth on continuation of interstice 5 bifid. Last abdominal sternite large and concave.

Holotype: In the collection of Schedl.

Locality: New South Wales, Australia.

HYPOCRYPHALUS MOOREI, n. sp.

Male. Pitchy black, 1.3 mm. long, 2.3 times as long as wide. A very distinct species of a general appearance similar to many species of the genus *Trypophloeus* Fairm.; moreover, with a rather rare sexual dimorphism. *Front* plano-convex on a wide area, limited above by a fine raised and curved carina, frontal face minutely punctulate, fine and densely punctured, sometimes with slight indications of a median longitudinal carina, pubescence dark and very short. *Pronotum* much wider than long (16.5 : 10.0), widest shortly before the base, postero-lateral angles of more than 90°, feebly rounded, sides distinctly divergent on the basal fifth, thence strongly and obliquely narrowed, a subapical constriction indicated, apical margin rather narrowly rounded, armed with four pointed asperities, the two median ones distinctly larger; summit very high, situated somewhat behind the middle, apical area steeply declivous, with medium-sized asperities on a rather narrow space, basal area short, shining, densely and finely punctured, a dark very short pubescence all over. *Scutellum* large, triangular, finely punctured. *Elytra* very feebly wider and more than twice as long as the pronotum, sides parallel on the basal half, gradually incurved behind, apical margin moderately broadly rounded, declivity commencing in the middle, gradually and obliquely convex; disc finely, densely punctured and more or less transversely wrinkled near the base and on the sides, the puncturation of the main rows difficult to separate from that of the interstices, the punctures on the suture replaced by a row of minute pointed granules toward the declivity, but nearly disappearing on the lower part of it, declivital face with the suture not the second interstice distinctly raised, the latter armed with larger and setose granules, the same type of granules on interstices 3 and 4; pubescence extremely short on the disc, distinctly larger on the declivity.

Female. Similar to the male but without granules on the declivity, finely and very densely punctured, the interstices indicated by rows of somewhat larger feebly spatulated hairs.

Types: Holotype and paratypes are in the collection of The Australian Museum, Sydney, New South Wales; paratypes also in the collection of Schedl and the Forestry Commission of New South Wales.

Locality: Somersby, N.S.W., 6 vi 1963, K. M. Moore.

Host-plant: *Hakea sericea* Schrad.

Notes: Larvae were collected in stems of the host-plant which had been fire-damaged several months previously. Adults emerged during October, 1963.

SPECIMENS FROM THE FORESTRY COMMISSION OF N.S.W.

Family Bostrychidae.

Dinoderus minutus Fab.

Widespread in all tropical regions. Sydney, 15 May 1962, from India.

Family Scolytidae.

Hypothenemus eruditus Westw.

Somersby, N.S.W., 6 vi 1963, K. M. Moore.

This species was reared from the same stems of *Hakea sericea* as was *Hypocryphalus moorei*.

Ozopemon fijianus Schedl.

Described from Fiji Islands. Sydney, 8 ii 1963, from Fiji; Sydney, 4 iii 1963, taken 26 iii 1963.

Xyleborus bidentatus Motsch.

Sydney, N.S.W., 9 i 1964, from New Guinea; live beetles cut from timber, H. Jaffe.

Xyleborus cognatus Blandf.

Distribution: Ceylon to the Philippines, east to New Guinea and Bougainville Is.; also reported from the Fiji Is.

Sydney, 4 ii 1963, from Malaya, ex *Shorea* sp., 19 ii 1963, R. Erskine; Sydney, 10 xi 1962, from North Borneo, live beetle from *Parashorea* sp., 4 ii 1963, H. Jaffe. (For earlier importations into Australia see Schedl, *Proc. Linn. Soc. N.S.W.*, 83: 215, 1958. The species also was found in Adelaide in 1957 (Schedl, *Ent. Arb. Mus. Frey.*, 13: 74, 1962.)

Xyleborus mascarensis Eichh.

Widely distributed over tropical countries, less common in the Indomalayan and Polynesian Regions.

Sydney, 15 xi 1962, from Africa, dead insect from *Bombax* sp. with < 40% moisture content, H. Jaffe.

This species has previously been reported from Australia (Schedl, *Rev. Ent. Moc.*, 5: 345, 1962), the localities being Queensland: Dalby, 1963, Emu Creek, 1941, and Yarraman, 1934, all specimens collected by A. R. Brimblecombe. The question whether *X. mascarensis* was endemic to Australia before white settlers arrived or if it has been introduced by human agencies, probably never will be solved with any degree of certainty.

Xyleborus perforans Woll.

Widely distributed over tropical countries, more common in the Indomalayan and Pacific Regions.

Sydney, 2 xi 1962, from North Borneo, taken from timber 30 i 1963, Mr. Penfold; Sydney, 21 i 1963, from N. Borneo, ex "meranti", 6 iii 1963, Mr. Penfold; Sydney, 12 iii 1963, from Borneo, ex *Shorea* sp., 3 iv 1963, Mr. Penfold.

Apparently an endemic and rather common species in Australia. A detailed account can be found by Schedl, *Rev. Ent. Moc.*, 5: 374-402, 1962.

Xyleborus sazeseni Ratz.

An endemic and widely distributed species in the holarctic region; also reported from northern India.

Yarras, N.S.W., 6 vii 1962, ex *Sloanea woollsii* at D.W.T., 10 viii 1962, M. Thompson.

X. sazeseni certainly was introduced into Australia a long time ago and has established itself in Queensland, New South Wales and Western Australia. For references, see Schedl, *Proc. Roy. Soc. Queensland*, 60: 28, 1949 (under the synonym *X. pseudoangustatus* Schedl); Brimblecombe, *Divn. Plant Ind. Bull.*, 71: 33-35, 1953 (*X. pseudoangustatus*); Schedl, *Ent. Arb. Mus. Frey.*, 13: 74, 1962, and Schedl, *Rev. Ent. Moc.*, 5: 498-508, 1962.

Xyleborus torquatus Eichh.

Distribution circumtropical, a very common species on a great many species of forest trees.

Sydney, 15 ii 1962, from Africa, ex timber with 34% M.C., H. Jaffe.

The first record of *X. torquatus* in Australia might be regarded as the specimens taken during 1963 at Yarraman, Queensland, by A. R. Brimblecombe. The species was also found by him in imported logs of Borneo cedar in Brisbane during 1948. It is still doubtful whether *X. torquatus* has become established in Australia.

Family Platypodidae.

Platypus curtus Chap.

Distribution: India, Malaya, Sumatra, Fukien, Philippine Is. and Sarawak.

Sydney, 6 xii 1962, from Borneo, ex "meranti" with M.C. > 40%, 16 i 1963, R. Erskine; Sydney, 4 iii 1963, from N. Borneo, live beetle taken 28 v 1963, dead beetle taken 11 vi 1963, H. Jaffe; Sydney, 12 iii 1963, from Philippine Is., live beetle taken 19 iii 1963, Mr. Penfold; also live beetle taken from timber 20 iii 1963, H. Jaffe; Sydney, 14 iii 1963, from N. Borneo, live beetle ex *Shorea* sp., 20 iii 1963, Mr. Penfold; Sydney, 27 iii 1963, from Borneo, live beetle ex *Shorea* sp., 1 iv 1963, H. Jaffe.

An earlier introduction into Australia: Brisbane, August 1947, in logs from Borneo, A. R. Brimblecombe (Schedl, *Mem. Queensland Mus.*, 13: 83, 1953).

Platypus hintzi Schauf.

Distribution: Africa, south of the Sahara; very common. Sydney, 15 xi 1962, from Africa, ex timber with > 40% M.C., H. Jaffe.

Platypus shoreanus subsp. *bifurcus* Schedl.

Described from the Philippines and also known from N. Borneo, Burma and Malaya.

Sydney, 12 iii 1963, from Philippines, live beetle ex *Pentacme* sp., 19 iii 1963, H. Jaffe.

Platypus shoreanus subsp. *mutilatus* Schedl.

Described from Malaya; also known from N. Borneo (Sandakan).

Sydney, 10 vi 1962, from Malaya, live beetle ex *Shorea* sp. (red meranti), 26 vii 1962, H. Jaffe; Sydney, 6 xii 1962, from Borneo, beetle emerged ex timber with > 40% M.C., 16 i 1963, R. Erskine; Sydney, 14 iii 1963, from N. Borneo, live beetle ex *Parashorea* sp., 27 iii 1963, R. Penfold; Sydney, 6 iii 1963, from N. Borneo, dead beetle ex timber, 18 iii 1963, H. Jaffe; adult ex *Shorea* sp., 15 v 1963, Mr. Penfold; Sydney, 6 iv 1963, from Borneo, live beetle ex *Parashorea* sp., 18 iv 1963, Mr. Penfold; Sydney, 22 iv 1963, from N. Borneo, live beetle ex *Parashorea* sp., 30 v 1963, Mr. Penfold; live beetle ex *Parashorea* sp., 31 v 1963, H. Jaffe.

A NOTE ON *CREIIS PERICULOSA* (OLLIFF) (HOMOPTERA: PSYLLIDAE).

By K. L. TAYLOR.

(Seven Text-figures.)

[Read 29th July, 1964.]

Synopsis.

The taxonomic status of *Psylla periculosa* Olliff (1894) has been examined. This species is now placed in the genus *Creiis* Scott, and a description based on specimens collected from *Eucalyptus rudis* at several localities in Western Australia is given.

In recent years a psyllid species in Western Australia has attracted increasing attention because of the damage it is causing to *Eucalyptus rudis* Endl., and an examination of the taxonomic status of this species has become necessary.

Mr. A. Sidney Olliff (1894) sent for exhibition at a meeting of the Linnean Society of New South Wales a number of specimens of a psyllid from Jarrahdale, W.A., which he proposed to call *Psylla periculosa*. The only description given was that it "makes elongate, semi-transparent, horny larval coverings, or tests, on the foliage of the Flooded Gum (*Eucalyptus rudis* Endl.)". However, this is sufficient to identify it as the same species (or as one of a complex) which is still "causing serious injury to its food-plant", and Olliff's name is valid on the basis of an "indication", according to the International Code of Zoological Nomenclature.

The species clearly belongs to the genus *Creiis* Scott, as defined by Tuthill and Taylor (1955).

The following description of the species is based on specimens collected from a number of localities in Western Australia, the host plant in each case being *Eucalyptus rudis*. Some variation in the characters is evident; thus specimens from some localities are larger than those from others. Series of specimens collected from *E. loxophleba* Benth. at Round Hill, W.A., and from *E. wandoo* Blakely at Wandering, W.A., appear to be conspecific. However, until studies can be made of the ecology and host relationships of this group of insects I prefer not to include the series from eucalypts other than *E. rudis* in *C. periculosa*. There is a possibility that more than one species is represented on *E. rudis*, but this also can best be resolved by ecological studies.

There is a complex of species closely related to *Creiis corniculata* (Froggatt) on *Eucalyptus* spp. in Eastern and Western Australia. Most of them are still undescribed, but my present knowledge of them leaves no doubt that their classification must be closely linked to their host relationships, as in the genera *Cardiaspina* Crawford (Taylor, 1962) and *Glycaspis* Taylor (Moore, 1961).

Genus *CREIIS* Scott.

Creiis Scott, 1882, *Trans. Ent. Soc. Lond.*, 1882: 462; Tuthill and Taylor, 1955, p. 233.

CREIIS PERICULOSA (Olliff). (Figs 1-7.)

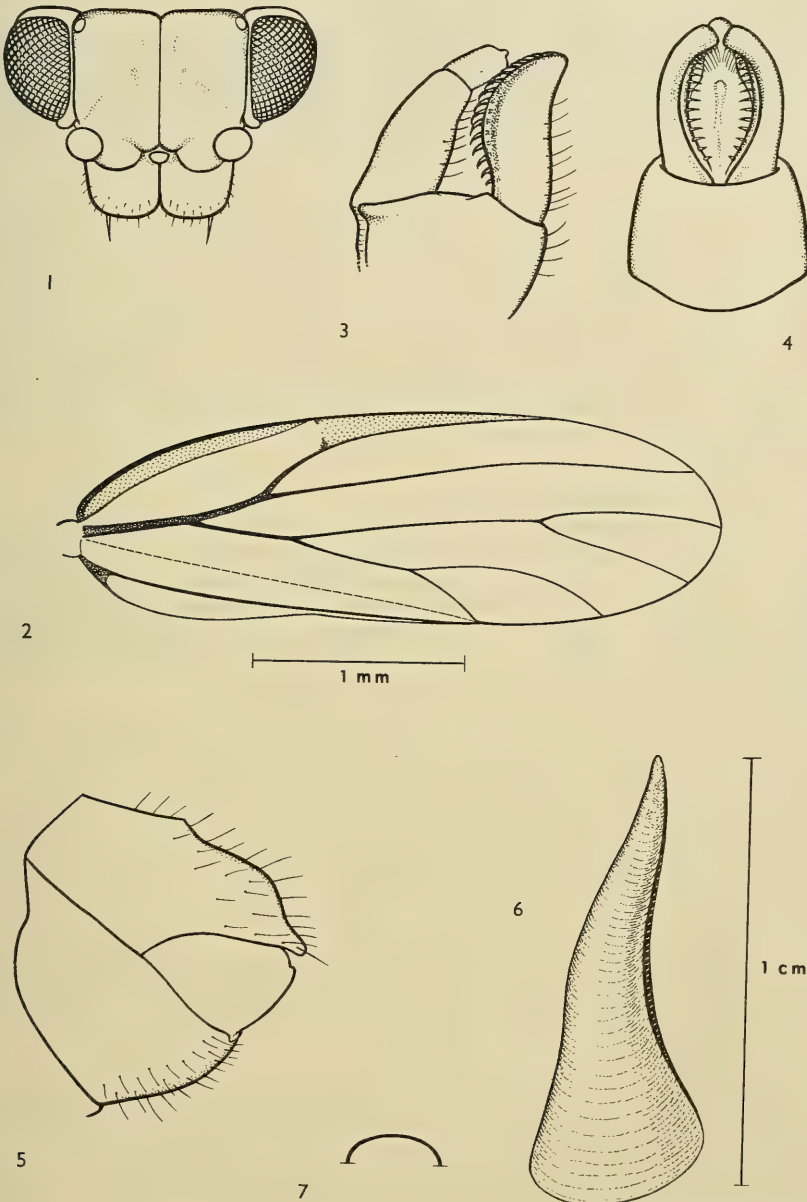
Psylla periculosa Olliff, 1894, p. 740.

Length (to tip of folded wings): ♀ c. 4.0 mm; ♂ c. 3.7 mm.

Colour: General colour light brown; patches of green in some specimens; forewings transparent with reddish brown veins; hindwings transparent.

Structure: Body surface finely punctate, shining; head (Fig. 1): width about equal to or slightly narrower than mesoscutum, at 90° to plane of body; vertex length about

$\frac{3}{4}$ width, ocular sclerite with prominent lobe anteriorly between eye and antenna, narrow posteriorly but completely separating eye from vertex; genal processes about $\frac{1}{8}$ length of vertex, broad and almost square apically, slightly separated at bases, one



Figs 1-7. *Cretils periculosa* (Olliff). 1, head; 2, forewing; 3, male genitalia, lateral aspect; 4, male genitalia, posterior aspect; 5, female genitalia, lateral aspect; 6, lerp, from above; 7, section of lerp (diagrammatic).

stout falcate seta towards outer side on each, and numerous small setae; antennal length about $2\frac{1}{4}$ times width of head; pronotum flat, length about $\frac{1}{3}$ vertex, wider than vertex; forewings (Fig. 2): ratio of length to width about 3 : 1, transparent with numerous small points, veins prominent, raised, pterostigma large, weak, open; medial

and cubital cells about equal in area, medial elongate (less so in ♂), cubital triangular; hindwings large, length about $\frac{3}{4}$ that of forewings, with numerous small points, more so than forewings; metatibiae flaring apically with 1-3 stout blunt spurs on outer margin, 3-4 on inner margin; claws on proximal segment of metatarsus lacking or very small.

Male genitalia (Figs 3, 4): Proctiger long, pyriform in lateral aspect, slender in posterior aspect, bipartite, apical segment cylindrical, length about $1\frac{1}{2}$ times thickness; forceps falcate in lateral aspect, long and broad, curving strongly inwards to meet at apex, inner margin with a row of strong black setae, inwardly and downwardly directed, spaced more closely towards apex, posterior margin with a row of short pale setae.

Female genitalia (Fig. 5): Short, stout; dorsal plate pyriform in dorsal aspect, broad at base, with large orifice dorsally, tapering sharply to blunt, rounded apex, apical half with numerous long fine setae; ventral plate short, broad, deep, apical margin with a V-shaped depression, apical half with numerous long fine setae.

Lerp (Figs 6, 7): Corniculate, length approximately 1 cm., width from about 0.5 mm. at base to about 4 mm. at open end when adult emerges; narrow basal portion almost white, remainder pale yellow to pale brown, constructed by immature stages, width and height about leaf surface being increased as size of insect increases, hence a series of fine curved striations visible across the lerp; sides close to leaf surface for full length, not curved under.

Host plant: Eucalyptus rudis Endl.

Neotype ♂ (here designated): (Waterloo, W.A. 24.xi.1960, M. M. H. Wallace) in Australian National Insect Collection, C.S.I.R.O., Canberra, and labelled "*Creiis periculosa* (Olliff), K. L. Taylor 21.v.1964, NEOTYPE". Enquiries have been made at the Western Australian Museum, Perth; the Australian Museum, Sydney; the Macleay Museum, University of Sydney; and the New South Wales Department of Agriculture, Sydney. Olliff's specimens are not in any of these institutions, and no information can be obtained as to whether they have been deposited elsewhere.

The above description is consistent with Olliff's brief description, the host tree is the same, and the locality, though not identical, is reasonably close and very similar.

Specimens examined: Waterloo, W.A., 24.xi.1960, M.M.H.W. (10 ♀♀, 9 ♂♂); Noble Falls, W.A., 8.xi.1960, M.M.H.W. (10 ♀♀, 10 ♂♂); Wannamal, nr. Gin Gin, W.A., 26.x.1960, M.M.H.W. (8 ♂♂, 4 lerps); Mt. Barker, W.A., 20.x.1960, C. F. H. Jenkins (numerous nymphs and lerps); nr. Toodyay, W.A., 9.ix.1960, M.M.H.W. (2 ♀♀, 2 ♂♂, 1 lerp); Wongamine, W.A., 9.ix.1960, M.M.H.W. (1 ♀, 1 ♂).

Specimens from the series collected at Waterloo, W.A., will be deposited in the Western Australian Museum, Perth; South Australian Museum, Adelaide; Australian Museum, Sydney; National Museum of Victoria, Melbourne; British Museum (Natural History), London; United States National Museum, Washington. All other specimens in the Australian National Insect Collection.

The specimens from nr. Toodyay, Wongamine, and Wandering are larger than those from the other localities, and the relative proportions of different parts of the body are not quite the same in the limited number of specimens available. These differences may be due to variations in the host tree, and it would be unwise to describe them as a distinct species without further material and more detailed knowledge of their ecology. It is possibly significant that their date of emergence is much earlier in spring than that of the others listed. Specimens examined from other host trees in Western Australia (Round Hill, W.A., 15.ix.1960, M.M.H.W.—*E. loxophleba* (2 ♀♀, 1 ♂), and Wandering, W.A., 27.ix.1951, I. F. B. Common—*E. wandoo* (9 ♀♀, 1 ♂, 6 lerps), appear to be identical with this larger form.

This species is distinguished from *Creiis corniculata* (Frogg.) (the only species of this complex so far described) by the paler colour and smaller size of the lerp, the weaker pterostigma, and the host relationships.

Acknowledgements: I am grateful to Mr. M. M. H. Wallace and Mr. C. F. H. Jenkins for collecting material for study, and to Mrs. E. M. Quick for assistance in preparing the figures.

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ON THE ADULT AND JUVENILE STAGES OF *VANBENEDENIA CHIMAERAE*
(HEEGAARD, 1962) (COPEPODA: LERNAEPODIDAE) FROM
AUSTRALIAN WATERS.

By Z. KABATA, Marine Laboratory, Aberdeen.

(Communicated by Dr. J. C. Yaldwyn.)

(Forty Text-figures.)

[Read 29th July, 1964.]

INTRODUCTION.

In his interesting paper on the parasitic Copepoda from Australian waters, Heegaard (1962) described a lernaepodid species, which he assigned to the genus *Tracheliastes* Nordmann, 1832, and to which he gave the name *T. chimaerae*. Heegaard's generic diagnosis was influenced by Wilson's (1915) description of *T. grandis*. It had been suspected, however (Monod and Vladykov, 1931), and eventually proved (Kabata and Bowman, 1961) that Wilson was at fault in this instance and that this species should have been placed in the genus *Vanbenedenia* Malmgren, 1860. The same is true of Heegaard's Australian species. The present author, with the knowledge and consent of the discoverer, proposes, therefore, to re-name it *Vanbenedenia chimaerae* (Heegaard, 1962).

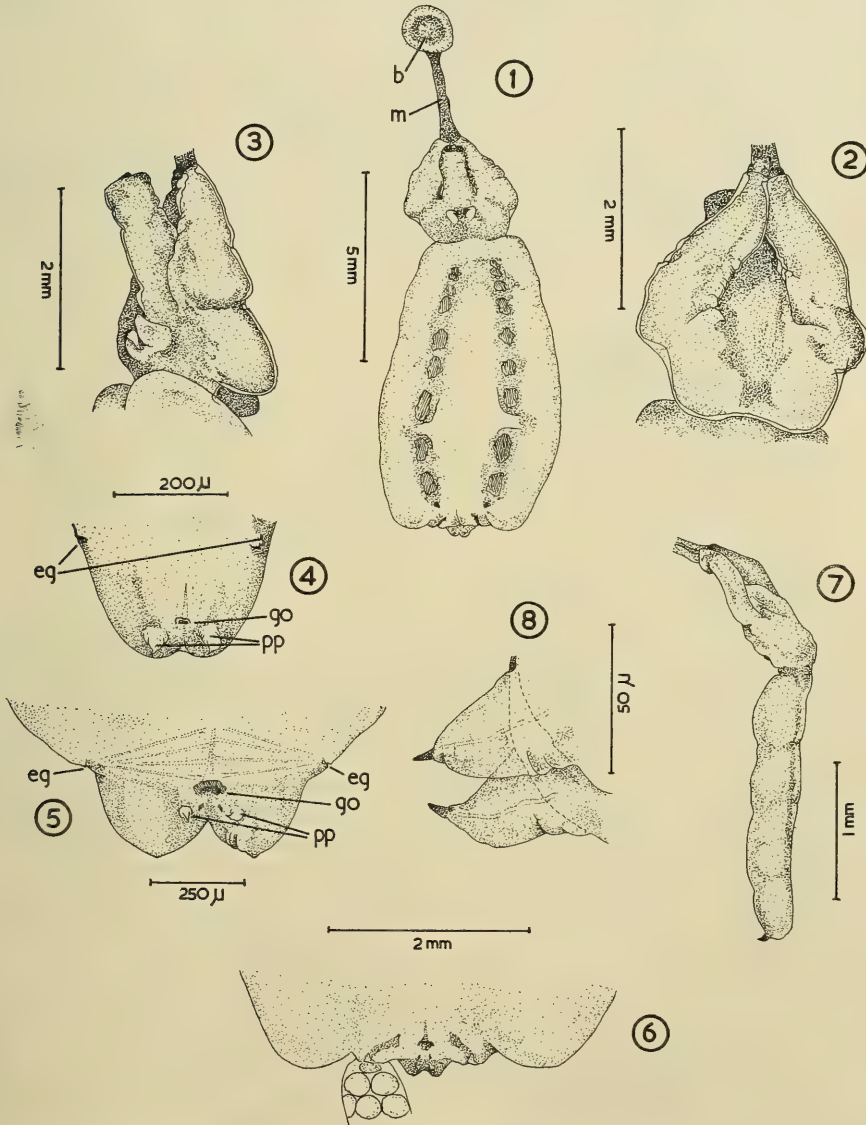
Tracheliastes and *Vanbenedenia* differ from each other in several important respects. Thus, to mention only two, the position of the cephalothorax in *Tracheliastes* (as suggested by the name) is dorsal to the main axis of the trunk, while the opposite obtains in *Vanbenedenia*; *Tracheliastes* parasitizes freshwater fishes of the Palaearctic Region, while the only known host of the genus *Vanbenedenia* is *Chimaera*, a deep-sea holocephalan genus with world-wide distribution.

The author's earlier work on the genus *Vanbenedenia* (cf. Kabata, 1958, 1959) suggested that the biology of this genus, as well as some of its morphological features, are of considerable interest to the student of Lernaepodidae. To explore these features further, the author studied, as a loan from the Australian Museum, the specimens of *V. chimaerae* which constituted a part of Heegaard's original material. The specimens included adult females, juvenile females and larval individuals at the stage of development which is variously referred to as "pupa" or "chalimus". They were examined, both entire and dissected for the better study of the appendages, under magnifications up to $\times 900$, with the aid of the phase-contrast illumination. The dissections were carried out in Berlese's fluid, which was also used as the mounting medium. No stains were employed. Each appendage was observed from as many aspects as possible, before final drawings were made. The illustrations shown below are all free-hand drawings, made with the aid of an eyepiece graticule.

DESCRIPTION OF THE ADULT FEMALE.

General appearance (Figs 1-3, 6). The body of the adult female is easily divided into the cephalothorax and the trunk. The cephalothorax is cylindrical and fairly short, forming with the "arms" (the first maxillipeds) a broad shoulder region, separated from the trunk by a distinct waist-like groove (Fig. 1). It is ventrally inclined to the main axis of the trunk, the arms fusing above it and preventing its dorsal movements (Figs 2-3). The trunk is longer than broad (length : width ratio about 1.5 : 1) in the adult ovigerous females. The greatest width of the trunk is usually about $\frac{2}{3}$ from the anterior end of the trunk. The trunk is flattened dorso-ventrally, the outer margins in the preserved specimens being more swollen than the area

immediately adjacent to them. At some distance from the lateral margins of the trunk a row of depressions extends almost along the entire length. These depressions (Fig. 1), which are about 10 in each row, are made by heavily sclerotized plaques and serve as the points of insertion for the dorso-ventral musculature of the trunk. The posterior end of the trunk is truncated, its exact shape and structure depending on the age of the female. In the youngest adult specimen available for examination (Fig. 7) and already attached to the host by means of the bulla, the end of the trunk appeared as



Figs 1-8.—1. Adult female, ventral. 2. Adult female, cephalothorax, dorsal. 3. Adult female, cephalothorax, lateral. 4. Young female, posterior end of the trunk, ventral. 5. Young female, older than in Fig. 4; posterior end of the trunk, ventral. 6. Adult female, posterior end of the trunk, ventral. 7. Young female, entire, lateral. 8. Posterior processes of specimen shown in Fig. 7, lateral.

Lettering on figures.

b, bulla; *ch*, central canal of manubrium; *eg*, point of attachment of egg-strings (oviduct opening); *en*, endopod; *ex*, exopod; *go*, genital orifice; *m*, manubrium; *pp*, posterior processes (caudal furca); *t*, ventral tubercle of 2nd mxp; *x*, *y*, *z*, elements of cephalic armature.

shown in Figure 4. The trunk of this specimen was 2.17 mm. long. The posterior processes (derived from the caudal furca of the juvenile stages), the genital orifice and the future points of attachment for the egg-strings can be seen in this specimen. Posterior processes are shown enlarged in Figure 8. With increasing age, the latero-posterior margins begin to swell out laterally and in a specimen with the trunk 3.13 mm. long the end of the trunk appears as shown in Figure 5. The swelling begins at the level of the oviduct openings (points of attachment of the egg-strings). The definitive shape of the extremity of the trunk, as seen in an ovigerous female with the trunk 6.44 mm. long, is shown in Figure 6. The lateral swelling has now progressed to the point at which the appearance of the end of the trunk becomes greatly modified. The relative sizes of the posterior processes in Figures 4, 5 and 6 give a good illustration to the changes, with age, of this part of the trunk.

Some idea of the dimensions of the adult females is given by the figures below. It must be remembered that the measurements (in mm.) were taken from specimens preserved for many years in alcohol and with cephalothoraces at different degrees of contraction. The data concerning this part of the body must, therefore, be taken as very general in character. The measurements are based on 12 female specimens.

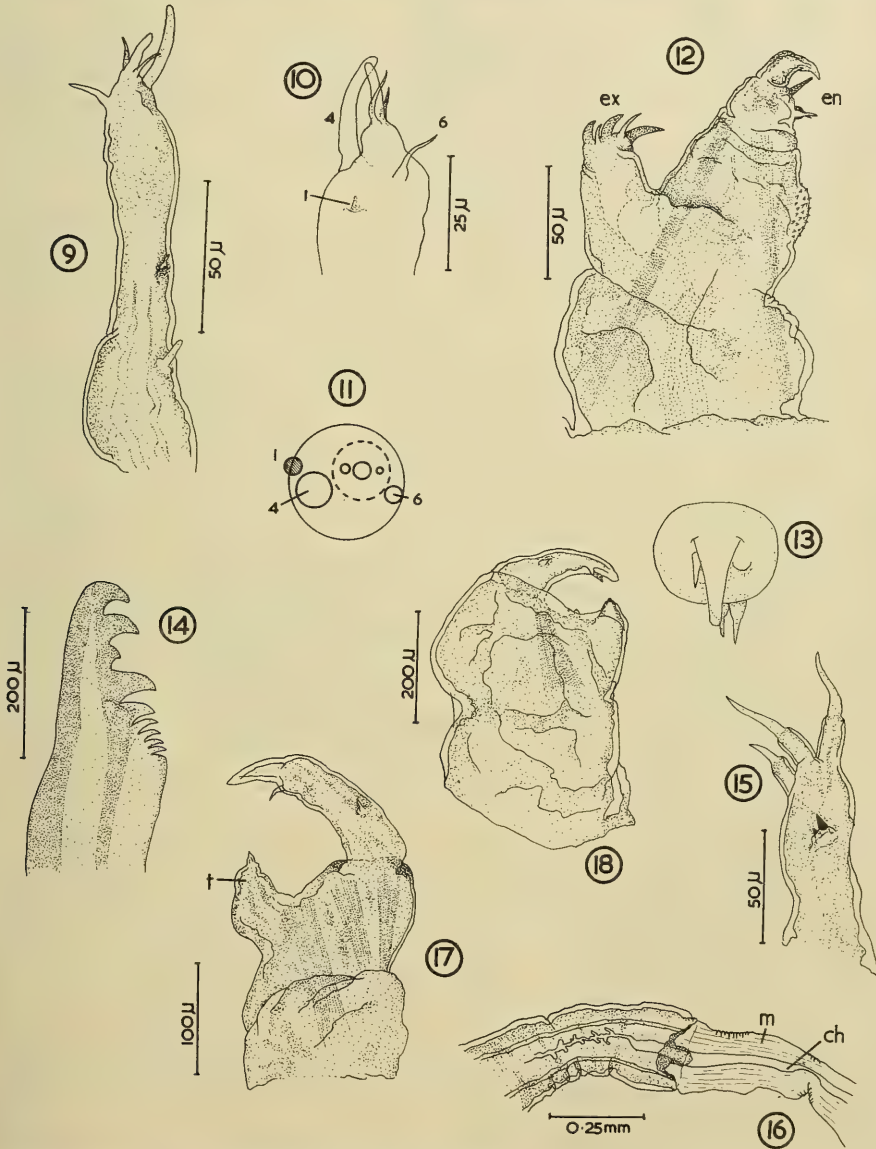
	Range	Mean
Cephalothorax length	2.2-2.8	2.4
„ „ width	0.6-0.7	0.7
Shoulder region, width	2.2-2.6	2.4
Trunk length	5.4-7.2	6.4
„ width	2.7-4.8	4.0
Arms, length	1.3-2.2	1.8
„ „ diameter at the base	0.6-0.9	0.8
Egg-strings length	6.2-9.4	7.8
„ diameter	0.7-0.8	0.8
Eggs, diameter (approximate)	0.2-0.3	0.3

Appendages.

The first antenna (Figs 9-11). Even in the smallest specimens, already attached by the bulla and, therefore, considered as adult, no true segmentation of the first antenna has been observed by the author. In some specimens, however, transverse wrinkles in the cuticle resemble segmental divisions. The base of the appendage (Fig. 9) is somewhat inflated and bears on its dorso-median aspect the usual lernaeopodid spine. It is possible that the spine shown in Figure 9 has been broken and is shorter than it should be. The central part of the antenna is more slender. It also carries on its dorso-median aspect a short spine, found in this position in some other genera of Lernaeopodidae. Towards its apex, the antenna dilates again in the manner typical for the genus *Vanbenedenia*. The apical armament of the first antenna is shown in detail in Figures 10 and 11. Near to the centre of the apex is a prominent swelling, shown in Figure 11 as a dotted circle. It is tipped by three spines, one central, strong and with a blunt, finger-like end, and two others on its both sides. The inner aspect of the tip is occupied by a strong and also blunt-ending spine, which can be seen as the homologue of the similar spines in all the other lernaeopodid genera studied by the author (Kabata, 1963, 1964, 1964a, 1964b) and labelled (4). The dorso-lateral aspect carries a slender, whip-like spine labelled (6) and also homologous with similar spines in other Lernaeopodidae. A small spine (marked 1 in Figs 10 and 11) is present near the base of spine (4).

The second antenna (Figs 12 and 13) resembles the corresponding appendages of most of the lower Lernaeopodidae. An indistinctly segmented sympod (consisting of either one or two segments) carries distally a two-segmented endopod and a one-segmented exopod. The proximal segment of the endopod (Fig. 12, *en*) has a spinulated pad on its ventral margin. Its distal segment is armed with a hook and several accessory spines, shown diagrammatically in Figure 13. One slender spine is located on

the ventro-median aspect of the base of the central hook and points obliquely upwards. Ventral to the base of the hook and at some distance from it are two structures, situated side by side. The lateral one is a sharp-pointed spine with slightly inflated base, while the medial one is relatively broader at the base and shorter, also ending in a sharp point. An indistinct swelling is present on the ventro-lateral aspect of the base of the central hook. In all its essential aspects, this armature resembles that of the second antenna of *V. kroyeri* (cf. Kabata and Bowman, 1961). The exopod (Fig. 12, *ex*) is not dorsal to the endopod, as in most lernaepodid genera, but rather dorso-



Figs 9-18.—9. Adult female, 1st antenna, dorsal. 10. Adult female, tip of 1st antenna, lateral. 11. Diagram of the apical armature of 1st antenna. 12. Adult female, 2nd antenna, lateral. 13. Diagram of the armature of endopod, 2nd antenna. 14. Adult female, distal part of mandible, lateral. 15. Adult female, maxilla, lateral. 16. Young female, distal part of 1st maxilliped and base of manubrium. 17. Young female, 2nd maxilliped, lateral. 18. Adult female, 2nd maxilliped, lateral.

lateral. The study of the position of this segment is made difficult by the great mobility of the tip of the endopod. The dorso-ventral axis of the second antenna is usually considered as being parallel with the long axis of the endopod's central hook. Since the twisting of the endopod changes the position of the hook, the relative positions of the two rami are also apparently altered. It can be accepted, however, that the exopod is not directly dorsal to the endopod. Since this position is one of the diagnostic features of the genus *Vanbenedenia*, it is rather important to know it. The tip of the exopod is armed with three powerful claws, pointing outwards. Between the bases of these claws are two spines, much more slender than the claws themselves and rather shorter.

The mandible (Fig. 14) is a long, blade-like structure, its dentiferous margin armed with a series of nine teeth. The teeth are not uniform in size (mandibular formula H2, Z1, H1, N5). The first two teeth are primary and are followed by a small secondary tooth. This, in turn, is followed by another primary tooth and a series of "Nebenzähne" consisting of five teeth, progressively smaller. The usual cutting blade follows the last tooth of the proximal series.

The maxilla (Fig. 15) is also a typical lernaepodid limb, with stout sympod and the endopod ending in three papillae, arranged dorso-ventrally and ending in stout setae. The ventral of these is the shortest. The exopod is lateral in position and vestigial, consisting of two short, subequal spines, the smaller one being difficult to observe.

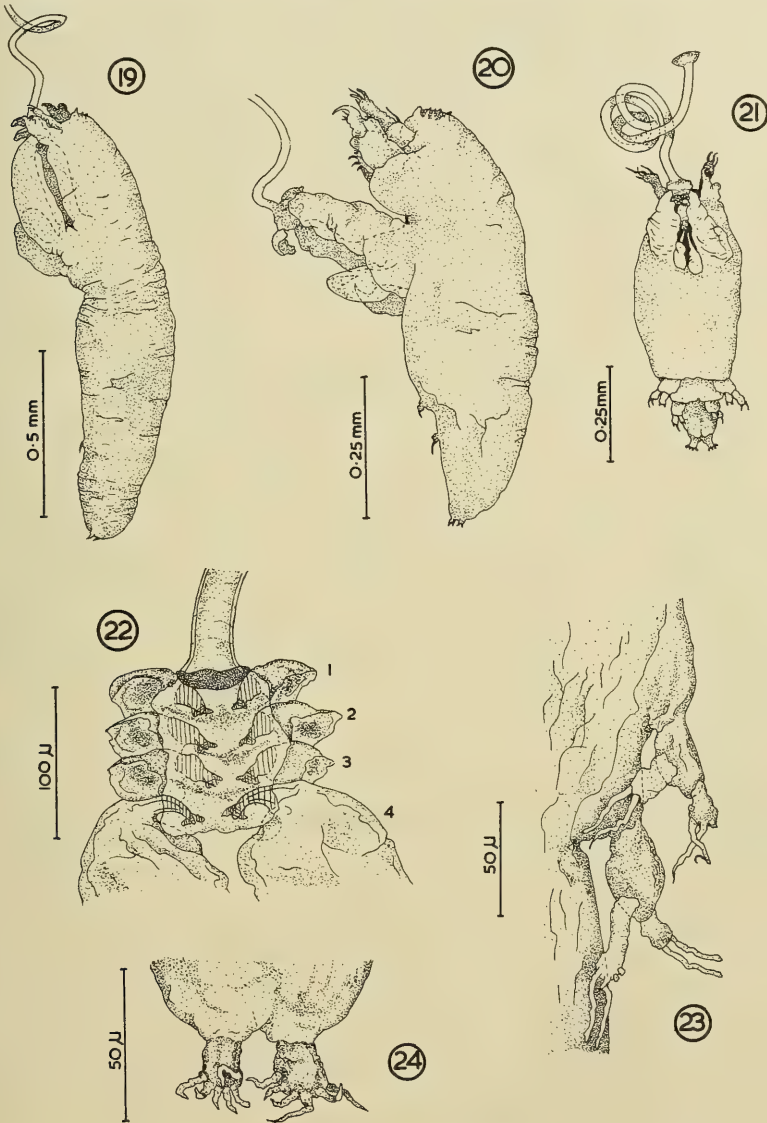
The first maxillipeds (Figs 1-3, 16) are the appendages which form the characteristic "arms". They arise from the cephalothorax near the point where it expands into the shoulder region. In the young adult females, with bulla recently formed, the tips of the arms are close together and fused by means of the manubrium (Figs 1 and 16, *m*), to the formation of which both arms have contributed. The bulla at this stage is still colourless and soft and the anchoring apical swelling (Fig. 1, *b*) is still missing. The manubrium appears like an empty sheath (Fig. 16, *m*) or rather two sheaths fused together, but readily pulled apart. Each half of the double central channel (Fig. 16, *ch*) can be clearly observed. In older specimens (Fig. 1) the bulla becomes sclerotized; it is hard and dark-brown. The two halves can no longer be separated. The manubrium now ends in a roughly lenticular or spherical swelling, formed by the secretion drained through the central channel. The length of the manubrium in the young females is about 1.75 mm., reaching up to 2.5 mm. in the fully mature specimens. The long diameter of the apical swelling of the bulla varies from 1.7 to 1.8 mm. The host which carried the specimens examined was infested by some 50 parasites and, since all of them were found on the claspers, the animals were crowded together. Their bullae were often fused in groups of three, or four, with some degree of distortion.

The second maxilliped (Figs 17 and 18) differs with the age of the female. In the young, recently attached females which carried no egg-strings, the shape of the second maxilliped was as shown in Figure 17. The main body of the limb appears to consist of two segments, though the subdivision is not clear. The apical segment forms a subchela which closes against a prominent tubercle on the ventral margin of the penultimate segment. The tubercle is tipped with a short but fairly strong spine. The tip of the subchela carries a slightly curving claw, with a short auxiliary spine near its base. There is also another short spine on the outer aspect of the subchela, near $\frac{1}{3}$ of its length from the base. All these features are also recognizable in the mature female (Fig. 18), though their relative sizes are much different. The subchela is much smaller, with claw and the other two spines much weaker. The ventral tubercle of the penultimate segment is also relatively smaller, its spine observable only with difficulty.

DESCRIPTION OF THE JUVENILE STAGES.

Of the 14 adult specimens examined by the author, nine had frontal filaments, or parts of filaments, of the juvenile stages attached to their cephalothoraces, mainly arms or second maxillipeds. Six of these specimens had the juveniles still suspended from

the proximal ends of the filaments. Among these developmental forms four stages could be distinguished. The developing parasites were attached to their frontal filaments by means of their first maxillipeds. The terminal claws of these limbs were firmly embedded in the enlarged bases of the filaments. With each succeeding moult another flow of secretion followed, gluing the next stage of the parasite to the end of



Figs 19-24.—19. *Chalimus* III, lateral. 20. *Chalimus* II, lateral. 21. *Chalimus* I, lateral. 22. *Chalimus* IV, tips of first maxillipeds and base of frontal filaments, showing claws of the preceding moults (numbered). 23. *Chalimus* I, thoracic legs. 24. *Chalimus* I, caudal furca, dorsal.

the filament. The cuticle of the preceding stage disintegrated, leaving the tips of the first maxillipeds hanging like empty gloves from the base of the filament (Fig. 22). The largest number of the discarded pairs of cuticular claws was three. The presence of these remains allows one to determine in each case the exact developmental stage of the specimen. Those which have no such empty claw belong obviously to the first

chalmus stage, those with one pair to the second chalmus stage, etc. The oldest specimen examined by the author belonged, therefore, to the chalmus stage IV.

The external examination of these stages of development showed no differences between the future male and female individuals until chalmus stage III, when the female specimens could be distinguished by more elongate "arms".

General appearance (Figs 19-21). The youngest stage examined (i.e., chalmus I) is shown in Figure 21. At this stage of development, the body of the parasite consists of the cephalothorax, free thorax and abdomen, with caudal furca. With the exception of the thoracopods, the appendages already present at this stage persist in the mature parasite. The number of the free thoracic segments is not easy to distinguish. The anterior two can be recognized by the presence of thoracopods, with which they are associated. Only one specimen at this stage was examined by the author. Its total length was 0.68 mm., the cephalothorax length being 0.51 mm. (from the anterior margin of the head to the level of the first pair of thoracopods). The cephalothorax is roughly oval and devoid of dorsal carapace.

No great change takes place in the appearance of the parasite between the chalmus I and chalmus II stages (Fig. 20). Two specimens at the latter stage measured 0.69 and 0.73 mm. respectively, the increase in size being due to the growth of the posterior part of the body (cephalothoraces of both specimens were 0.50 mm. long). There is some elongation of the "arms" and the thoracopods begin to atrophy. This trend in development continues on change to the chalmus III stage (Fig. 19), although the change is accompanied by a more pronounced increase in size. The only specimen of this stage was 1.37 mm. long. The relative increase in the sizes of the cephalothorax and the posterior (trunk) part of the body cannot be determined easily, since only one pair of thoracopods was found by the author in this specimen and the exact limits of the two parts could not be determined. There is little change between the general shape of chalmus III and chalmus IV stages. Two specimens of chalmus IV examined by the author were damaged and could not be measured, but the overall appearance of these specimens differed only little from chalmus III. The only possible difference was the now definitely pronounced elongation of the "arms", already noticeable in chalmus III.

The first antenna (Fig. 25) of the chalmus I shows all the features described for the adult appendage. The state of the specimens made the examination difficult, but it was possible to see that both the general shape of the limb and all the apical armament spines are quite like those of the adult. The main difference between the first antenna of chalmus I and that of the adult is the length of the apical armament spines, which can be seen by referring to Figures 9 and 25. Two unusual features are noticeable in the first antenna of chalmus I. The long spine present on the dorso-median aspect of the basal part of the limb appears to have another small spinule at its base. The two small spines present at the central prominence of the apex (marked ? in Fig. 25) appear to be fused at the bases. These two features, however, were observed in only one antenna, its companion from the opposite side having neither of them. It is, therefore, difficult to say whether the fusion of the two spines was an aberration of structure, or whether the additional spine on the dorso-median aspect of the base is a regular feature. Neither of these features was found in the following stages of development. Beginning with chalmus II, the first antenna differed from that of the adult in size only.

The second antenna (Figs 26-28). At the chalmus stage I, this appendage is already fully formed, showing most of the features present in the adult. Its sympod appears to consist of two segments, the distal one of which bears the endopod and the exopod (Fig. 26, *en*, *ex*). The endopod is two-segmented. The proximal segment is unarmed, the distal segment carries apical armament described for the adult and figured in Figures 12, 13, 26 and 27. Figure 26 shows the hook of the distal segment turning away from the observer, but its true shape can be seen in Figure 27, which shows the distal segment of the endopod of chalmus II in lateral view. The only

difference between the endopod of chalimus I and the succeeding stages is the appearance of the spinulated pad on the proximal segment, beginning with chalimus II. The central hook, which is long and slender in the early stages, becomes progressively shorter and more robust, to assume the adult shape shown in Figure 12. The exopod of the second antenna undergoes more extensive changes with age. In chalimus I, as shown in Figure 26, it is one-segmented and armed with two long setae. In chalimus II three small tubercles appear on the tip of the exopod, one between the bases of the setae and two on both sides of these structures. In chalimus III the tubercles increase in size and acquire sharp points (Fig. 28), while the setae between them become relatively shorter. This trend is further accentuated in chalimus IV. By the time the parasite becomes adult, the three tubercles will have developed into three powerful claws (Fig. 12), completely dwarfing the setae between them.

The mandible (Fig. 29) also undergoes only small changes from chalimus I to the adult parasite. At the earliest stage examined, it already has its definitive shape, differing from the adult only in size and in the absence of the third tooth, the only secondary tooth of the mandible. That tooth first appears at the chalimus III stage. The distal tooth of the mandible is somewhat smaller in chalimus I than in the succeeding developmental stages.

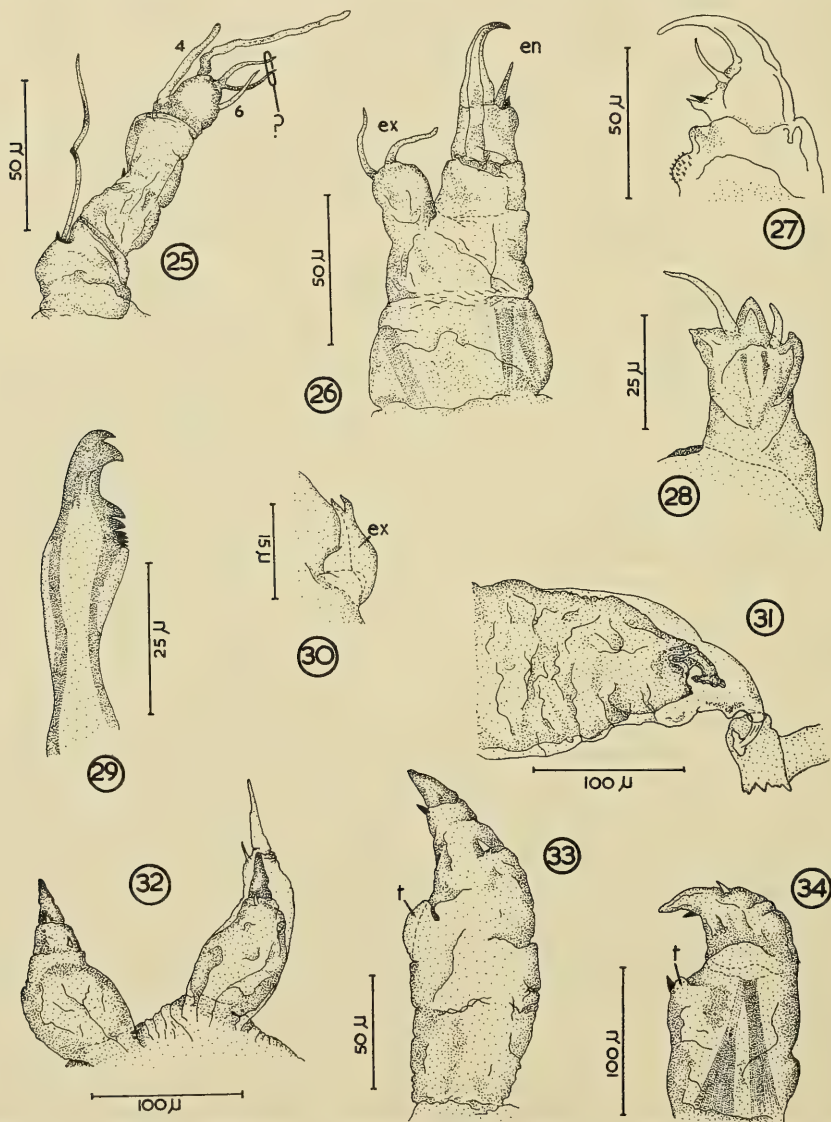
The maxilla (Fig. 30) also shows few changes in the course of its development. The difference between chalimus I and the adult (Fig. 15) is in the larger size of the exopod, which in chalimus I is a definite segment with a bifid tip. It appears to be gradually reduced and survives in the adult only as the two spines, vestiges of the tip.

The first maxilliped (Fig. 31) changes little in the four chalimus stages examined. Figure 31 shows the formation of the appendage of chalimus II within the cuticle of chalimus I. It can be seen that these appendages are quite similar. In both stages they end in curving claws, whose tips are provided with anchor-like extensions used to secure the limb in the base of the frontal filament. Under the cuticle of the preceding stage, the appendage of the next is usually profusely wrinkled, foreshadowing the expansion which is to occur at the moult. This expansion and elongation is the most marked feature of the development of the first maxilliped. By the time the animal reaches the adult stage, the limb is quite long and fused to its neighbour by the manubrium of the bulla. By then the terminal claw disappears, but it is still present in chalimus IV, the oldest pre-adult stage examined by the author (Fig. 22).

The second maxilliped (Figs 32-34, 40) is the appendage which shows most extensive changes in the course of its development, observed in chalimus specimens. The earliest stage is shown in Figure 32, illustrating both second maxillipeds of a chalimus I which is ready to moult. The right member of the pair shows the limb of the next stage, formed within the cuticle of chalimus I. In the course of dissection, this cuticle was pulled off the left member of the pair, showing the limb of the next stage. In chalimus I, then, the second maxilliped is apparently one-segmented, almost cylindrical and ending in an anteriorly-pointing, straight claw, with an auxiliary spine at its base. In chalimus II, the subchela, the second segment of the appendage begins to form and its lateral spine makes its appearance. Figure 33 shows the maxilliped of chalimus III, recently removed from the cuticle of the preceding stage. The subchela is now more distinguishable and the ventral tubercle of the penultimate segment begins to form (Fig. 33, *t*). A fully developed limb of chalimus III is shown in Figure 34. The subchela is now at an angle with the rest of the limb. Both its auxiliary spines and its terminal claw are easily observable. An apical spine has also appeared on the tip of the ventral tubercle. A great change appears to take place between chalimus III and IV, although the author could not determine with absolute certainty the course of development at this point of the parasite's life history. In one of the chalimus IV specimens examined, the second maxilliped did not greatly differ from the corresponding limb in chalimus III, while in the other specimen it seemed to have gone through extensive changes. The latter specimen, however, was badly preserved and it is possible that parts of its cuticle had been sloughed off, exposing structures properly belonging

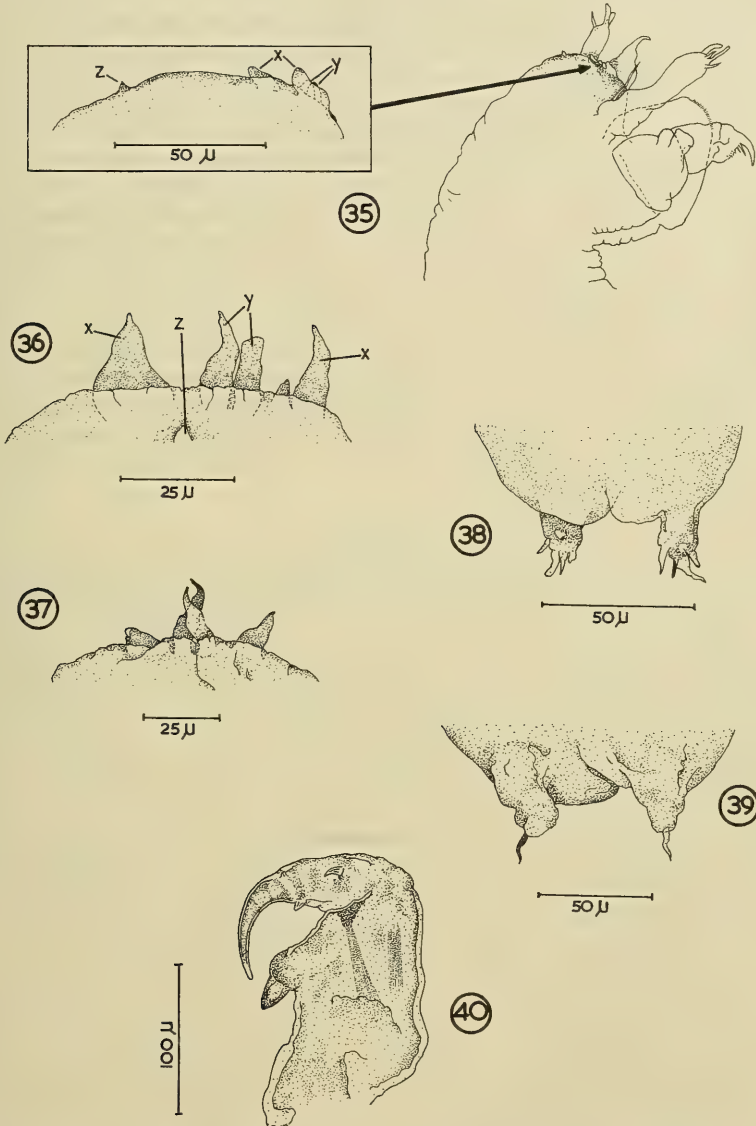
to the next developmental stage. This more advanced stage is shown in Figure 40. It has all the features of the adult appendage, but differs from it by the enormous elongation of the terminal claw of the subchela and the large size of the spine tipping the ventral tubercle.

The thoracopods (Figs 19–21, 23) could not be studied in detail, because of the shortage of material and poor stage of preservation. The only chalimus I available was, as mentioned above, ready to moults and the thoracopods of this specimen were no more than limp and empty cuticle with partly damaged setae hanging from the



Figs 25–34.—25. Chalimus I, 1st antenna, dorsal. 26. Chalimus I, 2nd antenna, medial. 27. Chalimus II, 2nd antenna, tip of endopod, medial. 28. Chalimus III, 2nd antenna, exopod, lateral. 29. Chalimus I, mandible, lateral. 30. Chalimus I, maxilla, exopod, ventro-lateral. 31. Chalimus I, 1st maxilliped and base of frontal filament. 32. Chalimus I, 2nd maxillipeds. (The cuticle of chalimus I pulled off the left appendage, showing that of next stage.) 33. Chalimus II, 2nd maxilliped liberated from the cuticle, to show the next stage. 34. Chalimus III, 2nd maxilliped, fully developed, lateral.

body of the animal. It could be seen (Fig. 23), however, that both pairs consisted of one-segmented sympods, each carrying also one-segmented endopods and exopods, provided with at least four setae. In chalimus II (Fig. 20), the legs become simple, one-segmented structures provided with a single seta each. In chalimus III the author



Figs 35-40.—35. Chalimus II, lateral view of anterior part (semi-diagrammatic). Arrow points to cephalic armature, enlarged in rectangular frame. 36. Chalimus III, cephalic armature, dorsal. 37. Chalimus IV, cephalic armature, dorsal. 38. Chalimus II, caudal furca, ventro-lateral. 39. Chalimus III, caudal furca, ventral. 40. Chalimus IV (or a later stage), 2nd maxilliped, lateral.

could find only one pair of thoracopods, which were no more than single setae with slightly inflated bases. No trace of the legs was found in the two specimens of chalimus IV examined.

The changes undergone by the caudal furca (Figs 24, 7, 4, 5, 6, 38, 39) are of considerable interest. Although the difficulties of study were here as great as with

the thoracopods, it could be seen that in chalimus I (Fig. 24) the anal furca consist of two blade-like segments, each equipped with six short though fairly robust setae. In chalimus II the blades are rather smaller and the number of setae decreases to four (Fig. 38), perhaps five. In chalimus III they become mere wart-like protuberances, tipped with a single seta each (Fig. 39). By the time the development has reached chalimus IV stage, the caudal furca have the appearance which persists until the adult stage. The changes, which occur then, are mentioned above.

Several noteworthy features were observed at the anterior end of the cephalothorax (Figs 35-37). As can be seen from Figure 35, the front end of the cephalothorax forms a bulbous "forehead", anterior to the mouth-cone. The apex of this forehead (with an arrow pointing to it in Fig. 35) is enlarged in the rectangular frame to show that it is equipped with five peculiar structures. Four of them are arranged in a transverse line (Fig. 35, *x*, *y*) and the fifth (*z*), a small denticle, is dorsal to them in the centre of the head. The line consists of two smaller, peg-like structures in the centre (*y*) and two larger, broad-based ones on the ends of the line and at some distance from the central pair. Figure 35 shows them in chalimus II. The author was unable to see similar structures in chalimus I. Figure 36 shows the same structures in chalimus III. At this stage the spines are larger and have sharper points than in the preceding stage. The central members (one of which has a broken tip in Fig. 36) are still slender, while the lateral members are broad-based and end in sharp points. In the examined specimen one of the lateral spines appears to have been broken, a part of it appearing as a small independent spine. In chalimus IV (Fig. 37) the cephalic armament persists without any changes.

DISCUSSION.

The first point made clear by the study of *Vanbenedenia chimaerae* is the similarity between its finer structural details and those of *V. kroyeri* (cf. Kabata and Bowman, 1961). These details are particularly evident in the structure of the antennae. As mentioned above, *V. chimaerae* has an inflated tip in its first antenna, which is unique to the genus. In discussing the first antenna of *V. kroyeri*, Kabata and Bowman stated that its apical armament included a powerful spine, which divided into two some way from its base. In the light of the present study, it seems certain that the structure should have been interpreted as the "central swelling", with two spines arising from its tip. Spines (4) and (6) were also present in *V. kroyeri*, though they were labelled (*b*) and (*d*) respectively. The second antennae of *V. chimaerae* also bear great resemblance to those of the other known species of the genus, particularly in the position of the rami and the armament of the endopod. Yet another similarity is provided by the mandible, which has characteristically small third tooth. In view of the diagnostic importance of the mandible (Kabata, 1963a), this point should not be overlooked when placing the present species in the genus *Vanbenedenia*.

The biological details, which can be inferred from the study of the specimens, also resemble those described for *V. kroyeri* (cf. Kabata, 1958, 1959) and are, apparently, unique among Lernaeopodidae. The author refers here to the fact that the young individuals of *Vanbenedenia* settle on the parent individuals and become attached to them by means of their frontal filaments, which in all other known genera are used for the attachment to the host directly. Of the 14 females examined, nine had either filaments or juvenile individuals attached to their cephalothoraces. The filaments ranged from 1 to 6 on one female, which suggests that this method of attachment is not an exception, but a normal occurrence in the genus. Three facts can account for this unusual method of settling of the free-swimming larvae; the host fish is not very common and normally does not occur in large schools; sometimes, therefore, it might be imperative for the newly-hatched parasite to gain hold of the host individual infested by the parasite's parent. Secondly, the area of the suitable attachment site appears to be limited. *V. kroyeri* has never been found attached to any other part of its host, except the dorsal fin or dorsal spine. The author (Kabata, 1959) recorded as many as seven parasites on one single spine. *V. chimaerae* appears to be limited to

the claspers of its host, the only known record showing as many as 50 parasites on one host fish. The parasites are rather large, which again means that they must be crowded and that the only way in which they can remain in contact with the host is by getting hold of the individuals of the parent generation, densely covering the available site.

The specimens, which the author examined in the course of this work, disclose the presence of at least four chalimus stages, with intervening moults, in the life history of *Vanbenedenia*. This fact provides a valuable addition to our imperfect knowledge of the life histories of Lernaeopodidae. Those members of the family whose life cycles have been studied so far show a tendency to the suppression of the chalimus stages, only the more primitive of them still retaining more than one chalimus stage in their development cycle. The tendency appears early in the family's history, with the primitive genera *Achtheres* and *Salmincola*. Wilson (1911) described the development of *Achtheres ambloplitis* Kellicott, 1880, which had a single chalimus stage. On the other hand, Zandt (1935) found as many as five chalimus stages in the development of *A. coregonorum* (Kessler, 1868). He presented evidence of the primitive character of this species. (It is of interest in this context that *A. ambloplitis* is among those more specialized species of its genus, which abandoned their original salmonid hosts to parasitize the more advanced percomorph fishes.) In the genus *Salmincola*, Friend (1941) described the one-chalimus cycle of *Salmincola salmonea* (Gissler, 1751). In contrast, *S. mattheyi* Dedie, 1940, has as many as five chalimus stages.

The caligid copepods, which are presumed to be close to the ancestral line of Lernaeopodidae, include sometimes even six chalimus stages (Lewis, 1963). Lernaeoceridae also have more than one (usually four) chalimus stages (Sproston, 1941; Kabata, 1958a). It appears, therefore, that Zandt's opinion on the primitive character of the multi-stage chalimus development in Lernaeopodidae was correct. *Vanbenedenia*, therefore, must be consigned among the more primitive members of the family.

In describing the male of *V. chimaerae*, Heegaard (1961) makes no mention of its mode of attachment. Apart from the definitely segmented trunk, his male shows no differences from the chalimus specimens examined by the author. The early investigators (Olsson, 1869) depicted the male of *Vanbenedenia kroyeri* as being attached by its frontal filament. Wilson (1915) did not question those descriptions; neither did the author himself in his earlier work (Kabata, 1958). In view of the present work, however, this opinion must be revised. As stated above, up to chalimus II no external differences between the sexes are observable. In chalimus III female the only distinguishing feature is the elongation of the first maxillipeds, which becomes very distinct in chalimus IV. Heegaard's description shows no such elongation. It is, therefore, possible that his description is the first record of the male of *Vanbenedenia*. It is certain that neither Olsson nor the author himself described an undoubtedly male specimen in their work.

The description of the development of the second maxilliped, shown in this paper, provides an excellent illustration of adaptive changes in the ontogeny of *Vanbenedenia*. This prehensile appendage develops progressively through the attached chalimus stages (Figs 32-34) to reach the peak at the time when the parasite is ready to relinquish the frontal filament and seek its permanent attachment to the host. At this stage, shown in Figure 40, the subchela of the second maxilliped is at its strongest, with the powerful claw, and the ventral tubercle is also strongly armed. It is obvious that the period transitional between the attachment by the frontal filament and that by the bulla requires this organ of prehension. Once the parasite becomes attached again, however, the need for prehension disappears and the second maxilliped undergoes regression, evident from Figures 17 and 18, illustrating this appendage in a young and a mature adult respectively.

The changes undergone by the caudal furca in the course of development of *V. chimaerae* throw some light on the fate of similar structures in other genera of

Lernaeopodidae. Kurz (1877) and Kabata (1964c) recorded the presence of small vestigial appendages near the centre of the posterior margin of the trunk in *Clavellisa emarginata* (Krøyer, 1837), while Gnanamuthu (1948) found them in his *C. dussumieriae*. Kurz suggested that these appendages represent the vestiges of thoracopods, a view opposed by Wilson (1915). It now seems probable that these structures, so similar in shape and position to the dwarfed caudal furca of the female *V. chimaerae*, are also homologous with them.

Describing the alleged male of *V. kroyeri*, the author (Kabata, 1958) noted the peculiar cephalic armament, never previously commented on, and suggested that this must be a juvenile feature. It is now clear that these structures are, indeed, juvenile, and that the sharp, spine-lamellae must be used in preparing the host tissues for the penetration of the parasite's bulla.

SUMMARY.

This paper gives a detailed description of the shape and appendages of *Vanbenedenia chimaerae* (Heegaard, 1962), originally described as a member of the genus *Tracheliastes*. The description includes the adult female and four developmental stages, referred to as chalimus I-IV. The concluding discussion asserts that morphological evidence places this parasite in the genus *Vanbenedenia* and that the genus should be considered as a primitive member of Lernaeopodidae. On the same basis inferences are made concerning the changing role of the maxillipeds and the fate of the caudal furca in the course of development of *Vanbenedenia*.

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CLASSIFICATION OF THE LORANTHACEAE AND VISCACEAE.

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[Read 29th July, 1964.]

Synopsis.

The commonly recognized subfamilies Lorantheae and Viscaceae of the Loranthaceae *sens. lat.* are accepted as distinct families Loranthaceae and Viscaceae respectively. The two families differ in many features of floral morphology, floral anatomy and embryology. The features which the two families have in common are features occurring elsewhere in the order Santalales and especially in the family Santalaceae, and the Loranthaceae and Viscaceae are the result of independent, convergent evolution towards aerial parasitism.

INTRODUCTION.

The Loranthaceae (*sens. lat.*) are a group with several very distinctive features, including considerable reduction and modification in ovary structure and a specialized hemiparasitic habit. The group consequently has been the subject of several monographic treatments, and most authors have regarded the common features of floral structure and life form as evidence that it constitutes a single family. Several authors have suggested, however, that the two widely accepted subfamilies Lorantheae and Viscaceae are independent groups and recent studies, particularly in ovary development and embryology, support this view. Two families, Loranthaceae and Viscaceae, have thus been recognized.

The recent authors who have accepted this treatment have not been concerned with taxonomic revision and have not provided formal diagnoses of the two families. The present author recognizes the independence of the two groups and considers it desirable to redescribe the families so as to incorporate the additional information which has become available since the first description of the Viscaceae more than a century ago. The following classification of the Loranthaceae and Viscaceae is proposed and has been adopted in taxonomic revisions which are in preparation. Further discussion of the proposed system is presented below.

Classification of the Loranthaceae and Viscaceae.

- A. Viscous layer of the fruit within the vascular bundles. Embryo sac single, of the allium type. Suspensor of the embryo absent or very short Family VISCACEAE.
- I. Anthers 4-celled. Placenta basal. Inflorescence a simple raceme or spike
 - Tribe EREMOLIPIDAE Tiegh.
 - a. Leaves alternate. Seeds with endosperm Subtribe EREMOLIPIDINAE Engl.
 - b. Leaves opposite. Seeds without endosperm Subtribe LEPIDOCERATINAE Engl.
- II. Anthers 2-celled. Placenta central. Embryo sac U-shaped, growing into the ovary tissue Tribe PHORADENDREAE Tiegh.
 - a. Inflorescence a spike of triads. Anthers not cohering Subtribe GINALLOINAE Engl.
 - b. Flowers in groups at the nodes. Anthers cohering Subtribe KORTHALSELLINAE Engl.
 - c. Flowers in groups on the internodes. Anthers not cohering
 - Subtribe PHORADENDRINAE Engl.
- III. Anthers 1-celled. Placenta central. Embryo sac straight, ascending within the placental column Tribe ARCEUTHOBIEAE Tiegh.
- IV. Anthers many-celled. Placenta basal. Inflorescence an axillary cyme or raceme of cymes Tribe VISCACEAE Tiegh.
- B. Viscous layer of the fruit outside the vascular bundles. Embryo sacs several, of the polygonum type. Suspensor of the embryo very long, multiseriolate Family LORANTHACEAE.

- I. Placental column (mamelon) with 3-6 basal lobes and the sporogenous cells in the lobes. Ovary often 3-6-celled in the lower part. Embryo sacs confined to the mamelon. Fruit drupaceous or baccate Tribe ELYTRANTHEAE Dans.
 - a. Fruit drupaceous. Pollen spherical. Terrestrial root-parasitic trees or shrubs Subtribe GAIADENDRINAE Engl.
 - b. Fruit baccate. Pollen trilobate. Aerial stem-parasitic shrubs Subtribe ELYTRANTHINAE Engl.
- II. Placental column (mamelon) with 4 basal lobes containing the sporogenous cells. Ovary 4-celled in the lower part. Embryo sacs ascending more than half-way up the style. Fruit dry, tripterous. Pollen trilobate. Terrestrial root parasitic trees Tribe NUYSISAE Tiegh.
- III. Placental column (mamelon) simple or absent, with the sporogenous cells in a single central mass. Ovary always 1-celled. Embryo sacs ascending in the style. Fruit baccate Tribe LORANTHEAE Engl.
 - a. Seeds with endosperm Subtribe LORANTHINAE Engl.
 - b. Seeds without endosperm Subtribe PSITTACANTHINAE Eng.

VISCACEAE Miq.

Fl. Ind. Bat., 1, 1 (1856) 803; Miers, *Contrib. Bot.*, (1851) 39 (*nom. provisorium*); *Ann. Mag. Nat. Hist.*, 8 (1851) 179 (*nom. provisorium*); Agardh, *Theoria Syst. Plant.*, (1858) 114; (-acées) Tiegh., *Bull. Soc. bot. Fr.*, 43 (1896) 247, 544; Maheshwari, Johri & Dixit, *J. Madras Univ.*, B, 27 (1957) 134; Johri & Bhatnagar, *Proc. Nat. Inst. Sci. India*, 26, B (1961) 215; Johri, *Recent Adv. Emb. Angio.* (1963) 410; Lorantheaceae subfam. Viscoideae Engl., *Pflanzenfam.*, 3, 1 (1889) 177; (-oidées) Tiegh., *Bull. Soc. bot. Fr.*, 41 (1894) 138; Dans., *Bull. Jard. bot. Buitenz.*, 11 (1931) 236; Viscales Tiegh., *Bull. Soc. bot. Fr.*, 43 (1896) 247; Arceuthobiacées, Ginalloacées Tiegh., *Bull. Soc. bot. Fr.*, 43 (1896) 543, 544; *Compt. Rend. Acad. Sci. Paris*, 124 (1897) 656; Lepidariacées, Razoumovskiacées, Eremolepidacées Tiegh., *Compt. Rend. Acad. Sci. Paris*, 150 (1910) 1717, 1718.

Flowers minute (usually less than 2 mm. long), monochlamydeous, unisexual. Perianth segments 2 to 4, valvate. Stamens opposite the perianth segments, adnate to them or free; anthers 1- to many-celled, opening by pores; pollen spherical. Ovary inferior, 1-celled, with a short placental column containing the sporogenous cells; ovules absent; embryo sac single, developing from one cell of a dyad (allium type), confined to the placental column or extending into the adjacent ovary tissue. Fruit baccate, the viscous layer within the vascular bundles; cleavage of the zygote usually transverse; suspensor absent or very short. Hemiparasitic shrubs on the branches of trees; haustorial attachment single, without runners. Leaves mostly opposite and curvinervous, occasionally alternate or absent.

The Viscaceae include 11 genera and about 450 species, of which the largest genera are *Phoradendron* (about 250 spp. in America), *Viscum* (about 65 spp. in the Old World) and *Dendrophthora* (about 60 spp. in Central and South America). The family is widespread in all continents but has its richest development in tropical and subtropical areas. It is poorly represented in Australia, where *Viscum* (5 spp.), *Notothixos* (4 spp.) and *Korthalsella* (2 spp.) are largely confined to the northern and eastern coastal and subcoastal districts.

Infrafamilial categories. The Viscaceae (as Lorantheaceae Viscoideae) have had a relatively stable taxonomic history and there has been general agreement among authors on classification within the group. The treatment adopted here is that of Engler and Krause (1935), without any change in rank in the infrafamilial categories. In view of the incomplete knowledge of floral structures and reproductive processes, modification of the system would be premature at this stage. In any case the present data conform fairly closely with the current system and show reasonable uniformity within the family, and the recognition of subfamilies may not be justified.

LORANTHACEAE D. Don.

Prodr. fl. nepal., (1825) 142; Miq., *Fl. Ind. Bat.*, 1, 1 (1856) 807; Agardh, *Theoria Syst. Plant.*, (1858) 117; (-acées) Tiegh., *Bull. Soc. bot. Fr.*, 43 (1896) 247; Lorantheaceae subfam. Lorantheoideae Engl., *Pflanzenfam.*, 3, 1 (1889) 177; (-oidées) Tiegh., *Bull. Soc. bot. Fr.*, 41 (1894) 138; Dans., *Bull. Jard. bot. Buitenz.*, 11 (1931) 235; Loranthes

Tiegh., *Bull. Soc. bot. Fr.*, 43 (1896) 247; Elytranthacées, Nuytsiacées Tiegh., *Bull. Soc. bot. Fr.*, 43 (1896) 247; Dendrophthoacées, Treubellacées Tiegh., *Bull. Soc. bot. Fr.*, 43 (1896) 543; *Compt. Rend. Acad. Sci. Paris*, 124 (1897) 656; Nuytsiales, Elytranthales Tiegh., *Compt. Rend. Acad. Sci. Paris*, 150 (1910) 1716; Lepidariacées, Gaiadendracées, Treubaniacées Tiegh., *Compt. Rend. Acad. Sci. Paris*, 150 (1910) 1717, 1718.

Flowers mostly more than 5 mm. long, dichlamydeous, hermaphrodite or, when unisexual, mostly dioecious. Calyx reduced to a lobed or truncate limb at the apex of the ovary, without vascular bundles. Corolla polypetalous or gamopetalous, usually actinomorphic, consisting of 4–12 segments, valvate. Stamens as many as the petals, opposite them and epipetalous; anthers primarily 2- or 4-celled (sometimes with transverse partitions), mostly basifixed and immobile but sometimes dorsifixed and then usually versatile, opening longitudinally; pollen mostly trilobate, rarely triangular or spherical. Ovary inferior, 1- to several-celled, with or without a central placental column (mamelon); ovules absent; sporogenous tissue massive, located in the mamelon or at the base of the ovarian cavity; embryo sacs several, developing from one cell of a tetrad (polygonum type), considerably elongated, confined to the mamelon or ascending in the style, and developing basal caeca which reach a collenchymatous pad at the base of the ovary. Fruit mostly baccate (rarely dry or drupaceous), the viscous layer, when present, outside the vascular bundles; cleavage of the zygote vertical; suspensor long, biseriate; endosperm compound. Hemiparasitic terrestrial root-parasitic shrubs or trees, or aerial stem-parasitic shrubs. Leaves mostly opposite.

The Loranthaceae *sens. str.* include about 65 genera and 850 species, and are well represented in the tropics of both hemispheres, with a lesser number of species in temperate habitats. The Loranthaceous floras of Africa, Asia-Australasia and America are all rather different in character and the three areas represent major secondary centres of development. The family is represented in Australia by 12 genera (seven of them endemic) and about 65 species, and is distributed throughout the mainland.

Infrafamilial categories. The taxonomic proposals of Danser (1933) for the family have been widely accepted. Further anatomical and embryological investigations may necessitate modification of the scheme, but it is proposed for convenience to follow Danser's system, without change in rank, at this stage. On the basis of ovary structure (Narayana, 1958) tribe Nuytsieae probably should be reduced to a subtribe of Elytranthaeae. The distinction of subtribe Psittacanthinae on the absence of endosperm is probably not justified (MacBride, 1937), and the group is probably unnatural.

DISCUSSION.

Miers (1851*a*) drew attention to the differences distinguishing *Viscum*, which was then taken in a broad sense, including the present genus *Phoradendron*, from the remainder of the Loranthaceae. The differences included the minute flower size, the unisexual, monochlamydeous flowers, the almost sessile anthers opening by pores and the sessile, clustered flowers. Miers also noted that *Viscum* had spherical pollen whereas that of the Loranthaceae available to him was trilobate. He considered *Viscum* to have a close affinity with the Santalaceae but regarded the remaining Loranthaceae as being more closely related to the Proteaceae. Miers proposed the raising of *Viscum*, together with *Lepidoceras* and *Myzodendron*, to family rank as the Viscaceae, but as an alternative suggested that they may be treated as a subfamily of the Santalaceae, thereby invalidating his description of the family Viscaceae. Miers' views were repeated soon afterwards in a second article on the same topic (Miers, 1851*b*). Miquel (1856) accepted Miers' first proposal and gave detailed descriptions of the Loranthaceae (*sens. str.*) and Viscaceae, attributing the latter name to Miers. A family Viscaceae was also recognized and described by Agardh (1858), who based his conclusions on floral characters but made no reference to the works of the earlier authors. The recognition of a family Viscaceae by Van Tieghem (1896*a, b*, 1897, 1910) was due to his use of new criteria for classification of the angiosperms and has little bearing on the present treatment.

Even though Miers', Miquel's and Agardh's conclusions were based on a limited range of material, there are few exceptions known to the criteria on which they distinguished the families, and each appears to be a relatively uniform group within itself. In the Loranthaceae the few occurrences of unisexual flowers are in distantly related groups and are presumably of independent origins. Small flowers (less than 10 mm. long) are rare and in one American genus only are they of the minute size of the Viscaceae. Spherical pollen in the Loranthaceae is known only in *Atkinsonia* and *Tupeia* and in each case the grains have distinctive features and show little evidence of a closer affinity with the Viscaceae than with other groups in the Santalales. Only in the male flowers of *Tupeia* is a truly monochlamydeous condition known in the Loranthaceae.

These differences between the two groups could thus be considered to justify their treatment as distinct families although the work of the earlier authors was largely overlooked. Most recent support for this approach, however, has arisen from embryological studies (Maheshwari, 1954, 1958; Maheshwari, Johri and Dixit, 1957; Johri and Bhatnagar, 1961), which have demonstrated several other differences in flower development and fruit structure, and Johri and his co-workers have adopted this treatment in several embryological reports (cf. Johri, Agrawal and Garg, 1957). In the Viscaceae the embryo sac is single, of the allium type (cf. Maheshwari, 1950), and is confined to the placental column or adjacent ovary tissue. The embryo sacs in the Loranthaceae are several, of the polygonum type; they elongate into the style and they develop caeca from the lower ends which reach a collenchymatous pad or tube at the base of the ovary. The first cleavage of the zygote in the Loranthaceae is vertical, and the embryo is pushed downwards by a long biseriate suspensor into a compound endosperm formed from several embryo sacs. In the Viscaceae the zygote commonly cleaves transversely, the suspensor is small or absent, and the endosperm is not composite. The two families are also distinguished constantly by the positions of the viscous layer in the fruit, being outside the vascular bundles in the Loranthaceae and within them in the Viscaceae, so that the mechanism for bird dispersal may have arisen independently in each group.

Most of the characters which the two families have in common are also features of the Santalaceae, where hemiparasitism is common (mostly root parasitism) and there are various degrees of reduction and suppression of ovules and elongation of embryo sacs (Johri and Bhatnagar, 1961). It is most likely that the two groups have had independent origins from ancestral stocks in the Santalaceae, so that by placing them in a single family they constitute a diphyletic and therefore unnatural group. The "new" characters which the groups share are the aerial habit, which in fact has been discovered in other families of Santalales and which therefore has probably originated several times, and the baccate fruits, which are a consequence of the aerial habit and of independent development.

The basic chromosome number of the Loranthaceae (*sens. str.*) is $n = 12$ (Barlow, 1963). Polyploidy appears to be entirely absent and chromosome evolution has involved progressive aneuploid reduction to $n = 8$, the various basic numbers conforming with taxonomic grouping and degree of advancement. In the Viscaceae fewer numbers are known, but the basic number is apparently higher and chromosome evolution independent. A low frequency of polyploidy is known in the Viscaceae (Barlow, 1963, 1964). The few known numbers of the Santalaceae (Darlington and Wylie, 1955; Love and Love, 1961) indicate a greater range of basic numbers and a higher incidence of polyploidy and secondary diploidy, which conforms with the suggestion that the Loranthaceae and Viscaceae have arisen from cytologically different stocks.

The Loranthaceae and Viscaceae are thus relatively uniform groups characterized by a high degree of reduction in the ovary and by a hemiparasitic habit, these being features also of the Santalaceae, from which they have independently arisen. While it is possible that further investigations may demonstrate independent groups within these taxa, the present treatment is considered the most satisfactory reflection of their phyletic position.

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NITROGEN ECONOMY IN ARID AND SEMI-ARID PLANT COMMUNITIES.

PART III. THE SYMBIOTIC NITROGEN-FIXING ORGANISMS.

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[Read 29th July, 1964.]

Synopsis.

Of the 80 legumes investigated from the arid and semi-arid areas of eastern Australia, at least 68 produce effective rhizobial nodules (Mimosaceae and Papilionaceae); Caesalpiniaceae do not nodulate. Herbaceous species usually nodulate freely and many of them fix highly significant amounts of nitrogen. Some species of *Acacia* nodulate sporadically and tardily in the seedling condition and this is probably of significance with regard to regeneration, especially on eroded soils. Five species of *Rhizobium* occur and these are distributed discontinuously. Most soils contain at least one species of *Rhizobium*. Rhizobial populations are likely to be reduced or removed by soil movement under the action of wind.

INTRODUCTION.

In a previous publication (Beadle and Tchan, 1955) the widespread death of *Acacia aneura* (mulga), particularly in western New South Wales, and the consequent depletion of the sandy soils of their organic matter by the winnowing action of the wind were discussed as an introduction to the nitrogen economy of arid and semi-arid soils. Tchan and Beadle (1955) assessed quantitatively the possible accessions of soil nitrogen by non-symbiotic organisms.

The present paper deals qualitatively with the native legume-rhizobia systems, the data including nodulation records chiefly from field observations, the approximate distribution of the rhizobia of certain of the common native legumes, and an assessment of the significance of the various species as nitrogen-fixers in the plant communities in which they occur. Data on the introduced legumes (chiefly Trifolieae) will be presented in another paper.

The area covered in the field survey lies west of the 15-inch isohyet in western New South Wales and Queensland, between the Murray River and the highway linking Charleville and Windorah; isolated records come also from the Lake Eyre and Lake Amadeus Basins, and the Alice Springs and Oodnadatta districts. The plant communities in the main area of study are mentioned in Table 1; they have been described by Beadle (1948).

Relatively little work has been done on the inland legumes; some data on a few of the species, or on other species of common inland genera found in more humid regions, have been investigated with regard to nodulation (listed by Bowen, 1956, and unpublished data of Allen and Allen in personal communications).

NODULATION.

The roots of about 80 legume species have been examined in the field for the occurrence of nodules and 68 of these are reported on (Table 1). The remaining twelve, on which a definite statement cannot yet be made, may nodulate. Included in these twelve and of particular significance with regard to nitrogen economy (because they are community-dominants or abundant species) are *Acacia pendula* A. Cunn. (Myall), *A. harpophylla* F. Muell. (Brigalow), *A. cambagei* R. T. Baker (Gidgee), *A. loderi* Maiden, and *A. excelsa* Benth. (Ironwood); on all of these five species what appear to be nodule-scars have been recorded. The remaining inland species, including those which have been examined and those not, are rare in the field so that, even if

they nodulate abundantly, their contribution to the fixed nitrogen in their respective communities must be small.

The data in Table 1 lead to the two generalizations: Firstly, with the exception of *Trigonella*, no genus is confined by a limited set of habitat conditions; this has some bearing on the distribution of specific rhizobia, which is discussed below. Secondly, members of the Papilionaceae and Mimosaceae nodulate in the field (with a very few exceptions), whereas Caesalpiniaceae do not.

Additional information from field observations, supplemented by pot tests made in the glasshouse, lead to the following comments and conclusions:

1. *Failure to record nodules.* This may be due to one or more of the following: (a) inability of the plant to nodulate; (b) absence of suitable rhizobia; (c) dry conditions at the time of digging when the nodules become desiccated and fragment, or the breaking off of nodules during sampling, especially in soils which form hard clods. By growing plants from seed in soil collected from around the roots of the same species (referred to as "own soil"), additional information was collected which provided the explanation for the absence of nodules from certain species. For example, *Cassia artemisioides* plants failed to produce nodules when supplied with cultured *Cassia* rhizobia, which suggests inability to nodulate; *Acacia oswaldii* and *A. colletioides* failed to produce nodules when grown in their own soil (from the mallee) but nodulated when supplied with *Acacia* rhizobia from crushed nodules from *A. rubida*, which implies an absence of rhizobia from the soil; *Glycyrrhiza anthocarpa* plants grown in their own soil to the 14-leaf stage produced only one nodule per plant, which probably indicates low numbers of the appropriate rhizobium in the field. Such observations are recorded in Table 1, column 5; a more detailed discussion of some of these points is given below.

2. *Nodulation and soil moisture.* Nodules are formed after rain and the life of the nodule is determined by the duration of moisture in the soil. Probably nodules rarely reach their maximum potential size, even in the case of annuals; this is suggested by the sizes of nodules developed on plants grown in pots, which are invariably larger than those in the field for both annual and perennial species. The only possible exceptions are the short-lived annuals, notably *Trigonella suavisissima*. After the soils have dried out and the nodules have fragmented, nodule-scars are sometimes discernible on the roots. Perennial nodules probably rarely occur.

Since moisture plays a significant part in the abundance of nodules, the number of nodules per unit length of root usually increases (a) from arid to semi-arid (or wetter) for those species which have a wide climatic range and (b) in the same stand of a single species which spreads over a varying microtopography. The second condition is exemplified by *Psoralea eriantha* and *Swainsonia burkittii*, both of which occur on sand dunes; on the crests of dunes nodules are rare and small (1-2 mm.) and white in colour (ineffectiveness is assumed), whereas at the bases of the dunes or in depressions where water lodges, nodules are larger and apparently effective. Plants of *Psoralea eriantha* grown in their own soil (sand from dune crests) in pots produced large effective nodules suggesting that inadequate moisture supply in the field is responsible for the small size of the nodules.

3. *Position of nodules on the roots.* From field and glasshouse data, nodules for both annuals and perennials may develop on either the taproot or lateral roots. In the field, the clustering of nodules at the top of the taproot has been observed in some species, notably species of *Psoralea*, and *Lotus coccineus*; the phenomenon is possibly due to the moister condition of the upper soil layers as a result of light showers of rain which fall after the plants have become established as seedlings or recommenced growth. Such nodules are often on short laterals.

4. *Depth of nodules in soil.* The location of nodules is determined partly by the distribution of the root system and partly by the rate at which the soils dry out. In the case of woody perennials, nodules rarely occur in the surface 10 cm.; they have been recorded in the case of *Acacia aneura* at a depth of 100 cm. In sandy soils (for annuals or perennials) nodules are rare in the surface 10 cm. of soil; in soils of heavy

TABLE 1.

Nodulation Records for Arid and Semi-Arid Legumes.

Explanation of terms, etc.: *Column 3*, Habitat: The terms "mallee", "scrub", "woodland" refer to the *Eucalyptus* shrub woodlands respectively. "Arid" and "semi-arid" refer respectively to areas which receive less than 10 inches of rain per annum, and between 10 and about 15 inches. "North" refers to areas which receive a predominantly summer rainfall; "south" to areas receiving a predominantly winter rainfall. "Watercourse" includes all depressions (large or small) in which water flows after rains. *Column 4*, Abundance of nodules: "Abundant" is used to indicate two or more nodules per 10 cm. of root; "common" one nodule per 10 cm. of root; "rare" less than one nodule per 10 cm. of root. *Ineffectiveness* is assumed for nodules which were white and small (1-2 mm.). *Column 5*, Estimated significance: The estimate is subjective and is based on the abundance of the plant in the field, the number of nodules on the roots and their assumed effectiveness, and the nature of the leaves with respect to size, degree of xeromorphy and the number of leaves which fall to the ground annually.

1.	2.	3.	4.	5.
	Habit of Plant.	Habitats in Arid and Semi-Arid Zones. Abundance in the Field.	Abundance of Nodules in the Field, their Shape and Size.	Estimated Significance of the Legume in Nitrogen Fixation in Communities in which it Occurs. Additional Comments.
PAPILIONACEAE.				
Tribe PODADIREAE. <i>Eutaxia microphylla</i> (R.Br.) J. M. Black.	Perennial shrub to 40 cm. high, sometimes almost prostrate.	Mallee. Arid and semi-arid; south. Rare. Sandy soils.	Rare. Cylindrical, 6-8 mm. long.	Insignificant. Nodules may pos- sibly be perennial in semi-arid areas.
Tribe HEDYSAREAE. <i>Aeschynomene indica</i> L. <i>Desmodium varians</i> Endl. <i>Rhynchosia minima</i> (L.) DC.	Annual herb to 1 m. high. Weak herbaceous twiner, pos- sibly perennial. Trailing perennial.	Watercourses. Mainly semi-arid, north. Locally common. Clays. Chiefly woodlands, Semi-arid; north and south. Widely distributed but never common. Sandy loams to clays. Mostly watercourses; also munga scrub. Arid and semi-arid; mainly north. Uncommon. Usually sandy soils.	Rare. Depressed globular, 5 mm. diam. Doubtfully effective. Abundant to rare. More or less globular, 4-5 mm. diam. Rare. More or less globular, 1-2 mm. diam.; possibly sometimes ineffective.	Insignificant. Probably significant. Insignificant.
Tribe LOTEAE. <i>Lotus coeruleus</i> Schlecht.	Decumbent perennial herb, often forming mats.	Widely distributed in many com- munities, often abundant on plains. Arid and semi-arid; north and south. Sands to clays.	Usually abundant. More or less globular, 2-4 mm. diam.	Significant.
Tribe TRIFOLIAE. <i>Trigonella savatissima</i> Lindl.	Decumbent or prostrate herb.	Mostly areas subject to flooding. Arid and semi-arid; north and south. Sometimes abundant. Usually clays.	Abundant to rare. Usually cylindrical, to 4 mm. long, sometimes coralloid, to 1 cm. across.	Significant.
Tribe GENISTEAE. <i>Crotalaria cunninghamii</i> R.Br. <i>C. dissitiflora</i> Benth.	Shrub to about 2 m. high. Shrub to 1½ m. high.	Usually on loose sands. Arid; north. Locally common. Sands. Scrubs on stable dunes. Arid; north. Locally common. Sandy soils,	Rare. Cylindrical to globular, 2-3 mm. diam. Rare. Cylindrical, 5 mm. × 2 mm.; or 1 mm. and white (in- effective?).	Insignificant. Insignificant.

TABLE 1.—Continued.

1.	2.	3.	4.	5.
	Habit of Plant.	Habitats in Arid and Semi-Arid Zones. Abundance in the Field. Soils.	Abundance of Nodules in the Field, their Shape and Size.	Estimated Significance of the Legume in Nitrogen Fixation in Communities in which it Occurs. Additional Comments.
PAPILIONACEAE.—Continued.				
<i>Templetonia</i> Benth.	Leafless shrub to 2 m. high.	Mainly mallee. Arid and semi-arid ; south. Rare. Usually sandy soils.	—	Plants grown in pots in own soils to 30-leaf stage produced no nodules.
Tribe GALEGEAE.				
<i>Clanthus formosus</i> et Vickery.	Prostrate annual herb, forming mats.	Rocky ridges, sandhills, scrubs. Arid ; north and south. Sometimes locally common. Sands ; skeletal soils.	Rare. Flat, cylindrical, some- times notched at apex, 6-7 mm. long.	Doubtfully significant.
<i>Glycyrrhiza anthocarpa</i> J. M. Black.	Shrub to 50 cm. high.	Areas subject to flooding. Arid ; mainly north. Rare. Clays.	—	Cylindrical to semi-coralloid nodules to 7 mm. long developed on plants grown in own soil in pots. Possibly locally significant.
<i>Indigofera australis</i> Willd.	Erect shrub to 1 m. high.	Mainly rocky outcrops. Mainly semi- arid ; mainly north. Sometimes locally common. Sandy and skeletal soils.	Rare to common. More or less globular, to 4 mm. diam.	
<i>I. enneaphylla</i> L.	Procumbent herb, possibly perennial.	Sandhills. Arid ; north. Rare. Sands.	Rare. Cylindrical, 6 × 2-3 mm.	Insignificant.
<i>I. hirsuta</i> L.	Decumbent annual herb to 60 cm. high.	Scrubs and woodlands. Arid and semi-arid ; north. Rare. Sandy soils.	Rare. Globular, to 3 mm. diam.	Insignificant.
<i>I. linifolia</i> Retz.	Prostrate herb, possibly per- ennial.	Sandhills, scrubs, woodlands. Arid and semi-arid. Rare to locally common. Sandy soils.	Rare. Globular, to 3 mm. diam.	Insignificant.
<i>I. viscosa</i> L.	Erect herb to 50 cm. high, pos- sibly perennial.	Sandhills, scrubs, woodlands. Arid and semi-arid ; north. Rare. Sandy soils.	Rare. Globular, to 3 mm. diam.	Probably insignificant.
<i>Psoralea eriantha</i> Benth.	Decumbent or semi-erect herb, usually perennial.	Usually on loose dunes. Arid ; north. Locally common. Sands.	Rare. Usually 1-2 mm. diam., white, probably ineffective.	Insignificant. Plants grown in pots with rhizobia from <i>P. patens</i> produced large effective nodules. Significant.
<i>P. patens</i> Lindl.	Erect perennial shrub to 1 m. high.	Treeless areas, watercourses, less common in scrubs. Arid and semi- arid, chiefly north. Common. Sands to clays.	Common. Globular or irregular, up to 7 mm. across.	

TABLE 1.—Continued.

1.	2.	3.	4.	5.
	Habit of Plant.	Habitats in Arid and Semi-Arid Zones. Abundance in the Field. Soils.	Abundance of Nodules in the Field, their Shape and Size.	Estimated Significance of the Legume in Nitrogen Fixation in Communities in which it Occurs. Additional Comments.
PAPILIONACEAE.—Continued.				
<i>P. tenax</i> Lindl.	Weak perennial herb to 40 cm. high.	Woodlands and treeless areas. Mainly semi-arid; mainly north. Common. Usually clays.	Common. Globular to irregular, up to 5 mm. across.	Significant.
<i>Sesbania aculeata</i> (Schreb.) Poir.	Shrub to 2 m. high, possibly perennial.	Watercourses, treeless areas. Arid and semi-arid; north. Rare to locally common. Clays.	Usually rare. Globular to irregular, to 5 mm. across; sometimes possibly ineffective.	Doubtfully significant in most areas. Abundantly nodulated plants recorded on Castlereagh River only.
<i>Suaresonia burkittii</i> F. Muell. ex Benth.	Erect shrub to 80 cm. high, probably perennial.	Usually on loose sands, rarely in scrubs. Arid and semi-arid; south. Locally common. Sands.	Rare. Usually white, $\frac{1}{2}$ –1 mm. diam., except in table-drains, see next column.	Insignificant except in table-drains, where roots bear cylindrical nodules 4–5 × 2–3 mm.
<i>S. campylantha</i> F. Muell.	Straggling or erect herb to 60 cm. high; possibly perennial.	Many communities. Arid and semi-arid; mainly north. Rare. Chiefly heavy soils.	Rare. Globular, 1–2 mm. diam.	Insignificant.
<i>S. fassimontana</i> J. M. Black.	Decumbent or ascending herb with stems up to 40 cm. long, possibly perennial.	Rocky ridges. Arid. Barrier and neighbouring ranges. Locally common. Chiefly skeletal soils.	Common. Cylindrical, flat or coralloid, up to 7 mm. across.	Significant.
<i>S. flavicarinata</i> J. M. Black.	Prostrate herb forming mats. Behaves as an annual.	Saltbush plains east of Broken Hill only; extends westward and north. Rare. Clays.	Common. Flat, wedge-shaped, 6–7 mm. long.	Insignificant.
<i>S. greyana</i> Lindl.	Erect perennial to 1½ m. high.	Chiefly along rivers. Arid and semi-arid; north and south. Locally common. Chiefly clays.	Common to rare. More or less globular, to 3 mm. diam.	Significant.
<i>S. leseritifolia</i> DC.	Weak erect herb, probably annual.	Scrubs. Mainly arid. Rare. Chiefly sands.	Rare. 1 mm. diam., white, possibly ineffective.	Insignificant. One record only.
<i>S. microphylla</i> A. Gray.	Prostrate or decumbent annual herb.	Many communities; widely distributed. Arid and semi-arid; north and south. Sometimes locally common. Chiefly sandy soils.	Rare, sometimes absent (arid areas), cylindrical, 3–4 × 1 mm.	Perhaps locally significant in very good seasons.
<i>S. oroboides</i> F. Muell. ssp. <i>oroboides</i> Lee.	Weak erect or straggling herb, possibly perennial.	Widely distributed in many communities. Arid and semi-arid; mainly north. Locally common. Sandy soils to clays.	Common to rare. More or less globular, 2–3 mm. diam., sometimes smaller and white (ineffective?).	Small to insignificant.
<i>S. phacoides</i> Benth. ssp. <i>phacoides</i> Lee.	Prostrate or ascending annual.	Many communities; often abundant on loose or stable dunes. Arid and semi-arid. Sandy soils.	Common to abundant. Flat, wedge-shaped or coralloid, up to 1 cm. across.	Significant.

TABLE 1.—Continued.

1.	2.	3.	4.	5.
—	Habit of Plant.	Habitats in Arid and Semi-Arid Zones. Abundance in the Field. Soils.	Abundance of Nodules in the Field, their Shape and Size.	Estimated Significance of the Legume in Nitrogen Fixation in Communities in which it Occurs. Additional Comments.
PAPILIONACEAE.—Continued.				
<i>S. procumbens</i> (F. Muell.) F. Muell. and <i>S. savinasioides</i> (Benth.) Lee.	Ascending annuals forming dense mats.	Widely distributed, chiefly plains. Arid and semi-arid; north and south. Locally common; sometimes dominant. Chiefly heavy soils.	Abundant to rare. Globular, cylindrical or coralloid, up to 6 mm. across.	Highly significant. These two species are difficult to distinguish except when in flower. For comment on variability of nodulation, see text. Insignificant. Plants rare.
<i>S. rigida</i> (Benth.) J. M. Black.	Ascending annual herb.	Recorded only from sandhills along Darling River south of Menindee. Rare. Sands.	Common to rare. Cylindrical to wedge-shaped, 5–6 mm. long; or 1–2 mm. and white (ineffective?).	
<i>S. stipularis</i> F. Muell.	Ascending annual herb.	Mainly plains; depressions in mulga scrub. Arid; mainly north. Sometimes locally common. Usually clays. Sandhills, mulga scrub and shrub woodlands. Arid and semi-arid, mainly north. Uncommon. Sandy soils.	Common to rare. Cylindrical to globular, up to 5 mm. diam.	Significant. Plants appear only every few years but often in large numbers. Insignificant.
<i>Tephrosia biduillii</i> Benth.	Decumbent or prostrate annual, often forming mats, possibly perennial.		Rare. 1–2 mm. diam., white, probably ineffective.	
Tribe PHASEOLEAE.				
<i>Glycine sericea</i> (F. Muell.) Benth.	Twining herb, probably perennial.	Rodky ridges, sand dunes, scrubs. Mainly arid; north and south. Rare. Sandy and skeletal soils.	Rare. 1 mm. diam., white, probably ineffective.	Insignificant. One record only of a larger nodule (5 mm. long).
<i>G. tomentosa</i> Benth.	Straggling perennial herb.	Mainly watercourses. Arid and semi-arid; north. Rare to locally common. Sands to clays.	Rare. 1 mm. diam., white, probably ineffective.	Insignificant.
<i>Vigna lanceolata</i> Benth.	Trailing herb.	Mainly watercourses. Arid and semi-arid; north. Rare to locally common. Sands to clays.	Rare. Ellipsoid, to 7 mm. long.	Probably insignificant.
Tribe ACACIEAE.				
<i>Acacia aneura</i> F. Muell.	Usually shrub 4–5 m. high; sometimes a small tree.	Dominant over large areas of stable dunes and rocky outcrops; occurs also in woodlands. Arid and semi-arid; mainly north. Usually sandy soils.	Rare to common. Globular to cylindrical, up to 4 mm. diam.	Significant. Nodules developed on potted plants become coralloid and up to 15 mm. across.
<i>A. buxifolia</i> A. Cunn.	Shrub to 3 m. high.	Rocky outcrops, woodlands. Semi-arid; central N.S.W. Locally common. Skeletal and sandy soils.	Common. Globular, flat or coralloid, up to 7 mm. across.	Significant.

TABLE 1.—Continued.

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1.	2.	3.	4.	5.
	Habit of Plant.	Habitats in Arid and Semi-Arid Zones. Abundance in the Field. Soils.	Abundance of Nodules in the Field, their Shape and Size.	Estimated Significance of the Legume in Nitrogen Fixation in Communities in which it Occurs. Additional Comments.
MIMOSACEAE.—Continued.				
<i>A. bynoeana</i> Benth.	Shrub to 2 m. high.	Mallee. Arid; south. Rare. Sandy soils.	Common. Globular or cylindrical up to 5 mm. long.	Significant over very small areas.
<i>A. cana</i> Maiden.	Shrub to 3 m. high.	Locally dominant in parts of west Darling. Arid; north. Sandy soils to clays; sometimes saline.	Nodules scars recorded.	Possibly significant (data in- adequate).
<i>A. calanifolia</i> Sweet.	Shrub to 3 m. high.	Woodlands, rocky ridges. Arid and semi-arid; north and south. Rare. Sandy and skeletal soils.	Rare to common. Globular. 2-3 mm. diam.	Insignificant. Abundant coralloid nodules developed on potted plants grown in own soil.
<i>A. colletioides</i> A.Cunn.	Shrub to 3 m. high.	Mallee, sandhills, rocky ridges. Arid and semi-arid; south. Uncommon. Sandy and skeletal soils.	—	Coralloid nodules have been de- veloped on plants grown in own soil in pots, but only when rhizobia were added.
<i>A. deanei</i> (R. T. Baker) Welch, Coombs et McGlynn.	Shrub to 5 m. high.	Mainly woodlands. Semi-arid; south. Locally common. Sandy soils.	Common. Globular, up to 4 mm. diam.	Significant.
<i>A. doratozylon</i> A.Cunn.	Shrub to 6 m. high, sometimes a small tree.	Rocky outcrops. Mainly semi-arid; north and south. Locally common. Skeletal soils.	Common. Globular, 2-3 mm. diam.	Probably significant.
<i>A. estrophiolata</i> F.Muell.	Tree to 15 m. high.	Stable dunes and rocky outcrops. Arid; north. Locally common. Sandy and skeletal soils.	—	Coralloid nodules developed on plants grown in pots.
<i>A. farnesiana</i> Willd.	Shrub to 5 m. high. bipinnate.	Watercourses, treeless areas. Arid and semi-arid; north; sometimes locally common or dominant. Clays.	Possibly common. Globular, up to 4 mm. diam.	Significant. Coralloid nodules developed on plants grown in pots.
<i>A. gladiiformis</i> A.Cunn.	Shrub to 3 m. high.	Rocky ridges, Barrier Range. Rare. Skeletal soils.	—	Insignificant. Abundant coralloid nodules on plants grown in pots.
<i>A. hakeoides</i> A.Cunn.	Shrub to 3 m. high.	Woodlands mallee. Semi-arid; Central N.S.W. Locally common. Sandy soils.	Abundant. Globular, flat, cylindrical, coralloid, up to 1 cm. across.	Significant.
<i>A. homalophylla</i> A.Cunn.	Shrub to 6 m. high.	Woodlands, mallee. Mainly semi-arid; north and south. Often locally common or dominant. Sandy soils.	Usually common. Globular, cylindrical to coralloid, up to 8 mm. across.	Significant.
<i>A. ligulata</i> A.Cunn.	Shrub to 5 m. high.	Usually sandhills. Arid; north and south. Locally common or dominant. Sands.	Rare to common. Globular 2-3 mm. diam.	Significant.
<i>A. oswaldii</i> F.Muell.	Shrub to 4 m. high.	Many habitats; woodlands to treeless areas. Arid and semi-arid; north and south. Rare. Sands to clays.	—	Coralloid nodules developed on potted plants, but only when rhizobia were added.

TABLE 1.—Continued.

1.	2.	3.	4.	5.
	Habit of Plant.	Habitats in Arid and Semi-Arid Zones. Abundance in the Field. Soils.	Abundance of Nodules in the Field, their Shape and Size.	Estimated Significance of the Legume in Nitrogen Fixation in Communities in which it Occurs. Additional Comments.
MIMOSACEAE.—Continued.				
<i>A. rigens</i> A.Cunn.	Shrubs to 2 m. high.	Mainly mallee. Arid and semi-arid; south. Locally common. Sandy soils.	Common. Cylindrical, up to 6 mm. long.	Significant, especially in semi-arid areas.
<i>A. salicina</i> Lindl.	Shrub, or small tree to 10 m. high.	In or near watercourses, rarely on dunes. Arid; north and south.	Rare. Globular, 2–3 mm. diam.; or coralloid, 1 cm. across.	Insignificant.
<i>A. stenophylla</i> A.Cunn.	Tree to 15 m. high.	Rare. Clays to sands. Watercourses. Arid, and semi-arid; north and south. Rare. Clays.	—	Nodules have not been developed on plants grown in their own soil in pots. Probably insignificant.
<i>A. tetragonophylla</i> F.Muell.	Shrub to 3 m. high.	Rocky ridges, dunes. Mainly arid; north. Sometimes common. Sands and skeletal soils.	Rare. Globular, 3 mm. diam.	
<i>A. triptera</i> Benth.	Shrub to 2 m. high.	Mallee. Semi-arid. Central N.S.W. Rare. Sands.	Rare. Globular, 2 mm. diam.	Insignificant.
<i>A. victorise</i> Benth.	Shrub to 4 m. high.	Usually near watercourses. Arid; north and south. Often forms mono- specific communities in watercourses. Clays; skeletal and sandy soils.	Mostly rare. Cylindrical, bi- furcating, coralloid, to 1 cm. across.	Probably significant.
Tribe ADEKANTHEREAE. <i>Neptunia gracilis</i> Benth.	Procumbent shrub.	Overflow country, watercourses, wood- lands, treeless areas. Mainly semi- arid; north. Sometimes common. Usually clays.	Common. Globular to irregular, up to 7 mm. across.	Significant.
<i>N. monosperma</i> F.Muell.	Procumbent shrub.	As <i>N. gracilis</i> .	Common. Globular to cylindrical, up to 5 mm. long.	Significant.
CAESALPINIACEAE.				
<i>Bauhinia carronii</i> F.Muell.	Tall shrub or small tree.	Bases of sand dunes. Arid; north. Usually rare, sometimes locally common. Sands.	Nodules not recorded.	Probably none.
<i>Cassia artemisioides</i> Gaudich., <i>C. desolata</i> F.Muell., <i>C. eremophila</i> A.Cunn., <i>C. phyllodinea</i> R.Br., <i>C. pleurocarpa</i> F.Muell., <i>C. sturtii</i> R.Br.	Shrubs to 3 m. high.	—	Nodules not recorded.	Probably none. No nodules re- corded on plants of <i>C. artemisi- oides</i> or <i>C. eremophila</i> grown in own soil in pots. Cultured <i>Cassia</i> rhizobia failed to induce nodula- tion on potted plants.
<i>Petalostylis labicheoides</i> R.Br.	Shrub to 2 m. high.	Usually rocky outcrops, sometimes in scrubs. Arid; mainly north. Rare. Sands.	Nodules not recorded.	Probably none. No nodules de- veloped on plants grown in own soil in pots.

texture, especially when subject to flooding (when they remain moist for periods of weeks), nodules on annuals and herbaceous perennials may occur as little as 1 cm. below the surface.

5. *Annual variation in abundance of nodules.* Those species which nodulate in the field produce nodules after rain at any time of the year, or during the appropriate season in the case of seasonal annuals. However, for certain species at least, the number of nodules produced from year to year or from season to season is by no means constant, but appears to vary with the interval between rains—the longer the interval the larger the number of nodules. The phenomenon was first observed in *Swainsona procumbens* which, during one good season following a dry spell of about three years at Fowler's Gap, north of Broken Hill, produced nodules at the rate of one per 2 cm. of root; one year later during a second good growing season for this species (which is an unusual occurrence) plants in the same area produced nodules at the rate of one per 50 cm. of root. A similar behaviour has been observed on two later occasions for this species in other parts of the State, and also for *Trigonella suavisissima*. Likewise, similar variations in the nodulation pattern have been observed on marked plants of *Acacia aneura*. Suppression of nodulation of exotic herbaceous legumes through the accumulation of nitrate is a well-known phenomenon, and it is probable that the native legumes, both herbaceous and woody, are behaving in a similar fashion. This is of interest and of economic importance in so far as the suppression of nodulation must inevitably tend to limit the total nitrogen capital in the communities, especially the herbaceous ones. Unfortunately the problem is one that cannot be studied satisfactorily in the field since successive favourable years or seasons are the exception rather than the rule.

TABLE 2.

Time of Nodulation, Expressed in Terms of the Number of Leaves on the Seedling (excluding Cotyledons) when the First Nodule was Observed.

Species.	Number of Leaves.
<i>Lotus coccineus</i>	3
<i>Psoralea eriantha</i>	4
<i>P. patens</i>	3
<i>Swainsona procumbens</i>	4
<i>Trigonella suavisissima</i>	Cotyledon stage
<i>Acacia aneura</i>	Usually 3 to 7
<i>A. colletioides</i>	About 25
<i>A. estrophiolata</i>	8
<i>A. oswaldii</i>	About 15
<i>A. tetragonophylla</i>	6
<i>A. victoriae</i>	4
<i>A. rubida</i>	3

6. *Age of plant and nodulation.* In Table 2 the ages of plants, expressed in terms of leaf number, at which the first nodules have been observed, are given. *Trigonella suavisissima* is noteworthy because of its early infection. Dry land acacias, on the other hand, nodulate sporadically and tardily, and warrant further discussion.

It is probable that all species of *Acacia* are capable of nodulation if supplied with the appropriate rhizobia (Bowen, 1956). The difficulties in recording nodules on some of the inland species is due partly to lack of rhizobia in certain soils (discussed in the next section), partly to the generally dry conditions leading to infrequent nodulation, and partly also by what appears to be a paucity of suitable sites on the root for infection, which results in tardy or sporadic nodulation. This last condition has been recorded for four of the inland species that have been studied in pot culture (*A. aneura*, *A. colletioides*, *A. estrophiolata* and *A. oswaldii*). In contrast, *A. tetragonophylla* and *A. victoriae* nodulate fairly regularly at the stated stages (Table 2).

Tardy or sporadic nodulation means that the species in question (particularly *A. aneura*) are unreliable as test plants for the recovery of rhizobia from soils, and the use of *A. aneura* for this purpose had to be abandoned. As a substitute, *A. rubida*, a tableland species, was used in all tests, and in most cases both this species and *A. aneura* were sown in the same pot, thus enabling a comparison of the nodulation pattern of the two species to be made, with the following results: Firstly, when supplied with abundant rhizobia from crushed nodules, *A. rubida* nodulated at the three-leaf stage and nodules continued to form at the rate of two or three for each added leaf, up to the 12-leaf stage. *A. aneura*, on the other hand, grown in the same pot nodulated rarely at the 3-leaf stage but usually before the 7-leaf stage; the single nodule became very large (1–2 cm. across) and remained as the sole nodule on the plant up to the 12-leaf stage (in some cases a second or third much smaller nodule developed). Secondly, when the two species were grown together in soils from the *A. aneura* scrub, *A. rubida* nodulated as described above, but at the 12-leaf stage the number of nodules per plant was often fewer than 20, suggesting a lower rhizobial population in the soil than under the first condition. *Acacia aneura* rarely nodulated before the 7-leaf stage and rarely produced a second nodule before the 12-leaf stage. An examination of the root systems showed the following contrasting characters: *A. rubida* produced a much-branched root system, white in colour. The roots of *A. aneura* in contrast are branched but little, and are heavily pigmented with what are assumed to be tannin derivatives, so that they are brown. Seedlings of *A. aneura* at the 7-leaf stage usually had taproots 60 cm. long and a total root length of about 200 cm. (longest recorded 308 cm., with no nodules). These seedlings of *A. aneura*, grown in their own soil, were invariably stunted, with phyllodes 2–3 cm. long which frequently showed the yellowing indicative of N-deficiency. This yellowing disappeared in later-formed phyllodes, when nodulation had occurred. If these data are typical of *A. aneura* seedlings, they suggest that nodulation sites occur at the rate of one per 100 cm. of root. This figure, however, does not apply to mature plants in the field where nodules have been recovered from established plants at the rate of three or four per 10 cm. of root.

GEOGRAPHIC DISTRIBUTION OF RHIZOBIA.

Some observations on the distribution of the rhizobia of five genera have been made, sufficient to provide a general picture on the presence or absence in most plant communities. The data have been accumulated from field records supplemented by testing soils from 140 sites for rhizobia by the growing of seedlings. Most of the soils selected for investigation did not support nodulated legumes in the field (except assumed nodules on *Acacia aneura*); one or more species were grown in the soils (*A. rubida*, *Psoralea patens*, *Lotus coccineus* and *Trigonella suavissima*). Although controlled cross-inoculation tests were not carried out (except for *Psoralea*), there is every reason to believe, both from experiences of other workers (Norris, n.d.) and from the soil tests mentioned above, that cross-infection between the legumes tested does not occur, and consequently it is to be concluded that at least five specific populations of rhizobia are present in the arid and semi-arid regions.

Table 3 presents the data on distribution. The following points are of interest.

1. With the exception of the *Casuarina* scrubs and most of the arid mallee, all soils contain at least one species of *Rhizobium*. The absence of rhizobia from these two communities is perhaps not unexpected, since they contain extremely few legumes, through which rhizobial populations could be built up. Or perhaps the converse is true: the absence of rhizobia prevents or retards invasion by legumes. Furthermore, some of the mallee areas are extremely low in soil phosphate (about 15–20 p.p.m. HCl-soluble P), which factor may contribute towards the exclusion of both legumes and rhizobia.

2. Widespread throughout the entire area are the rhizobia of *Acacia*, *Lotus* and *Psoralea*. The rhizobia of *Acacia* and *Lotus* were recorded in soils collected from the

mulga scrub on stable dunes in the Lake Amadeus Basin, and that of *Psoralea* from heavy saline soils (abundantly nodulated plants) from the Lake Eyre Basin.

3. Within any community the populations of all species of rhizobia vary in space, presumably since populations are built up by societies of legumes. However, rhizobia of the herbaceous legumes have been recovered from soils which do not support the legume in the field; this may be an illusion, partly since crops of herbaceous legumes appear sporadically after the infrequent rains and partly since grazing by domestic stock has removed legumes over large areas or decreased their abundance. The distribution of the *Trigonella* rhizobium is especially perplexing: *Trigonella suavisissima* occurs almost entirely on soils of heavy texture, chiefly along the major watercourses, around the inland lakes, and on some of the treeless plains, for example the Hay plains where it was first recorded by Mitchell (1838) at Lake Waljeers. Before the studies on the distribution of *Rhizobium meliloti* were made by Hely and Brockwell (1960), it was thought that *Trigonella* was infected only by the rhizobia from *Melilotus*. These two writers, however, show that *R. meliloti* from arid and semi-arid soils can infect and in some cases fix nitrogen in association with some species of *Medicago*. These findings must be viewed with caution with regard to the *Trigonella* rhizobium, since species of *Medicago* (chiefly *M. hispida*, *M. minima* and *M. laciniata*) now occur in

TABLE 3.

Approximate Distribution of the Rhizobia of Acacia, Psoralea, Lotus, Swainsona and Trigonella according to Plant Community and/or Topography.

+ indicates present, — probably absent, ± mostly present, ∓ mostly absent.

	<i>Acacia.</i>	<i>Psoralea.</i>	<i>Lotus.</i>	<i>Swainsona.</i>	<i>Trigonella.</i>
Moving dune-crests (arid)	—	±	—		—
Dry sandy creek beds (arid)	+	+	∓	∓	—
<i>Acacia aneura</i> scrubs on stable dunes	+	±	∓	∓	—
<i>A. aneura</i> scrubs on rocky ridges (tops)	+	—		∓	—
<i>A. aneura</i> scrubs on rocky ridges (bottoms and creeks)	+	+	∓	±	—
Mallee (arid)	∓	—	—	—	—
Mallee (semi-arid)	+	∓	—	—	—
<i>Casuarina cristata</i> scrubs (arid)	—	—	—	—	—
<i>Atriplex vesicaria</i> on stony downs	—	+	+	∓	∓
<i>A. vesicaria</i> on plains	—	+	+	+	±
<i>Astrelba pectinata</i> grassland	—	+	+		—
<i>Eucalyptus populnea</i> — <i>Acacia</i> shrub woodland	+	∓	∓	±	—
River flats (Darling R.)	±	+	±	±	±
River flats (semi-arid)	±	+	+	±	±

the west-Darling country both along and remote from the main rivers and, in the case of *M. hispida*, the plants are nodulated with rhizobia which will not infect *Trigonella* (tested by the present writer), which suggests that strains of *R. meliloti* are introduced with the *Medicago* and that the medics are not necessarily infected by the *Trigonella* rhizobia that originally existed. The presence of nodulated medics on sandy soils where *Trigonella* does not exist and has probably never existed supports this view. The finding of Vincent and Waters (unpublished data, quoted in Vincent, 1962) are relevant, namely, that isolates from *M. laciniata* will infect *Trigonella*, whereas isolates from other species of *Medicago* will not; this seems to explain the distribution of the *Trigonella* rhizobium provided by the present writer's observations from pot tests on 76 soil samples from the field. Of these samples, none are known to support *Trigonella* and about half were collected in the semi-arid zone where effectively nodulated medics are known to occur or are likely to occur. The *Trigonella* rhizobium was recovered from only five of these samples; one record, north of Tibooburra on the stony downs, can possibly be explained by the one-time presence of *Trigonella* in this area; the remaining four records from the Cobar and Bourke districts, on the grounds of Vincent and Waters' data, seem likely to be recoveries from *Medicago laciniata*, which species, abundantly and effectively nodulated, has been recorded by the writer in the Cobar district.

4. Rhizobia occur irrespective of soil texture. From the data available, populations of rhizobia are highest in sandy loams (except *Trigonella*). This is probably due to the abundance of legumes on such soils. This finding is in sharp contrast with the requirements of *R. trifolii* introduced into Western Australia where persistence of the rhizobia in sandy soils has proved difficult or impossible (Burvill, 1962; Parker, 1962). The ecological tolerances of the native rhizobia would thus appear to be different from those of *R. trifolii*. Furthermore, since different species of *Acacia*, *Psoralea* and *Swainsona* are in most cases confined to different kinds of soil, different strains of rhizobia may well exist.

5. *Psoralea patens* and *Lotus coccineus* occur on both saline and non-saline soils and nodulation may be abundant on both kinds of soil. A high salt tolerance of the rhizobia must be assumed from field evidence, a point which has been confirmed by Charley (unpublished data) in the laboratory, the rhizobia tolerating salt levels of 0.6 M. NaCl (in 2% agar), whereas germination of the seed and/or growth of seedlings of *Psoralea patens* were prevented by 0.2 to 0.3 M. NaCl.

EFFICIENCY OF THE N-FIXING MECHANISMS.

Some doubt has always existed as to whether the inland legumes are efficient nitrogen fixers, the doubt having arisen chiefly through the difficulty in recovering nodules in the field at any time when the legume happens to be dug. For reasons already discussed, absence of nodules at any one time does not imply that abundant fixation does not occur; conversely the presence of nodules on a plant cannot be used to indicate that the whole of the nitrogen in the plant has been derived from these nodules, since the plant may be absorbing free nitrate from the soil. It follows, therefore, that precise quantitative estimates of nitrogen fixation cannot be made merely by weighing and analysing crops of plants or leaves as they appear.

In order to test the efficiency of the nodules in fixing nitrogen and to compare growth by rhizobial fixation with that through absorption from nitrate solution, herbaceous plants and acacias were grown in the glasshouse, one set being fed with Hoagland's solution, the other with a nitrate-free solution based on Hoagland's solution and with the addition of specific rhizobia for each species. The herbaceous species used were *Swainsona fissimontana*, *Trigonella suavissima*, *Lotus coccineus*, *Psoralea patens*, *P. eriantha*. Nodulated plants in all cases grew as rapidly as the plants fed on Hoagland's solution and produced the same amount of dry matter. The tardy nodulation of the acacias rendered the comparison between nodulated and nitrate-fed plants useless. That fixation occurs, however, was apparent by the sudden increase in growth rate of seedlings, which coincided with the incidence of nodulation. Furthermore, analyses of leaves of ten effectively nodulated herbaceous species from the field gave N-contents (dry weight) ranging between 3.1% and 5.5%. The presumably ineffectively nodulated *Psoralea eriantha* had a N-content of 2.9%. Nodulated acacias from the field had a much higher N-content (about 2.0%) than *Hakea leucoptera* (0.5%), a sclerophyllous species growing with *A. aneura*.

These data suggest a significant N-fixing capacity in the field for those species which nodulate and a significant contribution to the N-capital of the community by those species which occur abundantly. The quantitative aspects will be dealt with in detail in a later publication.

DISPERSAL AND SURVIVAL OF RHIZOBIA.

Opportunities for dispersal of rhizobia are afforded by water movement along rivers and creeks and by the action of wind. Since the advent of white man and domestic stock in the inland, movement of soil by both water and wind has been greatly increased; exotic legumes and their rhizobia have been introduced, particularly in the wetter areas of eastern Australia, and from these areas and through the agency of the rivers which flow inland legumes, with or without their specific rhizobia, find appropriate migration paths to invade certain semi-arid and arid communities. Species of *Medicago* in particular and, locally, of *Vicia* and *Melilotus* have become naturalized

in certain habitats, chiefly on clayey soils but also, in some areas, on soils of light texture. The plants are effectively nodulated and the presence of both legume and rhizobia can be accounted for either by migration along a watercourse or by slow movement from the more humid east to the west as far as the 10-inch isohyet. Isolated records of nodulated medics and of *Vicia* are abundant from the west-Darling remote from rivers and these can be accounted for by the chance transportation of seed (burr) and rhizobia by man or animals, possibly during the cooler periods of the year.

By analogy, the native rhizobia may follow or have followed similar migration paths. This, however, seems unlikely, since the migration of legumes and rhizobia, either native or exotic, from the clayey river-flats on to the adjacent sandy country does not occur in the arid zone, e.g., westward from the southern portion of the Darling River flats, though it is possible in the semi-arid zone. It appears that both the leguminous and rhizobial floras of the inland have developed quite independently of the eastern floras, having survived the extreme arid period through which the country passed before the present vegetation developed (Crocker, 1959). The restriction to the inland of several leguminous genera not endemic to Australia, such as *Glycyrrhiza*, *Isotropis*, *Clanthus* and *Trigonella* (the last with a specific rhizobium), favours this view.

Within communities, local migration of both legumes and their rhizobia under the influence of water have been observed for *Medicago hispida* and *Trigonella*, and in recent years migration paths have been created by roads, which have accelerated the spread of some herbaceous species, e.g., *Medicago* and *Psoralea*, in tabledrains where water often flows for long distances and where soils are invariably moister than the adjacent country.

It is improbable that winds play an important role in the migration of rhizobia in arid regions. The question must be left open until dust samples have been tested for the presence of living rhizobia. The action of wind in transporting soil, however, is likely to be destructive to rhizobia, as evidenced by tests made on soil samples collected from moving sand dune crests, moving soil surfaces, sandy accumulations along roadsides and fences, and recently colonized sandpatches (e.g., Broken Hill Regeneration Areas and the sandpatches at Fowler's Gap) which formerly were covered by mulga and which, today, have been stabilized by species of *Cassia*. Tests made on such samples showed that the *Acacia* rhizobium is usually lacking, while those of *Lotus*, *Swainsona* and *Psoralea* are sometimes present. The most tolerant to transportation by the wind appears to be *Psoralea*.

The absence of *Acacia* rhizobium in transported soils is significant with regard to the regeneration of *A. aneura*. Whereas regeneration of *A. aneura* in healthy stands of scrub is considerable, particularly in south-west Queensland and Central Australia, regeneration in the disturbed and degenerating scrubs, notably those in western New South Wales, is a rare occurrence. In addition to an ever decreasing seed supply and more extreme climatic conditions as a result of exposure of the soil surface and loss of organic matter, establishment of seedlings of *A. aneura* in these disturbed areas is made more difficult by the reduction in the rhizobial population, a factor which is accentuated by the tardy nodulation of this species. While a reduction in the rhizobial population may not be directly causal in the death of mature *A. aneura* plants, it is a factor which may contribute to the general weakening of the plant, and in this respect it is significant that rhizobia cannot always be recovered from soils below dead *A. aneura* plants, even though the soils have not been eroded by wind to a significant depth. The data available suggest the *Acacia* rhizobia live a far more precarious existence in the arid zone than do the rhizobia of the other plants that have been investigated.

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SIR WILLIAM MACLEAY MEMORIAL LECTURE, 1964.

HOW ANIMALS CAN LIVE IN DRY PLACES.

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(Three Text-figures.)

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INTRODUCTION.

The larvae of *Polypedium vanderplanki*, a small midge of the Family Chironomidae, live in temporary pools formed in shallow hollows in rocks in Uganda. In their normal active condition water makes up about two-thirds of their total weight. When the pool dries up the larvae dry up also, becoming virtually as dry as the dust in which they are living. They survive the drought in this desiccated condition; when the next lot of rain fills the pool again they replenish their tissues with water and resume development. Hinton (1960) showed that when larvae in this condition of cryptobiosis were stored in air of relative humidity 60% the water-content of their bodies was about 8%. Some larvae that had been stored in dry dust in the laboratory for 39 months revived when they were placed in water, and subsequently they completed their development, apparently normally. Cryptobiosis occurs in other invertebrates, not necessarily closely related to the Chironomidae, but it is nevertheless an unusual adaptation for life in the desert.

By and large, the water-content of the bodies of desert-dwellers is not much different from that of related species living in moister places; about two-thirds of their body-weight is water. Many sorts of animals, camels, kangaroos, rodents, snails, spiders, ticks and insects, live in deserts by virtue of adaptations in physiology and behaviour which allow them to conserve a normal amount of water in their bodies despite the heat and dryness of the places where they live.

THE DROUGHT-HARDINESS OF DESERT-DWELLERS.

The trap-door spider, *Blakistonea aurea*, is abundant in grassland and savannah on the plains near Adelaide. During the winter the spider feeds on whatever small arthropods it can catch near the mouth of its burrow. On the approach of summer it seals the lid of its burrow with silk and retires to the bottom of the burrow where it remains inactive without food or drink throughout the summer. At first sight it seems odd that the spider should shut itself off from supplies of food during the hottest and driest part of the year when the need to replenish water lost by evaporation is greatest. It seems especially odd in the light of experiments which showed that the spider is not much good at resisting evaporation from its body: when several spiders were exposed to dry air (relative humidity close to zero) they died in three days, having lost 30% of their original weight.

During the summer in Adelaide on hot days the maximum shade temperature may exceed 40° C. and the relative humidity may fall below 10%. Hot dry weather is the rule for the five months from November to March. Yet most of the spiders that enter the summer are still alive at the end of it. The explanation of this paradox is that 20 cm. below the surface the weather is very different from near the surface; at the bottom of the burrow the relative humidity usually remains above 90%. Apparently it is safer for the spider to remain without food in a place where the air is moist than to seek food at the mouth of the burrow where the air is likely to be dry. The magnitude of this risk is doubtless a reflection of the spider's chancy way of seeking food—sitting at the top of the burrow waiting for an ant or beetle to blunder by.

By way of contrast the snail, *Helicella virgata*, seems to seek out places that are especially hot and dry when it is settling down for the summer; the top of a fencing post or the exposed northern face of a stone wall are characteristic places (Fig. 1). The snail, having settled in such a position, may spend the entire summer there without food or drink; or it may wake up briefly during a shower of rain only to resume its position when the rain dries up. During the five months that the snail sits in the exposed position it might evaporate about 120 mg. of water; a standard evaporimeter tank might evaporate 36 inches of water during the same time.



Fig. 1. The snail, *Helicella virgata*, seeks hot dry places in which to aestivate.

The kangaroo tick, *Ornithodoros gurneyi*, lives in the dust about half an inch below the surface in kangaroo "wallows" in country where the annual rainfall is about seven inches and annual evaporation about six feet. The ticks have no opportunity to eat or drink, except when a kangaroo happens to use the wallow. But the ticks can remain alive and conserve the water-content of their bodies for several months without food or drink.

The flour moth, *Ephestia kuhniella*, can grow from an egg, weighing less than 1 mg. to a pupa weighing 16 mg. (of which 10 mg. is water) in flour that has been dried in an oven and kept in a closed container over concentrated sulphuric acid (i.e., in air virtually at zero relative humidity). Even though it is eating such dry food and respiring such dry air the caterpillar can retain sufficient of the water of metabolism to maintain a water content of 64% in its body (Table 1).

The kangaroo rat, *Dipodomys merriami*, lives in the desert in Arizona, eating only dry grain and not drinking at all. It could (on occasion), if it would, gain water by eating succulent vegetation, but it seems never to do this. The kangaroo rat, like the trap-door spider, avoids the worst rigours of the desert by digging itself a burrow, but, unlike the trap-door spider, this is only part of the explanation of its success (see below).

The camel, being too large to escape the heat by going underground, lives and works on the surface exposed to the full severity of the desert sun. There is an authentic record of a journey of 600 miles made by camels in the Empty Quarter of the Sahara where there is no drinking water (Schmidt-Nielsen, 1964).

Finally, the brine shrimp, *Artemia salina*, lives in pools of sea-water and can thrive in sea-water which is drying up and from which the dissolved salts are crystallizing out of solution (Croghan, 1958).

I mention the brine shrimp in this cavalcade of drought-hardy animals in order to make the point that it is sometimes convenient to measure an animal's qualifications for living in a dry place in terms of the difference in the "activity" of water inside and outside its body. In this context "activity" is conveniently measured in units of osmotic pressure. For example, the body-fluids of the brine shrimp have an estimated osmotic pressure of eight atmospheres; the most concentrated brine in which it can live has an estimated osmotic pressure of 326 atmospheres. The brine shrimp loses a certain amount of water by osmosis and by excretion. To make good the loss it swallows brine, retains the water, and excretes the excess salts into the medium in which it is living, thereby doing work against a gradient in osmotic pressure of 318 atmospheres.

TABLE 1.
The Moisture Content of Pupae of the Flour Moth Reared in Food of Different Moisture-content.
(After Fraenkel and Blewett, 1944.)

Moisture in Food. %	Relative Humidity. %	Wet Weight of Pupa. mg.	Water-content of Pupa. %
14.4	70	25.5	68
6.6	20	18.7	66
1.1	0	15.8	64

There is a law of physical chemistry which relates the osmotic pressure of an aqueous solution to the relative humidity of the air that is in equilibrium with the solution:

$$\text{Log}_e H = 4.6052 - \frac{0.018P}{0.0821T}$$

where H = relative humidity in per cent; P = osmotic pressure in atmospheres; T = absolute temperature degrees centigrade.

This equation enables us to compare the brine shrimp which lives in "dry" brine with the tick which lives in dry air. Lees' (1947) experiments with *Ornithodoros moubata* (a close relative of the kangaroo tick) showed that ticks which had become desiccated after living for a while in air with relative humidity close to zero could replenish almost all the water that they had lost if they were kept for a while in air with relative humidity 85% (or moister); and Browning (1954) showed that the ticks could repeat this many times (see Figure 2). The design of these experiments left no room for doubt that the ticks were absorbing water from the water-vapour in the air. I have estimated that a relative humidity of 85% is equivalent to an osmotic pressure of 216 atmospheres. Assuming that the body-fluids of the tick have an osmotic pressure of eight atmospheres, the tick is able to build up the water-content of its body against an osmotic gradient of 208 atmospheres.

The kangaroo rat makes a highly concentrated urine with an osmotic pressure of 123 atmospheres. The difference in osmotic pressure between its body-fluids and the urine into which it excretes salts and urea is about 115 atmospheres.

In Table 2 I have brought together a number of animals that can be compared on the basis of the "activity" of the water against which they work to conserve the water-content of their bodies.

In Table 2 these animals are judged only by the pressure against which they can maintain the water-content of their bodies. This is only one aspect of their capacity

for living in a dry place. Other equally important questions that might be asked about them include:

- (a) How much *work* is done to conserve water? i.e. how much *energy* is used in water-conservation?
- (b) *Power* is the rate of doing work, and it would be pertinent to ask how much *power* can the animal devote to conserving water?
- (c) More can be achieved by a machine of efficient design than by one with less efficient design, so it is also interesting to inquire into the *mechanisms* whereby animals conserve water.

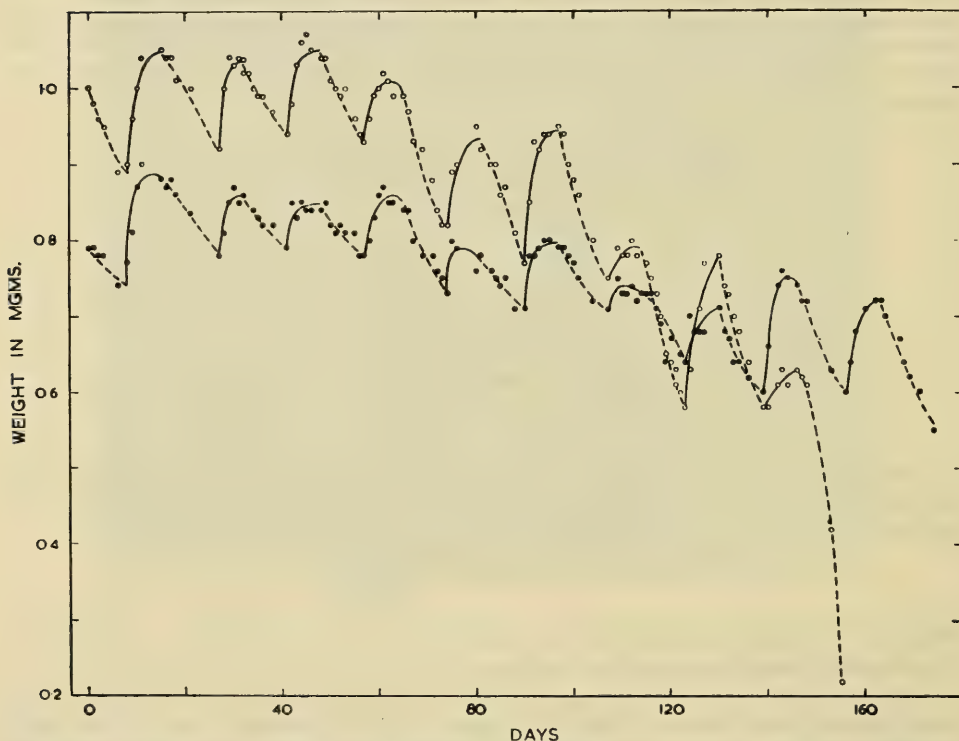


Fig. 2. Two ticks, *Ornithodoros moubata*, lost weight (water) while they were suspended in air of 5% relative humidity (broken lines) and gained weight by absorbing water when they were suspended in air of 95% relative humidity. One was still alive after 180 days. (After Browning, 1954.)

MECHANISMS OF WATER-CONSERVATION.

The gull excretes salt from a specialized nasal gland (if you watch a gull for a few minutes you will probably see it shaking drops of concentrated salt solution from its nose); but it also uses its kidneys in the normal way for excreting nitrogenous waste. Because in the camel and the kangaroo rat the kidneys have to excrete both salt and urea, their kidneys have to work against greater gradients in pressure to achieve the same result—it is a matter of design, like the difference between two-wheel and four-wheel brakes on a car.

Size is an important part of overall design and largely determines the mechanisms that can be used for conserving water. The temperature of the air in the Arizona desert where the kangaroo rat lives may go as high as 45° C. and the surface of the ground may exceed 70° C. in an exposed place. Because of its size (about 36 g.) the kangaroo rat can go underground during the day into a deep burrow where the temperature is not likely to exceed 31° C., and the humidity is also likely to be much

higher than at the surface. The kangaroo rat emerges from the burrow at night when the temperature at the surface is likely to have fallen well below the 36–38° C. which is its normal body temperature. Thus, because it is small, the kangaroo rat can contrive to spend all its time in a place that is cooler than itself, and, in these circumstances, because it has a large surface area relative to its weight (another consequence of small size), most of the heat of metabolism is dissipated by radiation. Some heat is also dissipated by evaporation of water from the lungs during the normal progress of respiration; and these two mechanisms suffice to keep the animal cool. The kangaroo rat does not need to expend water in sweat to keep cool. When one considers that during a hot day in Sydney a man working actively might sweat at the rate of a litre an hour, the economies that the kangaroo rat achieves by virtue of weighing only 36 g. and not requiring to sweat seem quite impressive.

TABLE 2.

The "Activity" of Water Against which Certain Animals Work to Conserve Water in Their Bodies.
 "Activity" is measured in atmospheres of osmotic pressure.

Species.	Empirical Information.	"Activity" Atmosphere.	Author.
Rat flea ..	Gains weight in air R.H. 50%.	910*	Edney (1947).
Brine shrimp	Maintains body-fluid in saturated brine.	326†	Croghan (1958).
Camel tick ..	Gains weight in air R.H. 85%.	216*	Lees (1947).
Kangaroo rat	Concentrates urine to 5.5 osmoles/litre.	123†	Schmidt-Nielsen (1964)
Camel ..	Concentrates urine to 2.8 osmoles/litre.	63†	" " "
Man ..	Concentrates urine to 1.4 osmoles/litre.	32†	" " "
Gull ..	Excretes concentrated solution of NaCl.	40†	Schmidt-Nielsen & Sladen (1958)
Eel ..	Excretes salts into sea water.	26*	Krogh (1939).

* Converted from measurements of relative humidity.

† Converted from measurements of depression of freezing point.

The kangaroo rat is also highly economical in the use of water for excretion. It makes a urine that is about four times as concentrated as the best that man can do. The efficient kidney is not, of course, a direct outcome of small size, but efficient kidneys seem, nevertheless, to be characteristic of small desert-living rodents. It is almost as if natural selection, having achieved such great economies with evaporation, went on to improve the kidney so that the kangaroo rat might live without drinking water or eating any watery food. It is so economical with water for evaporation and excretion that it can get enough water for its needs by metabolizing dry seeds.

The camel is too large to seek the shelter of an underground burrow. It often has to live in places that are much hotter than itself, and where it is exposed to direct radiation from the sun. Even when it is in a place that is slightly cooler than itself the camel, because of its small surface area relative to its weight (a consequence of large size), cannot dissipate enough heat merely by radiation: it must supplement radiation by the evaporation of sweat. Thanks to a series of elegant studies by Schmidt-Nielsen and his colleagues, we now know how the camel can do so well in the desert despite these seeming difficulties. The full story is told in Schmidt-Nielsen's book "Desert Animals". The following summary is inadequate because of its brevity

Compared to a man or a dog, a camel can lose proportionally more water from its body without dying. It a man loses more water than about 10% of his original weight he becomes incapable of looking after himself. As he loses still more water his blood becomes viscous and no longer flows freely enough to transport heat from deep tissues to the surface where it can be dissipated. As the loss of water approaches 18% the temperature probably rises explosively and the man probably dies quickly. By contrast a camel can lose water at least equal to 20% of its weight and still have its blood non-viscous and circulating freely. This is because the water that the camel loses comes largely from its tissues, whereas the water that a man loses comes largely from his blood.

On a warm day a man will start to sweat as soon as his temperature begins to exceed $37^{\circ}\text{C}.$; nor will his temperature fall much below $37^{\circ}\text{C}.$ even on a cold night. By contrast the temperature of a camel, especially one that is dehydrated, will fall, during the night, as low as $34^{\circ}\text{C}.$, and rise during the day to about $40^{\circ}\text{C}.$ Sweating does not begin until the body temperature exceeds $40^{\circ}\text{C}.$ Schmidt-Nielsen has estimated that an average size camel would require about 2500 kilo-calories to raise its temperature through $6^{\circ}\text{C}.$; to dissipate this much heat by sweating would require the evaporation of five litres of water. By a carefully controlled departure from strict homoiothermy the camel saves five litres of sweat a day.

The curly fur of a camel traps air which insulates the animal against the heat radiating from the sun and the hot ground. Also the fur ensures that when the camel is sweating the water will evaporate close to the skin where it can do most good.

The adaptations for water-conservation in the camel are made possible by its large size just as the adaptations in the kangaroo rat are related to its small size. The invertebrate animals that I have included in Table 2 are much smaller than the kangaroo rat and they are poikilothermic. Because they are poikilothermic and because in such small animals metabolic heat is readily dissipated by radiation they do not need to expend any water for evaporative cooling. Ticks and insects have cuticles that incorporate wax which makes them highly impermeable to water; they use almost no water for excretion because nitrogen is excreted as uric acid and the faeces are dried out in the rectum before being excreted; in addition the tick can absorb water-vapour from air with a relative humidity of 85%, and the prepupa of the *Xenopsylla* can absorb water-vapour from air with a relative humidity of 50%.

Browning (1954) showed that the tick could be dehydrated and then rehydrated in this way through about nine cycles before it eventually died (see Fig. 2). Lees (1947) showed that the tick could not absorb water-vapour in this way while the cells of the epidermis, lying immediately below the cuticle, were occupied repairing even a small area of cuticle which had been abraded with fine grit to remove the wax. From the results of these and other experiments Lees concluded that the site of water-absorption in the tick was in the cellular epidermis.

On the other hand, Mr. S. S. Walters, in Adelaide, working with the larvae of the mealworm, *Tenebrio molitor*, has shown that the power (i.e. rate of doing work) which the grubs devote to water-conservation is independent of humidity over a wide range of relative humidities; but it is closely dependent on temperature. The results of these and other experiments suggest that in *Tenebrio* water-conservation may be regarded merely as a by-product of respiration. The corollary is that the grubs of *Tenebrio* expire air that has been dried to about 90% R.H., but this hypothesis has not been confirmed empirically. If this is true for *Tenebrio* then it is also likely that the camel tick expires air that has been dried to 85% R.H. and the prepupa of the flea expires air that has been dried to 50% R.H. If this hypothesis can be verified it would suggest a mechanism for water-conservation quite different from any that is known in vertebrates. The camel and the kangaroo rat both expire water that is saturated with water-vapour at the temperature of their lungs—or at least at that of their nasal passages.

Water-conservation in the snail, *Helicella virgata*, is being studied in Adelaide by Mr. D. E. Pomeroy. Unlike the ticks and the insects, the snail seems not to be able to absorb water-vapour from humid air—its flair seems to lie in holding tenaciously to what it has already got. That this is an active process which goes on only while the snail remains alive is strongly suggested by Figure 3 which describes the changing weight of a snail that was kept continuously at $30^{\circ}\text{C}.$ in air with a relative humidity of 5%. The sharp inflexion in the curve which occurred about the 190th day coincided with the death of the snail. Similar curves could be drawn for the other 39 snails in the experiment. The average for the whole experiment is shown in Table 3.

At the beginning of the experiment a snail contained on the average 407 mg. of water; by the time of death this had fallen to 271 mg.

The figures in Table 3 allow us to speculate on the amount of work that a snail may have done (during the 234 days that it was living at 30° C. in air of relative humidity 5%) in order to conserve 271 mg. of the 407 mg. of water that it had in its body at the beginning of the experiment. If we assume that the abrupt change in the daily rate of water loss that occurred about the 234th day was caused by the death of the snail (Fig. 3) we can reasonably argue that the living snail was doing some sort

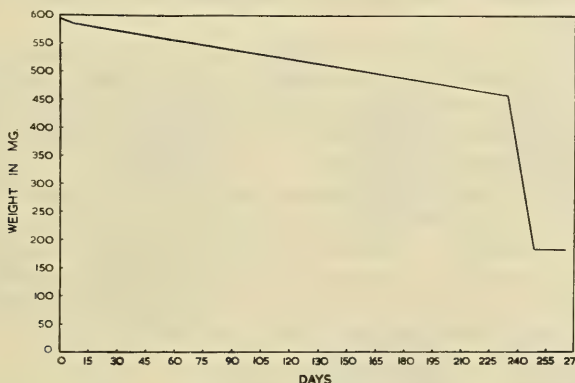


Fig. 3. The snail, *Helicella virgata*, suspended in air of 5% relative humidity at 30° C., lost weight (water) slowly until it died after 234 days.

of work that resulted in it not losing $19.830 - 0.559 = 19.271$ mg. of water a day. Now consider the analogy of a man who is pumping water into an overhead tank with a small hole in it from which the water is running away. If the hole is dripping at the rate of 19.830 gals. per hour and the amount of water in the tank, despite the man's pumping, is decreasing at the rate of 0.559 gals. per hour, by analogy the snail may be considered to be doing the equivalent of pumping 19.271 mg. of water per day into its body.

The work done by a pump is given by the equation:

$$E = Pv$$

where E is energy, P is pressure, and v is volume of fluid pumped against the pressure P . The pressure can be calculated from the equation given above; the volume, taking the density of water as 1, is 0.0198 c.cm. per day or 4.5 c.cm. in 234 days. The amount

TABLE 3.
The Mean Daily Loss of Weight (Water) by 40 Snails Kept at 30° C. in Air of 5% Relative Humidity.

Mean Weight at Beginning of Aestivation.	Mean Daily Loss of Weight During Life.	Mean Daily Loss of Weight After Death.	Mean Duration of Life.
mg. 592	mg. 0.559	mg. 19.830	days 234

of energy required to "pump" water from a place where the relative humidity is 5% (equivalent to an osmotic pressure of about 4000 atmospheres) to a place where the pressure is eight atmospheres (i.e. the body-fluids of the snail) is about 0.5 kilocalories which would require the oxidation of at least 20 times as much dry matter as the snail actually uses during its period of aestivation. Whatever the mechanism the snail may have for conserving water during aestivation, clearly there is no point in comparing it with a pump.

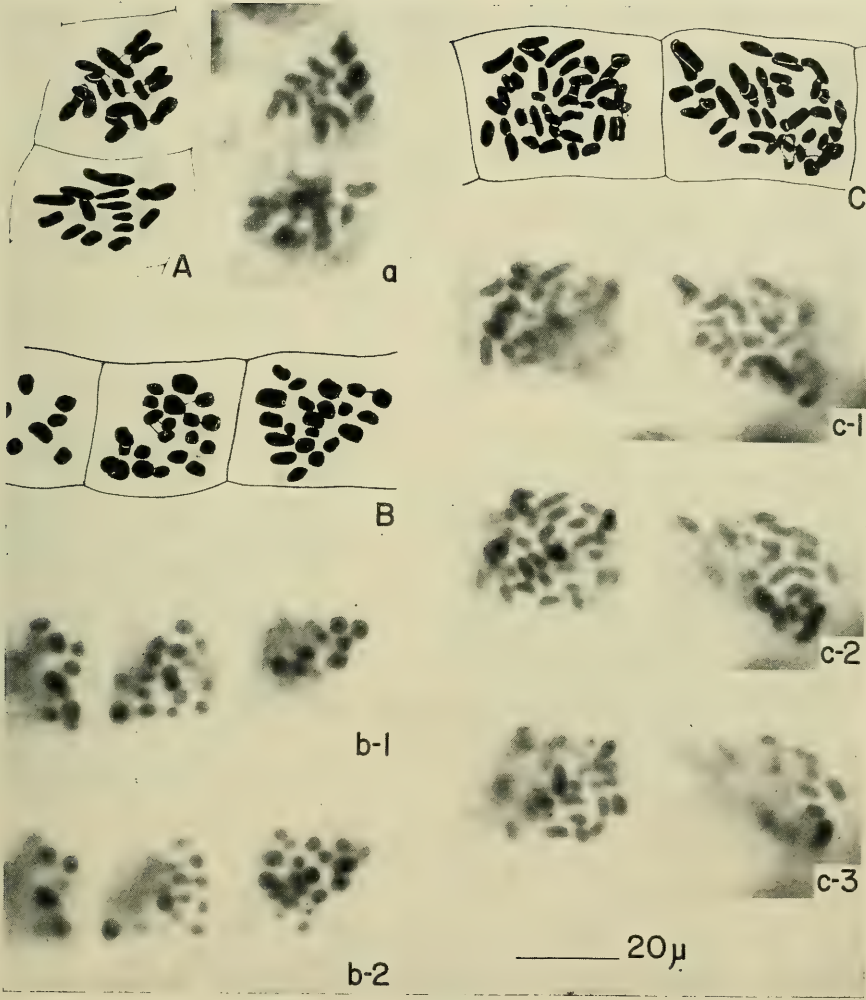
Yet it would seem to be some sort of active process. In addition to the evidence of the shape of the curve in Figure 3 Pomeroy's experiments have provided the following facts:

- (a) The conservation of water breaks down in the absence of oxygen.
- (b) When experiments, like the one from which Figure 3 was constructed, were repeated at various combinations of temperature and humidity it turned out that the duration of life was nearly independent of humidity but closely related to temperature.
- (c) The rate of loss of water depended on humidity, but even at the lowest humidities the snail seemed to have more than ample power (rate of doing work) to retain a safe amount of water in its body.
- (d) When it eventually died it seemed that death came from shortage of food rather than shortage of water.

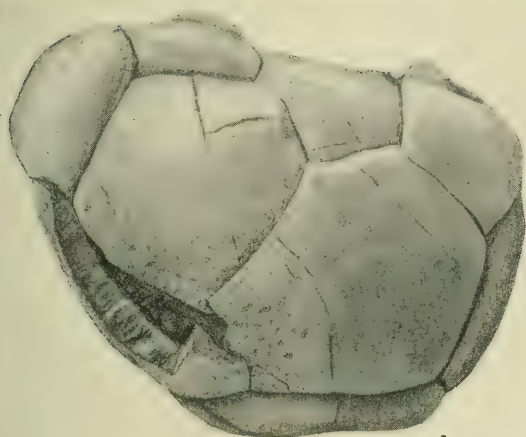
All these results, taken together, suggest an active (i.e. energetic) mechanism for water-conservation. It does not seem as if the energy is used in a process that has any resemblance to pumping; perhaps the work that the snail does is more like the process of mending holes in a ready-made wall. This is about as far as we can go at present; we still do not seem to be very close to having a plausible explanation for the way that the snail conserves water during aestivation.

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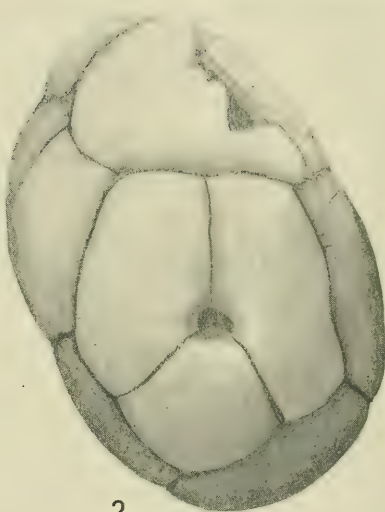
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Mitosis in *Chara leptopitys* A. Br.



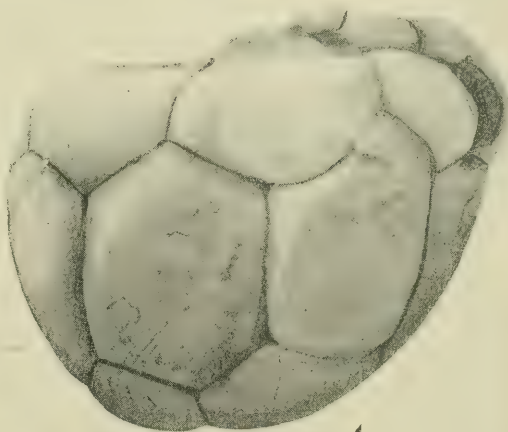
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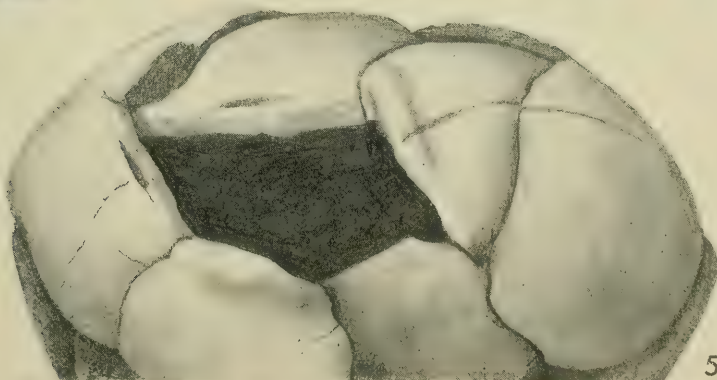
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Tribrachiocrinus clarkei McCoy.

OBSERVATIONS ON SOME AUSTRALIAN FOREST INSECTS.

20. INSECTS ATTACKING HAKEA SPP. IN NEW SOUTH WALES.

By K. M. MOORE, Forestry Commission of New South Wales.

(Plate iv.)

[Read 30th September, 1964.]

Synopsis.

Two plant species, *Hakea gibbosa* and *H. sericea*, both of which occur in New South Wales, have become widely established on agricultural land in the Republic of South Africa. To assist with information of possible value in the biological control of these plant species in South Africa, a limited investigation of the insects attacking them on the Central Coast and adjacent highlands of New South Wales was made during 1962 and 1963. From the information obtained, it appears that some of the insect species may assume importance as agents for biological control.

Some insects of *H. teretifolia*, *H. dactyloides*, *H. salicifolia* and *H. leucoptera* are also recorded.

INTRODUCTION.

In the Republic of South Africa, the encroachment on some thousands of acres of valuable pastoral and agricultural lands by the three plant species *Hakea gibbosa* (Sm.) Cav., *H. sericea* Schrad., and *H. suaveolens* R.Br., which are indigenous to Australia, has caused concern to the Department of Agricultural Technical Services of the Republic. *H. gibbosa* and *H. sericea* are also established in the north island of New Zealand.

When a request was received from the Republic of South Africa for information on insects associated with *H. gibbosa* and *H. sericea* occurring in New South Wales, with a view to the possible biological control of the *Hakea* spp. in South Africa, a limited investigation and survey to obtain relevant basic information was commenced during October, 1962.

Very limited information concerning insects attacking *Hakea* spp. in New South Wales has been published, as these plant species have been of little economic importance, and in the area of investigation they generally occur most abundantly on the poorer type soils of Hawkesbury or Gosford sandstone origin, and on steep or poorly drained, or rocky sites, which are generally not suitable for agricultural or forestry purposes.

These observations were made in the Central Coast Region and the adjacent highlands, at an approximate latitude of 33° 25' S., between the Hawkesbury River and Wyong. From records of the Department of Agriculture Citrus Experiment Station, Narara, over 47 years, the area has received an annual rainfall of from 24" to 86" with an average annual rainfall of about 50", more or less evenly distributed throughout the year. The elevation of the land surface varies from sea-level on the coastal fringe to about 1,000 ft. altitude 6 to 10 miles westward of the coastline. The general climate of the area may be regarded as warm and moist, although some seasons may be comparatively dry, with occasional maximum daily temperatures over 100° during summer, while some severe frosts in certain localities during winter have been recorded.

As observations on the following insect species and the assessment of certain species as possible agents of biological control were made during approximately 12 months only, they are essentially preliminary, and the details recorded would vary from year to year, and from one locality to another within the area. Any reliable assessment of the insect species considered for introduction to other environments must necessarily be based on more extensive and intensive observations on details of the insects' biology, together with a study of ecological factors. Development of techniques for studying and excluding the numerous parasites and predators of the insect species selected would be essential.

Some of the insect species studied are apparently host specific, but others occur on more than one *Hakea* sp. and on *Banksia*, *Persea* and *Grevillea* spp., so that the possibility of the introduced insect species attacking other than the plant species intended, in the area to which its introduction was to be considered, would need to be critically examined.

It has recently been suggested (Pimentel, 1963) that allied species and genera of parasites, rather than the particular species apparently exerting a measure of biological control in the country of origin, sometimes offer more efficient biological control of a pest species in other countries, and that greater chances for success lie with the alien species. Also, the insects available for the control of a weed are not limited to those attacking it in its native habitat, but include species that attack closely allied or other plants in other areas (Wilson, 1964).

Some of the insect species listed as occurring on *Hakea teretifolia*, *H. dactyloides*, *H. salicifolia* and *H. leucoptera* thus may be of value in the control of *H. gibbosa* and *H. sericea* in other countries.

Immature and adult stages of most of the species listed are in the collection of the Forestry Commission of New South Wales.

A. INSECTS OF HAKEA GIBBOSA.

(During these investigations, flowering of *H. gibbosa* occurred from February to September, with the greatest number of flowers during May.)

COLEOPTERA: CERAMBYCIDAE.

(i) *Aphanasium australe* (Boisd.).

Damage by larvae of this species occurs from below ground level in the larger portions of roots, to 5 ft. above ground level in the stems. Near the attacked area, the stem becomes swollen and exudes a considerable quantity of a soft colourless gum.

Larvae work in separate but contiguous galleries from which a powdery or granular material is usually extruded. As many as fourteen larvae may occur in the one area of damage on either *H. gibbosa* or *H. sericea*, and larvae of various instars may be found during most months of the year. One generation occurs each year, and adults may emerge during the period November to March. Coloration of adults is variable, some specimens being all dark brown and others having a wide median longitudinal cream-coloured area on the elytra.

Throughout the area examined, only a few plants were attacked. Most of the plants observed did not appear greatly debilitated by the current attack, and many had survived previous heavy attack, so that at present it appears that this insect species is of doubtful value as an agent for biological control. Injured plants, or those growing in apparently unfavourable sites, are attacked more readily than healthy plants.

A wasp parasite, *Aulacostethus* sp., Aulacidae, was reared from larvae.

(ii) *Uracanthus triangularis* Hope.

Damage by this species is confined to the smaller stems and branches, and larvae occur singly. The portion of the plant distal to the area of attack may be killed, so that the effect on the plant is subsequent branching below the attacked area. Damage may extend for more than 2 ft. in a single stem, with an accompanying extrusion of powdery or granular frass and a clear jelly-like gum from the attacked area. There appears to be a single generation each year, the adults emerging during January to May. *Banksia* spp. are also attacked by this longicorn.

Damage by this species appears to be of little value for purposes of biological control.

CURCULIONIDAE.

(i) *Cydmaea binotata* Lea.

Adults are often numerous on plants from August to September, and from February to April, feeding on and destroying unopened buds and tender young shoots. Oviposition sometimes occurs in the buds which may then be destroyed by the larvae.

As this species, which appears to be host specific, causes extensive damage to the buds, it could be of potential value in biological control.

(ii) *Cydmaea major* Blkb.

This species appears to offer considerable possibilities for the biological control of *H. gibbosa*, and damage was widespread and severe in the area of investigation. The seeds are destroyed by larvae, and damage to buds by adults is similar to that by *C. binotata* adults. *C. major* also appears to be host specific.

After the adults have fed during the winter months on buds, young seed capsules, or either young or mature foliage, oviposition may occur during August and the warmer months in one or both of the distal horns of a seed capsule (Pl. iv). The young larva emerges from the horn and moves over the external surface of the capsule to commence boring at almost any location on its surface. Seed capsules may be attacked before they are about one-third developed, and attack is denoted by an exudation of a colourless gum at the point of entry by the larva.

Some larvae leave the capsule which they originally entered and destroyed, to attack other capsules on the same plant. This habit, and that of moving over the surface of the capsule from the horn instead of boring directly into the capsule, would appear to expose larvae to considerable predation or parasitism, although this was rarely evident during these investigations. Most of the first or spring generation of larvae emerge from the capsules by December to pupate in the soil.

Adults of the second generation commence emerging during November and December, so that there appear to be at least three generations during a year. Throughout the winter months adults may be active during warm, sunny days, or on bushes in sheltered situations, and during cold or wet days they shelter between capsules or in previously insect-damaged capsules which have partly opened. Coloration of male and female adults is similar.

Larvae of a braconid parasite were collected during November, and adults emerged during the subsequent October and November.

Damage to the horns of seed capsules by other insects appears to reduce greatly the number of oviposition sites, and thus the numbers of subsequent generation adults of *C. major* during the late summer and autumn, although the lengthy flowering period of *H. gibbosa* provides a sequence of oviposition sites for the adults of the various generations.

(iii) *C. major* var.

One adult specimen of a uniformly grey colour was collected on *H. gibbosa*.

(iv) *Enchymus punctatonotatus* Pasc. (v) *Perperus lateralis* Boisd. (vi) *P. melancholicus* Boisd. (vii) *Syarbis niger* Roel.

Adults of *E. punctatonotatus* were present in large numbers during spring, summer and autumn, damaging young shoots, seed capsules and the smaller stems of plants. Small numbers shelter in previously insect-damaged, and partly opened, seed capsules during winter.

Adults of *P. lateralis* were very numerous, damaging and destroying young foliage and shoots during early spring; adults of *P. melancholicus* and *S. niger* caused least damage. *P. lateralis* and *P. melancholicus* have been recorded as attacking *Pinus radiata* (Moore, 1963).

Damage by each of these species is regarded as insignificant for purposes of biological control, but it appears that damage to seed capsules by *E. punctatonotatus* limits oviposition sites for *C. major*.

EUMOLPIDAE.

Geloptera porosa Lea.

Damage by adults of this species is similar to that caused by *E. punctatonotatus* and is considered as insignificant for purposes of biological control, although such damage appears to limit oviposition sites for *C. major*. Adults occur in moderate numbers during the spring, summer and autumn, and a few specimens overwinter in sheltered situations.

Egg capsules are dark brown, spherical, roughened, and are placed around the distal end of foliage about $\frac{1}{4}$ " below the tip. Adults have been recorded as damaging foliage of *P. radiata* (Moore, 1963).

Cleptor sp.

One adult was taken during March.

DIPTERA: CECIDOMYIIDAE.

Gen. et sp. indet.

Two species of this family from severely galled stems were associated with a complex of several species of Hymenoptera. Intensive investigations would be necessary to determine the part played by these species in the damage caused to the plant, and a revision of the taxonomy of the group appears necessary before accurate names can be applied to the species.

The galled stems and branches of plants die above the area of attack. Damage is widespread, and may be extensive on a single plant. It appears that the gall-forming cecidomyiids could be of considerable importance in the biological control of younger plants, provided that their numerous parasites and hyperparasites were screened.

The feeding site punctures caused by the adults of *Sertorius australis* Fairm. (Membracidae) may allow oviposition by the cecidomyiids to occur in the plant stems.

HEMIPTERA: CERCOPIDAE.

Philagra parva Don.

A single adult specimen only of this species was collected as it fed on a stem of *H. gibbosa* during September.

CICADELLIDAE.

Idiocerus sp.

One adult specimen only, feeding on a stem, was collected during April.

DERBIDAE.

Lamenia ? *kulia* Kirk.

One specimen only of this species was collected.

DIASPIDIDAE.

? *Remotaspidiotus* sp. nov.

This small white scale occurred in large numbers on the fruit and stems, and in small numbers on the foliage. It appeared to be particularly numerous on plants affected by the two species of cecidomyiids, but most specimens examined were parasitized. Because of parasitism, its role as a possible biological control agent was not evaluated under the conditions prevailing in the area of investigation.

FLATIDAE.

Siphanta granulicollis Stål.

A few specimens, feeding on stems and shoots, were collected during November and December.

ISSIDAE

Chlamydopteryx vulturnus Kirk.

A single specimen only of this species was collected.

MARGARODIDAE.

Auloiceryia ? *australis* (Maskell).

Small numbers of this species occurred on the stems and smaller branches during these investigations, and damage by them was not noticeable.

MEMBRACIDAE.

Sertorius australis Fairm.

Adults were numerous during the warmer months and small numbers persisted throughout the remainder of the year. Damage by adults of this species may allow oviposition in the stem tissues of the plants by the gall-forming cecidomyiids.

PSEUDOCOCCIDAE.

? *Paracoccus* sp.

A single specimen of this species was found on a stem during July.

TINGIDAE.

Tingis sp. near *hurdae* Drake.

A single specimen was taken during August.

HYMENOPTERA: PTEROMALIDAE (ASAPHINI).

Aphobetoideus sp.

Species of this genus have not been recorded previously from Australia (personal communication, E. F. Riek, 1963), and this species was reared from galled stems associated with the two species of cecidomyiids. It is apparently a hyperparasite. A complex of chalcidoid hyperparasites occurred in the galled stems with the cecidomyiids and Torymids, and predation by mites on larvae and pupae of all the species concerned was severe during spring.

TORYMIDAE.

Megastigmus sp.

A few adults were reared from buds of *H. gibbosa*. A hard rounded gall is formed by a larva in the centre of a bud, and this apparently kills the bud.

LEPIDOPTERA: GELECHIIDAE.

Gen. et sp. indet.

The narrow, serpentine mines of larvae occur in the foliage, and they appear dark red on the surface. Larvae mine toward the tip of the needle, and during the last instars destroy the entire parenchyma of the distal one-quarter. Larvae have been collected during March and April, and damage to the plant is slight.

GEOMETRIDAE.

(i) *Oenochroma vinaria* Guenée.

Larvae destroy foliage during February to May; pupation occurs during April and the adults emerge during May. There appear to be two generations each year, and damage to a single plant is slight. Parasitism by ichneumonids is common.

(ii) Sp. ?

Larvae of this species severely damage the green immature seed capsules by eating in to the seed and destroying about three-parts of the capsule. A single larva only was found and it was not reared to the adult stage for identification, but damage was observed in three localities. Several seed capsules on the one bush may be severely damaged by a single larva, and should mortalities of the species from parasitism be absent from areas to which it may be introduced, it should offer some potential for biological control of *H. gibbosa*.

NOTODONTIDAE.

Danima banksiae Lewin.

In the area of investigations, the extent and intensity of damage by larvae were similar to that by *O. vinaria*. Larvae occur during spring, autumn and winter, and it appears that there are two main emergence periods for adults, with considerable overlap in each generation.

XYLORYCTIDAE.

Neodrepta luteotactella (Walk.).

Damage by larvae is widespread, and relatively common during the autumn and spring, but parasitism by ichneumonids, entomophagous gordian-type worms and other factors greatly reduce their numbers. A wasp (*Bracon* sp.: Braconidae) emerged during August.

During early instars larvae bore into the tender young shoots, later feeding on foliage, stems and the surface of seed capsules under cover of their silken webbing to

which excreta are attached, on foliage or between contiguous seed capsules. Stems are often girdled by feeding larvae but are rarely killed by them. Larvae pupate during October to December, and adults emerge from November to January. Damage to a plant is considered as unimportant for purposes of biological control.

SUMMARY.—From these observations, the insect species at present appearing to offer the greatest potential importance in the biological control of *H. gibbosa* are *C. major*, *C. binotata*, the geometrid attacking the seeds, and the cecidomyiids which gall the stems.

B. INSECTS OF *HAKEA SERICEA*.

(During the period of observations, the plants flowered from early June to late October.)

COLEOPTERA: BUPRESTIDAE.

Gen. et sp. indet.

Larvae of this species mine below the thin outer bark of the stems, but damage does not appear to affect the plants adversely.

CERAMBYCIDAE.

Aphanasium australe.

Damage to *H. sericea* is the same as that occurring on *H. gibbosa*.

CURCULIONIDAE.

(i) *Cydmaea eucalypti* Lea.

Adults of this species feed on buds, shoots, foliage and probably seeds. They oviposit in some flower buds which may then be destroyed by the larvae. Adults were present in small numbers during April, and in large numbers during May, June and July. Numerous buds and young shoots were destroyed by larvae during July and August, and larvae were mining in foliage during November.

Because of the extent of damage to flower buds by this species, and its ability to survive in foliage and shoots of the host plant, it appears to offer a considerable potential for biological control of *Hakea sericea*.

(ii) *Enchymus punctatonotatus*. (iii) *Syarbis niger*.

Damage by these two species is similar to that on *H. gibbosa*.

EUMOLPIDAE.

Geloptera porosa.

Damage is similar to that on *H. gibbosa*.

SCOLYTIDAE.

(i) *Hypocryphalus moorei* Schedl. (ii) *Hypothenemus eruditus* Westw.

Damaged or debilitated stems are attacked by large numbers of larvae of the former species working beneath the thin bark. The stems from which these two species were reared were previously fire-damaged.

HEMIPTERA: DIASPIDIDAE.

? *Remotaspidiotus* sp. nov.

MEMBRACIDAE.

Sertorius australis.

PSEUDOCOCCIDAE.

Paracoccus sp. nov.

Damage by these three species is similar to that which they cause on *H. gibbosa*.

HYMENOPTERA: TORYMIDAE.

Megastigmus sp.

Damage by gall formation in a few buds is similar to that which occurs in buds of *H. gibbosa*.

LEPIDOPTERA: ANTHELIDAE.

Anthela ? acuta (Walk.).

A larva of this species was collected on foliage during May, and pupation occurred during July. Light damage only occurred.

GELECHIIDAE.

Gen. et sp. indet.

GEOMETRIDAE.

O. vinaria.

Damage by these two species on *H. sericea* was similar to that by the same species on *H. gibbosa*.

LIMACODIDAE.

? Anapaea sp.

A single larva was collected from foliage during June, but little damage occurred.

NOTODONTIDAE.

Teara variegata Walk.

A larva was collected on foliage during June, and damage was slight. Larvae attain a length of $2\frac{3}{4}$ " during late instars, and damage to foliage may be severe if a large number occurs on the one plant. This species is also recorded as attacking *P. radiata* (Moore, 1963).

OECOPHORIDAE.

Arachnographa micrastrella Walk.

Light damage to foliage and stems by larvae occurred during April, and it is considered that the species is of no value for biological control. It has also been recorded attacking *Pinus* spp. (Moore, 1963).

XYLORYCTIDAE.

(i) Gen. et sp. indet.

Larvae of this species destroy the seed by boring into the larger capsules. The species was not plentiful during these observations, but should large numbers occur they could be of considerable importance as a biological controlling agent.

(ii) *N. luteotactella*.

Damage is similar to that by the same species on *H. gibbosa*.

? (Family unknown.)

Small lepidopterous larvae mine beneath the thin bark of stems, and damage is similar to that caused by larvae of the Family Buprestidae.

SUMMARY.—The insect species considered to be of greatest potential importance for the biological control of *H. sericea* are *C. eucalypti*, the xyloryctid attacking the seeds, and possibly *T. variegata*.

C. INSECTS OF HAKEA TERETIFOLIA (SALISB.) J. BRITTEN.

(This plant species was in full flower from late December to late January, and was the *Hakea* sp. most plentiful and widespread occurring throughout the area of investigation. Although establishment of this and the following *Hakea* spp. has not been reported beyond Australia, insects associated with them are recorded.)

COLEOPTERA: CURCULIONIDAE.

(i) *Cydmaea diversa* Lea.

Larvae attack buds, foliage and flowers to such an extent that the setting of seed is greatly reduced. Adults occur in large numbers during January and February, and pupation occupies about 26 days.

(ii) *Cydmaea luctuosa* Pasc.

Damage by larvae was severe in the foliage of some plants. A larva was reared to the adult stage, pupation occupying about three weeks, and the adult emerged during March.

(iii) *Cydmaea crassirostris* Blkb.

The young green seed capsules which form in the absence of attack on buds and flowers by *C. diversa* may be destroyed by larvae of this species. Pupation occupies about three weeks, the adults emerging during March.

(iv) *E. punctatotonotatus*.

Damage was more extensive than that on *H. gibbosa* and *H. sericea*, and many young green seed capsules were destroyed. Adults are numerous throughout the warmer months.

(v) *P. lateralis*.

Less damage occurred on *H. teretifolia* than on *H. gibbosa*.

EUMOLPIDAE.

G. porosa.

Damage was more severe than on *H. gibbosa* and *H. sericea*, and young green seed capsules were also attacked.

HEMIPTERA: COCCIDAE.

? *Coccus* sp.

One specimen only occurred on a stem.

DIASPIDIDAE.

(i) *Phaulaspis hakeae* (Maskell).

These small rounded orange-red scales were numerous on some plants in certain localities, but damage was not evident.

(ii) ? *Remotaspidotus* sp. nov.

Scales occurred on stems and seed capsules.

FLATIDAE.

Siphanta acuta Walk.

A few specimens only occurred, and damage was not evident. The species has been reported as feeding on *P. radiata* (Moore, 1963).

MARGARODIDAE.

A. australis.

Specimens were more numerous on this plant species than on *H. gibbosa*, but damage was not evident.

MEMBRACIDAE.

S. australis.

Damage was similar to that on the other *Hakea* spp.

PSEUDOCOCCIDAE.

Paracoccus sp. nov.

A few specimens only occurred, and damage was not evident.

HYMENOPTERA: TORYMIDAE.

Megastigmus sp.

Large numbers occurred in buds and carpels, so that very few buds on some plants remained unaffected after heavy attack. This species offers effective control of the plants' ability to set seed.

LEPIDOPTERA: GELECHIIDAE.

Gen. et sp. indet.

Damage to flowers was severe in some areas, and the distinctive larvae, bearing alternate rose-red and white transverse bands, sheltered in fine webbing spun among

flowers near where they fed on the blossoms and opening shoot buds. Only small numbers occurred, and they were most numerous during early spring. Flowers of *Grevillea linearifolia* are also attacked by larvae of this species.

NOTODONTIDAE.

D. banksiae.

Damage was limited, and similar to that on *H. gibbosa*.

XYLORYCTIDAE.

(i) *Xylorycta strigata* Lewin.

Larvae bore in the small stems of *H. teretifolia*, *Banksia integrifolia*, *B. spinulosa*, *B. serrata* and *G. linearifolia*, killing attacked stems. Moderate numbers occurred in *Banksia* spp. and small numbers in *Hakea* spp.

(ii) *N. luteotactella*.

Damage was similar to that on other *Hakea* spp.

SUMMARY.—The insect species considered to be of greatest importance for the biological control of *H. teretifolia* are *C. diversa*, *C. crassirostris* and *Megastigmus* sp.

D. INSECTS OF HAKEA DACTYLOIDES (GAERTN.) CAV.

(Plants of this species were in full bloom during late November.)

HEMIPTERA: DIASPIDIDAE.

Phaulaspis hakeae (Maskell).

Large numbers occurred in some localities, but damage was not evident.

HYMENOPTERA: TORYMIDAE.

Megastigmus sp.

Numerous mortalities of buds occur from attack by this gall-forming wasp which appears to be the principal insect species limiting regeneration of *H. dactyloides*.

LEPIDOPTERA: GELECHIIDAE.

Gen. et sp. indet.

This is the same species as that which damages flowers of *H. teretifolia*, and damage is similar.

TORTRICIDAE.

Gen. et sp. indet.

The pale green larvae of this species damage numerous flowers of *H. dactyloides* and *G. linearifolia*. Adults are uniformly grey.

SUMMARY.—The insect species considered to be of greatest importance for the biological control of *H. dactyloides* is *Megastigmus* sp.

E. INSECTS OF HAKEA SALICIFOLIA (VENT.) B. L. BURTT.

HEMIPTERA: DIASPIDIDAE.

Phaulaspis hakeae (Maskell).

Larger populations than on *H. teretifolia* occurred on some plants, but damage was not evident.

LEPIDOPTERA: GRACILARIIDAE.

Acrocercops nr. *argyrodesma* (Meyr.).

Larvae mine in the young leaves and construct mines which are at first linear and then blotch in form. Larvae were numerous during December, and adults emerged during the same month. The life cycle occupies about five weeks at that time of the year.

SPHINGIDAE.

Coequosa triangularis Don.

Moderate damage occurred to foliage of *H. salicifolia*, *Banksia serrata* and *B. integrifolia*, and without the considerable control exerted by parasites damage may assume importance in the control of this *Hakea* sp. Larvae were reared on *Persoonia* sp.

SUMMARY.—The insect species considered to be of greatest importance in the biological control of *H. salicifolia* is *C. triangularis*, but its wide host range could detract from its importance.

F. INSECTS OF HAKEA LEUCOPTERA R.Br.

(This species was in full flower during early October. It occurs near the western extremities of the Central Western Slopes, where rainfall averages about 14" per annum, and temperatures are high, with restricted rainfall, during the summer months.)

COLEOPTERA: CURCULIONIDAE.

Cydmaea ? *diversa*.

Damage to flowers was severe during October and November, and from pupation to the adult stage occupied about three weeks.

DIPTERA: CECIDOMYIIDAE.

Gen. et sp. indet.

Damage by larvae causes foliage to become distorted, and may be severe on some branches.

HEMIPTERA: MEMBRACIDAE.

Cornutipo scalpellum Evans.

Adults occurred in large numbers during April, May, September and October, and adults and nymphs were attended by large numbers of ants. Punctures in stems by feeding adults may allow oviposition by the cecidomyiids mentioned above.

PSYLLIDAE.

Aconopsylla sp. nov.

Large numbers of nymphs and a few adults occurred during April and May, and young shoots were severely affected by them.

HYMENOPTERA: TORYMIDAE (MEGASTIGMINAE).

Gen. et sp. indet.

Larvae produce a "pineapple-top" formation in buds which are galled. Attack may be moderate to heavy during April, and adults emerge during May.

LEPIDOPTERA: XYLORYCTIDAE.

Xylorycta sp.

Larvae bore in stems, and sometimes girdle the stems externally. Those collected during early October pupated during November and adults emerged during November. Damage may be severe on small plants.

SUMMARY.—The insect species considered to be of some potential importance in the control of *H. leucoptera* are *C. ? diversa*, the torymid forming bud-galls, and *Xylorycta* sp.

CONCLUSION.

From observations in the area of investigations on the Central Coast of New South Wales it is evident that fire contributes considerably to the spread of *Hakea* spp., and, should an area be kept free from fire, regeneration is very limited. Fire causes the thick woody fruits to open and shed the seeds which are undamaged by the fire. In areas where no fire had occurred, some plants had retained the unopened seed capsules for at least five years.

Fire has often damaged the stands of *Hakea* spp. in the Republic of South Africa (personal communication, Mr. D. Webb, 1963), so that it has apparently been a contributing factor in the spread, and increase in density, of the *Hakea* spp. in that area.

The insects recorded in this paper, and their plant associations, are summarized in Table 1.

Acknowledgements.

The writer is grateful to the following for the identifications of the insects studied in these investigations: Dr. A. R. Brimblecombe, Department of Primary Industries, Brisbane (Coccidae, Diaspididae); British Museum Staff (Aulacidae, Cercopidae,

TABLE 1.

Summary of Insect-Hakea spp. Associations.

B.=Bud, F.=Flower, Fo.=Foliage, Fr.=Fruit, S.=Stem.

	H. gibbosa.	H. sericea.	H. teretifolia.	H. dactyloides.	H. salicifolia.	H. leucoptera.
COLEOPTERA						
BUPRESTIDAE	—	S.	—	—	—	—
CERAMBYCIDAE						
<i>Aphanasium australe</i>	S.	S.	—	—	—	—
<i>Uracanthus triangularis</i>	S.	S.	—	—	—	—
CURCULIONIDAE						
<i>Cydmaea binotata</i>	B., F., Fo.	—	—	—	—	—
<i>C. crassirostris</i>	—	—	Fr.	—	—	—
<i>C. diversa</i>	—	—	F., Fo., Fr.	—	—	—
<i>C. ? diversa</i>	—	—	—	—	—	F.
<i>C. eucalypti</i>	—	B., Fo.	—	—	—	—
<i>C. luctuosa</i>	—	—	Fo.	—	—	—
<i>C. major</i>	B., Fo., Fr.	—	—	—	—	—
<i>C. major</i> var.	?	—	—	—	—	—
<i>Enchymus punctatotonotatus</i>	Fo., Fr., S.	Fo., Fr., S.	Fo., Fr., S.	—	—	—
<i>Perperus lateralis</i>	Fo.	—	Fo.	—	—	—
<i>P. melancholicus</i>	Fo.	—	—	—	—	—
<i>Syarbis niger</i>	Fo.	Fo.	—	—	—	—
EUMOLPIDAE						
<i>Geloptera porosa</i>	Fo., Fr. S.	Fo., Fr., S.	Fo., Fr. S.	—	—	—
SCOLYTIDAE						
<i>Hypocryphalus moorei</i>	—	S.	—	—	—	—
<i>Hypothenemus eruditus</i>	—	S.	—	—	—	—
DIPTERA						
CECIDOMYIIDAE						
Gen. et sp. indet.	S.	—	—	—	—	—
" " " "	S.	—	—	—	—	—
" " " "	—	—	—	—	—	Fo.
HEMIPTERA						
CERCOPIDAE						
<i>Philagra parva</i>	S.	—	—	—	—	—
CICADELLIDAE						
<i>Idiocerus</i> sp.	S.	—	—	—	—	—
COCCIDAE						
? <i>Coccus</i> sp.	—	—	S.	—	—	—
DERBIDAE						
<i>Lamenia kulia</i> ?	S.	—	—	—	—	—
DIASPIDIDAE						
<i>Phaulaspis hakeae</i>	—	—	S.	S.	S.	—
<i>Remotaspidotus</i> sp.	Fo., Fr., S.	S.	Fr., S.	—	—	—
FLATIDAE						
<i>Siphanta acuta</i>	—	—	S.	—	—	—
<i>S. granulicollis</i>	S.	—	—	—	—	—
ISSIDAE						
<i>Chlamydopteryx vulturinus</i>	S.	—	—	—	—	—
MARGARODIDAE						
<i>Auloiceryia australis</i>	S.	—	S.	—	—	—
MEMBRACIDAE						
<i>Cornutipo scalpellum</i>	—	—	—	—	—	S.
<i>Sertorius australis</i>	S.	S.	S.	—	—	—
PSEUDOCOCCIDAE						
<i>Paracoccus</i> sp. nov.	S.	S.	S.	—	—	—
PSYLLIDAE						
<i>Aconopsylla</i> sp. nov.	—	—	—	—	—	Fo.
TINGIDAE						
<i>Tingis</i> nr. <i>hurdae</i>	S.	—	—	—	—	—
HYMENOPTERA						
PTEROMALIDAE						
<i>Aphobetoideus</i> sp.	S.	—	—	—	—	—
TORYMIDAE						
<i>Megastigmus</i> sp.	B.	B.	B.	B.	—	B.

TABLE 1.—Continued.

			<i>H.</i> <i>gibbosa.</i>	<i>H.</i> <i>sericea.</i>	<i>H.</i> <i>teretifolia.</i>	<i>H.</i> <i>dactyloides.</i>	<i>H.</i> <i>salicifolia.</i>	<i>H.</i> <i>leucoptera.</i>
LEPIDOPTERA								
ANTHELIDAE								
Gen. et sp. indet.	..	..	—	Fo.	—	—	—	—
GELECHIDAE								
Gen. et sp. indet.	..	..	Fo.	Fo., F.	—	F.	—	—
GEOMETRIDAE								
? .. .. .	..	..	Fr.	—	—	—	—	—
<i>Oenochroma vinaria</i>	..	..	Fo.	Fo.	—	—	—	—
GRACILARIIDAE								
<i>Acrocercops</i> nr. <i>argyrodesma</i>	..	..	—	—	—	—	Fo.	—
LIMACODIDAE								
<i>Anapaea</i> ? sp.	..	..	—	Fo.	—	—	—	—
NOTODONTIDAE								
<i>Danina banksiae</i>	..	..	Fo.	—	Fo.	—	—	—
<i>Teara variegata</i>	..	..	—	Fo.	—	—	—	—
OECOPHORIDAE								
<i>Arachnographa micrastrella</i>	..	..	—	S., Fo.	—	—	—	—
SPHINGIDAE								
<i>Coequosa triangularis</i>	..	..	—	—	—	—	Fo.	—
TORTRICIDAE								
Gen. et sp. indet.	..	..	—	—	—	F.	—	—
XYLOXYCTIDAE								
<i>Neodrepta luteotactella</i>	..	..	Fo., Fr., S.	Fo., Fr., S.	Fo., Fr., S.	—	—	—
<i>Xylorycta strigata</i>	..	..	—	—	S.	—	—	—
<i>Xylorycta</i> sp.	..	..	—	—	—	—	—	S.
Gen. et sp. indet.	..	..	—	Fr.	—	—	—	—
FAMILY unknown	..	..	—	S.	—	—	—	—

Curculionidae, Derbidae, Eumolpidae, Flatidae, Issidae, Tingidae); Miss H. M. Brookes, Waite Agricultural Research Institute, Adelaide, South Australia (Margarodidae, Pseudococcidae); Mr. I. F. B. Common, Division of Entomology, C.S.I.R.O., Canberra (Geometridae, Gracilariidae, Notodontidae, Oecophoridae, Xyloryctidae); Dr. J. W. Evans, Director, The Australian Museum, Sydney (Cicadellidae, Membracidae); Mr. G. F. Gross, South Australian Museum, Adelaide (Curculionidae); Mr. E. F. Riek, Division of Entomology, C.S.I.R.O., Canberra (Pteromalidae, Torymidae); Dr. K. E. Schedl, Lienz, Osttirol, Austria (Scolytidae); Mr. C. N. Smithers, The Australian Museum (Cerambycidae, Sphingidae); Mr. K. L. Taylor, Division of Entomology, C.S.I.R.O., Canberra (Psyllidae). The identifications of the *Hakea* spp., for which the writer is grateful, were made by Dr. Mary Tindale, of The National Herbarium, The Royal Botanical Gardens, Sydney. Thanks are expressed to my colleague, Mr. P. Hadlington, for criticism of the manuscript and for the photography.

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EXPLANATION OF PLATE IV.

Upper seed capsule showing hole made by larva of *Cydmaea major* Bk. when emerging from capsule of *Hakea gibbosa* to pupate. The distal horns, in which oviposition by adults occurs, are shown on the lower capsule.

Photo by P. Hadlington.

A REVIEW OF THE MARSUPIAL GENUS *SMINTHOPSIS* (PHASCOGALINAE) AND DIAGNOSES OF NEW FORMS.

By ELLIS TROUGHTON.

(Seven Text-figures.)

[Read 30th September, 1964.]

INTRODUCTION.

In his arrangement of the Genus *Sminthopsis* in the British Museum *Catalogue of the Marsupialia* (1888) Oldfield Thomas was limited to such sparse and inadequately localized material that this mouse-like group of terrestrial marsupials, with the description of additional species, has become involved in hopeless confusion. Referring to the unusually negative diagnostic features of the genus, Thomas, in a footnote to his "Synopsis of Species", stated that "Owing to the close resemblance existing between the skulls and teeth of the different species of *Sminthopsis* it has been found impossible to make this synopsis very definite in its details, but it is nevertheless thought useful to draw attention to such characters as, by reference to the fuller descriptions, will assist in the identification of specimens".

Lack of specific series also rendered his diagnoses of the physical characteristics far too general on such specific criteria as the sole-pad pattern, and the presence or absence of smooth or minutely striated apical areas. The comparative length and degree of incrassation of the tail also proves to be variable in individuals of several species, according to seasonal and environmental conditions. Such variation, combined with the general lack of distinctive coloration, has created the impression that specific differentiation is often impossible. As a result, specific relationships have been hopelessly confused, and a preposterous distribution attributed to several of the species.

The diagnostic pattern of the pads at the base of the toes may briefly be defined as: (a) In *crassicaudata* fine overall granulations, the subspecies *centralis* with an enlarged row of granules down the centre of each pad; (b) In *murina/leucopus* a longitudinal apical row of enlarged granules which, with wearing down, may appear as faintly serrated apical pads; (c) In *lumholtzi* the well-defined oblong-ovate apical areas have microscopic transverse striae, not conceivably due to granular wearing down; (d) In *larapinta* there is a small smoothly rounded apical area set amongst the relatively minute granules, as distinct from the enlarged apical "bead" on the pads of *macrura*. Two notable exceptions, *Sm. hirtipes* and *longicaudatus*, have the soles as subsequently described and figured.

Confusion regarding these sole-pad patterns has resulted mainly from a general neglect of the elementary collecting method never to skin the first specimen of any small mammal from each location, and then alternatively to skin and preserve specimens of a series in spirits. Not only are the sole-pads distorted by drying, but pinning-down through the apical pads obliterates their pattern. The feet should invariably be held down by pins crossed at the middle, preferably with the soles upward to avoid flattening the pads. The specific importance of the sole pattern in a genus so lacking in distinctive coloration and cranial characters is indicated by the following summary.

In his description of *murina* in the *Catalogue*, Thomas recognized a variation in the sole-pads (due to wear in this species) when stating that the finely granulated projections at the base of the toes were without "distinct transversely striated pads, although on their summits several of the granulations sometimes coalesce and form small irregular and smooth pads". This observation anticipated the eventual subspecific merging by Tate (1947) of *leucopus* of Tasmania and *ferruginifrons* (N.S.W.) with

murina. But evidently neither Thomas nor Tate appreciated that in *murina* wearing down of the apical rows of enlarged granules tends to produce smooth oblong apical areas, with the grooves between the worn granules appearing as transverse striations.

Evidently, failure to apply this coalescence of granules specifically resulted in Thomas according his "*leucopus*" a phenomenal range from Cape York to Tasmania, while restricting *murina* to "Australia south of the tropics". In doing so, Thomas misapplied the description and figure of the sole-pads of a "Cape York" specimen of *lumholtzi* to his description of *leucopus*. Because the feet of Gray's type of *leucopus* (Tasmania) were dried and distorted, Thomas, in his *Catalogue*, was evidently dependent on the two spirit specimens of the six listed for *leucopus* when describing and figuring the feet as having striated apical and hallucal pads.

However, examination of Pl. xxiii in the *Catalogue* makes it obvious that no wearing down of the apical granules depicted for *murina* (Fig. 7) could conceivably produce the clearly defined and minutely striated apical areas shown for *leucopus* (Fig. 6). From the relatively much larger foot and sole-pattern depicted for his "*leucopus*", compared with that of *murina*, it seems obvious that Thomas chose the Cape York specimen to illustrate the pes of his *leucopus* (*sensu lato*). This specimen cannot now be traced in the British Museum, or the Queensland Museum from which it was borrowed, but beyond doubt the pes figured for *leucopus* in the *Catalogue* agrees completely with the pes of the much larger-skulled *Sm. lumholtzi* Iredale & Troughton (1934), a replacement name for the species described as *Phascologale virginiae* by Collett (1886 and 1887), and not of De Tarragon (1847).

The holotype of *lumholtzi* is the specimen in the Oslo Museum, collected by Carl Lumholtz at Herbert Vale on the southern slopes of the Atherton Tableland, N.E. Queensland. While confirming Collett's description of the distinctive cranial characters of this specimen, in the *Catalogue* under "*Sminthopsis virginiae*", Thomas added that its sole-pads so far as discernible in the dried specimen were "precisely like those of *Sm. leucopus*". Therefore, the sole-pattern figured for *leucopus* (Pl. xxiii, 6) and presumably drawn from the "Cape York" spirit specimen is characteristic of *lumholtzi*, and not of *leucopus* = *murina* as previously assumed.

Because this assumption is responsible for much subsequent confusion regarding the presence or absence of striated apical pads, the question has been reviewed in detail before proceeding with a review of the genus. It is not necessary to discuss the "grouping" of species, essayed by Tate in his "Revision of the Dasyuridae" (1947), because preoccupation with fitting species of extremely generalized characters into groups, on limited material and without due knowledge of zoo-geographical conditions, has prejudiced the diagnostic value of Tate's important review of the genus *Sminthopsis*.

The *crassicaudata*-*macrura* Complex.

Originally described as *Phascogale crassicaudata* by Gould (1844) from the Williams River south of Perth (W.A.), this small species is readily identified by the uniformly fine granulation of the sole-pads, the large "leafy" ear with contrasting blackish marks on the outer anterior and inner margins of the lobe, and especially by relatively the shortest and most consistently incrassated tail of any species. Gould described and figured the tail (*Mamm. Austr.*, Pl. 47) as "much swollen, especially in the middle" which imparts the "spindle-shaped" character of the tail of *crassicaudata*, and which is in absolute contrast with the tail of *macrura* figured by Gould (Pl. 46).

The striking contrast in both form and colour makes it difficult to comprehend why Thomas, without explanation, placed *macrura* as a synonym of *crassicaudata* in the *Catalogue*; he also synonymized *froggatti* Ramsay (1887) the year after its description, from the coast near Derby, about 1,100 miles north of the type locality of *crassicaudata*. But Tate (1947) confirmed the specific status of *macrura* after examining the two "topotypes" from S.E. Queensland in the British Museum. Unfortunately, Tate made the cranial comparison with *murina* and, uncertain of the specific affinity of *crassicaudata centralis*, actually included *froggatti* of the north-west coast as a race of the eastern *macrura*.

Lack of adequate localized material and general knowledge of the zoo-geographical complex of soils and vegetation evidently confused the specific problems for both Thomas and Tate. For example, in the *Catalogue* Thomas listed only nine specimens of *crassicaudata* while recording the habitat as the "Whole of Australia (not yet recorded from the extreme north)". Included were Gould's type from south of Perth (W.A.), and the "co-types" of his *macrura* from the Darling Downs, S.E. Queensland. One specimen from the Darling River (N.S.W.) collected by the explorer Charles Sturt, and another from "South Australia" presented by Sir George Grey, when Governor of the State, are in the British Museum. The remaining three specimens are listed as "Purchased", from West Australia, Melbourne, and Queensland.

The subspecific distinction of *crassicaudata centralis* Thomas (1902) was confirmed by Finlayson (1933) in reviewing the Dasyuridae of the Lake Eyre Basin (S.A.). He also recorded an extraordinary increase of *centralis* accompanying the migratory waves of *Mus musculus* from north to south in 1930-1932. Coincidentally, an increase of the southern form was observed in settled areas along the Murray River east to Mildura. Specimens of the short-tailed "typical" *crassicaudata* are in the Australian Museum south-east to Albury (N.S.W.). But northward to the Queensland border, east of the coastal ranges, extensive series of Museum specimens display a bewildering variation with increasing size, while retaining the characteristic tail-formation and fine granulation of the sole-pads.

However, quite typical specimens of *centralis* in the Australian Museum extend its range some 150 miles across the South Australian border, to Thylungra in south-western Queensland. Because neither these specimens of *centralis*, nor the series assigned to *crassicaudata* from northern New South Wales, are reconcilable with Gould's description and colour-plate of *macrura*, it is accorded specific status, pending examination of the syntypes in the British Museum. This view is supported by specimens in the collections of the Australian and Queensland museums, as recorded in the descriptive notes on *macrura*.

SMINTHOPSIS CRASSICAUDATA CENTRALIS Thomas.

Sminthopsis crassicaudata centralis Thomas, 1902, *Ann. Mag. Nat. Hist.*, (7), 10, p. 492. Type from Killalpaninna, east of Lake Eyre, S.A.

Diagnosis. According with the detailed comparative description by Finlayson (1933); a longer-tailed and more brightly-coloured race, the colour ranging from the "pale isabella" of the type, through buffy grey, to "rich vinaceous cinnamon". The variable incracration of the tail at its maximum development may be greater than in the typical race (Finlayson, 1933). Sole-pads more coarsely granulate, with the outer inter-digital pads less inflated, and the three pads with a single row of enlarged granules down the midline, compared with the overall fine granulation in the typical form. Cranial and dental differences slight, the canine averaging longer but variable in lateral contour; pm^1 larger, and pm^3 and pm^4 almost subequal, the disproportion therefore less than the typical *crassicaudata*. Mammae 8 or 10.

Specimens examined. An adult ♀ from no. 1 bore 64 miles south of Innamincka (S.A.) is reasonably topotypical, also four from around Innamincka, near the Queensland border, collected in 1961 by Basil J. Marlow and R. D. Mackay; a pair from Thylungra (Q'ld) 260 miles east of Birdsville, presented by Dr. G. Gregory; and a pair from Barcarolle Station on the Thompson River, 130 miles south-west of Longreach, presented by the late F. L. Berney; in the Australian Museum.

Remarks. The bright dorsal coloration ranges from a topotypical pale isabella through cinnamon-buff to clay colour (Ridgway). Measurements in adults of both sexes are: ear-length 19-21.8; tail 66-71, somewhat longer than Finlayson's 64-66; pes 15-17 mm. The variable profile of the upper canine may assume the shorter "premolariform" shape, with a distinct posterior talon, as described by Tate (1947, p. 124) for a ♀ from the Birdsville area, over the Queensland border about 200 miles north of Killalpaninna. This A.M.N.H. specimen (fide Tate) "agrees in all essential features with the type of *stalkerii*", listed as a race of *larapinta* by Tate. As the comparative features of a strongly

incrassated and pedunculate tail (65–68 mm.), wholly granular pads, and large ears are equally comparable with *centralis*, further examination of the type of *stalkeri* may prove it synonymous with this northern race of *crassicaudata*. Despite Tate's understatement of the distance between the type locality of *stalkeri* on Alroy Downs, 250 miles from the Gulf of Carpentaria, in allying the Birdsville specimen, a comparison with *centralis* would seem more convincing because of the occurrence of that subspecies from intermediate localities. Also because Thomas made no reference to his *centralis* in describing *stalkeri*, while Tate wrongly regarded *centralis* as a race of *macrura* of south-eastern Queensland.

The suggestion by Tate (*loc. cit.*, p. 122) that *murina constricta* may equal *centralis*, as a race of *macrura*, is not sustained by the few objective details of Spencer's description, which also do not support the association of *constricta* as a "variety" of *murina*.

SMINTHOPSIS MACRURA Gould.

Podabrus macrurus Gould, *Proc. Zool. Soc. London*, 1845, p. 79; *id.*, *Mamm. Austr.*, 1849, Pl. 46 (animals). Locality, Darling Downs, S.E. Queensland.

Syntypes. Two in the British Museum, Nos. 46.4.4.62 & 87.5.4.1; a third in the Liverpool Museum destroyed by enemy action.

Diagnosis. According to Gould's description and colour-plate, as in contrast with his description and figure of the typical *crassicaudata* (Pl. 47). The decidedly longer tail, incrassated for about the basal 3rd, tapering to a slender tip, and darker and more coarsely haired; tail length of adults examined 77–82 mm., compared with 80.5 (about $3\frac{3}{12}$ in.) given by Gould from a "co-type". Ear relatively short, 16.5–17 mm., with less contrasted markings. Sole-pads with coarser granulations, and small rounded apical "beads" equalling 2 or 3 granules.

The cranial and dental measurements of an unsexed co-type skull of *macrura* from the Darling Downs, listed in the *Catalogue*, against those of a presumably typical specimen of *crassicaudata*, indicate some slight disparity in proportions. However, the upper canines are relatively longer and broader based, and the premolars are characterized by the very small pm^1 being about half the size of pm^3 , which is less than half the size of pm^4 . The relative smallness of the 1st and 3rd premolars distinguishes *macrura* from both northern and southern (N.S.W.) forms of *crassicaudata*, and from *centralis*, which have relatively subequal premolars.

Specimens examined. In the Australian Museum, a young adult ♀ (M.7402) from the Warialda district, 30 miles east of Moree (N.S.W.), and two sub-adults (♀) from Mungindi on the Queensland border; lent from the Queensland Museum, an adult ♂ (J.5746) from Oberina near Roma, an adult ♂ from Texas, on the border east of Goondiwindi, and three more or less adult specimens, from Milmeran on the Darling Downs, Dalby, and the Rannes district, 100 miles north of Mundubbera, south-east Queensland.

Remarks. The specific status of *macrura* is confirmed by specimens in the Australian Museum from Mungindi on the Queensland border (ear-length 15–16 mm.), and by several specimens of the large-eared northern form of *crassicaudata* (ear 20–23 mm.) from the same district. A young adult ♀ of *macrura* (M.7402) from the Warialda district, 100 miles south-east of Mungindi, with an ear-length 16.5 and tail 81.5 mm., also supports specific distinction in comparison with an unusually long-tailed breeding ♀ of *crassicaudata* from Mungindi (ear 20 and tail 67 mm.). A sub-adult ♂ from Cunnamulla (Q'ld), 200 miles north-west of Mungindi, provides the western-most record of the northern form of *crassicaudata*, thus confirming the distinction of *macrura* and circumscribing its range.

A Queensland Museum adult ♂ (J.5746) from the Roma district (Q'ld) has a remarkable thickening of the tail-base (7.3 mm.), as described by Gould ($3\frac{1}{2}$ lines—7.5 mm.) for a "co-type" of *macrura* from the adjacent Darling Downs. This seasonal fattening, as with the pigmy phalanger (*Dromicia*), markedly changes the appearance of the tail by expansion of the skin and hair, but the outer half tapers to a slender point, as described and figured by Gould. While this variable feature is reduced in drying of

the skin, some indication may have influenced Thomas to identify *macrura* with *crassicaudata* in the *Catalogue*.

However, Tate's examination of the syntypes of *macrura* (1947, p. 122) supported its specific distinction. Unfortunately, his cranial comparison with *murina* provided no diagnostic criteria, and certainly no evidence warranting the inclusion of *centralis* and *froggatti* as subspecies of *macrura*; and least of all Spencer's *constricta* from Oodnadatta, 100 miles west of Lake Eyre, with a relatively very broad foot. The adult male in the A.M.N.H. listed by Tate as from Malbon "west of Townsville, Central Queensland", is actually from within 150 miles of the Northern Territory border, 450 miles west of Townsville. In view of the occurrence of *larapinta* at the intermediate locality of Richmond, it seems more credible that the Malbon specimen (tail 80 mm.) represents that species.

From a comprehensive analysis of considerable material, and Gould's descriptions and figures, the relationship of *macrura* appears to rest with *larapinta* rather than *crassicaudata*. However, the specific status of *macrura* is maintained and discussion of specific alliance is deferred pending study of the syntypes in the British Museum, and selection of a lectotype.

SMINTHOPSIS MONTICOLA, sp. nov. (Fig. 1A-B.)

Holotype. Young adult ♀ A.M. No. B.9579, from Lawson, town altitude 2,403 ft, on the Dividing Range, 56 road miles west of Sydney; presented by E. H. Palmer, November, 1885.

Diagnosis. Body and tail proportions similar to those of the Roma (Q'ld) specimen of *macrura* (J.5746), but basal width of tail 10 mm., compared with 7.3 and the 7.5 of Gould's co-type; the length of tail (77 mm.) and the basal incassation in absolute contrast with the tail-formation of typical *crassicaudata*. Ear length 19.5 (fig. 1A) intermediate between *macrura* (16.5) and a range of about 20-23 mm. for *crassicaudata*; tragus larger and more broadly expanded above than in *crassicaudata*, with the rear margin arising from the mid-base rather than the edge of the tragus. The relatively broad pes (fig. 1B) distinguished from *crassicaudata* by its larger granulations, and smooth bead-like apical summits to the pads, equalling about three granules as in *macrura*. Cranial proportions as in northern *crassicaudata*, and *macrura*, but relatively broader at m^3 ; nasalia relatively narrower and straight-edged. Canine rather short and broad, with a minute anterior and decided posterior cingular talon; pm^3 definitely larger than in *macrura*, the premolars appearing more evenly subequal than in *crassicaudata*, because the more conical pm^4 lacks a decided cingular ridge and the strong posterior talon present in the other species.

Dimensions of holotype. In spirit: head and body 78; tail 77; pes 16.8; ear 19.5 mm. Skull: Greatest length 25.4; zygomatic breadth 14.2; interorbital width 4.7; nasals 8.9×2.2 ; palate, length 13, ant. foramina 2.4×1.4 ; breadth at m^3 8.5; upper tooth-row 12.7; canine height 1.7; p^4 base 1.3; m^{1-3} 5.2 mm.

Remarks. The holotype, in general form and according to the diagnosis, is distinguished so positively from *crassicaudata* that specific comparison rests with *macrura*, from which it differs in several diagnostic features, further confirming the specific status of *macrura*. From the wet holotype, a dark rostral mark is present, and the dorsal coloration seems of a brighter cinnamon-rufous compared with wet and dry specimens of *macrura*, and Gould's figure, but the tone may have been affected by long spirit preservation. The excessive thickening of the proximal half of the tail parallels the maximum seen in pigmy phalangiers from the Blue Mountains, which may be indicative of the richer food resources of the habitat.

SMINTHOPSIS GRANULIPES Troughton.

Sminthopsis granulipes Troughton, 1932, *Rec. Austr. Mus.*, vol. 18, no. 6, p. 350, fig. 1, ear & pes.

Holotype. Adult ♀ No. 669, in Palmer's register of the "old collection" in the Australian Museum; locality King George's Sound, south Western Australia, entered as "Coll. George Masters 1869?".

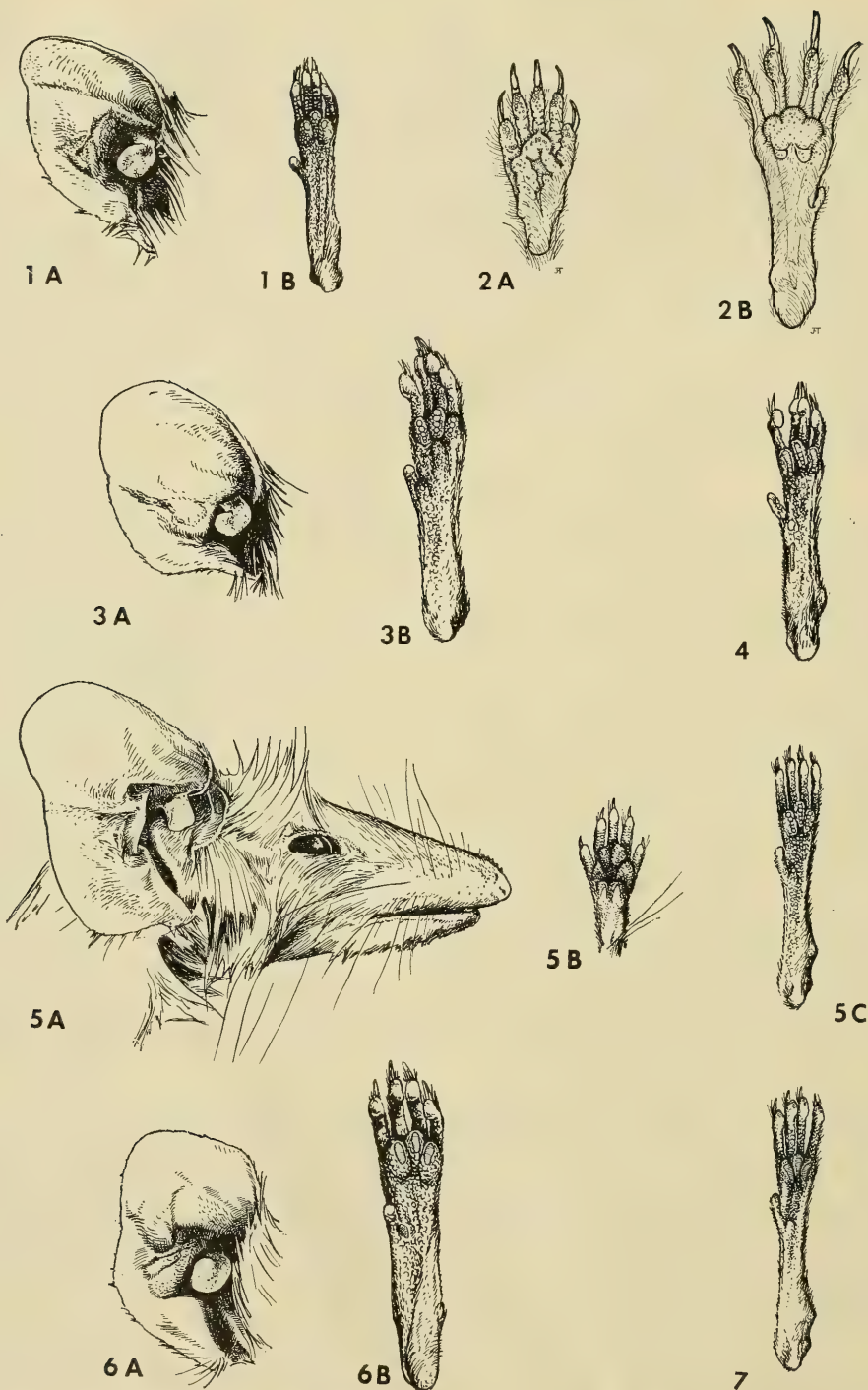


Fig. 1. A-B. *Sminthopsis monticola*, sp. nov. Holotype. 1A showing shape of ear and unusually broad tragus. Fig. 1B, the pes with smooth summits to the pads, equalling several of the large granules. Aust. Mus. No. B.9579. B. Bertram del.

Legend continued on p. 313.

Diagnosis. Body and tail of similar proportions to *crassicaudata*; but distinguished by the decidedly shorter and broader ear, not surpassing the centre of eye when pressed forward, and greater breadth due to marked convexity of the lower outer 3rd of the conch. Pads of manus and pes more finely and evenly granulated than in *crassicaudata*; the raised palmar area with a series of convolutions not divided into definite pads; pes with smaller central pad not separated from the two outer by definite grooves, the summits without coarsened granules as in *crassicaudata*. Tail incrassated. Mammae in holotype 5 and 6 a side, with traces of another teat, doubtless equalling 12. Skull proportionately larger and stouter than in *crassicaudata*; dentition as originally described.

Dimensions of the holotype. In spirits: head and body 87; tail 55; pes 13.5; ear from outer base 17.5; greatest width 15.5 mm. Skull: Greatest length 27.3; zygomatic breadth 15.2; nasals 10×2.3 ; interorbital 5.5; palate, length 15.6, ant. for. 3.4; breadth at m³ 9; upper tooth-row 14.1; molars¹⁻³ 4.9 mm.

Remarks. Re-examination of the holotype, in comparison with a series of *crassicaudata* from Tambellup, presented by F. R. Bradshaw in 1929, confirms the original description. The absence of a definite outer ulnar pad with a smooth elongated summit, characterizing *crassicaudata*, is a notable feature. In a brief personal note in May, 1939, L. Glauert of the Western Australian Museum wrote: "By the way we have today received our third *S. granulipes* Troughton—the localities are (1) female with 12 young from 30 miles E. of Ravensthorpe, (2) Nungarin, (3) male from Marvel Loch near Southern Cross." Tate (1947, p. 123) records a U.S.N.M. specimen No. 218646 (no skull) from Albany, marked *murina fuliginosa*, which "seems to be a topotype . . . pads are wholly granular". Examination of fresh skins in the W.A. Museum may indicate some distinctive coloration, that of the holotype having been "bleached" by almost a century of spirit preservation.

SMINTHOPSIS FROGGATTI Ramsay.

Antechinus (Podabrus) froggatti Ramsay, 1887, PROC. LINN. SOC. N.S. WALES, (2) ii, p. 552.

Sminthopsis crassicaudata Thomas, nec Gould, 1888, Cat. Mars. & Monotr. Brit. Mus., p. 306, Pl. xxiii, fig. 8 (pes).

Sminthopsis froggatti Troughton, 1932, Rec. Austr. Mus., xviii, 6, p. 352.

Holotype. Adult ♀ in the Macleay Museum, University of Sydney; caught under debris near a beach, in the "pindan" scrub bordering King Sound, near Derby, north Western Australia.

Diagnosis. According to the extended description (1932), total length comparable with *crassicaudata*, but the tail decidedly longer, with the incrassation in the proximal half and tapering to the tip. The ear is much smaller, and the sole-pads differ from the typical *crassicaudata* in having smooth apical summits instead of fine granulations, or

Legend continued from p. 312.

Fig. 2, A-B. *Sminthopsis hirtipes* Thomas. Holotype. Showing the remarkable pattern, and "gerbille-like" appearance of the manus (2A) and the pes (2B). British Mus. (Nat. Hist.) No. 1879-12.17.1. Joyce Townsend del.

Fig. 3, A-B. *Sminthopsis murina tatei*, subsp. nov. Holotype. Fig. 3A, ear, and 3B the pes, showing the typical unworn appearance of the apical row of granules. Aust. Mus. No. M.7157. B. Bertram del.

Fig. 4. *Sminthopsis murina leucopus* (Gray). The pes, showing apparent striations caused by wearing down of the apical row of granules; the striations should be wider apart, representing the divisions between the granules. Tasm. Mus. Pearson Coll. No. 568. B. Bertram del.

Fig. 5, A-B-C. *Sminthopsis murina ooldea*, subsp. nov. Holotype. 5A the head, 5B the manus, and 5C the pes. Aust. Mus. No. M.7502. B. Bertram del.

Fig. 6, A-B. *Sminthopsis lumholtzi* Iredale & Troughton. Showing the ear and tragus (6A), the pes (6B) with the oblong-ovate apical areas; the striae should be finer; compare with figures of pes of "*leucopus*" in the British Museum Catalogue. Aust. Mus. No. M.8420. B. Bertram del.

Fig. 7. *Sminthopsis longicaudatus* Spencer. The pes. W.A. Museum No. M.2394. B. Bertram del.

All drawings approximately twice natural size.

the longitudinal row of enlarged granules typical of *centralis*. Abdominal fur whitish from base to tip, not bicoloured. Dentition much as in *crassicaudata*, but premolars not so evenly increasing in size, pm^1 three-fourths the bulk of pm^3 , both definitely smaller than pm^4 .

Dimensions of holotype. Adult ♀ in spirit: head and body 73.5; tail 71; pes 14; ear from outer base 14, greatest width 9.5 mm. Skull: Basal length 21.3; zygomatic breadth c. 12.5; nasals 8.3×2.5 ; interorbital width 4; palate, length 11.6, ant. for. 2.8; breadth at m^3 7.6; upper tooth-row 11.2; molars¹⁻³ 4.5 mm.

Remarks. Named in honour of W. W. Froggatt who obtained the holotype when collecting for the Hon. Wm. Macleay. Froggatt subsequently became a distinguished Government Entomologist in the New South Wales Department of Agriculture. The placing of this species under the synonymy of *crassicaudata* by Thomas, within a year of its description, was not justified because Ramsay's dimensions conflicted with Gould's type, the only correctly localized specimen then available to Thomas. The inclusion of *froggatti* as a race of the eastern *macrura* by Tate (1947, p. 122) shows an even greater disregard for vast separations of faunal habitat. Tate did not examine the holotype, but regarded the smaller ears, basal incrassation of the tail, and granular pads as indicating that the species were "either synonymous or conspecific". Actually, comparison of specimens of *macrura* with the holotype admits no question of the distinction of *froggatti*, quite apart from *centralis*, the intervening sub-desert race of *crassicaudata*.

SMINTHOPSIS HIRTIPTES Thomas. (Fig. 2A-B.)

Sminthopsis hirtipes Thomas, 1898, *Novitates Zool.*, vol. 5, p. 3.

Holotype. Adult ♂ in British Museum, No. 97.12.17.1, from Station Point, Charlotte Waters, Central Australia.

Diagnosis. Medium-sized, with remarkably specialized palms and soles, long ears, and tail longer than the head and body, and without definite incrassation. From spirits, colour of back light brown, about sayal (Ridgway), contrasting with the whitish belly; no distinctive facial marks. Palm (fig. 2A) covered by a raised cushion with a central groove but no distinctive pads, and covered with fine white hairs. Sole with conical metatarsal pad unusually elevated, 3 mm. from toe-base to tip, the distal portion with two grooves, and proximal part with a concavity, the whole covered with minute granulations and fine white hairs; silvery-buff hairs of the pes unusually long, notably along the outer edge of the sole where they form a definite silvery fringe.

Skull larger and stouter than in *crassicaudata*, with decidedly larger bullae (Thomas). The pm^4 is exceptionally large (Tate, 1947, p. 124) and pm^1 definitely smaller than pm^3 .

Dimensions of holotype. In spirits: head and body 76; tail 81; pes 19; ear 22.5 mm. Skull: Basal length 24; zygomatic breadth 15.3; interorbital 5.1; palate length 13.2; length m^{1-3} 4.7 mm.

Remarks. A young ♀ in the Australian Museum (M.6477) agrees in all external characters with the original description, the feet presenting the remarkably Gerbille-like parallelism described by Thomas. The specimen from "Central Australia", presented by Professor A. A. Abbie of Adelaide University, had the calvarium removed; the premolars appear immature; tail length 79; pes 17.5 (s.u.) mm. Specimens in the W.A. Museum from near the Warburton Range, on the Canning Stock Route through the Sandridge Desert, central Western Australia, were recorded by Glauert (1933, p. 22); recorded also by Finlayson (1961, p. 155) from the area of Lake Mackay, on the south-western border of the Northern Territory.

SMINTHOPSIS MURINA Waterhouse. (Figs 3-5.)

Phascogale murina Waterhouse, 1838, *Proc. Zool. Soc. London*, p. 76.

Holotype. Young ♂ from "Hunter's River", mid-coastal New South Wales, No. 55.12.24.95 in the British Museum.

Remarks. As stated in the Introductory comment, Tate in his review of the genus (1947) indicated the subspecific relationship of *leucopus* of Tasmania, embracing no

doubt *ferruginifrons*, apparently of the Sydney district, about 100 miles south of the holotype locality. However, without a prolonged examination of the extensive series of *murina* (*sens. lato*) in the Australian Museum it is impossible to estimate the specific or racial relationships of the above forms, or that of *albipes*, and *fuliginosa* of south Western Australia. The *murina* "complex" indeed warrants preparation of another paper which it is hoped to undertake after examination of typical material in the British Museum during 1964.

The fact remains that because of the acknowledged lack of differential cranial characters it is impossible to provide objective diagnoses of the typical and allied forms of *murina* at present. However, as previously defined, the sole-pads provide a mutually diagnostic feature in having a longitudinal row of enlarged granules on each summit (fig. 3B), without trace of smooth apical areas, but often having the appearance of apical serrations due to wearing down of the enlarged granules, as figured for a specimen of *leucopus* from "Tasmania" (fig. 4). These "serrations", as noted in the Introduction, are not analogous with the minute apical striae figured by Thomas for *leucopus* in the *Catalogue*. It is a notable fact that Bensley (1903) evidently realized this erroneous association by Thomas, because his figure (Pl. 7, fig. 3) of the sole-pads of *leucopus* is typical of *murina* (*s.l.*).

Gerard Krefft (1866) believed *albipes* and *murina* to be alike, thus anticipating the conspecific treatment by Thomas (1888); while Tate (1947) considered that the general similarity of the skulls "indicates that they are geographical representatives of the one species". Despite the intermediate occurrence of *albipes* of coastal South Australia, it is difficult to reconcile the darker coloured and heavier footed *fuliginosa*, of the more fertile region between Perth and Albany (W.A.), with the subspecific status allotted it by Tate.

In his notes on "*murina fuliginosa*", Tate records the locality of the young adult ♂ in the British Museum as "River Avon, King George's Sound", but collector Gilbert's actual locality was Toodyay, on the Avon River, 15 miles from Northam, and about 50 miles north-east of Perth. This error in location was evidently due to Gould (1852) giving the local name "Twoor-dong—aborigines of King George Sound" at the heading of his description of the "Sooty Antechinus" (vol. 1, Pl. 41). While there may be no material difference in habitat, the specimens examined by Tate in the M.C.Z. from Albany, and from Kojonup, "a few miles to the north", cannot be regarded as virtually topotypical, as stated by Tate.

Regarding the distinctive habits of *fuliginosa*, Gould quoted most interesting field notes for which he was "Indebted . . . to researches of the late Mr. Gilbert" in part: "This is so much like the *Antechinus albipes*, that I considered it to be that animal, until, by hunting for it myself, I found that it not only differs in habits—but is of a somewhat larger size and very much darker colour. Its favourite resorts are newly burnt spots, especially those adjacent to swamps and moist meadows." There is also a detailed description of the nesting burrow, the top of which so resembled the nests of small black ants that Gilbert overlooked hundreds until aboriginals showed them to be nests of the marsupial. The stomachs of the night-feeding marsupials contained a variety of insects.

In his notes on the distribution of Western Australian marsupials, Glauert (1932-33) omitted *fuliginosa*, apparently assuming it to be synonymous with *albipes* for which he gives the range as "more or less coastal, but inland to . . . Bulong, near Kalgoorlie". It was also noted that "All the specimens seen have the carpal pad on the manus transversely striated, not granular". An adult ♂ *fuliginosa* from Tambellup, about 70 miles north of Albany (A.M. No. M.4742), has the total length 190; head and body 97; tail 93; pes 19.3; ear, outer 23, inner 18 mm. A younger male (A.M. No. M.4581), with a 91 mm. tail, has the ear-length 22, and the 19.3 pes a maximum width of 3.7 mm., the measurements generally emphasizing the larger proportions of the south-west coastal form. Subsequent study of the extensive Australian Museum series should establish the full specific status of *Sm. fuliginosa*.

Two new races of *murina* are described as follows:

SMINTHOPSIS MURINA OOLDEA, subsp. nov. (Fig. 5A-C.)

Holotype. Young ♂ M.7502 in the Australian Museum, collected by H. E. Green when mission-teacher at Ooldea on the Trans-Continental Railway, South Australia.

Diagnosis. Sole-pads agreeing with typical *murina*, but the longitudinal apical row of enlarged granules smaller and more bead-like; showing a similar tendency to coalescence with wear. Tail proportionately much longer, slimmer, and less coarsely haired than in *fuliginosa*. Ear comparatively very broad, and the tragus short and broad with the hind margin incurved only near the base. Sub-adult skull affected by maceration; relatively broad, breadth across m^3 7.3 mm., only 1 mm. less than in much larger skulls of *fuliginosa*; nasals proportionately long and narrow, widest within 1 mm. of tips (1.6), tapering posteriorly to 1.1 mm. Canine short and more premolariform; 1st and 3rd premolars subequal, decidedly smaller than pm^4 .

Dimensions of the holotype. In spirits: head and body 73; tail 102; pes 18; ear, outer length 18.8, maximum breadth 13 mm. Skull: greatest length c. 20; basal length c. 18.5; interorbital 4.8; nasals length 7.8; max. breadth 1.6; palate length 10.8, ant. for. 3.1; breadth at m^3 7.3; upper tooth-row 11.7; molars¹⁻³ 4.3 mm.

Remarks. Despite the sub-adult condition of the holotype, the granule pattern of the sole-pads allies it with *murina* and distinguishes it from *crassicaudata centralis*, while the relatively very broad ear and length of the "whip-like" tail distinguish it from *centralis* and as a race of *murina*. The situation of Ooldea at the edge of the vast Nullarbor Plain, edged by sand-wave country, and by some richer vegetation, may account for the occurrence of this intermediate form, the description of which may result in the collection of mature examples.

SMINTHOPSIS MURINA TATEI, subsp. nov. (Fig. 3A, B.)

Holotype. Adult ♂ M.7157 in the Australian Museum, from Tolga on the Atherton Tableland, at approximately 2,460 ft, north-eastern Queensland.

Diagnosis. Dimensions in general agreement with *fuliginosa*, at the extreme south-western extension of the distribution, but pes (fig. 3B) larger and tail longer (subequal to head and body) than in any intermediate mainland form, other than the race from Ooldea. Colour from skins of Tableland specimens (fide Tate, 1947) "brownish gray dorsally, much browner than our *S. m. leucopus* . . . underparts have creamy hair tips and gray bases . . . tail gray above, buffy underneath . . . hands and feet are white, much paler than those of our *leucopus*. There appear to be six nipples".

Skull strongly built, broader and more inflated cranially than in other subspecies; width at the stout zygoma 15.6, and breadth at outer m^3 8.9 mm.; nasalia largest in the species, 10.6 × 2.0; there is a weak sagittal crest. Anterior premolars subequal, half the size of the relatively small pm^4 .

Dimensions of holotype. Adult ♂ in spirits: head and body 95; tail 94; pes 20; ear, outer length 21.3, inner 17.3, width 15 mm. Skull: greatest length 27.9; basal length 25.4; zygomatic breadth 15.6; interorbital 5.4; nasals 10.6 × 2.9; palate length 14.5, ant. for. 3.5; breadth at m^3 8.9; upper tooth-row 13.8; molars¹⁻³ 5 mm.

Remarks. This distinctive Tableland race is named in honour of a much admired friend and associate in mammalogy, the late Dr. G. H. H. Tate, in memory of happy meetings during his visits with the Archbold Expeditions, and at the American Museum of Natural History where he was a distinguished and hospitable Curator in the Department of Mammals. This small tribute is the more appropriate since Dr. Tate (1947) regarded a male in the A.M.N.H., and female in the M.C.Z., from Atherton Tableland as possibly "members of a northern race". However, his decision to regard the specimens provisionally as representing the typical race (of *leucopus*) "in default of topotypes" was unwarranted because the type locality of *murina* is the Hunter River, central coast of N.S.W., and that of *leucopus* is Tasmania. The reference to the Atherton Tableland, at the base of Cape York, as in "central Queensland" is also misleading as to the sub-specific proximity.

SMINTHOPSIS MURINA CONSTRICTA Spencer.

Sminthopsis murina var. *constricta* Spencer, 1896, Report on . . . the Horn Scientific Expedition to Central Australia, Zoology, vol. 2, p. 33.

Holotype. From Oodnadatta, north-central South Australia (not seen by Tate, or the author).

Remarks. In the absence of the unique holotype, and because of the inadequate description, there is nothing diagnostic to be said about this "somewhat cryptic form" as Finlayson aptly stated (1961). However, the details of Spencer's description do not warrant the placing of *constricta* as a race of the eastern *macrura* by Tate (1947), or as possibly equalling *centralis*, which had already been clearly established as a northern race of *crassicaudata*. While the relationship with *murina* is extremely doubtful, the lack of striation of the sole-pads has little significance since Spencer did not distinguish between the types of granulation, while the distinct incassation of the tail would exclude *murina*, though this character proves variable in *crassicaudata centralis* and *larapinta*. The relatively great breadth of the pes in the possibly immature holotype, given as "Hind-foot 15.5 and Greatest width 4 mm." by Spencer, may have appeared to him as the outstanding character, since he did not repeat the width measurement for his *psammophilus*, with the longest foot recorded for the genus.

SMINTHOPSIS PSAMMOPHILA Spencer.

Sminthopsis psammophilus Spencer, 1895, *Proc. Roy. Soc. Victoria*, new ser., vol. 7, p. 223; *Id.*, 1896, Report on . . . the Horn Sci. Exped. to Central Australia, Zoology, vol. 2, pp. 35-6, Pl. 1, fig. 2, 2a-2b.

Holotype. Adult ♂ from near Lake Amadeus in the south-western angle of the Northern Territory. Not seen by Tate or the author.

Diagnosis. Apart from exceptional size, there can be no diagnostic support for the inclusion of this species as a race of *macrura*, by Tate. Failing examination of the holotype, the skull and dentition of which have never been described, it appears that the overall granulation of both manus and pes provides a distinctive character; especially regarding the pes the large size of which (25mm.), coupled with the overall even granulation and lack of either smooth or striated apical summits to the pads, eliminates both *larapinta* and the large-footed and stout-skulled *tumholtzi*.

Other distinctive characters (fide Spencer) include the very large ear (24.5 mm.) extending to half-way between the eye and muzzle when pressed forward. The very long tail (116 mm.) exceeds the head-and-body length (105 mm.), giving a total length of 221 mm., the largest overall proportions recorded for the genus; distinctively, the tail is described and figured as "long and thin" and covered with short whitish hairs, with a well-marked line of black hairs above and below, the hairs increasing slightly in length towards the tip "so as to form a slight crest". Coloration as figured for Spencer; the conspicuous dark flecking of the whitish underpart, not referred to in the description, evidently represents the artist's idea of indicating the dark basal half of the fur.

Remarks. When including this unique species as a race of the south-eastern *macrura*, apparently on the unstriated granulation of the sole-pads, Tate (1947) observed that it "is clearly a very much larger species than either *crassicaudata* or *murina*", a fact equally applicable to *macrura*. However, examination of the holotype, and especially the undescribed skull and dentition, is essential to establishing the affinities of this remarkable species. The habitat was recorded as "living amongst sand-hills covered with tussocks of porcupine grass . . . running about in daytime". There can be no doubt of its specific distinction (Spencer).

SMINTHOPSIS LARAPINTA Spencer.

Sminthopsis larapinta Spencer, 1896, *Proc. Roy. Soc. Victoria*, new ser., vol. 8, p. 8; *Id.*, 1896, Report on . . . the Horn. Sci. Exped. to Central Australia, Zoology, vol. 2, pp. 33-35, Pl. 2, figs 2, 2a-2b.

Holotype. From Charlotte Waters, in the Northern Territory, just north of the centre of the South Australian border.

Remarks. A full diagnosis is dependent on an examination of the typical specimens of *stalker*i Thomas (1906) in the British Museum, from Alroy Downs in the Northern Territory, about 100 miles from Camooweal on the north-west border of Queensland. The variable coloration is generally as in Spencer's figure, though tending to a lighter cinnamon-buff (Ridgway), notably in an excellent skin in the Queensland Museum from Richmond, north-central Queensland, where *larapinta* overlaps the range of the more robust *lumholtzi*, thereby providing the north-easternmost extension of the known range of *larapinta*.

The small and smoothly rounded apical summits to the sole-pads, as figured by Spencer, and defined comparatively in the Introduction, are diagnostic of the species. As figured, the tail apparently represents the maximum degree of incrustation for *larapinta*, such as noted in an Australian Museum young male (M.3928) from Barcarolle Station, on the Thompson River, 135 miles south of Longreach, Queensland.

The skull is smaller and more delicate in build than that of the stout bony texture of the skull of *lumholtzi*. The 1st and 3rd premolars are finer but relatively subequal and decidedly smaller than pm^1 as in *lumholtzi*, but the canine is relatively much smaller and rather "premolariform", only slightly exceeding the height of pm^4 .

Specimens examined. A skin, skulls, and four spirit specimens of the original Spencer series from Charlotte Waters, on loan from the National Museum, and a mounted specimen (M.1142) in the Australian Museum. Other A.M. specimens include one from the Diamantina River, western Queensland; two (M.3928-9) from 135 miles south of Longreach, and two (M.6955-6) from Cunnamulla (Q'ld), about 70 miles from the N.S.W. border, providing the south-easternmost known record for *larapinta*. Besides the valuable series of dried and spirit specimens from Richmond in the Queensland Museum, so kindly lent by the late Director, George Mack, there is a skin and skull from Richmond (M.2173) in the Australian Museum.

The more central range of *larapinta* has been mapped by Finlayson (1961) in his excellent paper, dividing the central region into faunal subdivisions. However, a specimen in the Australian Museum (M.3786) from Helen Springs, about 100 miles north-west of Alroy Downs, occurs well to the north of Finlayson's subdivisions 4 and 5. While emphasizing his statement that the range of *larapinta* probably covers most of "central Australia", the specific status of *stalker*i, from the locality intermediate between Richmond (Q'ld) and Helen Springs (N.T.) becomes involved.

SMINTHOPSIS STALKERI Thomas.

*Smintropsis stalker*i Thomas, 1906, *Proc. Zool. Soc. London*, p. 543.

Holotype. Sub-adult ♂ B.M. No. 6.3.9.91 from south-west of Alroy, in the Northern Territory, about 100 miles from Camooweal on the north-west border of Queensland.

Remarks. Pending examination of the two apparently sub-adult types in the British Museum, it is impossible to provide a diagnostic comparison, or to confirm the relegation of *stalker*i to a subspecies of *larapinta*. In adopting this view Tate (1947) noted that Thomas compared *stalker*i throughout with "*larapinta*", as he had earlier placed Collett's *nitela* in the synonymy of Spencer's *larapinta*. However, because of the occurrence of both *larapinta* and *lumholtzi* to the east, and *larapinta* to the north-west of Alroy, a distribution not then known to Thomas, the status of *stalker*i remains in doubt. There remains the possibility that the species may actually prove to be identical with *Sm. crassicaudata centralis*, because the general proportions and length of the tail (65-70 mm.) with a basal incrustation is in agreement.

SMINTHOPSIS NITELA Collett.

Smintropsis nitela Collett, 1897, *Proc. Zool. Soc. London*, p. 334.

Holotype. Young adult ♀ B.M. No. 97.4.12.6, in spirits, from the Daly River, probably within 50 miles of Darwin, Northern Territory.

Remarks. It is not clear why Tate placed *nitela* as a subspecies of *larapinta*, because his brief diagnosis shows its affinity to be obviously with his "*rufigenis* Division", inclusive of *lumholtzi*. According to his examination of the holotype, Tate (1947) wrote:

"The median facial stripe, "front and cheeks rufous orange", long canines, very large p^4 are all reminiscent of *S. rufigenis*, but the "smooth (not striated)" pads are not in agreement." Stating that his notes on the type did not cover the sole-pads, Tate evidently exaggerated the importance of the description of the pads in allying *nitela* with *larapinta* rather than *lumholtzi*, the north Australian ally of *rufigenis* of Aru Island, which includes Tate and Archbold's *Sm. rona* of Papua (1936). A specimen in the Australian Museum (M.4403) from 90 miles north-west of Anthony's Lagoon, en route to Newcastle Waters (N.T.), is regarded as a sub-adult male of *lumholtzi*. It was collected by my friend T. G. Campbell, ex Museum colleague, and now with the Division of Entomology, C.S.I.R.O. He described the Barkly Tableland habitat as "a treeless black soil plain, with cracks and burrows in the soil in which the mice lived". This note is significant because the types of *nitela* were "brought in by the natives who dug them out in the gardens". Combined with the extension of the range of *lumholtzi* west to Richmond (Q'ld) the above notes confirm the alliance with *nitela*, pending examination of typical specimens in the Oslo and British Museums.

SMINTHOPSIS LUMHOLTZI Iredale and Troughton. (Fig. 6A-B.)

Phascologale virginiae Collett, 1887 (1886), *Proc. Zool. Soc. London*, p. 548, Pl. lx (animal, skull, teeth); *Id.*, 1887, *Zool. Jahrb.*, Jena, vol. 2, p. 866. Not *Phascogale virginiae* De Tarragon, *Revue Zool.*, 1847, p. 177. (No locality, type unknown.)

Sminthopsis lumholtzi Iredale and Troughton, 1934, *Aust. Mus. Memoir* vi, p. 11 (*nom. nov.*).

Diagnosis. As described and figured by Collett and by Oldfield Thomas, who evidently figured the pes of a Cape York spirit specimen in the B.M. *Catalogue* (Pl. xxiii, fig. 6), which was mistakenly applied to the southern *leucopus* = *murina*, as detailed in my Introduction. This robust species is distinguished by the stout pes which has the summits of the pads with relatively large oblong-ovate smooth areas which are more or less microscopically and transversely striated. As figured by Collett, and confirmed by several specimens listed below, the broad and strongly-built skull is characterized by the parallel breadth of the nasalia, usual presence of distinct postorbital processes, and the overall proportions. Canine very long and rounded, almost double the height of pm^4 ; premolars rather disproportionate, as in Collett's figure, pm^1 smaller than pm^3 which is about half the size of pm^4 .

Measurements of holotype. Combined from Collett and Thomas (in brackets). Total length 245 (250); head and body 125 (125); tail 120 (125); pes c.u. 23 (s.u. 22); ear length 20.5, inner 14.5 (crown 13) mm. Skull: Greatest length 31.5; basal length 29.5 (29.5); zygomatic breadth 19 (19); interorbital 5.5 (6.1); nasalia—(11), breadth (3.1); palate length (16), ant. for. (3.1); breadth at outer m^3 (10.5); upper tooth-row 15 (—); p^4 horizontal length (1.5); molars 1-3 (5.3) mm.

Specimens examined. Two from Hampden, near Mackay, mid-eastern Q'ld (J.3109-10), and two from Julia Creek (J.5173 and J.5459), midway between Richmond and Cloncurry, north-central Qld, in the Queensland Museum collection; a young ♂ from Rocky River near Coen, Cape York Peninsula (M.8420), collected by Basil J. Marlow, and an adult ♂ skin and skull from Richmond, north Queensland (M.2172), presented by the late F. L. Berney, both in the Australian Museum.

Remarks. The name *lumholtzi* was established in tribute to the distinguished author-naturalist Carl Lumholtz, collector of the holotype, because of the lack of a diagnostic description of "*virginiae*", the lack of indication of locality, and of any indication of the existence of a type specimen or its place of lodgement. Considering the lack of objective characters in many species, and the great extensions of range now revealed, lack of location, in the absence of a type, becomes decisive.

Tate (1952) makes some important notes regarding the habitat and range of the species: "The type locality of *virginiae* Collett (not Tarragon) = *lumholtzi* Iredale & Troughton was given as Herbert Vale, in the upper Middle part of the Herbert River, doubtless where its headwater streams drain the grassy portions of the southern part of the Atherton Tableland before cutting down into the rain forest." He further stated

that the distribution pattern corresponded rather closely with a number of other "open-forest" species of marsupials and the naked-tailed rat *Melomys lutillus*. He found that *lumholtzi* avoided the dense rain-forest, favouring open "rocky forest and brushy places in full sunlight", and he suspected that it sometimes ate parts of the *Melomys* caught in traps. A female had the nipple formula $4-4=8$, whereas the formula of Papuan specimens of *rufigenis* appeared to be $3-3=6$, observed on dry skins.

SMINTHOPSIS LONGICAUDATA Spencer. (Fig. 7.)

Sminthopsis longicaudata Spencer, 1909, *Proc. Roy. Soc. Victoria*, new ser., vol. 21, p. 449.

Holotype. In the National Museum, Melbourne, described as from "West Australia", but L. Glauert, when Curator of the Perth Museum, concluded that the collector, G. A. Keartland, had obtained it in the region Pillendinnie (Marble Bar), Western Australia. The second known specimen, in the Western Australian Museum (No. M.2394) from the same area, was kindly lent for examination by the Director, Dr. W. D. L. Ride.

Remarks. In view of the impending paper to be published on the Western Australian species of *Sminthopsis*, it does not appear warranted to attempt a review of the characters or genetic relationships of this remarkable long-tailed species. As Tate stated (1947), the species "apparently represents a special, long-tailed development of the division of *Sminthopsis* having striated pads. As its describer pointed out, the tail is proportionately even longer than that of *Antechinomys*. There is no corresponding lengthening of the foot (18 mm.)."

Regarding the possible phylogenetic relationship with other genera, such as *Antechinomys* and *Antechinus*, it seems difficult to reconcile the lack of a hallux and the large cushion-pads of *Antechinomys* with the strong hallux and the divided and coarsely serrated pads of *longicaudata*. The remarkably long tail would be quite incompatible with the movements of *Antechinomys*, while its appearance otherwise agrees with *Sminthopsis*. The slenderness of the pes, apical serrations of the interdigital pads, and lack of any additional pads disagree strikingly with the pes of *Antechinus*. The species may represent some annectant generic form, based on cranial characters, but it seems difficult to relate it to the genera referred to within the scope of Bensley's phylogenetic review.

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Sincere thanks are expressed to the Trustees and Director (Dr. J. W. Evans) of the Australian Museum for making ample facilities available for the preparation of this paper, under my appointment as an Honorary Zoologist; and to my successor as Mammalogist, Basil Marlow, B.Sc., for graciously making the remarkably rich collection of *Sminthopsids* available for research. A revision was actually contemplated after examining typical specimens in the British Museum in 1930, when the fine drawings of *Sm. hirtipes* were kindly made for me by Miss Joyce Townend. Also when Dr. T. C. S. Morrison-Scott, now Director of the Natural History Museum, kindly obtained photos and drawings of the Gouldian "co-type" of *Sm. macrura* in the Liverpool Museum, afterwards destroyed by enemy action. More recently, J. Edwards Hill of the Mammal Section supplied sketches and notes of type specimens. Very keen appreciation is expressed to the memory of the late Director of the Queensland Museum (George Mack, B.Sc.) for his encouraging interest in making the entire *Sminthopsid* collection available for review. Thanks also go to my old friend C. W. Brazenor who, prior to retiring as Director of the National Museum of Victoria, made specimens of Baldwin Spencer's *Sm. larapinta* available for comparison; also to the Director of the Tasmanian Museum, Dr. W. Bryden, for lending the only available topotypical specimen of *Sm. leucopus*. At the Australian Museum, special thanks are due to my old colleague, G. P. Whitley, Curator of Fishes, for overseeing the manuscript for publication and, with the collaboration of Tom Iredale and Basil Marlow, completing the extensive bibliography. Finally, to Dr. D. F. McMichael, Curator of Molluscs, for the essential facilities provided within his Department, and for his effective arrangement of the plate. The excellent drawings, other than of *Sm. hirtipes*, were made by Brian Bertram of the Museum Department of

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GREY BILLY AND THE AGE OF TOR TOPOGRAPHY IN MONARO, N.S.W.

By W. R. BROWNE, D.Sc.

(Plate v.)

[Read 28th October, 1964.]

Synopsis.

Near Berridale tors and monoliths of granite are surrounded by sub-basaltic silicified sands and gravels (grey billy). The tor topography is thus Oligocene or older, not Pleistocene as usually assumed.

INTRODUCTION.

The present note was written primarily as the result of reading some entries in a field note-book of the late Sir Edgeworth David dating back to 1900. During his visits to Kosciusko, travelling by horse-drawn vehicle along the road from Cooma to Berridale and Jindabyne, he usually made copious geological notes on the rock formations encountered *en route*, and in particular examined a number of occurrences of grey billy, to some of which his attention had been drawn by Richard Helms, that most versatile and observant scientific collector from the Australian Museum. Interested in the Tertiary basalt and grey billy of the Monaro, my wife and I visited one of the occurrences mentioned by David and found the grey billy in such close proximity to some granite tors that it was possible to determine their relative ages. I am much indebted to my wife for help in the field work.

GREY BILLY.

In this note the name "grey billy" is applied with its original significance to the quartzitic rocks—silicified sands and gravels—often found underlying Tertiary basalts and representing original terrestrial sediments, mainly alluvial, which have been altered by the basalt flows. Occurrences of these silicified deposits are fairly numerous in the eastern highland belt of New South Wales and have also been reported from Victoria and Queensland. In the author's experience they are quite abundant in the country east, west and south of Cooma, and it is with some of these, situated within the basin of the Snowy River, that it is proposed to deal in this paper. The grey billy appears in outcrop as a result of the erosion of the overlying basalt, and its presence in any given locality may be accepted with confidence as evidence of the former presence of Tertiary basalt there. In many instances the grey billy may be traced continuously to a point where it disappears under basalt.

With one doubtful exception which has been tentatively assigned a Pliocene age (Owen, 1954), the Tertiary basalts of this State are, so far as is known, Oligocene, a fact deduced on physiographic grounds and attested by palynological examination of associated sediments (Cookson and Pike, 1957; Voisey, 1956).

It is not proposed here to give a detailed account of grey billy. It occurs in layers about 3 to 6 feet thick and may rest on unsilicified clays, sands, gravels and occasionally impure peat beds. Pebbles in the silicified gravels may be of the white quartz so common in the gravels of rivers flowing over a *terrain* of clay-slate intersected by quartz-veins, but pebbles and boulders of other rock-types may be found completely silicified and still retaining traces of original structures. Where silicification has been incomplete sand grains may be etched out and appear in relief, pebbles may be loosened and drop out, and the billy outcrop may be weathered differentially into cavities. After exposure to the atmosphere the rock, broken up into large blocks and tilted through undermining, may be rounded, smoothed and dimpled and show polygonal superficial cracking,

presenting a very characteristic appearance. The colour is mostly light grey, but where strongly iron-stained may be brown (Plate v, figs 1, 2 and 3).

It is obvious that remnants of the Tertiary basalt and grey billy scattered over a landscape may give important clues to early Tertiary palaeogeography, and indeed they have already been used to that end in New England (Voisey, 1942).

TOR TOPOGRAPHY.

Development of tor topography is not confined to any particular rock-type, but is most commonly found in granitic *terrains*. Little attention appears to have been given to it by geologists in this country, and here and elsewhere there seems to be a belief, implicit but seldom expressed, and not founded on any serious observation or reasoning, that it is a weathering phenomenon associated with the present cycle of erosion and produced through direct exposure of the rocks to the atmosphere. However, vertical sections in quarries and other excavations of certain susceptible rock-types like granite and dolerite, intersected by joint-cracks, commonly reveal a process of chemical weathering or rotting resulting from the downward passage of surface-waters seeping along the joint-cracks and spreading from them to leave rounded cores or kernels of fresh rock in the joint-blocks, surrounded by shells of decomposed material, the cores increasing in size with depth and in general disappearing completely near the surface. It is therefore most probable that, as envisaged by Blackwelder (1925), Davis (1938) and Linton (1955), tor topography originated through prolonged differential chemical weathering extending from the surface down to the water-table, where weathering ceases to operate, and that only when the rotted rock is removed by erosion, following, for example, slight or moderate uplift, are the residual blocks of undecomposed rock brought together and exposed in outcrop. As the intensity of weathering no doubt varies from point to point in the rock-mass in accordance with changes in composition and the frequency of joint-cracks, the stripped surface will not be completely plane, but certain remnants of fresh rock will stand up in relief.

Conditions for tor topography, therefore, would seem to be: (a) a *terrain* composed of silicate rocks susceptible to chemical weathering and intersected by joint-cracks; (b) an antecedent surface at an indeterminate height well above the top of the highest tor; (c) a prolonged interval of stillstand during which chemical weathering occurred; (d) a climate favouring deep decomposition of the rock (*e.g.*, high temperature and high rainfall); (e) subsequent moderate uplift and complete removal of the rotted rock by erosion.

Thus an area of tor topography may have important implications in regard to antecedent climate and earth-movements.

TORS AND GREY BILLY NEAR BERRIDALE.

The granite exhibiting the tor topography here considered is first encountered 8½ miles out of Cooma and is traversed by the Kosciusko road all the way to Berridale. It is part of a large batholith extending from some 20 miles north of Berridale south through Dalgety almost to the Victorian border with a width of 10 or 12 miles. Much of it, especially on the eastern side, is covered with Oligocene basalt, and outcrops of grey billy indicate that the basalt-covered area was formerly more extensive. In places the basalt is underlain by sediments including impure peat-beds which may be altered to a kind of coal (Dulhunty, 1946). The granite forms undulating country with a general slope from the Main Divide to the south-west, its elevation ranging from 3,600 feet a few miles east of the Cooma aerodrome to 2,500 feet at Dalgety.

At a point some 17½ miles from Cooma and one mile past the Rocky Plain turn-off is a small lake known locally as Spring Creek Lake (though it is actually on a tributary valley of Spring Creek), on the property known as "Glendale". It is half a mile S.E. of the road at an approximate altitude of 2,860 feet and is some 200 yards in diameter, in a broad, shallow valley trending in a general southerly direction. The lake is more or less surrounded by grey billy, which rises on the southern shore to a little "plateau" 30 feet above it, resting on granite, and slopes down into the lake (Pl. v, fig. 1). It

may be traced upstream from the lake to the Berridale road, and eastward at intervals over flat country for upwards of $\frac{3}{4}$ mile towards a low hill of basalt overlying ferruginous grit resting on granite at 2,900 feet; this may have been on the slope of the original valley-wall. On the northern side of the lake the grey billy includes silicified grits, gravel and boulder beds as well as sands (Pl. v, figs 1, 2 and 3). Locally, owing to imperfect silicification, it is somewhat cavernous. It is apparent that the billy is on the site of a wide, flat-floored, shallow pre-basalt river valley cut in the granite, now occupied by two tributaries of Spring Creek.

Some 400 yards south of the lake is an east-west line of tor-like masses of granite forming a narrow irregular ridge above the general level, the most easterly group rising 25 or 30 feet (Pl. v, fig. 4). Though essentially *in situ*, the granite has been slightly disrupted along joint-planes and some of the rounded joint-blocks have been displaced.

Between this ridge and the billy "plateau" is a shallow col with a few beehive or dome-shaped outcrops of granite up to seven feet high, completely surrounded by low isolated patches of grey billy appearing just above the surface soil (Pl. v, fig. 5), and these may also be traced around the base of the eastern side of the tor ridge to its southern side. These low outcrops of billy were evidently once completely soil-covered and have been bared by sheet-erosion since the clearing and stocking of the country; it is highly probable that they are continuous beneath a thin soil cover. Near the edge of the little "plateau" grey billy outcrops up to 4 or 5 feet high are seen close to and almost completely encircling a little granite dome (Pl. v, fig. 6). Not far away are two groups or lines of granite outcrops 40 or 50 yards apart and up to about 15 feet high, with low outcrops of billy at ground level between them. At one point on the western edge of the "plateau" two granite blocks a few feet high are separated by a space about six feet wide filled with grey billy. There can be no room for doubt that the granite tors and monoliths, great and small, were in existence as such before the Oligocene basalt was poured out and before the sub-basaltic sediments were laid down. True there has been some shrinkage of the granite masses through exfoliation and other weathering effects subsequently to their exhumation, but not to a significant extent.

AGE OF THE TOR TOPOGRAPHY.

Thus it is clear that the tor topography around Spring Creek Lake, being pre-basalt, is Oligocene or older. It is reasonable to infer that the same is true of all the tor topography in the granite area, and it is probable that diligent search would reveal further examples of grey billy or of basalt in contact with granite tors or monoliths. Indeed Mr. A. B. Costin, of C.S.I.R.O., has kindly drawn my attention to one such occurrence some 600 yards north of the road about two miles from Berridale towards Cooma, where there is a low granitic rise at about 2,830 feet, studded with granite monoliths 5 or 6 feet high having grey billy between them. The latter, partly of silicified gravel, must cover several acres and is apparently related to an Oligocene ancestor of the nearby Wullwey Creek. Again, some 12 miles to the S.S.E., where the road from Maffra to Dalgety descends to the valley of Bobundarah Creek, the left bank of the valley, cut in granite to a depth of 300 feet, shows an abundance of granite monoliths with basalt, part of a former valley-filling, forming a capping. Though the two rocks have not been seen in actual contact, it is almost certain that the monoliths existed as such in Oligocene time and were buried beneath basalt.

It is generally accepted that deep chemical weathering is a function of climate and that deep decomposition of granite is promoted by hot and moist conditions. If this is correct it may be assumed that the climate prevailing in the neighbourhood of Cooma and Berridale in early Tertiary time approached tropicality. The topographic conditions most favourable to the deep weathering would be those characterized by prolonged stability, with very gentle slopes and sluggish streams, in other words peneplain conditions.

HISTORY OF THE TOR TOPOGRAPHY.

The existence of an extensive late-Cretaceous peneplain in eastern Australia has been postulated by Australian geologists (Andrews, 1914; David, 1950), and it is believed

to have experienced elevation and dissection in the early Tertiary. It may, therefore, be tentatively suggested that in the Cooma-Berridale area during a long period of Cretaceous peneplanation the granite in suitable situations was decomposed to a considerable but unknown depth. About the close of Eocene time moderate uplift rejuvenated the senile streams and revived erosion, so that the regolith of rotted granite was in the course of time removed, producing a tor topography. This was preserved from destruction by being completely buried under great floods of Oligocene basalt and was later slowly exhumed by the descendants of the early Tertiary streams which had been responsible for laying it bare in the first instance, revealing a palimpsest topography. Ample evidence of the activity of the Oligocene revived streams is provided by the existing tributaries of the Snowy, which have partially removed the basalt fillings and revealed old valleys, in places up to two miles wide, excavated in the granite to depths of more than 200 feet. Exhumation probably began in Pliocene time and has continued to the present day.

Tor topography is not uncommon in granite country elsewhere in New South Wales, partially overlain by Oligocene basalt, as in New England. Some of it may conceivably prove to be, like that herein described, of early Tertiary age.

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EXPLANATION OF PLATE V.

Fig. 1.—Looking south towards Spring Creek Lake with the grey billy "plateau" in right background. In foreground grey billy with bed of silicified gravel, broken into blocks and tilted. Note differential weathering of gravel layer due to incomplete silicification.

Fig. 2.—Silicified boulder-bed. The original boulders are completely replaced by silica.

Fig. 3.—Block of grey billy smoothed, dimpled and polygonally cracked.

Fig. 4.—Looking south at the eastern end of the tor ridge. A few low, white outcrops of grey billy in foreground, at approximately the level of the "plateau", below and to right and left of figure.

Fig. 5.—Rounded granite monolith 7 ft. high, with small, flat outcrops of grey billy around it. In background the wide, shallow valley with granite outcrops marking the far bank.

Fig. 6.—Beehive-shaped outcrop of granite 4 ft. high, in middle foreground, with outcrops of somewhat cavernous grey billy around it.

THE GENUS *GERANIUM* L. IN THE SOUTH WESTERN PACIFIC AREA.

By R. C. CAROLIN, University of Sydney.

Plates vi-vii; ten Text-figures.)

[Read 28th October, 1964.]

Synopsis.

All the species known to occur in Australia, New Zealand, New Guinea and Indonesia are described and discussed. The following new taxa are described: *G. antrorsum*, *G. drummondii*, *G. graniticola*, *G. neglectum*, *G. obtusisepalum*, *G. solanderi* var. *grandis*, *G. potentilloides* var. *abditum* and *G. sessiliflorum* ssp. *novaezealandiae*; *G. solanderi* nom. nov. is proposed to replace *G. pilosum* Sol. ex Willd. non Cav. The following new combinations are made: *G. potentilloides* var. *ardjunnense* (Zoll. et Morr.) and *G. sessiliflorum* ssp. *brevicaule* (Hook.). The indigenous species show fairly close affinities with species found in South America.

INTRODUCTION.

The Australian species of *Geranium* were last revised by Knuth (1912). His treatment in general is unsatisfactory. He divides them between three more or less widely separated sections, which seem to have been based upon mainly geographical and not morphological considerations. Section *Andina* comprises those species, usually occurring at high altitudes, with compact and much branched perennial stems, or caulorrhiza, and usually very short flowering stems; the roots are robust and branched, not napiform. Knuth's morphological delimitation of this section would seem to be basically sound, although the hybrids between *G. sessiliflorum* and *G. potentilloides* may cast some doubt on this. Sect. *Chilensia* is based on the napiform root and perennial or biennial habit. Within this section is included "*G. pilosum* Forst. f." (*G. solanderi*), some of the varieties of which occasionally do not show this character. In Sect. *Columbina* he includes *G. dissectum* var. *glabratum* Hook. f. (*G. homeanum* Turcz.) which is not an annual, the main key character for the section. Sect. *Australiensia* is a rather nebulous conception and Knuth himself suggests relationships with several other sections; the solitary flowers and the thickened, but not napiform, tap-root appear to be his most significant characters.

Bentham (1863) had previously included all except the alpine species within *G. dissectum* var. *australe*, recognizing only two rather ill-defined "races", i.e., "*pilosum*" and "*potentilloides*". This is quite clearly most unsatisfactory now, if only from the point of view of the International Code of Botanical Nomenclature. *G. dissectum* is well defined from the Australian native species by a number of important characters that can be examined in the key and descriptions below.

The taxonomic arrangement adopted below is based primarily upon the characteristics of the seed coat alveolae (Pl. vi), the indumentum (Pl. vii) and the solitary or twinned flowers. It is backed, to some extent, by crossability. Whilst Knuth's sectional names are used, it does not imply that the present author believes that they should be recognized as sections, when the genus is considered as a whole. To some extent *G. homeanum* connects sects. *Australiensia* and *Chilensia* in Australia and it may be unsatisfactory to recognize these at sectional level. On the other hand, the hybrids *G. sessiliflorum* ssp. *brevicaule* × *G. potentilloides* var. *abditum* may make the taxonomic difference between them less than that of a section.

As with *Pelargonium*, the whole genus is badly in need of revision and, until an up-to-date, overall picture can be established, the category to which each supra-specific taxon is to be assigned must remain undetermined.

The Table of Names provides an index to the present author's views on the position of various names that have been proposed for native Australian *Gerania*.

The descriptions of the introduced species, and of Group I itself, apply only to Australian material. The references provided under the genus and species are to works that are important so far as the Australian material is concerned.

The basis for measurements is generally quite straightforward, but some comment is necessary. The length of the leaf is taken from the petiole attachment to the tip of the middle lobe. The rostrum length is taken as the length of the enlarged style and the mericarp measurements do not include the awn, which is generally given separately.

TABLE OF NAMES.

Name.	Date.	Synonym of
<i>G. pilosum</i> Sol. in Forst. f., non Cav., nom. nud.	1786	<i>G. SOLANDERI</i>
<i>G. patulum</i> Sol. in Forst. f. non Vill., nom. nud.	1786	<i>G. SOLANDERI</i>
<i>G. patulum</i> Sol. in mss., non Vill. nec Sol. in Forst. f.		<i>G. RETRORSUM</i>
<i>G. pilosum</i> Sol. ex Willd. non Cav.	1801	<i>G. SOLANDERI</i>
<i>G. parviflorum</i> Willd. non Curt. nec Andr.	1809	<i>G. HOMEANUM</i>
<i>G. australe</i> (Willd.) Poir.	1811	<i>PELARGONIUM AUSTRALE</i>
<i>G. inodorum</i> (Willd.) Poir.	1811	<i>PELARGONIUM INODORUM</i>
<i>G. RETRORSUM</i> L'Hér. ex DC.	1823	
<i>G. POTENTILLOIDES</i> L'Hér. ex DC.	1823	
<i>G. philonthum</i> DC.	1823	<i>G. POTENTILLOIDES</i>
<i>G. brevicaule</i> Hook.	1834	<i>G. SESSILIFLORUM</i> ssp. BREVICAULE
<i>G. australe</i> Nees in Lehm. non Poir.	1844	<i>G. RETRORSUM</i>
<i>G. microphyllum</i> Hook. f.	1844	<i>G. POTENTILLOIDES</i>
var. <i>debile</i> Hook. f.	1854	<i>G. POTENTILLOIDES</i>
<i>G. ardjunense</i> Zoll. et Mor.	1845	<i>G. POTENTILLOIDES</i> var. ARDJUNENSE
<i>G. potentilloides</i> var. <i>microphyllum</i> . Hook. f.	1854	<i>G. POTENTILLOIDES</i>
var. <i>parviflorum</i> (Willd.) Hook. f.	1854	<i>G. HOMEANUM</i>
<i>G. SESSILIFLORUM</i> Cav.		
<i>G. dissectum</i> var. <i>glabratum</i> Hook. f.	1853	<i>G. HOMEANUM</i>
<i>G. dissectum</i> var. <i>retrorsum</i> (DC.) Hook. f.	1853	<i>G. RETRORSUM</i>
<i>G. dissectum</i> var. <i>patulum</i> Hook. f.	1853	<i>G. RETRORSUM</i>
<i>G. HOMEANUM</i> Turcz.	1863	
<i>G. dissectum</i> var. <i>pilosum</i> (Forst. f.) Hook. f.	1864	<i>G. SOLANDERI</i>
<i>G. TRAVERSII</i> Hook. f.	1867	
var. <i>elegans</i> Chn.	1867	<i>G. TRAVERSII</i>
<i>G. sessiliflorum</i> var. <i>glabrum</i> Knuth	1906	<i>G. SESSILIFLORUM</i> ssp. BREVICAULE
<i>G. pilosum</i> var. <i>grandiflorum</i> Knuth, nom. illeg.	1912	<i>G. RETRORSUM</i>
<i>G. australe</i> (non Nees nec Poir.) Allen	1961	<i>G. RETRORSUM</i>
<i>G. microphyllum</i> var. <i>obtusatum</i> Simp. et Thom.	1943	<i>G. POTENTILLOIDES</i>
<i>G. microphyllum</i> var. <i>discolor</i> Simp. et Thom.	1943	<i>G. POTENTILLOIDES</i>
<i>G. sessiliflorum</i> var. <i>maculatum</i> Simp. et Thom.	1943	<i>G. SESSILIFLORUM</i> ssp. NOVAEZELANDIAE
<i>G. SESSILIFLORUM</i> var. <i>ARENARIA</i> Simp. et Thom.	1943	
<i>G. ANTRORSUM</i> , sp. nov.		
<i>G. DRUMMONDII</i> , sp. nov.		
<i>G. GRANITICOLA</i> , sp. nov.		
<i>G. NEGLECTUM</i> , sp. nov.		
<i>G. OBTUSISEPALUM</i> , sp. nov.		
<i>G. POTENTILLOIDES</i>		
var. <i>ARDJUNENSE</i> (Zoll. et Morr.), comb. et stat. nov.		
var. <i>ABDITUM</i> , var. nov.		
<i>G. SOLANDERI</i> , nom. nov.		
var. <i>GRANDIS</i> , var. nov.		
<i>G. SESSILIFLORUM</i>		
ssp. <i>BREVICAULE</i> (Hook.), comb. et stat. nov.		
ssp. <i>NOVAEZELANDIAE</i> , ssp. nov.		

MORPHOLOGICAL NOTES:

The rootstocks of the species described below can be divided into four main types: (i) Tap-root much branched, thin (annuals); (ii) Tap-root much branched but thick; (iii) Tap-root little branched, slightly swollen, \pm fusiform; (iv) Tap-root thick, napiform, little branched.

To some extent these intergrade with one another, probably as a result of the influence of the environment, but there does appear to be some distinct genetic basis. The first appears in the annual, introduced species only.

The stems are fairly consistent throughout the group in that there are two distinct types, the occurrence of which has not always been noted. All the native species are potentially perennial and possess more or less woody, thickened basal stems or caulorrhiza which have short internodes and are perennial. Even the annual species have comparable stems from which the floriferous stems arise. From these basal stems arise the spirally arranged basal leaves; these are altogether larger than the cauline leaves arising from the floriferous stems, they also have longer petioles, and when

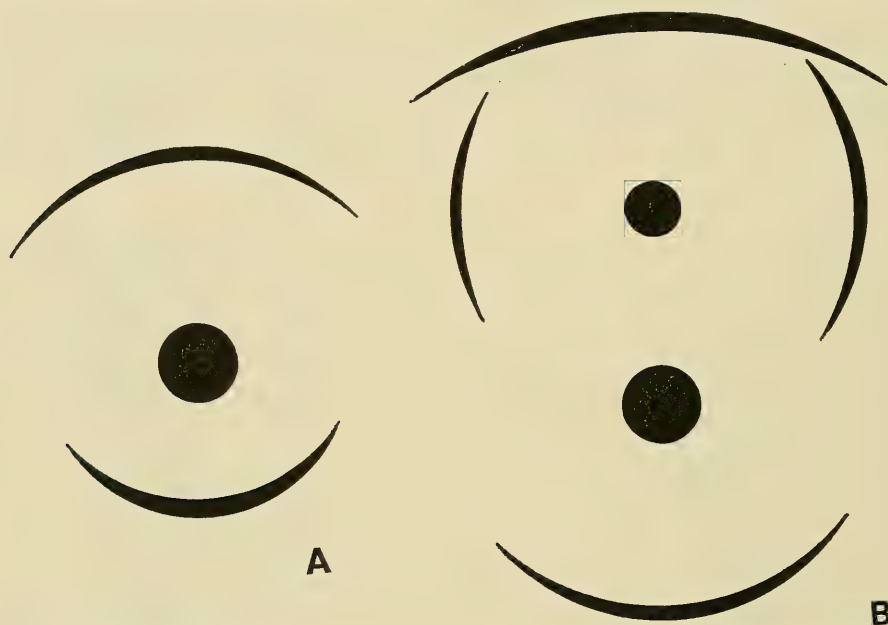


Fig. 1. Diagrams to show flowers, bracts and bracteoles of (a) 1-flower and (b) 2-flower groups.

they die the leaf bases and the stipules are generally persistent upon the stem as dry membranous structures. These leaves are usually more prominent in the winter, at least in the lowland species, and they die during the early stages of the growing season, or are masked by the growth of the cauline leaves. The result is that most previous descriptions are based upon the cauline leaves, omitting the basal leaves from consideration. In the alpine species, *G. antrorsum* and *G. brevicaule*, the basal leaves and stems are the most prominent all the year around.

The annual floriferous stems arise, apparently sympodially, from the basal stems and bearing opposite leaves. In species other than the alpine ones these floriferous stems are elongated and relatively weak, usually much longer than the basal leaves; moreover, in a number of species, they frequently root at the nodes, forming new plants when the intervening part of the runner stem decays, e.g., *G. graniticola*, *G. homeanum* and *G. neglectum*. The alpine species *G. antrorsum* and *G. brevicaule* have very short annual floriferous stems, usually shorter than the basal leaves. It is often reduced to a solitary flower. The two groups, lowland and alpine, then, exhibit a very different superficial appearance during the flowering season. The flowers are borne terminally either solitary or twinned, and the growth of the floriferous stems is sympodial (Eichler, 1887). When the flowers are twinned four bracteoles are present at the base of the pedicels. It appears that the inflorescence is a reduced monochasium retaining the bracteoles of its dichasial ancestry (see Eichler, 1878) (Fig. 1). The solitary condition

of the flower is a further reduction of the inflorescence, leaving only two bracteoles; the flower stalk in this case is herein referred to as a "pedicel-peduncle".

In all the species described below the sepals are arranged quincuncially. The petal aestivation, however, is by no means so consistent, an irregularity which appears to be common in the family. The commonest arrangement in the Australian species appears to be cochlear with quincuncial and convolute arrangements occurring much less frequently.

The five glands alternating with the petals have been interpreted as swellings of the base of the stamens (Eichler, 1878; Knuth, 1912), but this does not appear to be the case. There is a large area between the sepal and the "inner" whorl of stamens and it is upon this part of the receptacle that the nectary develops. In most of the species nectar secretion is extremely active and a large bead collects, trapped between the sepal and the filament. Although the bases of the adjoining petals are provided with hairs, these apparently do not prevent any insects from obtaining the nectar; the nectar usually completely submerges these hairs and in some species the hairs do not overlap at all, e.g., *G. sessiliflorum*.

The Geraniaceae are often cited as having obdiplostemenous flowers. The stamens which lie outermost in the mature flower are certainly those that lie opposite the petals. The sequence of maturation, as measured by dehiscence, does not correspond to their positions in the flower. In fact they follow a quincuncial sequence, the innermost whorl first. Thus, although morphologically obdiplostemenous, physiologically they are not. Possibly the development of the nectiferous gland at the base of the ante-sepal stamens may account for their displacement early in the development of the flower either by sheer force or by nutritional effects. A study of the development and vasculature of the flower might help to clear this up.

Moore (1961) has indicated that he considers there is a fundamental division between those groups having woody stems and alternate leaves and those having opposite leaves on herbaceous aerial stems. Within the first group he includes Sect. *Andina*. The distinction is probably not so very fundamental as a number of species of Sect. *Andina* can, under suitable conditions, produce \pm elongated herbaceous stems, bearing opposite leaves, in place of the (normal) solitary flowers on the caulorrhiza. The caulorrhiza of the "herbaceous" species are homologous with the branches of the "shrubby" species. It should also be noted that in some species, e.g., *G. molle*, the leaves on the flowering branches may be either opposite or alternate (but seldom spirally) arranged.

TAXONOMY.

GERANIUM L., *Gen. Pl.*, 306 (1754); Ait., *Hort. Kew*, 2: 432 (1789); Willd., *Sp. Pl.*, 3: 696 (1801); DC., *Prodr.*, 1: 639 (1824); Benth. et Hook. f., *Gen. Pl.*, 1: 272 (1862); Benth., *Fl. Austr.*, 1: 295 (1863); Moore et Betcher, *Handbk. Fl. N.S.W.*, 54 (1893); Bailey, *Queensland Fl.*, 1: 177 (1899); Rodway, *Fl. Tas.*, 19 (1903); Knuth, *Das Pflanzenreich-Geraniaceae*, 43 (1912); Ewart, *Fl. Vict.*, 681 (1931); Knuth in Engler et Prantl, *Der Natürlichen Pflanzenfamilien*, 2nd ed., 19a: 52 (1931); Black, *Fl. S. Austr.*, ed. 2, 2: 482 (1948); Curtis, *Stud. Fl. Tasm.*, 1: 90 (1956) (applying only to Australian species).

Herbs, usually with one or more basal stems (caulorrhiza) bearing large leaves, from which arise, sympodially, one or more leafy flowering stems. *Cauline leaves* opposite or alternate, dissected, lobed or broadly toothed. Peduncles terminally arranged in cincinnal sequence, often with supernumerary accessory buds at each node. *Flowers* twinned or solitary, with four or two (respectively) bracteoles at the base of the pedicels or along the length of the pedicel-peduncle. *Sepals* 5, imbricate. *Corolla* regular; petals 5, free, imbricate. *Stamens* 10, all bearing anthers or, very rarely, 5 staminodal; filaments broad, free or united at the base. *Glands* 5, alternating with the petals. *Ovary* 5-lobed, 5-locular with $2 \pm$ superposed ovules per loculus, with a distinct 5-fid style. *Fruit* with one basal axile seed per loculus, septicidal and generally septifragal so that the seed is actually exposed, this dehiscence carried on upwards into

the enlarged style, each mericarp thus being surmounted by a curved awn which is glabrous on the inside and separated from the central rostrum except at the summit. *Seed* frequently with a distinctly patterned testa and a funicle often equipped with stiff hairs; endosperm very little or absent; embryo with massive induplicate or convoluted cotyledons. 250-300 species mostly temperate but extending onto tropical mountains.

GROUP I. (All introduced.) Annuals, flowers twinned: hairs mostly coarse and minutely glandular with a line of crisped simple hairs on stems and petioles. Pedicels scarcely geniculate or swelling above at fruiting stage. Flowering stems long. Mericarps wrinkled, with a tuft of long white hairs at the top on either side of the ventral suture and breaking away from the awn at maturity. Seed-coat smooth. (= Sect. *ROBERTIANA* Boiss.)

1. *GERANIUM ROBERTIANUM* L., *Spec. Pl.*, 681 (1753); Burm. f., *Geran.*, 22 (1759); Willd., *Sp. Pl.*, 3: 714 (1801); DC., *Prodr.*, 1: 644 (1824); Knuth, *Pflrch-Geran.*, 64 (1912); Hegi, *Ill. Fl. Mitt-Eur.*, 4: 1712 (1924).

Nomenclatural Synonym. *Robertiella robertianum* (L.) Hank in Underwood-Britton, *North Am. Fl.*, 25: 3 (1907).

Annual herb with thin tap-root and short thin often obsolete caulorrhiza covered with small dry stipules. *Stems* ascending to decumbent, 20-40 (80) cm. long, terete or obscurely grooved, branched, bearing scattered coarse hairs minutely glandular in the young condition, and with a line of denser curled \pm arachnoid simple hairs. Leaves mostly opposite; petioles 2-10 cm. long, thin, bearing scattered coarse glandular hairs and a line of curled ones; laminae ovate to broad-ovate in outline, 2-5 (10) cm. long, 1-5 (8) cm. wide, with scattered coarse minutely glandular hairs on both surfaces \pm appressed (especially on the upper surface) and lines of small crisped simple hairs on the upper surface of the more prominent veins, palmatisect to palmate-compound or ternate; the lobes themselves ovate in outline, pinnatisect or deeply toothed, each secondary lobe or tooth terminated by a short mucronate tip; stipules broad-deltoid to obovate oblong or almost semi-orbicular, up to 3 mm. long and 1.5 mm. wide, glabrescent but for the ciliate margin, membranous, \pm mucronate to obtuse or acute. *Flowers* twinned; peduncles 3-7 cm. long, covered with a minute glandular pubescence and with scattered coarse glandular hairs and a line of crisped simple ones; pedicels 5-10 mm., similar to peduncles, straight and scarcely swollen in fruiting condition; bracteoles lanceolate-deltoid, c. 1 mm. long, acute, membranous, ciliate. *Sepals* 5, ovate to lanceolate or narrow-oblong, 5-7 mm. long, 1.5-2.5 mm. wide with a prominent terminal awn c. 1 mm. long, covered with coarse minutely glandular hairs, membranous towards the margin. *Petals* 5, oblanceolate-obovate to spatulate, 9-12 mm. long including the 4-6 mm. long claw, 3-4.5 mm. wide on the spreading limb, deep pink (to nearly white). *Stamens* 10, all fertile; filaments linear lanceolate, long-acuminate, 6 mm. long; anthers sub-globular; pollen orange. *Fruit*: mericarps ovoid, 2.5-3 mm. long, almost quite glabrous to pilose except for a long tuft of connivent white hairs at the top on either side of the ventral suture, reticulate-ridged but not deeply so and with fewer longitudinal than transverse ridges; awns glabrous except for upper pubescent region; rostrum 1-2 cm. (rarely 3 cm.) long. *Seeds* pale-brown, smooth but dull; raphe \pm basal.

Range. Temperate Eurasia and Mts. of North Africa. Introduced into temperate North and South America. In Australasia only in New Zealand.

Habitat. Disturbed areas.

Typification. There are sheets in LINN of this species labelled by Linnaeus. The synonymy is largely a European problem and is therefore omitted here.

Selected Specimens examined: *New Zealand:* Awakino Gorge, H. H. Allan, 19.11.1928 (CHR 453); Church St, Pukerua Bay, J. D. Hay, 4.2.1949 (CHR 68517); Port Nicholson, H. H. Allan, 13.11.1928 (CHR 812); Railway near Petone, A. J. Healy, 1.11.1945 (CHR 33774); Trentham, Hutt Valley, A. J. Healy, 19.5.1953 (CHR 81413).

2. *GERANIUM PURPUREUM* Vill., *Pl. Delph.*, 72 (1785) et *Hist. Pl. Dauph.*, 1: 272 (1786); Willd., *Spec. Pl.*, 3: 715 (1801).

Nomenclatural synonyms. *G. robertianum* β *purpureum* (Vill.) DC., *Fl. Franç.*, 4: 853 (1805) et *Prodr.*, 1: 644 (1824); Knuth, *Pflrch.-Geran.*, 66 (1912); *G. robertianum* ssp. *purpureum* (Vill.) Murbeck, *Contr. Fl. Tunis.*, 1: 52 (1897); Hegi, *Ill. Fl. Mitt.-Eur.*, 4: 1714 (1924).

Annual herb with a thin tap-root and short thin almost obsolete caulorrhiza covered with small dry stipules. *Stems* decumbent or ascending to 40 cm. tall, terete or obscurely grooved, branched from the base, bearing scattered coarse minutely glandular hairs and a line of small crisped simple ones. *Leaves* mostly opposite; petioles up to 10 cm. long with scattered coarse glandular hairs and a line of small crisped simple ones; laminae ovate to broad-ovate in outline, 2-5 (8) cm. long, 3-7 (9) cm. wide, with scattered minutely glandular hairs on both surfaces and lines of soft \pm crisped simple hairs on the upper surfaces of the larger veins, palmatisect to palmate-compound or ternate; the lobes themselves ovate in outline, pinnatisect or deeply toothed, each secondary lobe or tooth terminated by a short mucronate tip; stipules ovate-oblong to broad-ovate, up to 3 mm. long, glabrescent but for the ciliate margin, membranous, obtuse to acute. *Flowers* twinned; peduncles up to 6 cm. long, covered with a minute glandular pubescence, with coarse scattered glandular hairs and a line of soft \pm crisped simple ones; pedicels up to 10 mm. long, \pm straight and scarcely swollen above in fruiting condition; bracteoles lanceolate-deltoid, c. 1 mm. long, acute, membranous, ciliate. *Sepals* ovate elliptic to lanceolate, 6-7 mm. long, 2-3 mm. wide, with a prominent terminal awn c. 1.5 mm. long with coarse and minutely glandular hairs, membranous towards the margin. *Petals* 5, bright pink, oblanceolate-spathulate, 6-9 mm. long with a distinct claw and spreading limb. *Stamens* 10, all fertile; filaments linear-lanceolate, long-acuminate, c. 5 mm. long; anthers sub-globular; pollen yellow. *Fruit*: mericarps ovoid, 2.5 mm. long, almost quite glabrous but for long tufts of connivent white hairs at the top on either side of the ventral suture, deeply reticulate-ridged with some longitudinal ridges particularly towards the base; awns glabrous except for upper pubescent region; rostrum 1-2 cm. long. *Seed* pale-brown, smooth but dull; raphe \pm basal.

Range. A native of Europe, particularly Mediterranean area, and southwards into Africa (Uganda). Introduced into New Zealand.

Habitat. Roadsides and woodland margins.

Typification. The type has not been examined.

Discussion. Very close to *G. robertianum*, from which it can be distinguished most readily by the yellow pollen and much more prominently reticulate-ridged mericarps.

Specimens examined: New Zealand: nr. Onehunga, H. Carse, 15.10.1928 (CHR 5510); Lara Flats, Penrose, Auckland Isthmus, H. Carse, 15.10.1928 (CHR 5509).

GROUP II. (All introduced.) Annuals, flowers twinned. Glandular hairs conspicuous, often as long as simple ones. Pedicels geniculate, swelling above at fruiting stage. Flowering stems long: mericarps usually pubescent or wrinkled. Seed-coat light brown. (= Sect. COLUMBINA Koch.)

3. GERANIUM MOLLE L., *Sp. Pl.*, 682 (1753); Burm. f., *Spec. Geran.*, 25 (1759); Ait., *Hort. Kew.*, 2: 436 (1789); Willd., *Sp. Pl.*, 3: 710 (1801); DC., *Prodr.*, 1: 643 (1824); Benth., *Fl. Aust.*, 1: 296 (1863); Hook. f., *Fl. N. Zeal.*, 1: 40 (1853) et *Handbk. N. Zeal. Fl.*, 37 (1864); Terracc., in *Malpighia*, 4: 202 (1890); Cheeseman, *Man. N. Zeal. Fl.*, 90 (1906); Knuth, *Das Pflrch.-Geran.*, 57 (1912); Asch. et Graeb., *Syn. Mitt.-Eur. Fl.*, 7: 51 (1913); Hegi, *Illus. Fl. Mitt.-Eur.*, 4: 1701 (1924); Ewart, *Fl. Vict.*, 683 (1930); Black, *Fl. S. Aust.*, 2nd ed., 2: 482 (1948); Curtis, *Stud. Fl. Tasm.*, 1: 92 (1956). Icon: Ross-Craig, *Drawings of British Plants*, 6: 6.34 (1952).

Decumbent or usually ascending annual or short-lived perennial herbs with thin much-branched roots. *Stems* up to 50 cm. long, softly hairy. *Leaves* opposite; petioles up to 7 cm. long on basal leaves shorter on cauline ones covered with villous spreading hairs, laminae orbicular to reniform in outline, 1-0.5 cm. long, up to 3 cm. wide, 5-9-lobed to about the middle with narrow sinuses, each lobe divided into 3-5 obtuse teeth towards

the apex, with scattered villous hairs on both surfaces; stipules lanceolate to oblong, up to 4 mm. long, membranous, villous. *Flowers* twinned; peduncles with villous divergent simple hairs and some glandular ones, 0.8–1.5 cm. long; bracteoles minute, more or less deltoid to ovate, villous; pedicels densely covered with spreading small villous and glandular hairs, up to 12 mm. long, more or less geniculate in fruiting condition. *Sepals* narrow-oblong to elliptic, c. 4 mm. long and 2 mm. wide, villous and glandular hairy, with a very short blunt mucro. *Petals* obovate, about as long as or slightly longer than the sepals, ciliate towards the base, emarginate or bifid. *Stamens* 10; filaments lanceolate, up to 3 mm. long, with a few long hairs on the margin; anthers \pm globular, mauve, c. 0.5 mm. long. *Ovary* glabrous or nearly so; stigmata yellow white or green, c. 1 mm. long. *Fruit*: mericarps glabrous, transversely wrinkled, or smooth, c. 2 mm. long, funicular hairs absent or extremely small; awns glandular and simple hairy; rostrum 6–9 mm. long. *Seeds* ellipsoid, greenish-brown or brown, raphe \pm basal, almost quite smooth.

var. *MOLLE* mericarps wrinkled.

Range. Temperate Australia. A native of Europe, and North Africa, now very widely dispersed.

Habitat. Disturbed land, cultivated or waste places.

Typification. There are two sheets (73 and 74) in the Linnean herbarium, London, pinned together, which have been both labelled *G. molle* by Linnaeus, No. 74 on the back of the sheet, No. 73 on the front. They are, however, specimens of *G. pyrenaicum* Burm. f., a species not recognized by Linnaeus until much later, and have been named so by J. E. Smith.

Sheet 73 does not correspond to Linnaeus' description as it has opposite leaves; for this reason it can be discarded from consideration as a type since Linnaeus' diagnosis describes the leaves as being alternate. The other specimen has some leaves opposite and others alternate; otherwise Linnaeus' description could apply to it, even to the "calycibus muticis", for the sepals have only a tiny, blunt mucro. The trivial epithet "molle", however, scarcely applies to it, and when one considers the emphasis laid on the softness of the indumentum by the authors cited by Linnaeus (see below) it becomes clear that even this specimen must be discarded as a type.

The *nomen specificum legitimum* in the "Species Plantarum" is a new one; the one provided by Linnaeus in "Flora Suecica" is given as a synonym and differs from *G. molle* in "capsulis hirtis". It is possible that he mistook the wrinkles on the mericarps for hairs or that he was referring to the awns only (which is improbable). The Flora Suecica specimen is not extant, but was collected near Lund where both *G. molle* and *G. pyrenaicum* occur. Dalibard, in *Fl. Paris.*, gives a diagnosis which is a copy of Linnaeus' in the "Flora Suecica" except for the alteration of "capsula hirtis" to "capsula hirsutis". He also cites Vaillant's illustration (*vide infra*). Haller's diagnosis includes "foliis mollibus" which is scarcely characteristic of *G. pyrenaicum* but is of *G. molle*. Sauvage in *Fl. Monsp.* gives Haller's diagnosis slightly emended but also states "Geranium foliis alternis, Quia omnia alia foliis oppositis gaudent", which does not apply to the Linnaean specimens entirely.

The most important reference by Linnaeus is to the Vaillant illustration, for it is only in this case that all the characteristics given in Linnaeus' diagnosis are satisfied, with the exception of "Caule ramoso diffuso" which is not contradicted either. "Calycibus muticis" is contrasted in the following species by "calycibus aristatis", i.e., the very short mucro of *G. molle* versus the long one of *G. carolinianum*; such a description of this contrasting character is consistent with his handling of similar cases elsewhere. The agreement of leaf-arrangement should also be recognized.

The general emphasis laid by both Linnaeus and Vaillant on the softness of the indumentum ("molle" and "omnium villosissimum") also indicates that it is Vaillant's illustration that typifies Linnaeus' concept of *Geranium molle* and not the specimens in Linnaeus' herbarium. However, he seems to have had no clear idea of how to apply the

concept since the one specimen of *G. molle* in his herbarium (0-85) is identified as *G. pusillum*, presumably at a much later date.

Vaillant's illustration, *Bot. Paris.*, t. 15, f. 3 (1726), is herewith taken as representing Linnaeus' concept of *G. molle*.

It should be remarked that the alternate arrangement of leaves, stressed so much by both Linnaeus and Vaillant, is not characteristic of the species, plants of which frequently have opposite leaves.

Discussion. A variable species, but there seems little point in recognizing infra-specific taxa other than the very clearly defined one given below.

Selected Specimens examined: *Western Australia:* Subiaco, A. Morrison No. 19095, 18.9.1909 (K); Perth, F. Howard, No. 324 (K). *South Australia:* Mt. Compass, Mt. Lofty Range, J. B. Cleland, 30.10.1921 (AD 96117065); Encounter Bay, J. B. Cleland, 13.9.1931 (AD 96117066); Parklands between Botanic Garden and Rundle Street, Adelaide, H. J. Eichler No. 12050, 15.10.1956 (SYD). *Tasmania:* 4 miles W. of Strahan, R. Carolin No. 1268a, 14.1.1960 (SYD); Circular Head, Gunn No. 1035, 1842 (BM); Van Diemen's Land, Gunn No. 1035, 1842 (K); Embankment of R. Mersey, Devonport, W. M. Curtis, 28.10.1943 (K). *New South Wales:* Kurnell, R. Carolin No. 535, 29.9.1958 (SYD); Cowra, N. C. Beadle, Oct. 1943 (SYD); Woodstock, R. H. Anderson, 2.11.1932 (NSW 42555); Illawarra district, A. G. Hamilton, 10.1900 (NSW 42553); Murrurundi, R. H. Cabbage, No. 1797, 10.1907 (NSW 42557). *Queensland:* Wallangarra, D. Taylor, 19.10.1952 (BRI 037056); Ballandean, F. W. Clark, 19.10.1956 (K.BRI 037059). *New Zealand:* Port Hills, Christchurch, N. Lothian, Dec., 1936 (K); R. Lynd No. 78 (BM); Seatown, W. R. B. Oliver, 13.11.1921 (WELT 6060); Karaka Bay, W. R. B. Oliver, 16.10.1921 (WELT 6059); Mt. Wellington, T. F. Cheeseman, Oct. 1881 (WELT 30970B); Wairarapa, J. Hector (WELT 30976); Kapiti Island, W. R. B. Oliver, Jan. 1935 (WELT 6053); Invercargill Railway yards, A. J. Healy, 29.4.1945 (CHR 58527); Pt. Elizabeth, north of Greymouth, W. Mackay, 11.1928 (CHR 60404); Upper Hutt, A. J. Healy, 24.10.1950 (CHR 79268); Palmerston North, H. H. Allan, 11.1935 (CHR 17792); Hastings, V. D. Zotov, 2.12.1943 (CHR 58524).

var. *AEQUALE* Babbington, *Man. Brit. Fl.*, 2nd ed., 65 (1847); Clapham, Tutin and Warburg, *Fl. Brit. Isles*, 2nd ed., 309 (1962).

Taxonomic synonyms. *G. molle* f. *c preuschoffii* Abromeit, *Flora von öst-und West-preussen*, 156 (1898); Hegi, *Ill. Fl. Mittel-Eur.*, 4: 1702 (1924).

Mericarps quite smooth.

Range. Probably that of the type variety.

Habitat. Same as the type variety.

Typification. *G. molle* var. *aequale*. Babb. Holotype—near Leamington, J. J. Murcott, 1845 (CANTAB); *G. molle* f. *preuschoffii*—not traced.

Specimens examined: *New South Wales:* 9-mile Hill Reserve, Albany, E. J. McBarron, No. 3672, 2.10.1949 (NSW 42545. SYD). *Tasmania:* W. H. Archer (NSW 42544). *New Zealand:* Colenso No. 4458 (K).

4. *GERANIUM PUSILLUM.* Burm. f., *Geran.*, 27 (1759); L., *Sp. Pl.*, ed. 2, 957 (1763); Willd., *Sp. Pl.*, 3: 713 (1801); DC., *Prodr.*, 1: 643 (1824); Hanks et Small in Underwood-Britton, *North Amer. Fl.*, 25 (1): 7 (1907); Terrac. in *Malpighia*, 4: 212 (1890); Hegi, *Ill. Fl. Mitt.-Eur.*, 4: 1703 (1924).

Annual herbs with thin tap-root. *Caulorrhiza* usually short, up to 7 mm. wide and covered with brown scariose ciliate stipules. *Flowering stems* decumbent to ascending, often branched, up to 30 cm. long, pubescent with very short simple and glandular hairs. *Basal leaves* somewhat larger than cauline leaves but of short life-duration. *Cauline leaves* mostly opposite; petioles 1-4 cm. long, pubescent with mostly simple hairs; laminae reniform or orbicular to ovate in outline, 5-20 mm. long, 7-25 mm. wide, 3-5-dissected with broad sinuses, covered with \pm appressed simple hairs and small glandular hairs more numerous on the lower surface; the lobes obovate to oblanceolate

in outline, with 2-3 acute to obtuse secondary lobes or teeth in the upper third; stipules membranous, brown, lanceolate, 1-2 mm. long, 0.5-1 mm. wide, glabrescent on the surface but ciliate with long white simple hairs, acute. *Flowers* twinned; peduncles 1-2 cm. long, pubescent with short simple and glandular hairs; bracteoles linear-lanceolate, 1-1.5 mm. long, membranous, brown-red, ciliate; pedicels 6-10 mm. long, glandular and simple pubescent, geniculate at bracteoles when mature but apparently not swelling conspicuously. *Sepals* 5, elliptic to oblong, 3-4 mm. long, 2-2.5 mm. wide, pubescent with very short \pm appressed simple hairs and (in younger stages) numerous minute glandular hairs with longer stiffer simple hairs towards and on the margins, acute or minutely mucronate. *Petals* pale purple-pink, oblanceolate to narrow-obovate, 2-4 mm. long, emarginate. *Stamens* 10, but only five fertile; filaments lanceolate-acuminate, c. 2 mm. long; anthers broad-oblong. *Fruit*: mericarp smooth except for a longitudinal dorsal ridge often with 1-6 pairs of very short lateral ridges (c. one-eighth the breadth of the mericarp), pubescent with short soft closely appressed simple hairs; awns densely clothed with very short simple and some minute glandular ones; funicular hairs absent; rostrum 5-7 mm. long, stigmatic lobes less than 1 mm. long. *Seeds* oblong, c. 1.5 mm. long, with a \pm lateral raphe, very pale brown, smooth but dull.

Range. A native of temperate Eurasia and now introduced into temperate America. In Australasia at present only in New Zealand.

Habitat. Disturbed ground and pastures.

Typification. I have not examined the type, and as synonymy is largely concerned with European forms, this also is not dealt with here.

Discussion. Collections of this species in New Zealand appear to have commenced in 1928, and it may be, therefore, a relatively recent introduction.

Selected Specimens examined: New Zealand: Railway Station, Upper Hutt, A. J. Healy, 8.1.1945 (CHR 97570); Sandford Downs, Balmoral, North Canterbury, A. J. Healy, 6.12.1946 (CHR 70904); Wellington Harbour, A. J. Healy, 2.4.1941 (CHR 33443).

Geranium pratense L. has been recorded once from New Zealand probably as a garden escape; Banks of Avon, rare ex Europe. Sine leg. (CHR 5514).

It does not appear to have thoroughly established itself as a permanent part of the adventive flora of New Zealand.

5. GERANIUM ROTUNDIFOLIUM L., *Sp. Pl.*, 683 (1753); Ait., *Hort. Kew.*, 2: 436 (1789); Willd., *Sp. Pl.*, 3: 712 (1801); DC., *Prodr.*, 1: 643 (1824); Knuth, *Das Pflarch. Geran.*, 55 (1912); Asch. et Graeb., *Syn. Mitt.-Eur. Fl.*, 7: 48 (1913); Hegi, *Illust. Fl. Mitt.-Eur.*, 4: 1705 (1924); Curtis, *Stud. Fl. Tasm.*, 1: 92 (1956). Icon: Ross-Craig, *Drawings of British Plants*, 6: 6.36 (1952).

Annual herb with \pm thickened tap-root. *Caulorrhiza* short brown, but obscured by stipules and petioles, up to 4 mm. wide. *Flowering stems* ascending or erect, sometimes branched, up to 60 cm. long, covered with soft \pm patent glandular and simple hairs. *Basal leaves* usually larger than cauline leaves but of short life-duration. *Cauline leaves* opposite; petioles up to 15 cm. long, glandular and simple hairy; laminae orbicular to reniform in outline, 1-3 cm. long, 1-5 cm. wide, 5-7-dissected with narrow sinuses, covered on both surfaces with soft appressed hairs; the lobes with several, usually obtuse, teeth towards the top; stipules membranous, brown or red, lanceolate to narrow ovate, c. 3 mm. long and 1 mm. wide, acute with a few scattered appressed hairs on the surface and with long simple hairs on the margin. *Flowers* borne in pairs; peduncles glandular hairy, with a very few stiff simple hairs, 2-3 cm. long; bracteoles linear-lanceolate to lanceolate, c. 2 mm. long, red or brown, membranous, ciliate; pedicels similar to peduncles, 1.2-2.0 cm. long, geniculate and swollen above in the fruiting stage. *Sepals* 5, ovate to oblong, 3-5 mm. long, 1.5-2 mm. wide, covered with long soft white simple hairs and some glandular ones, narrowly membranous at the margin and shortly (0.5 mm.) mucronate. *Petals* purple or rose, broad-spathulate c. 7 mm. long and 2 mm. wide, the claw c. 3.5 mm. long and paler than the lamina, entire, glabrous at the base. *Stamens* 10; filaments lanceolate to elliptic-acuminate, c. 4 mm. long and 0.5 mm.

wide, yellowish-white below, pink above, ciliate; anthers yellow, sub-globular to oblong, c. 0.5 mm. long. *Ovary* hirsute; stigmata red. *Fruit*: mericarp smooth, covered with stiff simple hairs with some glandular ones towards the top, awns densely covered with both simple and glandular hairs; funicular hairs \pm erect, 12–20; rostrum c. 1.5 cm. long, upper contracted part plus stigmatic lobes c. 4 mm. long. *Seeds* \pm globular, c. 2 mm. long with a \pm basal raphe, light brown with very prominent alveolae.

Range. Probably a native of temperate Eurasia and now introduced into temperate America. In Australasia at present only in Tasmania.

Habitat. Disturbed ground, waste and cultivated.

Typification. Linnaeus provides a new original nomen legitimum in *Species Plantarum*. There are two specimens in the Linnaean herbarium in London, labelled *G. rotundifolium* by Linnaeus. One of these does not agree with Linnaeus' diagnosis which states "petalis integris". This specimen, with notched petals, is *G. pusillum* and can be discarded as a type. Likewise the Vaillant illustration (*Bot. Paris*, t. 15, f. 1) can be discarded as it, too, shows very distinctly notched petals; it also appears to be *G. pusillum*.

Haller, in the diagnosis cited by Linnaeus, states "Caulis . . . odoratia subviscidi", which is a good description of living specimens conspecific with the second Linnaean specimen, and "Capsulae glabrae", which is not strictly accurate as the carpels are sparsely hairy. It is, however, certainly not applicable to *G. pusillum* in which the mericarps are very distinctly hirsute.

It seems quite in order, then, to select the sheet No. 83 in the Linnaean herbarium as the LECTOTYPE.

Discussion. Not very widespread yet, but may become more important. It can be distinguished: from *G. molle* by the hairy, smooth mericarps, the longer rostrum, the entire petals and the deeply alveolate seed-coat; from *G. dissectum* by the wider leaf-lobes, shorter awn (or mucro) on the sepals and long-clawed glabrous petals.

Specimens examined: Botanical Gardens, waste ground, Hobart, W. M. Curtis, No. 4. 1942 (K); Waste ground, Launceston Tasmania, W. M. Curtis, 28.10.1943 (K).

6. *GERANIUM DISSECTUM* L., *Cent. I. plant.*, 21 (1755) et *Amoen. Acad.*, 4: 282 (1760) et *Sp. Pl.*, ed. 2, 956 (1763); *Burm. f., Geran.*, 21 (1759); Willd., *Sp. Pl.*, 3: 712 (1801); DC., *Prodr.*, 1: 643 (1824); Knuth, *Das Pflrch.-Geran.*, 51 (1921); Asch. et Graebn., *Syn. Mitt.-Eur. Fl.*, 7: 43 (1913); Hegi, *Illus. Fl. Mitt.-Eur.*, 4: 1681 (1924); Fernald, *Rhodora*, 37: 298 (1935); Bobrov in Schischkin et Bobrov, *Fl. U.S.S.R.*, 14: 74 (1949); Curtis, *Stud. Fl. Tasm.*, 1: 91 (1956).—Icon: Ross-Craig, *Drawings of British Plants*, 6: 6.37 (1952).

Taxonomic Synonyms: *G. angustifolium* Gilib., *Fl. Lith.*, 2: 176 (1786); *G. palmatum* Picard in *Mem. Soc. Agric. Boulogne*, Ser. 2, 1: 122 (1937); *G. minimum* Picard, *loc. cit.*, 122 (1837).

Decumbent or ascending annual herbs with thin branched roots and short caulorhiza. *Stems* up to 40 cm. long, obscurely angled and with scattered reflexed simple hairs. *Leaves* opposite; petioles up to 8 cm. long on basal leaves, shorter on cauline ones, covered with divergent simple hairs; laminae orbicular to reniform in outline, up to 2.5 cm. long and 4 cm. wide, usually c. 1.5 cm. long and 2.5 cm. wide, deeply palmately divided into 5–7 (9) narrow-oblong to linear lobes, themselves divided into linear acute secondary lobes or long teeth, with scattered hairs appressed on both surfaces; stipules narrow-deltoid to lanceolate, 4 mm. long, up to 1 mm. wide, more or less membranous, usually reddish in colour, with scattered superficial hairs, ciliate. *Flowers* twinned; peduncles 1–1.8 cm. long, with scattered retrorse simple hairs and few glandular ones; bracts linear-deltoid, up to 2 mm. long, otherwise similar to the stipules; pedicels 5–10 mm. long, with scattered simple hairs below succeeded by glandular ones above, geniculate at the bracteoles and swollen above in the fruiting condition. *Sepals* lanceolate to narrow-elliptic, 6–8 mm. long, 2–3 mm. wide, covered with glandular and some simple hairs of same length, usually prominently veined, ciliate, acuminate with an awn c.

1.5 mm. long. *Petals* oblanceolate, somewhat longer than sepals, emarginate, deep pink, paler and ciliate towards the base. *Stamens* 10; lanceolate-acuminate, up to 3 mm. long, ciliate; anthers with a blue dehiscence line; pollen blue. *Ovary* hirsute; stigmata white on the inner surface, c. 1 mm. long. *Fruit*: mericarps hirsute, 2.5 mm. long; funicular hairs absent or much reduced; awns with long glandular hairs; rostrum 10–12 mm. long. *Seeds* pale brown, more or less globular, very distinctly isolaterally alveolate, raphe basal.

Range. Temperate Australia, New Zealand, but only in the cooler parts. A native of Europe, but now very widely spread.

Habitat. Waste places generally.

Typification. *Geranium dissectum* L. Holotype. There is one sheet in the Herbarium of Linnean Society, London, which agrees with the Linnaean description and is labelled by Linnaeus.

Discussion. This species has been confused with all of the native species except the high alpine ones. It has been usual practice to refer them all, including the one at present under discussion, to *G. dissectum* var. *australe* Benth. It is, however, quite distinct; the leaves have \pm linear lobes; the pedicel and rostrum have long glandular hairs; the sepals have an awn c. 1.5 mm. long; funicular hairs are absent; the seed coat is pale brown with very characteristic alveolae and the raphe is mostly basal. There seems to be little doubt that it is not native.

The lengthy synonymy provided by Knuth is quite unreliable.

It appears to be a fairly variable species, but the Australian specimens correspond quite well with the type.

The species is also found in New Zealand and the Antarctic Islands.

Selected Specimens examined: *New Zealand:* Prov. Canterbury, Sinclair and Haast, 1860–61 (K) *pro parte*; Kermadec Group, Sunday Island, T. F. Cheeseman No. 4 Com. 5/1889 (K); Auckland, ex herb. Kirk No. 147 (BM); Tokomaru Swamp, Manawata Co., H. Carse, Jan. 1925 (WELT 31008); near Auckland, L. Cockayne, 833/5 (WELT 31010); Whangarei, H. Carse Oct. 1897 (WELT 30993); Mt. Wellington lava fields, D. Petrie, Nov. 1910 (WELT 30996); Palmerston North, C. E. Woodhead, 1.12.1934 (CHR 17838); Morton, I. W. Davey, 30.12.1938 (CHR 21558); Upper Hutt, J. A. Hay, 17.12.1950 (CHR 82587). *South Australia:* Mt. Lofty Range, National Park, J. B. Cleland, 13.12.1952 (AD 96117086). *Victoria:* Melbourne, Adamson No. 155, 9.10.53 (K); Shepparton, Broken River, F. W. Britten, 11.10.1925 (K). *Tasmania:* Wilmot-Waldheim, 14 miles, R. Carolin No. 1231, 10.1.1960 (SYD); Maning Ave., Sandy Bay, Hobart, W. M. Curtis, 17.12.1943 (K).

GROUP III. Perennials with \pm fleshy roots, rarely napiform. Flowers generally solitary (but cf. *G. homeanum*), pedicels usually geniculate and swelling above at maturity. Flowering stems long. Seed-coat brown, alveolae small, usually shallow and elongated or rarely black with deeper elongated alveolae. (= Sect. AUSTRALIENSIA Knuth.)

7. GERANIUM POTENTILLOIDES L'Hér. ex DC., *Prodr.*, 1: 639 (1824); Hook. f., *Fl. N. Zeal.*, 1: 40 (1852), et *Fl. Tasm.*, 1: 57 (1860), *non* Klotzsch (1862), *nec* Spreng (1826), *non nec* Bonpl. ex Wedd. (1855).

Nomenclatural Synonyms: *G. dissectum* L. var. *australe* Benth., "race" *potentilloides* (L'Hér. ex DC.) Benth., *Fl. Austr.*, 1: 296 (1863); *G. pilosum* Sol. ex Willd. var. *potentilloides* (L'Hér. ex DC.) Ewart, *Fl. Vict.*, 682 (1930); Black, *Fl. S. Aust.*, 2nd ed., 2: 482 (1948).

Taxonomic Synonyms: *G. philonothum* DC., *Prodr.*, 1: 639 (1824); *G. microphyllum* Hook. f., *Fl. Antarct.*, 1: 8, t. 5 (1844); *Handb. N. Zeal. Fl.*, 36 (1864); Cheeseman, *Man. N. Zeal. Fl.*, 89 (1906); Knuth, *Pflrch.-Geran.*, 151 (1912); Simpson and Thompson, *Trans. Roy. Soc. N.Z.*, 73: 156 (1943); Curtis, *Stud. Fl. Tas.*, 1: 91 (1956); Allan, *Fl. N. Zeal.*, 1: 235 (1961); *G. potentilloides* var. β *microphyllum* (Hook. f.) Hook. f., *Fl.*

N. Zeal., 1: 40 (1852); *G. potentilloides* var. *γ*, *debile* Hook. f., *Fl. N. Zeal.*, 1: 40 (1852); *G. sarawakatense* Knuth in *Fedde Rep.*, 45: 61 (1938); *G. microphyllum* var. *obtusatum* Simpson et Thomson in *Trans. Roy. Soc. N. Zeal.*, 73: 156 (1943); Allan, *Fl. N. Zeal.*, 1: 236 (1961); *G. microphyllum* var. *discolor* Simpson et Thomson, *loc. cit.*; Allan, *loc. cit.*

Perennial herbs with thickened but not napiform tap-roots and few (usually only 1 or 2) caulorrhiza up to 4 cm. long covered with the brown persistent leaf base and stipules. *Flowering stems* decumbent to ascending, up to 50 cm. long, pubescent with soft retrorse often closely appressed or very short hairs, sometimes glabrescent basally, often rooting at the nodes. *Basal leaves* not persistent through the summer, larger than the cauline ones but otherwise similar. *Cauline leaves* opposite; petioles slender, 1.5–3.5 cm. long, pubescent with retrorse hairs; laminae deeply palmately 5–7-lobed, semi-orbicular to broad-ovate in outline, 1–3 cm. long, 1–5 cm. wide, pubescent on both surfaces, usually paler and sometimes purplish on the lower surface; lobes oblong to narrow obovate, central one divided into 3 (rarely 5–7) obtuse secondary lobes or teeth, lateral ones less divided and usually making the lamina distinctly cordate; stipules lanceolate, 3–10 mm. long, long-acuminate, often 2-fid, subherbaceous on midrib becoming membranous towards the margin, pubescent. *Flowers* solitary (very rarely twinned); pedicel-peduncles slender, pubescent with soft short retrorse-appressed hairs or puberulent, 2–4 cm. long, with two linear to lanceolate subherbaceous pubescent bracteoles c. 2.5–4 mm. long at the midpoint or lower, geniculate at the bracteoles when mature and swollen in upper part in fruiting condition. *Sepals* 5, lanceolate to narrow-elliptic, 4–6 mm. long, 1.5–2.5 mm. wide, acuminate, pubescent with short more or less appressed hairs and some longer ones, ciliate, scarcely convex in fruiting stages. *Petals* 5, obovate, 5–6 mm. long, c. 3 mm. wide, pink, paler below and with translucent veins, ciliate at margin. *Stamens* 10; filaments lanceolate-acuminate, c. 3 mm. long and 0.5 mm. wide, ciliate at the base at margin. *Ovary* hirsute; stigmata white or pale pink, c. 1 mm. long. *Fruit*: mericarps oblong, c. 3.5 mm. long and 1.5 mm. wide, brown, covered with stiff spreading hairs with some minute glandular ones, funicular hairs c. 25; awns densely covered with short stiff simple hairs and some minute glandular ones on the outer surface. *Rostrum* 9–10 mm. long. *Seeds* dark brown, oblong, 2.0 mm. long, covered with shallow, somewhat elongated alveolae, minutely punctate; raphe lateral.

var. POTENTILLOIDES.

Indumentum mostly retrorse-appressed, that of the sepals soft and antrorse-appressed. Seed reticulation small but not minute. *Rostrum* c. 9 mm. long. *Leaves* divided into broad-linear to oblong or obovate segments.

Range. All over Temperate Australia, including Tasmania, New Zealand and Antarctic Islands, but tending to occur in the damper regions more commonly.

Habitat. Various, but generally in forests or woodlands.

Typification. *G. potentilloides* L'Hér. ex DC.—Holotype—Nova Zealandia Banks ("Nova Hollandia" must be misprint in DC's *Prodromus*) (GEN. photo SYD. isotype BM). *G. microphyllum* Hook. f.—Holotype—Lord Auckland's Group, J. D. Hooker (K. photo SYD.). The type consists of three specimens mounted towards the top of a sheet which also bears other apparently conspecific specimens. *G. philonothum* DC.—Holotype—In *Novae Hollandiae ora merid sine coll.* (GEN. Photo SYD.). *G. potentilloides* var. *debile* Hook. f.—Syntypes—Colenso, No. 1638 (K), and Raoul (K) (photos SYD.).

G. potentilloides Klotzsch in *Bot. Ergeb. Waldem Reise*, 123, t. 17 (1862), is a later homonym of *G. potentilloides* L'Hér. ex DC.

G. microphyllum var. *obtusatum* Simp. et Thom.—Holotype—Flagstaff Hill near Dunedin, G. Simpson & J. S. Thomas (CHR 75698). *G. microphyllum* var. *discolor* Simp. et Thom.—Holotype—Port Hills, Christchurch, G. Simpson (CHR 62979).

Discussion. The New Zealand and Antarctic Islands specimens were separated by J. D. Hooker as var. *microphyllum* or *G. microphyllum*. The type from Auckland Group differs from most in having somewhat coarser pedicel hairs, smaller leaves and smaller,

more obscure alveolae on the seeds. All these conditions are found in some other specimens. It seems inadvisable to recognize *G. microphyllum* as a separate taxon at present.

The type variety shows close affinity with *G. magellanicum* Hook. f., a native of South America. The latter, however, has consistently twinned flowers; apparently the petals are consistently white and the indumentum is somewhat coarser. Allan in *Fl. New Zeal.*, following Simpson and Thompson, recognizes two varieties of *G. microphyllum*. These do not correspond to any Australian material and gradations between their characters and those of the type occur. Moreover, many of the New Zealand specimens show long, stiff, patent hairs on the sepals, frequently associated with

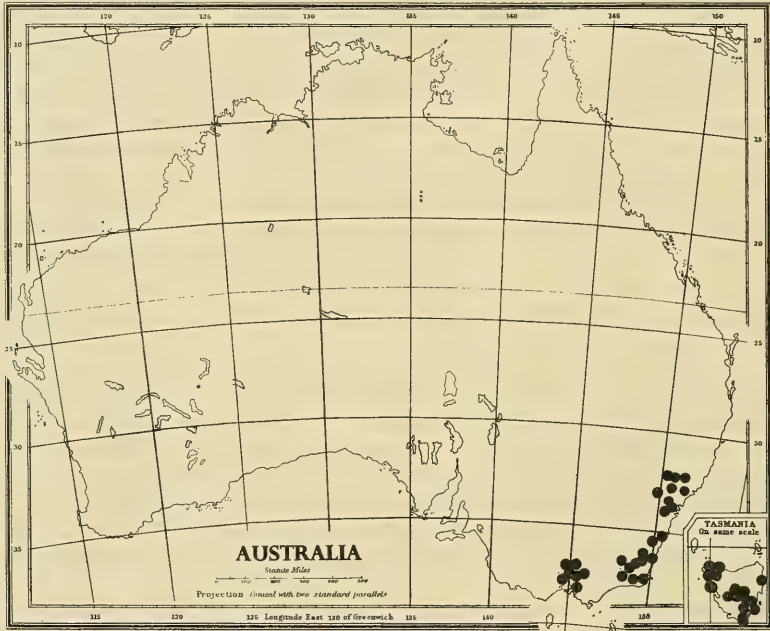


Fig. 2. Distribution of *G. potentilloides* var. *potentilloides* in Australia.

short (0.5 mm.) sepal awns and smaller leaves. This correlation of characters is not constant, neither have I been able to determine any geographical or ecological characteristics associated with this form from the herbarium labels; both var. *obtusatum* Simpson et Thomson and var. *discolor* Simpson et Thomson appear to show these characteristics. Some specimens show divergent glandular hairs. The situation can only be understood by some further fieldwork.

The specimens from the Antarctic Islands, i.e., Auckland Island and Campbell Island, are similar, differing in the long coarse hairs on the sepals, which, however, are appressed and not divergent as in the forms mentioned above. This corresponds to *G. microphyllum*, but the difference is not specifically distinct.

New Zealand authors have frequently remarked upon the possibility of hybrids occurring between "*G. microphyllum*" and *G. sessiliflorum*. This could explain some of the variability, but, so far, there is no direct evidence of such hybridization.

Specimens examined: South Australia: Caroline Forest Reserve, E. N. S. Jackson, No. 242 17.11.1959 (AD 96104260). Victoria: Healesville, N. N. Donner No. 420, 28.10.1961 (AD 96212003); Mt. Drummer, R. Carolin No. 1906, 15.2.1960 (SYD); Mt. Buller, R. Carolin No. 1096, 5.1.1960 (SYD); Delatite River, F. Mueller, 21.3.1853 (MEL); Emerald, Mr. Pitcher 8.12.17 (MEL); South Morang, P. R. H. St. John, 10.12.1903 (MEL); Lower Glenelg River, J. H. Willis, 29.12.1948 (MEL); Christmas Hills, North

of Melbourne, Helen I. Aston No. 563, 2.12.1959 (MEL); Fern Tree Gully near Melbourne, H. Salasoo No. 1736, 2.1.1959 (NSW 47353). *Tasmania*: Between Lake Sorrell and Great Lake, Hj. Eichler No. 16554, 10.1.1960 (AD 96107197); Nugent, N. end of Tasman Peninsula, R. Carolin No. 1836, 10.2.1960 (SYD); Prosser River, R. Carolin No. 1846, 10.2.1960 (SYD); Recherche Bay, Cockle Creek, R. Carolin No. 1405, 21.1.1960 (SYD); Gunn, Nos. 259 et 1035 (K) Ironstone, F. A. Rodway, 12.1900 (NSW 42647); J. Milligan, No. 446 (BM); Hobarton, James Backhouse No. 243, 1834 (BM). *A.C.T.*: Near Mt.



Southern Pacific Oblique Azimuthal Equidistant centred on c. long. 180° lat. 51°.

Fig. 3. Map to show the distributional tract of *G. potentilloides*, *G. magellanicum*, and related species.

Franklin, N. T. Burbidge No. 1735, 8.3.1947 (CANB 13052). *New South Wales*: Scout's Alley, Barrington Tops, R. Carolin No. 480, 13.4.1958 (SYD); Mt. Irvine, R. Carolin No. 604, 20.11.1958 (SYD); 10 miles S.E. of Nowendoc, R. Carolin No. 2063, 19.12.1960 (SYD); Point Lookout, R. Carolin No. B122, 19.3.1957 (SYD); Katoomba, J. H. Camfield, 1908 (NSW 42604). *New Zealand*: Picton, South Island, ex. Herb. Kirk No. 319 (BM); Whangarei, D. Petrie, Nov. 1900 (WELT 30893); Fautham Peak, Mt. Egmont, W. R. B. Oliver, 2 Jan. 1937 (WELT 6050); near Putaruru, Mata Mata Co., D. Petrie, March 1915 (WELT 30892); Te Akatea, Raglan Co., D. Petrie, 16th Jan. 1922 (WELT 30895); Tongariro, A. G. Whitehorn, Summer 1907 (WELT 30902); Signal Hill, Dunedin, D. Petrie, Jan. 1891 (WELT 30890); Mason Bay, Stewart Island, J. W. Murdoch, sine date (WELT 30901); Camp site Route to Irene Saddle, Mrs. M. Cookson, Jan. 1955 (CHR 96281); Campbell Island, W. B. Brockie, 4 Jan. 1947 (CHR 30919); Tauheren Kau, Wellington, L. B. Moore, 7.2.1942 (CHR 44656); Karioti National Park, H. L. Poole, 3.2.38 (CHR 19332). *New Guinea*: Andabare, McNicoll Plateau S.W. of Laiagam, R. G. Robbins No. 3336a, Aug. 22.1960 (CANB 88962); Northern Slopes of Sugarloaf complex, Wabag subdistrict, Western Highlands, R. D. Hoogland and R. Schodde No. 7215, 21 July, 1960 (CANB 84255.L.LAE); Eastern Highlands Distr., near Lake Aunde, E. Slope of Mt. Wilhelm, R. D. Hoogland and R. Pullen, No. 5708, 21 July, 1956 (CANB 41150.L.LAE);

Eastern Highlands Distr., Mt. Wilhelm east slopes, L. J. Brass NO. 30183, June 27, 1959 (CANB 101723).

var. *ABDITUM*, var. nov.

Herbae perennes adscendes vel decumbentes. Flores solitaires. Pediceli-pedunculi pilis confertis retrorso-appressis vestiti bracteolisque duo linearis pubescentis infra medium vel base. Rostrum 9–12 mm. longum. Semina oblong nigra alveolis elongatis.



Fig. 4. Distribution of *G. potentilloides* var. *abditum* (●), and *G. graniticola* (X).

Ascending or decumbent perennial herb. Flowers solitary. Pedicel-peduncles densely covered with retrorse-appressed hairs, the two linear bracteoles inserted at the base or in the lower half. Rostrum 9–12 mm. long. Seeds oblong, 2 mm. long, 1 mm. wide, black with deep elongated alveolae somewhat larger than those of the other two varieties.

Range. Eastern Highland of Australian mainland.

Habitat. In or on the margin of subalpine woodland.

Typification. Holotype—Munyang near Guthega, R. Carolin, No. 785, 21.1.1959 (NSW 66125). Named from having been concealed to date.

Discussion. It seems probable that this variety forms hybrids with *G. sessiliflorum* in the field. Many of the collections from the Kosciusko plateau appear to be the result of extensive crossing. One particular specimen, i.e., Carolin No. 799, corresponds almost exactly to an artificial first generation hybrid raised by this author. The actual extent of the crossing is not known as yet, but the two species do seem to remain distinct. The present variety is distinguished from *G. sessiliflorum* most easily by the longer flowering stems and deep alveolae on the seed coat; from *G. potentilloides* by the black seeds with deep alveolae and the finer indumentum and the lower placed bracteoles. It seems to connect this group with the sect. *Andina*.

Selected Specimens examined: Victoria: Mt. Buffalo, R. H. Cambage, No. 3731, 19.1.1913 (SYD); Mt. Buller, R. Carolin, No. 1097, 5.1.1960 (SYD). New South Wales: Charlotte's Pass, Mt. Kosciusko, R. Carolin, No. 786, 25.1.1959 (SYD); Island Bend, M. Woodward 21.1.1958 (SYD); White's River Hut near Guthega, R. Carolin, No. 796 26.1.1959 (SYD); Kanangra Walls, Kanangra Creek, R. Carolin No. 889, 22.3.1959 (SYD); Happy Jack River gorge, J. G. Milmer, 16.2.1957 (NSW 42565).

var. *ARDJUNENSE* (Zoll. et Mor.), comb. et stat. nov.

Nomenclatural Synonym. *G. ardjunense* Zoll. et Mor. in *Nat. en Geneesk. Arch. Ned. Ind.*, 2: 585 (1845); Knuth, *Pflarch. Geran.*, 15 (1912). BASINYM.

Sepal hairs long and stiff and often more or less divergent, especially towards the margins. Leaves with laminae reniform in outline, the main lobes further divided into linear secondary lobes. Bracteoles lanceolate. Rostrum 10–14 mm. long.

Range. Java, Sumatra and Celebes.

Habitat. Mountain forest.

Typification. Types: Zollinger No. 2246 (P.GEN.BO.B, destroyed).

Specimens examined. *Java:* Lawoe, J. H. Coert No. 994 12.1936 (L.); G. Lawoe, J. H. Coert No. 336 15.3.1925 (L.), C. A. Backer No. 37198, 7.6.1929 (L.); G. Kembar, C. Skottsberg and C. A. Backer No. 37199 9.6.1929 (L.); G. Merbaboe, J. H. Coert No. 119 22.4.1920 (L.); G. Kawi, Oro-oro, Drs. van Leuwen-Reynvaan No. 12330, 17.4.1929 (L.BO); Besoeki, Jang Plateau, van Steenis No. 10921, 15.7.1938 (L.BO); G. Lawoe, J. Dorgeb, Saranga No. 464, Nov. 1924 (L.); Pasoercean Mt. Welirang, van Steenis No. 7055, 4.6.1935 (L.BO). *Sumatra:* Atjeh, Laut Poependji, van Steenis No. 6400, 3–5.9.1934 (L.K.BO). *Celebes:* Gg. Bonthain, H. A. B. Bunnemejer No. 12388, 21.6.1921 (L.BO); Gg. Bonthain, H. A. B. Bunnemejer No. 12319, 19.6.1921 (L.BO); G. Bonthain, C. Monod de Froideville No. 229, 1938 (L.BO.K.P.BM). *Timor:* Huato-Builico, N.W. of Mt. Tata-Mailau, van Steenis No. 18378, 4.1.1954 (L.BO.K.COI); Mt. Tatamailau, van Steenis, No. 18444, 5.1.1954 (L.BO.K.COI); Forbes No. 3818, 1897 (BO); Moetis (de Voogd, No. 2272, 14.2.1935 (BO). Huata-Builico, Jaldas do Tata-Mailau, Ruy Cinatti No. 4 (COI).

Discussion. This variety shows some resemblance to *G. nepalense* Sweet. The flowers of this latter species, however, are twinned, it has a much thinner rootstock, and the secondary lobes of the leaf are more towards the base of the primary lobes and more acute. The seed form is very similar indeed, although the indumentum tends to be more villous and spreading in *G. nepalense*. The Celebes specimens are closer to var. *potentilloides* in leaf-shape but they still have the typical sepal-indumentum of var. *ardjunense*; the flowers of the latter are, moreover, smaller than those of the Java specimens which latter are consistently larger than in the type variety.

The specimens collected on Timor show a certain amount of variation in the arrangement of the flowers either solitary or in pairs. Moreover the roots appear to be, in general, thicker than those from Java and the seed alveolae are rather coarser. However, they appear to belong here although showing some resemblance to *G. retrorsum*.

8. GERANIUM MONTICOLA Ridley in *Trans. Linn. Soc. Lond. Bot.*, 9: 23 (1916).

Taxonomic Synonyms. *G. papuanum* Ridley, *loc. cit.*, 23; *G. clemensiae* Knuth in *Fedde Rep.*, 45: 61 (1938); *G. papuanum* var. *alpestris* Ridley, *loc. cit.*, 23.

Perennial herbs, often very compact, with thick ascending, often much-branched, caulorrhiza covered with persistent petioles and stipules. *Flowering stems* prostrate, stoloniferous or very short and ascending, frequently producing secondary erect caulorrhiza at the nodes, pubescent with very short hairs at least when young. *Leaves:* laminae usually reniform in outline, hirsute, particularly on the undersurface, or almost glabrous, deeply 3–5-lobed or dissected, 3–7 mm. long, 12–14 mm. wide, the lobes sometimes toothed towards the apex; petioles covered with retrorse-appressed hairs, c. 5–6 cm. long; stipules ovate to orbicular, 3–2.5 mm. long, 3–3.5 mm. wide, pubescent, membranous, brown. *Flowers* solitary, pedicel-peduncle pubescent with soft retrorse-appressed hairs, 2.5–5 mm. long; bracteoles ovate to orbicular, c. 2 mm. long, usually obtuse or very slightly acuminate, more or less pubescent, membranous, brown. *Sepals* elliptic to oblong, c. 3 mm. long, 1 mm. wide, pubescent with soft appressed hairs sometimes divergent at the apex with a short mucro. *Petals* spatulate, distinctly unguulate, 1.5–4 mm. long, 2–4 mm. wide, glabrous towards the base, pink. *Stamens* 10; filaments lanceolate, c. 3 mm. long, ciliate, bearing a sub-globular anther, the outer whorl sometimes with two teeth on the shoulders. Mericarp and seeds not seen.

Range. New Guinea.

Habitat. Alpine grasslands and rocky outcrops.

Typification. *G. monticola* Ridley—Holotype—Camp XIII, Mt. Carstensz, 10500 ft. (BM); *G. papuanum* Ridley—Holotype—Camps X–XI, Mt. Carstensz, 6700–8300 ft. (BM); *G. clemensiae* Knuth—Holotype—Mt. Sarawaket, auf dem Gipfel, Clemens No. 5872, 1937 (B destroyed) (no further specimens have been traced); *G. papuanum* var. *alpestris* Ridley—Holotype—Camps XIII–XI, Mt. Carstensz, 8300–10500 ft. (BM. K. isotype).

Discussion. Variable, particularly in the degree of hairiness of the leaves. *G. papuanum* is based upon a more glabrous specimen, *G. monticola* on one which is hirsute, particularly on the undersurface of the leaf. There seems to be every gradation between these two extremes. At higher altitudes the plants have a more compact habit—the basis for *G. papuanum* var. *alpestris*; again there seem to be gradations linking the normal form and the more compact one. It has not been possible to trace type material of *G. clemensiae*, but from the rather inadequate description of Knuth it appears that it belongs here.

This species appears to be another upland derivative of *G. potentilloides*, differing from the latter species in the smaller, usually less dissected, leaves, compact habit or producing secondary caulorrhiza at the rooting nodes of the stolons, ovate-orbicular and imbricate bracteoles and distinctly clawed petals which are glabrous on the margin at the base.

Specimens examined: New Guinea: 11 km. north-east of Wilhelmina Top, 3400 m. alt., L. J. Brass and E. Meyer-Drees, No. 9813, Sept. 1938 (L.); 2 km. east of Wilhelmina Top, 3800 m. alt., L. J. Brass and E. Meyer-Drees No. 10186, Sept. 1938 (L.); Lake Habbema, L. J. Brass, No. 9207, Aug. 1938 (L.); Meer-bir, G. Versteeg, No. 2494, 17.2.1913 (L.B.O.); 7 km. north-east of Wilhelmina Top, L. J. Brass and E. Meyer-Drees, No. 9868 Sept. 1938 (L.); Oranje Mts., G. Versteeg, No. 2527, 1912 (BO); Mt. Gilume, Southern Highlands Distr., R. Schodde No. 1946, 21.8.1961 (CANB 106990. LAE.L.BM.BRI); Mt. Wilhelm, Eastern Highlands Distr. R. G. Robbins No. 1282, 20.8.1957 (CANB) 46127).

9. GERANIUM TRAVERSII Hook. f., *Handbk. N. Zeal. Fl.*, 726 (1867); Kirk, *Stud. Fl. N. Zeal.*, 80 (1900); Knuth *Pflrch. Geran.*, 151 (1912); Allan, *Fl. N. Zeal.*, 1: 236 (1961).

Unrecognized variety: *G. traversii* var. *elegans* Chn. in *Trans. N. Zeal. Inst.*, 34: 320 (1902); Allan, *Fl. N. Zeal.*, 1: 237 (1961).

Perennial herb with a strong but not napiform tap-root and a thick more or less erect and branched caulorrhiza covered with persistent petioles and stipules. *Flowering stems* decumbent or ascending to 50 cm. long, much branched, pubescent with soft retrorse-appressed hairs, sometimes rooting at the nodes. *Basal leaves* larger than the cauline ones but otherwise similar. *Cauline leaves* opposite; laminae grey-green, reniform to orbicular in outline, 12–25 mm. long, 15–50 mm. wide, pubescent with soft grey appressed hairs, rather more densely so on the undersurface, deeply 5–7-lobed or dissected, the lobes obovate or obcuneate terminated by 3–5 more or less obtuse secondary lobes or teeth; petioles up to 5 cm. long, densely pubescent. *Flowers* solitary; pedicel-peduncle 3–6 cm. long, covered with soft retrorse-appressed hairs, with two linear-lanceolate acuminate bracteoles 3–4 mm. long at or below the mid-mark, swelling in the upper parts in the fruiting condition. *Sepals* ovate-elliptic to oblong, 9–10 mm. long, 3–4 mm. wide, softly pubescent with short dense appressed hairs, more or less flat in the fruiting condition and with a mucro about 1 mm. long, margin more or less membranous and ciliate. *Petals* obovate, 10–11 mm. long, 6–8 mm. wide, white or pink, entire, ciliate near the base. *Stamens* 10; filaments lanceolate, 4–5 mm. long, 0.5 mm. wide, ciliate; anthers sub-globular. *Ovary* villous-hirsute; stigmata yellow (?), c. 1.5 mm. long. *Fruit:* mericarps oblong, c. 4 mm. long and 1.5 mm. wide, covered with soft hairs; funicular hairs villous, 40–50; awns densely pubescent; rostrum 12–14 mm. long. *Seeds* oblong, 2.5 mm. long, 1–1.5 mm. wide, dark brown with shallow elongated alveolae and a lateral raphe.

Range. Endemic on the Chatham Islands.

Habitat. Coastal cliffs.

Typification. Holotype—Chatham Island, Travers No. 25 (K).

var. *elegans*—no type cited.

Discussion. A well-defined endemic species occupying a specialized habitat on the Chatham Islands. The indumentum and seed coat indicate a fairly close affinity with *G. potentilloides*. It differs from the latter species in the denser silvery-grey indumentum, larger flowers (2 cm. diam. when open) and a thicker, stronger caulorrhiza.

Specimens examined: Chatham Islands: Chatham Is. F. A. D. Cox, 1903 (K); Cultivated at Dunedin, H. Matthews (K); ex Herb. T. F. Cheeseman, coll. H. Matthews (K); Chatham Islands, F. A. D. Cox, 1901 (WELT 30950); Red Bluff, W. R. B. Oliver, 6.12.1909 (WELT 6071); Flowerpot, Pitt Island, B. G. Hamlin No. 675, 31.1.1957 (WELT 3315); Le Whanga Lagoon Flying Boat Base, N. T. Moar No. 1528, 5.11.1959 (CHR 97889).

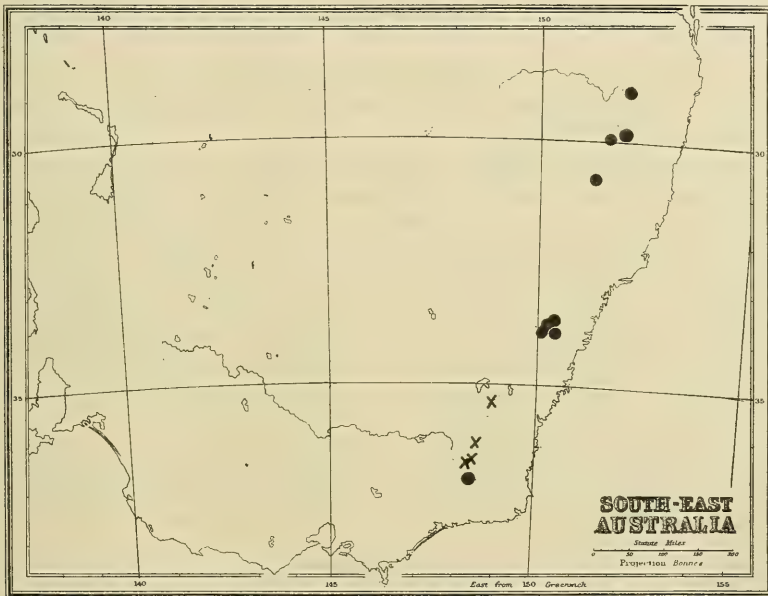


Fig. 5. Distribution of *G. neglectum* (●), and *G. obtusisepalum* (X).

10. GERANIUM NEGLECTUM, sp. nov.

Herbae decumbentes caulibus longis rubris floriferibus. Flores solitarii, pedicellus pedunculusque ad 10 cm. longus bracteolis mediis pilisque retrorso-appressis. Petala 14 mm. longa, 7 mm. lata. Rostrum 15 mm. longum semina fusca reticulatis parvissimis.

Decumbent or prostrate perennial herbs ascending only when supported, with a thick but not napiform tap-root and thick short (usually less than 3 cm.) more or less woody caulorrhiza bearing dead stipules and leaf bases. *Flowering stems* terete, reddened, up to 120 cm. long, often much branched, bearing a few closely appressed hairs or almost glabrous, often rooting at the nodes. *Basal leaves* larger than cauline ones but otherwise similar. *Cauline leaves* opposite; petioles slender, 2.5–7 cm. long, covered with closely retrorse-appressed hairs; laminae orbicular to reniform in outline, 1–3 cm. long, 2.5–4 cm. wide with scattered appressed hairs on both surfaces, although more concentrated on the veins of the paler lower surface, deeply palmately 5–7-lobed; lobes obovate to oblong, further divided into 2–5 mucronate secondary lobes; stipules membranous, long-deltoid or lanceolate-acuminate, 4–6 mm. long, 1–2 mm. wide, ciliate and with some scattered villous hairs towards the base. *Flowers* solitary; pedicel-

peduncle slender, up to 10 cm. long, sparsely covered with retrorse-appressed hairs becoming thicker towards the top, and with two linear herbaceous almost glabrous bracteoles c. 3 mm. long at about the mid-point, swelling in the upper parts in the fruiting condition. *Sepals* lanceolate to narrow-elliptic, 6–9 mm. long, 2–2.5 mm. wide, with scattered appressed hairs, more or less flat in the fruiting stages; margin broad, membranous, ciliate. *Petals* obovate, c. 14 mm. long and 6 mm. wide, pink becoming white towards the base and with darker veins, ciliate on the margin towards the base. *Stamens* 10; filaments lanceolate-acuminate, c. 6 mm. long and 0.5 mm. wide, pale yellow to white, ciliate surmounted by an oblong anther about 1 mm. long; pollen yellow. *Ovary* hirsute-villous; stigmata yellow, c. 2.5 mm. long. *Fruit*: mericarp oblong, 4 mm. long, 2 mm. wide, very dark brown covered with short stiff hairs, especially above, and some minute glandular ones, funicular hairs c. 25; awns covered with more or less appressed hairs and some minute glandular ones; rostrum c. 15 mm. long. *Seeds* dark brown, oblong, 3 mm. long, 1.5 mm. wide covered with very small almost isolateral alveolae, raphe lateral.

Range. Eastern Highlands; so far known as far north as Queensland–New South Wales border.

Habitat. Swamps and on creek banks, probably mainly in granite areas.

Typification. Holotype—Banks of the Boyd River, Jenolan-Kanangra. R. C. Carolin No. 916, 23.3.1959 (NSW 66124).

Discussion. The closest affinities of this species seem to lie with *G. potentilloides*, from which it can be distinguished by the larger flowers, longer pedicel-peduncle and finer reticulations on the seed coat. It also has a very distinctive habitat.

Specimens examined: *Victoria*: Delegate River Bridge, Bidwell, J. H. Willis, 18.1.1948 (MEL); *New South Wales*: Clarence River, H. Beckler (MEL); New England, C. Stuart (MEL); Timbarra, C. Stuart (MELB); Mt. Werong, R. H. Cambage No. 3177, 4.12.1911 (NSW 42607); W. A. Dixon, without date (NSW 42571); Torrington near Deepwater, H. Deane, 3.1906 (NSW 42585); Below Camp, Manning River, E. F. Riek No. 028, 6.4.49 (CANB 21436); *Queensland*: Wallangarra, J. L. Boorman, 5.1914 (NSW 42584).

11. GERANIUM OBTUSISEPALUM, sp. nov.

Radix princeps tuberosus. *Pedunculus* uniflorus. *Pedicellus* pedunculusque pilis patenti-retrorsis brevibus vestiti et medio bracteoles parvo lineari-deltaideo ferentes. *Sepala* late ovata obtusa vel mucroni obtuso brevissimo munita. *Semina* fusca obscure reticulata.

Decumbent or ascending perennial herbs with a very short erect caulorrhiza covered with persistent leaf bases and stipules and with a napiform tap-root. *Flowering stems* obscurely angled or terete, decumbent or ascending, up to 30 cm. long, thickly covered with short soft hairs and some longer villous ones. *Basal leaves* similar to the cauline ones but larger. *Cauline leaves* opposite; petioles 1–6 cm. long, densely pubescent; laminae orbicular to reniform in outline, 1–2 cm. long, 1–3 cm. wide, hirsute on both surfaces, deeply palmately 5–7-lobed, the lobes obovate and mostly divided into three obtuse secondary lobes towards the top; stipules linear-lanceolate, acuminate, 3 mm. long, 1 mm. wide, pubescent, ciliate with long hairs. *Flowers* solitary; pedicel-peduncles 2–4 cm. long, pubescent with upper hairs often retrorse appressed, geniculate at the bracteoles and becoming swollen in the upper part as the fruit matures, with a pair of linear pubescent bracteoles at about the mid-point. *Sepals* elliptic to oblong, 5–7 mm. long, 3–4 mm. wide, pubescent or hirsute, obtuse or with a very short blunt mucro; margin membranous and ciliate. *Petals* obovate, c. 6 mm. long and 3 mm. wide, emarginate or 3-toothed at the apex, ciliate towards the base, pink but paler towards the base. *Stamens* 10; filaments linear-lanceolate, c. 3.5 mm. long and 0.5 mm. wide, almost glabrous, ciliate at the margin surmounted by a more or less globular anther; pollen white to pale yellow. *Ovary* hirsute; stigmata green to white or very pale pink, 1.5 mm. long. *Fruit*: mericarp covered with coarse simple hairs and small glandular ones above, ovoid, 3 mm. long, 2 mm. wide, brown, funicular hairs mostly erect and

c. 25; awns covered with antrorse simple and numerous much smaller glandular hairs on the outer surface; rostrum 10–14 mm. long. *Seeds* ovoid, dark brown with small obscure alveolae, 2 mm. long, 1.5 mm. wide, raphe lateral.

Range. South-east of the Australian mainland.

Habitat. Montaine and sub-alpine woodland (probably more extensive).

Typification. Holotype—Munyang near Guthega, R. Carolin No. 783, 25.1.1959 (NSW 66126).

Discussion. A distinct species with a restricted distribution. It is unique amongst the Eastern Australian representatives of this group in having a swollen napiform tap-root and obtuse sepals.

Selected Specimens examined: New South Wales: Kiandra, New Chum Mine, R. Carolin No. 758, 21.1.1959 (SYD); Kosciusko hotel dam, R. Carolin, No. 779, 21.1.1959 (SYD); above Sawpit Creek, M. Woodward, 21.1.1958 (SYD); Yarrangobilly Caves, R. Carolin No. 762a, 21.1.1959 (SYD); Upper Tumut River near Junction Shaft, J. G. Filmer, 16.2.1957 (NSW 42564). *A.C.T.:* Ski run, Mt. Franklin, N. T. Burbidge No. 1670, 6.2.1947 (CANB 13003); Mt. Franklin Hut, R. Pullen No. 97, 15.3.1958 (CANB 53519).

12. GERANIUM GRANITICOLA, sp. nov.

Herbae decumbentes. Caulis pilis pubescentibus retrorsis vestiti. Flores solitaires. Bracteolae circa medium pedicellus pedunculusque pubescentis. Sepala saepe reflexa ad maturitatem fructus. Petala alba. Semina nigra alveolis prominentibus longis.

Weakly ascending or decumbent perennial herbs with thick but not napiform tap-roots and short branched caulorhiza covered with dead stipules and leaf bases. *Flowering stems* up to 50 cm. long, frequently rooting at the nodes, terete or somewhat compressed, puberulent with short patent or very slightly retrorse hairs. *Basal leaves* similar to cauline leaves but larger. *Cauline leaves* opposite; petioles slender, up to 20 cm. long, puberulent; laminae reniform to semi-orbicular in outline, somewhat cordate at the base, up to 30 mm. long and 40 mm. wide, deeply palmately 5–7-lobed, each lobe obovate and with 3–5 secondary lobes towards the top, pubescent on both surfaces. *Flowers* solitary: pedicel-peduncle pubescent with retrorse-spreading hairs, 2–4 cm. long with two linear, membranous to sub-herbaceous pubescent ciliate bracteoles just below the mid-mark, geniculate at the bracteoles and swelling towards the top at maturity. *Sepals* lanceolate to elliptic or oblong, c. 4 mm. long, 1–2 mm. wide, pubescent, acute to acuminate with a short mucro, membranous and ciliate at the margin, frequently reflexed in the fruiting stages. *Petals* obovate, c. 5 mm. long and 3.5 mm. wide, entire or undulate at the apex, white, ciliate on the margin towards the base. *Stamens* 10; filaments membranous, lanceolate, long-acuminate, up to 4 mm. long, sparsely ciliate at the margin; anthers oblong, 0.5 mm. long, yellow with purple dehiscence lines. *Ovary* hirsute-villous; stigmata white, c. 1 mm. long. *Fruit:* mericarps oblong, 3 mm. long, 1 mm. wide, covered with short spreading hairs and minute glandular ones, specially towards the top, funicular hairs c. 20; awns covered with very short simple hairs and minute glandular ones on the outer surface; rostrum 9–11 mm. long. *Seeds* black, oblong, 2.5 mm. long, 1.5 mm. wide, covered with prominent elongated reticulations, minutely punctulate, raphe lateral.

Range. Central Tablelands of New South Wales.

Habitat. High altitude woodlands, usually on soils derived from granite.

Typification. Holotype—Oberon, R. Carolin, No. 919, 23.3.1959 (NSW 66128). Named from its usual habitat on soils derived from granitic rocks.

Discussion. A species with a very small distribution, but, nevertheless, quite distinct. It shows affinities with *G. potentilloides* var. *abditum*, from which it differs in the retrorse-spreading hairs, the sepals divergent in the fruiting stages, the white petals, and the somewhat different shape of the alveolae of the seed coat. These two taxa have been observed growing in the field together but no intermediates have been found, although these have been sought.

Specimens examined: New South Wales: Duckmaloi River S. of Oberon, R. Carolin, No. 877, 21.3.1959 (SYD); Kanangra Walls, R. Carolin, No. 888, 22.3.1959 (SYD); Lowther-Jenolan, R. Carolin, No. 877, 21.3.1959 (SYD); Jenolan Caves valley, R. Carolin, No. 883, 21.3.1959 (SYD).

13. GERANIUM HOMEANUM Turcz. in *Bull. Soc. Imp. Nat. Hist. Soc. Mosc.*, 36: 591 (1863).

Taxonomic Synonyms. *G. parviflorum* Willd., *Enum. Hort. Berol.*, 716 (1809) non Curtis = *G. potentilloides* var. *parviflorum* (Willd.) Hook. f., *Fl. Tasm.*, 1: 57 (1860); *G. dissectum* var. *glabratum* Hook. f., *Handbk. N. Zeal. Fl.*, 36 (1864) = *G. glabratum* (Hook. f.) Small ex Hanks et Small in Underwood-Britton, *N. Amer. Fl.*, 25: 10 (1907).

Misapplied Names. *G. australe* (non Nees in Lehm.) Allan, *Fl. N. Zeal.*, 1: 233 (1961).

Annual or perennial herbs with thick fleshy but not napiform tap-roots which may be much branched, and very short caulorrhiza covered with persistent stipules and leaf bases. *Flowering stems* decumbent, ascending only when supported, much branched, up to 70 cm. long but usually about 30 cm., sparsely covered with coarse retrorse hairs or sometimes almost glabrous. *Basal leaves* similar to cauline ones only larger. *Cauline leaves* opposite; petioles covered with coarse retrorse hairs, up to 5 cm. long; laminae palmately 3-5-lobed, semi-orbicular to reniform in outline, 2-4 cm. long, 3-5 cm. wide, with scattered coarse appressed hairs on either side; lobes oblong-obovate, usually divided into three secondary lobes or deep teeth with more or less mucronate tips near the top; stipules linear-lanceolate, to linear-deltoid, 3-6 mm. long, 0.5-1 mm. wide, acuminate, membranous, brown, ciliate and with coarse appressed hairs on the lower surface, especially towards the midrib or glabrous. *Flowers* usually borne in pairs; peduncles 1.8-2.4 cm. long; bracteoles linear, 3 mm. long and c. 0.5 mm. wide, almost glabrous on the surfaces but ciliate at the margin; pedicels 1.5-2.2 cm. long, covered with coarse retrorse-appressed hairs becoming denser towards the top and more or less divergent above in the fruiting condition, geniculate at the bracteoles and swelling above in the fruiting condition. *Sepals* elliptic to oblong, 4-5 mm. long, 1.5-2.0 mm. wide, sparsely covered with coarse appressed hairs and some smaller ones; margin membranous, minutely denticulate or entire. *Petals* pale pink to almost white, broad-oblongate to obovate, 2-4 mm. long, c. 1.5 mm. wide, entire at apex, ciliate towards the base. *Stamens* 10; filaments lanceolate-acuminate, c. 2.5 mm. long, 0.5 mm. wide, ciliate but not dentate; anthers reniform to orbicular, white with purple dehiscence lines. *Ovary* hirsute; stigmata green, 1 mm. long. *Fruit:* mericarps covered with coarse often divergent hairs with a few minute glandular ones towards the top, ovoid, 3 mm. long, 2 mm. wide, funicular hairs 20-30; awns covered with short antrorse hairs and some minute glandular ones on the outer surface; rostrum 8-11 mm. long. *Seeds* dark brown, ovoid, c. 2.5 mm. long, covered with shallow elongate alveolae with a lateral raphe.

Range. Eastern Australia, coastal plains and lower parts of the Dividing Range; New Zealand, Java, and introduced into California.

Habitat. Usually in damp places on fairly good soils.

Typification. *G. homeanum* Turcz.—Holotype—Everard Home, Nova Zealandia loco dicto Perakiteri, No. 86 (KIEW. photo SYD. K); *G. parviflorum* Willd.—Syntypes—two sheets in Willdenow's herbarium (B. photo K.); *G. dissectum* var. *glabratum* Hook. f. There are no specimens at Kew labelled as such, but some labelled "*G. carolinianum*" correspond to the description and it seems that Hooker considered *G. carolinianum* as some sort of super-variety since it is printed in bold-face type in the Handbook; one of these specimens is selected as the lectotype—New Zealand, Edgersley (K).

Discussion. A species of warm temperate areas and generally damp environments, being quite common on the margins of subtropical rain forests of the eastern coast of Australia. It can be distinguished from *G. potentilloides* by the twinned, usually smaller flowers, coarser and usually sparser hairs on the pedicels which in the former tend to become divergent in the fruiting condition, and the broader larger alveolae of the

seed-coat. It differs from *G. retrorsum* in the indumentum being sparser and less appressed in the fruiting condition particularly, non-napiform tap-root, narrower leaf-lobes or segments, narrower alveolae of the seed-coat, and the usually longer sepal awns. From *G. solanderi* it differs in the non-napiform root, more appressed hairs and narrower alveolae of the seed-coat.

The Australian and Javanese specimens have smaller flowers than most of the New Zealand ones and those from the more northerly part of the Australian range (as known at present) have very short awns on the sepals. The Javanese specimens

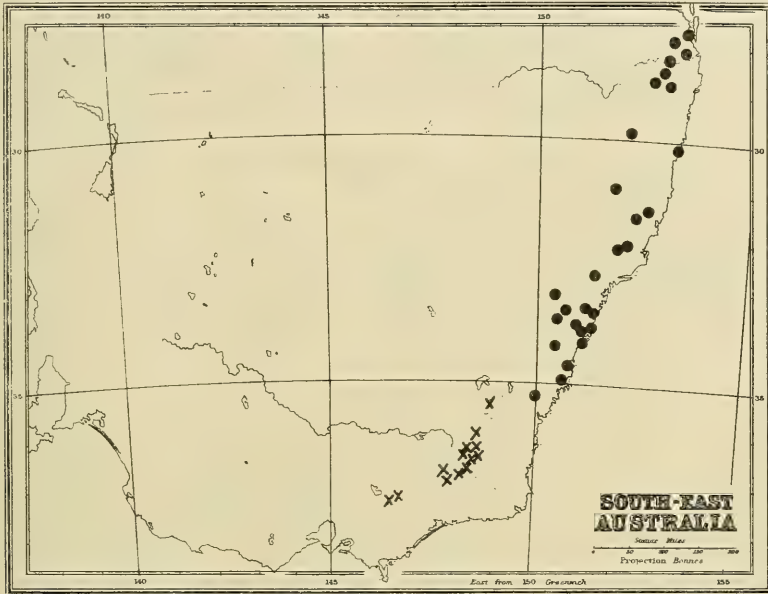


Fig. 6. Distribution of *G. homeanum* (●), and *G. antrorsum* (X).

do not seem to differ at all from those of eastern Australia. They have been referred to *G. nepalense* Sweet in the past, but differ from that species in the coarser alveolae of the seed-coat, obtuse leaf-lobes which are only toothed near the top, smaller flowers, more vigorous, decumbent stems. It is surprising that this species has so far not been collected in the montane forests of New Guinea, although it is just possible that it is not native in Java.

Selected Specimens examined: *New South Wales:* Bungonia Caves, R. Carolin No. 842, 1.3.1959 (SYD); Nowra, F. A. Rodway No. 14720, 26.3.1948 (NSW 42673); Byrne's Gap, Yerranderie-Kowmung River, L. A. S. Johnson 26.3.1948 (NSW 5017); Glenbrook Gorge, H. S. McKee No. 6770, 4.1.1959 (SYD); Garie Beach, Royal National Park, R. Carolin No. 940, March, 1959 (SYD); Port Jackson, R. Brown, No. 5224 (BM); Nova Cambria, Botany Bay, Banks and Solander (BM); Dee Why, Canon Michael No. 2061, 19.12.1960 (SYD); Curtis Creek nr. Grafton, R. Carolin No. 0767, 2.1.1959 (SYD); *Queensland:* Mt. Lindsay, R. Carolin No. 944, 31.5.1959 (SYD); Lamington National Park, R. Carolin No. 1046, 4.6.1959 (SYD); Ithaca Creek, C. T. White, Nov. 1913 (BRI 037048, NSW 42617); Ferny Grove nr. Brisbane, L. S. Smith (BRI 037049). *Java:* Tengger, M. Buysman, 8.11.1908 (LBO); Ngadiwana, C. A. Backer, No. 8403, 1913 (LBO). *New Zealand:* Onehunga, North Island ex herb. Kirk No. 232 (K); Reef Point, N. Auckland, H. H. Allan, 9.1.1932 (CHR 4358); Whangarei, A. J. Healy, 28.5.1950 (CHR 84329B); Mount Smart, T. Kirk No. 642, Jan. 6.1866 (WELT 30988); Mt. Wellington Lava field, Auckland, D. Petrie, Dec. 1914 (WELT 30984B); Kikurangi N. of Whangarei, D. Petrie, March 1898 (WELT 30983).

GROUP IV. Perennials usually with napiform tap-roots. Flowers twinned (very rarely solitary and then only some on each plant). Pedicels geniculate, swollen above in the fruiting stages. Flowering stems long. Seeds black or sometimes very dark brown with coarse more or less isolateral alveolae. (= Sect. *CHILENSIA* Knuth, but see in discussion.)

14. *GERANIUM RETRORSUM* L'Hér. ex DC., *Prodr.*, 1: 644 (1824); Hanks et Small in Underwood-Britton, *N. Amer. Fl.*, 25: 10 (1907); Munz, *Calif. Fl.*, 141 (1959).



Southern Pacific Oblique Azimuthal Equidistant centred on c. long. 180° lat. 51°.

Fig. 7. World distribution of *G. homeanum*.

Nomenclatural Synonyms. *G. patulum* Sol., *Prim. Fl. N. Zeal.*, msc. non Sol. in Forst. f., *Prodr.*, 91 (1796) *nom. nud.*; *G. dissectum* var. *patulum* Hook. f., *Handbk. Fl. N. Zeal.*, 36 (1864); *G. pilosum* var. *grandiflorum* Knuth *Pfarch.-Geran.*, 75 (1912) *nom. superfl.*; *G. pilosum* var. *retrorsum* (L'Hér. ex DC.) Jepson, *Man. Calif. Pl.*, 588 (1926).

Taxonomic Synonyms. *G. australe* Nees in Lehm., *Pl. Preiss.*, 1: 162 (1844) *non* (Willd.): Poir., *Encycl. Suppl.*, 2: 754 (1811) \equiv *G. pilosum* var. *australe* (Nees in Lehm.) Ostenf. in *Dansk. Vid. Selsk. Biol. Medd.*, 3: 71 (1921).

Perennial herbs with swollen napiform tap-root and short thick caulorrhiza frequently covered with dead stipules and leaf-bases. Stems decumbent or ascending, up to 40 cm. long, covered with short soft retrorse appressed hairs, glabrescent below. Basal leaves similar to cauline ones but larger and somewhat more deeply dissected. Cauline leaves opposite; petioles covered with short soft retrorse appressed hairs, 2-7 cm. long, laminae ovate to orbicular or reniform in outline, 1-2 cm. long, 1.5-3.0 cm. wide, deeply palmately (3)5-7-dissected or lobed, each segment or lobe divided into three narrow more or less acute secondary lobes, covered with appressed hairs on both surfaces; stipules membranous, brown, lanceolate to narrow-deltoid, up to 3 mm. long, covered with soft appressed hairs. Flowers twinned or very rarely solitary; peduncles

densely clothed with soft retrorse-appressed hairs, 6–20 (80) mm. long; bracteoles 4, linear to linear-deltoid, 2–3 mm. long, pubescent, ciliate at the margins; pedicels similar to peduncles, 18–35 mm. long, geniculate at the bracteoles and becoming swollen above in the fruiting stages. *Sepals* elliptic to oblong or ovate, 4–6 mm. long, 3–4.5 mm. wide, densely covered with more or less appressed hairs and with some scattered more or less divergent ones particularly towards the margins, mucronate. *Petals* obovate, 5–10 mm. long and 2–4 mm. wide, pink but paler towards the base with yellowish veins, almost quite entire at the apex or very slightly emarginate. *Stamens* 10; filaments lanceolate-acuminate, 3–4 mm. long, 0.5 mm. wide, ciliate at the margin with long hairs. *Ovary* hirsute; stigmata white or green, *c.* 1.5 mm. long. *Fruit*: mericarps 2 mm. long, 1.5 mm. wide, covered with coarse often divergent hairs and minute glandular ones towards the top, dark grey, funicular hairs 20–35; awns covered with short antrorse simple hairs and some minute glandular ones on the outer surface; rostrum 8–15 mm. long. *Seeds* black or very dark brown with coarse, usually deep, more or less isolateral alveolae, subglobose, 2.2 mm. long.

Range. Temperate Australia, New Zealand. Introduced into Hawaiian Islands and California.

Typification. *G. retrorsum* L'Hér. ex DC. Holotype—In Nova Zealandia, Banks and Solander (GEN photo SYD, isotype BM). This name was apparently meant to replace *G. patulum* Sol. which Solander had described in his unpublished flora of New Zealand, but which was unavailable owing to the existence of *G. patulum* Villars, *Hist. Pl. Dauph.*, 1: 283 (1786) (see under *G. solanderi*). *G. dissectum* var. *patulum* Hook. f.—Lectotype—*G. retrorsum* L'Hér. ex DC. Hooker cited the same species in synonymy of this variety as he had previously under *G. dissectum* var. *retrorsum*, i.e., *G. retrorsum* and *G. patulum* "Forst"; it is therefore superfluous in effect if not strictly so according to the Code of Botanical Nomenclature; the lectotype is selected to conform to Hooker's presumed intent, i.e., that he was describing the same variety under two different names. *G. pilosum* var. *grandiflorum* Knuth is superfluous as included in synonymy is *G. dissectum* var. *patulum* Hook. f. which varietal epithet is legitimate and available in *G. pilosum*. *G. australe* Nees in Lehm. *non* (Willd.) Poir.—Lectotype—part of Preiss No. 1907. Material of this number has been traced to Leningrad; the sheet was kindly lent. There are at least two taxa present on this sheet under the same number. The description clearly applies to only one of these parts, particularly with regard to the indumentum. This specimen has been marked appropriately both on the original sheet (LEN) and on the photograph (SYD).

Discussion. A fairly well-defined and widespread taxon. It is distinguished from *G. solanderi* by the closely appressed indumentum and usually by the much narrower leaf-segments. It grows in association with this latter species but does not appear to hybridize. Some of the South Australian specimens have solitary flowers and resemble *G. potentilloides* very closely; the napiform root, the seed coat alveolae and the presence of long hairs on the margins of the sepals, however, clearly differentiate *G. retrorsum* from *G. potentilloides*.

The description supplied for *G. australe* Nees in Lehm. in Allan, *Fl. N. Zeal.*, 1: 233 (1961), is quite clearly not applicable to any of the elements contained within the type number at Leningrad. It applies to *G. homeanum*, q.v.

It should be noted that some specimens from Western Australia referred here have exceptionally large flowers, e.g., Benger, R. D. Royce, No. 4377, 19.Sept.1953 (K. WA); Bridgetown to Kojonup and Slab Hut Gully, A. A. Dorrien-Smith, 1910 (K). No root systems and no seeds of these specimens, or anything like them, have so far been collected.

Selected Specimens examined: *Western Australia:* Porongurup Ranges, Twin Peaks, R. Carolin, No. 3450, 8.9.1961 (SYD); N.W. of Gnowangerup, B. G. Briggs, 8.10.1960 (NSW. SYD); near Claremont, ex herb. W. V. Fitzgerald, 9.1901 (NSW 42627); Smith's Hill, J. Sheath, 9.1901 (NSW 43648). *South Australia:* Yardea Station, Minnipa, Northern Eyre Peninsular, D. J. E. Whibley No. 405, 7.10.1958 (AD 95931007); Henley Beach

west of Adelaide, E. H. Ising, 13.11.1919 (AD 96117061); Encounter Bay, J. B. Cleland, 13.9.1931 (AD 96117077); Mt. Lofty Range, Max Koch, 9.1902 (NSW 42615). *Victoria*: Mt. Wycheproof, W. W. Watts, Oct. 1917, No. 714 (NSW 42625); Malden, Mrs. Nott (MEL); Ararat, Charl. Green (MEL); 2 miles N. of Kanya, J. H. Willis, 13.9.1960 (MEL). *New South Wales*: Armidale, R. Carolin, No. 0757, 1.1.1959 (SYD); Temora, J. W. Dwyer, 9.1915 (NSW 42697); Bega, F. A. Rodway, 12.1920 (NSW 42679); Bathurst, Peacock, 11.1901 (NSW 42606); Sunny Corner, J. L. Boorman, 11.1899 (NSW 42611). *New Zealand*: Harewood, Christchurch, G. Simpson, sine date (CHR 88013); Cockburn-Hornby district, A. J. Healy, No. 56/185 29.10.1956 (CHR 92182A); Kaituna, Banks Peninsula, A. J. Healy, 20.2.1945 (CHR 62928); Puponga, Manukau Harb. L. Cockayne, No. 833/4, sine date (WELT 31009).

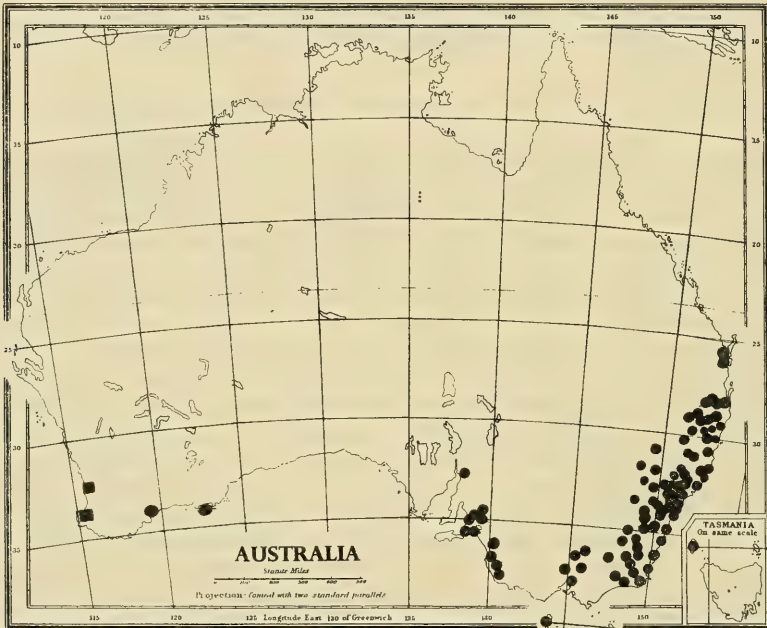


Fig. 8. Distribution of *G. solanderi* (●), and *G. drummondii* (■).

15. GERANIUM SOLANDERI, nom. nov.

Nomenclatural Synonyms. *G. pilosum* Sol. in Forst. f., *Prodr.*, 91 (1786) *non* Cav., *Diss.*, 5: 273 (1788) *nom. nud.* et in *Prim. Fl. N. Zeal.*, msc.; *G. pilosum* Sol. ex Willd., *Sp. Pl.*, 3: 706 (1801) *non* Cav., *loc. cit.*; DC., *Prodr.*, 1: 642 (1824); Sweet, *Geran.*, 2:t.119 (1822-29); Moore et Betche, *Handbk. Fl. N.S.W.*, 55 (1893); Knuth, *Pflrch.-Geran.*, 75 (1912); Jepson, *Man. Fl. Pl. Calif.*, 589 (1926); Ewart, *Fl. Vict.*, 682 (1930); Black, *Fl. S. Aust.*, 2nd ed., 2: 482 (1948); Curtis, *Stud. Fl. Tasm.*, 1: 91 (1956); Munz, *Calif. Fl.*, 141 (1959); Allan, *Fl. N. Zeal.*, 1: 234 (1961); *G. dissectum* var. *pilosum* Hook. f., *Fl. Tasm.*, 1: 57 (1860) et *Handbk. N. Zeal. Fl.*, 36 (1864); *G. dissectum* var. *australe* Benth., *Fl. Austr.*, 1: 296 (1863); Bailey, *Queensland Fl.*, 1: 177 (1899); Rodway, *Tasm. Fl.*, 19 (1903).

Taxonomic Synonyms. *G. patulum* Sol. in Forst. f., *Prodr.*, 91 (1786) *nom. nud.*, *non* Sol. in *Prim. Fl. N. Zeal.*, msc., *nec* Villars, *Hist. Pl. Dauph.*, 1: 283 (1786).

Misapplied names. *G. dissectum* var. *carolinianum* (*non* (L.) Hook. f.) Hook. f., *Handbk. N. Zeal. Fl.*, 36 (1864).

Perennial herbs with napiform or merely thickened tap-roots and short more or less erect caulorrhiza covered with dead stipules and leaf-bases. Flowering stems decumbent or more or less ascending, up to 50 cm. long, angular or compressed above but terete

below, covered with coarse retrorse-divergent or patent more or less villous hairs. *Basal leaves* similar to cauline ones but larger and frequently more dissected. *Cauline leaves* opposite; petioles covered with reflexed or patent hairs, up to 5 cm. long; laminae deeply 5-7-lobed, semi-orbicular to reniform in outline, frequently cordate at the base, 1-2.5 cm. long, 1.5-4 cm. wide, with coarse sub-appressed hairs on both surfaces; lobes obovate, divided into 3-5 mucronate to acuminate secondary lobes near the top; stipules sub-herbaceous, lanceolate to narrow-deltoid, 3-9 mm. long, up to 1.5 mm. wide, acuminate, covered with short appressed hairs and ciliate at the margin, rarely almost glabrous. *Flowers* twinned; peduncles 1-4 cm. long, hirsute or villous with reflexed or patent hairs; pedicels 2.5-5 cm. long, geniculate at the base and swollen above in fruiting stages, indumentum as peduncles; bracteoles lanceolate to linear-deltoid, up to 4 mm. long, membranous, villous, ciliate at the margins. *Sepals* elliptic to ovate, 5-9 mm. long, 2-5 mm. wide, acute to acuminate, covered with villous-patent hairs with longer ones at the margins and on the veins usually concave in the fruiting condition; margin membranous and ciliate. *Petals* obovate, 5-12 mm. long, 2-5 mm. wide, entire or emarginate, pink but paler towards the base and often with yellowish veins. *Stamens* 10; filaments lanceolate, narrow-acuminate, 4-10 mm. long, membranous, with long villous hairs at the margin and on the mid-rib near the base; anthers sub-globular, yellow. *Ovary* hirsute; stigmata white, green, or pale pink, 1-3 mm. long. *Fruit*: mericarps oblong or ovoid, 2.5-4 mm. wide, covered with stiff simple hairs and some minute glandular ones, funicular hairs c. 35; awns covered with stiff patent or antrorse simple hairs with some minute glandular ones on the outer surface; rostrum 9-20 mm. long. *Seed* black, sub-globular, 2-8 mm. long, with coarse more or less isolateral alveolae and a basal raphe.

var. SOLANDERI.

Tap-root almost always napiform. *Stems* decumbent, whole plant covered with reflexed or patent hairs. *Sepals* c. 5 mm. long. *Petals* c. 6 mm. long. *Stigmata* 1 mm. long. Mericarps ovoid, c. 2.5 mm. long. Rostrum 9-12 mm. long. Stems sometimes rooting at the nodes.

Range. Very widespread in temperate Australia including Tasmania and into New Zealand. Apparently introduced into California.

Habitat. Variable but usually in drier plant communities.

Typification. All of the synonyms cited are synonyms of the type variety. *G. solanderi* Carolin—Holotype—Habitat in New Zealand, Forster, sub "G. pilosum Forst" (K) see Carolin, 1963 for discussion of Forster's types; in any case this is the only relevant specimen which has been located. The types of *G. pilosum* Sol., *Prim. Fl. N. Zeal.*, msc (BM), are irrelevant as they refer to an unpublished name. *G. pilosum* Sol. ex Willd. Willdenow presumably based this description on J. R. Forster's material named by Solander for J. G. A. Forster's "Prodromus" which reached him in 1799 via Sprengel (Carolin, 1963). In any case the name is not available as it is a later homonym of *G. pilosum* Cav. *G. dissectum* var. *pilosum* is based upon the material at Kew derived from J. R. Forster's herbarium; it would, then, appear to be duplicate material of that used by Willdenow or it might even be identical. Hooker, however, refers only to the nomen nudum of Forster and the variety must therefore be attributed to him alone.

G. dissectum var. *australe* Benth.—Lectotype—*G. pilosum* Sol. ex Willd. When Bentham described this variety he included within it most of the species described before 1863. None of these synonyms was referred to as being more important than the others. As this combination has been used most frequently to cover the species at present under discussion the lectotype is selected so that it becomes a synonym.

G. patulum Sol. is a nomen nudum.

Named after Daniel Solander who first described the species under the name "G. pilosum" in msc. *Prim. Fl. N. Zeal.*

Discussion. Both the nomenclature and the biology of this species are involved. Only one variety is recognized here, but there is considerably more variation than this

implies. Other characters also vary, but the differences appear to grade into each other and there appears to be no obvious correlation of characters. Notable in this respect are sepal shape and indumentum, the latter varying from stiff reflexed to soft patent, or even puberulent, hairs, and the former from ovate to lanceolate-elliptic.

The important *differentiae* which serve to separate this species from allied ones are the patent or reflexed hairs, napiform roots and the coarse alveolae of the black or very dark brown seeds.

The species has been frequently compared and confused with *G. carolinianum* L. and *G. dissectum* L. Fernald has dealt with these species in North America, see *Rhodora*, 37: 298 (1935), and the Australian species with which they have been confused can be distinguished from these two as follows:

1. Annual. Flowers twinned and frequently grouped into heads. Pedicel and rostrum with some long glandular hairs. Seeds brown with small, shallow, elongate alveolae, oblong with a more or less lateral raphe *G. carolinianum*.
2. Annual. Flowers twinned, not grouped into heads. Pedicels and rostrum with numerous long glandular hairs. Seeds pale brown with large isolateral deep alveolae, more or less globular with a basal raphe *G. dissectum*.
3. Perennial. Flowers twinned, not grouped into heads. Pedicels and rostrum with no long glandular hairs. Seeds black or very dark brown with large usually isolateral distinct alveolae, globular or sub-globular with a more or less basal raphe *G. solanderi*.
4. Perennial. Flowers solitary. Pedicels and rostrum with no long glandular hairs. Seeds brown with small shallow elongate alveolae, oblong with a lateral raphe ..
..... *G. potentilloides*.

The *differentiae* are considered to be of specific significance and the action of earlier workers in including all these species under *G. dissectum* can no longer be justified.

Selected Specimens examined: *Western Australia:* Mt. Mylup, A. Oldfield No. 496 (MEL); Gordon River, Oldfield No. 123 (MEL). *South Australia:* Mambray Creek, lower Flinder's Range, Adel. Bot. Gard., Oct. 1960 (AD 96139066); Kinchina nr. Murray Bridge, M. C. R. Sharrard No. 712, 14.8.1960 (AD 96149261); Mount Lofty Ranges, J. B. Cleland, 12.12.1961 (AD 96104204); Flinders Range Wilpena, D. E. Symon No. 566, 13.9.1960 (ADW). *Victoria:* Narbethong nr. Healesville, R. Carolin No. 1107, 6.1.1960 (SYD); Mt. Buller, R. Carolin No. 1099, 5.1.1960 (SYD); Warrandyte, A. Meebold No. 21703, Nov.1936 (NSW 42619); Mt. Eccles, H. I. Aston, 21.10.1960 (MEL); Spring Creek, H. I. Aston No. 633, 12.10.1960 (MEL); Gattamurrah Gap, J. H. Willis, 25.2.1962 (MEL); St. Kilda, F. von Mueller, Sept. 1852 (MEL). *King's Island:* Chas. Walters, 11.1887 (NSW 42638). *Tasmania:* c. 2 miles n. of Dee Lagoon nr. Lyell Highway, R. Carolin No. 1323, 16.1.1960 (SYD); Mt. Nelson, R. Carolin No. 1767, 6.2.1960 (SYD); Devonport, R. Carolin, No. 1113, 7.1.1960 (SYD); The Gardens, sth. end of Bay of Fires, R. Carolin No. 1903, 12.2.1960 (SYD); Recherche Bay, R. Carolin No. 1416, 22.1.1960 (SYD); Hobarton, J. Backhouse No. 92, 1834 (BM). *New South Wales:* The Creel nr. Jindabyne, R. Carolin, No. 773, 24.1.1959 (SYD); Burruga-Rockley, R. Carolin No. 938, March 1959 (SYD); Cox's Gap, R. Carolin No. 2070 (SYD); 10 miles S.E. of Nowendoc, R. Carolin No. 2064, 19.12.1960 (SYD); Munyang near Guthega, R. Carolin No. 784, 25.1.1959 (SYD); Bungonia Caves, R. Carolin No. 841, 1.3.1959 (SYD); Oberon, R. Carolin No. 920, 23.3.1959 (SYD); The Oaks, Camden, S. M. McKay, 14.3.1958 (SYD); Ryde, O. D. Evans, 1.9.1924 (SYD); Chandler's Peak, J. L. Boorman, 3.1917 (NSW 42595); Bateman's Bay, J. L. Boorman, 6.1906 (NSW 42678); Currarong near Shoalhaven River, F. A. Rodway, 2.1928 (NSW 42675); Gudgenby, R. H. Cambage No. 3380, 13.1.1912 (NSW 42574); Merrigoen via Mudgee, F. H. Brown, 6.1899 (NSW 42690); 3 miles n. of Wallabadah, R. H. Goode No. 107, 11.11.1954 (BM). *A.C.T.:* Canberra, O'Connor district, R. D. Hoogland No. 3107, 10.1.1953 (CANB. BM). *Queensland:* Cunningham's Gap, R. Carolin No. 573, 15.5.1958 (SYD); Rathdowney, R. Carolin No. 1023, 1.6.1959 (SYD);

Millmerran, C. E. Hubbard No. 5848, 15.3.1931 (BRI 037028.K); Bunyah Mts., C. T. White, 10.19 (BRI 037031); 2 miles S. of Pittsworth, S. L. Everist and L. J. Webb No. 1234, 20.11.1946 (BRI 037032); Q.A.H.S. and College, Lawes, R. Roe, 8.10.1938 (CANB 5360). *New Zealand*: R. Lynd No. 77 (BM); Awamoko, Lower Waitaki Valley, D. Petrie, Oct. 1892 (WELT 30999); Coromandel, D. Petrie, Jan. 1899 (WELT 31004); Mount Eden, J. Kirk No. 644, Nov.19.1868 (WELT 31006); Napier, W. R. B. Oliver, 1913 (WELT 6058); Watchman's Island, Ahuriri Lagoon Napier, A. J. Healy, 13.4.1945 (CHR 58526); Taranga Island, L. B. Moore and L. M. Cranwell, 15.11.33 (CHR 95133); Cockburn-Hornby District, A. J. Healy, No. 56/185, 29.10.1956 (CHR 92182B) pro parte; Weka Creek, N. Canterbury, A. J. Healy, 9.12.1941 (CHR 33655).

var. *GRANDIS*, var. nov.

Radix princeps non napiformis. *Caules* adscendentes pilis patentibus mollibus obtecti. *Pedunculi* 3-4 mm. longi. *Petala* obovata, 12 mm. longa, 5 mm. lata. *Stigmata* 3 mm. longa.

Tap-root thick, woody, branched and swollen but not napiform. *Flowering stems* ascending, up to 60 cm. tall. Whole plant covered with soft patent hairs. *Basal leaves* with petioles up to 20 cm. long; laminae 7-10-lobed, up to 4 cm. long and 6 cm. wide; stipules c. 9 mm. long. *Peduncles* 3-4 cm. long, *pedicels* 3-5 cm. long. *Sepals* 6-9 mm. long. *Petals* obovate, 12 mm. long, 5 mm. wide. *Stigmata* pale pink, c. 3 mm. long. *Mericarps* oblong, c. 4 mm. long. *Stems* apparently never rooting at the nodes.

Range. New England Highlands.

Habitat. Usually in open forest on basaltic soils.

Typification. Holotype—Ebor Gorge, New England, R. Carolin No. 0766, 2.1.1959 (NSW), named after the flowers which are conspicuously larger than those of the type variety.

Discussion. This variety has an apparently restricted range on basaltic soils in northern New South Wales, but may eventually be found to have a more extensive distribution.

Specimens examined: *New South Wales*: Guy Fawkes Creek Gorge, R. Carolin No. 424, 17.11.1957 (SYD); Glen Innes, H. M. R. Rupp, 1.1914 (NSW 42580); Mt. Lindsay, H. M. R. Rupp, 1.1914 (NSW 42591); Clarence River, H. Beckler (MEL).

16. *GERANIUM DRUMMONDII*, sp. nov.

Herba perennis radice principi napiformi et floribus geminis. *Caules* petioli *pedunculi* et *pedicelli* capillis longis patulis albis plerumque simplicibus vestiti. *Folia* profunde 7-9-lobata. *Sepala* hirsuta. *Petala* ad basin ciliis longis plurimis. *Semina* fulva (vel nigra?) subglobularia. *Raphe* basilari alveolis parvis transverse elongatis.

Perennial herbs with a thickened napiform tap-root and short thick caulorrhiza covered with dead stipules and leaf-bases. *Flowering stems* decumbent or ascending, usually only sparsely branched, up to 50 cm. long, covered with long stiff patent white simple hairs with a few glandular ones. *Basal leaves* similar to cauline ones but larger and somewhat more deeply dissected. *Cauline leaves* opposite; petioles up to 5 cm. long, hirsute with long more or less patent hairs; laminae orbicular to reniform in outline, up to 2 cm. long and 3.5 cm. wide, covered with more or less appressed white hairs on either surface, deeply dissected into 5-7 segments which are further divided into three mucronate secondary lobes towards the top; stipules membranous, pale brown, linear to lanceolate, c. 3 mm. long, 1 mm. wide, pubescent, ciliate, acute or even acuminate. *Flowers* twinned; peduncles hirsute with dense spreading white simple hairs sometimes more or less entangled, 2-4 cm. long, bracteoles similar to stipules but smaller; pedicels similar to peduncles, up to 2 cm. long, geniculate at the bracteoles and swollen above in the fruiting stages. *Sepals* ovate, 5 mm. long, 2.5-3.5 mm. wide, densely covered with long white more or less spreading simple hairs; membranous and minutely ciliate at the margin with a mucro c. 0.5 mm. long. *Petals* pink (?), obovate, somewhat longer than the sepals, with long marginal hairs towards the base. *Stamens* 10; filaments lanceolate.

c. 4 mm. long, yellow-brown, distinctly ciliate; anthers not seen. *Ovary* hirsute; stigmata red (?). *Fruit*: mericarps smooth, hirsute with long stiff white simple hairs and some minute glandular ones, funicular hairs more or less erect, often almost half as long as the mericarp itself, 20–30; awns densely covered with spreading stiff simple hairs; rostrum 10–13 mm. long. *Seeds* more or less globular, 1.5–2.0 mm. long, with a basal raphe, dark brown (or black) covered with small but fairly prominent alveolae more or less elongated at right angles to the vertical axis.

Range. South-western Australia.

Habitat. Unknown.

Typification. Holotype—Drummond, Swan River No. 4 (K). There are two sheets bearing this number at Kew. Both bear specimens of this species. The sheet marked "4 bis" is the holotype. The type number collection of *G. australe* Nees in Lehm., i.e.,

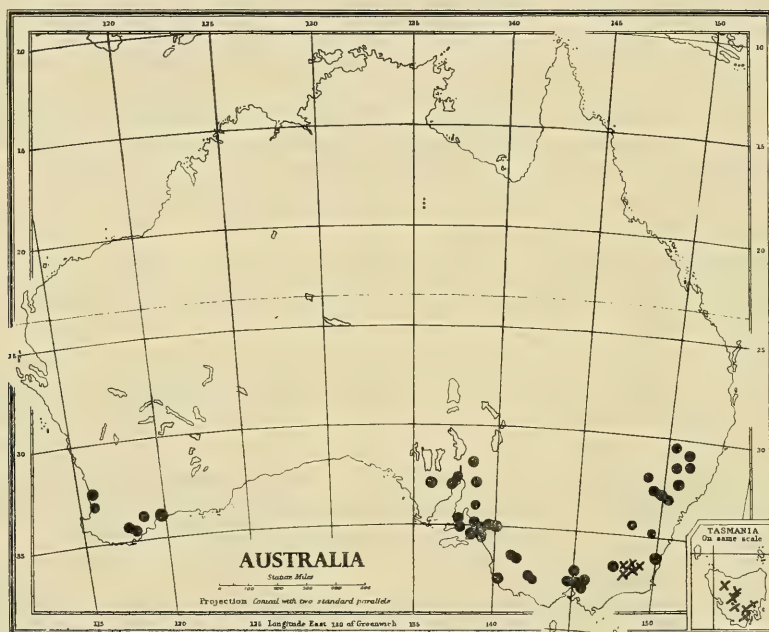


Fig. 9. Distribution of *G. retrorsum* (●), and *G. sessiliflorum* ssp. *brevicaule* (X).

Preiss No. 1907, contains elements of this species; the sheet at Leningrad bears specimens. Nees' description, however, disagrees in a number of respects, notably with respect to the indumentum. Named after the collector of the holotype.

Discussion. The author has not seen this species in the field but the herbarium material is quite distinctive. The long, dense simple hairs on the stems etc., the long basal cilia on the petals, the characteristic alveolae of the seed-coat and the swollen napiform root distinguish it from all the other species. The indumentum, twinned flowers and root form indicate an affinity with *G. solanderi*.

Specimens examined: Western Australia: Yallingup and Cape Naturaliste, A. A. Dorrien-Smith, 1910 (K); Drummond, Swan River No. 501 (K two sheets. MEL. BM).

GROUP V. Perennials with thick but not napiform roots, and with much branched caulorrhiza, covered with very persistent dead petioles. Pedicels more or less erect, not swelling above or geniculate in the fruiting stages. Flowers solitary. Flowering stems short. Seeds black, smooth or with minute alveolae.

17. *GERANIUM SESSILIFLORUM*. Cav., *Diss.*, 4: 198 (1787); Willd., *Sp. Pl.*, 3: 696 (1800); DC., *Prodr.*, 1: 639 (1824); Hook. f., *Fl. Ant.*, 252 (1847); Benth., *Fl. Austr.*,

1: 297 (1863); Hook. f., *Handbk. N. Zeal. Fl.*, 36 (1864); Moore et Betcher, *Handbk. Fl. N.S.W.*, 55 (1893); Sprg. in *Anal. Mus. Buenos Aires*, 7: 254 (1902); Rodway, *Fl. Tasm.*, 19 (1903); Cheeseman, *Man. N. Zeal. Fl.*, 89 (1906); Knuth, *Pflarch.-Geran.*, 83 (1912); Simpson et Thompson, *Trans. Roy. Soc. N. Zeal.*, 73: 157 (1943); Ewart, *Fl. Vict.*, 682 (1930); Curtis, *Stud. Fl. Tasm.*, 1: 91 (1956); Allan, *Fl. N. Zeal.*, 1: 234 (1961).

Compact perennial with thick usually much-branched tap-roots and much-branched woody caulorrhiza up to 7 mm. thick and covered with the very persistent stipules and petioles. *Basal leaves* crowded on the upper parts of the caulorrhiza: petioles 2–10 cm.



Southern Pacific Oblique Azimuthal Equidistant centred on c. long. 180° lat. 51°.

Fig. 10. World distribution of *G. sessiliflorum* (incl. spp.).

long, covered with long patent villous hairs and short appressed ones; laminae semi-orbicular to reniform in outline, 5–7 palmately lobed or dissected, 10–20 mm. long, 15–30 mm. wide, covered thickly or thinly with coarse appressed hairs on both sides; lobes oblong-ovate in outline with three secondary lobes above each, each secondary lobe obtuse with a callous tip or the lateral ones tending to be acute; stipules pale to dark brown, oblong to lanceolate-acuminate, c. 6 mm. long and up to 2 mm. wide, covered with short appressed hairs, ciliate at the margin, united to the petiole with only the tips free. *Flowers* solitary, borne on the usually very short annual branches; bracteoles membranous, brown, lanceolate to linear-lanceolate, c. 6 mm. long and 1 mm. wide, covered with short appressed hairs, ciliate at the margin and inserted on the lower third of the pedicel-peduncle; pedicel-peduncle 0.5–3.0 cm. long, more or less erect, densely covered with retrorse-appressed hairs, often with some long divergent ones, not swollen above in the fruiting stages. *Sepals* lanceolate to narrow-elliptic or narrow-oblong, 4–8 mm. long and up to 2.5 mm. wide, acuminate at the tip, covered with long spreading hairs and shorter antrorse-appressed ones, thinner but scarcely membranous towards the margin, ciliate, very slightly convex or flat in the fruiting stages. *Petals* oblong to narrow-elliptic or obovate, 4–8 mm. long, 1–3 mm. wide, deep pink to white with translucent veins, paler towards the base, with minute hairs scattered over the

surface at the margin or rarely glabrous. *Stamens* 10; filaments broad-lanceolate, acuminate, divergent at the apex, c. 2.5 mm. long, ciliate; anthers yellow, more or less orbicular, c. 1 mm. long, with 2-3 bristles at the apex. *Ovary* hirsute; stigmata, deep pink or white, c. 1 mm. long. *Fruit*: mericarps brown, oblong to ellipsoid, 3 mm. long, 1.5 mm. wide, covered with stiff spreading hairs; funicular hairs mostly erect, c. 25; awns covered with stiff short simple hairs and some minute glandular ones on the outer surface; rostrum 8-10 mm. long. *Seeds* black to very dark brown, ovoid to ellipsoid, c. 2.5 mm. long and 1 mm. wide, obscurely reticulate; raphe lateral.

ssp. *SESSILIFLORUM*.

Indumentum various; hairs of the calyx short and appressed with long \pm divergent villous ones towards the margin; mucro of the sepal c. 0.5 mm. long or obsolete. Petals oblong, scarcely clawed at all, 1.5-2 times as long as the sepals, red to white.

Range. South American Highlands, coming down to sea-level in higher latitudes.

Habitat. Grasslands and sand-dunes.

Discussion. This subspecies does not come within the geographic limits of this treatment. It is included to point out the distinctions between it and the Australasian material.

ssp. *NOVAEZEALANDIAE*, ssp. nov.

Pili calycis plerumque appressi patentiores longioresque versus marginem inserti. Petala obovata longiore sepalam.

Indumentum various; hairs of the calyx appressed, with the long divergent ones tending to be inserted towards the margin; mucro of the sepal c. 1 mm. long, frequently divergent or even reflexed in the fruiting stage. Petals obovate, clawed, c. 1.5 times as long as the sepals, usually white.

var. *NOVAEZEALANDIAE*. Leaves glabrescent to \pm hirsute, green.

Taxonomic Synonyms. *G. sessiliflorum* var. *maculatum* Simpson et Thomson, *loc. cit.*

Indumentum \pm thinly scattered. Leaves dark green, not glaucous.

Range. New Zealand.

Habitat. Grasslands to fairly high altitudes.

Typification. *G. sessiliflorum* ssp. *novaezealandiae*. Holotype—Saddle between Shin & Hodder Rivers, Inland Kaikoura Mts., Marlborough, B. G. Hamlin No. 915, 4 Dec. 1960 (WELT 11508); *G. sessiliflorum* var. *maculatum* Simpson et Thomson—holotype—shores of Lake Lyndon, G. Simpson and J. S. Thomson (CHR 75697).

Discussion. The diagnostic characters given in the main description separate this subspecies from the other two. It approaches closest to ssp. *sessiliflorum* in the sand-dune variety (below). It seems possible that it hybridizes with *G. potentilloides*.

Selected Specimens examined: New Zealand: Makara Hills, Wellington, A. P. Druce, 21.11.1947 (CHR 82267); Red Rocks Point, A. J. Healy, 8.12.1940 (CHR 33222); Desert Road, L.B.M., April 1955 (CHR 91942); Hora Hora, Middle Waikato, D. Petrie 16.11.1912 (WELT 30924); Tarawera, Hawke's Bay, D. Petrie, 2.2.1909 (WELT 30923); Upper Rangitikei Ford, D. Petrie, Jan.1915 (WELT 30939); Mt. Arthur, Nelson, J. A. Hay, 26.12.50 (CHR 89927); Summit Road, Banks Peninsula, T. W. Rawson, 28.12.1954 (CHR 94041); Eweburn Creek, C. Otago, sine coll. (CHR 95149); S. bank of L. Taylor, Upper Huranui, A. Lush, 8.11.1948 (WELT 30946); Porter's Pass, M.S., 6 Feb. (WELT 30944); Mingria valley, W. R. B. Oliver, 13.1.1928 (WELT 30907).

var. *ARENARIUM* Simpson et Thomson in *Trans. Proc. Roy. Soc. N. Zeal.*, 73: 158 (1943).

Leaves densely covered with greyish appressed hairs.

Range. New Zealand, south part of the South Island.

Habitat. Coastal sand-dunes.

Typification. Holotype—Paterson Inlet, Stewart Island, G. Simpson (CHR) but not located.

Discussion. A fairly distinct form occupying a rather specialized habitat. In some specimens it approaches ssp. *sessiliflorum* which also may occur on sand-dunes.

Selected Specimens examined: New Zealand: Fisherman's Bay, H. H. Allan, Jan. 1946 (CHR 76192); nr. Dunedin sine loc. et coll. (CHR 95148); Ramaru, H. H. Allan, 1.1929 (CHR 972); Dog Island, T. Kirk, Jan. 18.1884 (WELT 30934); Sealer's Bay, Codfish Island, R. K. Dell, 4.1.1948 (WELT 30945); Sandhills near Dunedin, G. M. Thomson, sine date (WELT 30930).

ssp. *BREVICAULE* (Hook. f.), comb. et stat. nov.

Nomenclatural Synonym. *G. brevicaule* Hook. in *Hook. Journ. Bot.*, 1: 252 (1834); Hook. f., *Fl. N. Zeal.*, 1: 40 (1852). *BASIONYM.*

Taxonomic Synonym. *G. sessiliflorum* var. *glabrum* Knuth in *Bot. Jahrb.*, 37: 565 (1906) et *Pflrch.-Geran.*, 85 (1912).

Indumentum various. Hairs of the calyx: some short and appressed, with long stiff \pm divergent ones scattered amongst them; mucro of the sepal 1 mm. or longer. *Petals* oblong to oblanceolate or narrow-elliptic, scarcely clawed at all, pink, shorter than to slightly exceeding the sepals.

Range. Tasmania and the S.E. highlands of continental Australia.

Habitat. Grasslands and woodlands, usually at high elevations.

Typification. *G. brevicaule* Hook.—Lectotype—Gunn No. 256; two collections are cited with the original description: "Van Diemen's Land, Gunn 256 and 324". There do not appear to be any specimens of the latter at Kew. Allan (*loc. cit.*) appeared to think that the type was "Chalky Bay, Lyall" at Kew: this is not so. *G. sessiliflorum* var. *glabrum* Knuth—Lectotype—Tasmania, Archer ex herb. Hooker (B, isolectotypes K.). Knuth included here both Tasmanian and New Zealand specimens. These syntypes were presumably destroyed during the war and I have been unable to locate any of the New Zealand material cited by Knuth. I have, therefore, chosen, as the lectotype, the specimen of which duplicates are available. It agrees fairly well with Knuth's very brief description.

Selected Specimens examined: Tasmania: 14 miles Wilmot-Waldheim, R. Carolin No. 1198, 10.1.1960 (SYD); 71 miles Hobart—Dee Lagoon, R. Carolin No. 1368, 16.1.1960 (SYD); 2 miles north of Dee Lagoon, Lyell Highway, R. Carolin No. 1326, 16.1.1960 (SYD). New South Wales: Daner's Gap, Kosciusko, M. Woodward, 21.1.1958 (SYD); Kiandra Distr., E.B. (etche), 2.1897 (NSW 42540); Bett's Creek, Kosciusko, L. A. S. Johnson & E. F. Constable, 25.1.1951 (NSW 15782).

18. GERANIUM ANTRORSUM, sp. nov.

Herbae confertae vix expandentes. Folia lobis tenuibus. Flores solitaires bracteolis. Partem in tertiam infimam pedicello-pedunculi insertis. Pediceli pilis albis antrorso-appressis. Petala obovata. Sepala lanceolato-acuminata circum fructum concava. Semina nigra obscure reticulata.

Perennial herb with thick fleshy branched tap-roots and numerous much-branched caulorrhiza (usually less than 3 mm. long), thick and covered with very persistent stipules and petioles. *Flowering stems* very short and bearing reduced leaves or reduced to a pedicel-peduncle. *Basal leaves* crowded towards the top of the caulorrhiza; petioles 3-16 cm. long, densely covered with appressed hairs and some more or less spreading villous ones; laminae semi-orbicular to cuneate in outline, 5-7 palmately dissected or lobed, 1-4 cm. long, 1.5-3.0 cm. wide, covered with coarse appressed hairs on both surfaces; lobes obovate, further divided into three secondary lobes above, the central one obtuse, the two lateral ones tending to be acute, scarcely mucronate; stipules brownish, membranous, oblong to elliptic or lanceolate, 4-6 mm. long, up to 2 mm. wide, obtuse or slightly acuminate, ciliate at the margin and with a distinct ciliated mid-rib. *Flowers* solitary on erect peduncle-pedicels; pedicel-peduncle 1-4 cm. long, densely

covered with antrorse sub-appressed hairs, not swollen above in the fruiting stages; bracteoles lanceolate to linear-lanceolate, c. 6 mm. long, ciliate and pubescent, inserted about one-third distance from the base. *Sepals* lanceolate to narrow-elliptic, long acuminate, 5–11 mm. long, 2–3 mm. wide, covered with closely antrorse-appressed hairs and with spreading hairs on the veins and on the membranous margins, concave in the fruiting stages and with spreading tips. *Petals* obovate, 6–12 mm. long, deep-pink with translucent veins, and paler towards the base, entire. *Stamens* 10; filaments lanceolate-acuminate, 2–3.5 mm. long, ciliate; anthers globular, c. 1 mm. diam., yellow with purple dehiscence lines. *Ovary* hirsute-villous; stigmata pink, c. 2 mm. long. *Fruit*: mericarps dark brown, covered with spreading hairs, funicular hairs erect, c. 25; awns covered with short coarse simple hairs and some minute glandular ones on the outer surfaces; rostrum c. 11 mm. long. *Seeds* black, ovoid, c. 2.5 mm. long and 1.5 mm. wide, obscurely reticulate; raphe lateral.

Range. Highlands of south-eastern Australia.

Habitat. Alpine and sub-alpine grasslands.

Typification. Holotype—Kosciusko Hotel dam, R. Carolin No. 778b, 24.1.1959 (NSW 66132), named after the antrorse hairs on the pedicel-peduncle.

Selected Specimens examined: Victoria: Mt. Buller, J. H. Willis, 9.3.1953 (MEL); Quambat Plain, W. Hunter, Dec. 1938 (MEL); Mt. Tainter, Bogong High Plains, A. J. Tadgell, 28.2.1926 (MEL); Cobungra, H. B. Williamson, Dec. 1928 (MEL); N.W. of Cobungra, T. & J. Whaite No. 1959, 2.1.1960 (NSW 50174). *New South Wales*: east of Nimitybelle, R. H. Cabbage No. 1850, 9.2.1908 (SYD); White's River Hut nr. Guthega, R. Carolin No. B103, 12.2.1957 (SYD); Yarrangobilly Caves, R. Carolin No. 761, 21.1.1959 (SYD); Snowy Mountains, between Charlotte pass and Snowy River, H. J. Eichler No. 13652, 5.2.1957 (SYD AD 95748026). *A.C.T.*: Upper Cotter Homestead, N. Burbidge No. 6371, 24.2.1959 (CANB 58449); Mt. Ginini, M. Gray No. 3570, 10.12.1958.

Discussion. This species has, to date, been included in *G. sessiliflorum* Cav. The main characters separating it from ssp. *brevicaule* are the antrorse hairs on the pedicel-peduncle, sepals concave in the fruit with divergent awns, petals obovate and the slightly different seed-coat pattern. It has a restricted distribution in the alpine areas of the south-east of the continent only and it is apparently not found in Tasmania. Its nearest affinities are, without doubt, with *G. sessiliflorum*.

There is a specimen from Dry Plain, which shows affinities with this species, but differs in the dense silvery indumentum and the narrow-linear segments to the leaves. A search has been made in the locality for further specimens but none have been found to date. As the specimen lacks some of the organs which provide the *differentiae* used in this treatment it has not been technically described here. It does not appear to be an introduced species and it has not been possible to equate it with any known species at all.

Key to the Species in Australia.

1. Surface of the mericarp glabrous and usually wrinkled *G. molle*.
- 1.* Surface of the mericarp hirsute to pilose, smooth.
2. Awns of the mericarps with conspicuous glandular hairs; seeds pale brown.
3. Leaves with broad lobes; petals clawed, glabrous *G. rotundifolium*.
- 3.* Leaves with linear lobes; petals not clawed, ciliate towards the base *G. dissectum*.
- 2.* Awns of the mericarps with mostly simple hairs and sometimes some minute glandular ones; seeds black or dark brown.
4. Flowers mostly twinned.
5. Hairs of the pedicel retrorse-appressed in flowering stage.
6. Tap-root branched, not napiform; leaf-lobes broad; seeds dark-brown with more or less elongated alveolae *G. homeanum*.
- 6.* Tap-root napiform; leaf-lobes usually linear; seeds black or very dark-brown with isolateral alveolae *G. retrorsum*.
- 5.* Hairs of the pedicel retrorse-reflexed or patent, never appressed.
7. Seeds with large alveolae; hairs stiff *G. solanderi*.

- 7.* Seeds with very small alveolae; hairs long and often more or less entangled *G. drummondii*.
- 4.* Flowers solitary.
8. Flowering stems usually shorter than basal leaves or reduced to a single pedicel-peduncle; seeds black, smooth or with minute alveolae.
9. Hairs of the pedicel retrorse-appressed; petals narrow-oblong *G. sessiliflorum* ssp. *brevicaule*.
- 9.* Hairs of the pedicel antrorse-appressed; petals oblong to obovate *G. antrorsum*.
- 8.* Flowering stems usually longer than the basal leaves; seeds with distinct alveolae.
10. Seeds black with large alveolae.
11. Bracteoles usually at the base of the pedicel-peduncle; petals pink *G. potentilloides* var. *abditum*.
- 11.* Bracteoles more or less inserted at the mid-point of the pedicel-peduncle; petals white *G. graniticola*.
- 10.* Seeds brown with small alveolae.
14. Tap-root napiform; sepals obtuse *G. obtusisepalum*.
- 14.* Tap-root not napiform; sepals with a distinct mucro.
15. Petals c. 14 mm. long; pedicel-peduncle c. 8 cm. long *G. neglectum*.
- 15.* Petals up to 10 mm. long; pedicel-peduncle up to 5 cm. long *G. potentilloides*.

GENERAL DISCUSSION.

The relationships of the Australian native *Geranium* species to others and the natural distribution of these natives which occur elsewhere show the well-known sub-antarctic relationship. Thus *Geranium potentilloides*, occurring in South-eastern Australia, New Zealand, New Guinea and into the mountains of Celebes, Timor and Java, shows a close affinity to the South American species grouped around *G. magellanicum* (Fig. 3). This is a similar situation to that found in such genera as *Nertera* and *Oreabolus* (van Steenis, 1962); a bifurcation of distributional tracts, one into Australia from the south and a second, northwards from the sub-antarctic zone, into the Malaysian region and becoming the "Papuan track" (van Steenis, 1935). It does not, however, conform absolutely to this latter since there are outliers of this species distributed within the "Sumatran track". It is interesting to note that those specimens occurring in this latter track are distinguishable fairly readily from the type, as var. *ardjunense* and, furthermore, that those closest to the Papuan track, i.e., in Southern Celebes, are closest morphologically to the type. This species extends to Sumatra and even shows some affinities with *G. nepalense* Sweet, as suggested by Lam (1945). Croizat (1952) maintains that this var. is a link "within a long continuous chain of affinities stretching South to North between Chatham Islands and the Himalayas". It seems we can extend this chain of affinities to South America and even North America. He suggests the group's dispersal "takes its start somewhere between New Zealand and Tasmania [sic!] and invades Timor from Australia, next following to Java and Sumatra". *G. potentilloides*, however, is essentially a microtherm species and there must be some doubt as to whether such conditions ever existed in northern Australia. The very close affinity of the alpine flora of New Guinea to that of New Zealand makes it seem probable that some fairly close floristic connection between these two land masses has existed in the past, possibly via an archipelago of islands along the Chatham Island ridge. Such, however, must remain speculation for so little is known of the past climatic history of northern Australia and the tectonic history of the sea-bed to the east. In Papua the alpine *G. monticola* has differentiated.

Geranium retrorsum and *G. solanderi* also show an affinity with the *G. magellanicum* group, but rather less so than *G. potentilloides*, although it must be admitted that too little is known about the South American species. *G. retrorsum* and *G. solanderi* appear to have developed as an adaptation to rather drier conditions in Australasia. They do not appear to have followed the Papuan track into Malaysia, possibly because the conditions to which they adapted are much less common, even in Papua itself.

G. homeanum is another derivative of this sub-antarctic group which shows adaptation to the damp conditions of montane forests and marginal rain-forest conditions

(micro-mesotherm). It shows a very well-developed southern limb of the bifurcation in south-eastern Australia, but the northern limb is quite disjunct, at least at present. It has been collected on one of the East Javanese mountains, in the centre of Sumatran track, but nowhere, so far in the Papuan track (Fig. 7). It is possible that this is a recent introduction, although it might be accepted as an outlier in Indonesia of an invader, from the sub-antarctic, presumably along the Papuan track. A disjunction of a similar order has been reported, recently, in *Viola hederacea* (Moore, 1962), a species with similar ecological requirements to those of *G. homeanum*.

G. sessiliflorum shows a classical sub-antarctic distribution (Fig. 10). It, and its relatives, are unknown in Papua. The section has reached its highest development in the Andes, but in Tierra del Fuego and the southernmost parts of the mainland it extends down to sea-level and apparently forms part of the sand-dune flora. It is interesting to note that the New Zealand subspecies also extends to sea-level in the South Island and there, also, inhabits sand-dunes. Whilst still quite easily distinguishable from each other, it is in these two littoral forms from the two sides of the Pacific that ssp. *sessiliflorum* and ssp. *novaezealandiae* approach closest to each other in general morphology. This may, of course, be simply a result of selection by the two similar environments or it may be an indication of the manner in which the ssp. has invaded New Zealand from South America. In Australia it is essentially a highland species together with the apparently derivative *G. antrorsum*.

Within Australia it is rather difficult to discuss distributions since collections of this genus from Western Australia are so few. However, it seems that the various climatic fluctuations and the formation of the Great Australian Bight cannot wholly explain the distribution of Group IV. *G. retrorsum* is found in both the S.E. and in the S.W., implying that the arid area north of the Bight is not an efficient barrier or that there has been little evolution on either side since the barrier was formed. *G. drummondii* may have developed as the western equivalent of *G. solanderi*, but the variation within the latter is so great that it is impossible to argue effectively without more collections being made.

By far the most important factor in speciation of *Geranium* in Australia must have been the uplift of the south-eastern highlands. Not only did this supply the alpine conditions necessary for the establishment of Sect. *Andina*, but also the rainfall necessary for the establishment of subtropical to montane rain-forest (*G. homeanum*) and montane woodlands (*G. potentilloides*). Furthermore, along the dividing range so created, a considerable number of environments of fairly local occurrence were formed. Some of these were exploited by the *G. potentilloides*-group as mostly they were of a damp nature. *G. neglectum* is the best example, a form adapted to bogs in montane woodlands; others are *G. obtusisepalum* in upland grasslands and sub-alpine woodlands, *G. graniticola* in montane woodlands on granite. Again, this divide produced something of a rain-shadow to the east enabling the dry-land species, *G. retrorsum* and *G. solanderi*, to become such a prominent component of the "Western Slopes" communities. Since peneplanation of eastern Australia seems to have been so widespread during the Miocene, much of the speciation within Group III must have taken place at least since then or, more probably, since the great uplift in Pliocene times. This is not to say that it may not be more recent still. Indeed, the advent of the microtherm species must also follow this pattern, at least as far as the mainland is concerned. The tectonic history of Tasmania is not so well known, but it is possible that the microtherm species have had a somewhat longer history there.

Van Steenis (1962) suggests that a land-bridge existed between South America and Australasia via Antarctica which more or less disappeared towards the upper Cretaceous. His curt dismissal of the continental drift theory is unfortunate, but the evidence for this land connection is very considerable. The fact that it is the microtherm species of *Geranium*, and not the mesotherm ones, which show this connection most clearly lends weight to the contention that the Antarctic continent itself supported a cool temperate flora during the Cretaceous and Tertiary and not a warm temperate flora.

Acknowledgements.

I wish to thank the Directors of the Royal Botanic Gardens, Kew; the British Museum (Nat. Hist.); the Conservatoire et Jardin botaniques, Geneva; the Rijksherbarium Leiden and the Laboratoire de Phanerogamie, Paris, for allowing me to use the facilities of their Institutes, and the Directors of all the Institutes mentioned above who loaned specimens to me. Also Mr. A. A. Bullock, Mr. H. K. Airy-Shaw and Dr. R. Melville and Dr. W. T. Stearn for their helpful discussion, and Mr. L. A. S. Johnson for help with the Latin diagnoses.

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EXPLANATION OF PLATES VI-VII.

Plate vi. Seeds of *Geranium* species.

1. *G. retrorsum*. R. Carolin no. 3450 (SYD).
2. *G. solanderi*. R. Carolin no. 920 (SYD).
3. *G. solanderi*. C. E. Hubbard no. 5848 (K).
4. *G. drummondii*. HOLOTYPE (K).
5. *G. homeanum*. R. Carolin no. 842 (SYD).
6. *G. potentilloides*. R. Carolin B68 (SYD).
7. *G. potentilloides*. R. Carolin no. 807 (SYD).
8. *G. potentilloides*. R. Carolin no. 1768 (SYD).
9. *G. potentilloides* var. *additum*. HOLOTYPE (NSW).
10. *G. graniticola*. HOLOTYPE (NSW).
11. *G. obtusisepalum*. HOLOTYPE (NSW).
12. *G. neglectum*. HOLOTYPE (NSW).
13. *G. sessiliflorum* ssp. *brevicaule*. R. Carolin no. 1368 (SYD).
14. *G. antrorsum*. HOLOTYPE.
15. *G. dissectum*. R. Carolin no. 1231 (SYD).

Plate vii. Fruiting pedicels of *Geranium* species.

1. *G. solanderi*. R. Carolin no. 786 (SYD).
2. *G. solanderi*. R. Carolin no. 841 (SYD).
3. *G. retrorsum*. R. Carolin no. 3450 (SYD).
4. *G. homeanum*. R. Carolin no. 842 (SYD).
5. *G. potentilloides*. R. Carolin no. 605 (SYD).
6. *G. potentilloides*. R. Carolin no. 1600 (SYD).
7. *G. obtusisepalum*. HOLOTYPE (NSW).
8. *G. neglectum*. HOLOTYPE (NSW).
9. *G. graniticola*. HOLOTYPE (NSW).
10. *G. antrorsum*. HOLOTYPE (NSW).
11. *G. sessiliflorum* ssp. *brevicaule*. R. Carolin no. 1368 (SYD).

NOTE ON *STIGMODERA VIRIDICAUDA* CARTER.

By C. M. DEUQUET.

(Two Text-figures.)

[Read 25th November, 1964.]

Sometime in 1910, the authorities of the Natural History Museum of Stockholm sent two members of their staff to Australia to study the remarkable flora and fauna and to obtain for their Museum specimens of scientific interest. During their stay of two years they collected a large number of specimens in the six Australian States, especially in Queensland and Western Australia. A few years later, the Directors of the Stockholm Museum sent all the insects of the Buprestidae family collected by their entomologists for examination by Mr. H. J. Carter, the leading Australian specialist in that family of beetles. Carter decided that a fairly large *Stigmodera* of the *Themognatha*



1. *Stigmodera viridicauda* Carter. 2. *Stigmodera lobicollis* Saunders.

subgenus from Yarrabah (a few miles south of Cairns) was new and described it as *S. viridicauda* Carter (*Arch. fur Zool.*, 120: 3) and returned the holotype, a ♂, to the Stockholm Museum. A few years later, I found reason to question the accuracy of Carter's identification, especially after reading the following lines which he wrote in 1931 in his "Notes on the Genus *Stigmodera*" (*Aust. Zoologist*, 6: 338-339): "I now think it probable that *viridicauda* Cart. is a form of *jansonii*." The unique type is in Stockholm Museum. Further on (p. 339) he added that *viridicauda* "may prove to be a variety of *jansonii* Saund., the distinction of which from *donovani* was at the time not clear to me". Those lines clearly disclose a state of perplexity in Mr. Carter's mind, which is surprising since his *viridicauda* actually is *Stig. lobicollis* described and named by Saunders (*Journ. Linn. Soc. Lond.*, 1868: 462).

It is a remarkable coincidence that Saunders should describe in the same paper and on the same date both *Stig. lobicollis* (= *viridicauda* Cart.) and *Stig. jansonii*. Saunders did not fail to see that these two species belong to different types of *Stigmodera*.

A glance at extracts of his descriptions of those two insects is most instructive:

lobicollis: Head and thorax green, the latter with its lateral margins ochreous-red;

jansoni: Head and thorax brassy-green, lateral margins of latter testaceous.

These few lines definitely show that Saunders considered them as clearly different from one another.

Carter himself, in his own description of *Stig. viridicauda* Cart., in 1920 calls it a species near *affinis* Snd., *sanguinea* Snd., and *viridicincta* Waterh. That is correct, but to suggest that *viridicauda* might prove to be a variety of *Stig. jansoni* is wrong because, if the three species mentioned above unquestionably have their heads and thoraces metallic-green with the margins of their prothorax sanguineous-red exactly like *lobicollis*, the same cannot be said of *Stig. jansoni* whose lateral thoracical margins are testaceous or yellow-brown.

How is it that Carter failed to mention in his paper that *Stig. lobicollis* was also like the three above-named? The most reasonable suggestion is that, in my opinion, he did not have at that time any example of *lobicollis* in his own collection and that consequently that insect was unfamiliar to him.

While in Europe, I had an excellent opportunity to solve the *viridicauda* problem. The Stockholm Museum authorities very kindly gave me all facilities to examine at leisure the "holotype". For that gesture I wish to express to them my gratitude. It did not take long to compare *S. viridicauda* with the examples of *lobicollis* in my own collection and to ascertain that the "rara avis" in front of me was no other than *Stig. lobicollis* described by Saunders (*Journ. Linn. Soc. Lond.*, 1868: 462). The two photographs illustrating this paper show fairly clearly that *lobicollis* and *viridicauda* are the same insect, although it will be noticed that the Stockholm example (No. 1) is slightly damaged (thorax in two places) while mine (No. 2) is in perfect condition. Carter's *Stig. viridicauda*, being a misidentified insect, should now be erased from the index list of Australian Stigmoderae.

The Buprestidae dealt with in this paper could be ranged into two groups of clearly different and easily distinguishable colour characteristics:

Group A of *lobicollis* pattern and Group B of *jansoni* pattern.

Here is an explanatory list limited to five names only of five species belonging to each group:

Group A: *S. lobicollis* Snd., *S. donovani* L. & G., *S. affinis* Snd., *S. limbata* Don., and *S. sanguinea* Snd.

Group B: *S. jansoni* Snd., *S. excisicollis* MacL., *S. sanguineocincta* Snd., *S. gemmelli* Deuq., and *S. franca* Cart.

Only the species in Group A have the lateral thoracical margin ochreous-red.

Stigmodera lobicollis may be regarded in these days as a rare insect, rarity due to destruction of forests and of the indigenous vegetation in all parts of Australia. It was occasionally seen, some forty years ago, in the Northern Rivers district of New South Wales (Grafton and Lismore district), but appears to be now almost entirely confined to Queensland. The ♀ is of darker brownish colour than the ♂. There is still quite a good deal of interesting work to be done before the Queensland Stigmoderae family is perfectly classified.

THE COMPARATIVE OSTEOLOGY AND SYSTEMATIC STATUS OF THE GEKKONID GENERA *AFROEDURA* LOVERIDGE AND *OEDURA* GRAY.

By HAROLD G. COGGER.

(Plate viii; eleven Text-figures.)

[Read 25th November, 1964.]

Synopsis.

The lizard genus *Afroedura* Loveridge was erected to accommodate those African geckos which were previously included in the Australian genus *Oedura* Gray. Succeeding workers have not always accepted this action, but the present study of the osteology of these two genera confirms their generic status and suggests that they are not closely related.

The use of pupil form in gekkonid classification is shown to be of doubtful validity when applied to living examples of Australian species.

1. INTRODUCTION.

The genus *Afroedura* was erected by Loveridge (1944) to accommodate those African geckos previously included in the genus *Oedura* Gray. It has as its type species and subspecies *Afroedura karroica bogerti* Loveridge.

Since its description *Afroedura* has not found universal acceptance among herpetologists. It has been used by some workers (Mertens, 1954, 1955; Underwood, 1954; Holder, 1960) but not by others (Webb, 1951; Tasman, 1958).

The genus *Oedura* has as its type species *Oedura marmorata* Gray from Australia. Indeed, the Australian members of this genus are remarkably homogeneous, both in their osteology and external morphology, and form one of the most discrete genera of Australian gekkonid lizards.

Although Underwood (1954), largely on the basis of the form of the pupil, placed *Afroedura* and *Oedura* in different subfamilies within the Gekkonidae (Gekkoninae and Diplodactylinae respectively), it appears that doubt still exists as to the taxonomic status of *Afroedura*; however, acceptance or rejection of this genus is of more than minor taxonomic importance. If these two groups of species, one in Africa and the other in Australia, are retained in the one genus *Oedura*, then the implications are of considerable geographic significance. Such a distribution pattern, in which two congeneric species groups were to occur in Australia and southern Africa without any closely allied forms in the intervening area, would be unique among reptiles (and most other groups of terrestrial animals). It was probably with this problem in mind that Darlington (1957) cautiously stated that "... *Oedura* is now restricted to numerous Australian species; the related or at least similar *Afroedura* is confined to southern Africa".

In view of these implications, and in the absence of a comparable degree of affinity between any other African and Australian herpetofaunal elements, the osteology of these two groups of gekkonid lizards has been examined in an attempt to establish the order of their relationship.

2. MATERIALS AND METHODS.

Material examined for comparative osteological features included 24 specimens representing all species of the Australian genus *Oedura* (Cogger, 1957), *Afroedura transvaalica platyceps* (Hewitt) and *Afroedura karroica* (Hewitt). Alizarin skeletal

transparencies were prepared using a technique modified from that outlined by Davis and Gore (1947). All illustrations of skeletal parts were prepared with an eyepiece graticule grid in a binocular dissecting microscope.

3. COMPARISON OF THE GENERA.

Loveridge, in describing his new genus *Afroedura*, offered the following diagnoses:

Oedura: Four or more pairs of scansors beneath the fourth toe; tail not verticillate. Australia.

Afroedura: One to three pairs of scansors beneath the fourth toe; tail verticillate (not noticeably so in *pondolia*). Southern Africa.

Loveridge proposed the term "scansors" for "... those specialized subdigital scales which have sometimes been referred to as 'adhesive lamellae' or frequently as just 'lamellae', resulting in confusion with the simple lamellae beneath the basal portion of the digit". Such terminology seems to be unnecessarily specialized, as in most geckos there is a wide range of intermediate conditions between the undivided basal lamellae and tubercles and the divided distal lamellae.

Loveridge's diagnoses are generally valid, although occasional specimens of several *Oedura* species are found with only three pairs of lamellae beneath the fourth toe.

The major osteological differences between the two genera are shown in Text-figures 1-11, and are numerated in Table 1.

TABLE 1.

<i>Oedura</i> .	<i>Afroedura</i> .
1. Nasals paired.	1. Nasals fused.
2. Vomers paired.	2. Vomers fused.
3. Premaxillaries partially fused.	3. Premaxillaries completely fused.
4. Stapes imperforate.	4. Stapes perforated at its base.
5. Interclavicle kite-shaped.	5. Interclavicle cruciform.
6. Scapulo-coracoid with minute or absent median coracoidal fenestra.	6. Scapulo-coracoid with very large median coracoidal fenestra.
7. No process on the posterior edge of the pleurapophysis of the second sacral vertebra.	7. A large, flattened, triangular process on the posterior edge of the pleurapophysis of the second sacral vertebra.

Although the degree of fusion between various pairs of cranial elements is known to vary ontogenetically, the adult condition is remarkably constant within any one genus (Camp, 1923; Stephenson & Stephenson, 1956; Stephenson, 1960; Kluge, 1962). Camp (1923) states that the nasals are paired in all gekkonids. Stephenson (1960) found fused nasals in only two of the genera that he examined (*Phyllodactylus marmoratus* and *Lepidodactylus woodfordi*).

Similarly Camp states that the vomers (= prevomers) are not fused in the geckos. Stephenson (1960) implies that the vomers were paired in all species examined by him.

In view of these findings, the fusion of both the nasals and vomers in *Afroedura* (as was also described by Webb, 1952, for *Afroedura karroica*) would certainly indicate a lack of close affinity between this genus and *Oedura*. Unfortunately no juveniles of any species of *Afroedura* were available to the author, so that it was not possible to determine whether fusion of these cranial elements occurs early or late in the ontogeny of members of this genus.

The other features noted in Table 1 are also known to be relatively stable in any one genus. Holder (1960) noted the occurrence of the large, triangular process on the hind edge of the pleurapophysis of the second sacral vertebra of *Afroedura transvaalica*. She also noted the absence of this process in every endemic Australian gekkonid genus except *Heteronota*, and stated that there was "... no indication ... of a transitional state between the smooth shaft and the shaft with a large process ..." in any of the

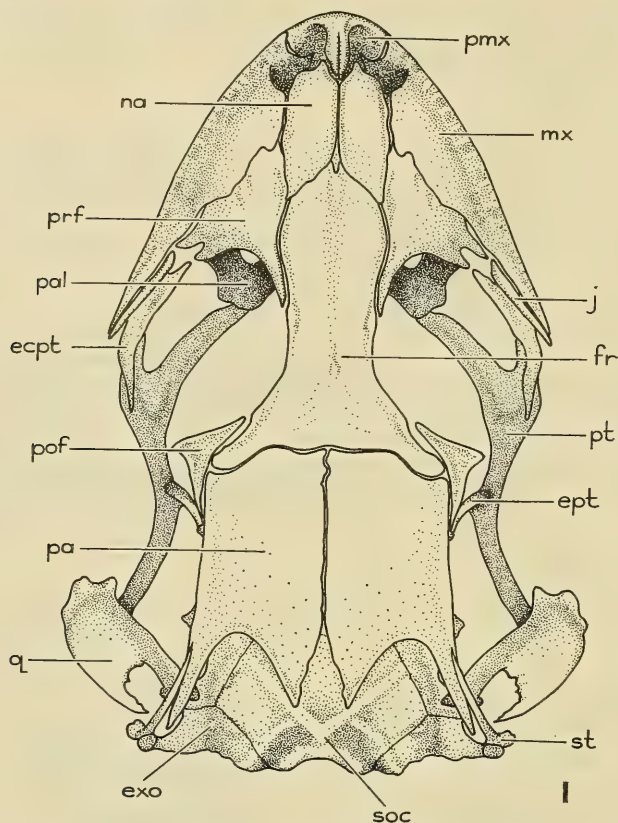


Fig. 1. Dorsal aspect of skull of *Oedura monilis*.

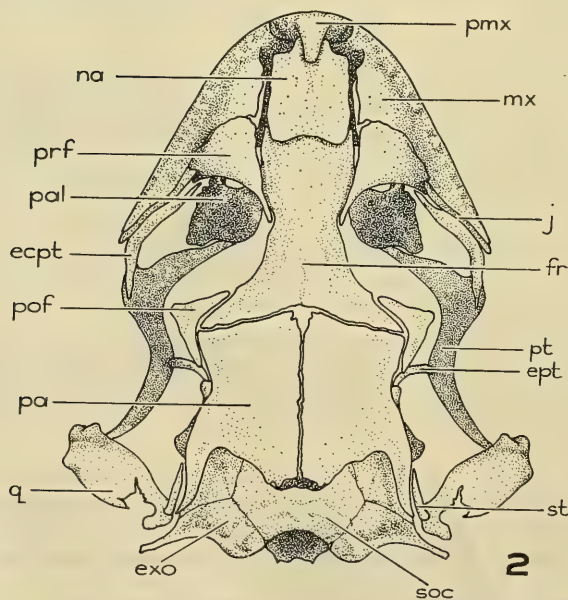


Fig. 2. Dorsal aspect of skull of *Afroedura transvaalica platyceps*.

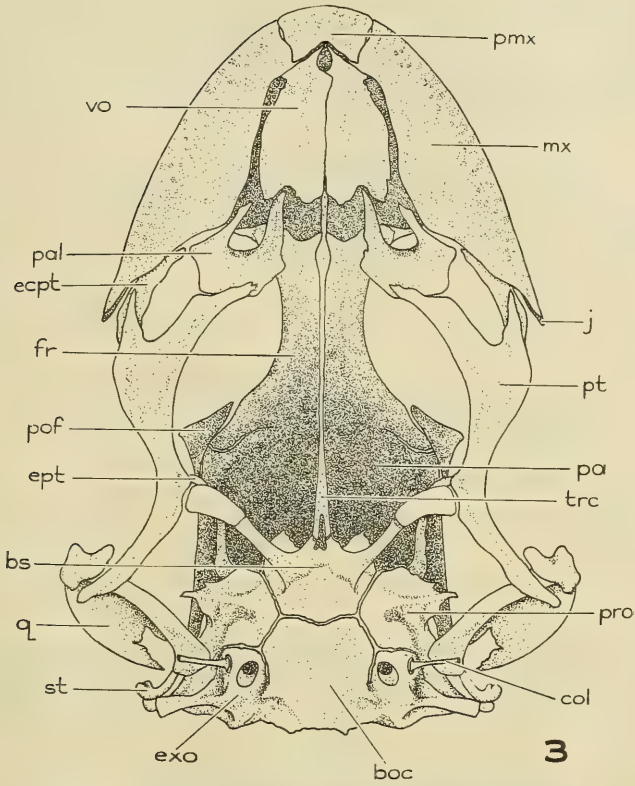


Fig. 3. Ventral aspect of skull of *Oedura monilis*.

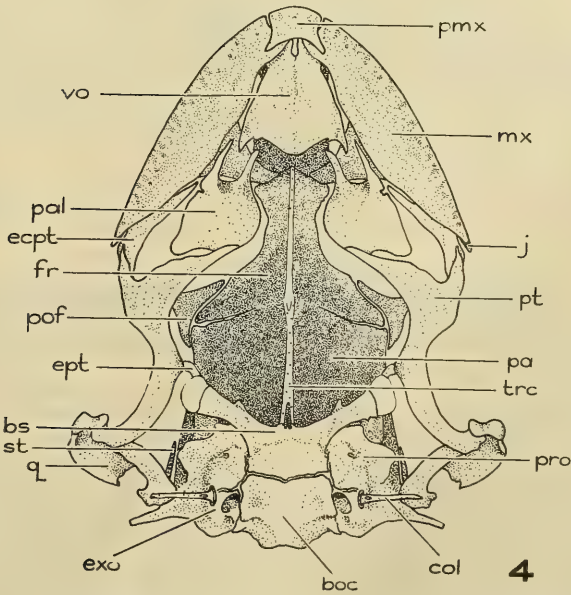


Fig. 4. Ventral aspect of skull of *Afroedura transvaalica platyceps*.

geckos that she examined. This process is extremely well developed in both of the *Afroedura* species examined, but is absent in all Australian *Oedura*.

The extreme difference in shape between the interclavicles of *Oedura* and *Afroedura* is undoubtedly of phyletic significance. The perforation of the columella auris by the stapedial artery, which occurs in only a few living reptiles, is considered by Romer

TABLE 2.

Species (Number of Specimens).	Presacrals.	Cervicals Without Ribs.	Lumbar.	Sacral.	Pygal.
<i>O. marmorata</i> (4) ..	26	3	1	2	4 (5)
<i>O. monilis</i> (4)	26	3	1 (2)	2	5
<i>O. tryoni</i> (1)	26	3	1	2	5
<i>O. robusta</i> (2)	26	3	1	2	5
<i>O. l. lesueurii</i> (11) ..	26 (25-27)	3 (2-3)	1 (1-2)	2	5 (4-5)
<i>A. transvaalica</i> (1) ..	27	3	2	2	4
<i>A. karroica</i> (1) ..	26	3	2	2	5

(1956) to be of considerable phyletic significance. Stephenson (1960) states that the columella is imperforate, presumably in all species examined by him, so that the perforation of the footplate of the columella in *Afroedura* and the imperforate condition in *Oedura* greatly substantiate the view that there is no close affinity between them.

No other differences of major or diagnostic significance were observed, and it should be noted that the expanded clavicle of *Oedura monilis* in Text-figure 7 is not charac-

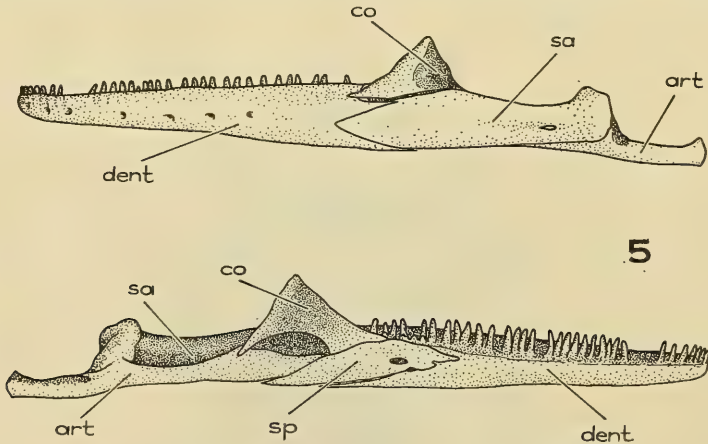


Fig. 5. Outer aspect (upper) and inner aspect (lower) of mandible of *Oedura monilis*.

teristic of the genus. Holder (1960) compared the axial skeletons of numerous gekkonid genera, including *Afroedura* and *Oedura*, without noting any significant differences between the two genera except in the structure of the second sacral vertebra (already noted in Table 1). Vertebral counts are given in Table 2. Where they deviate from those observed by the author, Holder's figures are placed in parentheses.

The phalangeal formulae of 2.3.4.5.3 for the manus and 2.3.4.5.4 for the pes are the same in both genera. The carpi and tarsi are also essentially identical in the two genera.

The skeleton of *Afroedura* tends to be relatively more expanded than that of *Oedura*, as shown in the skull and girdles (Text-figs 1, 2, 7, 8, 9 and 10), while the frontal and post-frontal regions of the skull are more elongate in *Oedura*. Although this flattening may be characteristic only of the two species of *Afroedura* examined (*karroica* and

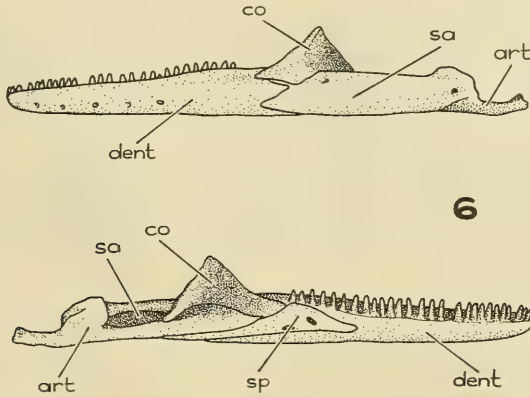


Fig. 6. Outer aspect (upper) and inner aspect (lower) of mandible of *Afroedura transvaalica platyceps*.

transvaalica), in both of these species the head and body are more depressed than in any species of *Oedura*.

FitzSimons (1943) states that femoral pores are lacking in all African species of *Oedura* (= *Afroedura*), whereas femoral pores are present in the males of all Australian species of *Oedura* (Cogger, 1957).

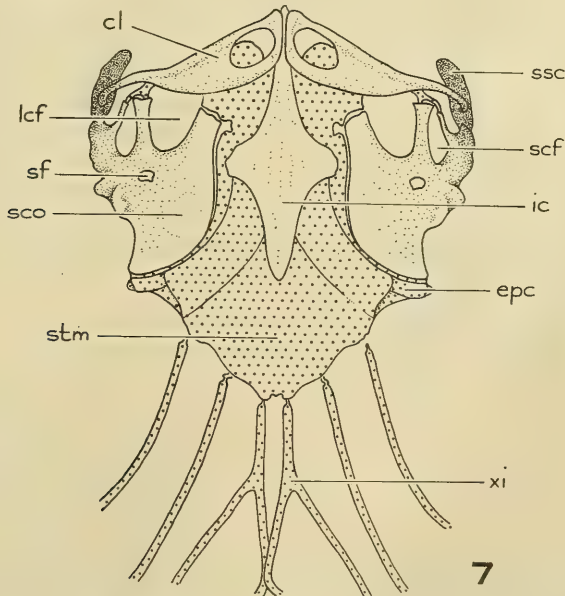


Fig. 7. Ventral aspect of pectoral girdle of *Oedura monilis*.

In the classification proposed by Underwood (1954) the form of the pupil was used as the diagnostic feature separating the Diplodactylinae from the Gekkoninae. The former (in which he included *Oedura*) he defined as "pupil vertical with straight margins, or circular", and the latter (in which he included *Afroedura*) as "*Gekko*-type pupil or secondarily circular".

It is interesting to note the extent to which the pupils of living specimens conform to Underwood's findings. The pupil margins of preserved *Oedura* (Plate viii, A) are almost invariably crenate (45 specimens of 5 species examined), yet in all living

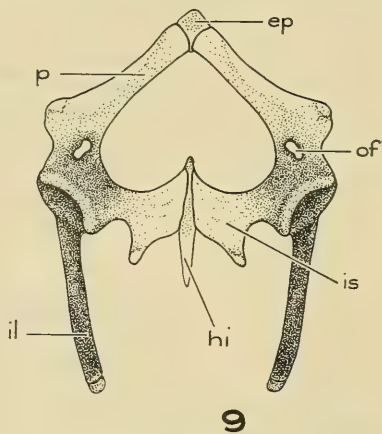
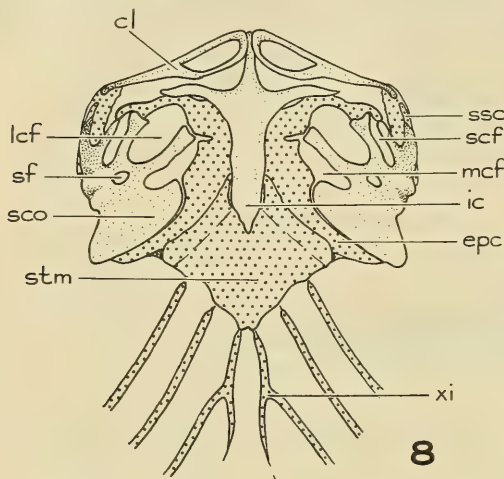


Fig. 8. Ventral aspect of pectoral girdle of *Afroedura transvaalica platyceps*.

Fig. 9. Ventral aspect of pelvic girdle of *Oedura monilis*.

specimens seen by me the pupil is vertical, with straight margins (Plate viii, B). However Bustard (*in litt.*) informs me that Central Australian *O. marmorata* may have pupils with crenate margins.

While examining pupil shape in various living examples of *Oedura*, and in view of the significance of pupil shape in living diplodactyline species, the pupils of some species

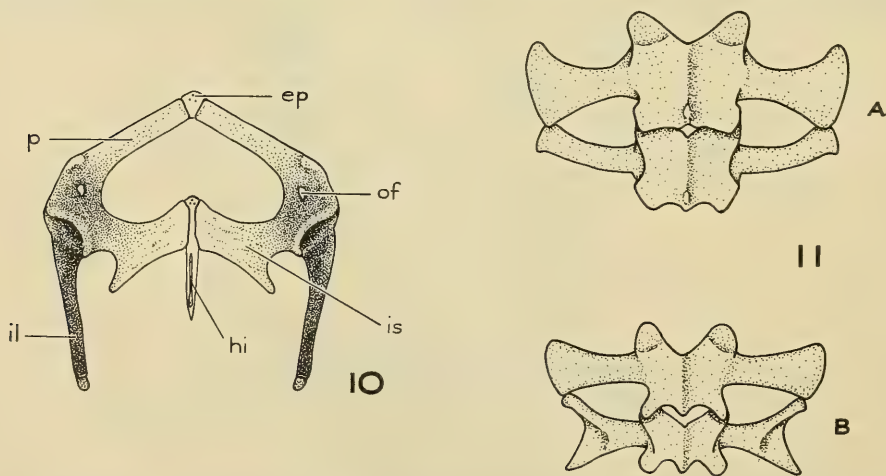


Fig. 10. Ventral aspect of pelvic girdle of *Afroedura transvaalica platyceps*.

Fig. 11. Sacral vertebrae of *Oedura monilis* (A) and *Afroedura transvaalica platyceps* (B).

of *Diplodactylus* were also examined, with interesting results. Although living specimens of *Diplodactylus vittatus* (Plate viii, D), *D. tessellatus* (Plate viii, H) and *D. steindachneri* were found to have the straight-margined vertical pupil described by Underwood, other species of the same genus (*D. intermedius*, *D. williamsi*, *D. ciliaris* and *D. taenicauda*) were found to have the characteristic gekkonine pupil (Plate viii, E-G) not unlike that of *Gekko vittatus* (Plate viii, J). It was also found that in those species

of *Diplodactylus* with *Gekko*-type pupils, the margins of the latter became smoother as the pupils expanded in poor light, so that in some living *D. elderi*, for example, the pupils were almost straight-edged, whereas in other specimens (Plate viii, I) the margins were clearly crenate. A typical diplodactyline pupil is shown in *Phyllurus platurus* (Plate viii, C).

It is not the author's intention to discuss here the merits of the classification proposed by Underwood; however, it is clear from Plate viii that many living diplodactyline species lack the "straight vertical pupil" described by Underwood, and that a critical re-examination of his diagnostic features is called for.

4. CONCLUSIONS.

The differences between *Oedura* and *Afroedura* are considered by the author to support fully their generic status; indeed, it appears highly probable that similarities between the two genera are the result of convergence, and are not indicative of close affinity.

Earlier assumptions of affinity were founded largely on the arrangement of the subdigital lamellae, a morphological feature on which much of the early classification of geckos was based. Yet even in this character the resemblance between *Oedura* and *Afroedura* is superficial; members of the two genera can generally be distinguished by using the simple diagnoses supplied by Loveridge (1944).

The criteria used by Underwood (1954) in allocating these genera to different sub-families within the Gekkonidae are of doubtful validity.

5. ACKNOWLEDGEMENTS.

I am grateful to Dr. C. K. Brain, Dr. V. F. M. FitzSimons and Dr. M. E. Malan for providing specimens of *Afroedura*. Dr. N. G. Stephenson and Mr. H. R. Bustard offered valued criticisms of the manuscript. Mr. A. Healy assisted with production of photographs.

6. ABBREVIATIONS USED IN TEXT-FIGURES.

art, articular; *boc*, basioccipital; *bs*, basisphenoid; *cl*, clavicle; *co*, coronoid; *col*, columella auris; *dent*, dentary; *ecpt*, ectopterygoid; *ep*, epipubis; *epc*, epicoracoid; *ept*, epipterygoid; *exo*, exoccipital; *fr*, frontal; *hi*, hypischium; *ic*, interclavicle; *il*, ileum; *is*, ischium; *j*, jugal; *lof*, lateral coracoid fenestra; *mcf*, median coracoid fenestra; *mx*, maxilla; *na*, nasal; *of*, obturator foramen; *p*, pubis; *pa*, parietal; *pal*, palatine; *pma*, premaxilla; *pof*, postfrontal; *prf*, prefrontal; *pro*, prootic; *pt*, pterygoid; *q*, quadrate; *sa*, surangular; *scf*, scapulo-coracoid fenestra; *seo*, scapulo-coracoid; *sf*, supracoracoid foramen; *soc*, supraoccipital; *sp*, splenial; *ssc*, suprascapula; *st*, supratemporal; *stm*, sternum; *trc*, trabecula communis; *vo*, vomer; *xi*, xiphisternum.

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EXPLANATION OF PLATE VIII.

A, Eye of preserved specimen of *Oedura l. lesueurii* (Duméril & Bibron). B, Eye of living specimen of *Oedura l. lesueurii*. C, Eye of living specimen of *Phyllurus platurus* (White). D, Eye of living specimen of *Diplodactylus vittatus* Gray. E, Eye of living specimen of *Diplodactylus intermedius* Ogilby. F, Eye of living specimen of *Diplodactylus williamsi* Kluge. G, Eye of living specimen of *Diplodactylus ciliaris* Boulenger. H, Eye of living specimen of *Diplodactylus tessellatus* (Günther). I, Eye of living specimen of *Diplodactylus elderi* Stirling & Zietz. J, Eye of living specimen of *Gekko vittatus* Houttuyn.

THE RHAPHIDOPHORIDAE (ORTHOPTERA) OF AUSTRALIA.

PART 2. A NEW GENUS.

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(Two Text-figures.)

[Read 25th November, 1964.]

Synopsis.

A new genus, *Australotettix*, n.g., is erected, and two new species, *Australotettix montanus*, n. sp., and *A. carraiensis*, n. sp., are described. Both species occur in New South Wales.

INTRODUCTION.

A new genus, *Australotettix*, n.g., belonging to the family Rhaphidophoridae, is recorded here from New South Wales. This is the first record of the family in the State. *Australotettix montanus*, n. sp., has been collected from several areas in the Blue Mountains, while *A. carraiensis*, n. sp., occurs in caves west of Kempsey. Both species share their habitats with large populations of glow-worms, *Arachnocampa* sp.

Rhaphidophorids occur in caves, tunnels, and in the bush, but usually a species occupies either a cave and tunnel, or a bush habitat, and is not found in both ecological niches. *A. carraiensis* is recorded from limestone caves only, but *A. montanus* has adapted itself to a wide range of habitats. It was first recorded from the bush in the Grose Valley near Katoomba, in the Blue Mountains. It was then observed in an old mining tunnel at Mt. Victoria; and was more recently collected from the walls of an overhanging sandstone shelter at Horseshoe Falls, Hazelbrook. The tunnel simulated conditions similar to those of a cave, and pools of water gave a high relative humidity. The rock shelter in contrast had a moderate light intensity in the daytime, a wide range in temperature fluctuation, and a much lower relative humidity than in the tunnel. As the cave crickets were observed on the walls of the rock shelter only at night, it is assumed that they spent the daylight hours in the surrounding bush in conditions of lower light intensity.

A. carraiensis occurs in limestone caves about 28 miles due west of Kempsey, or 48 miles by road. The caves are situated in two separate areas within a few miles of each other. These areas are known in the district as Carrai or Haydonville, and Windy Gap. All the caves are surrounded by dense rain forest. The Kempsey Speleological Society have numbered the Carrai caves as WW₁, WW₂, S₅ and S₆, and the Windy Gap caves as S₁, S₂, S₃ and S₄. The S stands for Stockyard Creek, and the WW for Willi-Willi Creek, the two main water-sheds on which the caves are located. Some of the caves have also been given names. The Carrai caves are about 2,300 ft. above sea-level, and half-way up the Carrai plateau; while the Windy Gap caves occur in a valley about 1,500 ft. above sea-level. *A. carraiensis* has been collected from S₅, S₆, S₁ and S₂ but, according to Mr. C. Carter, also occurs in WW₁, S₃ and S₄.

Australotettix is the largest genus of Rhaphidophoridae so far recorded from Australia, an adult male of *A. montanus* reaching a length of up to 30 cm. from the tip of its antennae to its hind tarsi. *A. carraiensis* is somewhat smaller, the length of an adult male being about 23 cm. Sexual dimorphism is strongly developed in both species.

Genus AUSTRALOTETTIX, n.g.

Body clothed with numerous short setae. Legs long and slender. Antennae very long and tapering, almost touching at their bases; scape about four times as large as pedicel, which is narrower than scape, but broader than other segments; from fourth segment onwards segments subequal in length, although steadily decreasing in size; all segments thickly clothed with short setae. A single anterior median ocellus only. Fastigium rising very abruptly, convex, grooved medianly and longitudinally. Metasternum bearing a median tubercle. Fore coxae each armed with a retrolateral spine. All coxae armed with a prolateral apical spine, spines very prominent on fore coxae, but decreasing in size on middle and hind coxae. All femora sulcate ventrally. Apical spines on femora, tibiae, first and second proximal segments of hind tarsi constant in number. Fore femur bears two apical spines beneath, one prolateral and one retrolateral; fore tibia bears four apical spines, one above and one beneath, both prolaterally and retrolaterally; fore tarsus unarmed. Middle femur bears two apical spines beneath, one prolateral and the other retrolateral; middle tibia bears four apical spines, one above and one beneath, both prolaterally and retrolaterally; middle tarsus unarmed. Hind femur bears two apical spines beneath, one prolateral and the other retrolateral; hind tibia bears a pair of long apical spurs above, a pair of subapical spines above, and a pair of short apical spurs beneath, one from each pair being prolateral and the other retrolateral; two proximal segments of hind tarsus each bear two apical spines above, one prolateral and one retrolateral; the other two segments unarmed. Subgenital plate of female trilobed. Subgenital plate of male triangular, keeled; latero-medianly the plate bears two very slender styli, one to each side.

Type species for the genus: *Australotettix montanus*, n. sp.

AUSTRALOTETTIX MONTANUS, n. sp. Text-fig. A, 1-5.

Colour. Basic colour mid-brown, with pronotum, mesonotum, metanotum and abdominal terga irregularly mottled with light brown and ochreous; femora and tibiae of all legs light brown with transverse ochreous bands; tarsi ochreous; antennae light brown; ovipositor deep reddish-brown.

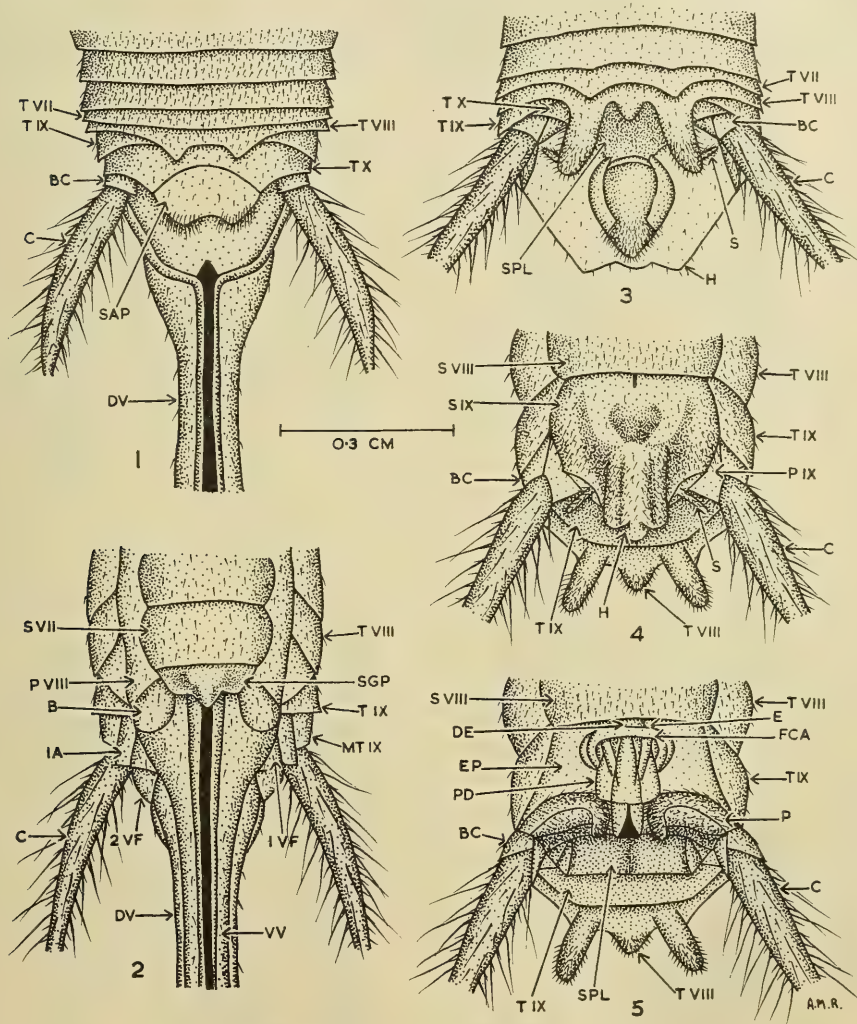
Body. Length up to 15 mm. Body sparsely clothed with setae. Ovipositor subequal with length of body; ventral valves armed distally with eleven teeth, gradually decreasing in size towards the apex, five more proximal teeth forming a scalloped margin, six distal teeth forming a strongly serrated margin. Antennae broken. Fastigium as high as long, with base touching scapes of antennae. Maxillary palps with third and fourth segments subequal in length. Sexual dimorphism shown by distal margin of tergite VIII of female being produced into two small lobes (Fig. A, 1). In male, distal margin of tergite VI slightly emarginate medianly with beginnings of two lobes; in tergite VII margin more deeply emarginate and lobes more definite in shape; in tergite VIII distal margin produced into two long lobes, distal portions of which are thickly clothed with short setae, between lobes lies a small median lobe also clothed with setae (Fig. A, 3).

Antennae. As in generic description. Third segment on dorsal aspect twice as long as pedicel in female, and 1.4 as long in male; on ventral aspect 1.25 as long as pedicel in female, and subequal in male. Sexual dimorphism present, male possessing slightly longer, stouter antennae than female. No spines present on flagellum of male or female.

Legs. Fore and middle legs subequal in length, with middle leg slightly shorter; hind leg 1.75 length of fore and middle legs. Sexual dimorphism shown by fore, middle and hind legs of female being 0.7 as long as male. Femora, tibiae and proximal two segments of hind tarsi armed with variable numbers of linear spines. No spines occur on fore or middle tarsi. No spines on middle femur of female, and spines on hind femur of female much fewer in number than those of male (Table 1). Apical spines constant in number, as in generic description. Length of proximal segment of hind tarsus subequal with other three segments together. Ratio of length of legs to length of body: Fore leg, male 3.6:1; female 2.7:1. Middle leg, male 3.4:1; female 2.4:1. Hind leg, male 6.1:1; female 4.4:1.

Genitalia.

Female: Suranal plate, Fig. A, 1 (SAP), convex laterally, distal margin emarginate; disto-laterally margin clothed with two groups of setae, rest of plate sparsely clothed with setae. Subgenital plate, Fig. A, 2 (SGP), trilobed, median lobe being longer than other two; all lobes acute at apex, median lobe slightly keeled; whole plate glabrous.



Text-figure A. *Australotettix montanus*, n. sp.

1, Female genitalia, dorsal view. 2, Female genitalia, ventral view. 3, Male genitalia, dorsal view. 4, Male genitalia, ventral view. 5, Male genitalia, ventral view, subgenital plate removed to expose structures beneath.

Male: Suranal plate, Fig. A, 3, 4, 5 (SPL), almost completely concealed by tergite VIII and subgenital plate; distal margin of plate truncate and clothed with short setae, rest of plate sparsely clothed with setae. Subgenital plate, Fig. A, 3, 4 (H), triangulate, convex proximally changing to concave distally, medianly plate is strongly keeled, distal margin trilobed, all lobes rounded at apex, median lobe longer than other two; distal half of dorsal surface thickly clothed with short setae, rest of plate sparsely clothed with setae; ventral surface sparsely clothed with setae; medianly it bears a large lobe thickly clothed with setae over more distal portion. Two styli, Fig. A, 3, 4

(S), very slender, thickly clothed with short setae, length of styli being 0.2 length of sternite IX (S IX). Parameres, Fig. A, 5 (P), elongate, rounded at apex, 2.7 longer than wide, prolateral margins thickly clothed with setae. Pseudosternite, Fig. A, 5 (PD), 1.5 longer than wide, with median spatulate-shaped lobe curving ventrally and two shorter lateral lobes. Penis not visible. Paraprocts absent.

TABLE 1.
Variability in Number of Linear Spines on the Legs of 25 Specimens of Australotettix montanus n. sp.

		Arith. Mean.		No. of Specimens.		Std. Dev.		Range (or Distribution).	
		L	R	L	R	L	R	L	R
Fore femur inf.	Pro.	0	0	25	25	0	0	0	0
	Retro.	0	0	25	25	0	0	0	0
Fore tibia inf.	Pro.	3	3	25	25	—	0	3 (24), 2 (1)	3
	Retro.	3	3	25	25	0	0	3	3
Fore tarsus	Pro.	0	0	25	25	0	0	0	0
	Retro.	0	0	25	25	0	0	0	0
Mid femur inf. ♂	Pro.	21.9	22.8	13	13	5.6	4.5	15-32	17-32
	Retro.	21.7	22.3	13	13	4.3	3.3	12-28	15-27
Mid femur inf. ♀	Pro.	0	0	12	10	0	0	0	0
	Retro.	0	0	12	10	0	0	0	0
Mid tibia sup.	Pro.	0	0	25	23	0	0	0	0
	Retro.	0	0	25	23	0	0	0	0
Mid tibia inf.	Pro.	3	3	25	23	0	0	3	3
	Retro.	3	3	25	23	0	—	3	3 (24), 4 (1)
Mid tarsus	Pro.	0	0	25	23	0	0	0	0
	Retro.	0	0	25	23	0	0	0	0
Hind femur inf. ♂	Pro.	52.8	52.4	13	12	10.9	11	37-72	34-75
	Retro.	76.7	78.7	13	12	11.4	9.7	60-94	65-100
Hind femur inf. ♀	Pro.	7.1	6.8	12	12	0.9	1.2	5-8	5-9
	Retro.	8	7.5	12	12	10.4	9.7	1-26	1-27
Hind tibia sup.	Pro.	31	31.4	25	23	4.4	4.3	23-43	24-41
	Retro.	37.1	38	25	23	4.5	4.3	29-46	31-45
Hind tarsus 1 sup.	Pro.	1.8	2	25	23	1.0	1.0	0-4	0-4
	Retro.	2.5	2.2	25	23	1.2	0.8	1-6	1-4
Hind tarsus 2 sup.	Pro.	1.2	1.4	25	23	0.4	0.6	1 (21), 2 (4)	0-2
	Retro.	1.2	1	25	23	0.3	0.4	1-3	0-2

(Figures in parentheses represent number of specimens.)

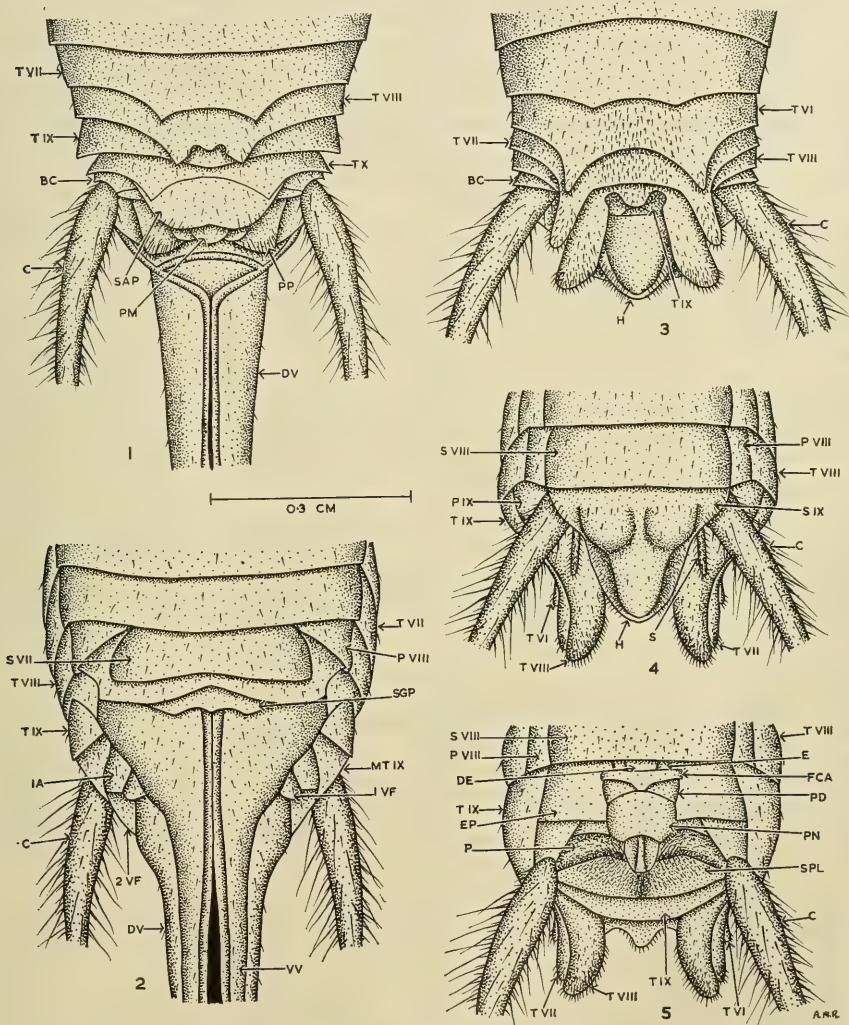
Locality. Old mining tunnel Mt. Victoria, New South Wales (type locality), coll. A. Healy 1961; Horseshoe Falls, Hazelbrook, New South Wales, coll. A. M. Richards 1963; Grose Valley, Katoomba area, New South Wales, coll. M. Montague 1958; sandstone cave, Springwood, New South Wales, coll. F. Evans 1961.

Types. Holotype male, Allotype female and Paratype male and female in Australian National Insect Collection, C.S.I.R.O., Canberra. Four Paratypes, two males and two females, in the Australian Museum Collection, Sydney.

AUSTRALOTETTIX CARRAIENSIS, n. sp. Text-fig. B, 1-5.

Colour. Basic colour mid-brown with all tergites irregularly mottled with light brown and ochreous. Femora and tibiae banded with light brown and ochreous; tarsi ochreous; antennae light brown; ovipositor reddish-brown.

Body. Length 17 mm. in female, and up to 20 mm. in male. Ovipositor subequal with length of body; ventral valves armed distally with eleven teeth forming a scalloped margin, the teeth gradually decreasing in size towards the apex. Antennae broken. Fastigium longer than high. Maxillary palps with third and fourth segments subequal in length. Sexual dimorphism present in female, median portion of distal margin of tergite VI slightly emarginate, tergite VII more deeply emarginate and produced on either side into two lobes, tergite VIII with more pronounced lobes and margin slightly convex between lobes. Variation in degree of development of lobes occurs from specimen to



Text-figure B. *Australotettix carraiensis*, n. sp.

1, Female genitalia, dorsal view. 2, Female genitalia, ventral view. 3, Male genitalia, dorsal view. 4, Male genitalia, ventral view. 5, Male genitalia, ventral view, subgenital plate removed to expose structures beneath.

specimen (Fig. B, 1). In male distal margin of tergite VI concave and produced into two lobes on either side, tergite VII with margin straight and lobes twice as long as in tergite VI; tergite VIII with two lobes longer and wider, and between them a small median lobe (Fig. B, 3). All lobes and distal margins clothed with short setae.

Antennae. As in generic description. Third segment on dorsal aspect 1.2 as long as pedicel in both male and female; on ventral aspect 1.2 as long as pedicel in male, and 1.4 as long in female. Sexual dimorphism present, male possessing slightly longer, stouter antennae than female. No spines present on flagellum of male or female.

Legs. Fore and middle legs subequal in length, with middle leg slightly shorter; hind leg 1.8 length of fore or middle legs. Sexual dimorphism present; fore, middle and hind legs of female being 0.8 as long as male. Femora, tibiae and proximal two segments of hind tarsi armed with variable numbers of linear spines. No spines occur on fore tarsi, middle tarsi, and fore femora of male or female, or middle femora of female. Spines on hind femora of female much fewer in number than those on hind femora of

TABLE 2.

Variability in Number of Linear Spines on the Legs of 29 Specimens of Australotettix carraiensis, n. sp.

		Arith. Mean.		No. of Specimens.		Std. Dev.		Range (or Distribution).	
		L	R	L	R	L	R	L	R
Fore femur inf.	Pro.	0	0	29	29	0	0	0	0
	Retro.	0	0	29	29	0	0	0	0
Fore tibia inf.	Pro.	3	3	29	29	—	—	2 (27), 1 (1), 2 (1)	3 (28), 2 (1)
	Retro.	3	3	29	29	—	0	3 (28), 4 (1)	3
Fore tarsus	Pro.	0	0	29	29	0	0	0	0
	Retro.	0	0	29	29	0	0	0	0
Mid femur inf. ♂	Pro.	28.4	26.4	10	10	5.1	4.5	19-35	17-32
	Retro.	22.5	23.8	10	10	4.4	4.9	16-30	17-34
Mid femur inf. ♀	Pro.	0	0	19	19	0	0	0	0
	Retro.	0	0	19	19	0	0	0	0
Mid tibia sup.	Pro.	0	0	29	29	0	0	0	0
	Retro.	0	0	29	29	0	0	0	0
Mid tibia inf.	Pro.	3	3	29	29	0	0	3	3
	Retro.	3	3	29	29	0	0	3	3
Mid tarsus	Pro.	0	0	29	29	0	0	0	0
	Retro.	0	0	29	29	0	0	0	0
Hind femur inf. ♂	Pro.	69.1	75.5	10	9	12.0	15.3	50-90	59-100
	Retro.	87.5	91.2	10	9	7.6	12.7	72-102	69-112
Hind femur inf. ♀	Pro.	5.6	5.0	19	17	6.9	4.1	2-28	4-21
	Retro.	2.9	3.3	19	17	4.0	5.4	0-18	0-22
Hind tibia sup.	Pro.	36.2	36.9	29	26	5.0	5.2	27-44	27-46
	Retro.	43	43	29	26	4.1	4.3	32-50	33-51
Hind tarsus 1 sup.	Pro.	1.5	1.4	29	26	1	0.6	0-4	1-3
	Retro.	1.5	1.3	29	26	0.9	0.8	0-3	0-3
Hind tarsus 2 sup.	Pro.	1	1.1	29	26	0.5	0.4	0-2	0-2
	Retro.	1.1	1.1	29	26	0.4	0.4	0-2	0-2

(Figures in parentheses represent number of specimens.)

male (Table 2). Apical spines constant in number, as in generic description. Ratio of length of legs to length of body: Fore leg, male 2.4:1; female 2.2:1. Middle leg, male 2.2:1; female 2.1:1. Hind leg, male 4.2:1; female 4:1.

Genitalia.

Female: Suranal plate, Fig. B, 1 (SAP), distal margin slightly emarginate and clothed with two groups of setae; rest of plate sparsely clothed with setae. Subgenital plate, Fig. B, 2 (SGP), trilobed, all lobes acute at apices which are approximately level distally; whole plate glabrous.

Male: Suranal plate, Fig. B, 3, 5 (SPL), almost completely concealed by tergite VIII and subgenital plate; distal margin emarginate and clothed with short setae; greater portion of plate thickly clothed with setae. Subgenital plate, Fig. B, 3, 4 (H), triangulate, convex proximally changing to concave proximo-medianly and convex distally, distal margin rounded. Proximally plate bears two tubercles; it is keeled medianly; disto-laterally dorsal and ventral surfaces thickly clothed with short setae; rest of plate sparsely clothed with setae. Two styli, Fig. B, 4 (S), very slender, thickly clothed with short setae, length of styli being 0.4 length of sternite IX (S IX). Parameres, Fig. B, 5 (P), elongate, rounded at apex, 2.4 longer than wide, prolateral margin thickly clothed with setae. Pseudosternite, Fig. B, 5 (PD), 1.3 longer than wide, distal portion spatulate-shaped. Penis, Fig. B, 5 (PN), two-lobed, each lobe 1.4 longer than wide. Paraprocts absent.

Locality. S6, Barnett's Cave, Carrai, west of Kempsey, N.S.W. (type locality), coll. P. F. Aitken 1962, C. Carter 1964; S5, Carrai Bat Cave, Carrai, coll. P. F. Aitken 1962, C. Carter 1964; S1, River Cave, Windy Gap, west of Kempsey, N.S.W., coll. R. Shepherd 1964; S2, Col's Cave, Windy Gap, coll. R. Shepherd 1964; Lot's Mansion Cave on Carrai-Kempsey road, coll. P. D. Dwyer 1961.

Types. Holotype male, Allotype female and Paratype male and female, in South Australian Museum Collection, Adelaide. Two Paratypes, one male and one female, in Australian National Insect Collection, C.S.I.R.O., Canberra. Two Paratypes, one male and one female, in the Australian Museum Collection, Sydney.

Australotettix carraiensis differs from *A. montanus* in: 1. Shape of subgenital plate of female; 2. Suranal plate of female less deeply emarginate; 3. Teeth on ventral valves of ovipositor scalloped, not serrated; 4. Subgenital plate of male with rounded apex, and not so strongly keeled; 5. In male, greater development of two lobes from tergites VI, VII and VIII. In female, development of two lobes from tergite VII, and greater development of lobes from tergite VIII.

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Index to Tables.

Arith. Mean, Arithmetic Mean; *Inf.*, Inferior; *L.*, Left leg; *Mid.*, Middle; *Pro.*, Prolateral; *R.*, Right leg; *Retro.*, Retrolateral; *Sup.*, Superior; *Std. Dev.*, Standard Deviation.

Index to Text-figures.

B, basivalvula; BC, basal segment of cercus; C, cercus; DE, ductus ejaculatorius; DV, dorsal valve; E, endapophysis; EP, endoparamere; FCA, feebly chitinized arch connecting rami; H, subgenital plate, male; IA, intersegmental apodeme; MT IX, membrane of tergite IX; P, paramere (ectoparamere); PVII, PVIII, PIX, pleurite VII, VIII, IX; PD, pseudosternite; PN, penis; S, stylus; SVII, SVIII, SIX, sternite VII, VIII, IX; SAP, suranal plate, female; SGP, subgenital plate, female; SGL, suranal plate, male; TVII, TVIII, TIX, TX, tergite VII, VIII, IX, X; 1VF, first valvifer; 2VF, second valvifer.

ABSTRACT OF PROCEEDINGS.

ORDINARY MONTHLY MEETING.

25th MARCH, 1964.

Miss Elizabeth C. Pope, President, in the chair.

The minutes of the last Monthly Meeting (27th November, 1963) were taken as read and signed.

The Chairman offered congratulations to Sir J. Burton Cleland (Kt.) on the knighthood conferred on him by Her Majesty the Queen, to Dr. Dorothy Hill on the award of the Lyell Medal by the Geological Society of London, and to Dr. Beryl Nashar on her appointment to an Associate Professorship in the Department of Geology, Newcastle University College.

The Chairman announced that library accessions amounting to 51 volumes, 444 parts or numbers, 16 bulletins, 37 reports and 14 pamphlets, total 562, had been received since the last meeting.

PAPERS READ.

(*By title only, an opportunity for discussion to be given at the April Ordinary Monthly Meeting.*)

2. Notes on the Subgenus *Chaetocrucomyia* Theobald (Diptera: Culicidae). By Elizabeth N. Marks.

3. Observations on some Australian Forest Insects. 17. Two New Species of *Glycaspis* (Homoptera: Psyllidae) and a Note on *Glycaspis occidentalis* (Solomon). By K. M. Moore.

4. Contributions on Palaeozoic Floras. I. On the Identification of *Glossopteris cordata* Dana. By J. F. Rigby.

ORDINARY MONTHLY MEETING.

29th APRIL, 1964.

Miss Elizabeth C. Pope, President, in the chair.

The following were elected Ordinary Members of the Society: Mrs. Jennifer M. E. Anderson, B.Sc.Agr., Macleay Museum, Sydney University; Mr. J. A. P. Blackmore, LL.B. (Syd. Univ.), Ashfield, N.S.W.; Mr. E. C. Harber, Katoomba, N.S.W.; Miss Margery O. Levy, B.Sc., Dip.Ed., Katoomba, N.S.W.; Dr. Murray J. Littlejohn, B.Sc., Ph.D. (W.A.), University of Melbourne, Victoria; Mr. Albert Rothwell, D.P.A., Cronulla, N.S.W.; Miss Dianne M. Shaw, B.Sc., Sydney University; and Dr. J. C. Yaldwyn, Ph.D. (N.Z.), M.Sc., Australian Museum, Sydney.

The Chairman referred to the death on 2nd April, 1964, of Miss Vera Irwin Smith, who had been a member of the Society since 1916 and a Linnean Macleay Fellow from 1919 to 1923.

The Chairman offered congratulations to Dr. Mary D. Tindale on the award of the degree of D.Sc., University of Sydney, and to Dr. Joyce W. Vickery, on the award by the Royal Society of N.S.W. of the W. B. Clarke Memorial Medal.

The Chairman announced that the Council had elected the following office bearers for the 1964-65 session: Vice-Presidents: Mr. G. P. Whitley, Professor B. J. F. Ralph, Professor S. Smith-White and Dr. T. G. Vallance; Honorary Treasurer: Dr. A. B. Walkom; Honorary Secretaries: Drs. A. B. Walkom and W. R. Browne.

The Chairman announced that library accessions amounting to 17 volumes, 176 parts or numbers, 4 bulletins, 1 report and 17 pamphlets, total 215, had been received since the last meeting.

PAPERS READ.

1. The *ulysses* Species-group, Genus *Haemolaelaps* (Acarina, Laelapidae). By Robert Domrow.

2. Observations on some Australian Forest Insects. 18. Four New Species of *Glycaspis* (Homoptera: Psyllidae) from Queensland. By K. M. Moore.

3. Contributions on Palaeozoic Floras. 2. An Unusual Fossil Tree from Wollar, New South Wales. By J. F. Rigby.

One of the papers (by Mr. J. F. Rigby) taken as read at the March Ordinary Monthly Meeting was outlined by the author and discussed.

SYMPOSIUM.

A Symposium on the Natural History of Kosciusko took place, the following speakers taking part: Dr. W. R. Browne, Geomorphology and Glaciation; Dr. R. C. Carolin, Botany; Mr. D. K. McAlpine, Entomology; Dr. D. F. McMichael, Aquatic Fauna.

Mr. G. P. Whitley exhibited specimens of *Galaxias findlayi*, the only freshwater fish known from the Kosciusko region, and made remarks on the circum-Antarctic distribution of the genus *Galaxias*.

ORDINARY MONTHLY MEETING.

27th MAY, 1964.

Miss Elizabeth C. Pope, President, in the chair.

The following were elected Ordinary Members of the Society: Miss Elysse M. Craddock, Five Dock, N.S.W.; Mr. R. A. Facer, Castle Hill, N.S.W.; Dr. R. G. Florence, M.Sc.(For.), Ph.D., Beerwah, Queensland; Mr. A. E. H. Pedder, M.A.(Cantab.), Armidale, N.S.W.; Mr. B. J. Richardson, Parramatta North, N.S.W.; Mrs. Marie V. Webb, B.Sc., South Hurstville, N.S.W.; and Mr. A. H. White, B.Sc.(Syd.), Armidale, N.S.W.

The Chairman announced that library accessions amounting to 17 volumes, 200 parts or numbers, 6 bulletins, 3 reports and 16 pamphlets, total 242, had been received since the last meeting.

PAPERS READ.

1. A New Genus and Species of Pallopteridae (Diptera, Schizophora) from Papua. By David K. McAlpine.

2. Chromosome Numbers and Relationships in *Chara leptopitys* A.Br. By A. T. Hotchkiss.

3. The Stratigraphy and Structure of the Upper Palaeozoic Sediments of the Somerton-Attunga District, N.S.W. By Andrew H. White.

4. Edaphic Control of Vegetational Pattern in East Coast Forests. By R. G. Florence.

NOTES AND EXHIBITS.

Mr. David K. McAlpine exhibited specimens and illustrations of species in connection with his paper and of other species about which a discussion took place and questions were asked.

Miss Kathleen English submitted the following notes on, and exhibited specimens of, some insects of the sandhills: larvae of Tabanidae and Therevidae were found in sandhills behind the beach at Cronulla and Avalon, N.S.W., and as both species are carnivorous the question arose "What did they eat?". To find the answer, periodic searches were made in these areas and the larvae of a number of other insects were found. To date we have representatives of the following orders: Coleoptera (3 species), Dermaptera (1), Diptera (6), Hemiptera (1), Lepidoptera (2), Neuroptera (1), Orthoptera (1). These would provide food for the carnivorous species. Special adaptations for life in the sand, either in colour or structure, have been found in the few larvae that have been examined carefully and no doubt these occur also in other larvae living in this unusual habitat.

Mrs. P. R. Messmer appealed for support in a request to the Council of the Society to make representations to, or even to arrange a deputation to, the Minister for Local Government for a more comprehensive Act of Parliament to be passed for the adequate protection of our fast-disappearing native flora. In the past two years complete devastation of rare, botanically important species has been noticed in some specific areas. The only solution to this problem is seen in the total prohibition of sale of all native species of plants and flowers. At present there exists only a list of protected species and these may be sold under licence, if a bill of sale, or permission from owners of land, upon which the species are grown, is produced. This permission may be open to abuse.

Dr. I. V. Newman exhibited (a) Two out of a crop of about 24 grape-fruit ranging in diameter from 6 to 7.5 cm. The small tree had three main branches, each about 4-5 cm. in diameter. Last year the foliage on one branch turned yellow and a mass of flowers appeared. A borer was found to have ringed the branch with a gap of about 7 mm. Six bridge-grafts of bark were attempted. Three took fully, one took scarcely at all and two failed. The foliage partly fell off and partly recovered greenness. On the remainder of the tree the foliage remained deep green throughout and flowers were absent. (b) Damaged leaves of *Cycas revoluta*. After about eight years of successful growth from transplanting, an annual crown of leaves at about half-growth dried off completely except for the rachis and about eight pairs of pinnae at both base and tip of each leaf, which remained fully green. This has happened for three years. No outward sign of infection appears. The only explanation offered is that delay due to production of the terminal pollen cone brought the immature crown into unaccustomed water stress in very hot weather. The parts remaining green were possibly near enough to water supply or, in the tip region, did not yet have stomata matured for passage of water vapour.

Miss Elizabeth Pope reported that the prolonged wet period in the winter and early spring of 1963 was followed by an outbreak of complaints about leeches. Many enquirers wanted to know about repellents and two farmers complained that their stock were so plagued by leeches that in one case he had had to abandon the use of a paddock where the infestation was worst. Parts of newly opened estates in the South Coast district were particularly affected by invasions of leeches. Two leeches were tabled showing preserved specimens of the dark and light forms of the common leech, *Limnodynastes australis*. Miss Pope mentioned that a forthcoming number of the magazine "Australian Natural History" would set out the formula for a leech-repellent used successfully in India and by the American Armed Services. Illustrations of a live leech were tabled to show the distinctive colour pattern of the living specimen, so much of which is lost after preservation.

Mr. Ellis Troughton (by permission of the Director of the Australian Museum) exhibited skins and skulls of the Whiptail Wallaby and Wallaroo taken from within 12 miles of Cooktown, where the *Endeavour* was beached for repair in 1770. Prior to examining these specimens, Iredale and Troughton had deduced evidence from Solander's field description that "Cook's Kangaroo" could not have been the Great Grey, and was more likely to have been a northern form of wallaroo. But from a study of the

two skins and skulls, in comparison with Solander's description, it became quite evident that the physical proportions, coloration, and dentition were in agreement with the description of the 38-lb. macropod shot, described, and eaten a fortnight before the capture of the 84-lb.* specimen, which was evidently a wallaroo. Unfortunately, the naturalists' overall comparison of the kangaroos as a "gigantic jerboa" created an obsession with "gigantism" with some contemporary authorities who have strenuously advocated the claims of the Great Grey against much evidence adduced to the contrary. Recently, despite recommendations to the International Commission on Nomenclature in support of the Great Grey theory, there now appears a remarkable *volte face* in such opinion, favouring the identity of Cook's Kangaroo as the wallaroo, based, as in the case of the Great Grey, on an equally unauthenticated skull. The fact remains that the skin and skull of the Whiptail Wallaby, in contrast with that of the wallaroo, are in general accord with the description by Solander, legally admissible as taxonomic evidence. Since the first 38-lb. animal so described, and figured by Parkinson, is acknowledged as the holotype of "*Mus*" *canguru* of Müller, as detailed by Iredale and Troughton in the PROCEEDINGS for 1962, it is reaffirmed, on the evidence of these skins and skulls alone, that the name of the Cooktown Whiptail Wallaby is *Wallabia canguru*, a name surely warranting inclusion in the list of *nomina conservanda*, not only from the zoological but also from the historical and educational view.

Dr. W. R. Browne gave a note illustrated by colour transparencies on the geological age of the topography in the Cooma area, which the evidence indicates to be Oligocene or earlier, and not Quaternary, as generally assumed.

ORDINARY MONTHLY MEETING.

24th JUNE, 1964.

Mr. G. P. Whitley, Vice-President, in the chair.

Mr. R. C. Jancey, M.Sc., Sydney University, was elected an Ordinary Member of the Society.

The Chairman announced that library accessions amounting to 20 volumes, 178 parts or numbers, 1 bulletin, 2 reports and 8 pamphlets, total 209, had been received since the last meeting.

PAPERS READ.

1. Observations on some Australian Forest Insects. 19. Additional Information on the Genus *Glycaspis* (Homoptera: Psyllidae): Erection of a New Subgenus and Descriptions of Six New Species. By K. M. Moore.

2. Australian Fossil Crinoids. II. *Tribrachiocrinus clarkei* McCoy. By G. M. Philip.

3. Taxonomic and Nomenclatural Notes on the Genus *Wahlenbergia* in Australia. By R. C. Carolin.

LECTURETTE.

A lecturette entitled "Reptile Collecting in New Guinea" was delivered by Mr. H. G. Cogger, Curator of Reptiles and Amphibians, Australian Museum, Sydney.

ORDINARY MONTHLY MEETING.

29th JULY, 1964.

Miss Elizabeth C. Pope, President, in the chair.

Mr. A. L. Bertus, B.Sc., N.S.W. Department of Agriculture, Rydalmere, N.S.W., and Miss Joyce W. Lanyon, B.Sc., Dip.Ed., Eastwood, N.S.W., were elected Ordinary Members of the Society.

* In the Abstract (No. 727, issued 3rd June, 1964) this figure was printed "180" in error.

The Chairman announced that library accessions amounting to 21 volumes, 171 parts or numbers, 15 bulletins, 11 reports and 6 pamphlets, total 224, had been received since the last meeting.

The Chairman drew the attention of members to the resolutions passed at a Public Meeting held on 8th June, 1964, regarding Conservation in New South Wales.

The Chairman reminded members and friends that the Sir William Macleay Memorial Lecture, 1964, will be delivered in the Large Hall, Science House, 157 Gloucester Street, Sydney, on Friday, 21st August, 1964, at 8 p.m., by Professor H. G. Andrewartha, Department of Zoology, University of Adelaide, the title of the Lecture being "How Animals can live in Dry Places". There will not be an Ordinary Monthly Meeting of the Society in August.

PAPERS READ (by title only).

1. A New Genus of Australian Clavicorn Coleoptera, probably of a New Family. By R. A. Crowson. (*Communicated by Dr. P. B. Carne.*)
2. Three New Species of Scolytidae from Australia, and some Introduced Coleoptera. (No. 224. Contribution to the Morphology and Taxonomy of the Scolytoidea.) By Karl E. Schedl. (*Communicated by Mr. K. M. Moore.*)
3. A Note on *Creis periculosa* (Olliff) (Homoptera: Psyllidae). By K. L. Taylor.
4. On the Adult and Juvenile Stages of *Vanbenedenia chimaerae* (Heegaard, 1962) (Copepoda: Lernaepodidae) from Australian Waters. By Z. Kabata. (*Communicated by Dr. J. C. Yaldwyn.*)
5. Classification of the Loranthaceae and Viscaceae. By B. A. Barlow.
6. Nitrogen Economy in Arid and Semi-arid Plant Communities. Part III. The Symbiotic Nitrogen-fixing Organisms. By N. C. W. Beadle.

EXHIBITS.

Mr. G. P. Whitley exhibited an old book from his library: G. E. Rumphius's *Thesaurus Imaginum piscium testaceorum . . .*, printed in 1711, illustrating marine invertebrates and other objects. Rumphius (c. 1627–1702) described many animals from the East Indies before he became blind about the year 1670. Author of the *Herbarium Amboinense*, the "blind seer of Amboina" and *Plinius indicus*, as he has been styled, was helped by Dutch Government assistants. The figures in this *Thesaurus* are the same as in Rumphius's *Rariteitkamer* (1741 edition in Australian Museum) and illustrate some types of species named years later by Linnaeus.

Miss Elizabeth Pope exhibited three species of starfishes belonging to the genus *Astropecten*, taken in the Sydney area. Although the late Dr. H. L. Clark in 1946 corrected previous mis-identifications made by himself in the Reports of the F.I.S. "Endeavour", confusion has remained in the minds of some local marine zoologists. The specimens tabled, together with the colour notes on them and the records of their typical habitats, should help zoologists unfamiliar with the group to make identifications in the field. *Astropecten polyacanthus* lives in or just below the tidal zone on muddy sand and is a dark burgundy red on the upper surface; *A. vappa*, which is generally large in size, has a general grey colour on the upper surface with the large marginal plates coloured a bright orange red. It is generally taken in moderate depths by trawlers—the bottom being a mixture of sand and mud; *A. pectinatus* is the smallest species of the three, is trawled in greater depths on the continental shelf than *A. vappa*, and is taken on a bottom of fine mud. The colour of its upper surface is salmon pink and much lighter in shade than *A. polyacanthus*. There are, of course, easily recognizable differences in body structure, but these are well described in the literature. The specimens and information about their occurrence were collected by Dr. J. MacIntyre

of C.S.I.R.O., Division of Fisheries and Oceanography, Cronulla, and submitted by him to the Australian Museum.

LECTURETTE.

A lecturette entitled "Some Aspects of Forestry in New South Wales" was delivered by Mr. G. Baur, Forestry Commission of N.S.W.

ORDINARY MONTHLY MEETING.

30th SEPTEMBER, 1964.

Miss Elizabeth C. Pope, President, in the chair.

Messrs. G. O. Bedford, Canberra, A.C.T., and F. R. Higginson, West Ryde, N.S.W., were elected Ordinary Members of the Society.

The Chairman announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1965, from qualified candidates. Each applicant must be a member of this Society and be a graduate in Science or Agricultural Science of the University of Sydney. The range of actual (tax-free) salary is, according to qualifications, up to a maximum of £1,600 per annum. Applications should be lodged with the Honorary Secretary, who will give further details and information, not later than Wednesday, 4th November, 1964.

The Chairman announced that library accessions amounting to 31 volumes, 307 parts or numbers, 39 bulletins, 14 reports and 10 pamphlets, total 401, had been received since the last meeting.

PAPERS READ.

1. A Review of the Marsupial Genus *Sminthopsis* (Phascogalinae) and Diagnoses of New Forms. By Ellis Troughton.

2. Observations on some Australian Forest Insects. 20. Insects attacking *Hakea* spp. in New South Wales. By K. M. Moore.

LECTURETTE.

A lecturette entitled "Chemistry and Insects" was delivered by Assoc. Professor E. W. K. Cavill, Department of Organic Chemistry, University of New South Wales.

ORDINARY MONTHLY MEETING.

28th OCTOBER, 1964.

Miss Elizabeth C. Pope, President, in the chair.

The following were elected Ordinary Members of the Society: Messrs. H. T. Moors, B.Sc., Sydney University; A. J. T. Wright, B.Sc., Sydney University; and G. R. Young, Earlwood, N.S.W.

The Chairman announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1965, from qualified candidates. Each applicant must be a member of this Society and be a graduate in Science or Agricultural Science of the University of Sydney. The range of salary is, according to qualifications, up to a maximum of £1,600 per annum. Applications should be lodged with the Honorary Secretary, who will give further details and information, not later than Wednesday, 4th November, 1964.

The Chairman announced that library accessions amounting to 13 volumes, 100 parts or numbers, 4 bulletins, 6 reports and 7 pamphlets, total 130, had been received since the last meeting.

The Chairman announced that the Council of the Society has set up a Committee to deal with matters connected with the Conservation of Fauna, Flora and Land-forms. This Committee is now considering the proposed National Park in the Myall Lakes area and the adjacent lakes. Information on the natural history of the area with a bearing on this subject should be communicated to the Hon. Secretary and marked "Conservation Committee".

The Chairman drew the attention of members to the "Arid Zone Newsletter", and the Liaison Officer's appeal for contributions for the 1964 issue; also to the Second Arid Zone Technical Conference, to be held at Alice Springs in September, 1965.

The Chairman announced that at a meeting of scientists interested in Nature Conservation, held in Canberra last January, it was agreed that this Society should explore the possibility of arranging an Exhibition illustrating the scientific aspects of Conservation. This Exhibition, mainly photographic, is now being assembled, in collaboration with the Australian Museum and the Fauna Protection Panel. There will be a private viewing for members and their friends, and for invited guests, in the Australian Museum on Saturday, 12th December, commencing at 2 p.m. Appropriate films will also be shown.

PAPERS READ.

1. The Genus *Geranium* L. in the South Western Pacific Area. By R. C. Carolin.
2. Grey Billy and the Age of Tor Topography in Monaro, N.S.W. By W. R. Browne.

LECTURETTE.

A lecturette entitled "Biological Studies in East Africa" was delivered by Mr. H. J. de S. Disney, Curator of Birds, Australian Museum, Sydney.

ORDINARY MONTHLY MEETING.

25th NOVEMBER, 1964.

Miss Elizabeth C. Pope, President, in the chair.

The Chairman announced that the Council had appointed Mr. A. J. T. Wright, B.Sc., to a Linnean Macleay Fellowship in Palaeontology for one year from 1st January, 1965.

The Chairman announced that Library accessions amounting to 23 volumes, 205 parts or numbers, 4 bulletins, 5 reports and 2 pamphlets, total 239, had been received since the last meeting.

The Chairman reminded members of the Exhibition illustrating the scientific aspects of Conservation. This Exhibition, mainly photographic, is now being assembled, in collaboration with the Australian Museum and the Fauna Protection Panel. There will be a private viewing for members and their friends, and for invited guests, in the Australian Museum on Saturday, 12th December,* commencing at 2 p.m. Appropriate films will also be shown. [See footnote re postponement.]

PAPERS READ.

1. Note on *Stigmodera viridicauda* Carter. By C. M. Deuquet.
2. The Raphidophoridae (Orthoptera) of Australia. Part 2. A New Genus. By Aola M. Richards.
3. The Comparative Osteology and Systematic Status of the Gekkonid Genera *Afroedura* Loveridge and *Oedura* Gray. By H. G. Cogger.

NOTES AND EXHIBITS.

Mr. H. G. Cogger exhibited (a) live and museum specimens illustrating his paper; (b) Crucifix toads (*Notaden bennetti*). This species is widely distributed throughout

* Owing to circumstances beyond the Society's control, the Exhibition, as well as the private viewing, has been postponed to a later date which will be announced in due course.

the drier parts of New South Wales and Southern Queensland, but is seldom seen except after heavy rains. The specimens shown were from Nyngan, N.S.W.

Dr. I. V. Newman exhibited colour slides of his recent visit to Poland. The following items of interest were connected with the work of the Forestry Faculty of the Central University of Agriculture, Warsaw, and were located at Rogow: Re-afforestation by planting in small clearings; precocious pruning up to 5 metres (still in experimental stage); control of dicotyledon weeds, chiefly *Vaccinium*, by spraying in a pine nursery, the pine seedlings being sometimes slightly affected. High-mountain conifers on the slopes of Mt. Swinica in the Tatra National Park were shown from the Cable Way at between 5000 and 6500 ft. (1600-2200 metres); the *Picea-Pinus mughus* ecotone; *Pinus mughus* cushions on the cliffs. Experimental work for producing controlled seeding of high-mountain conifers in the Nursery of the Tatra National Park is being done by Mgr. Czesław Madeyski (Director) at Zakopane: grafts of fruiting tips from adult trees in the mountains of *Pinus cembra* showed 100% take on *P. sylvestris* 3-year seedlings as stock; post-pollination cones are developing on scions of grafts that took one year before season of pollination. (*Picea* grafting is more difficult.) The following plants of Poland were shown: at Rogow, *Nymphaea alba*; in Koscieliska Valley of the Tatra National Park (near Zakopane), *Delphinium oxycephalum*, *Ranunculus glacialis* (with white corolla and at more than its "lowest range"), *R. platinifolius* (with white corolla, a branching shrub a metre or more high), and *Campanula glomerata* (with white corolla).

Dr. W. R. Browne exhibited colour transparencies of granite boulders from the Kosciuszko plateau showing a lichen-covered upper part sharply marked off horizontally from a lichen-free lower part. This is interpreted as due to removal of soil from around the base of the boulders, and indicates erosion during the human period of as much as two feet of soil in places.

Dr. Ida Browne exhibited and commented on a specimen of the mineral pseudomorph glendonite from the type-locality of Glendon near Singleton, N.S.W.

LIST OF MEMBERS.

(15th December, 1964.)

ORDINARY MEMBERS.

(An asterisk (*) denotes Life Member.)

- 1940 Abbie, Professor Andrew Arthur, M.D., B.S., B.Sc., Ph.D., c.o. University of Adelaide, Adelaide, South Australia.
- 1940 *Allman, Stuart Leo, B.Sc.Agr., M.Sc., Entomological Branch, N.S.W. Department of Agriculture, Private Mail Bag No. 10, Rydalmere, N.S.W.
- 1959 Anderson, Donald Thomas, B.Sc., Ph.D., School of Biological Sciences, Department of Zoology, Sydney University.
- 1964 Anderson, Mrs. Jennifer Merciana Elizabeth, B.Sc.Agr., Macleay Museum, Sydney University.
- 1922 Anderson, Robert Henry, B.Sc.Agr., Kareela Road, Chatswood, N.S.W.
- 1963 Ardley, John Henry, B.Sc. (N.Z.), School of Public Health and Tropical Medicine, Sydney University.
- 1927 *Armstrong, Jack Walter Trench, "Cullingera", Nyngan, N.S.W.
- 1952 Ashton, David Hungerford, B.Sc., Ph.D., 92 Warrigall Road, Surrey Hills, E.10, Victoria.
- 1912 Arousseau, Marcel, B.Sc., 229 Woodland Street, Balgowlah, N.S.W.
- 1962 Bailey, Peter Thomas, B.Sc., C.S.I.R.O., Division of Wildlife Research, P.O. Box 109, City, Canberra, A.C.T.
- 1961 Bain, Miss Joan Maud, M.Sc., 18 Onyx Road, Artarmon, N.S.W.
- 1949 Baker, Eldred Percy, B.Sc.Agr., Ph.D., Faculty of Agriculture, Sydney University.
- 1962 Ballantyne, Miss Barbara Jean, B.Sc.Agr., N.S.W. Department of Agriculture Private Mail Bag No. 10, Rydalmere, N.S.W.
- 1959 Bamber, Richard Kenneth, F.S.T.C., 113 Lucinda Avenue South, Wahroonga, N.S.W.
- 1950 *Barber, Professor Horace Newton, M.S., Ph.D., F.A.A., School of Biological Sciences, Department of Botany, University of N.S.W., P.O. Box 1, Kensington, N.S.W.
- 1960 Barber, Ian Alexander, B.Sc.Agr., School of Biological Sciences, Department of Zoology, Sydney University.
- 1955 Barlow, Bryan Alwyn, B.Sc., Ph.D., Department of Botany, University of Queensland, St. Lucia, Brisbane, Queensland.
- 1960 Batley, Alan Francis, A.C.A., 123 Burns Road, Wahroonga, N.S.W.
- 1954 Baur, George Norton, B.Sc., B.Sc.For., Dip.For., 3 Mary Street, Beecroft, N.S.W.
- 1935 *Beadle, Professor Noel Charles William, D.Sc., University of New England, Armidale, 5N, N.S.W.
- 1946 Bearup, Arthur Joseph, B.Sc., 66 Pacific Avenue, Penshurst, N.S.W.
- 1940 Beattie, Joan Marion, D.Sc. (née Crockford), 2 Grace Avenue, Beecroft, N.S.W.
- 1964 Bedford, Geoffrey Owen, B.Sc., c/- C.S.I.R.O., Division of Entomology, P.O. Box 109, City, Canberra, A.C.T.
- 1961 Bedford, Miss Lynette, B.Sc., School of Biological Sciences, Department of Zoology, Sydney University.
- 1952 Bennett, Miss Isobel Ida, Hon. M.Sc., School of Biological Sciences, Department of Zoology, Sydney University.
- 1960 Berrie, Geoffrey Kenneth, B.Sc., Ph.D., School of Biology, University of Lagos, Lagos, Nigeria.
- 1964 Bertus, Anthony Lawrence, B.Sc., Biology Branch, N.S.W. Department of Agriculture, Private Mail Bag, No. 10, Rydalmere, N.S.W.
- 1948 Besly, Miss Mary Ann Catherine, B.A., School of Biological Sciences, Department of Zoology, Sydney University.
- 1961 Bishop, James Arthur, School of Biological Sciences, Department of Zoology, Sydney University.
- 1964 Blackmore, John Allan Philip, LL.B. (Syd. Univ.), 25 Holden Street, Ashfield, N.S.W.
- 1958 Blake, Clifford Douglas, B.Sc.Agr., Ph.D., Faculty of Agriculture, Sydney University.
- 1941 Blake, Stanley Thatcher, D.Sc. (Q'ld.), Botanic Gardens, Brisbane, Queensland.
- 1960 Bourke, Terrence Victor, B.Sc.Agr., c.o. Post Office, Graman 5N, N.S.W.
- 1946 Brett, Robert Gordon Lindsay, B.Sc., 7 Petty Street, West Hobart, Tasmania.
- 1960 Brewer, Ilma Mary, D.Sc., 7 Thornton Street, Darling Point, Sydney.
- 1955 Briggs, Miss Barbara Gillian, Ph.D., 13 Findlay Avenue, Roseville, N.S.W.
- 1924 Browne, Ida Alison, D.Sc. (née Brown), 363 Edgecliff Road, Edgecliff, N.S.W.
- 1949 Browne, Lindsay Blakeston Barton, Ph.D., C.S.I.R.O. Division of Entomology, P.O. Box 109, City, Canberra, A.C.T.
- 1911 Browne, William Rowan, D.Sc., F.A.A., 363 Edgecliff Road, Edgecliff, N.S.W.
- 1952 Bunt, John Stuart, B.Sc.Agr., Ph.D., School of Agriculture, Sydney University.
- 1949 Burden, John Henry, 1 Havilah Street, Chatswood, N.S.W.

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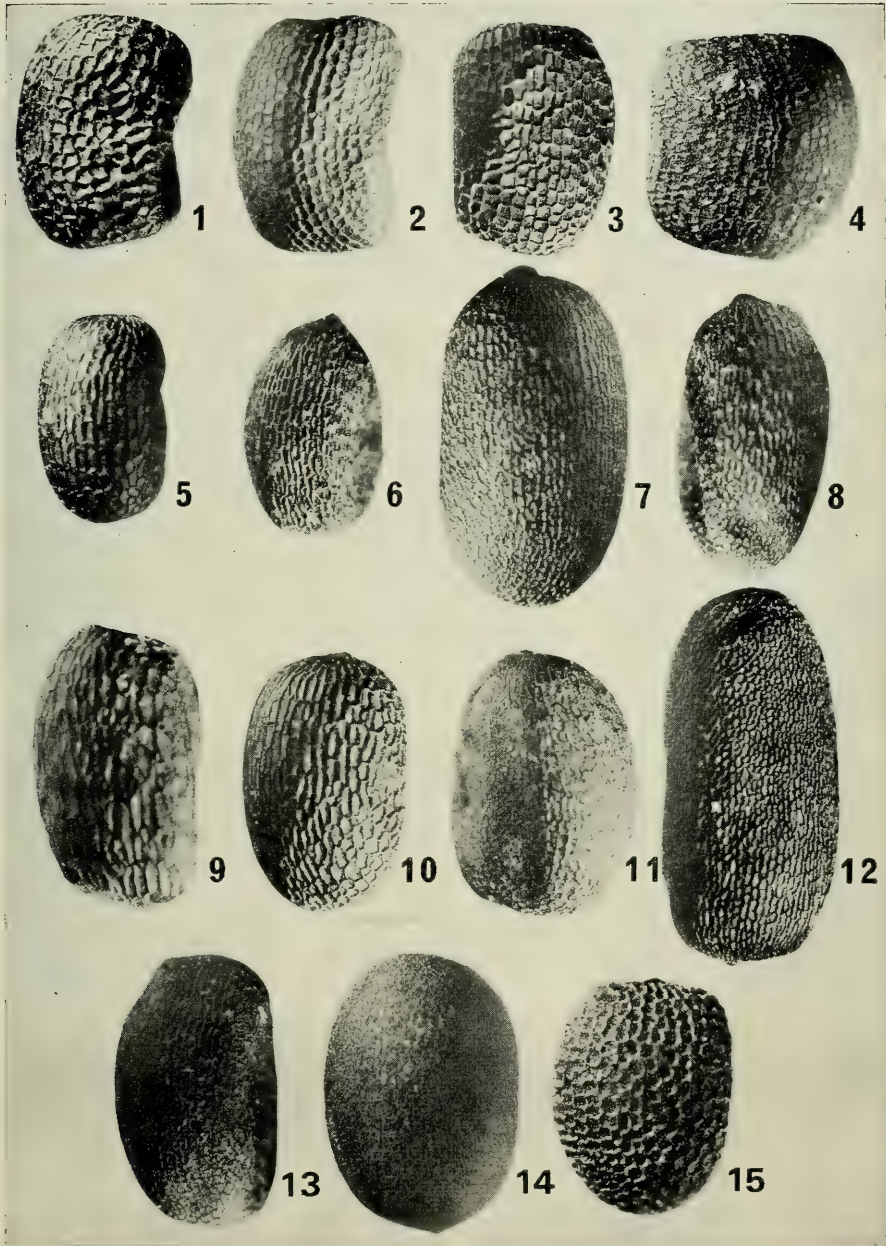
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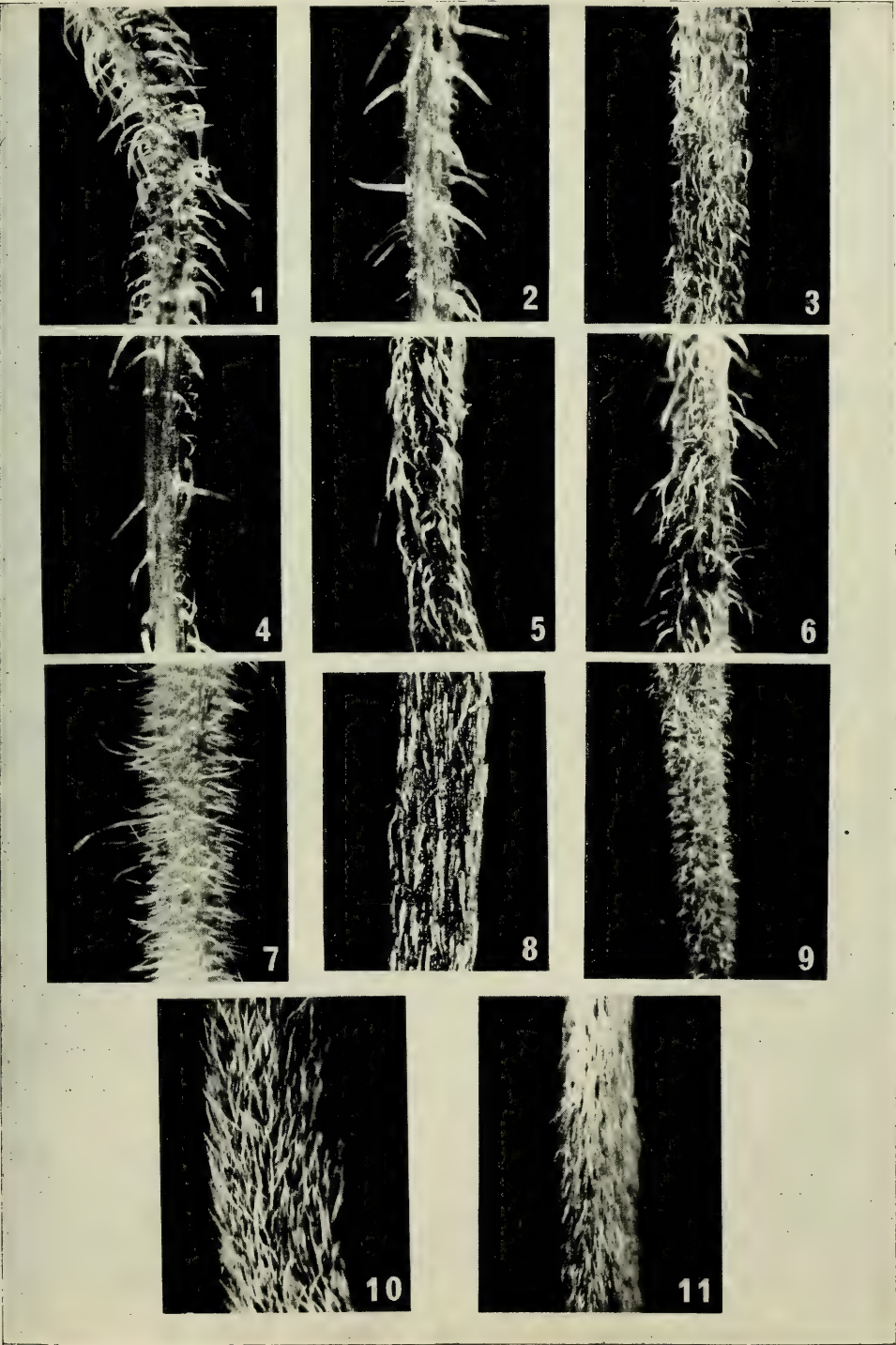
Capsules of *Hakea gibbosa* in which *Cydmetaea major* pupates.



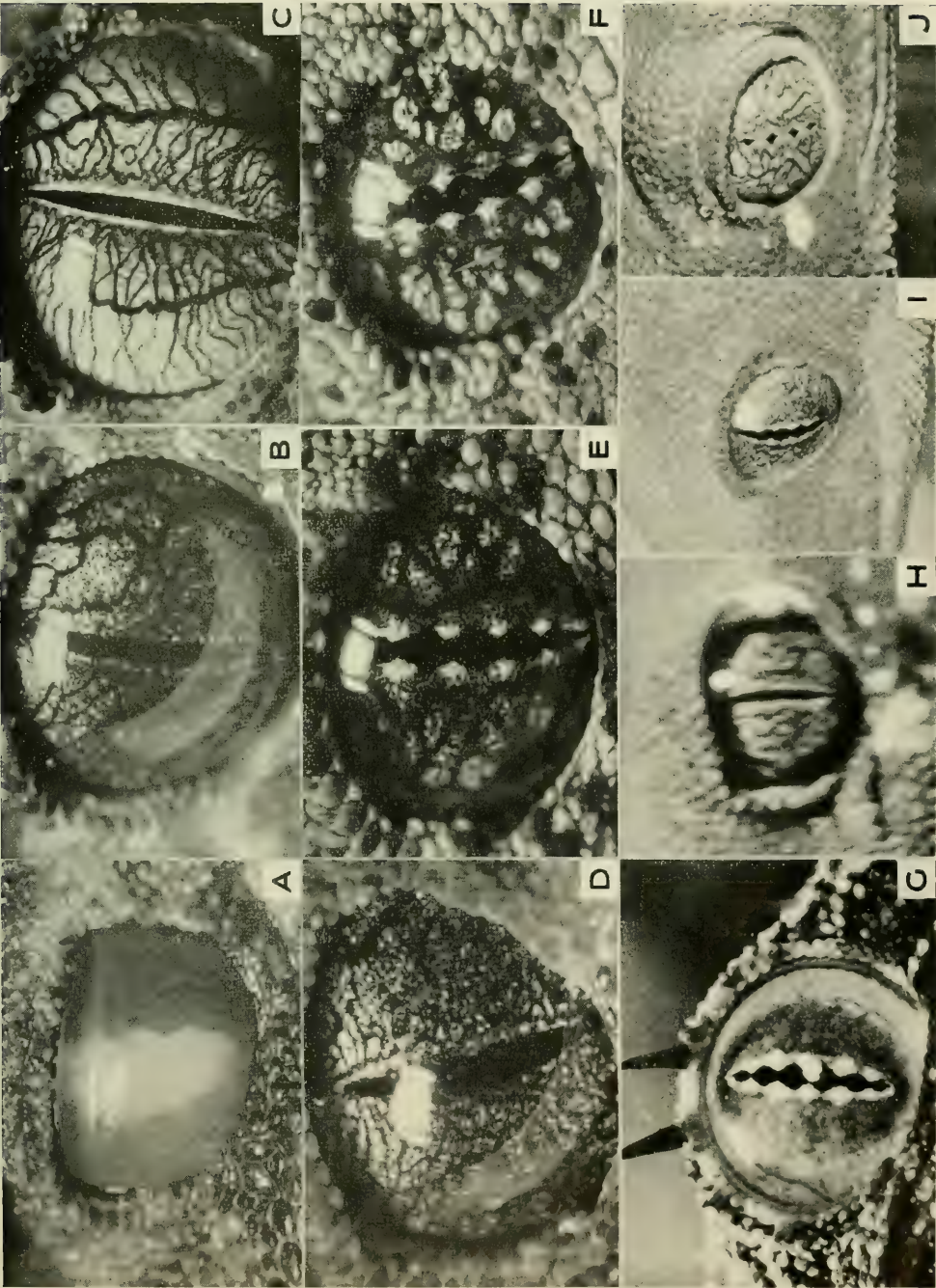
Grey billy and Tor topography.



Seeds of *Geranium* species.



Fruiting pedicels of *Geranium* species.



Eyes of species of Gekkonid genera.

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