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PART 1 (No. 413)

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(Papers read September–November, 1967)

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CORRIGENDA

Vol. 92, Part 1

Page 68.—Ninth line from bottom. Read under Fig. 1, page 70.

Page 70.—Fig. 1 should be reversed.

Page 71.—Third line and second last line. Read under Figs 2 and 3, page 70

Page 96.—Headings above descriptions of two new species are wrongly transposed. For heading "*Diplogeomyza annularis*, sp. nov." at top of page, read "*Diplogeomyza victoriae*, sp. nov.". For heading "*Diplogeomyza victoriae*, sp. nov." ten lines from bottom of page, read "*Diplogeomyza annularis*, sp. nov.".

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The Linnean Society of New South Wales

Founded 1874. Incorporated 1884

" For the cultivation and study of the science of Natural History in all its branches "

OFFICERS AND COUNCIL, 1967–68

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Auditor

S. J. Rayment, F.C.A., Chartered Accountant

Linnean Macleay Lecturer in Microbiology, University of Sydney: Y. T. Tchan, Dr. ès Sc. (Paris)

Linnean Macleay Fellow of the Society in Botany, 1967: Miss Alison K. Dandie, B.Sc.

The Society's headquarters are in Science House, 157 Gloucester Street, Sydney N.S.W., Australia

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ANNUAL GENERAL MEETING

29th March, 1967

The Ninety-second Annual General Meeting was held in the Society's Rooms, Science House, 157 Gloucester Street, Sydney, on Wednesday, 29th March, 1967.

Dr. D. T. Anderson, Vice-President, occupied the chair.

The minutes of the Ninety-first Annual General Meeting (30th March, 1966) were read and confirmed.

Report on the Affairs of the Society for the Year

The Society's Proceedings for 1965, Vol. 90, Part 3 was published on 22nd July, 1966. Vol. 91 (1966), Parts 1, 2 and 3 were published on 3rd November, 1966, 22nd December, 1966, and 22nd March, 1967, respectively.

During the year 15 new members were admitted to the Society, two died, nine resigned and three were removed from the list of members. The numerical strength of the Society at 1st March, 1967, was: Ordinary Members, 272; Life Members, 31; Corresponding Member, 1; Total, 304.

It is with regret that the deaths of the following members are recorded: Clifford Gerald Hansford, M.A., Sc.D. (Cantab.), D.Sc. (Adel.), F.L.S., on 18th February, 1966, at Uvongo Beach, Natal, South Africa. Dr. Hansford had been a Life Member since 1952 and had contributed four papers to the Proceedings — Australian Fungi, Nos. 1–4 — between 1953 and 1957; Mr. Melbourne Ward, on 6th October, 1966. Mr. Ward, who conducted the Gallery of Natural History and Native Art at Medlow Bath, Blue Mountains, New South Wales, had been a member of the Society since 1930. He lived a colourful life of many activities and a full memorial notice was published in the Proceedings of the Royal Zoological Society of New South Wales, 1965–66 (1967), pp. 15–21.

Papers read at Ordinary Monthly Meetings totalled 22. Lecturettes were given at the following meetings: April, The Fauna of the Intertidal Reefs at Darwin, Northern Territory, by Miss Elizabeth C. Pope; September, Dolphins and Small Whales in the Solomon Islands and New Guinea Waters, by Dr. W. H. Dawbin; October, Phylogeny and Evolutionary Patterns in the Flowering Plant Family Dipsacaceae, by Professor F. Ehrendorfer, Graz. Austria. Interesting discussions followed the lecturettes. We are grateful to these lecturers, who contributed greatly to the interest of the meetings. At other meetings notes and exhibits were presented. No meetings were held in May or August.

The Sir William Macleay Memorial Lecture, 1966 (Fifth) was delivered in the Large Hall, Science House, Sydney, on 15th July, 1966, by Professor D. G. Catcheside, the title being "The Centenary of Mendel". Some sixty members and visitors were present.

Immediately preceding the formal July Ordinary Monthly Meeting and the Sir William Macleay Memorial Lecture on 15th July, 1966, presentations were made, on behalf of members, to Drs. W. R. Browne and A. B. Walkom in recognition of their valuable services to the Society. The generous response of members to the Testimonial Fund indicated their deep appreciation of the services to the Society of the recipients.

Mr. G. N. Baur was elected a member of Council in place of Professor S. Smith-White.

Library accessions from scientific institutions and societies on the exchange list amounted to 2,199 compared with 2,016 and 2,222 for the years 1965 and 1964. The total number of borrowings of books and periodicals from the library by members and institutions for the year was 302. Members and others continued to consult publications in the Society's rooms, and books and periodicals were made available for photographic copying. The following requests for exchange of publications were acceded to during the year: the Proceedings for Revista de Biologia Marina, Universidad de Chile, Vina del Mar, Chile; the Proceedings for Revista, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, Mandoza, Argentina; Botanical Reprints to Instituto Botanico, Caracas, Venezuela, for Acta Botanica Venezuelica; and Abstract of Proceedings and any reprints required to Societe Royale de Zoologie d'Anvers, Antwerp, Belgium, for its Bulletin. The following books were donated to the Society's library: (1) "An ABC of the Royal Botanic Gardens, Sydney" by R. H. Anderson (Sydney, 1965)—presented by Mr. R. H. Anderson; (2) "Systematic Embryology of the Angiosperms" by Gwenda L. Davis (U.S.A., 1966)—presented by Professor Gwenda L. Davis, Armidale, N.S.W.; (3) "A History of the Vegetable Kingdom" by William Rhind (Glasgow, 1857) (with a frontispiece of Linnaeus)—presented by Miss E. M. Read, Lindfield, N.S.W. Disposal of old reprints and re-stacking have made much-needed library space available in the store-room.

The total revenue accruing to the Society from its one-third ownership of Science House was $1,956.38 for the year ending 31st August, 1966. Increased rentals in Science House are expected as from 1st January, 1967, when the matter is finalized.

Following on the resignations of the two Honorary Secretaries (Drs. W. R. Browne and A. B. Walkom), Mr. R. H. Anderson accepted an offer to become Honorary Secretary as from 20th April, 1966.

The Society has joined the Australian Conservation Foundation as a Member Body.

In pursuance of its interest in conservation the Society has given consideration to matters affecting the Dee Why Lagoon area, limestone mining in the Colong Caves area and the Kosciusko State Park.

Linnean Macleay Fellowship

No appointment was made for 1966. In November, 1966, Miss Alison K. Dandie, B.Sc. (Hons.) was appointed to a Linnean Macleay Fellowship in Botany for one year from 1st January, 1967. Miss Dandie proposes to continue the work begun in her honours year on the occurrence and importance of mycorrhizae in New South Wales, with particular reference to vesicular-arbuscular mycorrhizae. In the light of the apparent improved mineral absorption by vesicular-arbuscular mycorrhizae, Miss Dandie wishes to investigate further the nature and importance of such associations in both native and cultivated plants in New South Wales, particularly in regard to the fungi responsible, host range, effect on host nutrition and the effect of the double symbiosis by bacteria and vesicular-arbuscular mycorrhiza in legumes. We wish Miss Dandie every success in her research.

Linnean Macleay Lectureship in Microbiology

Dr. Y. T. Tchan, Reader in Agricultural Microbiology and Linnean Macleay Lecturer in Microbiology, University of Sydney, reported on his work for the year ending 31st December, 1966, as follows: The Ca requirement of *Beijerinckia* has been investigated. It was found that the requirement of this element is very variable according to the species and strain of the microorganism. It influences nitrogen fixation and pigment production; the study of fine structure of *Azotobacter* has reached a useful conclusion. A paper has been published in the Archiv. für Mikrobiologie, 54, 215–218, 1966. The study of herbicides has also made good progress. A paper has been accepted for publication and will appear in Plant and Soil in 1967. Serological study of *Azotobacter* has established that environmental factors will influence the qualitative and quantitative composition of the antigen structure of *Azotobacter*.

In the absence of the Honorary Treasurer (Dr. A. B. Walkom) the balance sheets for the year ending 28th February, 1967, duly signed by the Auditor, Mr. S. J. Rayment, F.C.A., were presented. On the motion of the Honorary Secretary it was resolved that they be received and adopted.

Presidential Address

The Concept of the Inflorescence in the Order Campanulales

The inflorescences of the Campanulales, in particular the families Goodeniaceae and Stylidiaceae, are discussed. Both closed and open inflorescences are found in these families; in the Goodeniaceae corresponding to the results found in previous investigations. Troll's concepts, in particular, are criticized and it is concluded that they do not provide a particularly satisfactory explanation of the observations.

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

President: L. A. S. Johnson, B.Sc.

Members of Council: G. N. Baur, B.Sc., B.Sc.For., Dip.For.; W. R. Browne, D.Sc., F.A.A.; S. J. Copland, M.Sc.; Professor F. V. Mercer, B.Sc., Ph.D.; A. K. O'Gower, M.Sc., Ph.D.; and H. S. H. Wardlaw, D.Sc., F.R.A.C.I.

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

The Chairman then installed Mr. L. A. S. Johnson as President.

A cordial vote of thanks to the retiring President (in absentia) was carried by acclamation.

LINNEAN SOCIETY OF NEW SOUTH WALES.

GENERAL ACCOUNT. Balance Sheet at 28th February, 1967.

LIABILITIES.	$	$
Accumulated Funds—		
Amount received from Sir William Macleay during his lifetime ..	28,000.00	
Further sum bequeathed by his will	12,000.00	
		40,000.00
Contingencies Reserve		47,324.13
Current Liabilities—		
Bookbinding Account	1,824.66	
Income Account	14,752.61	
Suspense	16.43	
		16,593.70
		$103,917.83

ASSETS.	$	$
Fixed Assets—		
Commonwealth Loans, at Cost ..	30,097.00	
Debentures:		
Metropolitan Water, Sewerage and Drainage Board, at Cost.. ..	29,688.75	
Sydney County Council	6,000.00	
Science House (one-third share), at Cost	30,070.43	
		95,856.18
Current Assets—		
Cash in Hand	20.00	
Commercial Banking Company of Sydney, Ltd.	8,041.65	
		8,061.65
		$103,917.83

INCOME ACCOUNT. Year Ended 28th February, 1967.

	$	$	$
To Honorarium and Salary ..		3,852.04	
,, Printing Proceedings		3,305.50	
,, Printing Reprints		1,085.92	
,, Illustrations		831.18	
,, Insurance		35.89	
,, Postage	377.58		
,, Petty Cash	76.19		
		453.77	
,, Audit	33.60		
,, Printing and Stationery ..	218.28		
,, Expenses	183.83		
,, Freight	14.13		
,, Cleaning	154.65		
,, Macleay Memorial Lecture ..	120.08		
,, Library	212.01		
		936.58	
Expenditure for Year ..			10,500.88
Balance to 1967–68 ..			14,752.61
			$25,253.49

	$	$	$
By Balance from 1965–66 ..			9,273.69
,, Subscriptions:			
1966–67	1,577.80		
Arrears	37.80		
Advance	28.00		
		1,643.60	
,, Interest		3,486.47	
,, Science House..		2,356.38	
,, Rent		70.32	
,, Sales		3,544.65	
,, N.S.W. Government Grant ..		800.00	
,, Fellowships Account (surplus income at 28th February, 1967, transferred)		2,914.89	
,, Sale of Reprints		955.82	
,, Library Sales, etc.		207.67	
Receipts for Year ..			15,979.80
			$25,253.49

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 28th February, 1967, and certify that the above Balance Sheet and accompanying Income Account are correct, and in accordance therewith, and in my opinion present the true state of the Society's affairs at 28th February, 1967, as shown by the books. Certificates of the investments have been inspected.

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

LINNEAN SOCIETY OF NEW SOUTH WALES.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.
Balance Sheet at 28th February, 1967.

LIABILITIES.	$	ASSETS.	$	$
Accumulated Funds—		Fixed Assets—		
Amount bequeathed by Sir William Macleay	70,000.00	Commonwealth Loans, at Cost	60,885.50	
Surplus Income Capitalized	50,939.66	Debentures :		
		Metropolitan Water, Sewerage and Drainage Board, at Cost	35,296.98	
		Rural Bank of N.S.W., at Cost	4,345.50	
		State Electricity Commission	5,000.00	
		Loan on Mortgage	12,070.00	
				117,597.98
		Current Assets—		
		Commercial Banking Company of Sydney, Ltd.		3,341.68
	$120,939.66			$120,939.66

INCOME ACCOUNT. Year Ended 28th February, 1967.

	$		$
To Salary of Linnean Macleay Fellow	533.32	By Interest	6,114.89
,, Capital Account	2,666.68		
,, Balance, being Surplus Income transferred to General Account	2,914.89		
	$6,114.89		$6,114.89

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 28th February, 1967, and certify that the above Balance Sheet and accompanying Income Account are correct, and in accordance therewith, and in my opinion present the true state of the Society's affairs at 28th February, 1967, 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.

Sydney, 9th March, 1967.

A. B. Walkom,
Hon. Treasurer.

2nd March, 1967.

LINNEAN SOCIETY OF NEW SOUTH WALES.

BACTERIOLOGY ACCOUNT.

Balance Sheet at 28th February, 1967.

LIABILITIES.	$	$
Accumulated Funds—		
Amount bequeathed by Sir William Macleay	24,000.00	
Accumulated Income Capitalized ..	12,620.00	
Research Fund	20.00	
		36,640.00
Current Liability—		
Income Account at 28th February, 1967		548.79
		$37,188.79

ASSETS.	$	$
Fixed Assets—		
Commonwealth Loans, at Cost	30,636.25	
Debentures :		
Metropolitan Water, Sewerage and Drainage Board, at Cost	1,600.00	
Loan on Mortgage	4,400.00	
		36,636.25
Current Assets—		
Commercial Banking Company of Sydney, Ltd.		552.54
		$37,188.79

INCOME ACCOUNT. Year Ended 28th February, 1967.

	$
To University of Sydney (towards salary of Lecturer)	1,850.00
,, Balance to 1967–68	548.79
	$2,398.79

	$
By Balance from 1965–66	498.98
,, Interest	1,899.81
	$2,398.79

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 28th February, 1967, and certify that the above Balance Sheet and accompanying Income Account are correct, and in accordance therewith, and in my opinion present the true state of the Society's affairs at 28th February, 1967, 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.

Sydney, 9th March, 1967.

2nd March, 1967.

A. B. Walkom,
Hon. Treasurer.

PRESIDENTIAL ADDRESS

THE CONCEPT OF THE INFLORESCENCE IN THE ORDER CAMPANULALES

Roger Carolin
School of Biological Sciences, University of Sydney

[Read 29th March, 1967]

Synopsis

The inflorescences of the *Campanulales*, in particular the families Goodeniaceae and Stylidiaceae, are discussed. Both closed and open inflorescences are found in these families; in the Goodeniaceae corresponding to the results found in previous investigations. Troll's concepts, in particular, are criticized, and it is concluded that they do not provide a particularly satisfactory explanation of the observations.

The inflorescence has been a particularly difficult concept to define and understand ever since Linnaeus proposed the term. Before embarking upon a treatment of the inflorescence of the Campanulales, and a criticism of previous concepts, it seems appropriate to consider two other concepts with a rather more general application—homology and typology. It is not intended to reiterate all the arguments centring around these two terms, but it appears to me that there is really no satisfactory, operational definition of either concept and, indeed, typology seems to be held in considerable contempt as a concept whilst the methodology associated with it is very widely used.

Firstly, let me state some of the philosophical dicta which I will attempt to use as a guide. Frank (1961) states "Truth cannot be sought outside of our experiences". The solution of a scientific problem consists of "inventing a procedure which, with the help of skilfully chosen symbols, is capable of bringing order into our experiences". One might add Occam's razor and state "inventing the simplest procedure which . . . ." and, as Frank himself indicates, it must be possible for further experiences of the same sort to be ordered by this same system of symbols and these experiences might even be predicted by this system. Thus I do not intend to admit that theories, or symbol-systems, have any absolute-truth in the layman's use of the term. If this word "truth" must be used at all in this connection, I would give it the pragmatic conception of an invention rather than a discovery of the absolute kind (Frank, 1961). As the logical-positivists have emphasized, the system of symbols must be connected with observed facts by "operational definitions": the symbols must be defined in terms of experience which actually occurs. Inferred experience is a prediction and, as such, serves as a basis for testing the suitability of the symbol-system.

"Concepts" play an important part in all intellectual activity and it seems appropriate to pause for a moment and determine what they are. Breckner (1959) considers in the main biological concepts but not a general definition of the term. The Oxford English Dictionary states "Concept . . . an idea of a class of objects" and also quotes W. Hamilton "Concepts are merely the results, rendered permanent by language, of a previous process of comparison". Language, of course, is a special case of symbolism. "Idea" has platonic overtones and is not really useful in this context. Concepts are symbolic inventions which allow us to assume a "key" position in ordinary experience: concepts, together with the symbols which describe their relationships with each other, are the basis of theoretical enquiry. It should be emphasized, once again, that all such symbols must be connected with observational facts, by operational definitions.

Now let us consider homology in the light of this basis. I do not want to go into the historic aspects here, several previous authors have done this (see Cain, 1959; Mason, 1957; Davis and Heywood, 1963). We have, here, to arrive at an *operational* definition of the concept. With regard to "special" homology (Cain, 1959) the phylogenetic definition of Simpson (1961), i.e., resemblance of organs, due to inheritance from a common ancestor must be rejected; it is not operational (Sokal and Sneath, 1963). Unless we can actually watch the evolutionary process occurring this definition just cannot be used. Furthermore, as many previous workers have pointed out (e.g., Withers, 1964), it is by the occurrence of homologous organs that common ancestry is inferred: Simpson's definition, in the context of neobiology, is circuitous. Even in the palaeobiological context it is equally circuitous since experience here consists of observing a number of essentially discontinuous facts and connecting them up with the concept of homology. It seems to me that the only thing which would make a phylogenetic definition operational is the invention of the time machine!

Boyden (1943) and Mason (1957) base definitions of both special and serial homology upon ontogeny, their emphasis is upon similar developments. Particularly in plants this is difficult to apply (see Davis and Heywood, 1963), and this, too, whilst theoretically applicable, is not so in practice. A basis for similarity of any sort, physiological or morphological, using modern biological concepts, is the gene. It should be possible to base a theoretical definition of homology on the concept of the gene: this would scarcely be operational, however, since the gene and its various derivations, are concepts in the sense defined above. This would be a case of providing a symbolic relationship between concepts: an operational definition, in Frank's sense, is still required.

The operational definition of the gene (etc.) is related to the supposed effect; a certain gene (etc.) is considered to produce a certain effect. The gene at a certain locus on the "nth" chromosome of *Drosophila* produces a variation in the bristle complement of such and such an abdominal segment. Indeed, the names given to the theoretical gene-concept reflect the morphological operational definition—ebony, scute, red-eye, etc. It would seem that we must define homology in the same way, which means, to a large extent, a reversion to the definitions of Darwin's time and before. We recognize homologous organs by criteria of similarity in position and construction. For example, in special homology we define the corolla by its position between the calyx and stamens on the floral receptacle, and by its vascular supply.

Eckhardt (1964) has emphasized three types of criteria of homology, (i) position criteria, (ii) special quality criteria and (iii) connection criteria. The first two correspond to those respectively given in the previous sentence and the last fits the concept of a morphological series. It seems to me that the third criterion relies entirely on the first two: i.e., we recognize a morphological series by position and special qualities: this, then, is not considered a primary criterion. In serial homology we define appendicular structures by their being borne on an axis and by their internal (vascular) structure and thus arrive at the classical concept of leaf metamorphosis. This emphasises the importance of the definition; particularly in the latter case, slight changes in it would have (and, indeed, have) altered the extension of the concept completely.

This type of argument has been developed, notably by Woodger (1945) and Withers (1964), under the concept of "morphological correspondence" which is synonymous with the use of the word homologous in the context we are discussing (see Withers, loc. cit.). In fact, Withers develops the concept quite extensively by defining spatial relations (relative position) by a series of co-ordinates based upon the polarization (of the animal) (left and right side, anterior and posterior, dorsal and ventral) and also using histologically determined sets of parts. It seems to me, however, that in determining the orientation of the animal, i.e., defining anterior and dorsal, he is using morphological correspondence, whereas he goes on to define morphological correspondence in terms of this orientation—essentially circuitous. "We shall call that end of the body possessing the nervous system in its enlarged state, the 'head end' or the 'anterior end'." This appears either a tacit assumption that the enlarged state is homologous or it is so arbitrary that it can have little basis for a general auxiliary language of much use. Withers does mention other correlated features which usually occur in definite relational positions to "the head". This would seem to be a much better way of orientating the animal than by a single feature. It also is more in keeping with the empirical approach.

Morphological correspondence (homology) is a concept to use to achieve *maximum* ordering of our experiences. Thus the co-orientation of the organisms or parts of organisms to be compared should be carried out to achieve the maximum morphological correspondence, a polythetic method (Sokal and Sneath, 1963) rather than Withers' monothetic method. I am not, at this point, going to develop new formal systems of definitions for this, but it should be clear that there will be no possibility of comparisons between leaf and root or head and hand by a polythetic method whereas the danger *does* exist in monothetic method. In fact, Withers gives a formal definition of "maximum identity correspondence" which seems to eliminate the need for his primary monothetic definitions. I refer you to Withers' original paper for the clear, formal definition.

A natural corollary to the concept of homologous organs is that of homologous series. In this case one assumes that certain sets of observed facts are more like another set of observed facts than any others. The concept of *degree* of similarity is introduced into the concept of homology. The term "series" is probably not appropriate and is something of a relic from the ideas of Lamarck and Geffroy St. Hilaire. We should probably think rather in terms of distance apart in multi-dimensional space defined in terms of the variation of the homologous structures under consideration. If only one feature of one structure is being considered, e.g., corolla fusion, there will be only one dimension, that is a series; with more than one dimension, e.g., flower, the situation will not be best represented by a series. "Homologous arrangements" might be a better basic terminology.

I hope that this has illustrated my concept of a concept. They are just as much inventions as the internal combustion engine—invented to do a job as efficiently as possible. There is no question of their being platonic ideals.

Again, I do not want to give an historical account of typology. You might refer to Sokal (1962) and Simpson (1961) for treatments of this from two opposed lines of thought. As Sokal (1962) says: "The (classifactory) philosophy of many proponents of typology is based upon platonic idealism", but, and this must also be concluded from my premises, this is beyond the field of scientific enquiry. The Type or Bauplan need not be interpreted as a platonic ideal, or for that matter, as a "real" ancestor, but as symbolic inventions enabling us to orientate our experiences. Sokal (1962) seems to have implied this attitude and developed a concept of types defined on the variation of characters. Again, Smirnov (1925) has developed the concept as defined on averages of characters. Both of these must have their uses and their respective symbol-systems, but neither appear to be used in descriptive morphology, at least when comparing taxa of a higher category. In fact, Woodger (1945) and Withers (1963) come closest to its normal abstractive or extrapolative concept. It is not necessarily the same as the average, although at the lower levels of the taxonomic hierarchy it is likely to be close to them. A considerable amount of subjective choice is involved but, on my premises, this does not matter. We are simply searching for the "key" position from which to orientate our experiences (observations). The "objective" systems of thought, such as proposed by Sokal are merely repeatable; but there is no reason to suppose that subjective methods are not repeatable since all that means is that a choice has been made. Indeed, even with objective methods a choice has been made to be objective! This "numerical" methodology, however, is only an auxiliary language: a series of operational definitions enabling us to connect relatively ancient concepts to the world of experience and observed facts. They provide us with no absolute truth any more than does the phylogenetic auxiliary language, although they would seem to be logically more rigorous. I do not want to pursue this line of thought any further at present; I do want to indicate, however, that this concept of the Type or "Bauplan" could also be related to the concept of the gene. I want to make it quite explicit that there is no phylogenetic implication in the type: the concept as outlined above is rooted in, and refers only to, observable phenomena.

Now I would like to turn for a brief look at two more general concepts which have played a fairly prominent role in the theory of the inflorescence mainly due to the work of Troll and his collaborators (Troll, 1964). This is Gestalt and (or) Organismic Biological Theory. This states that the properties of more complex, extended facts cannot always be deduced from the properties of independent local elements. This has assumed considerable importance in the case of the inflorescence since similar floral arrangements are borne in quite different ways in relation to the vegetative structure of the plant in different species. Many workers do not accept that Gestalt and Organismic methodology is valid. Madden (1952) shows how the description of the whole is a description of its parts *and* their relationships with each other. Thus the description of the whole will depend entirely upon what parts, what level of organization, the whole is split into. The definition of homology suggested here is partly "organismic" since it is referred to spatial relationships between organs; the organs themselves are described but this does not convey all the information necessary to determine their morphological correspondence—their relationships with each other must also be analysed. I agree with Madden that this does not necessarily mean a semi-mystical component of the whole or of the concept of homology, it is simply a necessary statement of the variables for this level of analysis. In this sense, and accepting our definition of concept as an invention to order our experiences, we are able to accept concepts at any level of organization, appropriate for our specific purpose, describe them and their relationships and use them to order past, present and future experiences—with respect to that level of organization. This last point is emphasized by Withers (1964), and bears repetition.

Now I want to turn to the inflorescence itself. Again, I do not intend to go into the history of the scientific treatment of the inflorescence. I would refer you to Rickett (1944) and Troll (1964) in particular. Much of the confusion surrounding the concept arises from its double use: that is (i) referring to the actual group of flowers, a structural concept and (ii) referring to the arrangement of the flowers, an abstract concept. Whilst the same set of symbols may double for both concepts, this double definition must never be lost sight of. Most of the earlier workers, except Linnaeus, used the structural concept and accepted the group of flowers as a separate structural unit of the plant. It became clear, however, that this provided a very poor "key" position from which to orientate the facts of inflorescence form; it became necessary to search for a more general concept which would include the whole of the branching shoot system (see Rickett, 1944). This Troll has attempted to provide in his concept of the paracladium (Troll, 1964; Weberling, 1965). This concept includes all branches of the shoot; the terminal shoot is given a special position but, basically, I doubt whether this is necessary. Thus, "paracladium" as considered by Weberling (1965) can be equated with branch, and there can be paracladia of primary, secondary, tertiary, etc., rank. Stauffer (1963) has a more limited definition when he restricts it to an axillary system with one or more inflorescences and including associated vegetative phases of the system. Thus paracladia become essentially part of the enrichment zone. It is in the serial homology of the flowering branches with the vegetative branches that Troll provides some new ideas. To pose the question: does the whole flower correspond to a paracladium of the same rank as the branches immediately below the flower group, or does the group of flowers? Troll's answer is that there are two basic types of inflorescence, one in which the first case is the correct interpretation and the other when the second is correct. Thus we have monotelic and polytelic inflorescences respectively (Troll, 1964). The zone of enrichment is a group of paracladia immediately below the terminal inflorescence, and the field of inhibition is the zone below that in which paracladia are suppressed. Figure 1 illustrates these concepts. This system is essentially based upon serial homology, although diagrams such as the one on p. 183 in Troll, 1964 (Abb. 178), and reproduced here, make clear my interpretation of his ideas on the special homologies existing between monotelic and polytelic inflorescences. Weberling (1965) has laid more emphasis on the presence or absence of a terminal flower (monotelic and polytelic respectively) in his interpretation of Troll's views than I have. It does, of course, accept that the definition of an inflorescence is concerned with the positional and developmental relation of its constituent flowers and also the relationships of the whole inflorescence with other parts of the plant. The names applied to different types of inflorescence are merely shorthand for these descriptions and, when they do not apply, the long-hand must be used. Stauffer supplies the descriptions (1963). Bolle (1940) makes an attempt to link the concept of the inflorescence to the concept of Plastochrone in morphogenesis. We can look upon this as providing symbolic relationships between the two concepts, but, unless the plastochrone can be determined, such relationships can hardly

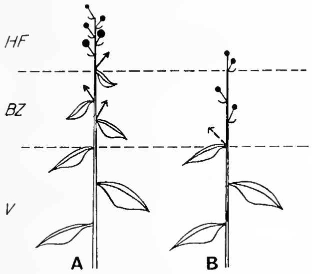

Fig. 1. Polytelic (*a*) and monotelic (*b*) inflorescences modified from Troll (1964).

be used in an operational definition. Such an approach should, as Weberling (1965) says, enable us to understand something of the complex of characters usually circumscribed by the word habit.

Accepting this position must affect a number of our inbuilt attitudes, e.g., those towards the cymose-racemose distinction, the boundaries of which tend to become very blurred (Rickett, 1944; Troll, 1964), and the so-called intercalary inflorescences (Parkin, 1914; Croizat, 1943). I do not intend to develop a general criticism of Troll's work but despite Weberling's (1965) statement to the contrary, vol. I contains scarcely any consideration of the inflorescences of woody plants. Instead, I would like to turn to a few selected flowering plant families and consider the inflorescences found in them in the light of the concepts outlined above.

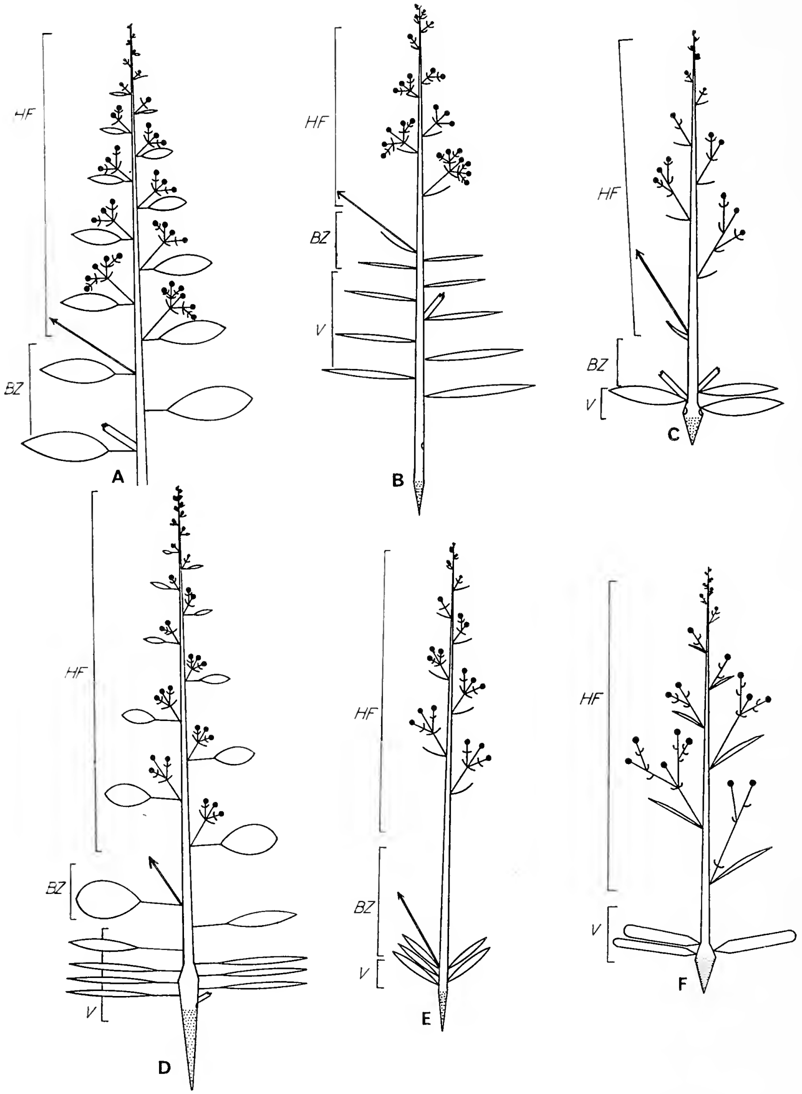

Fig. 2. Inflorescence Bauplane of *Goodenia* spp. A. *G. ovata,* B. *G. scapigera,* C. *G. pterygosperma,* D. *G. hederacea,* E. *G. stelligera,* F. *G. paniculata.*

Abbreviations used below are based on those used by Troll (1964).

HF—main inflorescence, PF—partial inflorescence, BZ—enrichment zone, PC—paracladium, HZ—inhibition zone, IZ—innovation zone, V—vegetative zone.

Troll (1964, p. 582) states that the polytelic form of inflorescence occurs throughout the family. As defined by the absence of the terminal flower, this is not correct. He also criticises Krause's (1912) treatment of the inflorescence of the family and there is no need to repeat it here.

Goodenia with its satellite genera *Selliera, Calogyne, Catosperma,* show variations on the open (polytelic) thyrsoid form (see Figs 2, 3, 4). Take the form found in *G. ovata* as the reference type 1 (Fig. 2A). In this case the terminal shoot terminates in an inflorescence. Immediately below this HF is a zone of enrichment and then a zone of inhibition—the classical situation as envisaged by Troll. The inflorescence terminates the growth of the terminal shoot and the subsequent year's growth is continued by lateral buds in the former year's field of inhibition, which now becomes a field of innovation. The variations on this basic theme that occur are as follows counting the *G. ovata* type as "1".

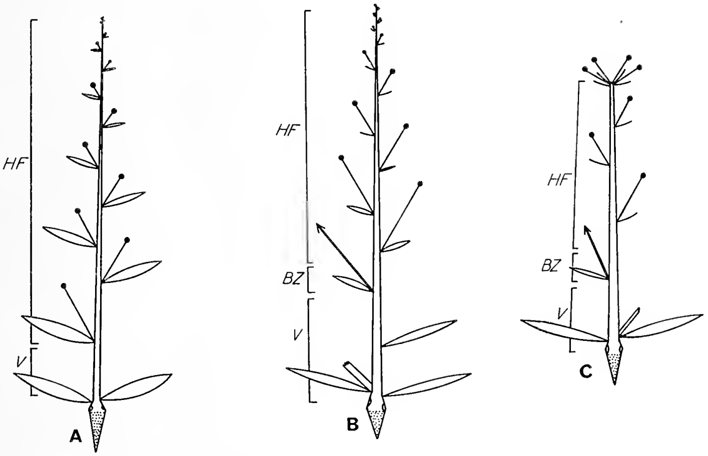

Fig. 3. Inflorescence Bauplane of *Goodenia* spp. A. *G. hispida,* B. *G. stelligera,* C. *G. pulchella.*

2. Every partial inflorescence, even the lowest, reduced to two or even one flower(s) per raceme, e.g., *G. barbata, G. phylicoides, G. laevis.*
3. As type 1 with reduced D–bracts (bracteose), e.g., *G. scapigera* (Fig. 2B).
4. Reduction of the zone of inhibition and the vegetative branching zone ("unterbau") below it to form a rosette of leaves, with ± bracteose inflorescence, *G. stelligera, G. ramellii, G. pterygosperma, G. paniculata* (Fig. 2C, E, F).
5. As in 4, but with leafy D–bracts, e.g., *G. hederacea* (Fig. 2D).
6. Loss of the bracteoles of the individual flowers of a leafy raceme (from 5), e.g., *G. hirsuta.*
7. Loss of the bracteoles from a "bracteose" raceme (from 4), e.g., *G. subintegra* (Fig. 3A, B).
8. Shortening of the inflorescence internodes of 5 to an umbel-like form (Fig. 3C).

Troll has considered all these modifications in some detail. Two small points might be made before proceeding: (i) in *G. hederacea* and its relatives, the HF may not produce an inflorescence but may continue vegetative growth for an unknown number of years, inflorescences being entirely a product of the enrichment zone: (ii) in some bracteolate inflorescences the bracteoles may not be always strictly opposite, e.g., *G. pterygosperma, G. paniculata* (Fig. 2C, F). This does not seem in my opinion, to alter the general conclusions. Thus, we can distinguish eight "Bauplane" within the genus *Goodenia,* based upon the description of form within the inflorescence (i.e., presence or absence of bracteoles; leafy or "bracteose" bracts; number of flowers per partial inflorescence) and the relationship of the inflorescence to other parts of the plant, i.e., reduction or not, of "unterbaue".

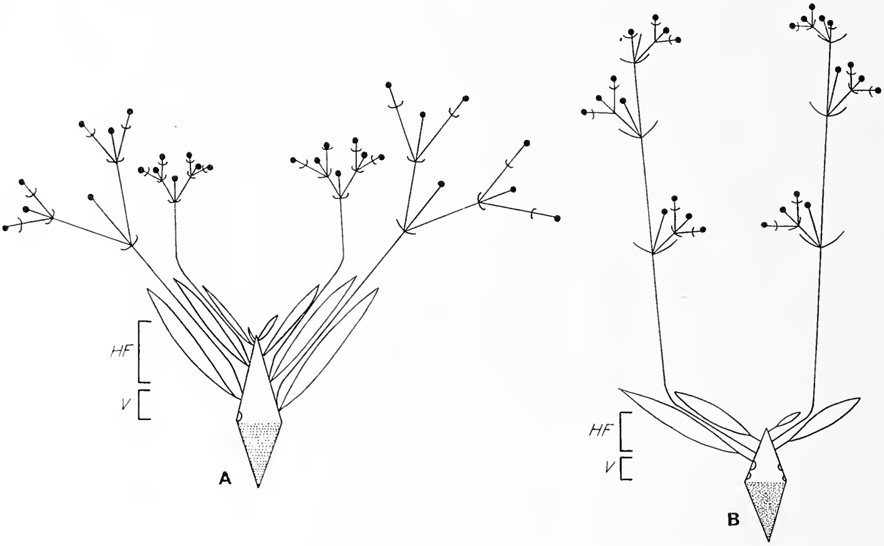

Fig. 4. Inflorescence Bauplane of *Velleia* spp. A. *V. lyrata,* B. *V. panduriformis.*

It is worthwhile pointing out here that these seven "Bauplane" seem to back up previous conclusions on the taxonomy of the genus derived from a study of the seeds (Carolin, 1966).

Table 1 shows the species that have been examined, an analysis of the characters used in determining the Bauplan. Accepting two alternatives for the four analysed characters (and there are three in the case of Flowers/PF), there are 4^2 possible combinations. Thus the organizational "Bauplane", empirically, reduce these to less than one half, since the other possibilities do not occur or occur extremely infrequently.

Velleia is clearly a development of the basic type with two important modifications (Fig. 4). Not only is the "Unterbaue" reduced but the whole of the terminal (paracladium) is contracted and peduncles of the PF are elongated, whilst the bracts are leafy (Fig. 4A). Troll (1965) has also described this. Furthermore, the terminal bud appears to grow on from year to year. In *V. macrophylla* the HF is somewhat more elongated than in the other species, it is therefore somewhat clearer. *V. panduriformis* shows a slight modification in that, at each branching of the PF, one branch grows stronger than the rest, producing a false main-axis (Fig. 4B and see also Philipson, 1953).

Scaevola is a large genus and there has not been quite the same opportunity to investigate it as has been the case with *Goodenia* (see Fig. 5).

I will take *S. nitida* as a basic reference type. Compared with *Goodenia* type 1 each PF is reduced to a single flower. All branches, however, do not necessarily produce flowers. Thus in one branch of degree n, the HF may continue vegetative growth for some considerable time and it is the lateral paracladia of degree n + 1 which develop into normal inflorescence structures with a terminal raceme, a number of enrichment branches and a BZ (Fig. 5A). *S. porocarya*, *S. crassifolia* and *S. globulifera* appear to show this sort of habit. These flowering branches are considered to be homologous with the paracladia of the BZ of Types 4 and 5, and the terminal vegetative shoot as homologous with HF of Types 4 and 5. By comparison with this *S. canescens* shows a similar situation but, in this case, the enrichment zones of the degree n + 1 paracladia (i.e., n + 2 paracladia) are eliminated and the result is a series of racemes arranged along a central axis (Fig. 5C). *S. tomentosa* is similar, and *S. spinescens* (Fig. 5D) differs in the possession of an accessory bud in each axil which normally produces a thorn. Another feature shown by *S. spinescens* is the ability of the inflorescence axis to continue growth after flowering, and on into a new phase of vegetative growth. This is also shown by *S. taccada* (Fig. 5B) and a number of other species of Section *Sarcocarpaea*. For the purposes of "Bauplane" construction I am not going

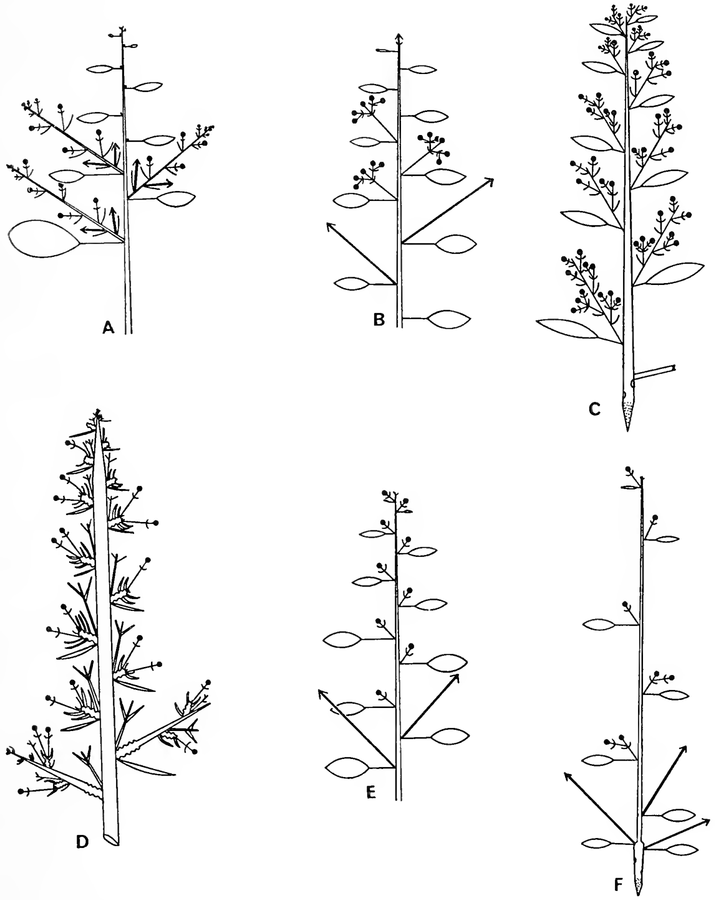

Fig. 5. Inflorescence Bauplane of *Scaevola* spp. A. *S. nitida*, B. *S. taccada*, C. *S. canescens*, D. *S. spinescens*, E. *S. stenophylla*, F. *S. ramosissima*. (See text for explanation.)

TABLE 1

Inflorescence-habit type of Goodenia *and satellite-genera with an analysis of principal characters used in the formulation of "Bauplane" (Taxonomic divisions from Krause, 1912)*

	"Bauplan"	D-Bracts L or N	Bracteoles	Flower/PF	"Unterbau" + or —
SECT. MONOCHILA					
G. phylicoides	2	L	+ —	1	+
G. scapigera	3	N	+	>3	+
G. watsonii	3	N	+	>3	+
SECT. EU-GOODENIA					
ser. RACEMOSAE					
G. racemosa	3	N	+	1	+
G. pinifolia	3	N	+	>3	+
G. elderi	3	N	+	>3	+
G. decurrens	3	N	+	>3	+
G. bellidifolia	3–4	N	+	>3	±
G. stelligera	4	N	+	>3	—
G. ramellii	4	N	+		—
ser. ROSULATA					
G. geniculata	5	L	+	1–2	—
G. lanata	5	L	+	1–2	—
G. affinis	5	L	+	1–>3	—
G. hederacea	5	L	+	>3	—
G. boormanii	5	L	+	>3	—
G. rotundifolia	5	L	+	1–2	—
G. glabra	5	L	+	1–2	—
ser. SUFFRUTICOSAE					
G. ovata	1	L	+	>3	+
G. varia	1–2	L	+	>3	+
G. strophiolata	2	L	+	1	+
G. barbata	2	L	+	1–2	+
G. mueckeana	1	L	+	>3	+
ser. COERULEAE					
G. pterygosperma	4	L–N	+	>3	—
G. eremophila	4	L–N	+	>3	—
G. incana	4	L–N	+	>3	—
G. eatoniana	1 ?	L	+	1	±
G. trichophylla	4	L–N	+	>3	—
ser. FOLIOSAE					
G. mitchellii	6	L	—	1	—
G. sepalosa	6	L	—	1	—
G. hispida	6	L	—	1	—
G. grandiflora	1–2	L	+	1–3	
G. calcarata	2	L	+	1	—
ser. PEDICELLOSAE					
G. cycloptera	6–7	N	—	1	+
G. pinnatifida	7	N	—	1	+
G. elongata	6	N–L	—	1	+
G. subintegra	7	N	—	1	+
G. vilmorinae	7	N	—	1	+
G. micrantha	7	N	—	1	+
G. concinna	7	N	—	1	+
G. filiformis	7–8	N	—	1	+
SECT. AMPHICHILA					
G. paniculata	4	N–L	+	>3	+
G. gracilis	4	N–L	+	>3	+
G. pumilio	6	L	—	1	+
Calogyne berardiana	7	N	—	1	+
C. pilosa	6	L	—	1	+
Selliera radicans	5	L	+	1	+
Pentaptilon careyi	4	N	+	>3	+
Catosperma goodeniacea	5	L	+	2–>3	+
Verreauxia reinwardtii	3	N	+	>3	
V. paniculata	4	N	+	>3	
Velleia	Special	L	+		+

D-bracts; L=leafy, N="bracteose". Bracteoles; +=present, —=absent. Unterbau; +=unreduced, —=reduced.

to consider this growing on of the inflorescence as important, it will be considered later. The gradations between leafy and bracteose bracts are much more gradual than in *Goodenia*; they appear to be important at a much lower taxonomic level. Therefore, I think in this case it is only worthwhile recognizing the following types:

1. *S. nitida* type (see above, Fig. 5A). 2. *S. canescens*—type (see above Fig. 5C). 4. Corresponding to type. 4 and 5 of *Goodenia* (terminal bud producing flowers, see Fig. 2C, E, F, and 5E, F). 3 Corresponding to type 3 of *Goodenia* where the terminal bud *always* produces an inflorescence and the bracts are *definitely* not leafy (Fig. 2B).

TABLE 2

Inflorescence-habit type of Scaevola *with an analysis of principal characters used in formulation of the "Bauplane"*

	"Bauplan"	D-Bracts	Flowers/ PF	Unterbau	Terminal bud producing flowers ±	HF grows on after flower
SECT. SARCOCARPAEA						
S. taccada	1	L		+	±	+
S. mollis	1	L		+	±	+
S. chamissoniana . .	1	L		+	±	+
SECT. ENANTIOPHYLLUM						
S. oppositifolia . .	2	L				
SECT. CROSSOTOMA						
S. spinescens	2	L	1	+	—	+
S. tomentosa	2	L	1	+	—	+
SECT. POGONANTHERA						
S. pilosa	4	L	1–3	—	+	—
S. ramosissima . .	4	L	1–3	—	+	—
S. hookeri	4	L	1	—	+	—
S. restiacea	4	(L)	1	+	+	—
S. collaris	4	L	1	+	+	+
SECT. XEROCARPAEA						
S. globulifera	1	N	1	+	±	—
S. porocarya	1	N–L	1	+	±	—
S. thesioides	3	N	1	+	+	—
S. nitida	1	N	1	+	—	—
S. crassifolia	1	N	1	+	—	—
S. holosericea	1	N	1	±	—	—
S. ovalifolia	4	L	1	±	+	—
S. calendulacea . .	1	N–L	1	+	±	—
S. albida	4	L	1	±	+	—
S. canescens	2	N	1	±	—	—
S. sericophylla	2	N	1	±	—	—
S. stenophylla	3	N	1	+	+	—
S. fasciculata	3	N	1	+	+	—
S. helmsii	3	N	1	+	+	—

The situation in *Dampiera* is obscured by the tendency to form fascicles of leaves at each node and especially at the ends of branches. However, it has been possible to distinguish three "Bauplane"

1. in which the inflorescence clearly terminates in a flower, (this has been distinctly observed in *D. trigona*, *D. stricta* and *D. lindleyi* whilst in many other specimens damage to the top of the stem obscures it), and the PF consist of dichasia with displaced bracts: in fact the whole structure resembles the thyrso-panicle (Fig. 6A). This may be quite widespread in the genus but the leaf fasciculation obscures it.

2. in which each PF is reduced to a single flower, the D-bracts are bracteose and the inflorescence does not clearly terminate in a flower, e.g., *D. spicigera, D. discolor, D. stenastachys.* (Fig. 6B.)
3. in which the simple raceme form of type 2 is contracted into a head, e.g., *D. wellsiana, D. eriocephala.*

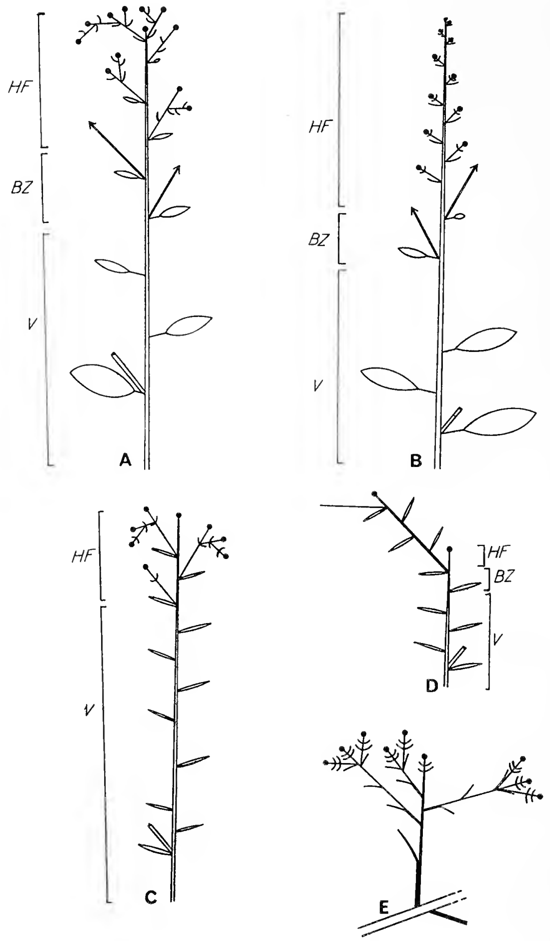

Fig. 6. Inflorescence Bauplane of A. *Dampiera trigona*, B. *D. spicigera*, C. *Leschenaultia hirsuta*, D. *L. formosa*, E. *Brunonia australis* (partial inflorescence).

Leschenaultia and *Anthotium* follow the general scheme of *Dampiera* type 1 except that the PF are much more clearly dichasial, e.g., *L. hirsuta* and *Anthotium rubriflorum* (Fig. 6C). *L. formosa* shows the reduction to the terminal flower alone (Fig. 6D).

The flowers of *Brunonia* are gathered into a compact head and it is rather more difficult to decide what their arrangement is. Philipson (1953) considers that the PFs are dichasia, but even the diagram he gives implies that this may not be so, since the ultimate terminal flower has three bracts on the pedicel and he figures only one bract at each "trifurcation". In fact the situation seems to be confused to some extent by the adnation of the lower bracts to the branches that they subtend ("Rekauleszenz" Troll, 1964). There are 4–6 involucral leaves subtending a branch system as shown in

Fig. 6E. Each branch, and so far as can be seen the main axis also, terminates in a flower surrounded by four scariose bracteoles. The bracts which actually subtend the flower are always quite different in appearance, i.e., herbaceous and narrower. There are also frequently a number of sterile herbaceous bracts.

The flower obviously represents a reduced inflorescence. It could be: (*a*) the terminal flower of a short closed raceme in which the sterile bracts on the lower part of the axis have become opposite; this would make the whole system a panicle: or (*b*) it could be the lateral flower of a 2-branched monochasium. In either case, it seems that the whole head represents both the HF and BZ zones and that the inflorescence is definitely closed and therefore closer to those of *Leschenaultia* and *Dampiera,* than to those of the *Goodenia* group.

That completes the survey of the family. Now to turn to the effect of these results on its taxonomy. Firstly they differ from Troll's (1964) results in that four genera appear, at least partially, to have closed (monotelic) inflorescences as defined by the terminal flower, i.e., they are closed. This follows the divisions suggested on the basis of other characters (Peacock, 1963; Carolin, 1958, 1966). Within *Dampiera* the three inflorescences types follow closely the sectional divisions of Krause (1912); indeed, the sections were largely based upon them.

The *Goodenia*-group is much more interesting. In *Scaevola* the Bauplane are not so clear-cut. Sect. *Pogonanthera* is fairly uniform but not the others. The distinction between types 1 and 2 is not really clear, type 2 is simply a more regular form of type 1: the occurrence of a more or less continuous vegetative leading shoot may be fairly common in shrubby species of various families (see Pilger, 1922). In particular this method does point up the heterogeneity of Sect. *Xerocarpaea*: special note might be made of the three last species in Table 2 which, once again, show closer affinity with *Goodenia scapigera*-group than most other *Scaevolas.*

Within *Goodenia* it is not surprising that the "Bauplane" follow Krause's general division since they were the basis for his sections and series. They also correlate quite well with seed characters (Carolin, 1966). *Calogyne* once again shows its double nature, and *Catosperma* and *Selliera* indicate an affinity with *Goodenia* ser. *Rosulatae.*

I will leave more general considerations until I have dealt with the next family.

STYLIDIACEAE

Troll (1965) has also dealt with this to some extent but his observations do not correspond to those set out below and consequently my interpretation is different. Troll states that the inflorescence of *Stylidium* is polytelic (i.e., open), and his whole interpretation of the cymose types is based upon this.

Stylidium laricifolium has a terminal thyrse with a distinct terminal flower (Fig. 7E). This is the situation in a very large number of species (e.g., *S. elongatum, S. assimile, S. graminifolium*). The PF may be each reduced to a single flower as in *S. eglandulosum.* In a number of species the terminal flower never opens past the bud stage or is quite abortive (e.g., *S. rupestre, S. eriorhizum*) (Fig. 7F). This latter is also the situation in *Levenhookia,* where each PF is reduced to a single flower (Fig. 7J). *S. calcaratum* shows a rather depauperate thyrsoid inflorescence with displaced bracteoles, consequently appearing like a true panicle (Fig. 7C).

Now to turn to the problem of those species with clearly "cymose" inflorescences which Troll concluded were due to contraction of the HF. *S. inaequipetalum* has usually four PFs the upper two of which are placed opposite each other (Fig. 7B). *S. leptorhizum* shows a thyrse with three PF, the distal two are very frequently opposite. There is no doubt about the terminal position of this inflorescence. *S. muscicola* also has an undoubted terminal inflorescence, as well as lateral ones, each appearing at first sight to be a straightforward cyme. If, however, one examines the base of the "scape" there is always present a bract which, moreover, often subtends a flower in the axil (Fig. 7A). *S. floodii* represents the end of the series where all vestiges of the PFs, other than the two distal ones, are suppressed and a straightforward dichasium results, in this particular case the peduncle is clearly terminal (Fig. 7D). One would expect, using Troll's interpretation of the contraction of the HF of a "polytelic" inflorescence, that the cymose inflorescence should never be terminal. This is certainly not the case. The interpretation given here is: the distal pair of PFs of a closed (monotelic) inflorescence become opposite and the lower PFs are

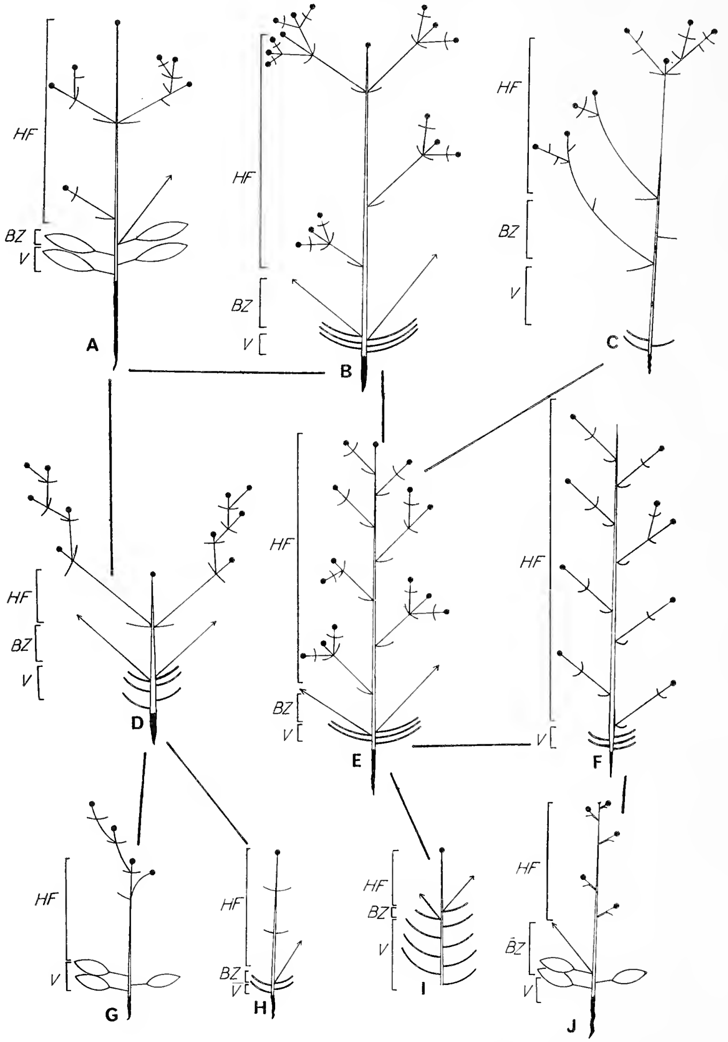

Fig. 7. Bauplane of Stylidiaceae and their relationships with each other. A. *Stylidium muscicola*, B. *S. inaequipetalum*, C. *S. calcarata*, D. *S. floodii*, E. *S. graminifolium*, F. *S. rupestre*, G. *S. rotundifolium*, H. *Forstera*, I. *Stylidium repens*, J. *Levenhookia dubia.*

suppressed. Philipson (1953) also considered the inflorescences of *Stylidium* although not in such detail. His nomenclature differs somewhat from the present in that he refers to a diagram of *S. utriculoides* as cymose when it corresponds, basically, to the type found in *S. eriorhizum* (see above).

To summarize these types:

1. A reduced panicle, e.g., *S. calcaratum* (Fig. 7C).
2. A closed thyrse, e.g., *S. laricifolium* (Fig. 7E).
3. A ± open thyrse, e.g., *S. eriorhizum* (Fig. 7FJ).
4. A thyrse with upper PFs opposite, e.g., *S. muscicola* (Fig. 7AB).
5. A cyme (mono- or dichasial), e.g., *S. floodii* (Fig. 7G).
6. A solitary terminal flower, e.g., *S. repens, Phyllachne* (Fig. 7H, I).

TABLE 3

Distribution of inflorescence "Bauplane" in Stylidium
(Subgenera after Mildbraed (1908))

Genus and Sub-genus	Species	Inflorescence type
Stylidium		
Centridium	*S. calcaratum* R.Br.	1
	S. perpusillum Hook.f.	2, 6
Fosteropsis	*S. preissii* (Sond.) Muell.	2
Andersonia	*S. kunthii* Wall.	5
	S. uliginosum Swartz	2 or 5
	S. rotundifolium R.Br.	5
	S. fissilobium F. Muell.	2
	S. muscicola F. Muell.	4 or 5
	S. schizanthum F. Muell.	2
Tolypangium	*S. despectum* R.Br.	4
	S. utricularioides Benth. in Endl.	5
	S. leptorrhizum F. Muell.	4
	S. floribundum R.Br.	2
	S. eriorrhizum R.Br.	3
	S. floodii F. Muell.	5
	S. laricifolium L. C. Rich. in Pers.	2
	S. eglandulosum F. Muell.	2
	S. repens R.Br.	6
	S. junceum R.Br.	2
	S. scandens R.Br.	2
	S. rupestre Sond. in Lehm.	3
	S. pritzelianum Mildbr.	3
	S. assimile R.Br.	2
	S. graminifolium Swartz	2
	S. soboliferum F. Muell.	2
	S. inaequipetalum Black	4
	S. lineare Swartz ex Willd.	2
Nitrangium	*S. divaricatum* Sond. in Lehm.	2
	S. appressum Benth.	2
	S. neglectum Mildbr.	2
	S. bulbiferum Benth. in Endl.	2
	S. dielsianum Pritzel	4
Forstera	*F. bellidifolia* Hook.f.	6
Phyllache	*P. colensoi* (Hook.f.) Berggr.	6
Levenhookia	*L. dubia* Sond. in Lehm.	3

It is difficult to assess these results from a taxonomic point of view except on the basis of Mildbraed's monograph (1908). In Table 3 is shown the occurrence in the various Subgenera of *Stylidium* of the Inflorescence Types.

There thus appears to be no significant correlation between Mildbraed's subgeneric divisions and the inflorescence type. In Phylogenetic terms, it is highly probable that the cymose inflorescence has evolved independently several times from the thyrsoid-(closed) racemose type. Despite Troll's dissension from the view that *Oreostylidium* is not terminal as Philipson (1953) states, it does appear to be so, either the remaining central flower of a reduced cyme of type 4 above or the terminal flower of a reduced thyrse of type 2 above. The pair of small "leaves" below the flower indicates that the former may be correct. Some forms of *Stylidium perpusillum* and also *S. ericksoniae* show a similar construction. There seems no reason to doubt that the solitary flowers of *Forstera, Donatia* and *Phyllachne* are terminal.

CAMPANULACEAE

Various authors have described some of the inflorescence forms found in this family and a brief summary here might be in order so that a comparison with other members of the order can be made. Philipson (1953) concludes that the basic form of the inflorescence is racemose. However, in many cases PFs are cymose in structure. Heidenhain (1952) in particular, emphasizes this. The terminating flower is a very common feature, although both Heidenhain and Parkin (1914) indicate that there are connecting series between the closed inflorescence of *Campanula rapunculus,* the closed inflorescence with a weak flower, e.g., *Campanula rapunculoides* and the open inflorescences of *Lobelia* spp. Thus, basically, it is doubtful if there is any real difference between the inflorescences of the three families. The basic closed thyrsoid unit as found in *Stylidium* and *Campanula glomerata* is homologous with the open thyrsoid units of *Goodenia* and *Levenhookia.* The thyrse, itself, is probably derived (phylogenetically speaking) from the panicle (c.f. Troll, 1964) represented in *Dampiera,* etc. In fact, it would seem that in almost every case in which a wide survey of inflorescence types is undertaken, the same paniculoid-thyrsoid basic type can be extrapolated without doing any injustice to the observations. It seems, therefore, that a comparison of the inflorescence types alone has much less value than the consideration of many other features alone.

The Campanulaceae show a trend to the formation of capitula: *Hedraianthus* with a large terminal flower; *Phyteuma,* with a small terminal flower; *Jasione,* without a terminal flower. The only corresponding trend in the other families is in *Brunonia* which is basically different (q.v.) and *Dampiera* sect. *Calocephalus* which is scarcely, effectively, a capitulum.

Now to turn to more general considerations. These results once more confirm the blurred nature of the distinction between cymose (acrotonic) and racemose (basitonic) inflorescences. Rickett's definitions of the inflorescence types (Rickett, 1955) based on branching type serves fairly effectively for basic descriptive work. At this point it is necessary to emphasize that some of these terms are based on one degree of branching, e.g., raceme, spike, etc., whilst others on more than one degree of branching, e.g., thyrse and panicle. In the homologous series drawn in *Goodenia* (Figs 2 and 3) it can be seen that the raceme of *G. hispida* is homologous with the thyrse of *G. ovata.* In *Stylidium* the dichasium of *S. eriorhizum* is homologous with the thyrse of *S. laricifolium* (Fig. 7). Clearly the dichasium of *Stylidium eriorhizum* is not homologous with the dichasial PFs of *G. ovata* — a different level of branching is involved. More will be said of this problem of level of branching. Let me put this into phylogenetic terms and say the dichasia mentioned above have not evolved in the same way.

And now another emphasis—the terms used to describe inflorescences simply describe what we see. They are not interpretative either in the sense of morphological correspondence or in the phylogenetic sense. Nowhere in morphological botany is it more important to remember this distinction between descriptive statements and interpretative statements than in the study of the inflorescence. On the other hand, "monotelic" and "polytelic", as introduced by Troll (1964) do appear to be interpretative and now we turn to a consideration of these.

Weberling (1965) in an exposition of Troll's ideas has laid particular emphasis on the presence or absence of the terminal flower. Moreover, it is considered that the two inflorescence types are distinct. In *Stylidium,* however, we have been able to see the loss of the terminal flower until, in *Levenhookia,* it is quite atrophied. Furthermore, in Goodeniaceae of the two groups within the family one shows a terminal flower, the other an atrophied axis: even in Campanulaceae the Campanuloideae generally have a terminal flower (Parkin, 1914; Philipson, 1953; Troll, 1964), whilst the Lobeloideae and Cyphioideae have an atrophied termination to the inflorescence axis. Taxonomically they do not appear to de distinct and the situation in Stylidiaceae shows that a series can be drawn showing a transition from closed to open inflorescences. Troll's typology (Troll, 1964; p. 183) seems to make all the flowers or flowering branches, beneath the terminal flower of a closed (monotelic) inflorescence part of the BZ i.e., homologous to the enrichment branches (paracladia) of the polytelic inflorescence (see Fig. 1). On this basis the PF of *Stylidium rupestre* would not be homologous with the branches below the terminal flower of *S. laricifolium* and this does not seem to be a satisfactory statement of the comparison between the two: the PFs of both these inflorescences are surely homologous as inferred from the series in Fig. 7. The presence or absence of a terminal flower has no effect on the overall situation. On the other hand, the situation in *Leschenaultia* (Fig. 6C) seems to me to correspond more closely with Troll's idea of monotelic. It is conceivable that the flowering branches below the terminal flower are enrichment branches. Especially since there are no obvious enrichment branches similar to those of *Goodenia,* etc. It is possible, however, to interpret the terminal flower group of *Leschenaultia hirsuta* as homologous with that of *Goodenia* whilst the BZ region is absent. In the light of the argument set out below, I consider this latter to be a more effective concept.

And, indeed, if Heidenhain's implied (but not stated) results on the order of opening of the flowers in Campanulaceous racemes are correct, this also must be taken as evidence of the homology of the closed and open racemes in that family. She clearly illustrates terminal flowers of the upper branches of the synflorescence opening acropetally whilst the lower ones open basipetally. Moreover, the morphological "break" also occurs more or less at the same point, i.e., these basal branches have the same basic construction as the main axis above them (see definition below). There seems no basis for accepting the monotelic-polytelic distinction as advocated by Troll, in this case.

In *Scaevola* I have noted the occurrence of a vegetative axis bearing a number of inflorescences laterally (*S. canescens*). This arrangement has been designated as "intercalary inflorescences" by Parkin (1914) and criticized by Croizat (1943). The term is simply describing a particular relationship of a series of flowering paracladia of order n and a vegetative main axis of order n–1 upon which they are borne. Frequently this relationship is a question of degree; thus the inflorescences of *S. canescens* are more clearly "intercalary" than those of *S. nitida* since they are shorter and have shorter vegetative zones at the base. Moreover, the dichasia of *S. taccada* and *S. spinescens* can also be *described* as intercalary although they are clearly not homologous to those of *S. canescens* (Figs 5C, B). Once again it is necessary to recognize the homologous *degrees* of branching in a comparative series. In the past, little attention has been paid to the vegetative parts of the plant when comparing inflorescences: it seems to be yet another inheritance from the predominantly temperate herbaceous botany of the past where vegetative growth tends to be hidden below, or at, ground level. Even in such groups as Proteaceae reported on by Johnson and Briggs (1963) and Rao (1965) which are predominantly woody, these authors pay scarcely any attention to the vegetative shoots and their relationships with the flower-bearing ones. The fact that the reference books (e.g., Bentham and Hooker, 1876) make various statements about the terminal or lateral position of the whole inflorescence indicates that this might be a profitable line of enquiry. All of these workers recognize that the inflorescences of *Bellendena* and *Persoonia* are closely related, although the former has an inflorescence with an atrophied apex and the latter has some species with similar inflorescences, but mostly the inflorescence axis continues growing into a further vegetative stage. Pilger (1922) also has noted this and suggests that is commoner in tropical species than in temperate ones, and also that the presence or absence may be a function of seasonal growth. I have noted a similar situation in *S. taccada* and *S. spinescens* above: species showing affinities with these have terminating inflorescences. This is an interesting case because here are series in which a "polytelic" inflorescence is compared with quite a different morphogenetic situation to that compared with the "polytelic" inflorescence of *Stylidium rupestre*; clearly the two states are not strictly homologous at the same level of organization. The serial relationships between closed (monotelic) and open (polytelic) inflorescences are not the same throughout the flowering plants: in phylogenetic terms the open (polytelic) type has evolved in several ways.

Although the definitions of mono- and polytely are based upon the presence or absence of the terminal flower, the words themselves refer to one or many "ends". Polytelic synflorescences end in a number of (lateral) flowers, monotelic ones end in a single flower. But these concepts seem quite non-operational. When one is searching for homologies: the terminal flower of *Stylidium laricifolium* and Campanuloideae is not homologous to the whole inflorescence of *S. rupestre* and Lobelioideae respectively but to their abortive apex. In these particular cases examined here it would appear that the polytelic-monotelic concept is not of much help; the interpretation which they provide of the open and closed inflorescence does not provide a particularly satisfactory "explanation". As more detailed information on the relationships between vegetative and flower-bearing shoots becomes available it should be possible to decide whether these concepts are of use in other groups. If we interpret homology to mean evolutionary relationship, then we must fix *a priori,* the primitive "starting points". Now, flowers terminate axes upon which they grow and Parkin's (1914) "starting point" of a panicle seems fairly reasonable. This would be a "monotelic" inflorescence. It is not difficult to imagine the abortion of the terminal flower of a group due, possibly, to drainage of growth materials by the lower flowers or some other physiological cause. Thus the polytelic condition is produced. The opposite is not so difficult either. But the replacement of a whole group of flowers with a single one, or vice-versa seems to require Occam's razor not only on the basis of such empirical, homologous arrangements as in Stylidiaceae and Campanulaceae, but also from the point of view of a general phylogenetic interpretation.

We must conclude, then, that Troll's concept of monotelic and polytelic inflorescences is an unsatisfactory statement of the facts. Also, that when it is tested in the families indicated by the normal process of morphological comparison and using a strict logic applied to homology, it is false. In addition, as Stauffer (1963) has said, there seems little reason to add the two new terms monotelic and polytelic when "closed" and "open" are already in use.

To sum up: I think that the following concept of the inflorescence is probably the most effective one.

The main inflorescence (HF) is a flower or collection of flowers on a main shoot separated from other such flowers or collection of flowers on the same plant, by one or more leaves or leaf-like organs and subtending enrichment paracladia (see below) of order n + 1 or only an axillary bud. We can thus recognize the inflorescence itself.

The synflorescence is a flower or collection of flowers borne on shoots of order n and > n, separated from other such flowers or collection of flowers on the same plant by one or more appendages subtending vegetative branches or only axillary buds.

Now this last definition, of course, will include not only the main axis (shoot order n) but also the branches of order n + 1 in the BZ. In other words, I would consider the panicle as homologous with the enriched thyrses or racemes of *Goodenia ovata* and *Goodenia barbata*. Furthermore, I would consider that the flowers or PFs immediately below a terminal flower were not part of the BZ as Troll seems to think but as part of the HF zone.

The distinction between the HF and BZ zone generally offers little difficulty except in the case of the panicle. The BZ zone is that region where the axillary paracladia of order n + 1 are constructed in the same way as the HF. The HF is the upper zone of the main axis, the axillary branches giving rise to cymes or PFs limited to two branches per peduncle, or to single flowers with up to two bracteoles. Admittedly, this definition is fairly arbitrary in the case of the panicle and it may need subsequent adjustment but for most inflorescences this will correspond to definite morphological changes. Stauffer (loc. cit.) attempts to define the BZ zone, following some earlier workers, by the fact that in the HF zone (of a raceme or panicle) the flowers are initiated and bloom centri-petally whilst in the BZ zone the sequence of branch maturation is basipetal. Using Bolle's (1940) analysis this is the point where the expected plastochrone sequence breaks down. The diagram he provides for *Veronica* shows a number of side-branches below the terminal inflorescence, each bearing an inflorescence. In some species these mature centripetally, in others, basipetally. One might say that morphologically speaking these all represent the BZ whilst, physiologically speaking, only the latter do so. It once again sharpens my point that definitions are the servants of our minds. Defined morphologically, BZ will assist us in determining taxonomic relationships, defined physiologically it can assist us in determining intra plant relationships. The partitioning of the shoot by morphological definition is no better than by physiological definition, or *vice versa,* although there may be good reasons for having separate symbols (words) for these definitions. In many cases the definitions coincide: fortunately this is the case in the families examined here.

Acknowledgements

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Bibliography

Bentham, G., and Hooker, J. D., 1876.—"Genera Plantarum", vol. II, pars II, London.

Breckner, M., 1959.—"The Biological Way of Thought." (Columbia University Press.)

Bolle, F., 1940.—Theorie der Blutenstande. *Verh. Bot. Verein. Prov. Bradenburg*, 80: 53.

Boyden, A., 1943.—Homology and analogy, a critical review of the meaning and implications of these concepts in biology. *Am. Midl. Nat.*, 37: 348.

Cain, A. J., 1959.—Deductive and inductive methods in Post-Linnean taxonomy. *Proc. Linn. Soc. Lond.*, 170: 185.

Carolin, R. C., 1959.—Floral structure and anatomy in the family *Goodeniaceae*. Proc. Linn. Soc. N.S.W., 84: 242.

Carolin, R. C., 1966.—Seeds and fruit of the *Goodeniaceae*. Proc. Linn. Soc. N.S.W., 91: 58.

Croizat, L., 1943.—The concept of inflorescence. *Bull. Torr. bot. Club*, 70: 496.

Davis and Heywood, 1963.—"Principles of Angiosperm Taxonomy." (London.)

Eckhardt, T., 1964.—Das Homologieproblem und Fühle Strittiger Homologien. *Phytomorph.*, 14: 79.

Frank, P., 1961.—"Modern Science and its Philosophy." (Harvard.)

Heidenhain, B., 1952.—über der Blutenstande der Campanulaceen. *Akad. Wiss. Lit. in Mainz. Klasse math-Wiss.*, 621.

Johnson, L. A. S., and Briggs, B. G., 1963.—Evolution in the Proteaceae. *Aust. Journ. Bot.*, 11: 21.

Krause, K., 1912.—"Das Pflanzenreich", 54. (Leipzig.)

Madden, E. H., 1952.—The philosophy of science in Gestalt Theory. *Theory and Philos. of Science*, 19: 228.

Mason, H. L., 1957.—The concept of the flower and the theory of homology. *Madrono*, 14: 81.

Mildbraed, J., 1908.—"Das Pflanzenreich", 35. (Leipzig.)

Parkin, J., 1914.—The evolution of the inflorescence. *Journ. Linn. Soc. Lond (Bot.)*, 42: 511.

Philipson, W. R., 1948.—Studies in the development of the inflorescence. V. The raceme of *Lobelia dortmanna* L. and other campanulaceous inflorescences. *Ann. Bot. M.S.*, 12: 147.

Philipson, W. R., 1953.—The relationships of the Compositae, particularly as illustrated by the morphology of the inflorescence in the Rubiales and the Campanulatae. *Phytomorph.*, 3: 391.

Pilger, R., 1922.—über die Verzweigung und Blutenstandbildung bei den Holzgewachsen. *Bibl. bot.*, 90: 1.

Rao, V., 1965.—Studies in the Proteaceae. V. Evolution of the inflorescence. *Journ. Ind. bot. Soc.*, 44: 244.

Rickett, H. W., 1944.—The classification of inflorescences. *Bot. Rev.*, 10: 187.

Rickett, H. W., 1955.—Materials for a dictionary of botanical terms. III. Inflorescences. *Bull. Torr. bot. Club*, 82: 419.

Simpson, G. G., 1961.—"Principles of Animal Taxonomy." (New York and London.)

Smirnov, 1925.—(In Sokal, 1962.) *Z. indukt Abstamm. Vererblungsl.*, 37: 28.

Sokal, R. R., 1962.—Typology and empiricism in taxonomy. *J. theor. Biol.*, 3: 230.

Sokal, R. R., and Sneath, P., 1963.—"Principles of Numerical Taxonomy." (San Francisco.)

Stauffer, H. U., 1963.—Gestaltwandel bei Blutenstanden von Dicotyledon. *Bot. Jab.*, 83: 216.

Troll, W., 1957.—"Practische Einfuhrung in die Pflanzemorphologie", vol. 2 (Jena).

Troll, W., 1964.—"Die Infloreszenzen", vol. I (Jena).

Weberling, F., 1965.—Typology of inflorescences. *Journ. Linn. Soc. Lond. (Bot.)*, 59: 215.

Withers, R. F. J., 1964.—Morphological correspondence and the concept of homology. *In* "Form and Strategy in Science". (The Hague.)

Woodger, 1952.—"Biology and Language." (Cambridge.)

Zimmerman, W., 1965.—Die Bluthenstande, ihr System und ihr Phylogenie. *Ber. deutsch. bot. Ges.*, 78: 3.

THE GENUS *VELLEIA* SM.

R. C. Carolin
University of Sydney

(Plates I and II)

[Read 29th March, 1967]

Synopsis

A systematic treatment of the genus is provided. All species recognized are described, the types together with other specimens are cited. The following species are described as new: *V. glabrata* and *V. parvisepta*. A key for the identification of the species is given.

The genus *Velleia* is restricted to Australia and New Guinea so far as its distribution is known to date. The last complete treatment of the genus is due to Krause (1912) since which date there has been considerable collection and a revision has been found necessary. The main outlines of Krause's treatment remain intact except in his delimitation of the genus.

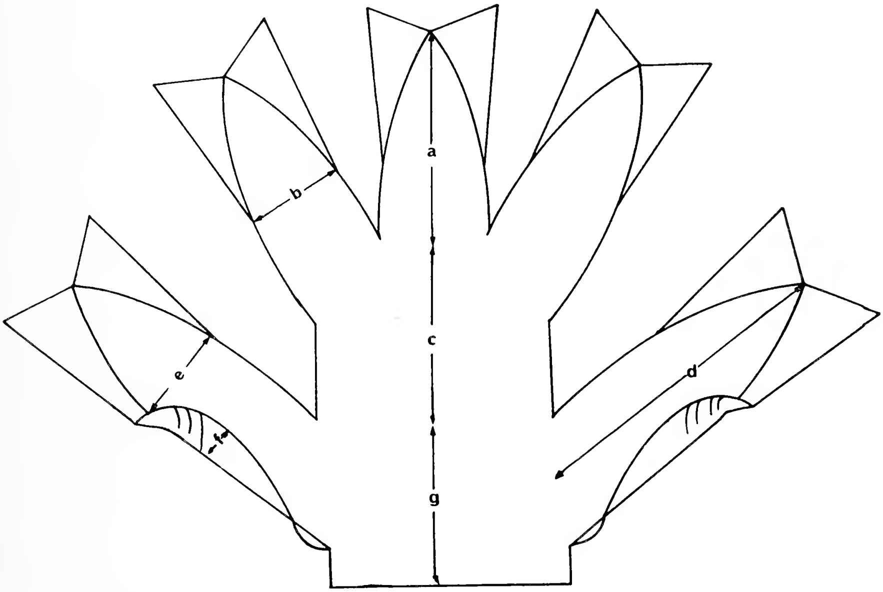

Fig. 1. Diagram of generalized expanded corolla of *Velleia* to show the various measurements given for each species. a, length of inferior lobe; b, breadth of inferior lobe; c, length of connate part of inferior lobes; d, length of superior lobe; e, width of superior lobe; f, width of auricle; g, length of tube.

Velleia can be recognized by its characteristic habit. The stem is distinct and elongated in two species in sect. *Euthales* but otherwise is usually very reduced and converted into a short caulorrhiza. From this stem arise peduncles bearing (usually) much branched dichasia. The inflorescence is thus a thyrse and the habit is derived directly from the characteristic *Goodenia* form (Troll, 1964; Carolin, 1967).

One series of measurements that requires explanation is that relating to the corolla. This is set out in Fig. 1.

The cytotaxonomy has been discussed previously and is known to be remarkably uniform throughout the genus with a basic number of eight

(Peacock, 1963). The voucher specimens indicated in Peacock's contribution are cited in the present work and indicated by an asterisk immediately following the herbarium location thus: "(SYD*)".

A consideration of the floral anatomy and that of the seed and the relationships shown by these characters between *Velleia* and other genera in the family will be found in previous contributions (Carolin, 1959, 1966).

Of those species included in *Velleia* by Krause, only one has been excluded here, i.e., *V. cusackiana* F. Muell. The habit and inflorescence are clearly those of *Goodenia*; even Krause's description makes this clear.

VELLEIA Sm.

In *Trans. Linn. Soc. Lond.,* 4: 217 (1798); R.Br., *Prodr.,* 580 (1810); DC. *Prodr.,* 7: 518 (1839); De Vriese, *Gooden.,* 171 (1834); Hook. f., *Fl. Tasm.,* 1: t.68 (1860); Benth., *Fl. Austr.,* 4: 45 (1869); Benth. et Hook. f., *Gen. Plant.,* 7: 537 (1873); Schönland in *Engl. et Prantl., Pflzfm.,* 4: (5); 7 (1894); Bailey, *Fl. Qld.,* 892 (1900); E. Pritzel in *Engl. Bot. Jahrb.,* 35: 554 (1905); Krause, *Pflzrch., Goodeniaceae,* 27 (1912); Ewart, *Fl. Vict.,* 1066 (1931); Robertson in *Black, Fl. S. Austr.,* ed. 2, 4: 827 (1957); Curtis, *Student's Fl. Tasm.,* 2: 398 (1963).

Orthographic variants: *Velleya* Roem. et Schult., *Syst. Veg.,* 5: 5 (1819); Walp. *Ann.,* 1: 47 (1848); Moore et Betche, *Handb. Fl. N.S.W.,* 309 (1893); Rodway, *Fl. Tasm.,* 100 (1903). *Velleya* Schrad., *Neues Journ. Bot.,* 3 (1): 118 (1890).

Taxonomic synonyms: *Euthales* R. Br.; *Menoceras* (R.Br.) Lindl. *Antherostylis* Gardner. See sections for full citations.

Annual or perennial herbs with a ± persistent tap-root. *Stems* reduced to a branched or simple caulorrhiza often covered with dead leaf-bases; in two species elongated to 50 cm. tall. *Leaves* simple, spirally arranged, appearing as a rosette in most species. *Flowers* arranged in a series of dichotomous axillary cymes, each cyme borne on a usually elongated, erect ascending or prostrate peduncle naked except for the opposite bracteoles. *Sepals* 5 or 3, free from the ovary or the posterior one adnate for some distance at the midrib, free from each other or ± connate. *Corolla* tubular at the base with an anterior spur or pocket and 5 lobes with lateral wings which are induplicate in the bud, ± epigynous; 2 superior lobes usually more deeply cut than the rest, ± auriculate. *Stamens* 5, free from each other but ± epigynous. *Ovary* incompletely 2-locular with an incomplete ± massive dissepiment bearing 4–c.20 ovules in two rows on either side: style simple: indusium sub-orbicular to oblong, curved or straight, usually ciliate, undivided: stigma notched or undivided. *Fruit* a 4- or 2-valved capsule, the latter often with 2-fid valves. *Seeds* few to several, compressed, winged or merely with a thickened rim. *Embryo* spathulate, embedded in endosperm.

Type species: *V. lyrata* R.Br.

Section EUTHALES, stat. nov.

Basionym: *Euthales* R.Br., *Prodr.,* 579 (1810); De Vriese, *Gooden.,* 169 (1854); DC., *Prodr.,* 7: 517 (1839).

Calyx united into a tube at least as long as the shortest lobes. Seeds punctulate with very narrow wing.

This small but well-defined group of species has a narrow distribution in the south-west of the continent. It is represented by one variable species occurring over most of that area (*V. trinervis*) and by two much more restricted species which appear to have rather narrower ecological tolerances.

Typification: *Holotype—Euthales trinervis* (Labill.) R.Br., the only species described with the original genus description.

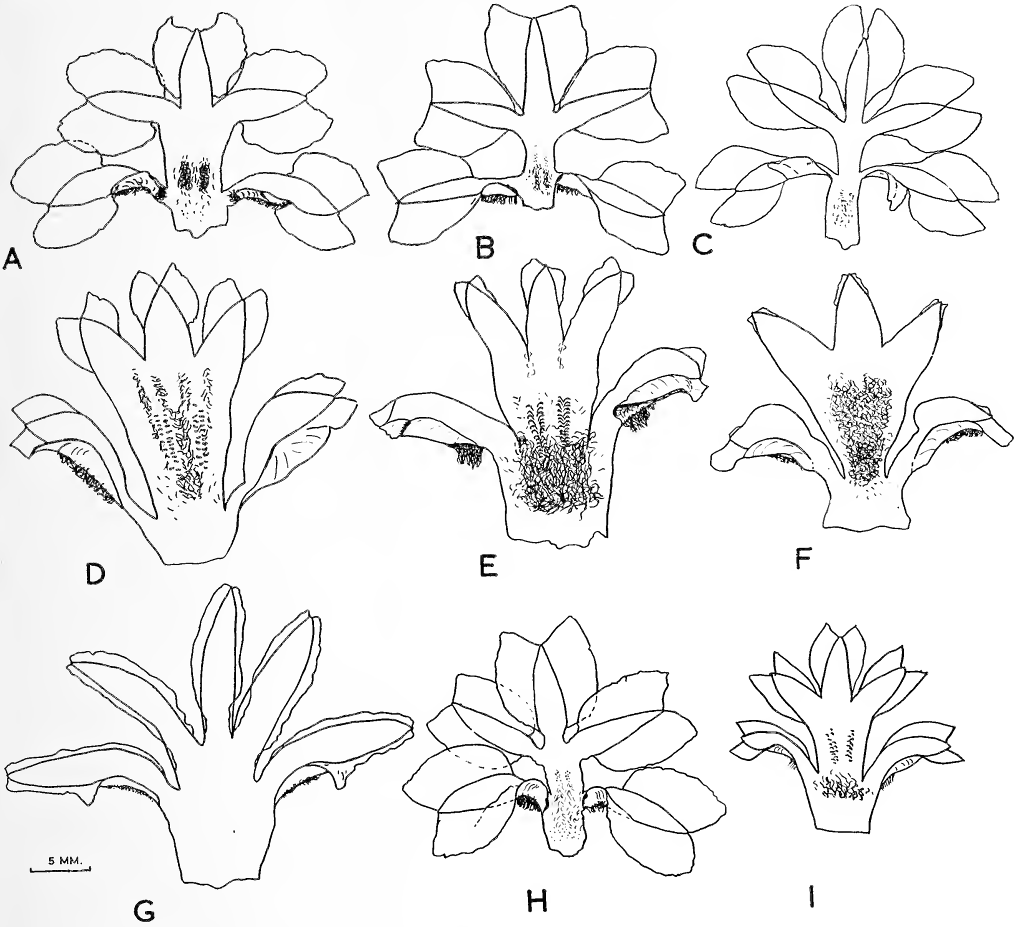

Fig. 2. Dissected corollas of *Velleia* sp. A, *V. trinervis*; B, *V. macrophylla*; C, *V. foliosa*; D, *V. daviesii*; E, *V. panduriformis*; F, *V. connata*; G, *V. discophora*; H, *V. rosea*; I, *V. arguta*.

1. V. TRINERVIS Labill.

Nov. *Holl. Pl.,* 1: 54, t.77 (1804) ; Benth., *Fl. Austr.,* 4: 47 (1869) ; Krause, in *Pflrch.,* 54: 38 (1912).

Nomenclatural synonyms: *Euthales trinervis* (Labill.) R.Br., *Prodr.,* 580 (1810) ; DC., *Prodr.,* 7: 517 (1839) ; De Vriese, *Gooden.,* 169 (1854).

Taxonomic synonyms: *Velleia trinervis* var. *villosa* Benth., *Fl. Austr.,* 4: 47 (1869) ; *Euthales pilosella* De Vriese in *Lehm., Pl. Preiss.,* 1: 414 (1845) ≡ *Velleia pilosella* (De Vriese) Christensen et Ostenf. in *Dansk. Vidensk. Selsk. Biol. Medd.,* 3 (2) ; 122 (1921) ; *Velleia trinervis* var. *lanuginosa,* E. Pritzel in *Engl. Bot. Jahrb.,* 35: 556 (1905).

Perennial (?) herb with a stout tap root and short stout caulorrhiza obscured by the ± persistent leaf-bases. *Leaves* arranged in an ascending to prostrate rosette on the caulorrhiza, linear to narrow-obovate or almost spathulate narrowing gradually towards the base into a linear petiole and broadening once more into a wide base, 5–20 cm. long (incl. petiole) 5–25 mm.

wide, glabrous (at least when mature) to villous, ± thick and fleshy dentate to entire or with blunt callous teeth, ± obtuse, villous-woolly in the axils. *Peduncles* erect to ascending to 40 cm. tall, ± terete, glabrous to villous. Bracteoles quite free or connate at the base into a very short tube (c. 1 mm. long), oblong to linear-deltoid, entire, glabrous to villous with some wool in the axils: lower ones 5–19 mm. long rarely longer: upper ones shorter. *Sepals* 5, connate into a tube 2–3 mm. long, attenuate towards the base, glabrous to densely villous on outside but always covered with long appressed villous hairs on inner surface: posterior lobe deltoid to ovate, 2–2·5 mm. long, 1·5 mm. wide, entire, acute rarely acuminate: other lobes only slightly smaller and narrower. *Corolla* yellow to orange with a red-brown throat, 8–12 mm. long with a very obscure anterior pocket adnate to about the mid-mark of the ovary, pubescent on outer surface, villous inside in the throat: tube 2·5 mm. long: superior lobes c. 6 mm. long and 1·5–2 mm. wide with broad (2 mm.) lateral wings and prominent auricles which are barbulate on their outer margin in the groove between auricle and lobe and on a callous at the base: inferior ones 4–5 mm. long, with broad lateral wings: connate part of inferior lobes 3–4 mm. long. *Stamens* 5, free: filaments linear-filiform, c. 2 mm. long: anthers linear to oblong, c. 1 mm. long. *Ovary* ovoid-globular, sprinkled with short-appressed hairs with a dissepiment not reaching the mid-mark and bearing c. 6 ovules: style ± glabrous, c. 3 mm. long: indusium with a few hairs towards the base on the outer surface and rather more on the inner surface (but not a bunch), folded, curved, broad-obovate when flattened, c. 2 mm. wide

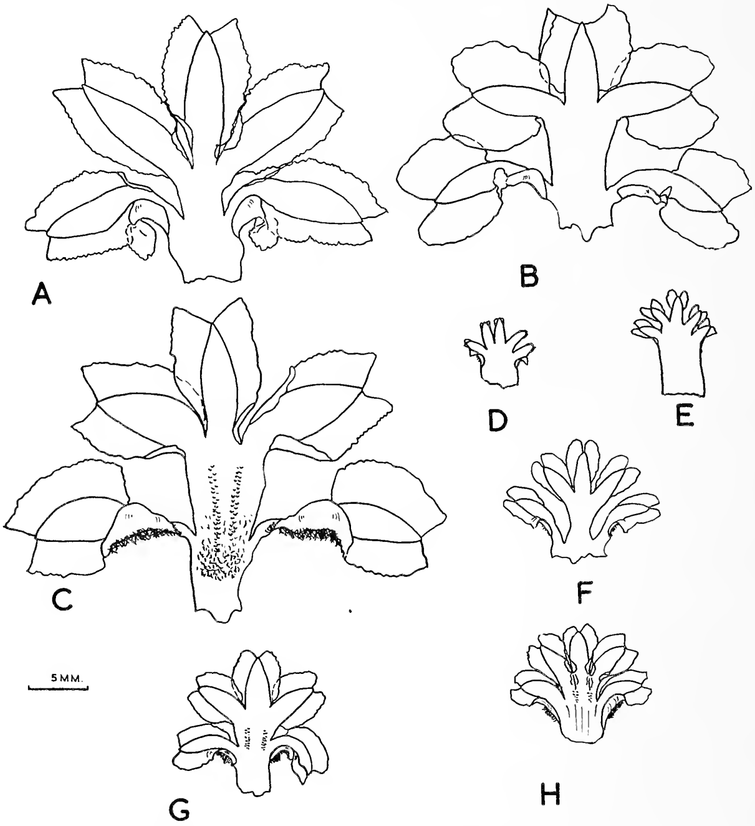

Fig. 3. Dissected corollas of *Velleia* sp. A, *V. paradoxa*; B, *V. glabrata*; C, *V. lyrata*; D, *V. spathulata*; E, *V. hispida*; F, *V. cycnopotamica*; G, *V. montana*; H, *V. parvisepta*.

and 1 mm. long with a slightly curved orifice beset with long stiff cilia (c. 0·5 mm. long). *Capsule* ovoid, 7 mm. long, 4 mm. wide, glabrous or nearly so, ± equally 4-valved. *Seeds* flat, orbicular, c. 2 mm. diam., minutely punctulate and with a thickened rim, yellow-brown.

Range: S.W. Province of S.W. Australia.

Habitat: Swamps and other damp places.

Chromosome number: 2n = 16 (Vouchers asterisked below).

Typification: *V. trinervis* Labill. — *Lectotype* — Habitat in terra van Leuwin — Labillardière, donated by Webb (P). *Isotypes*—ex Herb Maire (P) : (Fi). *Euthales pilosella* De Vriese. Preiss no. 1438 (G.P.L.). *V. trinervis* var. *villosa* Benth. *Syntypes*—Drummond 4th coll. no. 188(K) ; King George's Sound, Collie (K) ; Vasse River, Oldfield (K) ; Don River and Cape Arid, Maxwell (K). *V. trinervis* var. *lanuginosa* E. Pritzel-*Holotype*-Crescit in distr. Avon pr. Mogumber in lutosis herbaceis humidioribus Diels no. 4038. (B, destroyed). *Goodenia tenella* Andr., Bot. Rep. 7: t.466 (1807) non R.Br. is a superfluous name since Andrews states ". . . & it is by Labillardière figured under the title of *V. trinervis*".

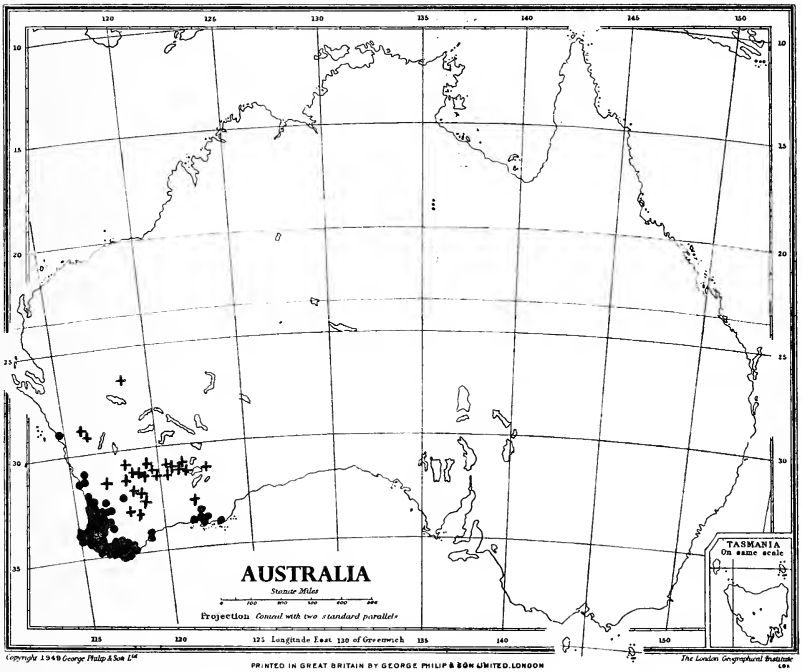

Fig. 4. Distribution of *Velleia trinervis* (●) and *V. discophora* (+).

Discussion: There is considerable variation within this species but none of the various character differences appear to be correlated consistently with each other. The colour of the petals varies from cream to orange, almost always with a brown colouration in the throat. The leaves vary from linear to broad-oblanceolate, the linear ones tending to occur west of the Darling Range and the broader ones in the more southerly parts of the distribution. The indumentum on the leaves has been made the basis for the erection of two varieties. There appear to be all gradations between villous and glabrous leaves and there seems little point in maintaining either at present. It differs from the rest of the species in this section in not having an elongated stem, and in the shorter, almost equal calyx-lobes.

Selected specimens examined: *Western Australia*: East of Bremer Bay, T. E. H. Aplin no. 2761 (PERTH) : Nth. Side of Mt. le Grand, A. S. George no. 2216, 12.12.1960 (PERTH) : Near Cape Arid, Maxwell, 1875 (MEL 9660) : S. of Grasspatch. Norseman-Esperance, J. H. Willis, 1.9.1947 (MEL 9691) : King George's Sound, R. Brown no. 1802 (MEL 9677. NSW 75637. BM) : Albany, R. Helms, Nov. 1896 (PERTH) : Kalgan River S. of Stirling Range, R. Carolin no. 3480, 8.9.61 (SYD) : Base of Mt. Toolbrunup, Stirling Range, T. E. H. Aplin no. 2060, 17.10.62 (PERTH) : 1 ml. N. of Darnalup, B. G. Briggs, 5.10.60 (NSW 52413. SYD) : Sources of Blackwood River—Cronin, 1888 (MEL 10011) : Albany Highway, 300 mls. S. Perth, W. J. Peacock, 60878.3, 28.8.60 (SYD*) : Cranbrook, W. J. Peacock no. 60881-3, 26.8.60 (SYD*) : 1 ml. S. of Borden, W. J. Peacock, no. 60887-2, 31.8.60 (SYD*) : Pinjarra, C. A. Gardner no. 901, 16.8.1920 (PERTH) : 4 ml. n. of Northcliffe on Quininup Rd., A. S. George no. 3180, 25.11.61 (PERTH) : Manjimup, Max Koch no. 254, Nov. 1920 (PERTH. MEL 9699) : Woorooloo, Max Koch no. 1568, 9.1906 (K. AD 96511154. NSW 75632. MEL 9658) : District Swan, E. Pritzel no. 772, 10.1901 (AD 96511148. NSW 75628) : Kelmscott, lower Canning River, A. Morrison no. 11139, 17.9.1902 (NSW 75623) : Dinner Hill, c-30 ml. W. of Watheroo, R. Carolin no. 3392, 1.9.61 (SYD).

2. V. FOLIOSA (Benth.) Krause

In *Pflrch.*, 54: 40 (1912).

Nomenclatural synonym: *V. macrophylla* var. *foliosa* Benth., *Fl. Austr.*, 4: 48 (1869).

Perennial herb with stout ± woody, glabrous, erect or ascending stem c. 5 mm. wide and up to 30 cm. tall. *Leaves* mostly spirally arranged and crowded (not distant) ± coriaceous, narrow-obovate, tapering very gradually towards the base but sessile with a broad base, 4–7 cm. long (incl. base) 10–15 cm. wide, serrate especially towards the apex, acute, glabrous except for some wool in the axil. *Peduncles* erect or ascending up to 20 cm. tall, glabrous, terete. *Bracteoles* free, coriaceous with a few scattered villous hairs, usually entire, acute with a considerable amount of wool in the axils: lower ones narrow-ovate to elliptic or linear, rarely with a few teeth, up to 13 mm. long and 4 mm. wide: upper ones narrower, smaller, entire. Central flowers on pedicels up to 2·5 cm. long. *Sepals* 5, glabrous on the outer surface but with villous appressed hairs scattered over the inner surface, connate into a tube c. 3 mm. long tapering towards the base, acute, entire: posterior lobe ovate, c. 5 mm. long and 2·5 mm. wide, other lobes lanceolate to deltoid, c. 4 mm. long and 1 mm. wide. *Corolla* yellow to orange with a red-brown throat c. 12 mm. long with a very obscure anterior pocket, adnate to ovary to the mid-mark, pubescent outside but for the wings, pubescent inside in the throat, enations absent: tube 3 mm. long: superior lobes narrow-elliptic, c. 8 mm. long, 2–3 mm. wide with broad (2 mm.) lateral wings and prominent auricles which are barbulate both on the surface and the margin and have a small basal callus: inferior ones c. 6–8 mm. long and 3 mm. wide with a broad wing (2 mm. wide); connate part of inferior lobes 4–5 mm. long. *Stamens* 5, free; filaments ± filiform, c. 2 mm. long: anthers oblong, c. 1 mm. long, apiculate. *Ovary* ovoid, pubescent, with a dissepiment not reaching to the mid-mark bearing c. 4 ovules: style glabrous, c. 2 mm. long: indusium slightly villous towards the base on outer surface and with a bunch of hairs on inner surface at base, folded, curved, ± deltoid when flattened with a slightly curved orifice beset with long stiff cilia. *Capsule* ovoid-acuminate, c. 7 mm. long and 4 mm. wide, sprinkled with a few short fine appressed white hairs or almost glabrous, ± equally 4-valved. *Seeds* flat, elliptic, c. 2 mm. long and 1 mm. wide including the obscure rim, minutely punctulate.

Range: Stirling Ranges, South-Western Australia.

Habitat: Hillside scrubs.

Chromosome number: Unknown.

Typification: *V. macrophylla* var. *foliosa* Benth.—*Lectotype*:—S.W. Australia, Drummond no. 192, 1848 (K.) *Isotypes*—(P. MEL 9736. NSW 75662).

Discussion: Differs from *V. macrophylla* principally in the sessile, crowded, coriaceous leaves and the shorter broader sepals, especially the posterior one. These two species differ from the remainder of the genus in having a consistently elongated stem.

Selected specimens examined: *Western Australia.* Warrengup, Stirling Range, B. G. Briggs, 8.10.60 (SYD) : Warrengup Hill, Stirling Range, A. A. Dorrien-Smith (K) : Stoney Places, Ross Peak, Stirling Range, C. A. Gardner, 7.12.34 (PERTH. K) : Near top of Bluff Hill, A. S. George no. 3117, 12.11.61 (PERTH) : Redgum Spring, Stirling Range, W. Rogerson, no. 54, Oct. 63 (PERTH).

3. V. MACROPHYLLA (Lindl.) Benth.

Fl. Austr., 4: 47 (1869) : Krause in *Pflrch.,* 54: 40 (1912).

Taxonomic synonym: *Euthales macrophylla* Lindl. in *Bot. Reg.,* 26: 54, t.119 (1840) : Maund, *Botanist,* t.209.

Perennial (?) herb to 20 cm. tall with erect or ascending ± woody, glabrous stem about 5 mm. thick. *Leaves* distant, spirally arranged above but frequently opposite below, obovate to elliptic-obovate narrowing gradually into a linear petiole 5–14 cm. (incl. petiole) long, 5–35 mm. wide, serrate or dentate and frequently with a small mucro on the teeth, acute, glabrous on both surfaces except for some wool in the axil. *Peduncles* erect, up to 40 cm. tall, glabrous, terete, much branched. *Bracteoles* free, glabrous: lower ones lanceolate, up to 3 cm. long and 12 mm. wide, serrate or dentate, acute, almost sessile with some wool in the axils: upper ones narrower, less dentate and generally smaller. Central flowers on pedicels c. 25 cm. long. *Sepals* 5. connate into a tube c. 3 mm. long, attenuate towards the base, glabrous on the outer surface but with short scattered appressed ± villous hairs on inner surface, entire: posterior lobe oblong to elliptic-narrow-obovate, 7 mm. long, 2·5 mm. wide, acute: other lobes 4 mm. long and narrower. *Corolla* yellow to orange with a reddish-brown throat, c. 12 mm. long with a very obscure anterior pocket adnate to mid-mark of ovary, pubescent outside and on inner surface in the throat: tube 2 mm. long: superior lobes narrow-oblong to narrow-elliptic c. 8 mm. long, 1·5 mm. wide broadly winged (c. 2·5 mm. wide) with a conspicuous auricle which is barbulate on the margin and has a basal callus: inferior ones 5–7 mm. long: connate part of inferior lobes 4 mm. long. *Stamens* 5, free: filaments ± filiform, c. 2 mm. long: anthers oblong, c. 1 mm. long, not apiculate. *Ovary* ovoid, pilose, dissepiment not reaching to mid-mark and bearing 2–4 ovules; style glabrous, c. 2 mm. long: indusium folded and curved with a few scattered villous hairs towards the base on the outer surface and a bunch of hairs on the inner surface, deltoid to depressed obovate, 1 mm. long and 1·5 mm. wide with a slightly curved orifice beset with long stiff cilia. *Capsule* ovoid, c. 5 mm. long, 2–3 mm. wide, glabrous or with a few scattered white hairs, 4-valved but 2 of them frequently failing to part to the base giving the appearance of 3 valves. *Seeds* flat, elliptic, c. 4 mm. long and 2 mm. wide, with a very narrow margin, brown, minutely punctulate.

Range: South-western Australia. In the extreme South West: Warren River district, thus differing from *V. foliosa* in distribution (and probably habitat).

Habitat: Forest?

Chromosome number: Unknown.

Typification: *Euthales macrophylla—Lectotype*—(ex) Hort. Soc. Nat. Lond. Grown from seed purchased of James Drummond 1840 (CANTAB) Isotype (K).

Discussion: A species with a rather restricted distribution; differs from *V. foliosa* in the petiolate leaves and the narrower, longer posterior sepal. Their geographical distributions and ecological preferences also differ.

Selected specimens examined: *Western Australia*: Pemberton, T. E. H. Aplin, no. 1383, 11.12.61 (PERTH): Swan River, Drummond? no. 141, (K. MEL 9724): Swan River, Drummond, no. 189, (K. MEL 9731): Pemberton, Max Koch, Dec. 1920 (PERTH): Scott River, R. D. Royce, no. 74, 17.1.45, (PERTH): Big Brook, Warren Dist., Max Koch, no. 2256, (K. BRI 058787. NSW. MEL 9728) Bank of Big Brooks, Karri Dale, 1857 P. Walcott (MEL 9729).

Section MENOCERAS R.Br.

Prodr., 580(1810): De Vriese, *Gooden.*, 172(1854).

Nomenclatural synonyms: *Euthales* sect. *Menoceras* (R.Br.) Steudel: *Menoceras* (R.Br.) Lindl., *Veg. Kingdom*, 695(1847).

Taxonomic synonyms: *Velleia* sect. *Aceratia* F. Muell. in *Trans. Phil. Soc. Vict.*, 1:18(1855): *Velleia* sect. *Pentasepala*, Krause, *Pflrch.*, 54: 28(1912): *Antherostylis* Gardner in *Journ. Roy. Soc. W. Austr.*, 19:91 (1934).

Sepals 5, free or connate, seeds winged or with a thickened margin.

Typification: sect. *Menoceras* R.Br.—*Lectotype*—*Velleia paradoxa* R.Br.: sect. *Aceratia* F. Muell.—*Holotype*—*Velleia connata* F. Muell: sect. *Pentasepala* Krause—*Lectotype*—*Velleia paradoxa* R.Br. Although *V. paradoxa* is selected as the lectotype, since Krause definitely states "n. sect" it appears that it cannot be accepted as a simple nomenclatural synonym of sect. *Menoceras*, *Antherostylis* Gardner—*Holotype*—*A. calcarata* Gardner.

4. V. DAVIESII F. Muell.

Fragm., 10:10(1876): Krause in *Pflrch.*, 54:39(1912).

Annual herb with a strong (?) tap root and very short caulorrhiza. *Leaves* all basal and arranged in an ascending rosette oblong to narrow elliptic in outline and narrowing very gradually towards the base into a linear petiole up to 20 cm. long (incl. petiole) and 2·5 cm. wide, lyrato-pinnatifid or incised below and dentate above, obtuse, pubescent when young but frequently glabrescent with maturity. Ciliate with villous wool in the axils. *Peduncles* erect or ascending, 20–40 cm. tall, pubescent, ± ridged, up to 4 mm. diam. *Bracteoles* free or only connate at the base, very leafy, incised or dentate acute, pubescent with some villous hairs in axils; lower ones lanceolate to oblong or ovate, up to 4 cm. long and 1·5 cm. wide: upper ones smaller and narrower. *Sepals* 5, connate into a tube c. 2 mm. long, pubescent on both surfaces with yellowish hairs; posterior lobe broad-ovate, c. 10 mm. long, 4 mm. wide, with ± long narrow teeth, acuminate; other lobes scarcely narrower and shorter but less dentate. *Corolla* lilac to white, up to 20 mm. long with a very obscure anterior pocket, adnate to ovary to below the mid-mark, pubescent on the outer surface, and with some long villous hairs on the inner surface particularly in the throat; tube c. 4 mm. long: superior lobes falcate-narrow-obovate, c. 15 mm. long and 3 mm. wide, winged with prominent (4 mm. wide) barbulate auricles: inferior ones obovate, 6 mm. long, 2 mm. wide with narrow wings near the apex. *Stamens* 5, free; filaments acuminate-deltoid, c. 3·5 mm. long: anthers oblong c. 3 mm. long. *Ovary* globular, pubescent with a dissepiment reaching to c. mid-mark bearing about 20 ovules, style covered with scattered villous hairs, 5 mm. long: indusium villous hairy, incurved at the margins but hardly folded, not curved, depressed obovate when flattened, c. 5 mm. wide with a slightly curved orifice beset with long cilia on outer lips and very short ones on inner lip. *Capsule* ovoid, c. 7 mm. diam., glabrous with a short mucro, 4-valved, the lateral splits slightly shorter than the antero-posterior ones. *Seeds* brown, orbicular, 4 mm. diam. including the broad (1 mm.) wing; body minutely punctulate and comma-shaped.

Range: Southern part of the salt lakes region of Western Australia.

Habitat: *Triodia* and probably scrub communities.

Chromosome number: 2n = 16.

Typification: *V. daviesii* F. Muell.—*Holotype*—Prope Ularing, Young (MEL 9647).

Discussion: A distinct species differing from *V. connata* in the almost free bracts and wider corolla wings and from *V. paradoxa* and *V. arguta* in corolla colour.

Selected specimens examined: *Western Australia*: Frazer's Range, C. A. Gardner, no. 2912, 26.Oct.1931 (PERTH. K): 30 miles west of Ballidu, W. E. Blackall, no. 1213, 29.Oct.1931 (PERTH): 1 mile east of Woolgangie, Calaby, 2.11.1947 (CANB 15011): Southern Cross, E. Merrall, 1890 (MEL 9982): 45 miles S. of Brown's Soak, W. J. Peacock, no. 60870.1, 19.8.1960 (SYD*): Coolgardie Goldfields, E. Pritzel, no. 850, 10.1901 (K.P. AD 96511150. NSW 75659).

5. V. PANDURIFORMIS A. Cunn. ex Benth.

Fl. Austr., 4: 46 (1869): Krause in *Pflrch.*, 54: 33 (1912): Ewart et Davies, *Fl.N.Terr.*, 263 (1917).

Annual (?) herb with a stout tap root and short caulorrhiza covered by persistent leaf-bases. *Leaves* arranged in an ascending rosette, obovate, dentate, shortly petiolate. *Peduncles* erect, glabrous, glaucous, terete, up to 1 metre tall, up to 4 mm. thick: at each node one of the lateral branches continues growth much more strongly than the other, giving a superficial appearance of a raceme of clusters. *Bracteoles* large, leafy, connate into a ± funnel-like disk up to 12 cm. diam., frequently slit nearly to the base on one side, glabrous except for some short hairs in the axils, glaucous. Central flowers on pedicels up to 3 cm. long. *Sepals* 5, free or connate only at the base, pubescent on both surfaces, rarely almost glabrous outside, acute to acuminate, dentate: posterior one broad-elliptic, 15–18 mm. long, 8–10 mm. wide: others narrow-elliptic to lanceolate, 9–11 mm. long, 4–5 mm. wide. *Corolla* 20–25 mm. long, yellow, with a short broad anterior pouch, adnate to the ovary to about the mid-mark, glabrous to sparsely pubescent on the outer surface, villous on the inner surface at the throat with enations: tube 5–6 mm. long: superior lobes falcate-oblong, c. 10 mm. long and 3 mm. wide with a narrow (0·5 mm.) short wing on the upper margin and a large redoubled deep barbulate auricle c. 3 mm. wide: anterior lobes oblong to narrow-obovate 7–8 mm. long: 3–4 mm. wide with short narrow (1 mm.) wings: connate part of anterior lobes 8–9 mm. long. *Stamens* 5, free: filaments linear, 5 mm. long; anthers linear, 4 mm. long. *Ovary* ± globular, glabrous or slightly pubescent with a swollen dissepiment scarcely reaching the mid-mark bearing c. 20 ovules: style sprinkled with long villous hairs, 7–9 mm. long: indusium transverse-oblong, 3 mm. long, 5 mm. wide, very sparsely villous to glabrous on both surfaces, slightly folded and curved with a slightly curved orifice beset with long white cilia on upper lip and shorter ones on lower lip becoming glabrous towards the centre. *Capsule* ovoid, 13–14 mm. long 10–12 mm. wide, glabrous or slightly pubescent, ± equally 4-valved. *Seeds* orbicular, 8–9 mm. diam. including the broad wing (2 mm. wide), body slightly comma shaped, pale brown, minutely punctulate.

Range: Kimberley Region of Western Australia.

Habitat: Unknown.

Chromosome number: 2n = 16. No voucher.

Typification: *V. panduriformis* A. Cunn. ex. Benth.—*Holotype*—Goodenough Bay and Point Cunningham, N.W. Coast, A. Cunningham (K)—*Isotypes* (BM. MEL 9640).

Discussion: Differs from *V. connata* in the obsolete calyx tube, pubescent calyx segments, larger flowers and the branching system of the scape in which one of the paired branches at each node shows much stronger growth than other and thus gives the appearance of a single, main axis.

Selected specimens examined: *Western Australia*: West Kimberley, G. F. Barnett, Aug.1936 (PERTH): Anna Plains Station, 80-mile Beach, N. T. Burbidge, no. 1426, 10.8.1941 (PERTH): Meda River, C. A. Gardner, no. 1624, 12.Oct.1921 (PERTH, NSW 75666): Near Derby, C. A. Gardner no. 9557a, 29 June 1950 (PERTH): Goody Goody, W. V. Fitzgerald, no. 236, April 1905 (PERTH): Mt. Anderson, West Kimberleys, K. Fitzgerald, no. 42, Aug. 1956 (CANB 38184): Fitzroy River, J. Forrest, 1883 (MEL 9645): Kajunjie Station, D. W. Rust, 2K, Nov. 1954 (CANB 109410): 16 miles N.E. of Karunje Station, N. H. Speck, no. 5011, 14.9.1954 (CANB 47038. CANB 109409).

6. V. CONNATA F. Muell.

In *Trans. Phil. Soc. Vict.*, 1:18 (1855) et in *Hook. Kew Journ.*, 8:162 (1856): Benth., *Fl. Austr.*, 4:46(1869): Moore et Betche, *Handb. Fl.* N.S.W., 309(1893): Bailey, *Qld. Fl.*, 3:893(1900): Krause in *Pflrch.*, 54:33(1912): Ewart et Davies, *Fl. N.Terr.*, 263(1917): Ewart, *Fl.Vict.*, 1066(1930): Robertson in Black, *Fl. S. Austr.*, ed. 2, 4:827(1957).

Taxonomic synonym: *V. helmsii* Krause in *Pflrch.* 54:33(1912).

Annual (?) herb with stout tap-root and short caulorrhiza. *Leaves* arranged in an ascending rosette, obovate to spathulate in outline narrowing basally into a short petiole, 5–20 cm. long (incl. petiole), 1·5–8·0 cm. wide, denticulate or dentate to lyrato-pinnatifid (the degree of dissection being extremely variable), obtuse, glabrous often glaucous, with a few short hairs in the axils. *Peduncles* ascending to erect, up to 60 cm. tall, glabrous, terete to slightly ridged, rarely showing a tendency for one branch to grow more strongly as in *V. panduriformis*. *Bracteoles* large, leafy, connate into a funnel up to 6 cm. diam. (usually c. 3 cm.) with a dentate margin, glabrous but for a few hairs in the axils. Central flowers on pedicels 2–7 cm. long. *Sepals* 5, connate into a tube 4–6 mm. long, glabrous, glaucous or pubescent outside with a few appressed hairs on the inner surface, acute to acuminate, entire to dentate: posterior one broad-ovate to ovate, 9–11 mm. long, 7–10 mm. wide: other lobes slightly smaller and narrower. *Corolla* yellow or brown yellow to white frequently with mauve markings, 15–17 mm. long with a short broad anterior pouch and adnate to the ovary to about the mid-mark, glabrous on the outer surface, densely villous on the inner surface with some enations: tube 2–3 mm. long: superior lobes falcato-narrow-obovate, 9–10 mm. long, 2·5 mm. wide with a narrow short wing on the upper margin and a broad (2·5 mm.) barbulate auriculate one on the lower margin: inferior lobes oblong 5–6 mm. long, 2 mm. wide with short narrow (less than 1 mm. wide) wings: connate part of inferior lobes 9–11 mm. long. *Stamens* 5, free: filaments linear, 4 mm. long: anthers linear 2·5 mm. long. *Ovary* ovoid, glabrous or nearly so with a swollen dissepiment reaching to about the mid-mark bearing 15–20 ovules: style sprinkled with long hairs in the upper half, 5 mm. long: indusium depressed obovate to transverse oblong, c. 4 mm. diam., slightly curved, slightly folded with a slightly curved orifice beset with long white bristles on the upper margin and shorter ones on the lower margin becoming nearly glabrous towards the middle. *Capsule* compressed-ovoid, c. 8 mm. diam., glabrous or nearly so and with a tiny mucro, ± equally 4 valved. *Seeds* orbicular or broad-elliptic, 5–6 mm. diam. incl. the broad (1 mm.) wing: body slightly comma-shaped, brown-yellow, minutely punctulate: wing paler.

Range: Throughout the Eremaea south of the 20th parallel and into the Murray Valley.

Habitat: Mulga scrubs and hummock grasslands dominated by *Triodia* spp.

Chromosome number: Unknown.

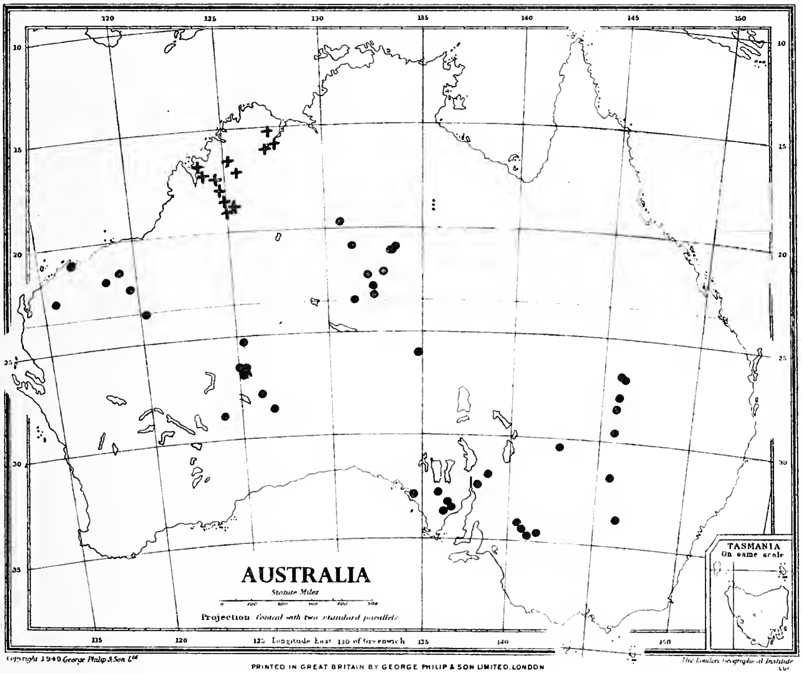

Fig. 5. Distribution of *V. connata* (●) and *V. panduriformis* (+).

Typification: *V. connata* F. Muell.—*Holo(?)type*—Murray Scrub—F. Mueller (K). There is no specimen in MEL corresponding to this and it is assumed that the holotype was sent to, and retained by K. *V. helmsii* Krause—*Holotype*—Victoria desert, Camp 53. Helms (B. destroyed)—*Isotypes* (K. MEL 9628. NSW 75658).

Discussion: *V. helmsii* was recognized as being distinct from *V. connata* by virtue of its laciniate or dentate calyx lobes. This characteristic, however, is not consistently associated with any other. The type has pubescent calyx-lobes but this is found in few specimens of this group with laciniate calyx lobes. It seems, therefore, unreasonable to admit this variation to taxonomic rank.

Selected specimens examined: *Northern Territory*: No. 2 Desert Bore, Hamilton Downs, G. Chippendale, 20.9.1955 (NT 1669. CANB. 37978. BRI 008984. NSW 75607) : 4 m. N. of Connor Well, C. Austr. G. Chippendale, 22.7.1958 (NT 4683) : 20 miles south of the Granites, J. B. Cleland, 20.8.1936 (AD 96511024) : 18 miles N.E. of Barrow Creek Township, M. Lazarides, no. 5823, 24.8.1956 (CANB 109403. CANB 55659. NT. PERTH. BRI 014356. MEL 9623. NSW 75612.K) : *Queensland*. Charleville, E. W. Bick, Dec. 1916 (BRI

058745. NSW 75609. K) : Gilruth Plains, Cunnamulla, G. H. Allen, 1.6.1942 (CANB 8187) : *New South Wales.* Riverina, P. Kennedy, 12.1924 (NSW 75602) : Upper Darling River, G. Day, 1878 (MEL 9638) : Waratah, Enngonia via Bourke, T. V. Egan, 7.1921 (NSW75604) : *South Australia.* Lone Gum near Berri, H. W. Andrew, 28.1921 (AD 96511023) : Wilpena Pound, J. B. Cleland, 30.11.1933 (AD 96511023.K) : *Western Australia.* 33 miles S.E. of Winduldu rockhole S.W. of Warburton, A. S. George no. 4002, Aug. 25. 1963 (PERTH) : Beyond Marie and Alfred Ranges, Giles (MEL 9643 and 9644) : 44 miles N. of Mundiwindi on Gt. N. Hwy., A. S. George (PERTH) : Hammersley Range to Marillana Stn., N. T. Burbidge, no. 6015, 7.5.1958 (CANB 53757. PERTH) :

7. V. DISCOPHORA F. Muell.

Fragm., 10:10(1876) ; Krause in *Pflrch.,* 54:35(1912).

Perennial herb with a stout tap-root and thick short caulorrhiza covered with dead leaf-bases. *Leaves* arranged in an ascending rosette, oblong to narrow-obovate in outline, tapering very gradually towards the base into a short linear petiole or almost quite sessile, up to 20 cm. long (incl. petiole) and 5 cm. wide, lyrato-pinnatifid and/or dentate (often coarsely so), acute, glabrous or glaucous with some short hairs in the axils. *Peduncles* ascending or erect, up to 80 cm. tall, glabrous, terete, up to 4 mm. wide, much branched. *Bracteoles* large, leafy, connate into a ± disc like funnel, toothed or entire, glabrous, glaucous with some short hairs in the axils; lower ones with discs up to 5 cm. diam., upper ones smaller. Central flowers on pedicels up to 3 cm. long or sessile. *Sepals* 5, connate into a tube 2–3 mm. long, entire, acute, glabrous on both surfaces; posterior lobe lanceolate or narrow ovate, 5–6 mm. long, 2·5 mm. wide: other lobes narrow-lanceolate, c. 2 mm. wide. *Corolla* yellow 10–13 mm. long with an obscure anterior pocket, adnate to ovary to above the mid-mark, glabrous on the outer surface, villous (particularly in the throat) and with enations on the inner surface: tube c. 3·5 mm. long; superior lobes ± oblong to narrow-obovate, falcate, 6 mm. long, 2 mm. wide, broadly (2 mm.) winged with conspicuous barbulate auricles; inferior ones oblong-elliptic, 2–4 mm. long, 2 mm. wide, broadly (1–2 mm.) winged: connate part of inferior lobes 4–5 mm. long. *Stamens* 5, free; filaments linear, 2 mm. long: anthers linear or narrow oblong, 2 mm. long, obtuse. *Ovary* sub-globular to ovoid, glabrous with a very short dissepiment bearing c. 12 ovules; style villous, c. 3 mm. long; indusium obovate to semi-orbicular, villous, folded, scarcely curved, c. 2·5 mm. wide, with an almost straight orifice beset with long, dense cilia on the upper lip and sparser very short ones on the lower lip. *Capsule* ovoid, c. 10 mm. long and 7 mm. diam., glabrous, shortly acuminate, ± equally 4-valved. *Seeds* elliptic to ± orbicular, c. 4 mm. wide incl. a pale yellow broad (1 mm.) wing; body pale brown to black, papillose.

Range: S.W. Margin of the Salt Lake country, Western Australia.

Habitat: Probably sandy or stony regions.

Chromosome number: 2n = 16. (Vouchers are marked with an asterisk below.)

Typification: *V. discophora* F. Muell.—*Holotype*—Prope Ularing, Young, 10–15 Oct (MEL 9649).

Discussion: This species differs from *V. connata* principally in the narrow-ovate sepals, broader wings of the corolla lobes and the papillose seeds.

Selected specimens examined: *Western Australia*: Salmon Gums Research Stn., R. D. Royce, no. 4036, 17.April 1953 (PERTH) : Near Gnarlbine, R. Helms, Elder Exped., 12.11.1891 (AD 96511015. MEL 9648. NSW 75654.K) : 12 miles North of Lake Grace, P. R. Jeffries, no. 641030, Oct. 1964 (PERTH) : Merredin, M. Koch, no. 2837, 10.1923 (NSW 75656.K) : Coolgardie Goldfields,

E. Pritzel, no. 877, 10.1901 (NSW 75657. AD 96511149.K): Yorkrakine N. of Tammin, C. E. Gardner, Sept. 1919 (PERTH): Koorda, C. A. Gardner, Oct. 1939 (PERTH): 13 miles E. of Meekatharra, N. T. Burbidge, no. 4718, 8.12.1955 (CANB 34049. PERTH): Garden at Glenmorgan Queensland, seeds ex Pindar W.A. W. J. Peacock no. 611.35.1, Nov. 1961 (SYD*).

8. V. ROSEA S. Moore

In *Journ. Linn. Soc. Lond.,* 34: 202 (1899) Krause in *Pflrch.,* 54: 37 (1912).

Taxonomic synonym: *V. rosea* var. *erecta* Krause in *Pflrch.,* 54: 37 (1912).

Annual herb with a thin tap-root and very short caulorrhiza. *Leaves* all basal, arranged in an ascending or prostrate rosette, narrow-obovate to spathulate in outline narrowing into a distinct linear petiole (c. 15 mm. long) towards the base, 3–5 cm. long (incl. petiole), 5–9 mm. wide, obtuse or acute, dentate or serrate usually coarsely so, sprinkled with hairs especially when young and on the mid-rib, ciliate. *Peduncles* prostrate to ascending, pubescent, terete up to 1·5 cm. long. *Bracteoles* leaf-like, usually quite free from each other, pubescent, acute: lower ones narrow-ovate or ovate in outline, up to 15 mm. long and 5 mm. wide, dentate or often (deeply) incised. Central flowers on densely pubescent pedicels up to 3 cm. long. *Sepals,* 5, free, pubescent to hirsute on both surfaces, ciliate, but otherwise entire, acute; posterior one narrow-ovate to narrow-elliptic, 5 mm. long, 1·5–2 mm. wide; others linear-ovate to narrow-oblong, 4·5–5 mm. long, c. 1 mm. wide. *Corolla* rose to pink or white, c. 13 mm. long, pubescent on outer surface but for wings and pubescent inside in the throat with a distinct anterior pouch, adnate to ovary to above the mid-mark: tube c. 5 mm. long: superior lobes falcate-elliptic 5–6 mm. long, 2 mm. wide broadly (2–3 mm.) winged with ± barbulate auricles which have a distinct membranous appendage separated from the wing: inferior ones elliptic-oblong, 6–7 mm. long, broadly winged; connate part of inferior lobes 4–5 mm. long. *Stamens* 5, free; filaments linear, 2–3 mm. long; anthers oblong, 1 mm. long, minutely apiculate. *Ovary* ovoid, minutely pubescent with a very short dissepiment bearing c. 4 ovules; style glabrous, c. 3 mm. long; indusium slightly folded and curved, sprinkled with villous hairs on both surfaces, depressed-ovate when flattened, c. 2 mm. wide with a slightly curved orifice beset with short cilia. *Capsule* compressed-globular, c. 4 mm. diam., pubescent except for a minute glabrous mucro, 2-valved. *Seeds* orbicular, 4–5 mm. diam. incl. the broad (1 mm.) wing, light brown; body wrinkled, comma-like.

Range: Western Australia.

Habitat: Scrub, mallee and *Triodia* communities.

Chromosome number: 2n = 16. (Voucher specimens marked with an asterisk below.)

Typification: *V. rosea* S. Moore—*Holotype*—Inter Wilson's Pool et lac. Darlot inveni mens Apr. florentem, Spencer Moore (BM). *V. rosea* var. *erecta* Krause—*Holotype*—Murrin-Murrin, W. J. George (B, destroyed).

Discussion: This species differs from *V. paradoxa* and *V. glabrata* in the pink to purple corolla, the appendaged auricles, wrinkled seeds and 2-valved compressed capsule. The distinction between it and *V. cycnopotamica* is not quite so clear cut; the latter, however, has consistently smaller flowers and the corolla wings are narrower even in proportion to the body of the lobes. There seems no point in maintaining Krause's var. *erecta* since there are all intermediates between the typical form and Krause's description. Even Krause writes "Species nec non varietas incomplete nota".

Selected specimens examined: *Western Australia*: Camp 62, R. Helms, Elder Exped. 26.9.1891 (AD 96511018. MEL 9800. NSW 75638.K): Cow-

cowing, M. Koch, no. 1324, 9.1904 (AD 96511153. NSW 75638): Coolgardie Road c. 7 miles S.W. of Kalgoorlie, D. Kemsley, 12.9.1951 (MEL 9804): 19 miles N.N.E. of Kalgoorlie on Broad Arrow Rd., B. G. Briggs, 29.9.1960 (SYD. NSW 52433): 20 miles South of Menzies near Kalgoorlie, R. Carolin, no. 3036 14.8.1961 (SYD): Malcolm, C. A. Gardner no. 2480, 13. Aug. 1931 (PERTH): 19 miles North of Agnew on road to Wiluna, T. E. H. Aplin, no. 2365, 19.8.63 (PERTH): Laverton, J. H. Maiden, Sept. 1909 (NSW 75642. 75643): 28 m. N. of Payne's Find, A. S. George, no. 685, 15.4 1960 (PERTH): Yuin Stn. N.E. of Geraldton, W. J. Peacock, no. 60856.1, 15.8.1960 (SYD*): Old Bullardoo Station, W. J. Peacock, no. 60854.1, 16.8.1960 (SYD*): 3 miles E. of junction of Menzies-Mt. Magnet Rd., with rabbit proof fence no. 1, W. J. Peacock, no. 60872.2, 21.8.1960 (SYD*):

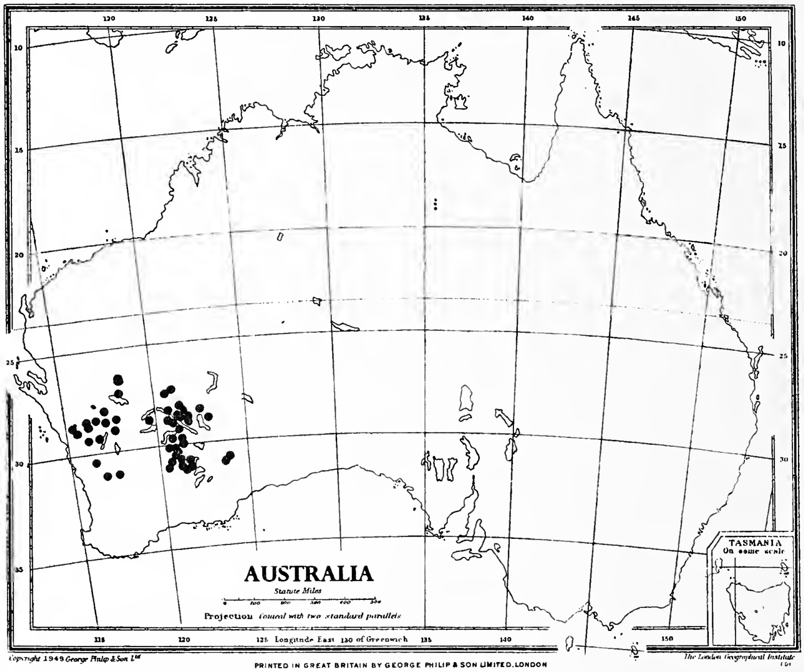

Fig. 6. Distribution of *V. rosea* (●).

9. V. CYCNOPOTAMICA F. Muell.

Fragm., 6:7(1867):Benth., *Fl. Austr.,* 4:48(1869):Robertson in *Black, Fl. S. Austr.,* ed. 2. 4:827(1957).

Annual herb with a thin tap root and very short narrow caulorrhiza. *Leaves* arranged in an ascending to prostrate rosette, oblong to narrow-obovate or spathulate in outline narrowing towards the base into a linear or filiform petiole, 2–6 cm. long (incl. petiole), 3–10 mm. wide, conspicuously dentate to lyrate-incised or almost pinnatifid towards the base, obtuse, sprinkled with scattered villous hairs on both surfaces and with some villous hairs in the axils. *Peduncles* ascending, up to 25 cm. tall, terete, slightly pubescent with short ± patent hairs or quite glabrous. *Bracteoles* free, pubescent and with villous hairs in the axils: lower ones very leafy, often deeply incised and toothed and ± auriculate towards the base, oblong or narrow-ovate, up to 15 mm. long and 7 mm. wide, acute; upper ones smaller and less incised and toothed. Central flowers on pedicels up to 2 cm. long. *Sepals* 5, free or united only at the very bottom, acute, sprinkled with antrorse hairs, on both surfaces, ciliate but otherwise entire: posterior ones oblong to narrow-elliptic,

c. 4 mm. long and 1·5 mm. wide; other ones scarcely shorter but slightly narrower. *Corolla* pink to white or bluish, 5–6 mm. long with an obscure anterior pouch, pubescent to almost glabrous on the outer surface, glabrous inside, enations absent, adnate to ovary to about mid-mark: tube 3 mm. long: superior lobes oblong to lanceolate c. 2 mm. long and almost 1 mm. wide, very narrowly winged with conspicuous auricles up to 1 mm. wide which are slightly barbulate and have a conspicuous membranous appendage: inferior ones oblong, 2 mm. long, 1 mm. wide with very narrow wings: connate part of inferior lobes c. 1 mm. long. *Stamens* 5, free; filaments filiform, 1–1·5 mm. long; anthers oblong, c. 0·5 mm. long, obtuse. *Ovary* globular, pubescent, with a very short dissepiment bearing c. 3 ovules: style glabrous, c. 1 mm. long: indusium incurved at the margins, straight, semi-orbicular, just less than 1 mm. long, with a few villous hairs especially on the inner surface and with a ± straight orifice beset with very short cilia. *Capsule* inflated-globular, c. 7 mm. diam., pubescent, 2-valved, each valve very rarely 2-fid (but see below!). *Seeds*, flat, orbicular, c. 3·5 mm. diam. incl. the broad wing (c. 1 mm. wide), the body wrinkled and distinctly comma-like.

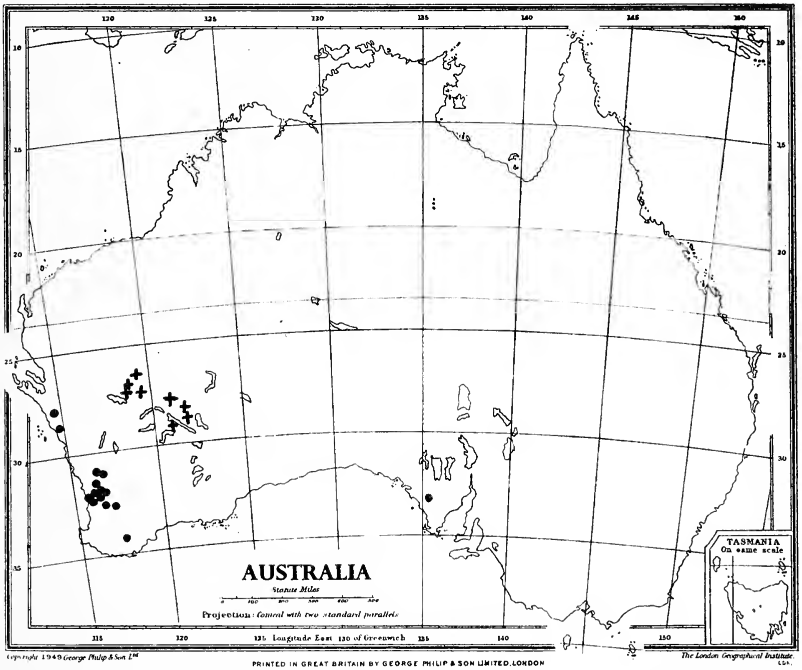

Fig. 7. Distribution of *V. cycnopotamica* (●) and *V. hispida* (+).

Range: South Western Province of Western Australia and South Australia.

Habitat: Waste places, cultivated land, open country in general.

Chromosome number: 2n = 16.

Typification: *V. cycnopotamica* F. Muell.—*Holotype*—Ad flumen cygnorum. Drummond no. 410 (MEL 9798)—*Isotypes*—(P.G).

Discussion: Differs from *V. rosea,* q.v., in the smaller corolla size and from *V. hispida,* q.v., most conspicuously in the pink to white rather than yellow petals.

Selected specimens examined: *South Australia*: Wudinna, C. W. Johns, no. 14, 1941 (AD 96511201). *Western Australia*: 8–10 miles east of Calingirie.

T. E. H. Aplin, no. 151, 10.9.1958 (PERTH) : Eastern sources of the Swan River, Alice Eaton, 1891 (MEL 9975) : Drummond no. 402 (K) : Wongan Hills, A. Morrison, no. 120, 13128 11.Oct.1903 (PERTH.K) : S. of Ogilvie, N. T. Burbidge no. 2170, 3.9.1947 (CANB 14541) : Corrigin, R. Carolin, no. 3142, 17.8.1961 (SYD) : Minginew, R. Carolin, no. 3404, 1.9.1961 (SYD) : 8 miles east of Mukinbadin on Bencubbin Rd. W. J. Peacock, no. 60812.1, 7.8.1960 (SYD*) : 1 mile east of Goomalling, W. J. Peacock no. 60817.1. 6.8.1960 (SYD*) : Northam-Perth, H. Salasoo no. 18, 11.9.1949 (NSW 75652).

10. V. HISPIDA W. V. Fitzg.

In *Journ. W.A. Nat. Hist. Soc.,* 1 : 25 (1904).

Annual herb with a narrow tap-root and almost no caulorrhiza. *Leaves* all basal, narrow-obovate to narrow-elliptic in outline tapering into a distinct linear petiole, 5–8 cm. long (incl. petiole), 10–18 mm. wide, lyrate-pinnate or deeply pinnately dissected to dentate, obtuse, pubescent, with some villous wool at the ± dilated base. *Peduncles* ascending up to 16 cm., pubescent, terete. *Bracteoles* often incised towards the slightly connate bases: lower ones narrow-ovate to ovate up to 2 cm. long and 5 mm. wide, pubescent to glabrescent, acute with very few short villous hairs in the axils: upper ones shorter and narrower. Central flowers on pedicels 1–3 cm. long. *Sepals* 5, scarcely connate at all, pubescent-villous on both surfaces, ciliate but entire, acute: posterior one ovate, 5 mm. long, 3 mm. wide; others slightly narrower but scarcely shorter. *Corolla* yellow, c. 8 mm. long with a short obscure anterior pocket, villous-pubescent outside, adnate to ovary to about 2/3rd. mark, almost quite glabrous inside with no enations: tube about 1 mm. long or less: superior lobes narrow-oblong-elliptic, 4 mm. long, 0·5 mm. wide ± conspicuously winged (c. 0·5 mm. wide) with distinct ± barbulate auricles, the wings widened above the auricles: inferior ones oblong to linear, 4–5 mm. long, 0·5 mm. wide, broadly (0·5 mm.) winged; connate part of inferior petals 3–4 mm. long. *Stamens* 5, free; filaments filiform, 1·5–2 mm. long: anthers sub-globular to short-oblong 0·5 mm. or less long. *Ovary* globular pubescent with a short dissepiment not reaching the mid-mark and bearing 6–8 ovules; style glabrous 1·5–2 mm. long; indusium broad-ovate, 0·5 mm. long, almost 1 mm. wide, ± folded, scarcely geniculate with a few hairs scattered on the back and a slightly curved orifice beset with short white bristles (c. 0·5 mm.) even shorter on the lower lip. *Capsule* slightly pubescent, globular, c. 5 mm. diam., scarcely compressed, ± equally 4-valved. *Seeds* brown, orbicular, c. 2·5 mm. diam. including the broad wing (c. 0·5 mm.), the body punctulate, comma-shaped.

Range: Salt Lake country of Western Australia.

Habitat: Unknown.

Chromosome number: Unknown.

Typification: *V. hispida* W. V. Fitzg.—*Holotype*—Nannine, W. V. Fitzgerald, Sept. 1903 (NSW 75661).

Discussion: This species differs from *V. cycnopotamica,* with which it has been consistently confused, in the punctulate seeds, 4-valved, scarcely compressed capsules, and yellow corolla with broader wings, adnate almost to the ovary summit. There is no separate appendage above the auricle, although the widening of the wing at this point is probably homologous with it, as in *V. paradoxa*.

Selected specimens examined: *Western Australia*: Meekatharra, 25 miles toward Wiluna, W. J. Peacock, no. 60866.3, 18.8.1960 (SYD) : Near Old Minnie creek H.S., E. of Laverton, A. S. George, no. 4656, July 13.1963 (PERTH) : Glenorie Station, Malcolm N. T. Burbidge, no. 272, Aug. 1938 (PERTH.K) : 13 miles South of Leonora on road to Menzies, T. E. H. Aplin, no. 2285, 17.8.1963 (PERTH): Tuckanarra, C. A. Gardner, no. 2278, 14 July 1931 (PERTH): Mt. Harris, 32 miles north of Agnew on road to Wiluna, T. E. H. Aplin, no. 2378, 19.8.1963 (PERTH): 24 miles N. of Standstone, A. S. George, no. 2656, 29th July, 1963 (PERTH).

11. V. ARGUTA R.Br.

Prodr., 580 (1810).

Taxonomic synonym: *Antherostylis calcarata* Gardner in *Journ. Roy. Soc. W. Austr.,* 19: 92 (1934).

Perennial herb with a stout tap-root and a thick (c. 5 mm.) strong, often branched, woody caulorrhiza covered with dead leaf bases. *Leaves* ascending from the caulorrhiza narrow-obovate to oblong-elliptic, tapering gradually towards the base into narrow petiole, 4–12 cm. long, up to 1 cm. wide, dentate (or rarely incised) with minutely acuminate teeth and usually terminated by an acute tooth, glabrous or almost so except for some short hairs in the axils. *Peduncles* ascending, terete, up to 40 cm. long, glabrous. *Bracteoles* free: lower one ovate to narrow-ovate, often deeply incised, up to 20 cm. long and 8 mm. wide, usually glabrous on the surface but with ± ciliate margin and with some villous hairs in the axils, acute, almost quite free; upper ones linear and shorter. Central flowers on pedicels 4–9 (rarely up to 20) cm. long. *Sepals* 5, free, scarcely cordate, glabrous or ± pubescent on outer surface especially towards the margin, covered with long villous hairs or almost glabrous on inner surface: posterior one oblong to narrow-ovate, 10–12 mm. long, 3–3·5 mm. wide: others narrower, c. 8 mm. long. *Corolla* yellow, frequently brownish towards the centre of each lobe, 12–20 mm. long with a prominent ± curved spur 3–6 mm. long, pubescent on outer surface, glabrous inside with a few obscure wrinkles towards the base: tube 5–6 mm. long: superior ones narrow-elliptic-oblong, falcate, 8–15 mm. long, 2 mm. wide narrowly (1–2 mm.) winged with a narrow ± barbulate auricle; the wing widening distinctly immediately above the auricle: inferior ones narrow-oblong, 8–15 mm. long, 2–3 mm. wide narrowly winged: connate part of inferior lobes 2–3·5 mm. long. *Stamens* 5: filaments linear, 4–5 mm. long and almost 1 mm. wide at the base: anthers narrow-oblong, c. 2·5 mm. long. *Ovary* ovoid, pubescent, dissepiment not reaching the mid-mark and bearing 10–16 ovules: style pubescent c. 3 mm. long: indusium folded, pubescent, oblong, 5–6 mm. long, 2–3·5 mm. wide with a very curved orifice beset with short white cilia or the upper lip glabrous: stigma scarcely lobed. *Capsule* ovoid, c. 9 mm. long, 6–8 mm. wide, densely pubescent but for a minute glabrous mucro, 4-valved but slightly unequally so. *Seeds* broad-elliptic, c. 4 mm. diameter including broad (2 mm.) wing; body almost smooth, long-acuminate towards the base.

Range: Drier parts of southern Australia from the Riverina in N.S.W. to S.W. Australia.

Habitat: Particularly on rocky outcrops in the drier areas.

Chromosome number: Unknown.

Typification: *V. arguta* R.Br.—*Holotype*—Base of the Mountains near Inlet no. XII South Coast. R. Brown (Bennett's no. 2548) BM. *Antherostylis calcarata* Gardner—*Holotype*—Jununa Rocks, C. A. Gardner, no. 2909, 24. Oct. 1931 (PERTH) *Isotype* (K).

Discussion: This has been confused with *V. paradoxa* in the past. It differs from that species in the higher indusium length-breadth ratio, i.e., 1.7–2·1, the ± equal brownish corolla lobes and the less hairy leaves; the eastern specimens differ from the western ones in having a glabrous upper lip to the indusium with the Eucla specimens being intermediate in this respect.

Selected specimens examined: *New South Wales*: Murrumbidgee River, G. Day, 1878 (MEL 9988) : Barrier Range, Corona Station, Marjorie Collins, 9.1921 (SYD) : Near Silverton, Mrs. Irvine, 8.1889 (MEL 10013) : Broken Hill, E. C. Andrews, 12.1917 (NSW 78428) : *Victoria*: Dimboola, H. E. D'Alton, 1901 (NSW 78425) : *South Australia*: Nat. Park, Belair, O. E. Menzel, Oct. 1896 (AD 96511014 *pro parte*) : Lower Murray Scrub, Rev. W. Schwarz, 1890 (MEL 9955) : Flinders Range, M. Koch, no. 583, 10.1901 (NSW 78424) : Wirrulla, ex. Herb. J. M. Black (AD 96511130) : Ooldea, Mrs. Bates, 2.5.1921 ex Herb. J. M. Black (AD 96511026) : *Western Australia*: Eucla to Madura, R. Carolin, 27.8.1963 (SYD) : About 1 mile west of Cocklebiddy, A. R. Main, 29.Aug.1955 (PERTH) : Near Mt. Rugged, Miss Brookes, 1889 (MEL 10001).

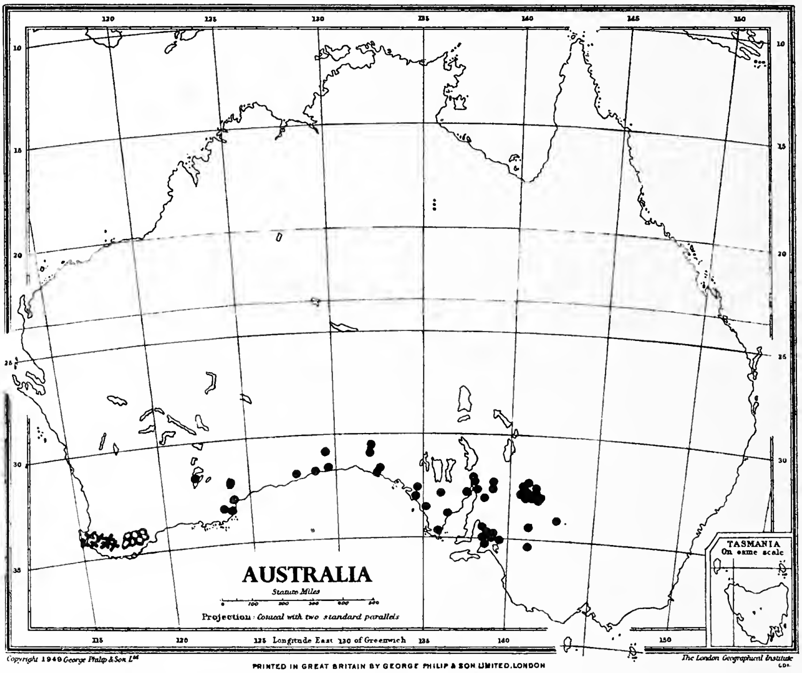

Fig. 8. Distribution of *V. arguta* (●), *V. macrophylla* (X) and *V. foliosa* (O).

12. V. PARADOXA R. Br.

Prodr., 580(1810) : *Bot Reg.*, t 971(1826) : DC. *Prodr.*, 7:518(1839) : De Vriese, *Gooden.*, 172(1854) : Hook. f., *Fl. Tasm.*, 1:233(1855) : Benth., *Fl. Austr.*, 4:48(1869) : Moore et Betche, *Hdbk. Fl. N.S.W.*, 309(1893) : Bailey, *Qld. Fl.*, 3:893(1900) : Rodway, *Tasm. Fl.*, 101(1903) : Krause in *Pflrch.*, 54:35 (1912) : Ewart, *Fl. Vict.*, 1067(1931) : Robertson in *Black. Fl. S. Austr.*, ed. 2, 4:827(1957) : Curtis, *Stud. Fl. Tasm.*, 2:398(1963).

Taxonomic synonym: *V. paradoxa* var. *stenoptera* F. Muell. ex. Benth., *Fl. Austr.*, 4:48 (1869) : Krause in *Pflrch.*, 54:37 (1912).

Perennial herb with a stout tap root and very short, frequently branched stems usually covered with dead leaf bases. *Leaves* erect or ascending, narrow-obovate to oblong or elliptic and gradually narrowing into a long-linear petiole 1–15 cm. long, 7–25 cm. long incl. petiole, 15–30 mm. wide, dentate to almost entire, obtuse ± glabrescent on both surfaces except for midribs, ciliate at the margins, with scarcely any wool in the axils. *Peduncles* erect or ascending or rarely decumbent, terete, 10–40 cm. tall, pubescent with simple mostly patent hairs. *Bracteoles* free: lower ones oblong to ovate, frequently deeply dentate even to appear 2-fid, up to 3 cm. long and 6 mm. wide, but usually shorter, ± pubescent especially so on the under-surface and on the midrib, ciliate, obtuse, with short axillary hairs. Central flowers on pedicels up to 10 cm. long. *Sepals* 5, free, pubescent on both surfaces but more so on inner surface, ciliate, entire: posterior sepal ovate to oblong, 4–9 mm. long, 1·5–3·5 mm. wide, acute: lateral ones narrower and slightly shorter. *Corolla* yellow, 10–20 mm. long with an anterior spur up to 7·5 mm. long or reduced to an obscure pocket, pubescent outside, glabrous or nearly so inside with no enations, adnate to the ovary up to 1/3rd of the length of ovary: tube 3–5 mm. long: superior lobes narrow-oblong, falcate, 5–13 mm. long, up to 2 mm. wide with obscurely dentate lateral wings up to 3 mm. wide and well developed slightly barbulate auricles up to 3·5 mm. wide; the wings distinctly broader just above the auricles: inferior lobes up to 10 cm. long and 3 mm. wide with broad lateral wings; connate part of inferior lobes to 4–5 mm. long. *Stamens* 5: filaments linear 3–5 mm. long: anthers narrow-oblong, 2·5–3 mm. long: connective obtuse. *Ovary* ovoid, pubescent with a dissepiment reaching to about $\frac{1}{4}$-mark and bearing 8–14 ovules; style glabrous or with a few scattered hairs, 3–6 mm. long: indusium pubescent, folded, ovate when flattened out, 3–6 mm. long, 2–4 mm. wide with a curved orifice beset with minute cilia: stigma scarcely lobed. *Capsule* ovoid, sometimes ± compressed, up to 9 mm. long, and 5 mm. diam., densely pubescent but for a minute glabrous mucro, 4-valved although sometimes unequally so. *Seeds* flat, orbicular, 3–5 mm. diam., incl. wing, brown, the wing from almost obsolete to 1 mm. diam.

Range: Southern Australia, from Eyre Peninsula eastwards and northwards into southern Queensland and southwards into Tasmania.

Habitat: Grasslands and woodlands.

Chromosome number: n = 8.

Typification: *V. paradoxa* R.Br.—*Lectotype*—Cow Pasture Plains, 1803 Oct., R. Brown (BM): *Isotypes*—(K. NSW 78419.BRI 058738). Brown gives specimens from three localities with his original description but two of these specimens have entire leaves. The one with dentate leaves is selected here since the description states "foliis obtus dentatis". *V. paradoxa* var. *stenoptera* F. Muell. ex Benth. syntypes—Bentham cites no actual specimens but says "to this belong the Queensland and the New England and Richmond River specimens". Several specimens agreeing with his description come from this region.

Discussion: A very widespread species which shows some considerable variation but it is rather difficult to define this variation in terms of the taxonomic hierarchy at present. In addition to what appears to be a gradual decrease in the size of seed-wing towards the north, there are some fleshy-leaved maritime forms in southern Queensland and northern New South Wales.

Selected specimens examined: *Queensland*: North Baffle Creek, Port Curtis Distr., Miss W. M. Peterson, 10.1930 (BRI 058733): Timba, plains of the Condamine, Leichhardt (MEL 9859): Darling Downs between Cambooya and Clifton, C. T. White, no. 12663, 19.10.1944 (BRI 1058730): Texas, J. L. Boorman, 9.1910 (NSW 78414): *New South Wales*: New England, Rev. R. Collie, 1886 (MEL 9980): Armidale, Mrs. Consett Davis, no. 142, 9.Jan.1941 (NSW 78447): North of Ulan. W. J. Peacock, no. 6111.8.1, Nov. 1961 (SYD*): Salisbury Plains, New England, R. W. Jessup and M. Gray, no. 3033, 12.1954 (CANB 94138, NSW 78452): Warrumbungle Ranges, W. Forsyth, 10.1901 (NSW 78463): 70 miles west of Cobar, P. Brough and N. C. Beadle, 24.8.1939 (SYD): 12 miles south of Dubbo, W. J. Peacock no. 6110.11.2, Oct. 1921 (SYD*): Sydney, Mosman, no. 167 (BRI 058779): Jenolan Caves, W. F. Blakely, 12.1899 (NSW 78444): Wagga, J. J. Fletcher, 5.1.1891 (NSW 78459): Braidwood District, W. Bäuerlen, no. 382, Jan. 1885 (MEL 9949): Kosciusko below Sawpit Creek, J. McLuckie and A. H. K. Petrie, Jan. 1925 (SYD. CANB

8192). Delegate, Howitt, no. 574, 1883 (MEL 9933). *Australian Capital Territory*: Gudgenby, R. H. Cambage, no. 3392, 14.1.1912 (NSW 78440): 1 mile north of Dingo Dell Flats, P. Darbyshire, no. 46, 7. Dec. 1960 (CANB 86032. NSW 78434.K): *Victoria*: Mansfield, R. A. Black, no. 587.000(2), 13.1.1940 (MEL 9901): Wimmera, Dallachy (MEL 9876.K): Omeo, C. Allen ex Herb. Morris, 1920 (ADW 15000): Laverton, Helen I. Aston, no. 835, 16.10.1962 (BRI 055998). *Tasmania*: New Town, D. Spicer, Jan. 23. 1876 (K): Launceston, F. A. Rodway, 12.1915 (NSW 78420): Gunn, no. 46 (K): *South Australia*: Naracoorte, E. H. Ising, 26.10.1933 (AD 96511008): Mt. Lofty Ranges, M. Koch, no. 583, 9.1902 (NSW 78404): Blackwood, J. M. Black, 20.10.1913 (AD 96511132).

13. V. GLABRATA, sp. nov.

Herba annua radice principali tenui et caule brevissimo. Folia lyrata vel dentata. Pedunculi erecti vel ascendentes usque ad 4–20 cm., admodum vel fere glabri. Bracteolae dentatae vel profunde incisae. Sepala 5, libera, postice glabra. Corolla flava 12–14 mm. longa ± calcarata, lobi antici parte connato partem liberum aequanti vel paulo superanti. Indusium depresse ovatum. Ala seminis lata.

Annual herb with thin tap-root and very short, only slightly branched stem. *Leaves* ascending, lyrate-incised or deeply dentate becoming less so towards the apex, oblong or narrow-obovate in outline but narrowing ± gradually into a linear petiole 1·5–4 cm. long; the whole leaf 4–8 cm. long, up to 1 cm. wide, usually obtuse, glabrous or sprinkled with a few short hairs and frequently ciliate with some short villous hairs in the axils. *Peduncles* erect or ascending, 4–20 cm. tall, quite glabrous or with a few long villous hairs, terete. *Bracteoles*: lower ones ovate to lanceolate, frequently dentate and even deeply incised to appear 2– or more –fid, 8–20 mm. long, up to 4 mm. wide, acute, glabrous or with a few scattered hairs, connate basally into a tube or funnel scarcely 2 mm. long: upper ones linear, smaller scarcely incised: central flowers on pedicels 8–20 mm. long. *Sepals* 5, scarcely connate; posterior one ovate to broad-elliptic, 5–6 mm. long, c. 3 mm. wide, acute, glabrous on the outer surface, and with a few antrorse hairs on the inner surface, entire or rarely dentate towards the base; lateral ones narrow-ovate c. 1 mm. wide, slightly shorter than posterior petal. *Corolla* yellow, 12–14 mm. long with an obscure anterior pocket or a spur up to 2·5 mm. long, adnate to the ovary to c. the mid-mark, pubescent on outer surface, villous towards the base on the inner surface, without enations: tube 2·5–3·5 mm. long: superior lobes oblong-narrow-obovate 6–8 mm. long, 2 mm. wide, broadly (2 mm. wide) winged with prominent slightly barbulate auricles; the wings broadened just above the auricle: inferior lobes elliptic-oblong; connate part of inferior lobes 4–6·5 mm. long. *Stamens* 5: filaments linear, c. 2 mm. long; anthers narrow-oblong to linear, c. 1·5 mm. long, obtuse. *Ovary* ovoid, minutely pubescent, dissepiment very short bearing c. 6–12 ovules: style ± pubescent, c. 4 mm. long: indusium folded, very depressed-ovate when flattened, ± villous especially towards the base, c. 2 mm. long, 3 mm. wide with a slightly curved orifice beset with small cilia. *Capsule* subglobular, sometimes ± compressed, c. 5 mm. diam., shortly pubescent, surmounted by a minute mucro, ± equally 4-valved. *Seeds* flat, orbicular, 4·5 mm. diam. including the broad (1 mm.) wing, brown, punctulate.

Range: The drier parts of southern Australia.

Habitat: Scrubs and open desert communities.

Chromosome number: Unknown.

Typification: Urumburi, South of Thargomindah, Queensland. R. C. Carolin, no. 4080, 16.Aug.1964 (NSW 100797).

Discussion: This species has previously been included with *V. paradoxa* R.Br. It differs from this latter species in the glabrous, or nearly so, peduncles; the lyrate-incised leaves; the shorter indusium with a ratio of length to breadth of c. 1; the longer connate region of the inferior corolla lobes and, consequently, shorter inferior corolla lobes themselves. In almost all the specimens from Western Australia the spur is reduced to an obscure pocket.

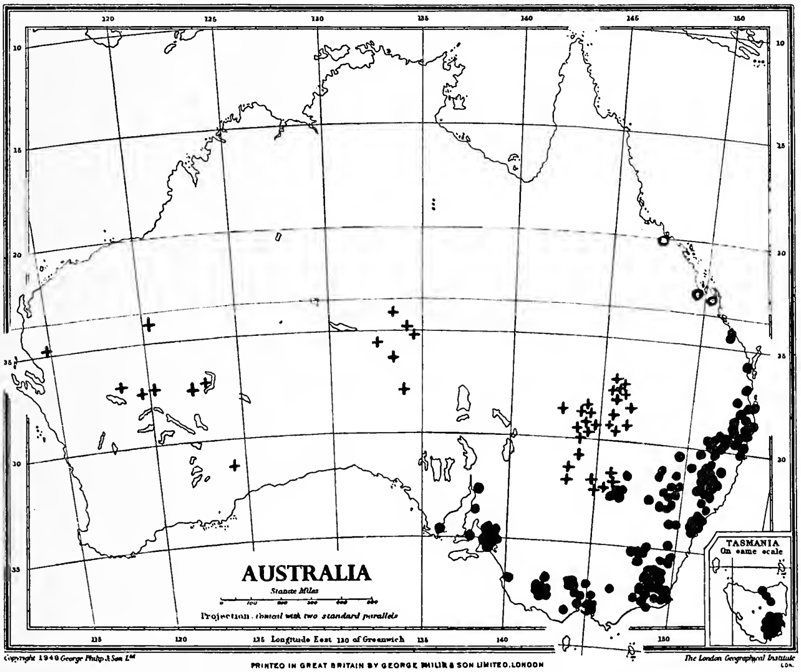

Fig. 9. Distribution of *V. glabrata* (●), *V. paradoxa* (+) and *V. pubescens* (O).

Selected specimens examined: *Queensland*: Charleville, E. W. Bick, Dec. 1916 (BRI 058737. NSW 78400): Gilruth Plains near Cunnamulla, S. L. Everist, no. 1641, 17.9.1938 (BRI 058822): Nockatunga, R. Carolin, no. 4162, 17.8.1964 (SYD): Thargomindah, R. Carolin, no. 4067, 16.8.1964 (SYD): Boorera Station north of Hungerford, R. Carolin, no. 4051, 15.8.1964 (SYD). *New South Wales*: Coolabah, J. H. Maiden and J. L. Boorman, 12.1908 (NSW 78480. SYD): White Cliffs, J. Farrell, 7.1914 (NSW 78482): Mt. Drysdale, N. C. Beadle, 2.1921 (SYD): *South Australia*: c. 30 miles N.W. Woomera, F. L. Hill, no. 18, 1.9.1953 (CANB 31667. BM): *Western Australia*: Sandstone Rd. 60 miles from Wiluna, F. M. Bennett, July 1941 (PERTH): 6 miles South of Meekatharra, C. A. Gardner, no. 2302, 15. July, 1931 (PERTH). *Northern Territory*: Charlotte Waters, O. Schwartz, 1889 (MEL 9997): 3–6 miles west of Curtin Springs H. S., G. Chippendale, 12.9.1956 (NT 2860. NSW 78402. CANB 38636).

Section Velleia

Sepals 3, free or only shortly connate: seeds with thickened rim but scarcely winged.

Synonyms: *Velleiae verae* R.Br. Prodr. 580(1810): De Vriese, Gooden. 173(1854). Sect. *Trisepala* Krause in Pflrch., 54:28(1912).

Typification: sect. Velleia—*Holotype*—*V. lyrata* R.Br. *Velleiae verae*—*Lectotype*—*V. lyrata* R.Br. sect *Trisepala* Krause—*Lectotype*—*V. lyrata* R.Br.

14. V. LYRATA R.Br.

Prodr., 580(1810): Hook., *Exot. Fl.,* t.24(1823): *Bot. Reg.,* t.551: DC. *Prodr.,* 7:518(1839): De Vriese, *Gooden.,* 173(1854): Benth., *Fl. Austr.,* 4:49(1869): Moore et Betche, *Hdbk. Fl. N.S.W.,* 310(1893): Krause in *Pflrch.,* 54:29(1912).

Misapplied name: *V. spathulata* sensu Juss. et Rich., in *Ann. Mus. Par.,* 18:17, t.4(1811) non R.Br.

Perennial herb with tap roots and a short, thick caulorrhiza covered with dead leaf-bases. *Leaves* ascending to prostrate, towards the summit of the caulorrhiza, obovate to narrow-obovate-elliptic, narrowing gradually towards the base into a linear petiole, 3–18 cm. long (incl. petiole) 1–4 cm. wide, thick, pinnatifid-lyrate or serrate at the base becoming dentate towards the apex and each lobe frequently dentate, obtuse, quite glabrous or nearly so except for some villous wool in the axils. *Peduncles* ascending to erect, up to 50 cm. tall, terete, glabrous except for some villous wool in the axils of the bracts. *Bracteoles* free, or connate at extreme base, ovate-elliptic to linear, entire or minutely dentate, glabrous; lower ones 4–15 cm. long, 1–4 mm. wide: upper ones smaller and narrower. Centre flowers on pedicels 5–15 mm. long. *Sepals* 3, completely free or nearly so, cordate, glabrous outside, villous inside or rarely quite glabrous, entire or with a few narrow teeth towards the base, acute: posterior one very distinctly cordate at the base, broad-ovate to narrow ovate, 4–8 mm. long, 2–8 mm. wide; lateral ones narrower. *Corolla* yellow with an obscure anterior pocket, sparsely to densely pubescent outside but for the wings, slightly pubescent or villous inside, adnate to the ovary to just above the midmark: tube 3–4 mm. long: superior lobes narrow-obovate, 4–8 mm. long, 1–2 mm. wide, broadly (1 mm. wide) winged with prominent auricles c. 1 mm. wide which are barbulate on the margin: inferior lobes 3–6 mm. long, 1–2 mm. wide, also broadly winged; connate part of inferior lobes 3–5 mm. long with small enations. *Stamens* 5: filaments narrow-linear, 2–3 mm. long: anthers linear, 1–2 mm. long, obtuse. *Ovary* ovoid to globular, pubescent in upper part with a dissepiment reaching the mid-mark bearing 4–10 ovules: style 2–4 mm. long with scattered villous hairs: indusium ± erect, slightly folded with villous hairs on both surfaces, very-broad-ovate, 1–2 mm. wide with a slightly curved orifice beset with prominent white bristles. *Capsule* ovoid to sub-globular, 3–6 mm. diam., glabrous or pubescent, ± equally 4-valved. *Seeds* flat orbicular to elliptic, 1–2·5 mm. wide, minutely punctulate, surrounded by a very narrow rim.

Range: Central coast of N.S.W.

Habitat: Swamps and other wet sites on sandstone.

Chromosome number: n = 8.

Discussion: Distinguished from *V. spathulata* by the glabrous peduncles and the cordate posterior sepal and from *V. parvisepta* by free, cordate sepals.

Hamilton (*Austr. Nat.,* 2:212(1913)) noted that specimens of "*V. spathulata*" from National Park were quite different from those occurring at Narrabeen. In fact the National Park specimens are a form of *V. lyrata* with shorter corolla, narrower posterior sepal and fewer (4) ovules per ovary. All these characters, however, appear to intergrade with those of the typical form and consequently it does not seem appropriate to raise this variation to taxonomic rank. A specimen from the Clarence River (NSW 75585) is placed in this species but the pedicels are definitely pubescent and in its narrower sepals and leafy basal bracts it shows some resemblance to *V. macrocalyx.*

Typification: *V. lyrata Lectotype*—South Head of Port Jackson, R. Brown 1803 (BM)—*Isotype* (P).

Selected specimens examined: *New South Wales*. Mangrove Mt., K. Mair, 22.1.1948 (NSW 5247): Wondabyne, W. F. Blakely and D. W. C. Shiress, 9.1923 (NSW 75699): Mt. White, W. J. Peacock, 5.11.1958 (SYD*): Bowen's Creek, R. Carolin, 20 Nov. 1958 (SYD): Glenbrook, H. S. McKee, no. 6751, 4.1.1959 (SYD): Manly, J. J. Fletcher, Nov. 3 1889 (NSW 75698): Middle Head, J. H. Forrest, Aug. 1892 (BRI 058821): Woolloomooloo, A. Cunningham, Jan. 3 1817 (BM): Sutherland, O. D. Evans, 8.1914 (SYD): Waterfall, A. A. Hamilton, 6.1914 (NSW 75668): Sublime Point, G. Rodway, no. 1336, 22.4. 1934 (NSW 75667): National Park, A. A. Hamilton, March 1900 (NSW 75669).

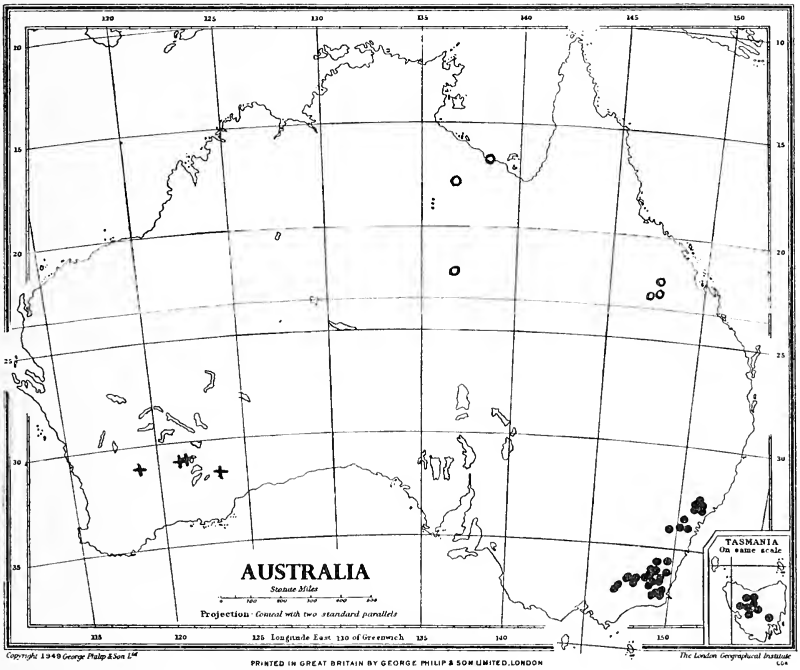

Fig. 10. Distribution of *V. macrocalyx* (O), *V. montana* (●) and *V. daviesii* (+).

15. V. PARVISEPTA, sp. nov.

Herba perennis. Folia dentata glabra. Bracteolae lineares vel leneari-angusto-ovatae. Sepala 3 connata basin versus, extus glabra, elliptica. Corolla flava, 8–12 mm. longa sacco brevi antico: lobi antici parte connato partem liberum plus minusve aequanti. Indusium depresse ovatum vel fere semicirculare. Semina margine angusto.

Perennial herb with a strong tap-root and caulorrhiza covered with dead leaf-bases. *Leaves* arranged in an ascending basal cluster or rosette, narrow-obovate-elliptic narrowing very gradually into a linear ± concave petiole with a broad base, 8–15 cm. long, 8–20 mm. wide, thick, dentate to shallowly incised, acute or obtuse, glabrous except for a few axillary hairs. *Peduncles* erect or ascending up to 40 cm. tall, glabrous, smooth. *Bracteoles* free or very shortly connate at the base, linear to linear-narrow-obovate, up to 10 mm. long and 2 mm. wide, acute, entire, glabrous but for some axillary villous hairs. *Sepals* 3, free except right at the base, not cordate at the base, glabrous outside but villous-pubescent inside, entire: posterior one elliptic to elliptic-oblong, 7–8 mm. long, 2–3 mm. wide, acute to acuminate: anterior-lateral ones narrow-elliptic, 6 mm. long, 1·5 mm. wide. *Corolla* yellow, 8–12 mm. long with a short anterior pouch, adnate to the ovary usually above the mid-mark, pubescent outside but for the lateral wings, glabrous or nearly so inside with distinct enations: tube 2–3 mm. long: superior lobes falcate-narrow-obovate, 4–5 mm. long, 1·5 mm. wide, broadly (2 mm.) winged with prominent barbulate auricles: inferior ones narrow-ovate, 4 mm. long, 1·5 mm. wide, broadly winged; connate part of inferior lobes 3 mm. long. *Stamens* 5: filaments linear, 2 mm. long; anthers oblong, 1 mm. long, minutely apiculate. *Ovary* globular to ovoid, glabrous or nearly so with a very short dissepiment bearing 6–8 ovules: style c. 2 mm. long, covered with scattered villous hairs especially towards the top: indusium depressed-ovate to almost semi-circular, c. 1 mm. wide, villous, incurved to folded with a ± curved orifice beset with long white bristles on the upper lip becoming shorter at the sides and on the lower lip. *Capsule* sub-globular, 4–5 mm. diam., glabrous with a minute mucro, 4-valved to the base. *Seeds* pale-brown, orbicular, 2 mm. diam. with a narrow mucilaginous margin.

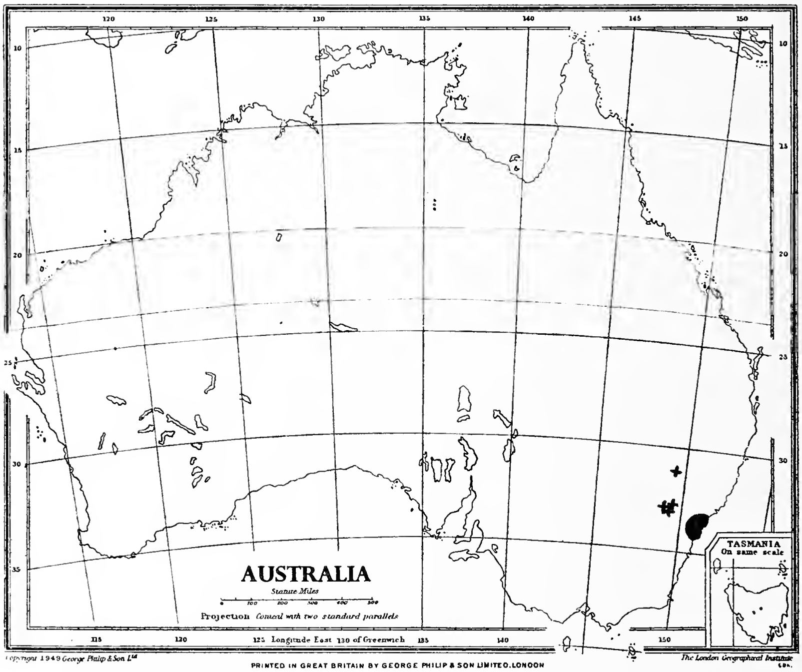

Fig. 11. Distribution of *V. lyrata* (●) and *V. parvisepta* (+).

Range: Western Slopes of N.S.W.

Habitat: Forests and woodlands, mostly on sandy soils.

Chromosome number: Unknown.

Typification: *Holotype*—Dubbo, J. Peacock, 8.11.1960 (NSW100660).

Discussion: Differs from *V. spathulata* in the glabrous peduncles and pedicels, narrower leaves, distinctly barbulate auricles and the very short dissepiment. It also shows similarities with *V. lyrata* from which it is readily distinguished by the cordate, wider sepals of the latter.

Specimens examined: *New South Wales*: Goonoo Forest, Eumungerie, G. Chippendale and E. Constable, 26.9.1951 (NSW 17367): Goonoo Forest, A. G. Graham, 24.1.1959 (NSW 75710) Warrumbungle Ranges. W. Forsyth, Oct. 1901 (NSW 75696).

16. V. SPATHULATA R.Br.

Prodr., 580(1810): DC. *Prodr.*, 7:518(1839): De Vriese, *Gooden.*, 174 (1854): Benth., *Fl. Austr.*, 4:50(1869): Moore et Betche., *Hdbk. Fl. N.S.W.*, 310(1893) :Bailey, *Qld. Fl.*, 3:894(1900); Krause in *Pflrch.*, 54:29(1912): Merrill et Perry in *Journ. Arn. Arb.*, 22:387(1941) :van Steenis in *Blumea*, 7:597(1954): Leenhouts in *Fl. Males.*, 5:336(1957).

Perennial herb with a thin tap root and a conspicuous caulorrhiza covered with dead leaf-bases up to 1 cm. thick and 3 cm. long. *Leaves* arranged in a spreading or prostrate rosette, thick and often fleshy, narrow-obovate to obovate narrowing very gradually into a broad petiole up to 10 cm. long (incl. the petiole), 0·5–2·5 cm. wide, entire sinuate or with short blunt teeth, obtuse, glabrous or glabrescent with some pale brown villous hairs in the axils. *Peduncles* prostrate to weakly ascending, 7–25 cm. long, terete with retrorse-appressed or reflexed ± villous hairs. *Bracteoles free*: lower ones narrow-ovate or elliptic to linear up to 12 mm. long and 3 mm. wide, acute to obtuse, glabrous with a few villous hairs in the axils. Centre flowers on pedicels 5 cm. long. *Sepals* 3, free, cordate or scarcely so, acute or even slightly acuminate, entire or with a few blunt teeth towards the base, glabrous or glabrescent on the outer surface, ± densely covered with appressed villous hairs on the inner surface especially towards the top: posterior ones ovate or narrow-ovate to oblong, 4–7 mm. long, 2–3 mm. wide: lateral ones narrower and slightly shorter. *Corolla* yellow often with brownish-purple markings and a short anterior pocket, pubescent on the outside but for the wings, adnate to the ovary up to the mid-point or further: tube 2 mm. long: superior lobes falcate-narrow-ovate, 4–6 mm. long, 1–2 mm. wide, broadly (c. 1 mm. wide) winged with prominent auricles c. 1 mm. wide which are minutely ciliate at the margin: inferior lobes ovate to elliptic, 2–4 mm. long, c. 1 mm. wide with broad (1 mm.) lateral wings; connate part of inferior lobes 2–3·5 mm. long with some small enations. *Stamens* 5: filaments linear-filiform, c. 2 mm. long; anthers oblong, c. 1 mm. long with a minute incurved mucro. *Ovary* ovoid, minutely pubescent with a dissepiment reaching to mid-mark and bearing 18–24 ovules: indusium slightly curved and slightly folded with a few short scattered hairs, semi-orbicular, c. 1 mm. long and 1 mm. wide with a ± curved orifice bearing on the upper lip short cilia: stigma 2-lobed. *Capsule* ovoid, c. 4 mm. long, acute or slightly acuminate, ± equally 4-valved, almost glabrous. *Seeds* flat, orbicular, 1·5 mm. diam., minutely punctulate with scarcely any rim at all.

Range: Eastern coast of Australia from Port Jackson northwards and into Western Division of Papua and the Louisiade Archipelago.

Habitat: Damp soil, mostly sandy.

Chromosome number: n = 8.

Typification: There are two sheets in K from R.Br.'s Collection: one bears two R.Br. collections but is labelled only with Bennett's labels: "Shoal Water Bay" and "Newcastle". The other is mounted on the same sheet as "Brisbane River, Ferd. Mueller, Dec. 1856" and is labelled with one of Brown's own labels "Newcastle District" and "Keppil Bay Port I and c". The R.Br. material in BM is mounted all on the same sheet. The uppermost collection, is herewith selected as the lectotype. *Lectotype*—R. Brown, Kingstown, Newcastle, Oct.-Nov. 1804 (BM) *Isotype*: MEL 9776 (pro parte).

Discussion: This species can be distinguished from *V. lyrata* by the narrower sepals and the appressed villous hairs on the peduncles and pedicels. It differs from *V. pubescens* principally in the indumentum of the peduncle and pedicel of the latter the hairs of which are pubescent and spreading.

Selected specimens examined: *Papua*: Joe Landing, Sudest Isl. L. J. Brass, no. 27757, 19 Aug. 1956 (CANB 56768. K.L.): Dagura, Orioma River, Western Division, L. J. Brass, no. 5931, Feb.–March 1934 (K.L.). *Queensland*: Cape York Peninsula, W. Hann, no. 263 and 264, Dec. 1873 (K): Endeavour River, Allan Cunningham, no. 19, 1820 (BM): Atherton, E. Betche, 8.1901 (NSW 75691); Elimbah, H. S. McKee, no. 9734, 4.12.1962 (CANB 118014. NSW 75685): Port Douglas, Dr. Lucas (MEL 9792): Hinchinbrook Island, J. Dallachy, 9 Nov. 1847 (MEL 9784): Rockhampton, A. Thozet, 1875 (MEL 9773): Fraser Island, F. C. Epps, no. 137, June 1919 (BRI 058766): Caboolture, R. Carolin, no. 569, 15.5.1958 (SYD): Coolum Beach, Moreton Distr., M. S. Clemens, 4 April 1945: (K) 10 miles N. of Southport, J. Peacock, no. 611.22.3, 21.1.1961 (SYD*): *New South Wales*: Barcoonger State Forest, W. J. Peacock, no. 6012.2.4, 10.12.1960 (SYD*): Port Macquarie, J. L. Boorman, June 1915 (SYD): ½ mile from Pacific Highway on Budgewoi Rd., W. J. Peacock, no. 611.24.2, 31.1.1961 (SYD*): Narrabeen Swamps, A. A. Hamilton, 4.1901 (NSW 75670).

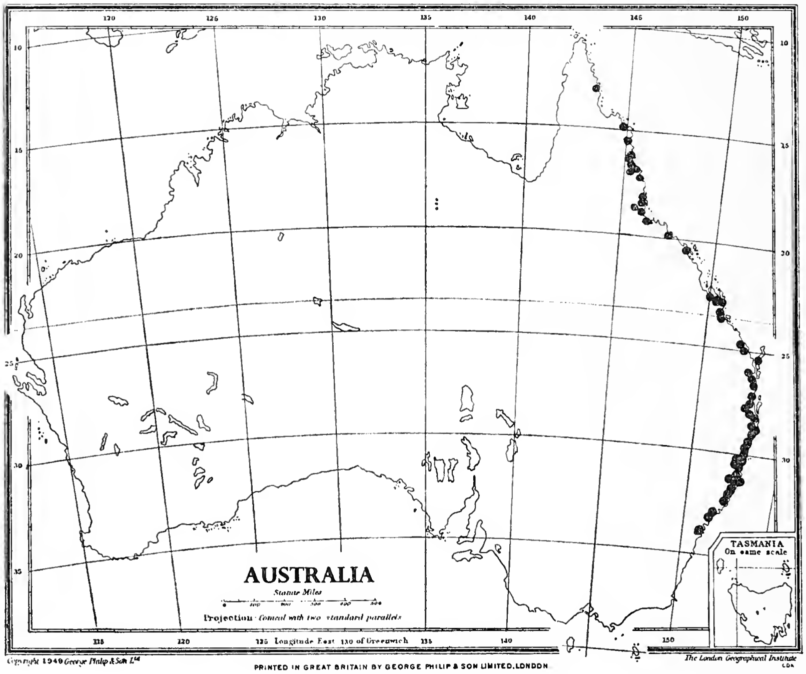

Fig. 12. Distribution of *V. spathulata* (●).

17. V. PUBESCENS R.Br.

Prodr., 581 (1810): D.C., *Prodr.*, 7: 518 (1839): Benth., *Fl. Austr.*, 4: 50 (1869): Bailey, *Qld. Fl.*, 3894 (1900): Krause in *Pflrch.*, 54: 31 (1912).

Perennial herb with a thin tap root and conspicuous caulorrhiza covered with dead leaf-bases. *Leaves* arranged in a spreading rosette, elliptic to narrow-obovate, narrowing gradually into a short petiole 5–12 cm. long, (incl. petiole) 12–25 mm. wide, shortly dentate, obtuse, pubescent with simple hairs especially on lower surface and with some long white villous wool in the axils. *Peduncles* ascending to decumbent, up to 15 cm. tall, pubescent with short simple patent hairs. *Bracteoles* free; lower ones oblong-elliptic to narrow-oblanceolate, up to 3 cm. long and 10 mm. wide, dentate, pubescent, ± acute with some villous wool in the axils: upper ones becoming smaller and narrower. Centre flowers on pedicels 5–20 mm. long. *Sepals* 3, free;

sometimes slightly cordate, pubescent with spreading hairs on outer surface and ± appressed ones on inner surface, acute to obtuse, entire or with a few blunt teeth towards the base: posterior one ovate-elliptic, 6·5–11 mm. long, 4–7 mm. wide: lateral ones narrower. *Corolla* yellow with a short anterior pocket, pubescent outside but for the wings, adnate to the ovary to just below the mid-mark: tube 3 mm. long: superior lobes narrow-oblanceolate, 5–15 mm. long, 1–2 mm. wide, broadly (c. 1 mm. wide) winged with prominent auricles c. 1 mm. wide which are sparsely barbulate on the margin: inferior lobes narrow-elliptic, 2·5–5 mm. long, 1–2 mm. wide with broad (1 mm. wide) lateral wings: connate part of inferior lobes 3·5–6 mm. long with some small enations. *Stamens* 5: filaments linear-filiform 2–4 mm. long: anthers narrow-oblong c. 1 mm. long, minutely apiculate. *Ovary* ovoid, pubescent with a dissepiment reaching to about the mid-mark and bearing c. 20 ovules: style 5–7 mm. long with scattered villous hairs: indusium depressed-obovate, slightly folded and curved covered with scattered ± appressed hairs and with a curved orifice bearing short (c. 0·3 mm.) cilia. *Capsule* sub-globular to ovoid, 4–6 mm. diam., minutely pubescent or glabrous above, 4-valved. *Seeds* flat, orbicular to elliptic, c. 2 mm. diam., punctulate with scarcely any rim at all.

Range: Tropical Queensland, east of the Divide.

Habitat: Unknown.

Chromosome number: Unknown.

Typification: There are two sheets of R.Br. material at K, both labelled "East Coast, Shoalwater Bay and Broad Sounds". Also an extremely pubescent specimen "Burdekin riv. Dallachy Herb. F. Mueller" "Velleya abessam F. Muel."! At BM two gatherings are mounted on the same sheet in such a manner that it is impossible to decide which label applies to which specimen. Fortunately there seems little doubt that they are conspecific. *Syntypes*: Shoalwater Bay, R. Brown no. 87 et Shoalwater Bay, Thirsty Sound, Broad Sound, R. Brown, same number (BM): *Isotypes* (P. MEL 9796).

Discussion: This species is very similar to *V. spathulata*. However, the pubescent leaves and calyx, the generally broader posterior sepal and the longer more oblong indusium serve to distinguish it. The illustration of the corolla in Krause is misleading since the wings are shown as being very narrow. This is not the case although in herbarium specimens these wings are frequently eaten by insects.

Selected specimens examined: *Queensland.* Bay of Inlets, Banks and Solander, 1770 (BM): Broad Sound, E. Bowan, 1871 (MEL 9794).

18. V. MACROCALYX De Vriese

In Mitch., *Journ. Exp. Trop. Austr.*, 258(1848) et De Vriese in *Gooden.*, 176(1854) t.34: Benth., *Fl. Austr.*, 4: 49(1869): Bailey, *Qld. Fl.*, 3: 893(1900): Krause in *Pflrch.*, 54: 29(1912).

Taxonomic synonym: *V. prostrata* Ewart et Kerr in Proc. Roy. Soc. Vict. n.s., 39:7(1936).

Perennial herb with a long ± stout tap root and a large woody caulorrhiza bearing dead leaf-bases. *Leaves* all basal, inserted on the caulorrhiza, elliptic to narrow-obovate, tapering gradually in a long (2–4 cm.) petiole, 5–15 cm. long (incl. petiole), 2–4 cm. wide, entire or dentate towards the base, obtuse, ± thick, glabrous but for some conspicuous wool in the axils. *Peduncles* ascending or decumbent, up to 35 cm. long, terete, glabrous showing a definite tendency for one of the dichotomies to grow more strongly than the other (c.f. *V. panduriformis*). *Bracteoles* free: lower bracts linear to elliptic, 5–40 mm. long, 1–25 mm. wide, entire or nearly so, glabrous but for a little wool in the axils, acute or obtuse, free: upper bracts becoming smaller. Central flowers on pedicels up to 1 cm. long; all pedicels with a line of hairs arising from between the two lateral sepals. *Sepals* 3, free, bases not cordate and frequently decurrent on the pedicel, glabrous on the outer surface but pubescent on the inner surface with ± appressed hairs, elliptic to ovate, c. 10 mm. long and 5 mm. wide, entire or with a few teeth towards the base, acuminate to almost obtuse: posterior sepal only very slightly larger than the others. *Corolla* yellow with a very obscure nectary pocket, 10–12 mm. long, closely pubescent on the outer surface, villous to sparsely pubescent towards the base on the inner surface and without prominent enations: tube c. 3 mm. long and adnate to the ovary to about the mid-mark: superior lobes linear-falcate, 9–11 mm. long, 1–1·5 mm. wide with narrow almost obsolete wings and a slightly barbulate auricle 1·5 mm. wide; inferior lobes oblong to narrow-obovate 3–4 mm. long, 2–2·5 mm. wide; connate part of inferior lobes 6–7 mm. long. *Stamens* 5; filaments linear, 2 mm. long; anthers oblong, 1 mm. long. *Ovary* oblong-ovoid, c. 3 mm. long and 1·5 mm. wide, pubescent with a dissepiment reaching to the mid-point and bearing 14–16 ovules: style pubescent, 3–4 mm. long: indusium transverse-oblong, 2 mm. long, 3–5 mm. wide, pubescent, slightly folded, slightly curved with a slightly curved orifice beset on the upper lip with long white bristles but scarcely any on the lower lip. *Capsule* narrow-ovoid 7–8 mm. long, 2–3 mm. wide, pubescent, ± acuminate or acute splitting into 4 narrow ± equal valves. *Seeds* broad-elliptic, 1·5 mm. wide, minutely punctate, margin ± thickened but not winged.

Range: Queensland and Northern Territory from the Burdekin River to Barkly Tablelands and Sandover River.

Habitat: Savannah.

Chromosome number: Unknown.

Typification: *V. macrocalyx* De Vriese—*Holotype*—River Belyando—Mitchell (L). *V. prostrata* Ewart and Kerr—*Holotype*—Wycliffe Well, June 1924, A. J. Ewart (MEL 1806).

Discussion: Differs from *V. lyrata* most obviously in the habit of the scape in which one branch at each dichotomy grows more strongly than the other giving a panicle like appearance (cf. *V. panduriformis*). It also has narrow wings on the petals and the sepals are not so distinctly cordate.

There is some variation in that the specimens from the Burdekin River area have narrower bracts, the petals are more villous inside, the sepals are almost obtuse and the panicle-like scapes are not well developed. It seems unreasonable to admit these differences to a taxonomic rank with such scanty material.

The illustrations by De Vriese and Ewart are somewhat misleading, particularly the former. Specimens from Herberton (BRI 058783) may belong to this species although the pubescence and habit seem to indicate they do not. More collections are needed before a decision can be made.

Specimens examined: *Queensland*: Massacre Inlet, L. J. Brass, no. 190, Aug. 1922 (CANB 23741. BRI 058756): Burdekin, Mueller (MEL 9720.K). *Northern Territory*: 35 miles N.E. of Alexandria Station, R. A. Perry, no. 1510, 24.6.1948 (CANB 58678 and 109408 and 109407. NT. BRI 017228. NSW 75584. MEL 9719): Argadargada, G. Chippendale, 19.9.1954 (NT 324).

19. V. PERFOLIATA R.Br.

Prodr., 581(1810): DC., *Prodr.*, 7:518(1839): Benth., *Fl. Austr.*, 4:47 (1869): Moore et Betche, *Hdbk. Fl. N.S.W.*, 309(1893): Krause, in *Pflrch.*, 54:28(1912).

Perennial herb with a thick strong caulorrhiza covered by dead leaf-bases. *Leaves* arranged in an ascending rosette, elliptic to narrow-obovate, 10–12 cm. long (incl. petiole) 3–4 cm. wide, deeply serrate the teeth each with a short blunt mucro, obtuse and terminated by a blunt mucro, glabrous except for some yellow-brown villous wool in the axils, tapering gradually into a short broad petiole with an abruptly broadened scariose base. *Peduncles* erect, c. 30 cm. tall, terete, glabrous, (probably ± glaucous). *Bracteoles* connate into disc-like funnels up to 7 cm. diam., conspicuously toothed, each tooth terminated by a short blunt mucro, glabrous except for some wool in the axils. Central flowers on pedicels up to 3·5 cm. long. *Sepals* 3, free, glabrous on outside but villous inside, laciniate serrate or entire towards the base: posterior one broad-elliptic to almost orbicular, 8 mm. long, 7 mm. wide: lateral ones narrower. *Corolla* yellow, with a short anterior pocket, pubescent outside but for the wings, glabrous inside or nearly so, adnate to the ovary to about the mid-mark: superior lobes oblongo-falcate, 6 mm. long, 2 mm. wide, broadly (c. 1 mm.) winged with distinct densely barbulate auricles c. 1 mm. wide: inferior lobes ovate-elliptic, 4 mm. long, 2 mm. wide, broadly winged; connate part of inferior lobes 5 mm. long: tube 5 mm. long with conspicuous enations in the throat. *Stamens* 5: filaments linear, 2 mm. long; anthers narrow-oblong, 2 mm. long, minutely mucronate. *Ovary* ovoid to globular, sparsely pubescent with a dissepiment reaching to about $\frac{1}{4}$-mark and bearing c. 10 ovules: style 4–5 mm. long, densely villous towards the top: indusium semi-orbicular, 3 mm. wide, 1 mm. long, villous on the back, densely villous on the front, folded, slightly curved with a more or less straight orifice densely beset with short white cilia. *Capsule* ± globular, c. 4 mm. diam., ± equally 4-valved, glabrous. *Seeds* flat, elliptic, c. 3 mm. wide with a very narrow mucilaginous wing, yellow-brown, punctulate.

Range: Mainly in the northern parts of the Blue Mts. of N.S.W. and even there rare.

Habitat: Unknown.

Chromosome number: Unknown.

Typification: *V. perfoliata* R.Br.—*Holotype*—A. Gordon, Blue Mountains, 1803 (BM).

Discussion: This species is easily distinguished from all others of this section by the connate bracteoles.

Specimens examined: *New South Wales*: Blue Mountains Miss Atkinson, no. 29 (MEL 9639. NSW 75695): Wiseman's Ferry, Adelaide Chapman, 8.9.1907 (SYD).

20. V. MONTANA Hook.f.

In Hook. *Lond. Journ. Bot.,* 6:265(1847): et in *Fl. Tasm.,* 234 t.68(1860): De Vriese, *Gooden.,* 176(1854): Benth., *Fl. Austr.,* 4:50(1869): Moore et Betche, *Hdbk. Fl. N.S.W.,* 310(1893): Rodway, *Tasm. Fl.,* 101(1903): Krause in *Pflrch.,* 54:3(1912): Ewart, *Fl. Vict.,* 1067(1931): Curtis, *Stud. Fl. Tasm.,* 2:399(1963).

Perennial herb with a narrow tap-root and a short, stout caulorrhiza. *Leaves* arranged in a spreading or prostrate rosette, narrow-obovate to obovate-elliptic gradually narrowing into a short petiole at the base, 1·5–8 cm. long, 6–25 cm. wide, obscurely dentate to almost quite entire, obtuse, villous-pubescent to quite glabrous, with some soft brownish villous hairs in the axils. *Peduncles* decumbent to ascending, up to 10 cm. long but usually much shorter than the leaves, villous-pubescent to glabrous, terete. *Bracteoles,* free, linear to linear-narrow-obovate, up to 5 mm. long, c. 2 mm. wide, villous to pubescent, entire, acute. Central flowers on pedicels up to 5 mm. long. *Sepals* 3, connate right at the base, the tube attenuate, sprinkled with villous hairs on both surfaces, entire, ± acute, posterior one ovate or narrow-ovate to oblong, 5–6 mm. long, 2–3 mm. wide: lateral ones slightly narrower. *Corolla* yellow, 7–10 mm. long with an obscure very short anterior pouch, adnate to ovary to about the mid-mark, pubescent outside but for the wings and pubescent in the throat: tube 4–5 mm. long: superior lobes oblong-elliptic, 2 mm. long, 1 mm. wide with wings about 0·5 mm. long but the auricle almost obsolete: inferior lobes oblong-elliptic, 2 mm. long, 1 mm. wide with conspicuous wings about 0·5 mm. long: connate part of inferior lobes 1 mm. long or less. *Stamens* 5: filaments, linear to filiform, c. 2 mm. long; anthers ovate, 1 mm. long, apiculate. *Ovary* ovoid, minutely pubescent to almost glabrous with a dissepiment reaching to about the mid-mark bearing up to 20 ovules: style about 1 mm. long with a few villous hairs: indusium depressed-ovate, c. 1 mm. across, slightly folded and curved with a slightly curved orifice beset with very short cilia. *Capsule* sub-globular, c. 2 mm. diam. with a few hairs sprinkled over the outer surface, ± equally 4-valved. *Seeds* flat, orbicular to elliptic, c. 1·5 mm. diam., very minutely punctulate with an obscure rim.

Range: Tasmania and eastern mainland at high altitudes as far north as Barrington Tops.

Habitat: Alpine grassland and savannahs in damper places.

Chromosome number: n = 8.

Typification: Hooker cites three localities. Labels (and presumably specimens) corresponding to these localities are all affixed to the same sheet at K. The bottom three are selected as the *Lectotype*—Hampshire Hills. Gunn, no. 227, Feb. 1837 (K). N.B. The same number is applied to the Marlborough collection made in 1841 and to an Arthur's Lake collection in 1845, both made by Gunn.

Discussion: A very distinct species but very variable with regard to the indumentum. The Tasmanian specimens tend to have narrower sepals and are more glabrous altogether but these are not consistent differences.

Selected specimens examined: *New South Wales*: Barrington Tops L. R. Fraser, J. W. Vickery and N. A. Burgess, 7.1.1934 (SYD) : Happy Jacks Plain, R. Carolin, no. B99, 10.2.1957 (SYD) : Mt. Werong, R. H. Cambage, no. 3163, 4.12.1911 (SYD) : Clarence-Wolgan, J. H. Maiden, 11.1906 (NSW 75586) : Medlow, A. A. Hamilton, 3.1903 (NSW 75587) : Blackheath, O. D. Evans, 1.1932 (SYD) : Cooleman Plain, Currango, Walker, no. ANU953, Dec. 1962 (CANB 122232) : Daner's Gap, Kosciusko, M. Gray, no. 0093, 1.1959 (CANB 61276) : Braidwood District, W. Bäuerlen, no. 214, Dec. 1884 (MEL 9759) : *Australian Capital Territory*: Coree Flats, P. Darbyshire, no. 139, 1 Feb. 1961 (CANB 89548.K). *Victoria*: Mt. Buffalo, T. B. Muir, no. 643, 1.1.1959 (MEL 9756) : Lost Plain, Mt. Wellington, T. B. Muir, no. 3751, 14.1.1965 (MEL 9755). *Tasmania*: South Esk near Evandale, F. Mueller, 1849 (MEL 9744. NSW 75600) : Middlesex Plains, C. S. Sutton, Jan. 1909 (MEL 9743) : Great Lake, E. R. Rodway, 26.12.1937 (NSW 75598) : Lake Leake, R. Melville, no. 2536, 19.12.1952 (NSW 75591.K) Lake St. Clair, L. S. Gibbs, no. 6500 (K.BM) : Near Evandale, W. H. Archer, no. 141 (NSW 75595).

Excluded Species

1. *V. lanceolata* Lindl. in Swan River. App. Bot. Reg., 26 (1839) = *Goodenia filiformis* var. *pulchella* Benth.
2. *V. macroplectra* F. Muell., Fragm., 12: 22 (1882) = *Symphyobasis macroplectra* (F. Muell.) Krause. This species appears to be a *Goodenia*.
3. *V. salmoniana* F. Muell. in Vict. Nat., 9: 127 (1892) et in Bot. Centr., 53 :124 (1893). A *Goodenia* species.
4. *V. cusackiana* F. Muell. in Vict. Nat., 12: 124 (1896) : Krause in Pflrch., 54: 38 (1912). A *Goodenia* species.
5. *V. dichotoma* auct. ex DC. Prodr., 7 :519 (1839), nom. nud.
6. *E. filiformis* De Vriese in Lehm., Pl. Preiss., 1 :414 (1844) et Gooden., 171 (1854). The type, Preiss no. 1889 (L) is a specimen of *Stellaria filiformis* (Benth.) Mattf. see Kern in Blumea, 13: 116 (1965).

Key to the Species

1\. Sepals 5.
2\. Calyx united into a tube at least as long as the shortest lobes.
3\. Stem short and leaves therefore basal: calyx segments ± equal .... 1. *V. trinervis*
*3. Stem elongated.
4\. Leaves sessile, crowded .... 2. *V. foliosa*
*4. Leaves narrowing gradually into a distinct petiole .... 3. *V. macrophylla*
*2. Sepals quite free or connate only towards the base.
5\. Bracteoles connate.
6\. Sepals almost completely free .... 5. *V. panduriformis*
*6. Sepals connate into a short tube 2–4 mm. long
7\. Sepals broad-ovate to ovate: seeds ± smooth ...... 6. *V. connata*
*7. Sepals narrow-ovate: seeds papillose .... 7. *V. discophora*
*5. Bracteoles free or nearly so.
8\. Corolla lilac, white or pink.
9\. Corolla up to 7 mm. long .... 9. *V. cycnopotamica*
*9. Corolla more than 10 mm. long.
10\. Seeds smooth; auricle attached to wing .... 4. *V. daviesii*
*10. Seeds wrinkled; auricle with a membranous appendage separated from the wing .... 8. *V. rosea*
*8. Corolla yellow.
11\. Corolla up to 8 mm. long .... 10. *V. hispida*
*11. Corolla more than 10 mm. long.
12\. Lobes of the corolla ± equal (connate part of inferior lobes 2–3·5 mm. long); indusium narrow-oblong .... 11. *V. arguta*
*12. Lobes of the corolla distinctly unequal; indusium broad-ovate to depressed-ovate.
13\. Peduncles pubescent; indusium broad-ovate .... 12. *V. paradoxa*
*13. Peduncles glabrous or nearly so; indusium depressed-ovate .... 13. *V. glabrata*
*1. Sepals 3.
14\. Bracteoles connate .... 19. *V. perfoliata*
*14. Bracteoles free.
15\. Corolla lobes ± equal; peduncles usually shorter than the leaves .... 20. *V. montana*
*15. Corolla lobes distinctly unequal; peduncles usually longer than the leaves.
16\. Peduncles glabrous or glabrescent.
17\. Posterior sepal distinctly cordate; bracts narrow. .... 14. *V. lyrata*
*17. Posterior sepal not distinctly cordate.
18\. Peduncles ascending to decumbent; ovary dissepiment reaching the mid-mark of the ovary .... 18. *V. macrocalyx*
*18. Peduncles erect: ovary dissepiment very short .... 15. *V. parvisepta*
*16. Peduncles pubescent.
19\. Peduncle hairs coarse, appressed .... 16. *V. spathulata*
*19. Peduncle hairs divergent or patent .... 17. *V. pubescens*

References

Carolin, R. C., 1967.—The concept of the inflorescence in the order Campanulales. Proc. Linn. Soc. N.S.W., 92: 7–26.

Krause, K., 1912.—Goodeniaceae und Brunoniaceae. *Das Pflrch.*, 54 (Berlin).

Peacock, W. H., 1963.—Chromosome numbers and cytoevolution in the Goodeniaceae. Proc. Linn. Soc. N.S.W., 88: 8–27.

Troll, W., 1964.—"Die Inflorezenzen". (Jena.)

EXPLANATION OF PLATES

Plate I. Photographs of seeds of *Velleia*. A, *V. trinervis*; B, *V. foliosa*; C, *V. macrophylla*; D, *V. daviesii*; E., *V. panduriformis*; F., *V. discophora*; G, *V. connata*; H, *V. cycnopotamica*; I, *V. rosea*.

Plate II. Photographs of seeds of *Velleia*. A *V. glabrata*; B, *V. paradoxa*; C, *V. arguta*; D, *V. hispida*; E, *V. spathulata*; F, *V. lyrata*; G, *V. perfoliata*; H, *V. pubescens*; I, *V. parvisepta*; J, *V. montana*.

THE OCCURRENCE, ORIGIN AND VEGETATION OF LOWLAND PEAT IN MALAYA

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[Read 29th March, 1967]

Synopsis

The extent, origin, distribution and vegetation of the lowland peat of Malaya are described. Some reference is made to similar peat formations in adjacent areas in south-east Asia and factors responsible for the development of peat are discussed.

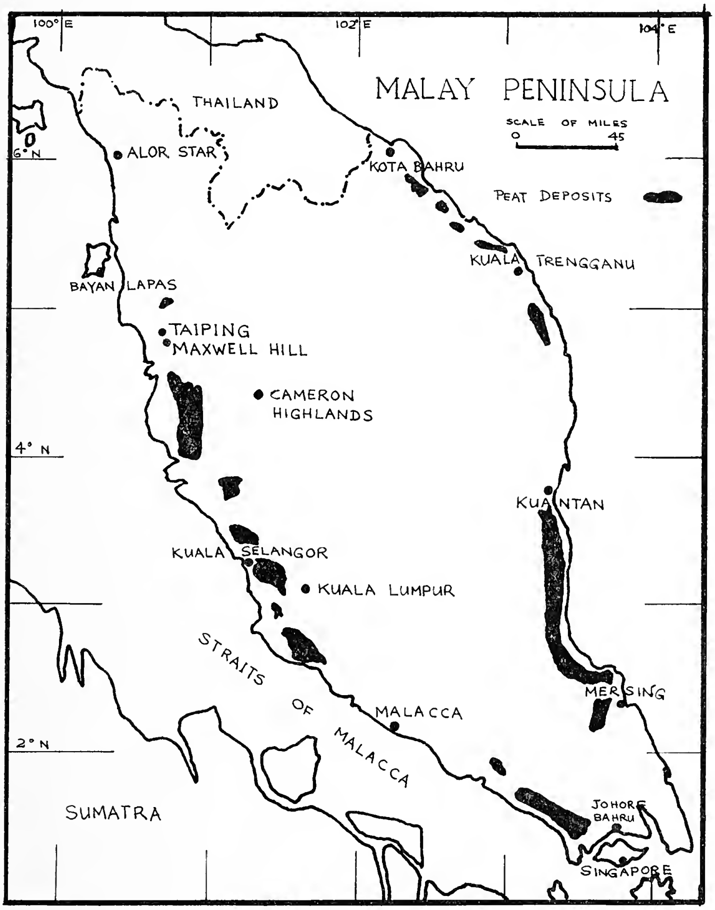
Introduction

Peat swamps cover extensive areas of the humid tropics and occur in the three main rain forest regions of the world; in south-east Asia, tropical America, and tropical Africa. Richards (1952) has summarized some of the available information on the vegetation and nature of peat swamps. In the humid tropics of south-east Asia, on the landward side of the mangrove or beach forests, peat forests are encountered in many areas extending along the coastal plains. They cover almost one fifth of the area of Sumatra and occur along the coasts of the Malayan Peninsula, Borneo and southern New Guinea. Next to the sub-arctic peat formations of the northern hemisphere, particularly in the U.S.S.R., these tropical peats probably belong to the largest ever described. Lowland peat is of great importance in south-east Asia because of its occurrence in areas where rice can be grown. Due to the physical conditions, high acidity, low fertility and often toxic concentrations of some elements it is very difficult to grow padi on peatland. There are approximately 2 million acres of peat on the Malayan Peninsula and 40 million acres in Indonesia.

The study of tropical peat began in Indonesia, the first publications appearing in 1854. Bernelot Moens (1865) described a kind of peat he found in Java and noted the resemblances between coal and peat formation. In 1870, Edeling gave a description of the Bidara Tjina swamp and mentioned floating islands in the swamp. Stoop in 1886 described the Rawa Pening near Ambarawah in Java in which a floating island formed. This phenomenon had already been described by Junghuhn in 1854. Potonie and Koorders in 1909 published their findings after crossing Sumatra and commented that the formation of tropical peat was an example of coal formation. Up to this time it was generally accepted in scientific circles that peat soil can originate only under a temperate or cold climate. Nevertheless, Schimper in 1908 stated that in the tropics "zur Torfbildung auszer im Gebirge über 1200 m. nirgends kommt". After 1909, the study of tropical peat attracted greater attention and the number of publications increased.

Lang in 1914 described the accumulation of peat and the presence of black water rivers in Sumatra and Malacca. Keilhacks (1915) described peats in the mountains and on the lowlands of Ceylon. In the same year Gates (1915) mentioned a small swamp containing peat in the mountains of the Philippines.

Tropical peat in Africa was described by Krenkel in 1920. He mentioned Cyperaceae-Gramineae moors in the mountains and forest swamps in the lowlands. It would appear from his description that these bogs in Africa are similar to those in south-east Asia. He commented "Die Feuchtigkeit ist für die Bildung eines Moores in allen Klimaten ausschlaggebend. Die Temperatur steht ihr als weniger wichtig nach, wenn sie auch nicht unter ein Mindest hinabreichen darf". This conclusion is quite important and is true for peat formation in all climates. The forest peat swamps on the east coast of Sumatra were described by van Heurn (1923) and Mohr (1922) and those of Palembang in South Sumatra by Schürmann (1922). Cooke in 1930 mentioned the extensive peatlands of the Malayan Peninsula while Polak in 1933 described the peats and moors of Indonesia including lowland and mountain peats mainly from the islands of Sumatra, Borneo, Java, and Celebes. This study included a detailed description of the spores and pollen grains in the peat together with a description of the vegetation. A general description of the tropical peats of Indonesia followed in 1950 (Polak), while the origin and construction of floating islands of vegetation in a large marsh (the Rawa Pening) in Java were described in 1951 (Polak).



Further descriptions of the lowland peat of Malayan Peninsula were published by Coulter in 1950 and Coulter, MacWalter and Arnott in 1956.

Climate

The climate of the Malayan Peninsula has been described as a Hot Equatorial Climate of the monsoonal sub-type (Miller, 1931). This classification is primarily based on temperature and secondarily on rainfall. It is, however, difficult to explain by generalization the rainfall regime of the lowland stations where the distribution depends on position and exposure in relation to the two monsoon currents. The temperature regime is dependent on altitude and is quite different in the lowlands and the highlands.

However, rainfall in Malaya is one of the most important criteria in establishing both divisions between the seasons and any seasonal variations. There are four seasons delineated by the two monsoons:

1. The north-east monsoon commencing in October and ending in March.
2. The south-west monsoon which commences at the end of May and ends in September.

Table 1

Station	Mean annual temperature range °F.	Range °F.	Height above sea-level (ft.)
Kota Baharu	72·6–89·8	17·2	15
Kuala Trengganu	72·4–89·0	16·6	105
Kuantan	71·2–90·0	18·8	62
Mersing	73·1–88·0	14·9	149
Johore Baharu	72·8–89·1	16·3	50
Malacca	73·1–86·3	12·8	22
Kuala Lumpur	72·1–90·8	18·7	111
Kuala Selangor	73·1–89·4	16·3	40
Cameron Highlands	57·3–73·4	15·9	4,750
Maxwell Hill	63·4–76·4	13·0	3,400
Taiping	71·7–91·2	19·5	59
Bayan Lepas	73·6–88·1	14·5	11
Baling	71·2–89·5	18·3	170
Alor Setar	71·3–88·7	17·4	15

The other two seasons correspond to the inter-monsoonal periods which vary according to the location of the station. The north-east monsoon therefore brings a heavy rainfall to the east coast from October to March while the south-west monsoon is mainly effective on the west coast from May to September. Generally, the rains occur as thunderstorms of short duration during which heavy rain falls, and the absence of general rain over large areas tends to make the incidence of those falls unpredictable. The climatic factors of temperature, rainfall, humidity, sunshine and radiation are dealt with for some selected stations which are marked on the map.

Temperature

Atmospheric temperatures are very uniform with little diurnal or seasonal variation. There are, however, marked differences between stations. These are dependant on altitude. For example, at Johore Baharu at a height of 50 feet (15·2 m.) above sea level the mean annual temperature range is from 72·8° F. to 89·1° F. (22·7° C. to 31·7° C.) whereas at Cameron Highlands at a height of 4,750 feet (1,447·8 m.) the range is 57·3° F. to 73·4° F. (14·1° C. to 23·0° C.). There is therefore a fall in temperature of 0·324° F. for every 100 feet (0·6° C. per 100 m.) increase in altitude (see Table 1).

With the exception of the elevated stations of Cameron Highlands and Maxwell Hill the mean temperature for any month is always greater than 64° F. (17·8° C.). According to Miller's classification (1931) the climate of

TABLE 2

Average rainfall (in inches)

Station	Average number wet days per year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
East Coast														
Kota Baharu ..	179	9·16	5·31	5·68	4·33	5·44	6·18	5·69	6·50	8·43	10·22	23·19	23·34	113·47
Kuala Trengganu ..	184	5·85	6·69	6·72	5·88	4·46	4·30	3·97	5·63	8·09	11·68	23·14	21·38	107·89
Kuantan	180	15·16	7·47	8·89	6·58	6·62	5·33	5·25	5·72	8·21	9·66	14·93	23·19	117·01
Mersing	198	14·60	7·83	7·42	5·34	5·81	5·21	6·03	6·34	6·31	8·19	12·84	20·54	106·46
Johore Baharu ..	200	12·82	8·70	10·06	7·56	8·55	6·23	6·36	9·03	7·49	8·63	11·32	13·17	109·92
West Coast														
Malacca	162	4·91	4·04	6·39	5·87	6·72	7·91	7·68	8·65	7·97	10·01	8·34	6·05	84·54
Kuala Lumpur* ..	204	5·90	5·60	9·32	10·80	7·75	5·56	4·11	5·90	7·69	10·86	10·48	8·50	92·47
Kuala Selangor ..	134	7·30	4·29	5·21	6·53	5·13	3·70	3·51	4·44	5·83	9·05	9·39	8·68	73·06
Cameron Highlands†	239	6·29	5·04	8·60	12·32	9·59	5·57	5·09	6·90	10·15	13·30	13·20	9·43	105·48
Maxwell Hill† ..	216	11·17	8·76	14·41	20·64	19·28	13·85	11·21	15·69	19·33	25·90	22·30	15·15	197·69
Bayan Lepas ..	172	3·80	4·41	6·00	9·71	11·57	6·37	8·82	9·83	15·44	16·37	10·18	4·12	106·62
Taiping*	223	13·59	11·90	17·16	19·70	13·29	7·03	6·87	9·37	12·49	20·59	18·73	15·04	165·76
Baling*	151	3·50	3·80	6·09	10·39	8·73	5·69	6·02	6·95	9·65	14·16	11·00	5·81	91·79
Alor Setar	181	2·22	2·02	5·72	8·73	10·23	7·35	8·04	10·28	11·85	12·45	8·42	4·41	91·72

* Inland.
† Elevated.

the stations is a hot equatorial type of a monsoon variety. He classifies sub-tropical climate as having all months above 43° F. (6·1° C.) and with no cold season. On the basis of temperature alone the hill areas from about the 3,833 feet (1,000 m.) contour level upwards would be classified as sub-tropical. However, such areas are probably better classified as a hot tropical monsoon hill climate.

The rainfall data for these stations are given below (Table 2) and include the mean monthly rainfalls, average annual rainfall and the average number of wet days per year (that is, at least 0·09 inches (0·25 mm.) per day). The east coast receives rain maxima from October to January. The rainfall pattern on the west coast is not as consistent and position and topography are very important, while nearness of the island of Sumatra has great influence. The effect of the south-west monsoon is clearly seen at Alor Setar, the most northerly west coast station out of the main influence of the island of Sumatra.

TABLE 3

Average relative humidity (%)

Station	June		December	
	6 a.m.	1 p.m.	6 a.m.	1 p.m.
Kota Baharu ..	93	68	93	76
Kuala Trengganu ..	95·9	71·9	94·4	80·4
Kuantan	98·4	65·6	97·3	81·0
Mersing	95·4	76·4	93·1	81·6
Johore Baharu.. ..	—	69·0	—	70·7
Malacca	97·9	74·4	95·9	68·8
Kuala Lumpur ..	94·7	60·8	97·7	64·0
Kuala Selangor ..	—	65·5	—	68·4
Cameron Highlands ..	—	98·7	—	98·3
Maxwell Hill	—	60·1	—	63·4
Bayan Lepas	94·3	69·3	89	63·5
Taiping	—	63·8	—	68·7
Baling	—	60·6	—	59·4
Alor Setar	94	67	94	60

At this station most rain is received during the months April to November. Taiping receives a high rainfall which is inconsisent for the lowland stations. This is perhaps due to its close proximity to the elevated area of Maxwell Hill. On comparing the rainfall of Indonesia (Mohr and van Baren, 1959) with that of the Malayan Peninsula it is evident that there is greater variation in Indonesia. According to Mohr and van Baren's (1959) modification of Köppens (1916) classification all stations in Malaya are continuously wet or moist since the rainfall never falls below 2·4 inches (60 mm.) except at one station, Alor Setar on the west coast where the average monthly rainfalls for January and February are 2·2 inches and 2·0 inches (56 and 51 mm.). However, these monthly averages are so little below 2·4 inches that they can be regarded as forming a very weak dry season.

Humidity

The highest relative humidity occurs at 6 a.m. simultaneously with the minimum daily temperature, and the lowest relative humidity usually occurs at the same time as the maximum daily temperature at 1 p.m. (Table 3).

Sunshine

Sunshine is nowhere constant and, in fact, the number of sunshine hours at the stations on the Malayan Peninsula are less than at many places in more temperate climates. The following data (Table 4) show the amount of sunshine recorded as a percentage of the total maximum possible, together with the mean daily sunshine hours and the daily average for the sunniest month.

TABLE 4

Hours of sunshine

Station	Yearly percentage of total possible	Mean daily sunshine (hours)	Highest daily mean for one month	
Kota Baharu	57	6·97	10·09	March
Kuala Trengganu	57	6·90	10·16	March
Kuantan	49	5·88	8·34	Feb.
Mersing	50	6·11	7·99	March
Johore Baharu (Singapore) ..	45	5·40	7·16	March
Malacca	49	6·01	7·32	May
Kuala Lumpur	53	6·35	7·45	March
Ipoh	55	6·65	7·82	March
Bayan Lepas	56	6·78	8·29	March
Aor Setar..	61	7·31	9·02	March

Radiation

It is often thought that the total radiation at the tropics is greater than elsewhere. However, often, the radiation in temperate latitudes is greater than in the tropics due to absorption by the water vapour in the humid air of the tropics. The figures in Table 5 (Landsberg, Lippman and Paffen, 1965) illustrate this point.

TABLE 5

Radiation

Area	Radiation in K cal/cm$_2$/Year
Malay Peninsula	140–160
Most of Australia	160–200
Southern Africa	160–200
Southern U.S.A.	160–200

OCCURRENCE AND ORIGIN OF LOWLAND PEAT

The Malayan Peninsula extends 700 miles from the Isthmus of Kra in the north to Singapore in the south and has a total area of approximately 51,000 square miles. In general, it consists of a central backbone of mainly granite mountain ranges running north and south. The Kerbau Coulisse constitutes the main range which includes individual peaks over 7,000 feet in height (Scrivenor, 1931). Skirting the central ranges are the coastal alluvial plains which are about 40 miles wide on the western side and 20 miles wide on the eastern side. The lowland peat occurs on the coastal plain near and parallel to the coast (see map).

The topographic units of lowland Malaya are readily distinguished by their relief features, drainage pattern and manner of distribution. Topography is the most consistent and most important feature associated with the occurrence of peat swamps and is closely related to the Recent geological history of the area. The coastal plain is probably a relic of the Sunda peneplanation which was submerged after the Pleistocene glaciation and later filled in by deposits from the older central mountain ranges of the Peninsula (Molengraaf, 1922). The Recent changes in sea level have influenced the topography so that a number of topographical units have been formed which are conducive to the formation of lowland peat.

Below the central ranges on the Malayan Peninsula are the remnants of a terrace which are covered with poor heath forest with an excessively drained soil composed of white quartz sands and silts. The formation of the terrace corresponds to several stages in the lowering of the sea level during the Quaternary. The terrace remnants are elongated parallel to the former coastline and mostly lie approximately 200 feet above sea level, although the height given for lowland Sarawak is between 25 feet and 100 feet (Wall, 1964).

Other lowland soil-topographic units include the riverine soils and vegetation, the estuarine unit and the beaches. The riverine unit is characterized by flat topography and poorly drained gley soils. The estuarine unit consists of estuaries, deltas, lagoons, abandoned meanders and coastal flats which are still subject to occasional or periodic tidal incursions and have halomorphic soils carrying mangrove and nipah vegetation. The beaches carry a characteristic vegetation and soil and vary in width from a few feet to more than a mile. The soils are podsolized and carry grasses and shrubs on old strand lines together with *Casuarina equisetifolia* on the most recent beach which is usually about 4 ft. above high tide level.

With the exception of terrace remnants peat swamps occur in association with all these topographic units. They occur when barriers known as permatong impede drainage. The permatong may arise as a result of change in river courses, floods depositing heavy alluvium along part of the river or building a dyke preventing tidal incursions but mainly they have been formed because of Recent changes in sea level resulting in the presence of beach ridges at varying heights up to about 50 feet above sea level (Nassin, 1964), and orientated parallel to the present coastline. Behind each of these barriers peat swamps may develop. Within the peat swamp itself a mixture of organic and mineral soils may occur due to the type of under lying sediment, deposition of silt by floods and the depth of the peat present. So that the peat swamp contains peat itself, which has an ash content less than 35%, together with muck soils and organic clays with ash content between 35% and 65%, which grade into mineral soils.

Stages in the formation of peat swamp can be summarized as:

Stage 1.—Deposits of alluvium in bays, deltas or sheltered embayments along the coast are colonized by mangrove. With continued deposition further offshore accentuated by Recent changes in sea level the more inland mangrove is progressively replaced by transitional communities and a shallow peat overlying mangrove clays is formed.

Stage 2.—With the continued deposition of alluvium on the seaward perimeter the swamps advance replacing mangrove. Therefore as the distance from the sea of the original swamp increases rivers tend to back up and begin depositing alluvium along their banks, which consequently are raised above the level of the original swamp subsoils so that the characteristic saucer-shaped foundations of the peat evolve. Peat accumulation then proceeds rapidly and a shallow lenticular structure develops.

Stage 3.—The rate of peat accumulation in the swamp centre falls and a typical flattened bog plain develops, usually occupied by a characteristic vegetation community.

There is little differentiation in a peat profile. However, a typical description is:

0–3 inches. A black amorphous material with a granular structure, and containing some wood fragments.

3–12 inches. The colour changed from black to dark coffee brown colour.

12–36 inches. Reddish brown fibrous material.

36–72 inches. Reddish brown material.

VEGETATION

The peat carries a type of tropical rainforest which is characteristically heterogenous in regard to species but contains less variety of species than the normal lowland rain forest on dry land (Wyatt–Smith, 1959). This is due to the special conditions required for growth and support in a soft, acid and anaerobic medium, so that only those species specifically adapted can survive. Therefore many trees have stilts and aerial roots. The main species present are: GONYSTYLACEAE, *Gonystylus bancanus*; GUTTIFEREAE, *Calophyllum retusum, C. scriblitifolium, Cratoxylon arborescens*; THEACEAE, *Tetramerista glabra*; MYRISTICACEAE, *Myristica lowiana*; DIPTEROCARPACEAE, *Anicoptera marginata, Shorea rugosa var. uliginosa, S. teysmanniana, S. platycarpa*; EUPHORBIACEAE, *Blumeodendron tokbrai*; LINACEAE, *Ctenolophon parvifolius*; LEGUMINOSAE, *Dialium patens, Koompassia malaccensis*; BOMBACACEAE, *Durio carinatus, Neesia altissima*; MYRTACEAE, *Eugenia* spp.; SAPOTACEAE, *Ganua motleyana, Palaquium ridleyi*; LAURACEAE, *Litsea grandis*; ANONACEAE, *Polyalthia glauca, Xylopia fusca*; BURSERACEAE, *Santiria nana*; ICACINACEAE, *Stemonurus capitatus*; PALMAE, *Cyrtostachys lakka, Zalacca conferta*; CYPERACEAE, *Mapania palustris*; PANDANACEAE, *Pandanus* spp.

DISCUSSION

The sequence of formation of lowland peat commences with the formation of a bar to give a basin in which drainage is impeded. Most peat swamps are formed by cutting off the sea from the basin so formed so that the original vegetation would consist of typical sea-coast formations which are gradually replaced by peat swamp vegetation. Evidence for this mode of formation has been obtained by palynological and C_{14} analysis of peat from Morudi peat swamp, Sarawak (Wilford, 1959) and the Lawas peat swamp, Brunei Bay. The depth of peat in the Lawas swamp was a maximum of 15 feet and peat from 10 feet was found to be 1,830 ± 120 years old.

The Morudi swamp contains peat to a depth of 35–40 feet and has an area of about 120 square miles. The age of the peat was as follows:

Depth in feet	
16	2,255 ± 60 years
33	3,850 ± 55 years
39	4,270 ± 70 years

Palynological evidence showed that at the base of the peat the clay contained abundance of Nipah (*Nipa fruticans*) and mangrove pollen (*Rhizophora someratia*) while from 28 feet upwards *Gonostylus* pollen occurs, and from 16 feet upwards *Shorea* and *Pandanus* pollens occur. The last two species are typical of the peat swamp vegetation.

The results therefore indicate that the peat has accumulated on mangrove swamp at the rate of 1 foot per 100 years for approximately the last 4,500 years. Since the coastline is at present 30 miles from the sampling area the lowlands have extended seawards at the rate of approximately 30 feet per year for 4,500 years.

The presence of peat presupposes an abundance of vegetative source material and rainfall which is usual in the equatorial tropics. However, areas adjacent to the peat swamps which are freely drained contain very little humic materials in their soil profiles. An additional special edaphic factor of waterlogged conditions is therefore required, which will prevent or inhibit oxidation of the vegetable matter. Once the peat swamp is formed it may form a dome-shaped structure with its centre above the general level of the surrounding land (Polak, 1933). In addition to anaerobic, waterlogged conditions in the peat swamp, low pH is probably also required. In this respect Mohr and van Baren (1959) have observed that in Indonesia peat is fairly rare on the island of Java where mainly alkaline rocks occur, whereas islands such as Sumatra, Banka, Belliton, Borneo and West Irian which have acidic rocks low in bases, have appreciable areas of peat swamp.

On the Malayan Peninsula a number of factors favour the development of peats. These are the continually wet climate with no marked drought season, an abundance of vegetation and the presence of acidic granite rocks over most of the Peninsula. However, peat accumulations occur only on the lowlands and the highlands and the amount of humic material in soils between these two is very low. On the highlands peat accumulates in areas where the temperatures are relatively low, while on the lowlands peat occurs under special conditions of waterlogging and where surface run-off water can accumulate from adjacent areas. In the freely drained areas on the lowlands and slopes the temperatures are high enough for all organic matter to be rapidly oxidized.

References

Bernelot Moens, J. C., 1865.—Onderzoek eine turfsoort voorkommende nabij de desa Djoengelangan, in de Residentie Besoeki. *Nat. Tijdschr. Ned. Indie,* 28.

Cooke, F. C., 1930.—Coconuts on peat. *Malayan agric. Journ.*, 18: 587–595.

Coulter, J. K., 1950.—Peat formations in Malaya. *Malayan agric. Journ.*, 33: 63–81.

Coulter, J. K., McWalter, A. R., and Arnott, G. W., 1956.—Soil survey reports. No. 3: The Trans-Perak swamp. *Malayan agric. Journ.*, 39: 19–120.

Edeling, A. C. J., 1870.—Botanische wandeling in dem outrek van Bidara Tjina. *Nat. Tijdschr. Ned. Indie,* 31.

Gates, F., 1915.—A sphagnum bog in the tropics. *Journ. of Ecology* III.

Junghuhn, F., 1854.—"Java, seine gestalt, Pflanzendecke und innere Bauart." (Leipzig.)

Keilhacks, K., 1915.—Tropische und subtropische Torfmoore auf Ceylon und ihre Flora. Vortr. a. d. Gesamtgebied der Botanik. Herausg. v. d. Deutsch. Bot. Ges.

Köppens, W., 1916.—Klassifikation der Klimate, Temperatur, Niederschlag und Jahreslauf. *Peterm. Mitteil.*, 62: 197–203.

Krenkel, E., 1920.—Moorbildungen im tropischen Afrika. *Centralblatt f. Min. Geol. und Paläont.* Stuttgart.

Landsberg, H. E., Lippman, K. H., and Paffen, 1965.—"Weltkarten zur Klimakunde." (Sprüger, Berlin.)

Lang, R., 1914.—Geologisch—mineralogische Beobachtungen in Indien. *Zeitschr. f. min. geol. und paläont.*

Miller, A. A., 1931.—"Climatology." (Methuen, London.)

Mohr, E. C. J., 1922.— "De grand van Java en Sumatra." (Amsterdam.)

Mohr, E. J. J., and van Baren, F. A., 1959.—"Tropical Soils." (Van Hoeve, The Hague.)

Molengraaff, G. A. F., 1922.—De geologie der zee en van Nederlandsch Ooste-Indie, De Zeeen van No. 1.

Nassin, J. J., 1964.—Beach ridges on the East Coast of Malaya. *J. trop. Geog.*, 18: 111–117.

Polak, B., 1951.—Construction and origin of floating islands in the Rawa Pening (Central Java). *Contr. gen. res. Sta.* No. 121: 1–11, Bogor.

Polak, B., 1950.—Occurrence and fertility of tropical peat soils in Indonesia. *Contr. gen. Agr. res. Sta.* No. 104, Bogor.

Polak, E., 1933.—über Torf und Moor in Niederländische Indien. *Verh. Kon. Akad. v. Wetensch,* 20. Amsterdam.

Potanie, H., and Koorders, S. H., 1909.—Sumpfflachmoor Natur der Moore des Produktiven Karbons. Jahrb. der Kön. Preusz. Geol. Landesanstalt, Berlin.

Richards, P. W., 1952.—"The tropical rain forest." (Methuen, London.)

Schimper, A. T. W., 1908.—"Pflanzenphysiologie auf physiologischer Grundlage." (Jena.)

Schürmann, H. M. E., 1922.—Over de neogene geosynclinaal van Zuid-Sumatra en het outsaan van bruinkool. De mijninenieur.

Scrivenor, R. S., 1931.—"The Geology of Malaya." (Macmillan, London.)

Stoop, A., 1886.—Verschlag van een onderzoek naar het outsaan van een eilangje, dat zich in de nacht van 4 op 5 Februari, 1885 in de Rawa Pining heeft gevorung. *Natuurk. Tijdschr. v. Ned. Indie,* 45.

Van Heurn, F. C., 1923.—"De Studien betreffende van Sumatra s Oostkust, Zijn interlijk en ziju outstaan." (Bussy, Amsterdam.)

Wall, J. R. D., 1964.—Topography - soil relationship in Lowland Sarawak. *J. trop. Geog.*, 18: 192–199.

Wilford, G. E., 1959.—Radiocarbon age determination of quaternary sediments in Brunei and Northeast Sarawak. *Brit. Borneo Geol. Survey Ann. Rept.*, 16–20.

Wyatt-Smith, J., 1959.—Peat swamp forest in Malaya. *Malay Forester* XXIII: 5–32.

NEW SPECIES OF PERMIAN GASTROPODS FROM QUEENSLAND

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Synopsis

Three new species of gastropods, *Peruvispira parva*, sp. nov., *Keeneia afflicta*, sp. nov., and *Strotostoma*, sp. nov., are described and figured from Permian sediments at Cracow, Queensland.

INTRODUCTION

Recent work by the writer on faunas of the Cracow District in the south-eastern Bowen Basin, Queensland has revealed specimens of the species *Peruvispira parva* and *Keeneia afflicta* in the Buffel Formation. Specimens of *Strotostoma* sp. nov. are recorded from the Barfield Formation. All species were recorded by Wass (1965).

This account is based on part of a B.Sc. Honours thesis submitted in 1962 to the Department of Geology, University of Queensland. Fossil specimen numbers prefixed by "F" and locality numbers prefixed by "L" belong to the University of Queensland, Department of Geology catalogues. All fossil specimens are housed within the Department. Map references, unless otherwise stated, refer to the Mundubbera 1:253,440 military map.

SYSTEMATIC DESCRIPTIONS

Order	ARCHAEOGASTROPODA Theile, 1925
Suborder	PLEUROTOMARIACEA Swainson, 1840
Superfamily	PLEUROTOMARIINA Cox and Knight, 1960
Family	EOTOMARIIDAE Wenz, 1938
Subfamily	NEILSONIINAE Knight, 1960
Genus	*Peruvispira* Chronic, 1949

1949, *Peruvispira* Chronic, p. 146.
1953, *Peruvispira* Chronic, p. 139.
1958, *Pleurocinctosa* Fletcher, p. 139.
1961, *Peruvispira* Dickins, p. 144.

Type Species.—(By original designation) *Peruvispira delicata* Chronic, 1949, p. 146, pl. 28, figs 9–12 from the Lower Permian Copacabana Group of Peru.

Diagnosis.—Small turbinate pleurotomoriids with a moderately acute spire and a rounded anomphalous base; a peripheral, concave selenizone lies below centre of the whorl and is bounded by carinae; a concave zone is present below selenizone; sutures impressed and lying below selenizone at a distance about equal to the selenizone width; aperture rounded.

Discussion.—The familial classification of the pleurotomariids is under review and that presented above follows the Treatise (Moore, 1960). Dickins (1961) has a full discussion of the genus noting the distinguishing features between *Peruvispira* and *Ptychomphalina*, and *Mourlonia* and *Neilsonia*.

Range and Distribution.—Within Australia the genus is widespread. Fletcher (1958) records it from the Dalwood, Shoalhaven and Maitland Groups in New South Wales; Banks (in Spry and Banks, 1962) has found the genus in the Quamby and Golden Valley Groups in Tasmania; Dickins (1957, 1963) records the genus from the Lyons Group and Fossil Cliff Formation respectively in Western Australia. These stratigraphic horizons are of Permian age.

P. kuttungensis Campbell, 1961 from the Issacs and Booral Formations and *P. kempseyensis* Campbell, 1962 from the upper horizon of the Kullatine Series in New South Wales are Westphalian in age. Maxwell (1964) records the previous two species as *Montospira* from the Middle Carboniferous of the Yarrol Basin, Queensland.

Dickins (in Veevers *et al.,* 1964 and Dickins *et al.,* 1964) has found the genus previously in the Permian of Queensland. Waterhouse (1963*b*) records it from the Permian of New Zealand.

PERUVISPIRA PARVA, sp. nov.

(Fig. 1)

Holotype.—F. 43401 from the Buffel Formation, Cracow, Queensland; L. 2575, 32128451, Par. Cracow, Co. Dawson, at the base of the ridge, half a mile north-west of "Cracow", six miles south of Cracow, Queensland.

Diagnosis.—Small, turbinate *Peruvispira* with a length/width ratio approaching unity; apical angle acute; concave area below the selenizone increases in width with each successive whorl.

Description.—The shells are thick, turbinate and anomphalous with an apical angle between 49 and 57 degrees. Four whorls are developed although in some cases five may be present. The upper whorl surface is slightly convex at all stages but not as convex as the lower surface. A concave peripheral selenizone is present, being bounded on both sides by a carina with the lower one forming the periphery of the shell. On the body whorl the selenizone is 0·8 mm. wide. Sutures are not deeply impressed, lying a short distance below the lower carina. This distance is very small in early apical whorls but increases with each successive whorl. The concave area below the selenizone is best studied on the body whorl where it is 0·9 mm. wide. Ornamentation of the selenizone comprises fine lamellae that are concave to the aperture. The upper whorl surface is ornamented by growth lamellae that are slightly convex to the aperture and not as fine as lamellae in the selenizone. Lamellae leave the suture at an approximate right angle and sweep back across the whorl surface away from the aperture, reaching the upper carina at an approximate angle of 50°. Ornamentation on the lower whorl surface is characteristic. Lamellae leave the lower carina and swing forward over the concave area before turning down vertically or swinging back over the revolving ridge or the base of the whorl.

1. *Peruvispira parva* sp. nov., apertural view of F. 43401 from L. 2575, approx. × 5.

Remarks.—*Peruvispira elegans* (Fletcher) has a smaller apical angle and more whorls than *Peruvispira parva*; *P. allandalensis* (Fletcher) and *P. trifilata* (Dana) have a different length/width ratio.

Peruvispira imbricata Waterhouse, 1963*b* may be of similar size but has more whorls and a different whorl profile. The New Zealand species of the genus are usually similar in size and possess more whorls with a different profile.

Range and Distribution.—The writer has found the species only in the Buffel Formation of the Cracow District.

Localities.—In addition to the previously mentioned localities, the species is found at L. 2483, 31758603, 0·8 mile north-north-west of Rose's Pride Mine, Cracow. One specimen, F. 44306, is recorded from this locality.

Dimensions.—

	F. 43401	F. 43406	F. 43607	F. 44285
Height (mm.)	10·5	8·0	8·0	7·5
Width (mm.)	9·0	7·0	6·5	6·0
Apical angle	57°	56°	49°	53°

Family	SINUOPEIDAE Wenz, 1938
Subfamily	TURBONELLININAE Knight, 1960
Genus	*Keeneia* Etheridge, Jr, 1902

1902, *Keeneia* Etheridge, Jr, p. 198, pl. 32, figs 1, 2; pl. 33, figs 3–5.

1958, *Keeneia* Fletcher, p. 131.

1958, *Planikeeneia* Fletcher, p. 135.

Genolectotype.—(Chosen Knight, 1941, p. 163) *Keeneia platyschismoides* Etheridge, Jr, 1902, p. 198, pl. 32, fig. 2, from the Lower Permian, Allandale Formation at Harper's Hill, 432564 Singleton 1:63,360 military map, approximately one mile north of Allandale, Hunter Valley, New South Wales.

Diagnosis.—Shells turbinate or trochiform, narrowly phaneromphalous with few whorls, flattened to slightly convex; aperture large, obliquely quadrangular; columella lip thickened with narrow insinuation in outer lip; ornamentation sharp with fine transverse lirae and pseudoselenizone.

Discussion.—The genus *Keeneia* was erected in 1902 for specimens previously referred to *Trochus oculus* (J. Sowerby) 1838, *Platyschisma ocula* Morris, 1845, Dana (1849), Johnston (1888), Etheridge, Jr, (1892) and *Euomphalous oculum* de Koninck, 1877.

Branson (1948) considered *Trochus oculus* and *Keeneia platyschismoides* to be conspecific and placed the former in the genus *Keeneia*. *Keeneia platyschismoides* differs from *Trochus oculus* in ornament and the shape of the periphery. Etheridge, Jr had noted differences and considered them to be of specific, not generic value.

Trochus oculus, Platyschisma ocula Morris and *Euomphalous oculus* are now placed in *Keeneia ocula* (J. Sowerby), *Platyschisma ocula* Dana is placed in *Keeneia platyschismoides* and *Platyschisma ocula* Johnston is regarded as a possible synonym of *Keeneia trochiforme* Fletcher, 1958.

Etheridge, Jr (1902) figured specimens of *Keeneia platyschismoides*. Fletcher has studied this material and is of the opinion that specimens figured in pl. 33, figs 4, 5 are not typical of *Keeneia platyschismoides*.

Following Moore (1960), *Planikeeneia*, proposed by Fletcher (1958) for depressed low-spired gastropods with whorls of low convexity is placed in synonymy with *Keeneia*.

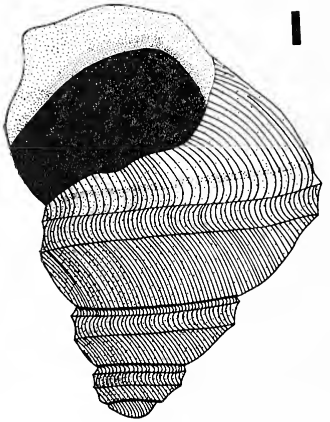
Range and Distribution.—The genus is confined to Permian strata. *Keeneia* has been recorded from the Lower Permian strata in Central India (Sahni and Dutt, 1962). It is abundant in the Dalwood Group and Branxton Formation of New South Wales (Fletcher, 1958) and in Tasmania, *K. platyschismoides* occurs in the Quamby Group and in the overlying Darlington Limestone and Brumby Formation of the Golden Valley Group (Banks, in Spry and Banks, 1962).

In Western Australia, *K. carnarvonensis* Dickins is found in the upper portion of the Lyons Group in the Carnarvon Basin (Dickins, 1963); in Queensland the genus has been recorded from the Cattle Creek Formation (Hill, 1957). Waterhouse (1963*a*) records the genus from the New Zealand Permian.

Keeneia afflicta, sp. nov.

(Fig. 2)

Holotype.—F. 43390 from the Buffel Formation, Cracow, Queensland; L. 2575, 32128451, Par. Cracow, Co. Dawson, at the base of the ridge, half a mile north-west of "Cracow", six miles south of Cracow, Queensland.



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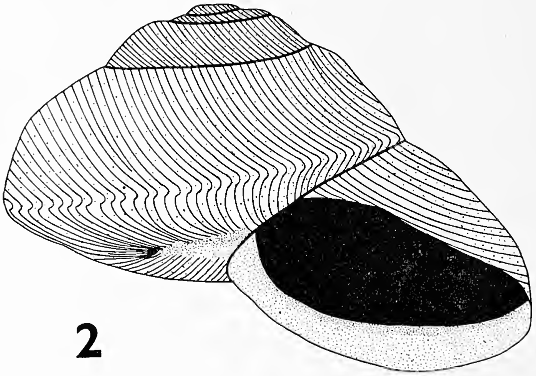

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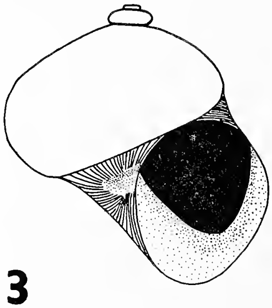

3

Diagnosis.—Small *Keeneia* with a very transverse whorl profile and a large apical angle; whorls few, with the lower whorl quite convex.

Description.—The shells are small, low-spired, narrowly phaneromphalous and have, in general, three whorls. The whorls are much wider than they are high and are flat or of very low convexity on the upper surface. The basal whorl profile is more convex. Sutures are shallow. The periphery of the body whorl is sharply angular with a small pseudoselenizone poorly developed. The occurrence of the periphery on the lower section of the whorl profile enables the aperture to be obliquely distended. Growth lamellae are very fine and run transversely across the whorl profile. They leave the suture at an angle of approximately 75° and are slightly convex to the aperture on the upper whorl surface. In the pseudoselenizone, lamellae swing back slightly and are gently concave to the aperture. On the lower whorl surface lamellae are concave to the aperture.

2. *Keeneia afflicta* sp. nov., apertural view of F. 43390 from L. 2575, approx. ×2.

Remarks: This species resembles *Keeneia minor* (Fletcher) from the Lower Permian, Dalwood Group of the Hunter Valley, New South Wales. However, *K. minor* has a more flattened whorl profile together with many more whorls. The lower whorl profile is more convex in *K. afflicta* than it is in *K. minor*.

Other species of *Keeneia* have a greater or smaller apical angle than *K. afflicta* and are larger.

Range and Distribution.—The species, *Keeneia afflicta,* is found only in the Buffel Formation of the Cracow District.

Localities.—In addition to the type locality, *K. afflicta* has been recorded from L. 2483, 31758603, Par. Coteeda, Co. Dawson, 0·8 mile north-north-west of Rose's Pride Mine, Cracow. Specimens found at this locality are F. 44286–44288.

Dimensions.—

	F. 43390	F. 43391
Height (mm.)	23	20
Width (mm.)	32	29
Apical angle	115°	129°

Suborder	Trochina Cox and Knight, 1960
Superfamily	Platyceratacea Hall, 1859
Family	Platyceratidae Hall, 1859
Genus	*Strotostoma* Fletcher, 1958

1958, *Strotostoma* Fletcher, p. 127.

Type Species.—(By original designation) *Strotostoma rylstonensis* Fletcher, 1958, p. 127, pl. 8, figs 7–11, pl. 9, fig. 5, from the base of the Capertee Group, 294946 Dubbo 1:253,440 military map, approximately 2 miles north-west of Rylstone, New South Wales.

Diagnosis: Moderately large naticiform gastropods, transversely produced with a low spire and a large inflated body whorl; whorl profile somewhat flattened above and below; sutures deep; aperture large, suboval to oval; surface with well defined spiral and transverse ornament. (Adapted from Fletcher, 1958.)

Discussion.—Fletcher (1958) notes how outstanding the genus is as far as form and ornament are concerned. Only two genera, *Platystoma* Conrad and *Strophostylus* Hall, show any resemblance to *Strotostoma*. The former does not have the same whorl profile and it has a closely coiled body whorl. *Strophostylus* closely resembles *Strotostoma* but has a strongly developed, twisted, plate-like fold on the columella.

Range and Distribution.—The genus is known only from the Permian Capertee, Maitland and Shoalhaven Groups in New South Wales. This is the first record of the genus outside the state.

3. *Strotostoma* sp. nov., apertural view of F. 43434 from L. 2572, approx. natural size.

STROTOSTOMA, sp. nov.

(Fig. 3)

Description.—The shells are naticiform with a large apical angle. The spire is low and the height/maximum width ratio approaches unity. Whorl profile on the three to three and a half whorls is broadly rounded. A flattened portion occurs on the upper half of the profile. Sutures are deep. The body whorl is greatly enlarged with the aperture correspondingly large, oval in outline, and situated underneath the major portion of the shell. It is not obliquely distended. Ornament consists of a lattice-like structure which can be observed only on a small part of the shell. Coarse spiral costae are cut by finer transverse costae that run convex to the apertural margin. The ornament resembles pustules in spiral rings that have fine costae between them. Spiral costae are approximately 0·05 mm. apart.

Remarks.—The position of the aperture and its lack of oblique distention separate this species from *S. rylstonensis* which also has a greater apical angle. *Strotostoma* sp. nov. resembles *S. inflata* Fletcher in the shape and position of the aperture but it is a much larger species with a different whorl profile.

Localities.—This species is found in the Barfield Formation, south-west of Cracow at L. 2572, 31698408, Par Cracow, Co. Dawson, approximately 4·0 miles south-west of "Cracow", Queensland. Specimens recorded are F. 43434–43435.

Dimensions.—

	F. 43434	F. 43435
Height (mm.)	36	29
Maximum diameter (mm.)	36	30
Apertural height (mm.)	20	
Apertural width (mm.)	17	
Apical angle	114°	114°

Acknowledgements

The writer wishes to thank Professor Dorothy Hill, F.R.S., University of Queensland who supervised the project and Dr. J. M. Dickins, Bureau of Mineral Resources, for critically reading the manuscript. Appreciation is due also to Mr. H. O. Fletcher, Australian Museum for discussion of problems and Dr. John Chronic, who sent the writer the relevant portion of the 1949 publication on *Peruvispira*.

References

BRANSON, C. C., 1948.—Bibliographic index of Permian invertebrates. *Mem. geol. Soc. Am.*, 26.

CAMPBELL, K. S. W., 1961.—Carboniferous fossils from the Kuttung Rocks of New South Wales. *Palaeontology*, 4 (3): 428–474.

CAMPBELL, K. S. W., 1962. Marine fossils from the carboniferous Glacial Rocks of New South Wales. *J. Paleont.*, 36 (1): 38–52.

CHRONIC, J., 1949.—*In* NEWELL, N. D., CHRONIC, J., and ROBERTS, T. "Upper Palaeozoic of Peru." New York.

CHRONIC, J., 1953.—*In* NEWELL, N. D., CHRONIC, J., and ROBERTS, T. Upper Palaeozoic of Peru. *Mem. geol. Soc. Am.*, 58.

DANA, J. D., 1849.—*In* United States Exploring Expedition during the years 1838, 1839, 1840, 1841 under the command of Charles Wilkes, U.S.N., 10, *Geology*, 681–713.

DICKINS, J. M., 1957.—Lower Permian pelecypods and gastropods from the Carnarvon Basin, Western Australia. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*, 41.

DICKINS, J. M., 1961.—*Eurydesma* and *Peruvispira* from the Dwyka Beds of South Africa. *Palaeontology*, 4 (1): 138–148.

Dickins, J. M., 1963.—Permian pelecypods and gastropods from Western Australia. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*, 63.

Dickins, J. M., Malone, E. J., and Jensen, A. R., 1964.—Subdivision and Correlation of the Permian Middle Bowen Beds, Queensland. *Rep. Bur. miner. Resour. Geol. Geophys. Aust.*, 70.

Etheridge, R., Jr., 1892.—*In* Jack, R. L., and Etheridge, R., Jr. Geology and palaeontology of Queensland and New Guinea. *Publs geol. Surv. Qd*, 92.

Etheridge, R., Jr., 1902.—A new Permo-Carboniferous genus (*Keeneia*) of Pleurotomariidae and a *Straparollus* in New South Wales. *Rec. Aust. Mus.*, 4 (5): 195–200.

Fletcher, H. O., 1958.—The Permian gastropods of New South Wales. *Ibid.*, 24 (10): 115–164.

Hill, D., 1957.—Explanatory notes, Springsure 4-mile geological series. *Note Ser. Bur. miner. Resour. Geol. Geophys. Aust.*, 5.

Johnston, R. L., 1888.—"Systematic account of the geology of Tasmania." Govt. Printer, Hobart.

Knight, J. B., 1941.—Palaeozoic gastropod genotypes. *Spec. pap. geol. Soc. Am.*, 32.

de Koninck, L. G., 1877.—Recherches sur les Fossiles Paleozoiques de la Nouvelle-Galles du Sud (Australie); Texte et Atlas. *Mem. roy. Soc. Sci. Liege*, 2nd ser., II.

Maxwell, W. G. H., 1964.—The geology of the Yarrol region. Part 1: Biostratigraphy. *Pap. Dep. Geol. Univ. Qd*, 5 (9): 1–77.

Moore, R. C., ed., 1960.—*Mollusca* 1 *in* Treatise on invertebrate Paleontology. Part I. Lawrence, Kansas, Univ. Kansas Press *for* Geological Society of America.

Morris, J., 1845.—Descriptions of Fossils *in* Strzelecki, P. E. de. "Physical Descriptions of New South Wales and Van Diemen's Land", 270–290. Longmans, London.

Sahni, M. R., and Dutt, D. K., 1962.—Argentine and Australian affinities in a Lower Permian fauna from Manendragarh, Central India. *Rec. geol. Surv. India*, 87: 655–670.

Sowerby, J., 1838.—Fossils *in* Mitchell, J. L. "Three expeditions into the interior of Australia." Boone Bros., London.

Spry, A. H., and Banks, M. R., eds., 1962.—The geology of Tasmania. *J. geol. Soc. Aust.*, 9 (2).

Veevers, J. J., Randal, M. A., Mollan, R. G., and Paten, R. J.—The geology of the Clermont 1 : 250,000 Sheet area, Queensland. *Rep. Bur. miner. Resour. Geol. Geophys. Aust.*, 66.

Wass, R. E., 1965.—The marine Permian formations of the Cracow District, Queensland. *J. Proc. roy. Soc. N.S.W.*, 98 (3): 159–167.

Waterhouse, J. B., 1963*a*.—Permian gastropods of New Zealand. Part 2—Pleurotomariacea (in part). *N.Z. Jl Geol. Geophys.*, 6 (2): 115–154.

Waterhouse, J. B., 1963*b*.—Permian gastropods of New Zealand. Part 3—Pleurotomariacea (concluded). *Ibid.*, 6 (4): 587–622.

THE AUSTRALIAN SPECIES OF DIPLOGEOMYZA AND ALLIED GENERA (DIPTERA, HELEOMYZIDAE)

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The Australian Museum, Sydney

[Read 29th March, 1967]

Synopsis

The Australian species of the genus *Diplogeomyza* Hendel and three related new genera are described, and keys are given for their identification. Of these species 17 are described as new, two having been previously described. One of the new species is divided into two subspecies. It is pointed out that these genera, together with the New Zealand genera *Allophylopsis* Lamb and *Allophylina* Tonnoir and Malloch, form a compact monophyletic group to which may be attributed the status of a tribe.

Introduction

The family Heleomyzidae is distributed mainly in the temperate areas of the world. Some workers, stationed in North America and Europe, have maintained a division into two families—the Heleomyzidae and Trixoscelidae. With a study of southern temperate forms these concepts lose their meaning through the long series of annectant forms. Among the Australian genera here reviewed, *Leriopsis* has most of the characters associated with Heleomyzidae *sensu stricto,* whilst the closely related *Trixoleria* has a preponderance of the characters of Trixoscelidae. It is significant that of the characters given by Wheeler (1955) in defining the Trixoscelidae, the only one which can be claimed to separate even the Nearctic forms from the Heleomyzidae *sensu stricto* is the nature of the subcosta. When southern hemisphere forms are considered, even this character shows too much variation among related forms to have family value.

Explanatory Notes Pertaining to Descriptions

The nomenclature of wing veins is based on the system of Loew (1862 and elsewhere). The first branch of the radial veins is designated vein 1, and the subsequent veins are numbered up to vein 6 (=cubital + first anal). The term subcosta is, however, preferred to auxiliary vein. This system has the advantage of not implying unprovable homologies, and, in its application to the Schizophora, is the simplest possible notation.

The terminology of the male postabdomen is, for the most part, that used by me previously (McAlpine, 1960). The terms basiphallus and distiphallus are used to designate the distinct basal and distal divisions of the phallus or aedeagus.

The months in which specimens have been collected are indicated in small Roman numerals after each locality, followed by the extreme range of years of collection. The number of specimens and their present location are placed in parentheses. The names of the collectors D. H. Colless and D. K. McAlpine are abbreviated to the initials.

Collections in which examined material is located are indicated by the following abbreviations:

AM, Australian Museum, Sydney: BM, British Museum (Natural History), London: CSIRO, Division of Entomology Museum, Commonwealth

Scientific and Industrial Research Organisation, Canberra: DEI, Deutsches Entomologisches Institut, Eberswalde, East Germany: NMV, National Museum of Victoria, Melbourne: QM, Queensland Museum, Brisbane: SAM, South Australian Museum, Adelaide: SPHTM, School of Public Health and Tropical Medicine, University of Sydney: UQ, Entomology Department, University of Queensland, St. Lucia, Brisbane: USNM, United States National Museum, Washington, D.C.

CLASSIFICATION

The genera here considered form a well defined unit morphologically, with restricted geographical limits, and are therefore combined as a new supra-generic taxon. Because there are at present no acceptable subfamily divisions in the Heleomyzidae (the old division into Heleomyzidae and Trixoscelidae being difficult to apply for many genera), the new taxon is given the rank of tribe.

Tribe ALLOPHYLOPSINI nov.

Heleomyzidae with two pairs of fronto-orbitals, both of which are reclinate; propleural bristle minute; no mesopleural bristle; middle tibia with two very strong approximated dorsal bristles beyond middle but with no other bristles but the terminal ones; costa distinctly weakened just beyond humeral cross-vein; vein 7 abruptly discontinued well before margin; male postabdomen (Fig. 30) asymmetrical, with sternites 6 and 7 laterally placed, and tergite 6 free.

Distribution: The tribe occurs throughout New Zealand, including the Snares and Chatham Islands; and in Australia it probably occurs in all temperate forests. In tropical Queensland all recorded specimens are from an altitude of 2000 ft. or higher. This corresponds approximately with the distribution of the whole family Heleomyzidae in the Australian region, excepting the genus *Cairnsimyia* (Rhinotorinae) and a species of an undescribed genus, which occur in tropical lowlands. Within this region the Allophylopsini is the largest tribe or equivalent group. In Australia 19 of the 56 heleomyzid species known to the author (many undescribed) belong here. In New Zealand there are 16 described Allophylopsini among the 32 described species of Heleomyzidae (the species recorded under the genera *Heloclusia* (Pseudopomyzidae) and *Tethinosoma* (Tethinidae) being excluded from the family).

The genera *Diplogeomyza* (15 spp.), *Austroleria* (2 spp.), *Trixoleria* (1 sp.), and *Leriopsis* (1 sp.) are endemic to Australia. The genera *Allophylopsis* (= *Huttonomyia*) (15 spp.) and *Allophylina* (1 sp.) are endemic to New Zealand. Records of the former genus from Australia are undoubtedly due to misidentification of species of *Diplogeomyza* or *Austroleria*.

Biology: Very little is yet known on this subject. Adults of a majority of species are most frequently encountered in wet forest country, some of them being most prevalent in mountainous areas. They frequently settle on ferns and other low vegetation and, as their movements are not rapid, they are readily taken by sweeping. Feeding has not been observed in the field. In many areas, including such cool localities as Mount Wilson (3000 ft., Blue Mountains), adults may be taken in any month of the year. They could not be found, however, on days of very severe frost.

An adult of *Austroleria extensa* sp. nov. from Mount Majura near Canberra was reared from the fungus *Boletus granulatus* (Family Polyporaceae) by Dr. D. H. Colless. This is the only available indication of the larval habits of the tribe. It is noteworthy that in the possibly allied subfamily (or tribe) Suilliinae the larvae occur principally in fungi.

Key to Genera of Allophylopsini

1\. Scutellum bare, with only the major bristles 2
Scutellum haired or setulose 4
2\. Scutellum short, broadly rounded; arista plumose; costa not spinose .... *Allophylina* Tonnoir and Malloch
Scutellum more elongate, ovate-triangular; arista with very short hairs only; spaced costal spines usually distinguishable 3
3\. Dorsocentrals 0 + 3; mesopleuron bare; wings with small markings on crossveins only .... *Leriopsis* nov.
Dorsocentrals 1 + 2; mesopleuron setulose; wings with extensive blackish markings .... *Trixoleria* nov.
4\. Prosternum setulose; base of radial vein with one or two fine posterior setulae on dorsal surface near hm crossvein; scutellum with a few fine hairs; dorsocentrals 0 + 3 .... *Allophylopsis* Lamb
Prosternum bare; base of radial vein bare; scutellum with rather coarse black setulae 5
5\. Dorsocentrals 0 + 3; mesopleuron setulose; scutellum with a few setulae on ventral surface near apex .... *Austroleria* nov.
Dorsocentrals 1 + 3; mesopleuron bare; scutellum without ventral setulae .... *Diplogeomyza* Hendel

Genus Leriopsis nov.

Head similar structurally to *Diplogeomyza*; fronto-orbital plates rather short, with two reclinate orbitals, the anterior one at about level of middle of frons. Antenna with third segment rounded-oval, almost orbicular, somewhat decumbent; arista minutely pubescent. Mesoscutum shortly setulose; scutellum similarly formed to that of *Diplogeomyza,* with four strong bristles and no hairs or setulae; three strong dorsocentrals, the foremost well behind suture; propleurals minute; mesopleuron bare; one sternopleural; prosternum bare. Fore coxa without very large hairs in male; hind femur with a series of anteroventral and posteroventral spines or thickened bristles in male only, legs otherwise as described for *Diplogeomyza.* Wings with distinct spaced costal spines; subcosta distinct throughout and distally diverging from vein 1; vein 1 not haired; vein 2 very slightly curved forward at extreme tip; venation otherwise as in *Diplogeomyza.* Male with abdominal sternite 6 sublateral, sternite 7 extending right round ventral surface; structure of post-abdomen of both sexes otherwise as in *Diplogeomyza.*

Type species: *Leriopsis montana* nov.

This genus shows most resemblance to *Trixoleria,* having a bare, subacute scutellum and pubescent arista. On the other hand there are characters which link it to the Suilliini, notably the shortened fronto-orbital plates which slope inwards from the eye margin, and the well developed subcosta diverging from vein 1. As the absence of a strong propleural bristle and the shortening of vein 7 are characters shared by all Suilliini, it is possible that this is a primitive genus linking the two tribes.

Leriopsis montana sp. nov.

♂ ♀. Head, including palpi, fulvous; cheeks a little paler than frons; third antennal segment brownish. Thorax fulvous, darkening to tawny on dorsal surface. Legs fulvous to brownish-yellow, fore femur, tibia, and tarsus brown; hind femur, tibia, and tarsus variably browned distally. Wing (Fig. 3) greyish hyaline with darker grey marks on anterior and posterior crossveins only. Abdomen tawny, tergites 2–4 brown.

Head about as long as high; frons slightly over half as wide as head, with numerous short setulae anteriorly; cheek about one third as high as eye, with numerous short setulae between vibrissa and posterior cheek bristle; face concave in profile.

Prescutellar pair of acrostichals present; mesoscutum with numerous short, coarse black setulae. Second section of costa (between veins 1 and 2) 4·6–4·8 times as long as third section; ultimate section of vein 4, 1·6 times as long as penultimate section.

Male postabdomen with a well developed epandrial lobe (Figs. 6A, B) in front of each surstylus, which is flexed inwards anteriorly and bears setulae on its inner surface near apex; surstylus slightly more than twice as long as wide (not taking into account the posteriorly expanded base), anterior margin almost straight, posterior margin convexly curved, apex obtuse, a number of short setulae on inner surface; paramere (Fig. 6C) narrowed distally, subacute at apex, with three fine setulae anteriorly near base; basiphallus sclerotized, rather short, but with a very long epiphallus, which is curved, with a rounded, slightly expanded apex; distiphallus somewhat elongate, membranous, with a pair of faintly sclerotized longitudinal strips; cerci with rather long, crimped hairs.

Female postabdomen without exceptionally modified segments.

Dimensions: total length, ♂ 2·9–4·5 mm., ♀ 3·3–4·5 mm.; length of thorax, ♂ 1·7–2·2 mm., ♀ 2·0–2·5 mm.; length of wing, ♂ 3·8–5·2 mm., ♀ 4·5–5·6 mm.

Distribution: highlands of Tasmania and southern Victoria.

Material examined: *Tasmania*: Lake Wilks to Lake Dove, Cradle Mountain, i 1960 (*holotype* ♀, *paratypes,* 10 ♂, 8 ♀, AM), D.K.M.; Hanson's Peak to Cradle Mountain, 3500 ft., i 1960 (*paratypes,* 3 ♂, 6 ♀, AM), D.K.M.; Waldheim, Cradle Mountain, 2850 ft., i 1960 (*paratype* ♂, AM), D.K.M.; Cradle Mountain, 3000 ft., i 1925 (*paratypes,* 1 ♂, 1 ♀, QM); 16 miles NE of Cradle Mountain, i 1960 (*paratype* ♂, AM), D.K.M.; Mount Barrow, near Launceston, 3000 ft., i 1960 (*paratype* ♂, AM), D.K.M.; Franklin River crossing, Lyell Highway, i 1960 (*paratype* ♂, AM), D.K.M.; Lake Esperance, Hartz Mountains, i 1960 (*paratypes,* 1 ♂, 2 ♀ AM), D.K.M. *Victoria*: Mount Baw Baw, 5000 ft., ii 1960 (3 ♀ NMV), F. E. Wilson; Mount Baw Baw, near Tanjil Bren, 4200 ft., iii 1964 (1 ♀ AM), G. L. Bush.

Habitat: mountain forest and scrub; most plentiful within a short distance of tree line in Tasmania.

Genus TRIXOLERIA nov.

Head similar structurally to *Diplogeomyza*; face not concave, with a slight median carina; fronto-orbital plates rather long, with two fronto-orbital bristles, the anterior one well in front of middle of frons. Third antennal segment rounded oval; arista with rather dense, short hairs, no longer than its basal diameter. Mesoscutum setulose; three dorsocentrals, the anterior one slightly in front of suture; prescutellar acrostichals absent or poorly differentiated; scutellum shaped as in *Diplogeomyza,* bare except for the four strong scutellars. Propleural very minute; mesopleuron with a few coarse setulae; one sternopleural with a group of setulae in front of it; prosternum bare or with one or two minute hairs at anterior extremity. Legs as in *Diplogeomyza* but fore coxa of male without very long distal hairs; hind femur of male not spinose. Wings with short, spaced costal spines; subcosta weak distally and situated rather close to vein 1; vein 2 rather short and curved forward distally; veins 3 and 4 slightly divergent distally; venation otherwise as in *Diplogeomyza.* Male postabdomen with tergite 6 sclerotized, setulose on posterior margin; other characters as in *Diplogeomyza.* Female postabdomen simple.

Type species: *Trixoleria maculata* sp. nov.

The name *Trixoleria* is derived from the generic names *Trixoscelis* and *Leria* and not directly from the Greek *νρὶξ*, genitive *τριχός* (thrix, trichos); hence the spelling is trix- and not trich-.

TRIXOLERIA MACULATA, sp. nov.

(Figs 1, 7)

♂ ♀. Frons brown, yellowish anteriorly, orbital margins whitish-dusted; occiput grey; cheeks and face yellowish; antennae brown, base of third segment yellowish; proboscis and palpi yellowish. Mesoscutum grey with two broad intradorsocentral dark-brown bands, a brown dot surrounding each setula and a larger brown spot at base of each dorsocentral bristle, some additional brown markings laterad of dorsocentrals, lateral margins greyish-yellow without markings; scutellum brown with greyish margins and median stripe; pleura brownish-grey with a darker brown longitudinal band on upper part. Legs brownish yellow, fore femur and usually also hind femur and four distal segments of fore tarsus dark-brown. Wings hyaline, with blackish and less distinct greyish markings as in Fig. 1. Halteres yellowish-brown, darker apically. Abdomen brown, distal margin of tergites paler.

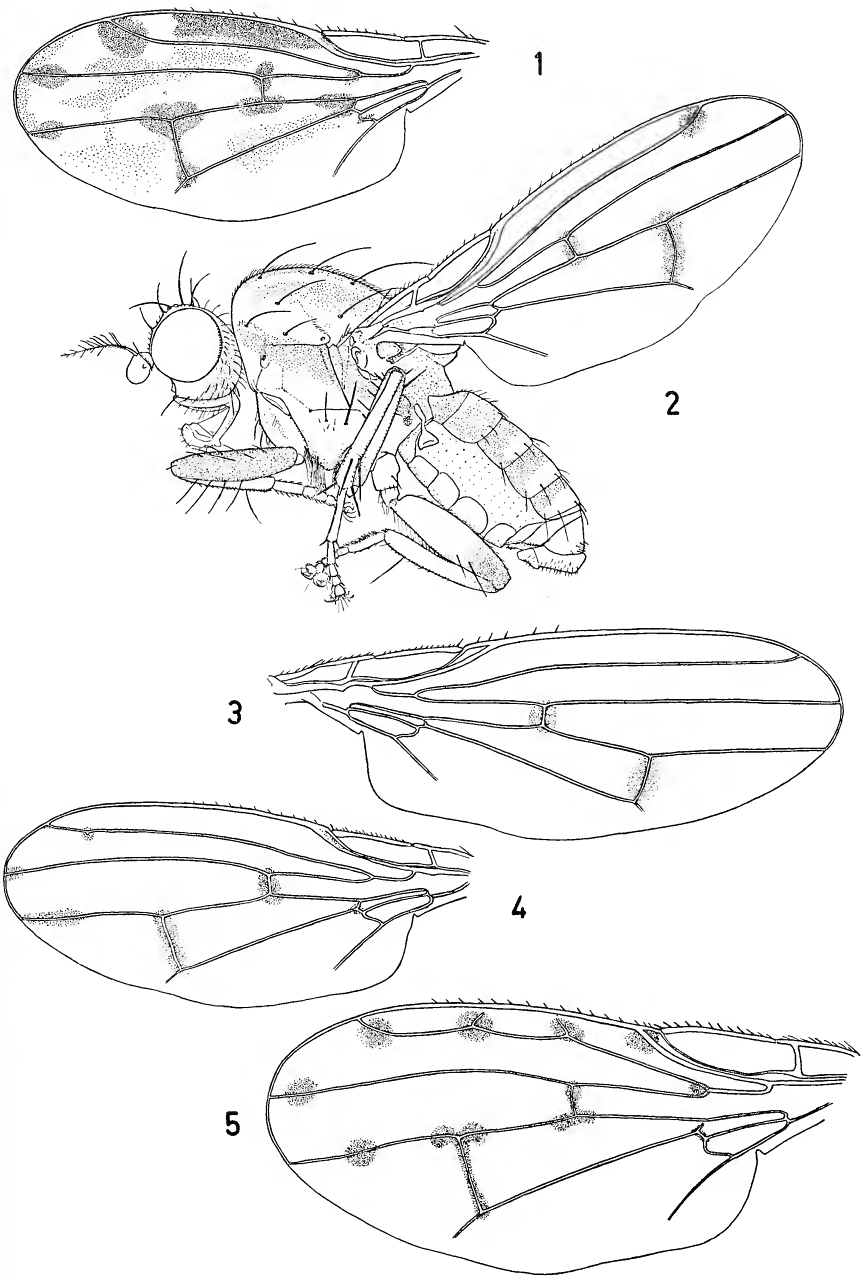
Eye longer than high; cheek bristles short and fine. Wing with second section of costa about 1·9–2·1 times as long as third section.

Male postabdomen (Figs 7A, B) with surstylus oblong, broadly rounded apically, placed in an almost transverse plane, minutely setulose on inner surface; paramere narrowed, rather short, truncate at apex with the upper angle produced into a fine point; basiphallus stout, mostly membranous, with a pair of short broad lobes at base of distiphallus; distiphallus membranous, with a pair of large black sclerites, each of which is forked distally; cerci well developed, rounded, setulose.

Dimensions: total length, ♂ 2·6–3·0 mm., ♀ 3·0–3·4 mm.; length of thorax, ♂ 1·4–1·6 mm., ♀ 1·4–1·8 mm.; length of wing, ♂ 3·2–3·5 mm., ♀ 3·1–3·7 mm.

Distribution: New South Wales; Victoria; Tasmania; in the north, principally tablelands.

Material examined: *New South Wales* and *Australian Capital Territory*: Mount York, Blue Mountains, x 1960 (*holotype* ♂, AM), D.K.M.; Mount Boyce, Blue Mountains, iii iv 1963–1964 (*paratypes,* 4 ♂, 2 ♀, AM, 1 ♂, 1 ♀, BM, 1 ♂, USNM), D.K.M.; Wentworth Falls, Blue Mountains, xi 1960 (*paratype* ♂, AM), D.K.M.; Blue Mountains, i 1922 (*paratype* ♂, SPHTM); *Berowra Creek, near Sydney,* x 1960 (*paratype* ♀, CSIRO), D.H.C.; New England National Park, near Ebor, x 1962 (2 ♂, 1 ♀, CSIRO), D.H.C.; Gwydir Highway, 72 miles W of Grafton, xi 1964 (2 ♂, AM), D.K.M.; Black Mountain, Canberra, light trap, x 1955 (*paratype* ♀, CSIRO), vi 1960 (*paratype* ♀, CSIRO), I.F.B. Common; Pretty Point Creek, Mount Kosciusko, 5300 ft. (*paratype* ♂, CSIRO); Kunama, near Batlow, viii 1961 (*paratype* ♂, CSIRO), D.H.C.; Snowy-Thredbo Junction, Snowy Mountains, xi 1961 (*paratype* ♀, CSIRO), D.H.C.; 12 miles NW of Adaminaby, xi 1961 (*paratypes,* 2 ♂ CSIRO, 2 ♂, BM), D.H.C.; Burke's Creek, near The Rock, iv 1963 (*paratype* ♀, AM), D.K.M. *Victoria*: swamp margin, Benalla, iv 1963 (1 ♀, AM), D.K.M.; Devil's Elbow, 6 miles N of Woods Point, 3000 ft., iv 1963 (3 ♂, AM), D.K.M.; Frenchman's Gap, near Woods Point, 3500 ft., iv 1963 (2 ♀ AM), D.K.M.; 13 miles W of Matlock, iv 1963 (1 ♀, AM), D.K.M. *Tasmania*: Corinna, Pieman River, i 1960 (1 ♂, 1 ♀, AM), D.K.M.; Pieman River near Rosebery, i 1960 (2 ♀, AM), D.K.M.; Franklin River Crossing, Lyell Highway, i 1960 (4 ♀, AM), D.K.M.; Hobart, xi 1916 (1 ♀, NMV), C. E. Cole; Eaglehawk Neck, iv 1916 (1 ♂, 1 ♀, NMV), C. E. Cole.



Figs 1–5

1, *Trixoleria maculata*, sp. nov., right wing of holotype; 2, *Diplogeomyza wirthi*, sp. nov., holotype; 3, *Leriopsis montana*, sp. nov., left wing of holotype; 4, *Austroleria extensa*, sp. nov., right wing of holotype; 5, *Diplogeomyza pectinervis*, sp. nov., right wing of holotype.

Habitat: Forest Country and woodland; on the mainland occurring in sclerophyll forest and open woodland, but also in rain forest and mixed forest in Tasmania.

Genus AUSTROLERIA nov.

Head structurally as in *Diplogeomyza*; arista with very short hairs, which are slightly or not at all longer than its basal diameter. Thorax with three dorsocentrals, all behind suture; scutellum formed as in *Diplogeomyza*, coarsely setulose on dorsal surface and with a few hairs ventrally near apex; four scutellars; propleurals minute; mesopleuron setulose; one sternopleural; a group of very minute setulae usually visible on hypopleuron (metepimeron) below metathoracic spiracle; prosternum bare. Male postabdomen with segment 7 forming a sclerotized ring encircling the protandrium. Female postabdomen simple, without modified segments; cerci free, shortly cylindrical.

Type species: *Austroleria extensa* sp. nov.

The genus *Austroleria* is intermediate in most characters between *Allophylopsis* and *Diplogeomyza*, but differs from these and other Allophylopsini in the presence of minute hypopleural setulae. In the coarsely setulose scutellum, bare prosternum, bare base of vein R, and coloration of thorax, it approaches *Diplogeomyza* and differs from *Allophylopsis*. In the setulose mesopleuron and possession of only three pairs of dorsocentrals it resembles *Allophylopsis* more closely.

Key to Species of Austroleria

1. Median brown stripe on mesoscutum broad and diffuse, or sometimes obsolete; surstylus club-shaped; paramere without basal tubercle; sclerotized strips in distiphallus separate, weakly sclerotized .... *extensa* nov.
   Median brown stripe on mesoscutum very narrow; surstylus very broadly truncate; paramere with setulose tubercle anteriorly at base; sclerotized strips in distiphallus strongly sclerotized and pigmented, fusing into a conspicuous sclerite proximally .... *truncata* nov.

AUSTROLERIA EXTENSA, sp. nov.

(Figs 4, 8)

♂ ♀. General colour brownish-yellow. Frons lightly suffused with brown; third antennal segment brown, paler at base; palpi brown to almost black, paler basally. Mesoscutum with three broad brown longitudinal bands, the outer ones partly divided by a paler stripe, the median band broad, but abruptly narrowed at anterior extremity; sometimes all these markings more or less obsolete; a conspicuous brown stripe commencing on humeral callus and extending over upper part of mesopleuron, pteropleuron, and pleurotergite to base of haltere; scutellum brownish dorsally, paler towards margins. Fore femur brown, paler basally; middle and hind femur broadly dark brown at apices; extreme bases of tibiae brownish. Wing (Fig. 4) greyish-transparent with distinct dark marks on anterior and posterior crossveins and vein closing base of discal cells; much fainter marks on apices of veins 2, 3, and 4. Abdominal tergites 2–5 and sternite 8 suffused with brown towards their posterior margins.

Male postabdomen (Figs 8A, B) with tergite 6 and sternite 6 reduced, the latter displaced to left; main body of sternite 7 on left lateral surface of protandrium, broadly fused with sternite 8 dorsally, its thickened, pigmented posterior rim forming a complete ring encircling the protandrium. Surstylus club-shaped, setulose distally on both inner and outer surfaces; paramere simple, directed posteriorly, setulose along anterior margin only; basiphallus largely membranous, with a sclerotized region on posterior surface and a pair of longitudinal pigmented sclerotized strips; distiphallus with a pair of separate weakly sclerotized strips, one of which is very short.

Dimensions: total length, ♂ 3·2–4·8 mm., ♀ 3·1–4·5 mm.; length of thorax, ♂ 1·8–2·4 mm., ♀ 2·0–2·4 mm.; length of wing, ♂ 3·8–4·9 mm., ♀ 4·2–5·0 mm.

Distribution: *New South Wales*—principally tablelands, in north and south; *Victoria*—coast and mountains; *Tasmania*—generally distributed.

Material examined: *New South Wales and Australian Capital Territory*: Mount Wilson, Blue Mountains, 3000 ft., iii 1961 (*holotype* ♂, AM), i iii iv v vi ix x xii 1956–1964 (*paratypes,* 47 ♂, 56 ♀, AM, 2 ♂, 1 ♀, BM, 3 ♂, 3 ♀, USNM), D.K.M.; Mount York, Blue Mountains, x 1960 (*paratype* ♀, AM) D.K.M.; below Govett's Leap, Blue Mountains, xii 1956 (*paratypes,* 2 ♂, AM), D.K.M.; Katoomba, vi 1957 (*paratype* ♀, AM), G. H. Hardy; Wentworth Falls, x xi 1957–1965 (*paratypes,* 2 ♂, 2 ♀, AM), D.K.M.; Kurrajong, near Richmond, ix 1961 (*paratype* ♂, AM), D.K.M.; Tubrabucca, Upper Hunter district, 4000 ft., x 1956 (*paratypes,* 3 ♂, 2 ♀, AM), D.K.M.; Point Lookout, near Ebor, 5000 ft., iii 1960 (3 ♂, 4 ♀, AM), D.K.M.; Wright's Lookout, New England National Park, iii iv 1961 (8 ♂, 2 ♀, AM), D.K.M.; New England National Park, x 1962 (1 ♂, 1 ♀, CSIRO), D.H.C.; Otford, Illawarra District, x 1957 (*paratypes,* 2 ♂, 1 ♀, AM), D.K.M.; Clyde Mountain, near Braidwood, 2400 ft., ii 1961 (*paratypes,* 2 ♀, AM), D.K.M.; Monga, near Braidwood, vii 1962 (*paratypes,* 1 ♂, 1 ♀, CSIRO), D.H.C.; Mount Majura, near Canberra, ix 1961 (1 ♂, CSIRO), D.H.C.; Rutherford Creek, Brown Mountain, near Nimmitabel, viii 1962 (1 ♀, CSIRO), D.H.C.; The Creel, Snowy Mountains, xi 1961 (1 ♂, 1 ♀, CSIRO), D.H.C.; Leather Barrel Creek, Snowy Mountains, xi 1961 (2 ♀, CSIRO), D.H.C.; Snowy River, 5700 ft., xi 1961 (1 ♀, CSIRO), D.H.C. *Victoria*: Tyers, near Lakes Entrance, v viii 1925 (1 ♂, 2 ♀, NMV), J. Galbraith; Stratford, near Sale, x 1961 (2 ♀ CSIRO), D.H.C.; Mount Beauty, near Bright, x 1961 (1 ♂, 3 ♀, CSIRO), D.H.C.; Frenchman's Gap, near Woods Point, iv 1963 (6 ♂, 2 ♀, AM), D.K.M.; 13 miles W of Matlock, iv 1963 (3 ♂, 2 ♀, AM), D.K.M.; Mount Dom Dom (Black Spur), near Healesville, x 1961 (3 ♂, 2 ♀, CSIRO), D.H.C.; Mount Donna Buang, near Warburton, iv 1963 (1 ♀, AM), D.K.M.; Cement Creek, near Warburton, iv x 1961-1963 (1 ♀, CSIRO), D.H.C., (6 ♂, 6 ♀, AM), D.K.M.; Warburton, iv 1963 (3 ♂, 2 ♀, AM), D.K.M.; Ferntree Gully, iv 1963 (1 ♂, 3 ♀, AM), D.K.M. *Tasmania*: 2 miles E of Weldborough, i 1960 (1 ♀, AM), D.K.M.; Mount Barrow, near Launceston, 3000 ft., i 1960 (4 ♂, 1 ♀, AM), D.K.M.; Marakoopa Caves, near Mole Creek, i 1960 (7 ♂, 1 ♀ AM), D.K.M.; Western Tiers, Lake Highway, 2250 ft., i 1960 (3 ♂, AM), D.K.M.; 12 miles S of Wilmot, i 1960 (1 ♀, AM), D.K.M.; 16 miles NE of Cradle Mountain, i 1960 (1 ♂, AM), D.K.M.; Hellyer Gorge, Waratah Highway, i 1960 (1 ♀, AM), D.K.M.; Pieman River, near Rosebery, i 1960 (1 ♂, 2 ♀, AM), D.K.M.; Franklin R. crossing, Lyell Highway, i 1960 (2 ♂, 2 ♀, AM), D.K.M.; Lake Saint Clair, i 1960 (1 ♂, AM), D.K.M.; near Russell Falls, Mount Field National Park, i 1960 (1 ♂, AM), D.K.M.; Eaglehawk Neck, i 1960 (3 ♂, 1 ♀, AM), D.K.M.; Ferntree, near Hobart, i 1960 (1 ♂, 4 ♀, AM), D.K.M.; Arve River, near Geeveston, i 1960 (1 ♂, 3 ♀, AM), D.K.M.; Hartz Mountains, 800 ft., i 1960 (1 ♂, AM), D.K.M.

Habitat: principally wet forest. The specimen from Mount Majura was reared from the fungus *Boletus granulatus* (family Polyporaceae).

AUSTROLERIA TRUNCATA, sp. nov.

♂ ♀. General characters as described for *A. extensa* with the following notable differences.

Third antennal segment usually paler than in *A. extensa,* sometimes browned only at apex; antennae yellowish, sometimes darkened at extreme apex. Mesoscutum with median dark-brown band very narrow and well defined. Spots at apices of veins 2–4 usually obsolete.

Male postabdomen (Figs 9A–C) similar to that of *A. extensa* with the following notable differences. Surstylus very broadly dilated and truncated distally; paramere with anterior basal tubercle, setulose on anterior margin, on basal tubercle, and on part of outer surface; basiphallus sclerotized and pigmented except on left lateral region, with two lobes at distal end, one of which is sclerotized, the other membranous; distiphallus with two long sclerotized strips which fuse basally to form a large heavily pigmented sclerite.

Dimensions: total length, ♂ 3·3–5·2 mm., ♀ 3·3–4·9 mm.; length of thorax, ♂ 2·2–2·6 mm., ♀ 2·2–2·7 mm.; length of wing, ♂ 4·4–5·3 mm., ♀ 4·5–5·5 mm.

Distribution: *New South Wales*—Central and Southern Tablelands; *Victoria*—coast to ranges; *Tasmania*—generally distributed.

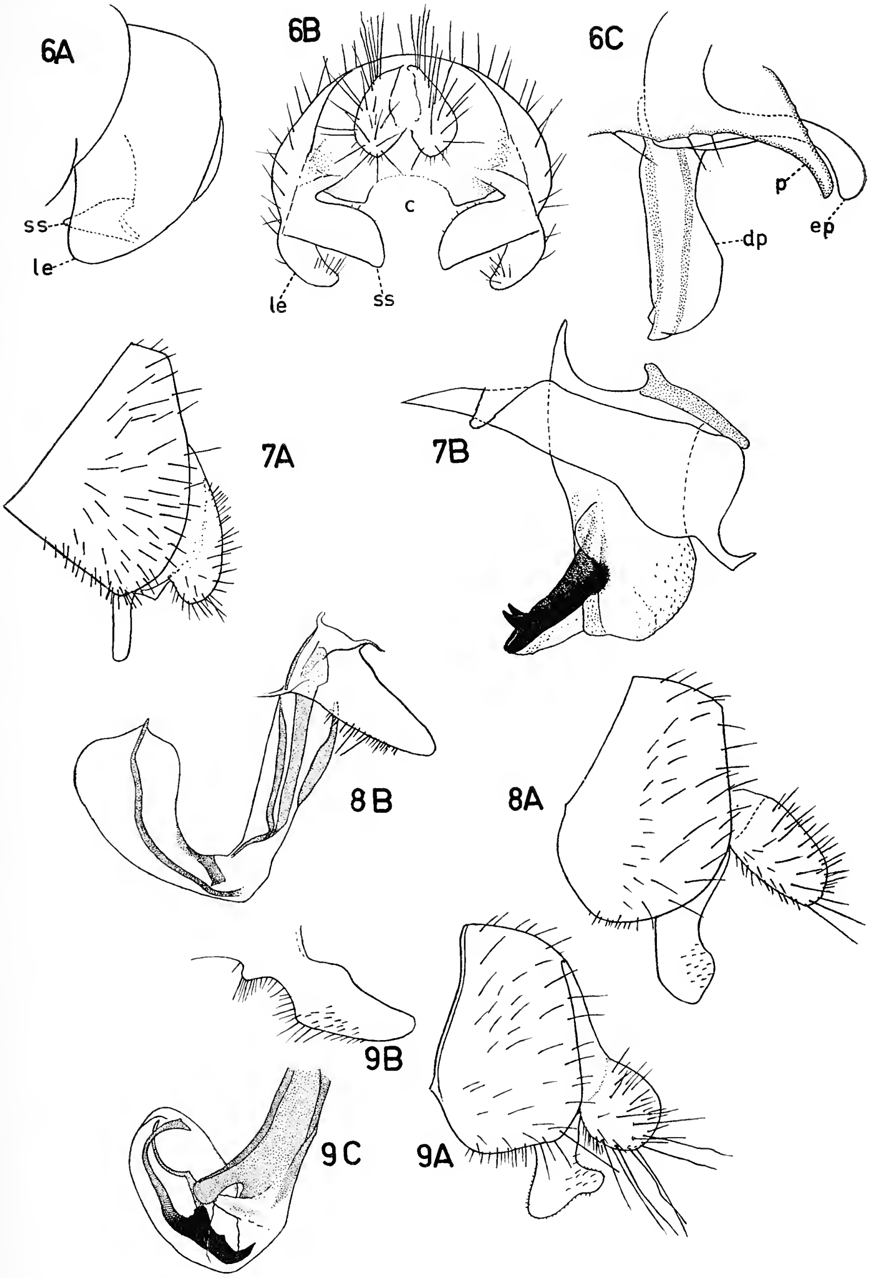
Material examined: *New South Wales*: Mount Wilson, Blue Mountains, 3000 ft., iii 1961 (*holotype* ♂, AM), i iii iv vi vii ix x xii 1956–1963 (*paratypes,* 4 ♂, 4 ♀, BM, 4 ♂, 4 ♀, USNM, 49 ♂, 59 ♀, AM), D.K.M.; below Govett's Leap, Blue Mountains, xii 1956 (*paratype* ♂, AM), D.K.M.; Wentworth Falls, xi 1957 (*paratype* ♀, AM), D.K.M.; Kurrajong, near Richmond, ix 1961 (*paratype* ♀, AM), D.K.M.; Rutherford Creek, Brown Mountain, near Nimmitabel, iii xi 1961 (1 ♂, 1 ♀, CSIRO), D.H.C. *Victoria*: Nowa Nowa, x 1961 (1 ♂, 1 ♀, CSIRO), D.H.C.; Tarra Valley, South Gippsland, iii 1953 (1 ♂, NMV), A. Neboiss; Warburton, iv x 1961–1963 (1 ♂, CSIRO), D.H.C., (29 ♂, 25 ♀, AM), D.K.M.; Ferntree Gully, iv 1963 (3 ♂, 6 ♀, AM), D.K.M.; Sherbrook Forest, near Ferntree Gully (1 ♂, NMV), Mr. Singleton. *Tasmania*: 2 miles E of Weldborough, i 1960 (4 ♀, AM), D.K.M.; 2 miles E of Tonganah, i 1960 (1 ♂, AM), D.K.M.; Hellyer Gorge, Waratah Highway, i 1960 (2 ♂, 1 ♀, AM), D.K.M.; near Russell Falls, Mount Field National Park, i 1960 (1 ♂, 3 ♀, AM), D.K.M.; Eaglehawk Neck, i 1960 (1 ♂, 1 ♀, AM), D.K.M.

Genus Diplogeomyza Hendel

Two strong, reclinate fronto-orbitals; face somewhat concave. Third antennal segment oval. Dorsocentrals 1 + 3; acrostichals absent or represented only by the prescutellar pair; mesoscutum with numerous setulae on most of surface; scutellum oval, slightly produced between the apical bristles, with rather coarse black setulae; four strong scutellars and sometimes four additional shorter ones; mesopleuron devoid of hairs or bristles; one or sometimes two sternopleurals; propleurals weak or vestigial; prosternum bare. Fore coxae of male with numerous very long hairs, which are very fine and tend to curl at the tips; middle femur with strong anterior bristles; fore and hind tibiae each with one distinct preapical dorsal bristle; middle tibia with a pair of strong, approximated preapical dorsal bristles. Costa with short, spaced spines, weakened just beyond humeral crossvein, broken at end of subcosta; subcosta reaching to costa but not always easily distinguished from the sclerotized area in front of vein 1; vein 1 not haired; vein 2 rather long, curved forwards apically; anal cell complete, second basal cell almost so; vein 6 not nearly reaching margin. Abdomen of male with tergite 6 weakly sclerotized and bristleless; sternites 6 and 7 sublateral; articulated surstyli and distinct cerci present. Female with distinct cylindrical cerci.

Type species: *Diplogeomyza diaphora* Hendel.

It is possible to divide the species into groups on such characters as chaetotaxy, development of hairs on arista, and development of supernumerary crossveins. A careful study of the morphology of the fifteen species suggests



Figs 6–9

6, *Leriopsis montana*, sp. nov., paratype, Hanson's Peak to Cradle Mountain. A, antero-lateral aspect of epandrium. B, posterior aspect of epandrium. C, left paramere and aedeagus; 7, *Trixoleria maculata*, sp. nov., paratype, Wentworth Falls. A, epandrium. B, left paramere and aedeagus; 8, *Austroleria extensa*, sp. nov., paratype, Mount Wilson. A, epandrium. B, left paramere and aedeagus; 9, *Austroleria truncata*, sp. nov., paratype, Mount Wilson. A, epandrium. B, left paramere. C, aedeagus.

c, cercus; dp, distiphallus; ep, epiphallus; le, lobe of epandrium; p, paramere; ss, surstylus.

that the structure of the female postabdomen is more significant in grouping the species naturally, and it is here used for distinguishing primary groups within the genus. No purpose would be served in giving these groups subgeneric names, as they cannot be readily keyed out for the male sex.

Group 1: ♀ postabdominal segments (Fig. 26) all short, not spinose; segment 7 with tergite and sternite free: ? *incisa* (female unknown), *wirthi, conformis, immaculata*.

Group 2: ♀ postabdominal segments (Fig. 27) not spinose; segment 7 elongate with tergite and sternite free: *hardyi, flavipalpis, diaphora, tridens*.

Group 3: ♀ postabdominal segments (Fig. 28) all short, not spinose; segment 7 with tergite and sternite fused into a complete ring: *victoriae, annularis*.

Group 4: ♀ postabdominal segments (Fig. 29) all short; tergites 7, 8 and sometimes 6, with short strong spines; segment 7 with tergite and sternite free: *spinosa, signata, media, maculipennis, pectinervis*.

As in the related genus *Allophylopsis*, the external copulatory organs of the male provide very clear cut specific characters, but are usually supported by characters of colour-pattern. *D. wirthi* and *D. conformis* can so far only be distinguished by the male sexual structures, and the females can only be determined by the uncertain method of association with males.

Key to Species of Diplogeomyza

1. Arista with very short hairs only; mesonotum patterned with small whitish spots and no longitudinal bands; female postabdominal tergites not spinose, segment 7 elongate .... *hardyi* nov.
Arista plumose 2

2. A series of blackish spots on anterior margin of wing; female postabdomen with numerous short spines on tergites 7 and 8, segment 7 short 3
Wing margin spotted only at apices of veins 4

3. Costal margin of wing with three large squarish spots from apex of vein 1 to apex of vein 2, without supernumerary crossveins .... *maculipennis* Malloch
Costal margin of wing with four or more narrow spots in marginal cell, which enclose incomplete crossveins .... *pectinervis* nov.

4. Scutellum with four long bristles and four (rarely more) shorter ones (in addition to usual dorsal setulae); female with postabdominal tergites not spinose, segment 7 elongate 5
Scutellum with four long bristles only (in addition to setulae) 6

5. Fore femur largely greyish-brown, only the basal quarter or less paler, dull yellowish; hind femur conspicuously blackish or dark-brown apically; prominence on anterior margin of surstylus closer to base than to apex; paramere slightly swollen near apex, the extreme apex directed forwards; basiphallus short, the epiphallus nearly as long; distiphallus not toothed at apex .... *diaphora* Hendel
Fore femur dull yellowish, variably suffused with light-brown on distal half; hind femur brownish at extreme apex only; prominence on anterior margin of surstylus closer to apex than to base; paramere finely acuminate, the apex curved backwards; basiphallus long, heavily sclerotized, the epiphallus much shorter, distiphallus tridentate at apex .... *tridens* nov.

6. Two (rarely three) sternopleural bristles; wing with distinct blackish spot at apex of vein 2, but none at apices of veins 3 and 4; the short distiphallus with a pair of ring-like sclerites 7
One sternopleural bristle; dark spot at apex of vein 2, when present, not much more distinct than spots at apices of veins 3 and 4; distiphallus without paired ring-like sclerites 8

7. Surstylus very broad at base, then abruptly contracted, making the distal part comparatively narrow; paramere with two recurved, thorn-like processes near anterior margin; distal part of basiphallus with a spinous process on each side, the apex rounded and but slightly dilated .... *wirthi* nov.
Surstylus not much broadened at base nor much contracted beyond base; paramere with a single downwardly directed process near centre; basiphallus without spinous processes, the apex dilated and truncate .... *conformis* nov.

8. Mesoscutum with two intradorsocentral dark-brown bands enclosing a much paler median band; no dark spots at apices of veins; postabdominal tergites of female not spinose, segment 7 short, with free tergite and sternite ...... *immaculata* nov.
Mesoscutum without a median pale band; dark spots present, though sometimes faint, at apices of veins 2, 3 and 4 9

9. Sternopleuron without dark oblique band on lower part 10
Sternopleuron with dark oblique band connecting fore and middle coxae 13

10. Tibiae blackened apically; a brown spot (rarely indistinct or absent) close in front of sternopleural bristle; distiphallus with a pair of opposed claws; female with abdominal tergites 7 and 8 spinose .... *spinosa* nov.
Tibiae not darkened apically; no brown spot in front of sternopleural bristle; distiphallus without opposed claws; female without spines on postabdominal tergites (female unknown in *D. incisa*) 11

11. Palpi pale yellowish; distiphallus strap-shaped, with long, strong basal spines; female postabdomen with segment 7 elongate, the tergite and sternite free .... *flavipalpis* nov.
Palpi brown; distiphallus not strap-shaped or spinose 12

12. Mesoscutum with a median blackish stripe, the dorsocentral lines with pale stripes; basiphallus very elongate, distiphallus with a pair of small lunular sclerites (female unknown) .... *incisa* nov.
Mesoscutum with markings obsolete; basiphallus rather short, expanded distally, distiphallus without lunular sclerites; female postabdomen with segment 7 short, the tergite and sternite fused .... *victoriae* nov.

13. A pair of narrow dark brown bands on dorsocentral lines; basiphallus elongate, distiphallus with numerous, densely packed black spines .... *media* nov.
A pair of pale bands on dorsocentral lines; distiphallus not spinose 14

14. Mesopleuron suffused with brown on most of surface, somewhat darker above than below; band on sternopleuron rather diffuse; surstylus produced into a slender, tapering incurved apical part; skeletal structure of basiphallus forked, distiphallus with a ring-like sclerite; female without spines on postabdominal tergites, segment 7 short, with tergite and sternite fused .... *annularis* nov.
Mesopleuron divided into dark-brown upper section and pale-yellowish lower section; band on sternopleuron narrow and distinct; surstylus short, blunt; aedeagus not as above, with several sclerites in distiphallus including a triradiate terminal one; female with tergites six to eight spinose, segment 7 short, with tergite and sternite free .... *signata* nov.

DIPLOGEOMYZA INCISA, sp. nov.

(Fig. 10)

♂. Coloration generally as described for *D. wirthi* (below), but the following characters are noteworthy. Antennae yellowish brown, the distal part of third segment only slightly darker. Fore femur brownish-yellow, darker brown on dorsal surface of distal half. Wings with dark-greyish marks on anterior and posterior crossveins and at apices of veins 2, 3, and 4, those on veins 3 and 4 not as dark as others.

Structure and chaetotaxy very similar to those of *D. wirthi*. Only one sternopleural bristle.

Postabdominal structures (Fig. 10A–C) most like those of *D. wirthi* and *D. conformis* but differing in detail; surstylus about three times as long as wide, not narrowed towards the apex, which is broadly rounded; paramere broad basally, contracted just before the very broad, truncate apical part; basiphallus long, tubular, sclerotized, not expanded at distal end where there is a lightly sclerotized median fissure, and an elongate lobe on left side; distiphallus extending well beyond basiphallus, membranous, with a dark, almost divided sclerite on posterior surface beyond which is a pair of lunular or Ω-shaped sclerites, apparently homologous with the ring-like sclerites of *D. wirthi* and *D. conformis*; cerci much shorter than surstyli, with moderately long hairs on most of surface.

Dimensions: total length 4·5 mm.; length of thorax 2·5 mm.; length of wing 4·8 mm.

Distribution: Victoria.

Material examined: Fernshaw, 6 miles E of Healesville, iv 1963 (*holotype* ♂, AM), D.K.M.

Habitat: wet sclerophyll forest.

Though only one specimen is available of this form, it is possible to establish its status with a reasonable degree of accuracy. Its relationships are undoubtedly with *D. wirthi* and *D. conformis* but it differs from these two very closely related species in having only one sternopleural bristle and dark spots at the ends of veins 3 and 4. The characters of the surstyli. parameres and aedeagus are also quite distinctive.

DIPLOGEOMYZA WIRTHI, sp. nov.

(Figs 2, 11)

♂ ♀. Head dull yellowish; antennae yellowish-brown, third segment deeper brown to brown-black except at base; palpi brown to black. Mesoscutum reddish-brown, lateral margins pale yellowish, a pair of light greyish bands on dorsocentral lines and a broader light-grey median band which is divided by a dark-brown median stripe anteriorly; scutellum brown with grey dusting at sides; pleura brownish yellow with the usual dark brown band on upper part. Legs yellowish; fore femur dark-brown usually paler basally; middle femur narrowly brown and hind femur broadly blackish at apex; hind tibia slightly brownish at base and apex. Wing with a conspicuous blackish spot at apex of vein 2 and a blackish mark on anterior and on posterior cross vein. Abdomen greyish-brown, sometimes with yellowish markings.

Cheek bristles moderately developed; third antennal segment ovate; arista plumose, the longer upper hairs slightly shorter than width of third antennal segment.

Scutellum with coarse setulae on its entire upper surface; sternopleuron with two well developed upper bristles and some small setulae, one of which is occasionally developed into a third bristle. Second section of costa 2·3–2·5 times as long as third section.

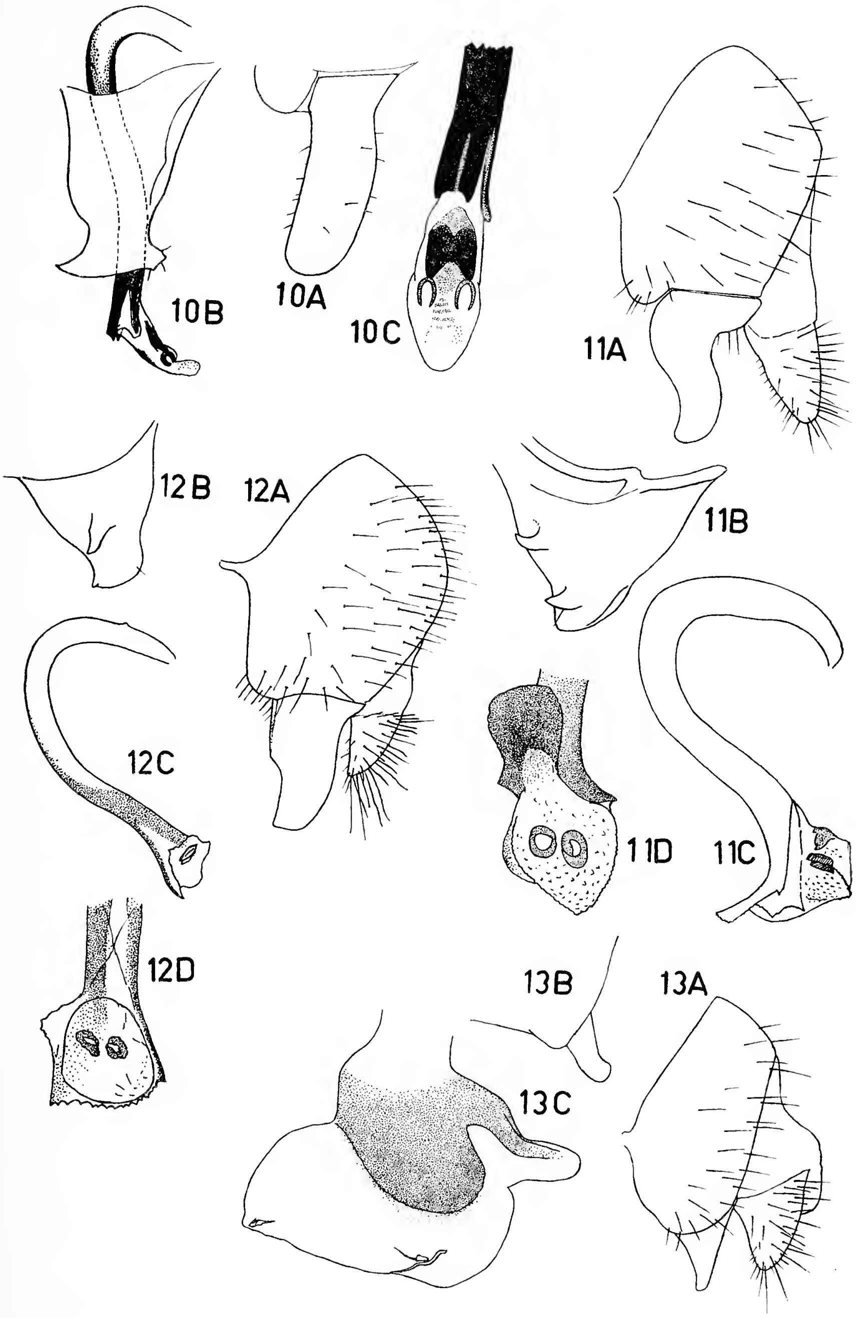
Epandrium (Fig. 11A) with surstylus very broad basally, abruptly contracted into a narrow, slightly curved, obtuse distal part making the posterior margin deeply sinuate; paramere (Fig. 11B) broad, subtriangular, with two recurved thorn-like processes, one just before apex and one near middle of anterior margin; basiphallus (Fig. 11C) forming a long, heavily sclerotized tube which is split open distally, where it has a small sharp process on each side, the apex very slightly dilated and rounded; distiphallus (Fig. 11D) very short, membranous, arising from posterior surface of distal part of basiphallus, and containing two small ringlike sclerites; cerci shorter than surstyli with rather short hairs.

Female abdomen with tergites six to nine all distinct and setulose; simple, without obvious structural modifications; sternites six, seven and eight narrowed medially, setulose; sternite ten compact with numerous setulae; cerci rather short, with some long hairs at tip.

Dimensions: total length, ♂ 2·9–4·2 mm., ♀ 2·1–4·0 mm.; length of thorax, ♂ 1·5–2·3 mm., ♀ 1·5–2·4 mm.; length of wing, ♂ 3·5–4·7 mm., ♀ 3·1–5·0 mm.

Distribution: New South Wales—Tablelands as far north as Blue Mountains; Victoria; Tasmania.

Material examined: *New South Wales*: Colo Vale, near Mittagong, iii 1957 (*holotype* ♂, AM, *paratype* ♂, 2 ♀, USNM), W. W. Wirth; Clyde Mountain, near Braidwood, 2400 ft., ii 1961 (8 *paratypes* ♂, AM), D.K.M.;



Figs 10–13

10, *Diplogeomyza incisa*, sp. nov., holotype. A, left surstylus. B, left paramere and aedeagus. C, terminal aspect of aedeagus; 11, *Diplogeomyza wirthi*, sp. nov., paratype, Mount Wilson. A, epandrium. B, left paramere. C, aedeagus. D, terminal aspect of aedeagus; 12, *Diplogeomyza conformis*, sp. nov., paratype, Black Mountain, Canberra. A, epandrium. B, left paramere. C, aedeagus. D, terminal aspect of aedeagus; 13, *Diplogeomyza immaculata*, sp. nov., paratype, the Crater. A, epandrium. B, left paramere. C, aedeagus.

Otford, Illawarra District, x 1959 (1 ♀, AM), D.K.M.; Katoomba, xi 1956 (1 ♀, AM), G. H. Hardy; Mount York, Blue Mountains, x 1960 (*paratype* ♂, AM), D. K. M.; Mount Wilson, Blue Mountains, ii iii x 1957–1961 (7 *paratypes* ♂, 4 ♀, AM), D.K.M. *Victoria*: Frenchman's Gap, near Woods Point, 3500 ft., iv 1963 (1 ♂, AM), D.K.M. *Tasmania*: Mount Barrow, near Launceston, 3000 ft., i 1960 (1 ♂, 1 ♀, AM), D.K.M.; Arthur Plains, Southwest District, ii 1965 (2 ♂, NMV), A. Neboiss.

Habitat: forest country.

This species can only be distinguished from *D. conformis* by the structure of the male terminalia, and the females of the two species cannot therefore be separated. All the above records of females are therefore open to doubt, and records of female specimens from localities where both species are known or suspected to occur are omitted. In males the distinguishing characters of the surstyli can be seen without dissection or clearing.

Diplogeomyza conformis appears to be able to withstand greater extremes of dryness than *D. wirthi.* The latter species is not kown to occur in areas of less than 30 inches mean annual precipitation.

DIPLOGEOMYZA CONFORMIS, sp. nov.

(Fig. 12)

♂ ♀. Agrees in all characters, except those of the male postabdomen, with the description of *D. wirthi.*

General structure of postabdomen and appendages (Figs 12A–D) somewhat similar to that of *D. wirthi*; surstylus not much broadened at base and but slightly narrowed towards apex, slightly curved sigmoidally, apex broadly obtuse to almost truncate, the inner surface setulose; paramere with one process near centre, apex of paramere subacute and bent outwards; distal part of basiphallus desclerotized medially, the apex dilated and truncate, denticulate on distal edge but without any processes, two ring-like sclerites present as in *D. wirthi.*

Dimensions: total length, ♂ 3·4–4·8 mm., ♀ 3·5–5·0 mm.; length of thorax, ♂ 1·9–2·4 mm., ♀ 1·9–2·5 mm.; length of wing, ♂ 4·0–4·9 mm., ♀ 4·1–5·2 mm.

Distribution: New South Wales—Southern tablelands to south western slopes; Victoria; Tasmania.

Material examined: *New South Wales* and *Australian Capital Territory*: Black Mountain, Canberra, in light trap, ix 1959 (*holotype* ♂, CSIRO), v ix x 1955–1960 (15 *paratypes* ♂, 17 ♀, CSIRO, 3 *paratypes* ♂, 5 ♀, AM), I. F. B. Common; Black Mountain, Canberra, ex blowfly trap x 1956 (7 *paratypes* ♂, 10 ♀, CSIRO), no collector's name; Mount Majura, Canberra, ix 1960 (*paratype* ♂, 1 ♀, CSIRO), D.H.C.; Mount Gingera, A.C.T., 5500 ft., i 1955 (*paratype* ♂, CSIRO), I. F. B. Common; Uriarra State Forest, A.C.T., x 1960 (1 ♀, CSIRO), D.H.C.; Sweetwater, Kain, near Braidwood, ix 1960 (*paratypes,* 2 ♂, CSIRO), D.H.C.; 18 miles SSE of Braidwood, x 1955 (*paratype* ♂, CSIRO), I. F. B. Common; 13 miles SE of Braidwood, x 1955 (*paratype* ♂, CSIRO), I. F. B. Common; Clyde Mountain, near Braidwood, 2400 ft., ii 1961 (*paratype* ♂, AM), D.K.M.; Paddy's River, near Marulan, ix 1956 (*paratype* ♂, 1 ♀, AM), D.K.M.; Gerogery, near Culcairn, x 1951 (*paratype* ♂, CSIRO), J. Calaby; The Creel, Snowy Mountains, xi 1961 (*paratype* ♂, 1 ♀, CSIRO), D.H.C. *Victoria*: Frenchman's Gap, near Woods Point, 3500 ft., iv 1963 (10 ♂, 2 ♀, AM), D.K.M.; 13 miles W of Matlock, iv 1963 (11 ♂, 13 ♀, AM), D.K.M.; Warburton, iv 1963 (3 ♂, 1 ♀, AM), D.K.M.; Cement Creek, near Warburton, x 1961 (1 ♂, CSIRO), D.H.C., iv 1963 (3 ♂, 2 ♀, AM), D.K.M.; Mount Donna Buang, near Warburton, iv 1963 (12 ♂, 10 ♀, AM), D.K.M.; Fernshaw, near Warburton, iv 1963 (1 ♂, 1 ♀, AM), D.K.M.; Black Spur (or Mount Dom Dom), near Healesville, ii x 1953–1961 (1 ♂, NMV), A. Neboiss, (2 ♂, CSIRO), D.H.C.; Kinglake, x 1953 (1 ♂, NMV), A. Neboiss; Nunawading, near Melbourne, iv 1957 (1 ♂, NMV), A. Neboiss; Melbourne, ix 1928 (1 ♂, NMV), F. E. Wilson; Lismore, viii 1953 (1 ♂, NMV), A. Neboiss; Branxholme, near Hamilton, viii 1953 (3 ♂, 2 ♀, NMV), A. Neboiss. *Tasmania*: near Russell Falls, Mount Field National Park, i 1960 (1 ♂, AM), D.K.M.; Eaglehawk Neck, i 1960 (1 ♂, AM), D.K.M.

Habitat: forest country.

As with *D. wirthi,* the specific identification of all females is doubtful, and no female paratypes are designated.

DIPLOGEOMYZA IMMACULATA, sp. nov.

(Fig. 13)

♂ ♀. Head dull yellowish; frons suffused with brown, except on anterior margin; antennae brownish-yellow; palpi yellowish. Mesoscutum light reddish-brown, except for the pale yellowish lateral margins, a pair of darker brown longitudinal bands between the dorsocentrals, and two sublateral brown bands on each side which coalescence at the suture to form a single band on each side anteriorly; scutellum deep reddish-brown with a paler median stripe and apex; pleura light yellowish with a broad brown longitudinal stripe passing from humeral callus, across upper half of mesopleuron and of pteropleuron, and covering all of pleurotergite; mesopleuron with an additional brown mark on lower margin; sternopleuron unmarked. Legs yellowish; femora brownish at apices. Wings almost completely hyaline, with only posterior crossvein margined with brown. Abdomen yellowish-brown, with the posterior and lateral edges of tergites darker brown.

All *cheek bristles* reduced to small setulae; third antennal segment ovate; arista, plumose, the longer hairs longer than width of third antennal segment.

Scutellum with two pairs of bristles and numerous setulae which are finer and shorter than in *D. diaphora* and *D. spinosa;* sternopleuron with one upper bristle.

Male with surstylus (Fig. 13A) rather small, broadened basally, the distal part narrow and blunt at the apex; paramere (Fig. 13B) moderately short, curved backwards, blunt; aedeagus (Fig. 13C) short and very stout, the basiphallus represented by a pair of black, sclerotized plates which are fused anteriorly but free posteriorly where each bears a slender basal process which projects between parameres; distiphallus consisting of a broad flattened membranous bulb with some small, weak sclerites on distal surface; cerci about as long as surstyli.

Female postabdomen without spines on any tergites; segment 7 short with separate tergite and sternite; tergite 8 entire; cerci moderately short.

Dimensions: total length, ♂ 4·0–5·0 mm., ♀ 3·7–4·8 mm.; length of thorax, ♂ 2·6–3·1 mm., ♀ 2·5–3·0 mm.; length of wing, ♂ 4·9–5·8 mm., ♀ 4·9–5·5 mm.

Distribution: North Queensland.

Material examined: Barron River, at the Crater (or Mount Hypipamee), near Herberton, 3100 ft., i 1959 (*holotype* ♀, *paratype* ♂, AM), D.K.M. xii 1961 (*paratypes,* 4 ♂, 8 ♀, AM, 1 ♀, BM, 1 ♂, USNM), R. Lossin and D.K.M.

Habitat: stream margins in rain forest.

DIPLOGEOMYZA HARDYI, sp. nov.

This species is separated from all others of the genus by the short-haired arista and pattern of whitish spots on the mesoscutum. The long strap-shaped distiphallus with two longitudinal serrated ridges is unlike that of any other known species.

Distribution: New South Wales—principally tablelands; Victoria; Tasmania.

As far as can be ascertained at present, Tasmanian specimens show slight but consistent differences from mainland specimens in the structure of the male postabdomen, but no other differentiating characters have been found. There is no evidence that the distributions of the two forms overlap. It is possible that two distinct species are concerned but because it is not at present possible to test the decisive criteria the two forms are here called subspecies.

DIPLOGEOMYZA HARDYI HARDYI, subsp. nov.

(Fig. 14)

♂ ♀. Head yellowish; posterior part of frons brown; antennae and palpi black. Mesoscutum reddish brown with whitish lateral and anterior margins and a pattern of whitish spots, six in a circle surrounding first two pairs of dorsocentrals, one behind or surrounding each of the last pair of dorsocentrals, one behind each supra-alar, one at each basal corner and one at apex of scutellum; pleura dull yellowish variably suffused with brown, upper margin darker brown. Legs dull yellowish; fore femur and apices of other femora brown. Wings greyish hyaline with distinct dark grey markings as follows: apical spots on veins 1 to 4, that on vein 4 elongate, a spot at fork of veins 2 and 3 and one at base of discal cell, a mark along anterior cross-vein, and another along posterior cross-vein. Abdomen brown.

Fronto-orbital bristles situated rather close together near middle of frons, the anterior one distinctly shorter; arista with short hairs up to twice as long as its basal diameter.

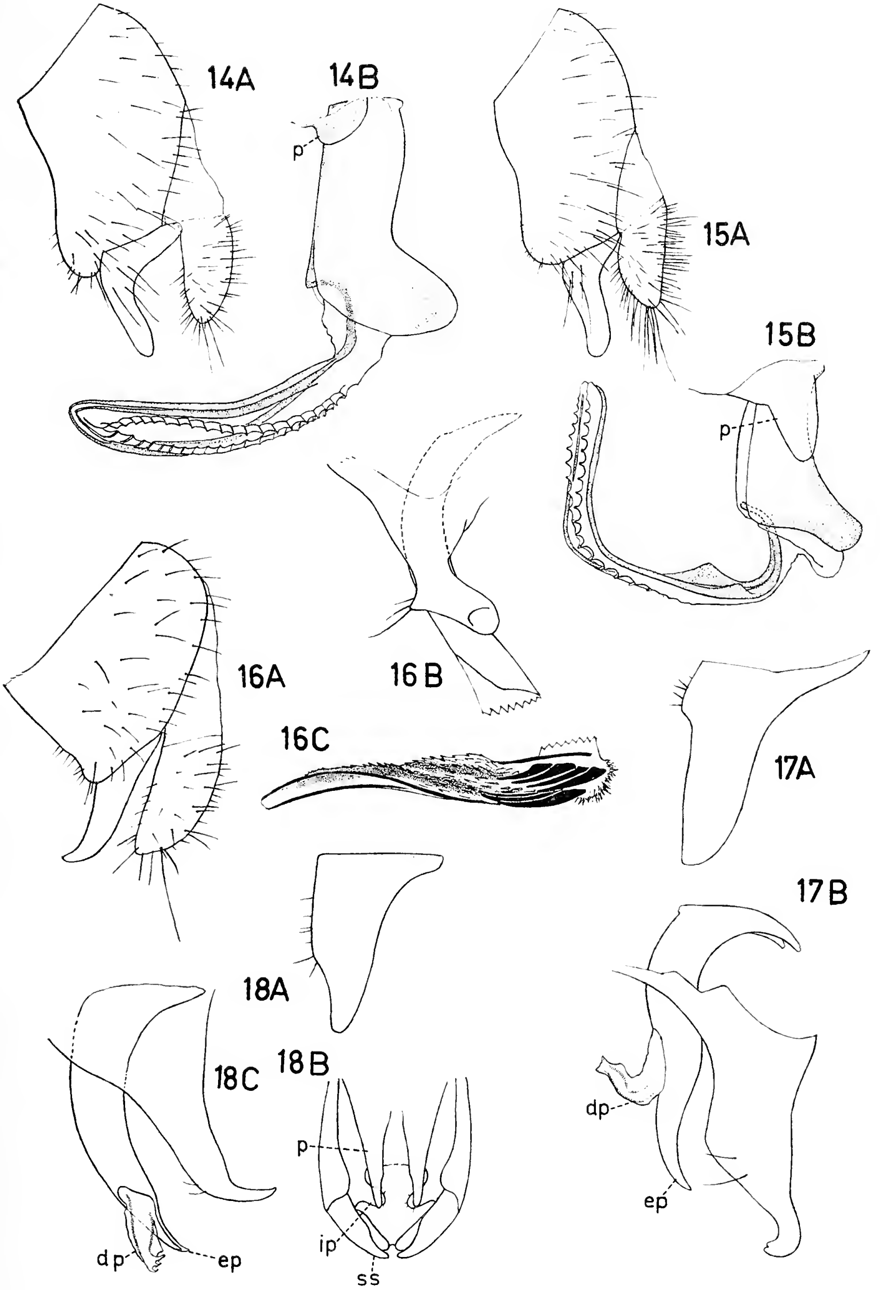
Thorax with four dorsocentrals, no acrostichals, four scutellars, one sternopleural; setulae on mesoscutum and scutellum somewhat finer than in other species.

Male abdomen with tergite 6 distinctly sclerotized, usually bare, though sometimes distinctly setulose. Lateral lobe of tergite 9 produced downwards in front of base of surstylus; surstylus (Fig. 14A) with broad, posteriorly extended basal part and narrow distal part, rather obtuse at apex and with several long setulæ on outer surface of basal half; paramere (Fig. 14B) very short, ear-shaped, not as long as wide; basiphallus elongate, well sclerotized, somewhat dilated distally where it extends posteriorly into a broadly rounded, bilaterally compressed epiphallus; distiphallus longer than basiphallus, strap shaped, tapered at apex, contracted at base with a double pigmented strip along each margin and two serrated longitudinal submedian ridges, the serrations especially pronounced on the basal half; cerci about as long as surstyli.

Female without spines on postabdominal tergites; segment 7 longer than other segments.

Dimensions: total length, ♂ 3·4–5·5 mm., ♀ 3·4–5·6 mm.; length of thorax, ♂ 2·0–3·0 mm., ♀ 1·8–3·0 mm.; length of wing, ♂ 4·4–6·0 mm., ♀ 4·0–6·0 mm.

Distribution: New South Wales (principally tablelands); Victoria.



Figs 14–18

14, *Diplogeomyza hardyi hardyi*, subsp. nov., paratype, Mount Wilson. A, epandrium. B, left paramere and aedeagus; 15, *Diplogeomyza hardyi tasmanica*, subsp. nov., paratype, Pieman River. A, epandrium. B, left paramere and aedeagus; 16, *Diplogeomyza flavipalpis*, sp. nov., holotype. A, epandrium. B, left paramere and basiphallus. C, distiphallus; 17, *Diplogeomyza diaphora* Hendel, Mount Wilson. A, left surstylus. B, left paramere and aedeagus; 18, *Diplogeomyza tridens*, sp. nov., paratype, Binna Burra. A, left surstylus. B, anterior aspect of epandrium. C, left paramere and aedeagus.

dp, distiphallus; ep, epiphallus; ip, internal process of epandrium; p, paramere; ss, surstylus.

Material examined: *New South Wales and Australian Capital Territory*: Katoomba, v 1959 (*holotype* ♂), iv v vi vii viii ix x xi xii 1955-1959 (*paratypes,* 2 ♂, 14 ♀, AM, 2 ♀, BM, 2 ♀, DEI, 2 ♀, USNM) G. H. Hardy; Mount Wilson, Blue Mountains, iii v vi vii ix x xi xii 1957-1964 (*paratypes,* 41 ♂, 35 ♀, AM), D.K.M.; Mount Gibraltar National Park, 64 miles W of Grafton, ii 1965 (2 ♂, AM), D.K.M.; New England National Park, near Ebor, 4000 ft., xi 1961 (1 ♂, CSIRO), I. F. B. Common and M. S. Upton; Point Lookout, near Ebor, 5000 ft., iii 1960 (1 ♂, 2 ♀, AM), D.K.M.; Wright's Lookout, New England National Park, iii iv 1961 (3 ♂, 3 ♀, AM), D.K.M.; Minnamurra Falls, near Kiama, x 1961 (1 ♂, 1 ♀, AM), D.K.M.; Clyde Mountain, near Braidwood, 2400 ft., ii 1961 (3 ♂, 2 ♀, AM), D.K.M.; Rutherford Creek, Brown Mountain, near Nimmitabel, iii 1961 (3 ♂, 3 ♀, CSIRO), D.H.C.; Blundell's, A.C.T., x 1930 (1 ♀, CSIRO), H. M. Barnes; Coree Creek, A.C.T., x 1960 (1 ♀, CSIRO), D.H.C.; Uriarra State Forest, A.C.T., x 1960 (1 ♀, CSIRO), D.H.C.; Cotter River, A.C.T., xi 1960 (1 ♂, CSIRO), D.H.C. *Victoria*: Warburton, iv 1963 (2 ♂, 2 ♀, AM), D.K.M.; Cement Creek, near Warburton, x 1961 (1 ♂, CSIRO), D.H.C., iv 1963 (1 ♂, AM), D.K.M.; Ferntree Gully, iv 1963 (1 ♀, AM), D.K.M.; Yarra River, 9 miles E of Warburton, iv 1963 (2 ♂, AM), D.K.M.; Fernshaw, near Healesville, iv 1963 (2 ♀, AM), D.K.M.; Mount Dom Dom (Black Spur), near Healesville, x 1961 (1 ♂, CSIRO), D.H.C.; Gunyah, near Foster, ii iii 1955–1957 (2 ♀, CSIRO), G. F. Bornemissza; Upper Buckland River, near Mount Buffalo, xi 1964 (1 ♀, NMV), A. Neboiss.

Habitat: principally wet forests.

DIPLOGEOMYZA HARDYI TASMANICA, subsp. nov.

(Fig. 15)

♂ ♀. *Coloration* darker than in New South Wales specimens of *D. hardyi hardyi,* but not consistently darker than Victorian specimens of that subspecies.

Male postabdomen (Fig. 15A, B) as described for *D. hardyi hardyi* but with the following differences: surstylus not so broadly extended posteriorly (this character slightly variable in both forms); lateral lobe of tergite 9 scarcely produced downwards in front of base of surstylus; paramere about twice as long as basal width, rounded at apex; submedian strips on distiphallus very weakly sclerotized basally, the serrations much weaker, almost obsolete basally, where the lateral strips are expanded into a pair of narrow auricles.

Dimensions: total length, ♂ 4·4–5·1 mm., ♀ 4·0–5·1 mm.; length of thorax, ♂ 2·1–2·9 mm., ♀ 2·3–2·7 mm.; length of wing, ♂ 4·5–6·0 mm., ♀ 4·9–5·9 mm.

Distribution: Tasmania—probably in all districts.

Material examined: Arve River, near Geeveston, i 1960 (*holotype* ♂, *paratypes,* 3 ♂, 4 ♀, AM), D.K.M.; Hartz Mountains, 800 ft., i 1960 (*paratype* ♀, AM), D.K.M.; Ferntree, near Hobart, i 1960 (*paratypes,* 3 ♂, 4 ♀, AM, 3 ♂, USNM), D.K.M.; near Russell Falls, Mt. Field National Park, i 1960 (*paratype* ♂, AM), D.K.M.; Eaglehawk Neck, i 1960 (*paratypes,* 3 ♂, AM), D.K.M.; Arthur Plains, South-west District, ii 1965 (1 ♀, NMV), A. Neboiss; Lake Saint Clair, i 1960 (*paratypes,* 2 ♂, AM), D.K.M.; Renison Bell, i 1960 (*paratype* ♀, AM), D.K.M.; 13 miles NW of Queenstown, i 1945 (*paratype* ♂, CSIRO), K. H. L. Key, P. B. Carne, and R. W. Kerr; Pieman River, near Rosebery, i 1960 (*paratypes,* 2 ♂, 1 ♀, AM, 2 ♂, BM), D.K.M.; Waldheim, near Cradle Mountain, 2850 ft., i 1960 (*paratype* ♀, AM), D.K.M.; Marakoopa Caves, near Mole Creek, i 1960 (*paratypes,* 1 ♂, 1 ♀, AM), D.K.M.; Western Tiers, Lake Highway, 2250 ft., i 1960 (*paratype* ♂, AM), D.K.M.; Mount Barrow, near Launceston, 3000 ft., i 1960 (*paratype* ♀, AM), D.K.M.

Habitat: principally wet forests.

DIPLOGEOMYZA FLAVIPALPIS, sp. nov.

(Fig. 16)

♂ ♀. *Coloration* as described for *D. victoriae* below except as here indicated. Palpi testaceous-yellow. Mesoscutum with a median brownish stripe, sometimes indistinct; the submedian yellow-dusted stripes tending to fuse medially so as to obscure the darker median stripe. Halteres pale-yellowish. Abdomen yellow-brown.

Structure of head and thorax as described below for *D. spinosa,* except that the arista is shorter-haired, only two or three dorsal hairs as long as or slightly longer than half the width of third antennal segment, the other hairs notably shorter.

Male with surstylus (Fig. 16A) directed obliquely forward from base, rather narrow, the acute apex curved forward, inner surface setulose; paramere (Fig. 16B) much longer than surstylus, bent backward beyond middle, at the bend an anterior gibbosity with a horizontal row of three or four setulae, the apex rounded with a recurved tooth on outer surface; basiphallus forming an elongate curved tube, without epiphallus; distiphallus (Fig. 16C) joined to anterior surface of basiphallus, strap shaped, with a narrow smooth black strip along each margin, anterior surface hispid, particularly so along the two submarginal ridges, which run for its full length and are each armed with three or four long strong black spines basally; cerci shorter than surstyli, with rather short setulae, one of the subapical ones notably longer.

Abdomen of female with segment 7 elongate, much as in *D. diaphora* and *D. tridens.*

Dimensions: total length, ♂ 3·5 mm., ♀ 3·6–4·0 mm.; length of thorax, ♂ 2·0 mm., ♀ 2·1 mm.; length of wing, ♂ 4·0 mm., ♀ 4·6–4·7 mm.

Distribution: New South Wales—Blue Mountains.

Material examined: Mount Boyce, near Blackheath, iv 1964 (*holotype* ♂, *paratype* ♀, AM), D.K.M.; Mount Wilson, v 1958 (*paratype* ♀, AM), D.K.M.

Habitat: specimens from Mount Boyce taken in dry sclerophyll forest at top of ridge.

In spite of its similarity in colouring to *D. victoriae,* this species is evidently more closely related to *hardyi, diaphora,* and *tridens* which have a similarly elongate segment 7 in the female abdomen. Within this group it resembles *D. hardyi* most closely in having a strap like aedeagus with longitudinal skeletal strips, and the aristal hairs shorter than in the other species. The paramere is, however, well developed and resembles that of *D. diaphora* in its hooked apex and group of anterior setulae.

DIPLOGEOMYZA DIAPHORA Hendel

(Fig. 17)

Diplogeomyza diaphora Hendel, 1917: 38–39.

♂ ♀. Very similar to *D. tridens* (see below) in most characters, differing in the darker colouring on the femora and in the structure of the postabdomen of both sexes.

Legs dull yellowish; fore femur greyish brown on distal three quarters or more; middle femur brown at apex; hind femur broadly dark-brown to black at apex; tibiae brownish basally.

Male with surstylus (Fig. 17A) broadened basally, narrowed beyond base and acute at apex, a prominence bearing some small hairs on anterior side near base; inner surface of epandrium without processes; paramere (Fig. 17B) elongate, tapering, with a group of two or three fine erect hairs on anterior side well before apex, the apex slightly swollen and curved forwards with two short teeth; basiphallus rather short; distiphallus membranous, arising from anterior surface of basiphallus, with two weak longitudinal sclerotized strips; epiphallus long, curved, heavily sclerotized.

Female postabdomen very similar to that of *D. tridens* but differing as follows: sternite 6 slightly narrowed medially; posterior margin of segment 7 convexly curved; segment 8 comparatively short, the sternite consisting of two short, oval sclerites.

Distribution: *Southern Queensland*—tablelands; *New South Wales*—coast to tablelands and south western slopes; *Victoria* (*holotype*—no further locality stated); *Tasmania*—generally distributed; *South Australia*—near Adelaide.

Material examined (localities only given): *Queensland*: Bunya Mountains (AM); Binna Burra, Lamington National Park (AM, UQ). *New South Wales*: Mount Gibraltar National Park, 64 miles W of Grafton (AM); Dorrigo National Park (AM); Point Lookout and Wright's Lookout, New England National Park (AM); Tubrabucca, near Barrington Tops (AM); Eccleston, Allyn River (SPHTM); Goulburn River, near Baerami (AM); Narrabeen, near Sydney (SPHTM); Mooney Mooney Creek, near Gosford (AM); Mount Wilson, Blue Mountains (AM, CSIRO, BM, DEI); below Govett's Leap, Blue Mountains (AM); Katoomba (AM); Wentworth Falls (AM, BM); Springwood (AM); Royal National Park (AM); Otford, Illawarra District (AM); Mount Keira, near Wollongong (CSIRO); Colo Vale, near Mittagong (AM, USNM); Minnamurra Falls, near Kiama (AM); Clyde Mountain, near Braidwood (AM); Sweetwater, Kain, near Braidwood (CSIRO); Rutherford Creek, Brown Mountain, near Nimmitabel (CSIRO); Geehi River, Snowy Mountains (CSIRO); Gerogery, near Culcairn (CSIRO). *Victoria*: Nowa Nowa (CSIRO); Stratford (CSIRO); Bright (CSIRO); 13 miles W of Matlock (AM); Ferntree Gully (AM); Warburton (AM); Cement Creek, near Warburton (AM); Fernshaw, near Healesville (AM); Mount Dom Dom (Black Spur), near Healesville (CSIRO); Belgrave (AM); Eltham, near Melbourne (UQ). *Tasmania*: 2 miles east of Tonganah, near Scottsdale (AM); Pieman River, near Rosebery (AM); Renison Bell (AM); Franklin River crossing, Lyell Highway (AM); Arve River, near Geeveston (AM); Hartz Mountains, 800 ft. (AM). *South Australia*: Belair, near Adelaide (SAM).

Habitat: forest country.

DIPLOGEOMYZA TRIDENS, sp. nov.

(Figs. 18, 30)

♂ ♀. Head dull yellowish; frons suffused with brown; palpi brown; antennae yellowish-brown. Mesoscutum deep reddish-brown with pale yellowish lateral margins, a median light greyish longitudinal stripe, and one pair of such stripes just inside and one just outside dorsocentral lines; scutellum deep brown with paler margins; pleura dull yellowish with a broad brown band on upper part; sternopleuron variably suffused with light-brown. Legs dull yellowish; fore femur gradually becoming brownish towards apex; middle femur at most indistinctly brownish at apex; hind femur usually slightly browned at extreme apex. Wing brownish-hyaline with darker marks on anterior and posterior cross-veins and faint brown spots at apices of veins 2, 3, and 4. Abdomen yellowish-brown, the distal edge of the tergites usually darker.

Anterior cheek bristles numerous, rather coarse; third antennal segment ovate; arista plumose, the longer hairs as long as or longer than width of third antennal segment.

Scutellum with numerous rather fine setulae, two pairs of long marginal bristles, and two pairs of shorter bristles, one basal, and one intermediate, sometimes one or more of the short bristles duplicated; sternopleuron with one upper bristle.

Male postabdomen with surstylus (Fig. 18A) somewhat elongate, broadened basally, the apex obtuse or subacute, a prominence on anterior side shortly beyond middle; inner surface of epandrium (Fig. 18B) with a pair of blunt processes projecting inwards behind parameres; paramere (Fig. 18C) elongate, the distal part long-acuminate and curved backwards; aedeagus with long tubular sclerotized basiphallus which terminates distally in a short, curved epiphallus (spinus), the membranous distiphallus arising from left side of basiphallus, with a pair of weak sclerotized longitudinal strips and three fine, sharp terminal teeth; cerci not as long as surstyli.

Female abdomen with segment 6 short; sternite 6 slightly wider than preceding sternites, not narrowed medially; segment 7 elongate, conical, posterior margin of sternite 7 straight; segment 8 also rather elongate, retractile within the segment 7, both tergite and sternite divided longitudinally, the sternite consisting of two quite narrow plates; tergite 9 and sternite 9 entire; cerci slender.

Dimensions: total length, ♂ 3·8–5·0 mm., ♀ 3·4–5·7 mm.; length of thorax, ♂ 2·2–3·0 mm., ♀ 2·0–3·2 mm.; length of wing, ♂ 3·6–5·2 mm., ♀ 3·9–5·5 mm.

Distribution: *Queensland*—as far north as Atherton Tableland; *New South Wales*—coast district, extending to tablelands only in the north.

Material examined: *Queensland*: Binna Burra, Lamington National Park, i 1961 (*holotype* ♂, *paratypes*, 4 ♂, 4 ♀, AM), ii 1961 (*paratypes*, 2 ♂, QM), D.K.M.; Lamington National Park, x 1957 (*paratype* ♀, UQ), I. C. Yeo; Tamborine Mountain, ii xii 1961 (*paratypes*, 2 ♂, 4 ♀, BM, 11 ♂, 14 ♀, AM), D.K.M.; Mount Glorious, near Brisbane, i 1961 (*paratypes*, 2 ♂, AM), D.K.M.; Summer Creek, Little Yabba Forestry Road, near Kenilworth, ii 1961 (*paratypes*, 8 ♂, 12 ♀, AM), D.K.M.; Mapleton, ii 1961 (*paratype* ♀, AM), D.K.M.; The Crater, Mount Hypipamee, near Herberton, xii 1961 (2 ♂, 2 ♀, AM), D.K.M. *New South Wales*: Huonbrook, near Mullumbimby, i xii 1961 (*paratypes* 1 ♀, AM, 1 ♀, USNM), D.K.M.; Bruxner Park, near Coffs Harbour, i 1961 (*paratype* ♂, AM), D.K.M.; Dorrigo, no date (*paratype* ♂, SAM), W. Heron; Dorrigo National Park, i 1961 (*paratypes*, 4 ♀, AM), D.K.M.; Upper Allyn, near Eccleston, 1000 ft., xi 1965 (1 ♂, 1 ♀, AM), D.K.M.; Upper Allyn River, 1500 ft., xi 1960 (1 ♀, CSIRO), I. F. B. Common and M. S. Upton; Palm Grove, near Wyong, vii 1961 (1 ♂, AM), D.K.M.; Royal National Park, near Sydney, i iv vi viii ix x xi xii 1956–1965 (2 ♂, 1 ♀, BM, 1 ♂, 1 ♀, USNM, 6 ♂, 10 ♀, AM), D.K.M.; Otford, Illawarra District, i ii iii x 1961–1965 (1 ♂, 1 ♀, CSIRO, 4 ♂, 5 ♀, AM), D.K.M.

Habitat: principally rain-forest.

DIPLOGEOMYZA ANNULARIS, sp. nov.

(Fig. 19)

♂ ♀. Head and thorax yellowish-brown, somewhat darker on dorsal surface. Palpi deep brown to blackish; antennae yellowish-brown, third segment darker brown except at base. Markings on mesoscutum very indistinct except for the usual yellowish marginal area on notopleuron and humeral callus; a pair of faint yellow-dusted submedian marks at anterior end of mesoscutum which tend to extend posteriorly as a pair of very faint stripes, and a faint pale narrow band immediately outside dorsocentral line; pleura with a dark upper marginal band; sternopleuron unmarked. Legs yellowish brown; fore femur suffused with darker brown except at base; knee of middle leg narrowly dark-brown; apex of hind femur more broadly dark brown. Wings marked as in *D. spinosa* (see below). Halteres yellowish with brown knobs. Abdomen brown, darker in male than in female.

Structure generally as described for *D. spinosa* below.

Male with surstylus (Fig. 19A) almost parallel-sided in mid section, expanded basally, apex curved inwards and slightly forwards, obtuse or subacute; paramere (Fig. 19B) elongate, apex acute and slightly curved forwards and inwards; basiphallus (Fig. 19C) much swollen distally on posterior side; distiphallus short, mostly membranous, with a Ω-shaped sclerite; cercus long-haired on most of surface.

Female with all postabdominal segments short, without spines on tergites; segment 7 forming a complete ring.

Dimensions: total length, ♂ 4·0–4·6 mm., ♀ 3·3–4·6 mm.; length of thorax, ♂ 2·1–2·9 mm., ♀ 1·9–2·9 mm.; length of wing, ♂ 4·3–6·0 mm., ♀ 4·5–5·9 mm.

Distribution: *Victoria*. All available specimens are from the eastern half of the state but this may merely indicate that little collecting has been done by dipterists west of Melbourne.

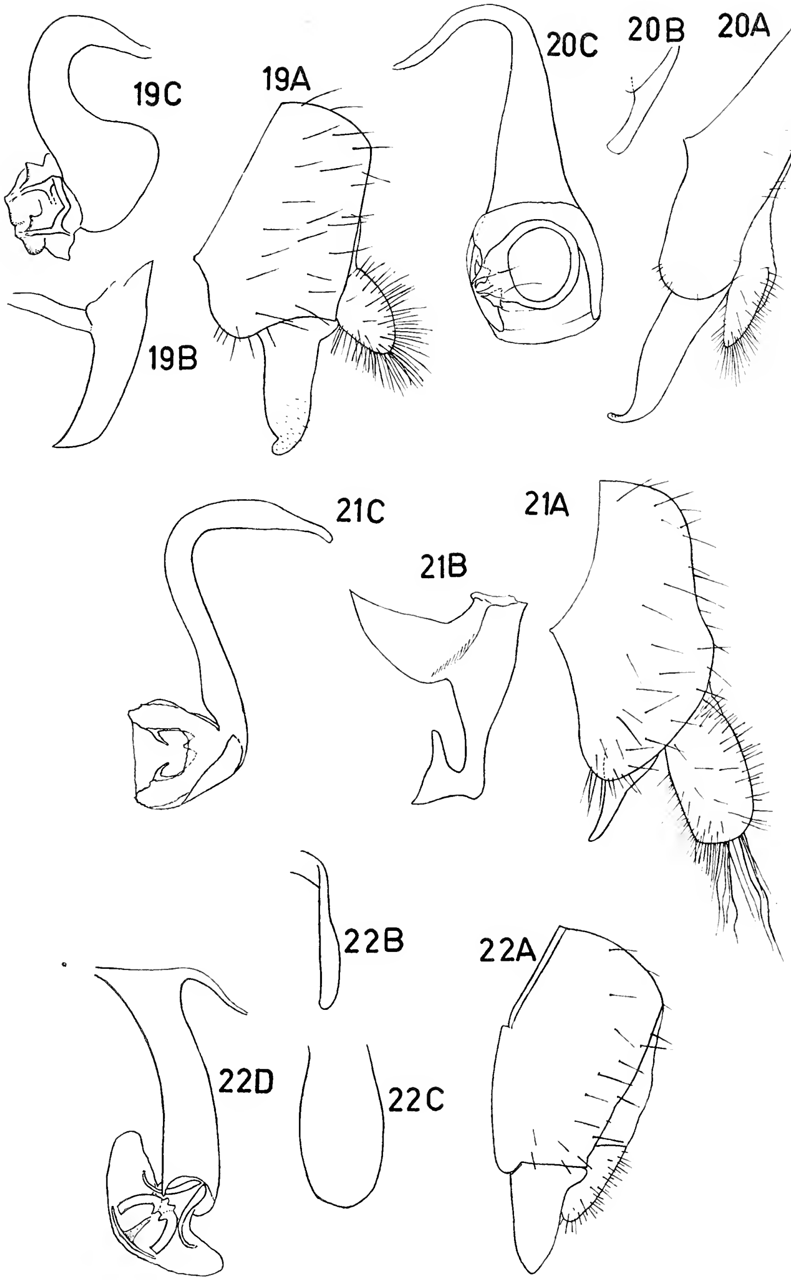
Material examined: Mount Donna Buang, near Warburton, iv 1963 (*holotype* ♂, *paratype* ♂, AM), D.K.M.; Cement Creek, near Warburton, x 1961 (*paratypes*, 3 ♂, 1 ♀, CSIRO), D.H.C., iv 1963 (*paratypes*, 1 ♂, 3 ♀, USNM), iv 1963 (*paratypes*, 5 ♂, 6 ♀, AM, 1 ♂, BM), D.K.M.; Warburton, iv 1963 (*paratypes*, 1 ♂, 2 ♀, AM, 2 ♀, BM), D.K.M.; Ferntree Gully, iv 1963 (*paratype* ♂, AM), D.K.M.; Mount Dom Dom (Black Spur), near Healesville, x 1961 (*paratypes*, 1 ♀, CSIRO, 2 ♀, NMV), D.H.C.; 13 miles west of Matlock, iv 1963 (*paratype* ♂, AM), D.K.M.; Frenchman's Gap, near Woods Point, 3500 ft., iv 1963 (*paratype* ♂, AM), D.K.M.; Mount Beauty, near Bright, x 1961 (*paratype* ♂, CSIRO), D.H.C.; Stratford, x 1961 (*paratype* ♂, CSIRO), D.H.C.; Sardine Creek, Bonang Highway, x 1961 (*paratype* ♂, CSIRO), D.H.C.

Habitat: wet sclerophyll forest and rain forest.

DIPLOGEOMYZA VICTORIAE, sp. nov.

(Fig. 20)

♂ ♀. Coloration generally similar to that of *D. spinosa* and *D. signata*. Frons light yellowish-brown with a pair of darker brown blotches on interfrontalia. Mesoscutum marked as in *D. signata* but with the brown longitudinal bands paler and the median one narrower; pleura similarly marked to that of *D. signata* but the markings more diffuse; mesopleuron suffused with brown on most of its surface but distinctly paler on lower part; brown band on sternopleuron rather pale and not very distinct because of additional faint suffusions of brown. Legs yellowish; fore femur brownish;



Figs 19–22

19, *Diplogeomyza victoriae*, sp. nov., paratype, Cement Creek. A, epandrium. B, left paramere. C, aedeagus; 20, *Diplogeomyza annularis*, sp. nov., paratype, Royal National Park. A, epandrium. B, left paramere. C, aedeagus from right; 21, *Diplogeomyza spinosa*, sp. nov., paratype, Royal National Park. A, epandrium. B, left paramere. C, aedeagus; 22, *Diplogeomyza signata*, sp. nov., paratype, Royal National Park A, epandrium. B, left paramere, lateral aspect. C, left paramere, posterior aspect. D, aedeagus.

middle and hind femur brown apically; base of middle tibia and bases and apices of fore and hind tibiae brownish. Abdomen brownish yellow, the tergites darkened on lateral margins.

General structure as described for *D. spinosa* below.

Surstylus (Fig. 20A) similar to those of *D. media* but more elongate with very long incurved hook-like apical part; paramere (Fig. 20B), small, rod-like, almost straight; aedeagus (Fig. 20C), with sclerotized basiphallus which is dilated and forked distally, the limbs supporting the distiphallus; the latter short and broad, containing a ring-like sclerite and with two superimposed pairs of claw-like processes; cerci much shorter than surstyli.

Female without spines on tergites of terminal segments; segment 7 with tergite and sternite fused into a complete ring, but this segment not elongate.

Dimensions: total length, ♂ 3·6–4·5 mm., ♀ 3·2–4·6 mm.; length of thorax, ♂ 1·8–2·5 mm., ♀ 2·2–2·5 mm.; length of wing, ♂ 3·7–5·4 mm., ♀ 4·2–5·0 mm.

Distribution: *New South Wales*—Coast to eastern edge of tablelands; eastern *Victoria*.

Material examined: *New South Wales*: Royal National Park, x 1956 (*holotype* ♂, AM), ix x xi 1955–1965 (*paratypes*, 3 ♂, 2 ♀, AM), D.K.M.; Waterfall, Royal National Park, iv 1925 (*paratype* ♂, CSIRO), I. M. Mackerras; Otford, Illawarra District, iii x 1959–1961 (*paratypes*, 1 ♂, 1 ♀, AM), D.K.M.; Monga near Braidwood, vii 1962 (*paratype* ♂, CSIRO), D.H.C. *Victoria*: Nowa Nowa, x 1961 (1 ♀, CSIRO), D.H.C.

Habitat: stream margins in forest country.

DIPLOGEOMYZA SPINOSA, sp. nov.

(Fig. 21)

♂ ♀. Head pale yellowish; frons suffused with brown; antennae yellowish-brown; palpi dark-brown. Mesonotum light-brown, lateral margins including humeri and notopleura pale buff, a pair of narrow darker stripes along dorsocentral lines, a median darker stripe usually present but diffuse and ill defined, a pair of sublateral dark brown bands posteriorly which join the dorsocentral bands at the suture, a pair of indistinct whitish submedian bands anteriorly which are usually interrupted at the suture; pleura buff, with a broad dark-brown band along upper margin from humeral callus to base of haltere; sternopleuron with a light brown spot in front of and often more or less enclosing the sternopleural bristle. Legs pale-brown or buff, all femora with apices broadly black or dark-brown, fore femur usually with an additional brown submedian band; tibiae with bases brown to black and apices broadly blackish; tarsi darkened apically. Wings greyish hyaline, with brown spots on anterior and posterior cross-veins and at apices of veins 2, 3, and 4. Halteres light-brown. Abdomen light-brown with posterior and lateral edges of tergites dark-brown.

Anterior cheek bristles rather strong but usually short; third antennal segment ovate, arista plumose, the longer dorsal hairs about as long as width of third segment, the ventral hairs shorter.

Scutellum with two pairs of bristles and numerous coarse setulae; sternopleuron with one upper bristle.

Male with surstylus (Fig. 21A) broad basally, narrowing into an almost straight acuminate apical part. Paramere (Fig. 21B) rather long, bent forwards and dilated near tip where there are two angular projections, the longer one directed towards base. Aedeagus (Fig. 21C) with basiphallus rather long, tubular; distiphallus with forked skeletal element supporting a pair of opposed claws. Cerci large with long apical hairs.

Female postabdomen symmetrical, blunt at apex. Segment 6 similar to preceding segments but slightly shorter; tergite 6 without spines; segment 7 short, the tergite with a patch of thick black spines on each side, posterior margin entire, lateral edges produced ventrally and embracing the sternite; the latter divided by a median suture but the halves not separated; tergite 8 divided into two sclerites, with numerous thick black spines; sternite 8 sinuate medially on posterior margin; cerci short and rounded.

Dimensions: total length, ♂ 3·8–7·2 mm., ♀ 4·2–6·9 mm.; length of thorax, ♂ 1·9–3·5 mm., ♀ 2·3–3·5; length of wing, ♂ 4·2–6·8 mm., ♀ 4·5–7·3 mm.

Distribution: New South Wales and southern Queensland—Coast to tablelands; Victoria.

Material examined: *New South Wales*: Royal National Park, x 1960 (*holotype* ♂, AM), iii iv vi x xi xii 1956-1965 (*paratypes*, 19 ♂, 32 ♀, AM, 2 ♂, 1 ♀, DEI, 1 ♂, 2 ♀, USNM), D.K.M.; Otford, Illawarra District, ii x xii 1957-1965 (*paratypes*, 10 ♂, AM, 2 ♂, 2 ♀, BM), D.K.M.; Minnamurra Falls, near Kiama, xi 1960 (*paratype* ♂, CSIRO), I. F. B. Common and M. S. Upton, ii x xii 1961-1962 (*paratypes*, 10 ♂, 6 ♀, AM), D.K.M.; Clyde Mountain, near Braidwood, 2400 ft., ii 1961 (paratype ♂, AM), D.K.M. Rutherford Creek, Brown Mountain, near Nimmitabel, iii 1961 (2 ♀, CSIRO), D.H.C.; Springwood, i 1956 (*paratype* ♀, AM), D.K.M.; Wentworth Falls, ix x xi 1958–1965 (paratypes, 4 ♂, 3 ♀, AM, 2 ♂, 1 ♀, BM), D.K.M.; Below Govett's Leap, Blue Mountains, ix 1957 (*paratype* ♀, AM), D.K.M.; Mount Wilson, Blue Mountains, iii v vii viii ix x 1957-1961 (*paratypes*, 6 ♂, 3 ♀, AM), D.K.M.; near Mangrove Mountain, Hawkesbury River, viii 1956 (*paratype* ♀, AM), D.K.M.; Mooney Mooney Creek, near Gosford, x 1956 (*paratype* ♂, AM), D.K.M.; Wright's Lookout, New England National Park, iii iv 1961 (6 ♂, 6 ♀, AM), D.K.M.; Dorrigo National Park, i 1961 (1 ♂, 1 ♀, AM), D.K.M.; Bruxner Park, near Coffs Harbour x 1962 (2 ♂, 1 ♀, CSIRO), D.H.C.; Mount Gibraltar National Park, 64 miles W of Grafton, ii 1965 (1 ♂, AM), D.K.M.; Huonbrook, near Mullumbimby, xii 1961 (1 ♂, AM), D.K.M. *Queensland*: Binna Burra, Lamington National Park, ii 1961 (1 ♂, AM), D.K.M.; Summer Creek, Little Yabba Forestry Road, near Kenilworth, ii 1961 (2 ♂, 1 ♀, AM), D.K.M. *Victoria*: Warburton, iv 1963 (1 ♂, AM), D.K.M.

Habitat: forests, especially near streams.

DIPLOGEOMYZA SIGNATA, sp. nov.

(Fig. 22)

♂ ♀. General colour as described for *D. spinosa*, but the following characters are noteworthy: frons with three broad brown longitudinal bands; mesoscutum with a pair of narrow pale-yellowish stripes along dorsocentral lines and a pair of similar submedian stripes which divide the intradorsocentral region into three broad, brown, well defined bands which coalesce and form two bands posteriorly; two sublateral brown bands on each side of mesoscutum behind suture, coalescing to form a single band in front of suture; mesopleuron dark-brown on upper part where the dark pleural band crosses it as in *D. spinosa*, pale yellowish on the lower third; sternopleuron without brown spot at base of sternopleural bristle, but with broad, dark-brown band almost reaching from fore coxa to middle coxa; legs brownish-yellow, femora broadly blackish at apices; tibiae brownish at bases and less distinctly so at apices; abdomen brown.

General structure as described for *D. spinosa.* Legs of male normal; fore tibia of female with a broad anterodorsal band of soft cuticle (tending to collapse in dried specimens) extending from near base to extreme apex, which is densely pilose but almost or completely without any normal setulae.

Epandrium (Fig. 22A) with rather short subacute surstylus, broadened at extreme base; paramere (Fig. 22B, C) compressed, with almost parallel sides, broadly rounded apically, placed in an almost transverse plane; aedeagus (Fig. 22D) with tubular sclerotized basiphallus, distiphallus membranous with a pair of narrow. tapering, diverging sclerites where it joins the basal part, a triradiate sclerite on distal surface, and a small compact central sclerite with two slender arms; cerci almost as long as surstyli, without conspicuously long hairs.

Female postabdomen structurally similar to that of *D. spinosa,* symmetrical; tergite 6, unlike *D. spinosa* and *D. media,* with some short spines mixed with the longer hairs near posterior margin; tergite 7 spinose except on median line, the posterior margin sinuate medially, the lateral parts not produced ventrally; seventh sternite simple, transversely oblong; tergite 8 completely divided, spinose; sternite 8 with straight posterior margin.

Dimensions: total length, ♂ 3·0–5·1 mm., ♀ 3·3–4·2 mm.; length of thorax, ♂ 1·6–3·0 mm., ♀ 2·1–2·6 mm.; length of wing, ♂ 3·1–5·4 mm., ♀ 3·8–4·8 mm.

Distribution: New South Wales and Queensland—coast and tablelands.

Material examined: *New South Wales*: Wentworth Falls, Blue Mountains, xi 1958 (*holotype* ♂, *paratype* ♀, AM), xi 1960 (*paratypes,* 2 ♂, 2 ♀, AM,); below Govett's Leap, Blue Mountains, ix 1957 (*paratype* ♂, AM); Mount Wilson, Blue Mountains, vi 1964 (*paratype* ♀, AM); Royal National Park, i iii vi viii xi 1955-1965 (*paratypes,* 10 ♂, 7 ♀, AM, 2 ♂, 1 ♀, USNM); Otford, Illawarra District, ii x 1957-1962 (*paratypes,* 1 ♂, 1 ♀, AM, 1 ♂, 1 ♀, BM); Minnamurra Falls, near Kiama, i ii x 1961-1962 (*paratypes,* 1 ♂, 4 ♀, AM, 1 ♂, 1 ♀, CSIRO); Mooney Mooney Creek, near Gosford, x 1956 (*paratype* ♂, AM); Dorrigo National Park, i 1961 (3 ♂, AM); Mount Gibraltar National Park, 64 miles W of Grafton, ii 1965 (2 ♂, AM); all the above collected D.K.M. *Queensland*: Brisbane, iv 1933 (1 ♂, UQ), F. A. Perkins; Bunya Mountains, ii 1961 (1 ♂, AM), D.K.M.; Broken River, Eungella, xii 1961 (2 ♂, 2 ♀, AM, 1 ♀, QM), D.K.M.; Mount Dalrymple Road, Eungella, xii 1961 (1 ♂, 1 ♀, AM), D.K.M.; The Crater (or Mount Hypipamee), near Herberton, xii 1961 (2 ♀, AM), R. Lossin and D.K.M.

Habitat: rain forest bordering streams.

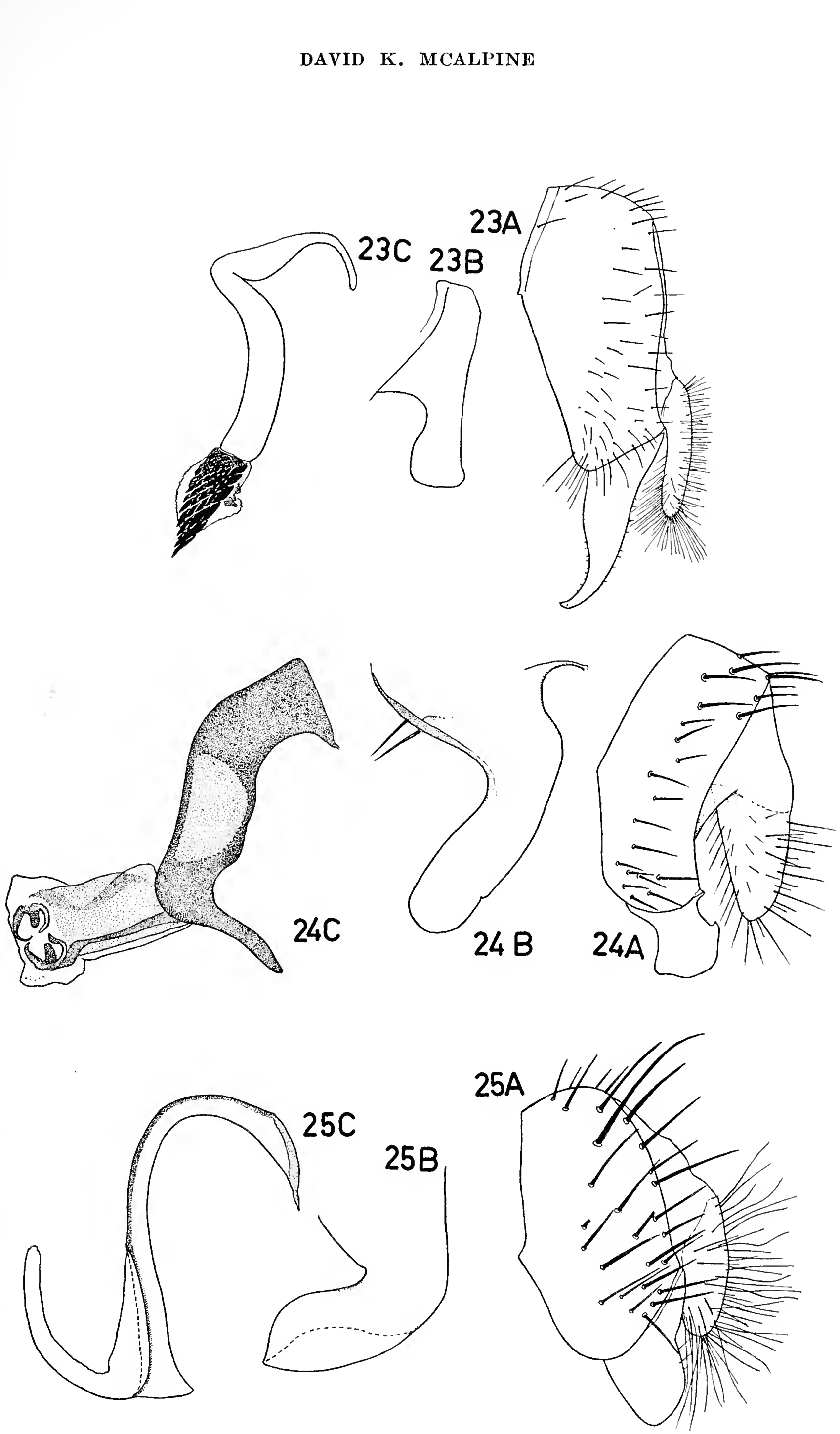
The females of this species differ from all others of the genus in the structure of the fore tibia. The specialized area described above may be a sense organ.

DIPLOGEOMYZA MEDIA, sp. nov.

(Fig. 23)

♂ ♀. General colour as described for *D. spinosa,* but the following differences are notable: mesoscutum with a distinct blackish median band, submedian whitish bands not interrupted at suture; no brownish patch associated with sternopleural bristle, but sternopleuron with a brown oblique stripe, connecting fore and middle coxae or almost so; fore femur brown, paler on ventral surface; apices of tibiae narrowly brownish.

General structure as described for *D. spinosa.*



Figs 23–25

23, *Diplogeomyza media*, sp. nov., paratype, Royal National Park. A, epandrium. B, left paramere. C, aedeagus; 24, *Diplogeomyza maculipennis* (Malloch), Royal National Park. A, epandrium. B, left paramere. C, aedeagus; 25, *Diplogeomyza pectinervis*, sp. nov., paratype, Royal National Park. A, epandrium. B, left paramere. C, aedeagus.

Epandrium (Fig. 23A) with elongate surstylus, its distal half tapering, acuminate and incurved at tip; parameres (Fig. 23B) large, almost straight, much dilated basally, and broadly clavate at apices, the left one slightly broader than the right; aedeagus (Fig. 23C) with basiphallus forming a long, heavily sclerotized, incomplete tube; distiphallus consisting of a membranous posterior part with an area of short, dense hairs, and an anterior part armed with numerous thick, black spines which are longest apically; cerci large with hairs on distal part quite long.

Female postabdomen similar to that of *D. spinosa* with the following notable differences: tergite 7 asymmetrical, produced further on to ventral surface on right side than on left, spinose on the whole of the posterior part of dorsal surface; sternite 7 also asymmetrical through the encroachment of the tergite on the right side, without a median suture; tergite 8 incompletely divided; sternite 8 not sinuate but prominent near centre of posterior margin.

Dimensions: total length, ♂ 4·1–5·4 mm., ♀ 4·2–5·1 mm.; length of thorax, ♂ 2·4–3·0 mm., ♀ 2·3–3·0 mm.; length of wing, ♂ 4·9–6·2 mm., ♀ 4·4–5·7 mm.

Distribution: New South Wales, Victoria, southern Queensland—principally tablelands.

Material examined: *New South Wales*: Mount Wilson, Blue Mountains, viii 1958 (*holotype* ♂, AM), iii iv v vi vii viii ix x xii 1956–1964 (*paratypes,* 7 ♂, 7 ♀, AM, 1 ♂, 1 ♀, BM, 1 ♂, USNM), D.K.M., ii 1936 (*paratype* ♀, CSIRO), D. F. Waterhouse; Mount York, Blue Mountains, x 1960 (*paratype* ♀, AM), D.K.M.; Wentworth Falls, xi 1958 (*paratype* ♂, AM), D.K.M.; Gowee Gulch, near Rylstone, viii 1956 (*paratype* ♀, AM), D.K.M.; Royal National Park, near Sydney, i ix 1955–1957 (*paratypes,* 2 ♂, 1 ♀, AM), D.K.M.; Colo Vale, near Mittagong, iii 1957 (*paratype* ♀, USNM), W. W. Wirth; Clyde Mountain, near Braidwood, x 1960 (*paratypes,* 2 ♂, CSIRO), D. H. C. and S. J. Paramonov, ii 1961 (*paratypes,* 3 ♂, AM), D.K.M.; Gwydir Highway, 72 miles W of Grafton, xi 1964 (1 ♂, AM), D.K.M. *Victoria*: Warburton, iv 1963 (1 ♀, AM), D.K.M.; Cement Creek, near Warburton, x 1961 (2 ♂, CSIRO), D.H.C.; Mount Beauty, near Bright, x 1961 (1 ♂, CSIRO), D.H.C.; Noorinbee, near Orbost, xi 1965 (1 ♂, NMV), A. Neboiss. *Queensland*: Lamington National Park, x 1934 (1 ♀, UQ), F. A. Perkins.

Habitat: forest country, especially near streams.

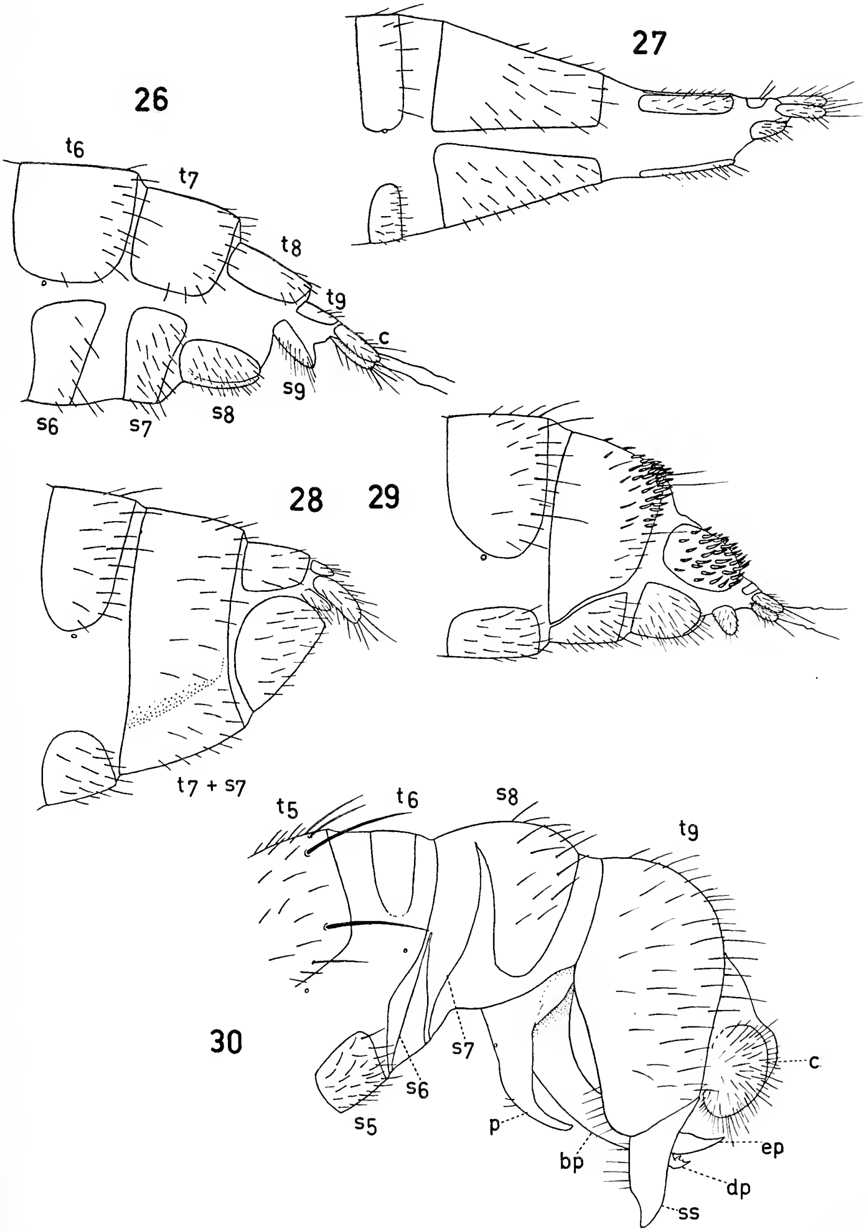
DIPLOGEOMYZA MACULIPENNIS (Malloch), new comb.

(Fig. 24)

Huttonomyia maculipennis Malloch, 1926: 552, Fig. 6 (wing).

Malloch's description and his figure of the wing are adequate for identification. The wing pattern is particularly characteristic. The species is evidently closely related to *D. pectinervis,* but is without crossveins in the marginal cell. The distinct brown band on the sternopleuron is evidence of relationship to *D. signata* and *media,* which have a similar female postabdomen. It is the only species of the genus with the eyes distinctly longer than high.

Epandrium (Fig. 24A) with surstylus very short, narrowed in basal half, produced into a short angular projection of posterior side; paramere (Fig. 24B) elongate, exceeding surstylus, bent forward near base, rounded at apex, more slender than in *D. pectinervis* and without internal carina; sternite 9 sclerotized on each side of and in front of aedeagus, with a small gibbosity on each side in front of which are two setulae, internal part



Figs 26–30

26, *Diplogeomyza*, group 1. Diagram of ♀ postabdomen; 27, *Diplogeomyza*, group 2. Diagram of ♀ postabdomen; 28, *Diplogeomyza*, group 3. Diagram of ♀ postabdomen; 29, *Diplogeomyza*, group 4. Diagram of ♀ postabdomen; 30, *Diplogeomyza tridens*, sp nov., Royal National Park; ♂ postabdomen.

c, cercus; bp, basiphallus; dp, distiphallus; ep, epithallus; p, paramere; s5–s9, sternite 5 – sternite 9; t5–t9, tergite 5 – tergite 9.

(*Gabelplatte*) rather weak; aedeagus (Fig. 24C) with basiphallus forming a sclerotized tube, desclerotized on distal part of right side, where it gives rise to the distiphallus, with a straight, slender epiphallus at distal end; distiphallus directed to right, a large oblong sclerite covering most of its left side, a pair of longitudinal pigmented strips on right side, each with two short processes before the apex; cerci longer than surstyli, with numerous hairs, longest on posterior surface.

Female postabdomen as described for *D. pectinervis* with the following differences: segment 7 incompletely desclerotized on median line; sternite 8 transverse, divided into two rounded lobes by a deep median sinuation in posterior margin; tergite 9 vestigial, represented by a very narrow bare transverse strip above bases of cerci.

Distribution: south-east Queensland; eastern New South Wales; Victoria; Tasmania; south-western Australia.

Material examined (localities only given): *Queensland*: Stanthorpe (UQ). *New South Wales* and *Australian Capital Territory*: Mount Gibraltar National Park, 64 miles W of Grafton (AM); Ponds Creek, E of Armidale (CSIRO); Wootton, near Bulahdelah (CSIRO); Mount Wilson, Blue Mountains (AM); Katoomba, Blue Mountains (AM); Blue Mountains (SPHTM); South Creek, Dee Why, near Sydney (USNM); McCarr's Creek, near Sydney (CSIRO); Manly Reservoir, near Sydney (CSIRO); Royal National Park, near Sydney (*holotype* SPHTM, AM); Otford, Illawarra District (AM); Colo Vale, near Mittagong (AM, USNM); Clyde Mountain, near Braidwood (AM); Monga, near Braidwood (CSIRO); Cotter River, A.C.T. (CSIRO); Coree Creek, A.C.T. (CSIRO); 11 miles S of Eden (CSIRO); Leather Barrel Creek, Kosciusko (CSIRO). *Victoria*: Lorne (SAM); Bright (CSIRO); Ferntree Gully (AM); Noorinbee, near Orbost (NMV). *Tasmania*: Marakoopa Caves, near Mole Creek (AM); 12 miles S of Wilmot (AM); 3 miles S of Oonah, Waratah highway (AM); Hellyer Gorge, Waratah Highway (AM); Waratah (SAM); Corinna (AM); Lake Margaret (CSIRO); 13 miles NW of Queenstown (CSIRO); Strahan (SAM); Eagle Eagle Creek, Gordon River, (CSIRO); Franklin River Crossing, Lyell Highway (AM); near Russell Falls, Mount Field National Park (AM); Hobart (UQ); Eaglehawk Neck (AM). *Western Australia*: Beedelup Falls (CSIRO).

Habitat: sclerophyll forest (especially the richer forms) and rain forest.

DIPLOGEOMYZA PECTINERVIS, sp. nov.

(Figs. 5, 25)

♂ ♀. Head pale yellowish with reddish brown marks on frons; antennae yellowish with brown apices; palpi brown except at bases. Mesonotum reddish-brown with irregular yellowish longitudinal stripes including an acrostichal, a dorsocentral, and an intra-alar pair which contain a brown dot at the base of each setula, also the usual pale stripe on lateral margin; pleura pale yellowish suffused with brown, a broad upper marginal brown band. Legs yellowish; coxae paler; fore femur brown; middle and hind femora with dark brown apices. Wings greyish hyaline with dark spots as follows: one on fork of veins 2 and 3, faint ones on vein 4 near base of discal cell, and on apex of vein 6, an apical one on vein 1 and on vein 2, a preapical one on vein 3 and vein 4, a strong mark along anterior and posterior crossveins. each of which spreads for a short distance along vein 4 to make a T-shaped mark, a series of two to five spots in marginal cell. Abdomen brown.

Arista plumose. Scutellum with four bristles and moderately numerous coarse setulae; one sternopleural. Wing with two to five incomplete crossveins in the blackish spots in marginal cell, which extend from vein 2 towards costa but do not reach the latter.

Epandrium (Fig. 25A) with surstylus rather short and broad, very obtuse, the base slightly dilated; paramere (Fig. 25B) as long as surstylus, rather broad, obtuse, bent forward near base, with a longitudinal carina on inner surface making it triangular in section; aedeagus (Fig. 25C) with rather long tubular sclerotized basiphallus, bilaterally compressed at its distal end, the distiphallus arising from anterior surface of basiphallus as a simple, membranous tube; cerci nearly as long as surstyli, with long hairs, particularly on dorsal surface.

Female postabdomen with segment 6 similar to segment 5 but slightly shorter, some short spines near posterior margin of tergite 6; segment 7 shorter, the tergite with numerous short spines, narrowly divided at median line, not produced ventrally at sides; sternite 7 transversely narrowed, posterior margin straight; tergite 8 divided into two well separated spinose plates; sternite 8 trapezoid, the posterior margin almost straight with a small median notch; tergite 9 reduced to a narrow transverse band, with a pair of setulae near centre; sternite 10 normal, setulose; cerci short.

Dimensions: total length, ♂ 2·7–5·6 mm., ♀ 3·5–5·3 mm.; length of thorax, ♂ 1·8–3·5 mm., ♀ 2·0–3·1 mm.; length of wing, ♂ 3·9–6·1 mm., ♀ 3·9–6·8 mm.

Distribution: New South Wales and southern Queensland—coast and eastern part of tablelands.

Material examined: *New South Wales*: Kurrajong, xii 1959 (*holotype* ♂, AM), x xii 1959–1966 (*paratypes,* 1 ♂, 2 ♀, AM), 1 ♂, 1 ♀, BM), D.K.M.; Mount Wilson, Blue Mountains, xi 1959 (*paratype* ♀, AM), D.K.M.; Wollombi, near Cessnock, viii 1956 (*paratype* ♀, AM), D.K.M.; Palm Grove, near Wyong, vii 1961 (*paratype* ♀, AM), D.K.M.; Mooney Mooney Creek, near Gosford, ix 1956 (*paratypes,* 3 ♀, AM), D.K.M.; Royal National Park, south of Sydney, i iii iv vi viii ix xii 1955–1964 (*paratypes*, 4 ♂, 9 ♀, AM, 1 ♂, BM, 1 ♂, QM, 1 ♀, USNM), D.K.M.; Colo Vale, near Mittagong, i iii 1957 (*paratypes,* 1 ♂, 1 ♀, USNM), 1 ♂, AM), W. W. Wirth; Macquarie Falls, near Robertson, x 1960 (*paratype* ♂, CSIRO), D.H.C.; Kangaroo Valley, ix 1960 (*paratype* ♂, CSIRO), D.H.C.; Cabbage Tree Creek, near Clyde Mountain, x 1960 (*paratype* ♂, CSIRO), D.H.C.; 4 miles N of Bateman's Bay, ix 1959 (*paratype* ♂, CSIRO), Z. Liepa. Queensland: Binna Burra, Lamington National Park, i ii 1961 (1 ♂, 1 ♀, AM), D.K.M.

Habitat: stream margins, principally in rain forest and wet sclerophyll forest.

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References

HARRISON, R. A., 1959.—Acalypterate Diptera of New Zealand. *Bull. N.Z. Dep. sci. industr. Res.*, 128: vii + 382 pp.

HENDEL, F., 1917.—Beiträge zur Kenntnis der acalyptraten Musciden. *Dtsch. ent. Zeitschr.*, 1917: 33–47.

LOEW, H., 1862.—Monographs of the Diptera of North America. Part I. *Smithson. misc. Coll.*, 6, art. 1: xxiv + 221 pp.

MCALPINE, D. K., 1960.—A Review of the Australian species of Clusiidae (Diptera, Acalyptrata). *Rec. Aust. Mus.*, 25: 63–94.

MALLOCH, J. R., 1926.—Notes on Australian Diptera. No. ix. PROC. LINN. SOC. N.S.W., 51: 545–554.

TONNOIR, A. L., and MALLOCH, J. R., 1927.—New Zealand Muscidae Acalyptratae. Part III. Helomyzidae. *Rec. Canterbury* [*N.Z.*] *Mus.*, 3: 83–100, pl. 18–20.

WHEELER, M. R., 1955.—*Paraneossos*, a new genus of Trixoscelidae (Diptera: Acalyptrata). *Wasmann J. Biol.*, 13: 107–112.

THE EARLY DEVELOPMENT OF TASMANIA'S ENDEMIC ANURA, WITH COMMENTS ON THEIR RELATIONSHIPS

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Synopsis

The early development of the Tasmanian endemic anurans *Crinia tasmaniensis* (Günther) and *Hyla burrowsi* Scott is described. In each case the development is compared to that of other congeneric species, and some suggestions as to the affinities of the two species are made.

Introduction

Tasmania has two endemic anuran species: *Crinia tasmaniensis* (Günther) and *Hyla burrowsi* Scott (Littlejohn and Martin, 1965*a*). Their biology is not well known; Blanchard (1929) has described some aspects of the breeding biology of *C. tasmaniensis,* but there is virtually no literature on *H. burrowsi,* apart from the original description by Scott (1942), which is repeated with a few additional comments by Copland (1957); and a recent note on distribution (Hewer, 1965). The affinities of these species, likewise, are not entirely clear. While there is little doubt that *C. tasmaniensis* is fairly closely related to *C. signifera* Girard (Parker, 1940; Moore, 1954), the only relationship suggested for *H. burrowsi* is to the Western Australian *H. adelaidensis* Gray (Scott, 1942).

The present account gives a description of embryonic and larval material of both species, collected during two visits to Tasmania. The study was undertaken with two purposes in mind: (i) as a contribution to our very limited knowledge of the Tasmanian anuran fauna; and (ii) to assess whether their developmental biology provides any clue to the relationships of these species. The life histories of most southern Victorian anurans are now known, at least in outline (Littlejohn, 1963; Martin, 1965; Martin, Littlejohn and Rawlinson, 1966), and thus some basis for comparison is available.

Methods

For both species embryonic and/or larval material was collected in the field. Part of each sample was fixed immediately after collection, and part further reared in the laboratory at room temperature (15–25° C.), with more individuals being preserved at irregular intervals. All measurements, drawings and descriptions are based on preserved material. Techniques of rearing, fixation, measurement and drawing are those of Martin and Littlejohn (1966). The staging system used in describing embryos and larvae is that of Gosner (1960). However, Gosner's table was designed for other groups of anurans, and can be used to represent only approximately the developmental stages of the Australian Hylidae and Leptodactylidae.

Crinia tasmaniensis

Material.—The account of development to stage 34 is based on a series of embryos collected at 3,500 ft. on Mt. Wellington on 11.x.65, and reared in the laboratory. A series of stage 34 larvae was obtained at the same locality on 28.xii.64, and the description of a larva at this stage, and also the notes on tadpole diet, are based on this sample. Identification of these two samples is considered certain since no other leptodactylid is known to breed at the locality (Hickman, pers. comm.), and the embryos, in particular, do not resemble those of any other species known to inhabit the general area (Martin, 1965 and unpublished). A few larvae were collected near Lake Dobson (altitude 3,382 ft.) on Wombat Moor on 31.xii.64, and two of them reared to metamorphosis to confirm their identity. A single juvenile was obtained 4 miles S. of Parrawe (near Waratah) on 6.x.65.

Eggs.—The process of oviposition was not observed. A series of early embryos was found lying singly or in small clumps on the bottom of a shallow pool (2–8 cm. deep) fed by a small rivulet. Several stages of development were represented: stage 8 (mid-cleavage), stage 11 (mid-gastrula), and stage 17 (tail bud). At stage 8 the animal hemisphere is dark brown in colour, while the vegetal hemisphere is greyish white. Each embryo has its own separate capsule, which is composed of two layers of jelly (Fig. 1A). The inner layer has a double outer wall and a diameter about twice that of the embryo. It is composed of firm jelly, while the outer layer is composed of relatively fluid jelly. The dimensions (mean and range) of 15 stage 8 embryos are: embryo diameter, 2·27 mm. (2·05–2·55); outer capsule diameter, 6·94 mm. (6·25–7·45).

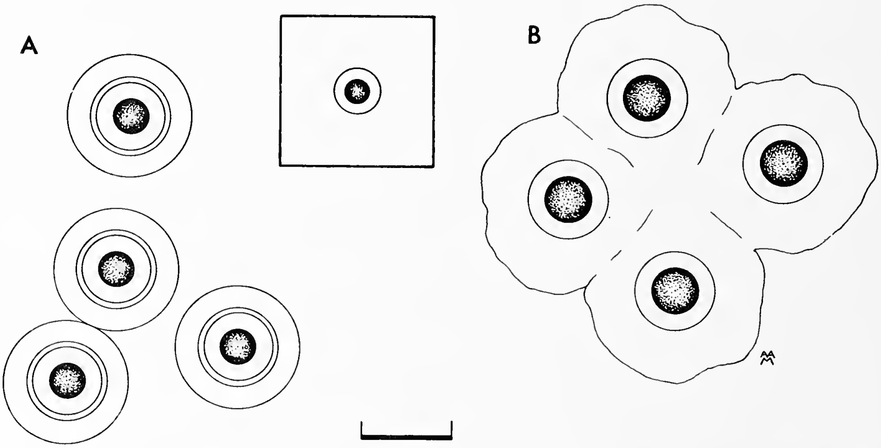

Fig. 1. Eggs of A, *Crinia tasmaniensis*, and B, *Hyla burrowsi* (part of mass). Inset: Egg of *Crinia signifera* for comparison. The bar represents 5 mm.

The total egg complement of a single female was not determined. Blanchard (1929) made ovarian egg counts of two females, resulting in figures of 46 and 69 eggs.

Pre-Hatching Embryos.—Gastrulation appeared normal and neurulation was not observed. The stage 17 embryos (Fig. 2A) have a total length of about 3 mm. The colour is dark brown. There is little external differentiation in the head region, apart from a slight stomodaeal depression and bulges marking the positions of the visceral arches. The tail bud, which has a rudimentary fin along its dorsal edge, is bent to the right, and points in a dorsal rather than a posterior direction.

Three days later the embryos are in about stage 21 (Fig. 2B). Olfactory pits and ventral suckers are present, but there is no marked optic bulge, nor is the cornea clear. The mouth is open, the pronephros is recognizable, and the rectal tube has differentiated. There are no external gills. The tail fin appears slightly lighter than the general body colour, which remains dark brown. The total length is about 8 mm.

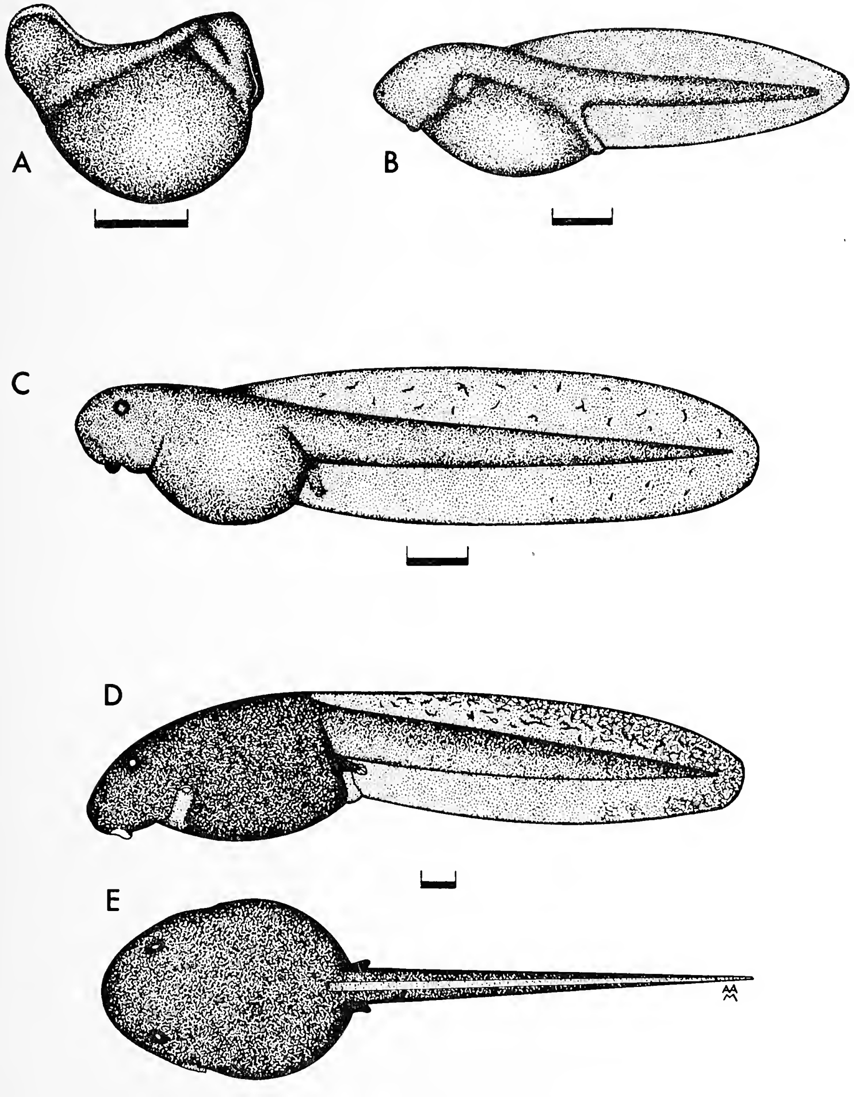

Fig. 2. Larval development of *Crinia tasmaniensis*, Mt. Wellington. A: stage 17; B: stage 21; C: stage 25 (hatching); D and E: stage 34. The bar in each case represents 1 mm.

Post-Hatching Embryos.—Hatching occurred 7 days after collection, when the embryos had reached about stage 25 (Fig. 2C). The cornea is beginning to clear. The ventral suckers are well developed and an opercular fold is present, though no spiracular opening is discernible. Pigment spots are scattered through the dorsal fin and posterior third of the ventral fin. The mean total length of four newly hatched individuals is 11·85 mm. (range 11·25–12.40).

Larvae.—Seven days later, in stage 29, a spiracle is present, though its mode of formation is obscure. The ventral suckers are much reduced, and the labial teeth bordering the mouth are visible. On the dorsal surface of the body there is a T-shaped glandular area extending laterally between the eyes and external nares, and posteriorly down the dorsal midline almost to the origin of the dorsal fin. Two larvae in this stage have total lengths of 13·7 and 15·8 mm. respectively.

The T-shaped gland is still apparent in larvae fixed 15 days later, when they are in stage 31, but the ventral suckers remain only as minute pigmented patches. The tail fin has a dusky, reticulated appearance, particularly in the dorsal half. Four larvae in this stage have a mean total length of 16·8 mm. (range 16·3–17·2).

The five remaining larvae in the culture were preserved after a further interval of 6 weeks, on 21.xii.65, when they had reached stages 33–34. Their mean total length is 18·9 mm. (range 17·8–20·4).

TABLE 1

Body dimensions (in mm.) and proportions of nine Crinia tasmaniensis *larvae at stage 34, from Mt. Wellington*

	Total length	Tail length	Maximum body width	Maximum body depth	Maximum tail depth	Mouth disc width	Tail length / Total length	Tail depth / Tail length	Tail depth / Body depth
Mean	19·29	11·62	5·22	4·15	3·61	1·46	0·60	0·31	0·87
Range ..	17·65–20·30	10·50–12·65	4·80–5·85	3·85–4·35	3·40–4·00	1·30–1·60	0·58–0·62	0·28–0·32	0·83–0·94

The following description of a larva at stage 34 is based on a series collected at the Mt. Wellington locality on 28.xii.64, and preserved immediately. A larva of this series is shown in Figs 2D and 2E, and its mouth disc in Fig. 3A. The tadpole is characterized by a plump body and relatively narrow tail fin. The spiracle is situated high on the left side of the body, and the anus opens to the right of the tail fin. The body is darkly pigmented dorsally, but slightly lighter in colour ventrally, enabling the intestine to be seen through the ventral body wall. The dorsal fin has scattered dark spots imposed on a reticulated pattern, while the ventral fin is more or less clear. The mouth formula is $\overset{1}{\underset{2}{\frac{1}{1}\;\frac{1}{1}}}$, the third lower tooth row being short and arched upwards (Fig. 3A). In a few larvae the gap in the first lower row of labial teeth is somewhat narrower than that shown in Fig. 3A, but apart from this there appears to be little variation in the mouth structure. The body dimensions and proportions of 9 larvae in this series are given in Table 1.

Larval Diet.—The gut contents of several larvae selected at random from the 1964 Mt. Wellington series included desmids, diatoms, and colonial and filamentous green algae, as well as fragments of higher plant tissue. Vascular and non-vascular plant material was roughly equally abundant in the intestinal contents.

Metamorphosis.—Two larvae collected on Wombat Moor on 31.xii.64 metamorphosed in the laboratory on 16.i.65. The juveniles have body lengths of 10·6 and 10·8 mm., which are comparable to the lengths of 9 to 10 mm. given by Blanchard (1929) for newly metamorphosed juveniles from the same locality. The ventral surface of the body is markedly granular in texture, but the red colouration usually present on the thighs and groin of the adult is not developed. However, an older juvenile collected near Parrawe on 6.x.65, and measuring 12·5 mm. in body length, has the red colouration fully expressed.

Larval Life Span.—From the fact that breeding was taking place in early October, and newly transformed juveniles were found in mid-January (A.A.M.) and late January—early February (Blanchard, 1929), it seems likely that the larval life span extends over 3–4 months.

Comparison with Other Species.—In Tasmania the genus *Crinia* is represented by two other species: *C. signifera* Girard and *C. laevis* (Günther) (Littlejohn and Martin, 1965*a*). The life history of *C. signifera* has been described by Moore (1961). The eggs are small and are laid in water, hatching occurs after a few days, and larval development follows the typical pattern.

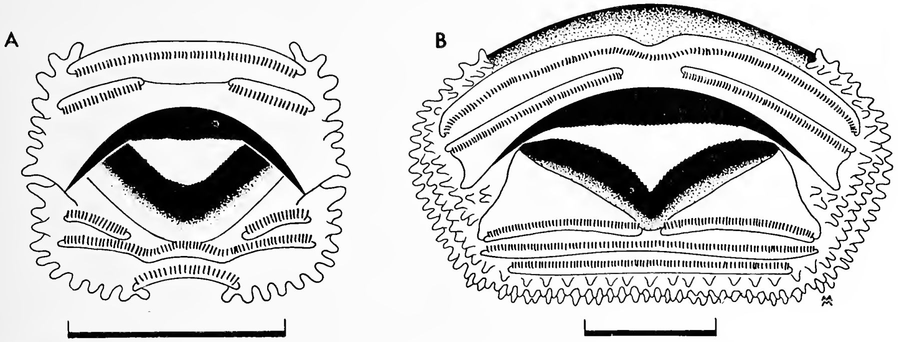

Fig. 3. Mouth discs of A, *Crinia tasmaniensis* larva at stage 34, and B, *Hyla burrowsi* larva at stage 31. The bar in each case represents 1 mm.

C. laevis has a markedly different type of development (Littlejohn and Martin, 1964). The eggs are relatively large and are laid on land. Development to an advanced larval stage occurs within the capsule, and hatching is delayed until the eggs are flooded. Thereafter there is a normal aquatic larval phase.

The life history of *C. tasmaniensis* is somewhat intermediate between these two contrasting patterns. It resembles *C. signifera* in having aquatic oviposition, but the morphology of the eggs themselves is more reminiscent of *C. laevis*. The figures for embryo and capsule diameters are: *C. tasmaniensis,* 2·27 and 6·94 mm.; *C. signifera,* 1·39 and 2·60 mm. (Littlejohn and Martin, 1965*b*; Martin, unpublished). No data are available for *C. laevis,* but for the sibling *C. victoriana* Boulenger the comparable figures are 3·1 and 6·2 mm. (Littlejohn and Martin, 1964). *C. signifera* has a single layered capsule (Fig. 1, inset), while *C. victoriana* (and presumably *C. laevis*) resemble *C. tasmaniensis* in having a double capsule (Martin, unpublished).

The larger eggs of *C. tasmaniensis* and *C. laevis* give them the potential for extended intracapsular development. Thus the hatchlings of the two species resemble each other in being large and well advanced (Fig. 2C, and Martin, unpublished). In contrast, *C. signifera* embryos hatch at about stage 20, when their total length is 5–6 mm. (Martin, 1967), i.e., about half the size of *C. tasmaniensis* hatchlings.

Correlated with the larger ovidiameters of *C. tasmaniensis* and *C. laevis* is the lower clutch size of these species. Numbers of eggs per clutch are: *C. signifera,* about 150 (two clutches; Harrison, 1922); *C. laevis,* 111 (mean of six clutches; Littlejohn and Martin, 1964); and *C. tasmaniensis,* 46 and 69 (two clutches; Blanchard, 1929).

The subsequent larval development of the three species is much more similar. Larval size and morphology are closely comparable for all three, and their mouth discs are also similar (Littlejohn and Martin, 1964; Martin, 1965).

Affinities.—In general the genus *Crinia* is divisible into two species groups: the smooth-bellied forms, of which *C. laevis* and *C. victoriana* are examples; and the granular-bellied, often polymorphic forms, including *C. tasmaniensis* and *C. signifera* (Parker, 1940; Main, 1957). This division is to some extent supported by life history characters (Martin, 1967). Most of the smooth-bellied species lay large eggs out of water, and the development is partially or entirely terrestrial. The majority of the granular-bellied group, in contrast, lay small eggs in water, and have typical aquatic development.

On the grounds of both adult morphology and life history, *C. tasmaniensis* is clearly a member of the granular-bellied group. In outline its life history does not differ greatly from that of *C. signifera,* and the embryos of the two species also share some peculiar anatomical features, e.g., the lack of external gills and the presence of the T-shaped gland (Moore, 1961). The differences between the two may, in the main, be correlated with the larger ovidiameter of *C. tasmaniensis.* This feature, and the advanced stage of development of the hatchlings that is consequent upon it, are more reminiscent of *C. laevis* than of *C. signifera.* Nevertheless, *C. tasmaniensis* does not possess the characteristics associated with large eggs shown by the *C. laevis* group; namely, terrestrial oviposition and extended terrestrial development. This suggests that the large ovidiameters of the two forms represent independent adaptations to different ecological conditions. In this regard it is noteworthy that the geographic range of *C. tasmaniensis* includes a large proportion of sub-alpine and alpine areas (see locality lists in Blanchard, 1929; Parker, 1940; and Hickman, 1960). The situation is paralleled by Moore's (1949) account of the genus *Rana* in North America, where the species existing under lower temperature regimes have larger eggs. A similar correlation may apply in the present instance, but with altitude, rather than latitude, providing the temperature gradient.

HYLA BURROWSI

Material.—The account of this species is based entirely on a small series of embryos collected 5 miles W. of Queenstown on 6.x.65, and reared in the laboratory. Unfortunately none of the larvae survived to metamorphosis, and thus direct confirmation of their identity is not available. There can be little doubt, however, that the material represents *H. burrowsi,* since (i) calling males of this species were found near the egg masses, and (ii) the egg masses, embryos, and larvae do not resemble those of any other anuran known to occur in Tasmania (Littlejohn, 1963; Littlejohn and Martin, 1965*a*; Martin, 1965).

Eggs.—Oviposition was not observed. Eggs were found in a roadside pool (depth about 40 cm.) in open country. The eggs were in large clusters attached to reeds, twigs, and blades of grass. Each egg has two jelly capsules (Fig. 1B). The outer capsule has a brownish-yellow tinge and is not clearly demarcated around each egg, i.e., forms part of a more or less continuous mass of jelly around the whole egg mass. The inner capsules are separate and composed of clear jelly. The outer capsule is somewhat fluid, while the inner one is firm.

The earliest stage present was stage 14 (neurula). The following measurements are of a series of ten embryos in this stage. Neurulation is accompanied by elongation of the embryo, and the measurement taken was the shortest (i.e., transverse) diameter of the embryo. The mean dimensions (with ranges) are embryo diameter, 2·67 mm. (2·50–2·90); outer capsule diameter, 10·28 mm. (9.20–11.00).

The total egg complement of a single female is unknown.

Pre-Hatching Embryos.—Neural fold formation appeared to follow the typical pattern. The only other pre-hatching embryos available for study are in about stage 18 (Fig. 4A). Optic bulges, visceral arches, and pronephric swellings are all well developed. The ventral suckers are already present and relatively very large. The tail bud may be bent either to the right or to the left, and bears a rudimentary fin. The colour is golden brown. The total length is about 5 mm.

Post-Hatching Embryos.—The embryos began hatching on 11.x.65, when they were in about stage 21 (Fig. 4B). Three newly hatched embryos have total lengths of 8·65, 8·85, and 9.20 mm., respectively. Two pairs of external gills are present, the anterior pair each having four branches, and the posterior pair two. Olfactory pits are discernible and the ventral suckers are still present, but the cornea is not yet clear. The dorsal fin extends well up the back and is pale yellowish, while the body colour remains golden brown.

Larvae.—The number of larvae available is too small to allow for detailed data on body dimensions. A single larva was fixed in stage 26 on 22.x.65. The mouth disc and spiracle are fully developed and the ventral suckers are reduced to small pigmented patches. The total length is 16·35 mm.

A larva fixed on 25.xi.65 is in stage 28, and has a total length of 25·00 mm. Figs. 4C and 4D show a stage 31 larva, fixed on 2.ii.66. The total length is 30·10 mm. A single larva survived to stage 35, and was fixed on 19.v.66, when its total length was 34·30 mm.

The larvae are light yellowish-brown in colour, with a dark patch between the eyes and a dark layer over the intestinal mass. The dorsal edge of the tail musculature is brown, while the remainder is pale yellowish. The fins are almost clear and a few blood vessels can be discerned. The spiracle is situated low on the left side of the body and the anus opens to the right of the tail fin. The mouth disc (Fig. 3B) has a formula of $\begin{matrix} & 1 & \\ \frac{1}{1} & \text{—} & \frac{1}{1} \\ & 2 & \end{matrix}$, and is bordered by 2–3 rows of papillae. At the corners of the mouth a few papillae extend medially towards the jaws. The jaws are relatively wide and the lower one is notched.

No data are available on larval diet, larval life span, or metamorphosis.

Comparison with Other Species.—Two other hylid species, *H. aurea* (Lesson) and *H. ewingi* Dumeril and Bibron, occur in Tasmania (Littlejohn and Martin, 1965*a*). Studies of adult morphology do not suggest a close relationship between either of these two and *H. burrowsi.* Life history data are of limited assistance in assessing hylid relationships, since, as has been pointed out by Martin (1967), all known Australian hylid life histories follow a common pattern. However, there is some variation in the form of the egg mass. The eggs may be laid as a film at the water surface, e.g., *H. aurea* (Littlejohn, 1963) and *H. caerulea* (White) (Harrison, 1922); or in submerged clusters attached to vegetation, e.g., *H. phyllochroa* Günther (Harrison, 1922), *H. ewingi* (Waite, 1929), and *H. jervisiensis* Dumeril and

Bibron (Martin and Littlejohn, 1966). *H. burrowsi* clearly belongs in the latter category. Apart from this there are few features of the life history of *H. burrowsi* that are not shared by most other Australian hylids. The fairly deep fins, ventrolateral, sinistral spiracle, dextral anus, and 2/3 mouth formula are all characteristic of hylid larvae in general (Martin and Littlejohn, 1966).

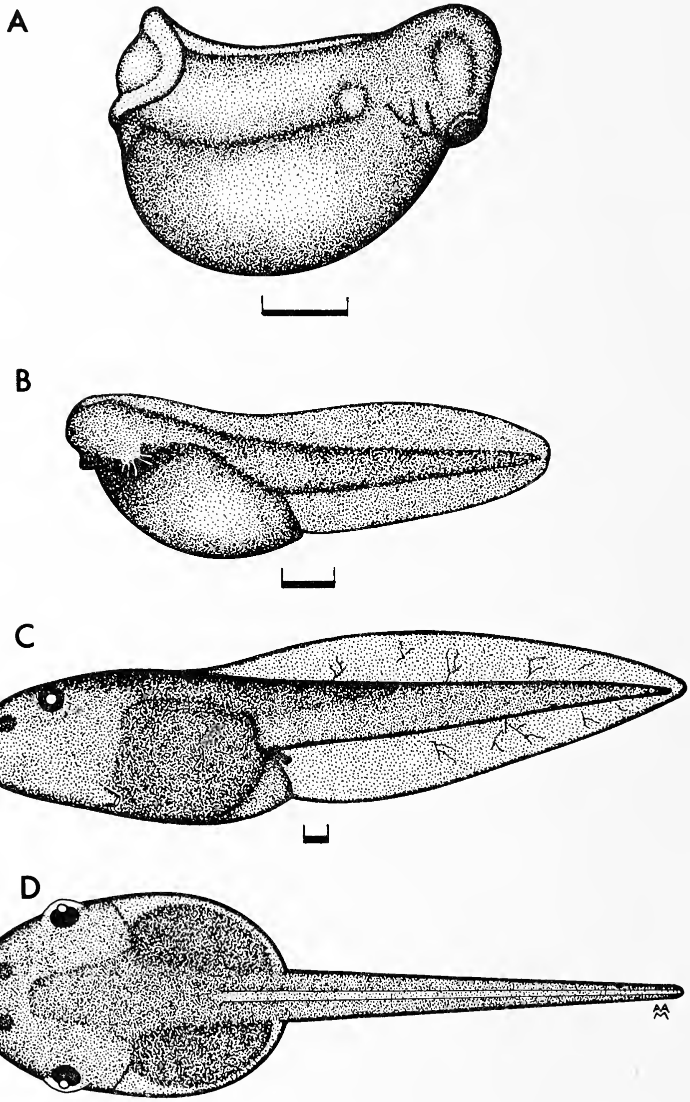

Fig. 4. Larval development of *Hyla burrowsi*, 5 miles W. of Queenstown. A: stage 18; B: stage 21 (hatching); C and D: stage 31. The bar in each case represents 1 mm.

Affinities.—It has been noted above that the form of the egg mass of *H. burrowsi* is similar to that of *H. ewingi.* This does not necessarily imply any relationship, especially since the majority of Australian hylid life histories are very poorly known. Nevertheless it may be worth examining the other members of the *H. ewingi* complex (*H. verreauxi* Dumeril and *H. jervisiensis*; Martin and Littlejohn, 1966) to see whether any other affinities are apparent.

One feature is immediately obvious: *H. jervisiensis* and *H. burrowsi*, with ovidiameters of 2·33 and 2·67 mm. respectively, have unusually large egg diameters among the Australian Hylidae (Martin and Littlejohn, 1966). The egg clusters of these two species, with their large capsules attached to vegetation, are also similar. Their larvae are of the common hylid type and there is nothing particularly distinctive about them. They do, however, share one small peculiarity: in the mouth discs of both species the labial papillae extend inwards at the sides towards the jaws (Fig. 3B, and Martin and Littlejohn, 1966).

In the absence of detailed data on most Australian hylid life histories, the suggested affinity with *H. jervisiensis* can only be very tentative. Nevertheless the adult morphology of the two is also generally similar, to judge from the descriptions by Scott (1942) and Moore (1961). It may be objected that its pigmentation would tend to ally *H. burrowsi* with the "Green Hylas" (*sensu* Moore, 1961) rather than with the predominantly brown-coloured members of the *H. ewingi* complex. However, green colouration appears to be a remarkably labile character in the *H. ewingi* group. Thus *H. verreauxi* is brown at low altitudes but bright green in some alpine areas (Moore, 1961, as *H. ewingi*; see Littlejohn, 1965); and *H. ewingi*, which is brown over most of its range, has a green dorsum in parts of western Victoria (Littlejohn, pers. comm.). The presence or absence of green pigment is therefore not a stable character upon which to base assessment of relationships in this group. Moreover, the true "Green Hylas" are characterized by a uniform leaf-green dorsal surface (Moore, 1961), rather than the brown-mottled green that occurs in *H. burrowsi* (Scott, 1942).

There are two further areas of investigation in which the relationship suggested above should be tested. Firstly, a detailed study of adult morphology is necessary. Secondly, the structure of the male mating call may provide some evidence. All the known members of the *H. ewingi* complex have a call consisting of an extended series of pulsed notes (Littlejohn, 1965; Martin and Littlejohn, 1966). The tentative affinity suggested here would be reinforced should *H. burrowsi* be found to share this type of call. The calls of two males heard near Queenstown were noted at the time as sounding like "wa-a-a-ar, wa-a-a-ar, wa-a-a-ar", and Hewer (1965) describes the call as a "very loud and penetrating honking". These descriptions suggest a repetitive, pulsed structure, but unfortunately tape recordings have not been made. Further analysis along these lines must await the recording of a series of *H. burrowsi* calls.

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Dr. M. J. Littlejohn originally suggested this study. I am deeply indebted to Dr. J. L. Hickman of the Zoology Department, University of Tasmania, who assisted me with advice, transport, and in many other ways while collecting *Crinia tasmaniensis* material. Mr. A. R. Martin and Mrs. S. M. A. Martin assisted in the field. Dr. Hickman and Dr. Littlejohn read the manuscript.

References

BLANCHARD, F. N., 1929.—Re-discovery of *Crinia tasmaniensis*. *Austr. Zool.*, 5: 324–328.

COPLAND, S. J., 1957.—Australian tree frogs of the genus *Hyla*. PROC. LINN. SOC. N.S.W., 82: 9–108.

GOSNER, K. L., 1960.—A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica*, 16: 183–190.

HARRISON, L., 1922.—On the breeding habits of some Australian frogs. *Austr. Zool.*, 3: 17–34.

HEWER, A. M., 1965.—Distribution of the species *Hyla burrowsi* in Tasmania. *Tas. nat. Bull. Suppl.*, 3: 1–2.

HICKMAN, J. L., 1960.—Cestodes of some Tasmanian Anura. *Ann. Mag. nat. Hist.*, (13) 3: 1–23.

LITTLEJOHN, M. J., 1963.—Frogs of the Melbourne area. *Vict. Nat.*, 79: 296–304.

————, 1965.—Premating isolation in the *Hyla ewingi* complex (Anura : Hylidae). *Evolution*, 19: 234–243.

————, and MARTIN, A. A., 1964.—The *Crinia laevis* complex (Anura : Leptodactylidae) in south-eastern Australia. *Austr. J. Zool.*, 12: 70–83.

————, ————, 1965*a*.—The vertebrate fauna of the Bass Strait Islands: 1. The Amphibia of Flinders and King Islands. *Proc. roy. Soc. Vict.*, 79: 247–256.

————, ————, 1965*b*.—A new species of *Crinia* (Anura : Leptodactylidae) from South Australia. *Copeia*, 1965: 319–324.

MAIN, A. R., 1957.—Studies in Australian Amphibia: I. The genus *Crinia* Tschudi in south-western Australia and some species from south-eastern Australia. *Austr. J. Zool.*, 5: 30–55.

MARTIN, A. A., 1965.—Tadpoles of the Melbourne area. *Vict. Nat.*, 82: 139–149.

————, 1967. Australian anuran life histories: Some evolutionary and ecological aspects. Chapter 7 in "Australian Inland Waters and their Fauna: Eleven Studies" (ed. A. H. Weatherley). (Australian National University Press.)

MARTIN, A. A., and LITTLEJOHN, M. J., 1966.—The breeding biology and larval development of *Hyla jervisiensis* (Anura : Hylidae). PROC. LINN. SOC. N.S.W., 91: 47–57.

————, LITTLEJOHN, M. J., and RAWLINSON, P. A., 1966.—A key to the anuran eggs of the Melbourne area and an addition to the anuran fauna. *Vict. Nat.*, 83: 312–315.

MOORE, J. A., 1949.—Patterns of evolution in the genus *Rana*. Chapter 17 in "*Genetics, Paleontology and Evolution*" (ed. Jepsen, Simpson and Mayr). (Princeton University Press.)

————, 1954.—Geographic and genetic isolation in Australian Amphibia. *Amer. Nat.*, 88: 65–74.

————, 1961.—The frogs of eastern New South Wales. *Bull. Amer. Mus. nat. Hist.*, 121: 149–386.

PARKER, H. W., 1940.—The Australasian frogs of the family Leptodactylidae. *Novit. Zool.*, 42: 1–106.

SCOTT, E. O. G., 1942.—A new *Hyla* from Cradle Valley, Tasmania. *Rec. Queen Vict. Mus.*, 1: 5–11.

WAITE, E. R., 1929.—"The Reptiles and Amphibians of South Australia." (Harrison Weir, Adelaide.)

GEOMORPHOLOGY OF THE KOSCIUSKO BLOCK AND ITS NORTH AND SOUTH EXTENSIONS

W. R. Browne

[Read 26th April, 1967]

(Plate III)

Synopsis

A topographical account is given of the high country from Kiandra south to the Victorian border, bounded by the Eucumbene–Snowy and Indi rivers, with particular reference to the portion between Jagungal and Cascade Creek (the Kosciusko block). Lineaments are prevalent, mostly indicating ancient shear-zones, and the evidence suggests that these became the loci of Kainozoic faults. In common with the rest of the eastern highlands the area experienced Tertiary crustal movement, chiefly, it would seem, in the Eocene, late Miocene and later Pliocene, and it is thought that the Kosciusko block was differentially elevated above the adjacent country, probably in at least three stages, during the last of these epochs.

Attention is drawn to the influence on the topography of rock composition and structure and of glacial sculpture, and the characteristics of a number of the principal streams are briefly described.

INTRODUCTION

The following notes are based on incidental observations made over the last 25 years in the course of field-studies, chiefly of the glacial aspects of Kosciusko geology, combined with the examination of contour-maps and air-photographs. They are necessarily very incomplete, and will certainly need revision, but the improbability of opportunities for future field-work has prompted this recording of results in the hope that other geologists may be incited to more detailed examination of the problems considered. Certain of the matters dealt with at some length here have been touched on in previous papers, references to which are made below.

The work of earlier investigators was hampered by lack of reliable maps and by difficulties of access. The latter have been to a considerable extent resolved by roads and tracks made by the Snowy Mountains Hydroelectric Authority; the former drawback was partly made good by the very useful topographic map with spot-heights, made by the State Department of Lands in 1944, but the present study would have been impossible without the accurate topographical maps produced by the S.M.H.E.A. over the past 15 years. I am under great obligation to the Authority for copies of these and for the loan of air-photographs, and to the Commonwealth Bureau of Mineral Resources for making available a set of air-photographs. Free use has been made of the excellent reconnaissance reports and geological maps of parts of the area by members of the Geological Survey of N.S.W., and frequent references are made to them below.

Over the years I have been very fortunate in having the help and companionship in the field of a number of geological colleagues including Mr. W. H. Maze and Dr. J. A. Dulhunty, Drs. T. G. Vallance and G. H. Packham and, more recently, my wife, Dr. Ida A. Browne. Dr. Marie E. Phillips and Messrs. D. Wimbush and D. Svenson have shown me features of geological interest, and Mr. D. G. Moye, until recently Chief Geologist of the S.M.H.E.A., has generously placed at my disposal his unrivalled knowledge of the geology and topography, has kindly read and discussed these notes in draft manuscript and has in many other ways shown a practical interest in the work. To all these helpers I am most grateful, but for all observations and conclusions the responsibility is mine alone. A number of my interpretations differ from those given by Mr. Moye in a recent brief account of the tectonics of the area (in Cleary, Doyle and Moye, 1964, pp. 101–104).

The replication of names of rivers and creeks within the area described may cause some confusion to the reader; there are three Diggers Creeks, two each named respectively Waterfall, Dead Horse, Farm, Sawpit, Cascade and Toolong, and one Boogong and two Bogong Creeks; there are Pound Creek and Pounds Creek, Bull Creek, Bulls Head Creek and Bulls Peaks River, Snowy Creek (tributary to the Indi) and Snowy River, Geehi Creek and Geehi River, Swampy Plain Creek and Swampy Plain River. There are also two peaks named Round Mt. and two eminences called Granite Peak and Granite Peaks respectively. In most instances where any of these is mentioned in this paper the context should make clear which is meant.

Most of the country on the east of the area is referred to as it appears at present, but with the completion of a dam below Jindabyne that village will be submerged together with the Snowy valley up towards Kalkite and Waste Point. Already a new Jindabyne is in being a little distance south of the old, and part of the Kosciusko road from Jindabyne *via* The Creel and Waste Point has been superseded by another skirting the western margin of the area to be submerged. The Eucumbene River is dammed 5½ miles up from Eastbourne bridge, and the country upstream below 3,800 feet submerged.

General Description

(Plate III)

The tract of country here referred to as the Kosciusko block is part of the Southern Highlands of New South Wales near the Victorian border, and includes the highest land in the continent, culminating in Mt. Kosciusko (7,314 ft.). From this point it stretches some 23 miles N to Mt. Jagungal and 9 miles to the south and it extends EW for some 30 or 35 miles between the Eucumbene-Snowy and Indi (Upper Murray) rivers, with a maximum relief of some 6,000 feet in that distance. From the country immediately E and W the block rises so sharply as to suggest that it is of the nature of a horst, for which, however, precise tectonic limits are hard to define. On the east a fairly satisfactory meridional boundary may be drawn south along the Eucumbene River following the Eucumbene fault, then turning SSW along the Waste Point fault marking the western wall of the Snowy valley. For the west of the block one might draw an irregular boundary, altitudinal rather than tectonic, traversing the lowlands of Bridge Creek, Swampy Plain River and the Indi River, but if these are fault-troughs, as is possible, the line would be unsatisfactory. The structural significance, if any, of the Indi is obscure; for most of its length it seems to be merely a deep trench incised in a belt of highland country passing SW from N.S.W. into Victoria, determined in part by ancient faulting, whilst the northerly continuation of its general trend, passing up Tumbarumba and/or Mannus Creek, marks a break between the higher country on the east and the lower on the west. For present purposes the Indi forms a convenient boundary. The fall to the SE is defined by fault-steps and the lineament of Mowamba River may be regarded as bounding the block, but on the north beyond the stated limit the downthrow is less than elsewhere and the horst seems to merge into the general level of the highlands. In the south beyond Cascade Creek the plateau surface descends rather sharply, marking the southern extension of the block, and narrows, apparently as the result of faulting on the east. The block and its extensions show marked asymmetry in cross-section, the backbone or highest land being on the western side in the south and the eastern side in the north; there is also a marked difference in altitude between the eastern and western margins (Fig. 1).

In this essay the topography is interpreted as the result of repeated differential uplift of a Miocene peneplain surface along submeridional fault-planes, with concomitant faultings in other directions. Post-uplift erosion, fluvial and glacial, has profoundly modified the *terrain* and obscured many structural details, particularly at the higher levels where Pleistocene glaciers were most active and where rainfall, now of the order of 100 inches *p.a.* and probably much higher in Pleistocene time, has been a powerful agent of erosion.

In these notes it may seem that the concept of faulting as opposed to differential erosion to explain the major features of the topography has been used to excess. In general the facile appeal to faulting is to be deprecated, but the widespread occurrence of ancient belts of weakness has been abundantly demonstrated for the area and there is what is believed to be good evidence that many of these have been the loci of Kainozoic faults. The topography of much of the area is shown in the folding contour-map in an earlier paper (Browne and Vallance, 1957).

Miocene Peneplain

The original suggestion that the Kosciusko block is the result of differential elevation by faulting is due to David, who (1908) postulated step-faulting for its eastern side. Sussmilch (1909) envisaged bounding faults east and west, and further faulting was suggested by Browne *et al.* (1944) and Noakes (1946). The deduction that the original surface was a peneplain is based on the appearance of the topography at various levels when viewed from suitable vantage-points, from which, despite severe river-erosion, the distant skyline is seen to be singularly smooth and level. Looked at from east or west the Summit plateau exhibits this characteristic remarkably well. From the top of Mt. Kosciusko or Mt. Twynam the distant horizon, particularly to the north, shows the same uniformity, though anyone familiar only with the broken country SW of Jagungal might find this hard to believe. Viewed from the east Grey Mare Range has a smooth and level profile merging up into a monadnock, the westerly prospect from which discloses an apparent succession of more or less uniform meridional ridges stretching away towards the Murray River. Ramshead Range, the Thredbo plateau across the Crackenback River, the Burrungubugge ridge, the Brassy Mts. and The Kerries, though at varying altitudes and interrupted here and there by cols and monadnocks, are clearly dissected peneplain remnants, and to the south the Tin Mine plateau is evidently part of a peneplain at a lower level. In the northern extension of the block beyond Jagungal the old peneplain surface is plainly recognizable at many places, linking up with that at Tumut and Batlow. Around Kiandra, Cabramurra township and elsewhere the surface is cut partly in Oligocene basalt overlying valley-deposits of sand, gravel and clay, and in the east the Adaminaby plateau and its southern continuation, from which the Kosciusko block rises, are composed in part of Oligocene basalt and sub-basaltic deposits. It is thus evident that the faulted surface forming the Kosciusko block and its extensions is that of the Miocene peneplain, relics of which are so common in other parts of the eastern highlands.

LINEAMENTS

(Plate III)

The Kosciusko block and its extensions to north and south abound in lineaments, manifested in the straightness, alignment and parallelism of river-valleys and to a less extent of scarps. Only the more prominent are plotted; many others have been noted by Adamson (1955), Hall and Lloyd (1954), Moye (in Cleary *et al.,* 1964) and den Tex (1959).

Accurate plotting of lineament-trends is, of course, impracticable and the lines shown on the map are at best approximate whilst some are rather conjectural. The negative lineaments marked by relatively youthful valleys are more reliable than the positive, defined by scarps which may have been substantially modified by erosion.

On the east of the area the meridional lineament along the Eucumbene valley is evident nearly to Kalkite Mt., beyond which the much-dissected scarp of the Kosciusko block bears away to the SSW, though the general meridional trend of the river is maintained as far south as old Jindabyne. In the middle of the block are a number of prominent parallel lineaments, the most conspicuous being that made by the straight valley of Guthega River, which is aligned with Upper Windy Creek and a small tributary of Geehi River farther north; on the south the lineament follows up Farm Creek and Upper Betts Creek and may continue south of the Crackenback River. The line of Upper Munyang River is prolonged north over Schlink Pass into Dicky Cooper Creek and Duck Creek, and on the south may follow up Perisher Creek and cross Ramshead Range. The lineament of Valentine River–Finns River, virtually parallel to this, may be continued to the north.

Lower Spencers Creek follows a generally straight course within a meridional belt of intensified foliation which also contains the lower stretch of Wrights Creek. The belt is prolonged north in tributaries of Three Rocks Creek and a tributary of Windy Creek, crossing the latter in the vicinity of Leaning Rock falls; to the south it passes up the valley of Trapyard Creek, through the deep col at its head and across the Crackenback, continuing by collinear tributaries of Mowamba River to Waterfall Creek, a tributary of Jacobs River.

Lady Northcote Canyon is cut along a meridional line to its head at Moraine Pass, and the lineament probably continues south as the eastern scarp of the Etheridge Range, though it may bend slightly west to follow Upper Cootapatamba valley and Upper Leatherbarrel Creek. Diggers Creek, entering the Snowy near Island Bend, makes a lineament that passes south near Pretty Point and may cross the Crackenback. Other lineaments in the eastern half of the block trend approximately SSE, viz. those of Munyang River, Tolbar Creek–Dead Horse Creek and stretches of Gungarlin River collinear with Bundara Creek and Kalkite Creek respectively. The Burrungubugge River lineament may curve to the SE along the Upper Snowy.

In the SE is a series of conspicuous lineaments. From Diggers Creek to Spencers Creek the Summit road follows a remarkably straight course along a number of collinear valleys belonging to the Snowy system, its general direction parallel to that of the Crackenback River. The latter makes with Dead Horse Creek a lineament 25 miles long, the most striking and impressive in the whole region. Parallel to it but much less well defined are the Little Thredbo–Wollondibby lineament and that of Mowamba River. There appears also to be a minor parallel lineament along the Ramshead Range and another following Upper Wrights Creek and Merritts Creek.

In the SW are the parallel lineaments of Jacobs River and Moyangul River, the former cutting off the Little Thredbo and Mowamba lineaments, and the NS line made by Lookout, Bills Garden and Toolong creeks.

On the west the sinuous lineament of Geehi River may be traced to its head and is prolonged by Straight Creek and the headwater valley of Tumut River, whilst the Bogong Creek lineament continues north through Pretty Plain, along a stretch of the Tooma River and perhaps farther still. In the NW a lineament is made by Upper Welumba Creek trending south and passing some 2 miles E of Khancoban, where it forms the eastern wall of Swampy Plain valley. Other lineaments are noted in the next section.

For the lineaments as a whole no well-defined pattern emerges. Submeridional trends are dominant, varying from about N 10° W on the east to N 10° E on the west; thus the two groups converge northwards at a very acute angle, and those on the west seem to persist farther north. The Crackenback lineaments have a pretty constant azimuth around 240°, and almost at right angles to these are the NW to NNW trends in the east and SW. One might expect some offsetting at fault intersections, but as the hade is probably small this may be neglected.

Hobbs (1911) stressed the significance of topographic lineaments as indicators of direction of jointing and faulting. In the Kosciusko area most of the negative lineaments are closely related to belts of shearing or intensified foliation, as emphasized by Moye and den Tex, or to zones of close jointing, but while it is believed that many of these formed the loci of Kainozoic movements it is clear from the field-evidence that not all of them functioned in this way, since sheared and close-jointed granites have been found on crests of ridges.

The widespread occurrence of zones of shearing in the area is evidence of ancient (probably Palaeozoic) deep-seated relative movement, horizontal and/or vertical, due to horizontal compression, and when the present land-surfaces on either side of a lineament are similar in appearance but at substantially different levels the evidence for Kainozoic faulting is strong and in this study is held to be reasonably conclusive, particularly where rocks of about the same erosional resistance are concerned. The positions of some of the inferred faults were tentatively plotted in a previous paper (Browne, 1952) but further field-examination and study of topographical maps have necessitated much modification. It should be emphasized that the mere occurrence of a lineament does not *ipso facto* imply the existence of a Kainozoic fault, for apart from any differential vertical movement the course of a river-valley may have been determined by an ancient shear-zone; no evidence of Kainozoic faulting, for example, has been observed along the lineaments of Bundara Creek and Kalkite Creek though Hall (1955) found small shears on the bank of the latter creek. On the other hand scarp-lineaments may well betoken faults that did not exist prior to Tertiary time.

FAULT-STEPS, HORSTS AND FAULT-TROUGHS

(Plate III; Figs 1 and 2)

Though generally much modified by erosion, traces of the Miocene peneplain may be discerned on the present surface, and its variation in altitude on adjacent fault-steps affords some measure of the extent of the dislocation. The faulting is illustrated in the profile-sections forming Fig. 1; these show clearly that the major faulting of the block has been marginal and has been markedly greater on the western than on the eastern side.

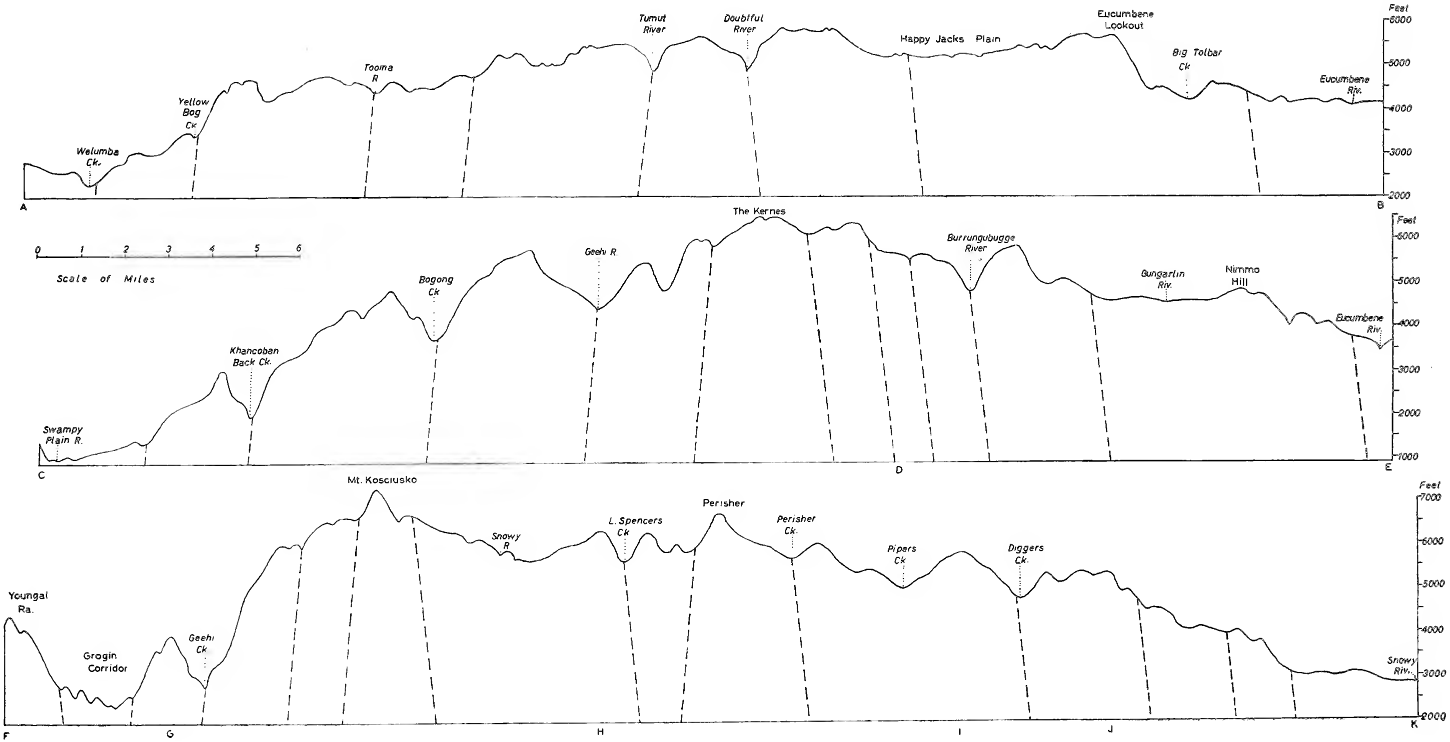
Eastern Side

A stepped pattern may be observed in the course of a traverse west from the Eucumbene River. At the Eastbourne bridge the river (3,390 ft.) is some 500 feet below the Adaminaby plateau and is bordered by what appears to be a dissected river-terrace less than ½ mile wide at about 3,600 feet. This is backed by the remnant of another surface at 4,200 feet and behind it is the Nimmo platform, rising to nearly 4,900 feet, which persists to north and south, attaining 5,000 feet in a few places to the south, and rising to much higher levels in the north. Out of this the Gungarlin River has carved a wide, mature and locally swampy valley known as Snowy Plains. Behind it is Burrungubugge ridge, the dissected remnant of a fault-step with a summit level between 5,600 and 5,800 feet, interrupted by two wide and conspicuous cols, Brassy Gap (5,360 ft.) and another a mile south at 5,440 feet. This step is cut obliquely by the Burrungubugge River, and behind it the Brassy Mts. step containing the Main Divide rises to more than 6,200 feet, fronted by a submeridional scarp. As noted in an earlier paper (Browne *et al.*, 1944), there appears to be a flight of small steps between the Brassy Mts. and Burrungubugge River; some of these may be erosional but the Tolbar Creek–Dead Horse Creek lineament is certainly suggestive of a minor fault throwing ENE. The actual positions and directions of the postulated faults bounding Brassy Mts. step and Burrungubugge ridge step are uncertain, though the step-structure is clearly marked. Perhaps the former fault should be shown a little more to the east and cut off northwards by an extension of the Burrungubugge fault to Doubtful River, and the latter rotated so as to be collinear with the Brooks Mill fault.

The Brassy Mts. step slopes gently west to the wide, swampy valley of Valentine River, beyond which is the flattish ridge of The Kerries at 6,700 feet, dying out to the south in Disappointment Spur and apparently merging northwards into the Brassy Mts. level. The ridge gives the impression of a horst bounded east by Valentine River and Finns River and west by Duck Creek, Dicky Cooper Creek and Munyang River. It culminates in the low monadnock of Gungartan.

If now the traverse is continued to the SW across Munyang River the Granite Peak ridge is first reached, rising to 6,500 feet and extending north to Dicky Cooper Bogong. Mr. Svenson suggested that there are a number of small meridional step-faults on either side of the Granite Peak horst, throwing down to the east on the Munyang side and the west on the Guthega side. This may well be, and indeed the wide basin of Munyang River may conceivably mark the site of a fault-trough tapering to the north. The next step, west of the Guthega lineament, has a general level below 6,400 feet in the north suggesting a shallow tectonic depression, though the discrepancy seems to diminish south of Consett Stephen Pass. Across the Spencer Creek lineament the Miocene peneplain surface probably attains an altitude of 6,800 feet or more, but a reliable estimate is difficult. West of it the Lady Northcote fault has no marked topographic expression, but there is certainly rather more ground over 7,000 feet to the west than to the east of it. The narrow Summit horst has but a small visible extent, having suffered severely from post-uplift erosion.

A traverse across the country SE of the Upper Snowy discloses some differences in the fault sequence. The Summit road ascending from the old Crackenback River bridge at The Creel passes over level stretches at Waste Point (3,100 ft.) and Sawpit Creek (4,100 ft.). The first is probably an erosional river-terrace similar to that noted at Eastbourne bridge; the other may be equivalent to the 4,200-foot step at Eastbourne bounded east by the



Text-fig. 1. Profile-sections across the Map (Plate III).

Waste Point fault and west by a parallel fault cutting the Summit road at the Sawpit Creek crossing. West of this is a step reaching 4,800 feet, bounded west by the lineament following Brooks Mill Creek and apparently equivalent to the Nimmo level, and higher still is the Panorama ridge step, traversed by the road at Rennix Gap and reaching 5,600 feet. In between there seems to be a step at 5,300 feet, bounded west by a NS lineament running just east of Andrews Lookout, in which Boggy Plain (5,180 ft.) is excavated.

David (1908) suggested that Diggers Creek follows the line of a meridional fault passing just east of Pretty Point (5,920 ft.), where it has an easterly throw of about 250 feet. This fault seems to have no continuation north of the Snowy, and on the other hand the prominent Brassy Mts. step does not persist south of the Snowy. The Kerries ridge likewise disappears between Gungartan and the Snowy River, and the next sign of crustal movement is marked by the Perisher Creek lineament, beyond which is the much-dissected Perisher Range culminating in The Perisher (6,743 ft.)* and contrasting with the country immediately to the east, which barely reaches 6,000 feet, and with The Paralyzer (6,523 ft.) on the west. The same dominance appears farther south in Ramshead Range, where Mt. Wheatley and The Porcupine exceed 6,300 feet, and the strip as a whole would appear to be of the nature of a horst. The Guthega and Spencers Creek lineaments cross the Snowy, Ramshead Range and Crackenback River, with a continuance between them of the trough-structure noted north of the Snowy. West of the Spencers Creek line heights exceeding 6,700 feet are attained in the Kangaroo ridge, and across the Lady Northcote fault in Ramshead Range the general altitude is higher still, reaching 7,000 feet in places. The same rule holds in the Thredbo plateau.

The failure of some of the steps to persist to the south may be due to meridional faults being cut off against a Snowy fault, the wedging out of steps or local horsts between undetected intersecting faults, or the dying out of the faults.

Western Side

From the summit of Mt. Kosciusko the surface falls away very steeply to the west, dropping more than 5,800 feet to the Indi River in a distance of 8 miles. Owing to heavy dissection recognition of fault-steps is well-nigh impossible. The ridge forming Mt. Kosciusko descends abruptly, possibly through faulting, to a shelf or platform at 6,600 feet, traces of which are also visible a few miles to the north and south. There appears to be another step at about 6,000 feet, fronted by a steep slope leading down to the conspicuous Geehi Creek lineament some 4 miles west of Mt. Kosciusko. This is traceable for 5 miles, being prolonged southward to the headwater stretch of Snowy Creek. The ridge to the west of it rises to 4,850 feet, and there is little doubt that the lineament marks a fault throwing more than 1,000 feet and that the ridge, its flanks east and west fretted and nibbled by countless small torrents, is the eroded remnant of a fault-step. It in turn falls away rather steeply to form a wall that flattens out at 2,500 feet to the wide Grogin corridor running from Geehi to Tom Grogin and crossing the Indi obliquely into Victoria; this is bounded on the west by the Youngal Range rising to more than 4,800 feet, and may be, as suggested by Moye, a fault-trough. It is drained by Bridge Creek to the north and by an unnamed creek to the south.

None of these lineaments is traceable farther north than the Geehi River, but it is highly probable that, as suggested by Moye (in Cleary *et al.*, 1964,

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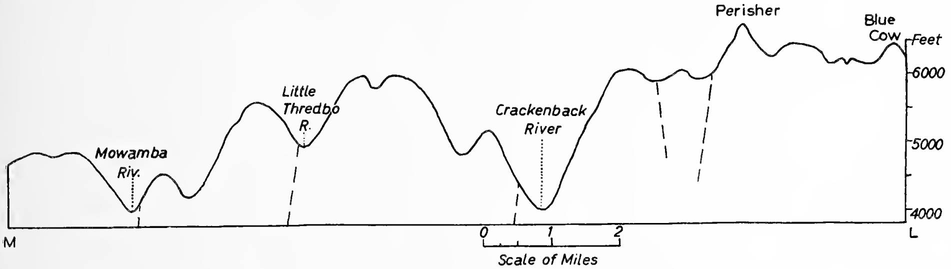
* The upper part of The Perisher may be a residual.

map), they swing round to the NNE in general conformity with the belts of metasedimentary rock enclosed in the granite. Certainly the great topographic blocks of Grey Mare Range and The Dargals seem to be separated from each other and from the higher country on the east by faults along Geehi River and Bogong Creek, as pointed out by Hall and Lloyd (1954), some of which may diminish in throw and die out northwards. The highest plateau surface at 6,200 feet is followed west by Grey Mare Range, a ridge or step, flat-topped in places, varying from a little over 5,000 feet in the south to about 5,400 feet in the Toolong Range. Separated from it by Bogong Creek is The Dargals Range, a long, narrow remnant rising north from 5,000 to a little over 5,200 feet. West of this the country is very deeply dissected by tributaries of the Indi, but some of the rapid descents, like that at Yellow Bog Creek, are probably due to faulting and the Welumba Creek lineament almost certainly marks a fault with heavy westward throw that may continue south as the eastern wall of Swampy Plain valley. Whether this wide valley-plain at 2,000 feet is a fault-trough is not known; it is separated from the Indi River by the Indi Range, rising to 3,000 feet.



Text-fig. 2. Profile-section SSE through The Perisher.

South-East

The country descends by a series of great fault-steps bounded by parallel rivers of the Snowy system (Fig. 2). The most important and the most conspicuous fault in the whole area follows the Crackenback valley, first recognized as marking a fault by David (1908). On its left bank Ramshead Range varies from 6,600 feet in the SW to 5,900 in the NE and the Thredbo step or plateau on the right bank from 6,200 to 4,600 feet. This is bounded in turn by the fault making the Little Thredbo-Wollindibby lineament. The next ridge, between the Wollindibby and Mowamba faults, varies from 6,000 to less than 4,000 feet and the country SE of it is lower by more than 400 feet.

The decline of the steps in altitude from SW to NE is doubtless in part an erosional effect, but cross-faulting is also responsible; the Thredbo step, for instance, is crossed by submeridional faults and in one place is breached by the very striking lower valley of Little Thredbo River, which divides it into a higher western part and an eastern part lower by more than 1,000 feet. A road-cutting near the river displays fairly close-spaced vertical jointing in the granite with a strike of *ca.* 165° (true), perhaps related to an adjacent fault.

On the SW the Crackenback fault continues along Dead Horse Creek almost to the Indi River, but the Wollindibby and Mowamba faults seem to be cut off by a fault along the Jacobs River lineament. On the NE all the faults would appear to terminate against the Waste Point fault, as there is no topographic indication of any of them beyond it. If this is correct the recent Berridale earth-tremors in the country to the NE (Cleary *et al.*, 1964) may not have been directly related to the Crackenback fault.

The Summit Road lineament is thought to mark the course of a fault hading SE; in the NE it may end against the Diggers Creek fault.

Between the Crackenback River and the Summit road is a minor parallel lineament indicated by close jointing along a branch of Wragges Creek, and by alignment or parallelism of the valleys of Wheatley and Rock Creeks and a tributary of Diggers Creek. The surface on the SE is as much as 100 feet higher than that on the NW, which may form the eroded floor of a shallow fault-trough.

It has been suggested that the Upper Snowy valley follows the course of a fault. True, the country is on the whole higher on the left than on the right bank, and between Island Bend and Guthega River the valley is closely parallel to that of the Crackenback, but upstream the parallelism disappears, and the fault, if there is one, may die out or be cut off.

Northern Extension

Beyond the latitude of Jagungal much of the surface on the east is considerably over 5,000 feet, but is extensively dissected by the headwaters of the Gungarlin River and by Happy Jacks River and other tributaries of the Tumut. Along the eastern margin extensive erosion by the Eucumbene and its tributaries has made it difficult to trace the course of the Eucumbene fault, which may follow Hughes Creek and Nungar Creek. The Summit peneplain level between Tumut and Doubtful River faults, about 6,100 feet A.S.L. south of Jagungal, drops rather abruptly to 5,600 feet, perhaps through cross-faulting, but thereafter slopes gently NNE. To the east and NE the surface reaches 5,600 feet in the Munyang Range and north of Happy Jacks Plain, but slopes away thereafter so that it does not exceed 5,000 feet beyond Kiandra on the north and Tumut River on the west. Transverse profile-sections (Fig. 1) emphasize the westerly slope of the surface and the rapid descent of its western margin through step-faulting. There are faults also along and/or near the Tumut River, but whether any exist between it and the Eucumbene fault is not known, though submeridional shatter-zones were encountered in the Eucumbene–Tumut tunnel near Eucumbene Lookout.

It is of interest that in the latitude of Kiandra there appears to be no great disparity in elevation between the Kosciusko plateau sloping north and the country to the east where the elongated high land-mass of the Australian Capital Territory is descending to the south. These two highland masses, both submeridional in trend and both notably elevated above the level of the adjacent Southern Highlands, are arranged *en échelon.*

Southern Extension

South of South Ramshead the surface drops abruptly to Dead Horse (Grogin) Gap, through which the Crackenback fault passes; on the ridge beyond the peneplain surface barely reaches 6,000 feet and south of Cascade Creek it does not rise above 5,500 feet, possibly as the result of cross-faulting. A few miles north of Tin Mine Huts it has fallen to 4,600 feet and is traversed by shallow, swampy, meandering valleys, some tributary to the Indi, others to the Snowy. In this surface the Indi is entrenched to more than 2,000 and the Snowy to more than 3,000 feet, and the valleys of Jacobs, Moyangul and Ingeegoodbee rivers and their tributaries deepen rapidly to profound gorges, breaking up the plateau into ridges. Tin Mine plateau may have been let down by the Moyangul River fault against the country to the NE, which rises to more than 5,400 feet. This latter wedge of country, cut off to the east by Bills Garden fault, is succeeded by the Charcoal Range step (4,800 ft.), which in turn descends by the Jacobs River fault to an extensively dissected block rarely exceeding 4,400 feet. This may also be faulted down along the Thatchers Hole—Grosses Plain lineament from the high country to the NW rising to well over 5,000 feet.

MONADNOCKS

Above the Miocene peneplain surface at its various altitudes rise several erosion-residuals. One of the most familiar to those visiting the Summit is Jagungal (6,764 ft.) on the northern horizon; others are Mt. Tate (6,789 ft), the shapely Dicky Cooper Bogong (6,570 ft.), Gungartan (6,788 ft) and Big Brassy (6,450 ft.). Viewed from Grey Mare Range a strip of country 10 miles long by 2½ miles wide, extending from a little N of Mt. Twynam (7,207 ft.) south to South Ramshead (7,189 ft.), and rising above the peneplain surface, has the appearance of a residual mass, the more conspicuous from the complete absence of trees. In addition to the high points mentioned it includes Mt. Kosciusko, Mt. Townsend (7,251 ft.) and North Ramshead (7,145 ft.). The Grey Mare Range is crowned by a narrow monadnock ridge with a few peaks, culminating in The Grey Mare (6,139 ft.). The residuals of the Thredbo plateau include Drift Hill (6,340 ft.) and Paddy Rushs Bogong (6,300 ft.) and on the southern extension the most striking monadnock is The Pilot (6,005 ft) towering 1,400 feet above the general surface of Tin Mine plateau. In the east Kalkite Mt. (5,101 ft.) is a conspicuous landmark.

All the residuals north of the latitude of Jagungal are well below 6,000 feet, the principal being Cabramurra or Tabletop Mt. (5,858 ft.), the graceful cone of Round Mt. (5,762 ft.), The Bald Hill (5,787 ft.) and Tantangara Mt. (5,702 ft.).

THE MAIN DIVIDE

The watershed between the Snowy and Murray systems, which is part of the Main Divide of eastern Australia, has a general NNE trend following the backbone of the country from The Pilot to beyond Kiandra, with a big embayment to the east beyond Jagungal to take in the drainage of Happy Jacks River. Locally it runs NS at Granite Peak and EW at the head of Munyang River. It includes many high points such as Mt. Kosciusko, Ramshead, Twynam and Mt. Tate, but leaves Mt. Townsend, The Kerries and Jagungal on the west, and its elevation varies from 7,314 feet on Mt. Kosciusko to 4,300 feet in the neighbourhood of Tin Mine Huts. In places it is a narrow ridge, as on Muellers Peak, west of Mawson and Club cirques, and at The Pilot; elsewhere, as in the Tin Mine Plateau, it is flat and ill-defined. Six miles N of Kiandra at the head of the Eucumbene it turns sharply to run SE.

RIVERS

(Plate III)

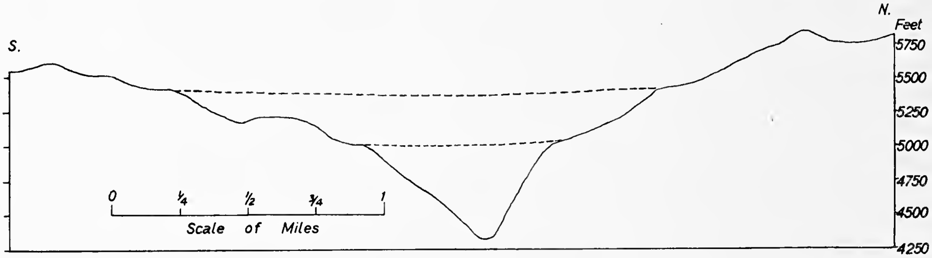
General

The Snowy drainage is dominant in the south and that of the Indi in the north of the block. In the northern extension the Tumut River drains an ever-increasing proportion of the country.

The block and its extensions are traversed at various levels by wide, shallow and swampy valleys. These are thought to be earlier Pliocene, but those at the highest altitudes owe their present aspect in some measure to the passage of Pleistocene glaciers, and indeed glacial modification of the landscape at these levels may help to account for the more mature appearance of the higher country observed from the air by Moye (in Cleary *et al.*, 1964).

The significance of the distribution of these wide valleys is referred to below; they include the headwaters of the Tooma, Geehi and Tumut rivers, the Gungarlin, the Snowy headwaters and in the north the wide, dissected Happy Jacks Plain. Similar but smaller valleys are a feature of the Thredbo plateau and the Ramshead Range, and at lower levels are the broad, alluviated valley of Wollindibby Creek and the headwaters of the streams on Tin Mine plateau.

Valley-in-valley structure, a sensitive indicator of vertical crustal movement, is common. Remnants of wide, shallow valleys antedating the existing gorges appear along the Upper Snowy (Fig. 3) and Crackenback and, less obviously, along the Eucumbene, the Indi and some of its tributaries; and there are minor valleys incised within some of the main gorges. Excavation by glaciers has given a catenary cross-profile to many of the river-cut valleys at the higher altitudes, with widening and probable over-deepening in places. In progressing up the valley of a trunk-stream rejuvenation has affected the tributaries in turn, so that the lower have been subjected to it longer than those farther upstream. Begun, it is thought, in the later Pliocene Kosciusko epoch, the process has continued through Pleistocene time to the present day, though with some intermission while the valleys were protected by ice, and as a consequence quite a number of glaciated valleys show clear signs of rejuvenation, including those of Diggers Creek, Dicky Cooper, Windy, Dead Horse, Lower Pipers and Cascade creeks. As the result of rejuvenation of Leatherbarrel Creek its capture of the headwaters of Cootapatamba Creek is imminent (Browne *et al.*, 1955). Many tributaries, unable to keep pace with the main stream in eroding their beds, join it with steepening gradients and exhibit inflexions or kink-points. This feature is particularly well shown by tributaries of the Upper Snowy, some of whose thalwegs are marked by two inflexions, corresponding probably to successive elevations indicated by valley-in-valley structure in the main stream. Of course, in any tributary the rate of erosion is a function of the volume of water it carries and the existence of readily or difficultly erodible rocks in its bed, and at the higher altitudes a disturbing factor has been introduced by the Pleistocene valley-glaciation.



Text-fig. 3. Profile-section across the Snowy River at the mouth of Munyang River in a general NS direction, showing remnants of the earlier and later Pliocene valleys and the present inner gorge.

A number of late-mature or senile E- or W-flowing streams on the higher surfaces become youthful downstream and descend rather steeply to a lower platform where they regain maturity. For instance, Bulls Peaks River rises above 6,000 feet at the northern end of the Brassy Mts., and descends through 800 feet in a mile to Snowy Plains, over which it meanders to join the Gungarlin. Other transverse streams that deepen downstream from a mature or senile condition are Rocky Plain River, Macdonalds Creek, Valentine River, Windy Creek and Dicky Cooper Creek. These peculiarities are doubtless due to differential uplift or step-faulting athwart the courses of the streams.

Quite striking is the prevalence of boathook-bends (Taylor, 1910, 1914) or barbed junctions, where a tributary makes with the main stream an acute angle downstream. Fryingpan Creek (now part of the Eucumbene reservoir), an important and mature left-bank tributary of the south-flowing Eucumbene on the Adaminaby plateau, is directed to the NW and Braemar Creek flows due N. On the right bank S of Kiandra a number of small tributaries also flow north. Farther south the Upper Snowy and Crackenback Rivers and Wollindibby Creek enter from the SW. Guthega, Munyang and Finns rivers and Tolbar Creek make boathook-bends with the Upper Snowy and on the west Geehi River and Bogong Creek meet Swampy Plain River and Snowy Creek joins the Indi River with boathook junctions. A similar relation exists between the Upper Geehi and its tributaries Dicky Cooper Creek and Valentine River, and in the southern extension Jacobs River and Moyangul River have boathook tributaries. This anomalous behaviour is no doubt due in large measure to the oblique intersection of structural or other features controlling the stream directions. River-capture, however, must be invoked to account for the direction of flow of Fryingpan Creek and some smaller left-bank tributaries of the Eucumbene. More than 20 years ago I noted basalt within the wide valley of Buckenderra Creek, an affluent of Fryingpan Creek, at 3,700 feet A.S.L., 300 feet or more below the surface of the Adaminaby plateau, and some years later this outcrop and others, together with underlying drift, were mapped by the Geological Survey of N.S.W. (Adamson, 1955). This valley, therefore (and inferentially that of Fryingpan Creek) existed in Oligocene time. Andrews (1901) showed that at Kiandra the dissected basalt-capped lead adjacent to the Eucumbene slopes to the N and crosses the Main Divide at Bullock Hill, 6 miles beyond the township, suggesting that a north-flowing stream was captured through headward erosion by a south-flowing Eucumbene.

The watershed between the Upper Snowy and Crackenback rivers is very asymmetrical, being much closer to the latter; this peculiarity is apparently related to faulting and the consequent general tilting of the Ramshead Range step to the NW. The surface of the range near the divide is characterized by swampy flats, as at the head of Trapyard Creek and Betts Creek, and in Prussian Flat and Thompsons Plain; these may be relics of the early Pliocene drainage captured from the Crackenback by tributaries of the Snowy. The headwater of Prussian Creek, a tributary of Upper Pipers Creek, is in such a flat valley sloping to the SE, and gives the impression of having been captured at the very edge of the Crackenback valley by the present north-flowing creek.

Tilting of the Thredbo fault-step would explain the marked asymmetry of the Crackenback–Little Thredbo divide, and there is an obvious westerly slope of the Brassy Mts. step towards the Valentine River fault.

Notes on Individual Systems

Eucumbene.—At its head, just N of Kiandra, this river occupies a wide mature valley-plain, and downstream deep gorges alternate with flood-plain tracts as far as Alpine Creek, below which the river leaves the northern extension of the Kosciusko block. Lower down youthful give way to more mature characters, and near the site of old Adaminaby the river was joined by the wide, alluviated Fryingpan and Buckenderra Creeks. At the dam it is already becoming entrenched below the Adaminaby plateau. After receiving the Upper Snowy and Crackenback rivers, which are probably to be regarded as over-developed subsequent tributaries, the valley widens rapidly and at old Jindabyne its floor is nearly 1,000 feet below the plateau on the east.

As Andrews (1910, p. 445) pointed out, the Eucumbene is the structural continuation of what is known as the Snowy, and is really the main stream, though usually regarded as a Snowy tributary. Just above their junction the rate of fall of the Eucumbene is 14 feet and that of the Snowy 20 feet to the mile. In the 5 miles from the junction to old Jindabyne the fall is 25 feet.

Except for Fryingpan and Buckenderra creeks the Eucumbene has no important tributaries. Rocky Plains Creek meanders for 8 miles over the Adaminaby plateau before deepening in the last mile to meet the main stream. Kalkite Creek, only 4 miles long, is notable for rising in a low gap or col at 4,500 feet that leads on to Snowy Plains, and drops about 1,200 feet in three miles.

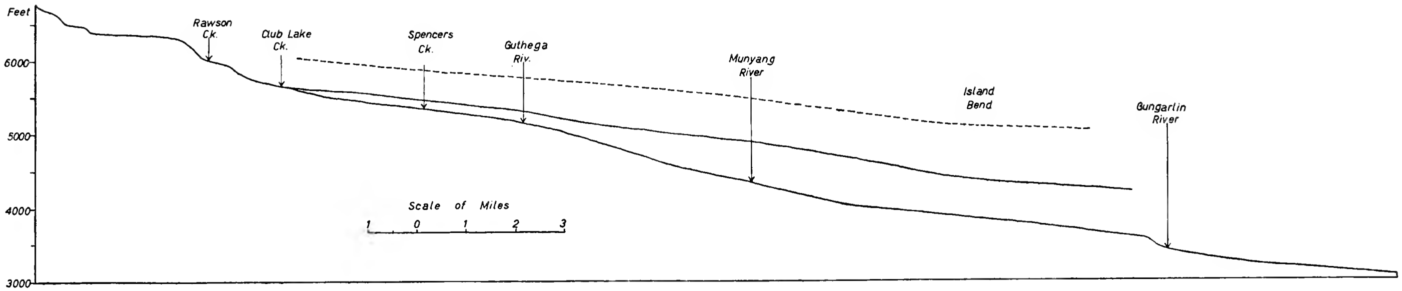
Evidence of rejuvenation following on uplift is provided by the 3,600-foot terrace at Eastbourne bridge (3,390 ft.), which may be traced at intervals downstream, and by the Waste Point step at 3,100 feet on the Upper Snowy. A corresponding level is visible on the eastern bank of the Snowy valley as a dissected terrace a few miles up from old Jindabyne. Slight rejuvenation is also to be seen in the headwaters just north of Kiandra.

Upper Snowy.—Rising at 6,800 feet on the rim of a shallow basin fronting the Etheridge Range, this river is joined by Merritts Creek from the right and by Rawson Creek heading at Rawson Pass (6,960 ft.). From Charlottes Pass it descends at an average rate of *ca.* 105 feet to the mile for 26 miles to its exit from the Kosciusko block. A few miles below Island Bend it turns sharply right and flows SE to its junction with the Crackenback, and the combined stream joins the Eucumbene 1½ miles further down.

The valley-in-valley structure of the Upper Snowy is of considerable interest. In Fig. 4 is shown as a broken line the thalweg of the older Pliocene outer valley, which appears on the ground as terrace-remnants; it may have been up to 2 miles wide and at least 500 feet deep. The points determined on it by inspection of large-scale contour-maps are really too far apart to be joined by continuous lines, but are linked for convenience. At Charlottes Pass the terrace is at 6,050 feet and 14 miles down near Island Bend at 5,200 feet A.S.L. It may be significant that the thalweg as plotted is apparently continuous with that of the present Snowy above Rawson Creek.

The middle profile represents a valley-level within the main gorge which merges upstream into that of the present river at Charlottes Pass, and may be followed at intervals downstream as a terrace to the vicinity of Guthega River; below this it appears less distinctly as terrace-remnants almost to Gungarlin River. Its incision to as much as 750 feet below the floor of the outer valley affords some measure of the local vertical extent of the first stage in the late Pliocene uplift; however, there is reason to believe that the Snowy glacier, which may have been upwards of 400 feet thick just below Charlottes Pass, caused some widening and perhaps over-deepening of the valley there (Browne and Vallance, 1957), and for some miles downstream. The degree of maturity attained by this valley before later uplift was due in part to the existence of a temporary base-level along the eastern base of the uplifted block.

The lowest profile, that of the present stream, shows a marked inflexion just above the entry of Rawson Creek and a smaller one above Club Lake Creek. Above Charlottes Pass it is only a little below the thalweg of the



Text-fig. 4. Longitudinal profile of the Snowy River from its head to a point 3¼ miles above its junction with the Crackenback. The thalwegs of the earlier and later Pliocene valleys are shown approximately.

Snowy glacier but downstream diverges from the middle profile, and is 120 feet below it at Guthega River. From this point there is a distinct steepening, and the drop of 800 feet in the next 4½ miles was a determining factor in the siting of the hydroelectric power-station at the mouth of Munyang River. The next steepening (200 feet in a mile) is 3 miles below Island Bend, and thereafter the gradient flattens considerably. No appreciable change marks the exit of the river from the Kosciusko block or its junction with the Crackenback. The inflexions in the thalweg are considered to indicate the upper limits of rejuvenation following on the Kosciusko uplifts, but the two abrupt ones near the head may be related to the Pleistocene glaciation.

The incision of the present stream in the thalweg of the former Snowy glacier below Charlottes Pass strongly suggests that fluvial rejuvenation, interrupted while the valley was protected by ice, was resumed following deglaciation.

The Snowy tributaries exhibit considerable diversity of character. Of those on the left bank Rawson, Club Lake and Blue Lake creeks drain the highest country in the block. Pounds Creek, with an overdeveloped submeridional tributary, also receives drainage chiefly from the high, steep country on the west. The main creek, some 3½ miles long, heads in Twynam cirque and descends more than 1,750 feet to its mouth, with a distinct inflexion 2 miles up at 5,900 feet and a marked flattening of the thalweg to meet the Snowy at 5,250 feet. One of its tributaries drains a cirque on the southern slope of Mt. Anderson.

Guthega River, 3 miles long, is remarkable for its straightness, steep descent of more than 1,100 feet with only a slight inflexion, and absence of significant tributaries. The valley has been determined by a relatively narrow, easily eroded shear-zone in the granite, so that rejuvenation has been comparatively rapid.

Munyang River has several tributaries, mostly on the right bank, and a much larger catchment-area than its neighbours. Near its head a relatively rapid rise of 500 feet, in part due to a thick transverse moraine, leads up to a gently-sloping, swampy, erratic-strewn floor, and the valley-head widens out, especially on the west, through glacial erosion to a great bowl-shaped hollow upwards of 800 feet deep. Down the valley occasional terrace-remnants and isolated hills mark the level of a former valley-floor. Rejuvenation has left a number of tributaries hanging well above the floor of the main valley. Munyang and Guthega rivers both meet the Snowy at grade.

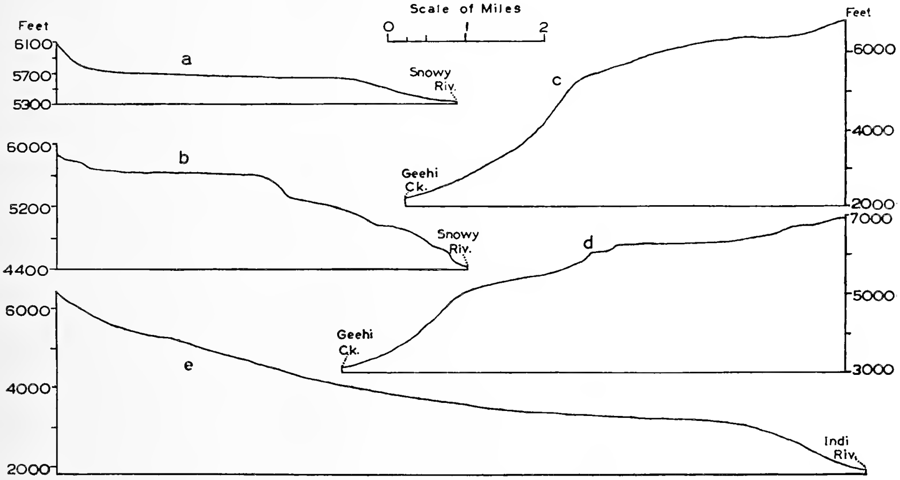
Finns River is hung above the Snowy and from a swampy flat at 4,950 feet drops 950 feet in the last mile of its course. Behind the flat the valley-floor rises more steeply to a very gentle slope at 5,500 feet marking the floor of a cirque, before its final sharp rise to the col (6,200 ft.) at its head. The neighbouring Tolbar Creek descends through 950 feet in 1½ miles to the Snowy.

The largest of the Snowy tributaries is the Gungarlin which with its tributary the Burrungubugge drains an area of 90 square miles. Rising at 5,400 feet it pursues a general SSE course over Snowy Plains with an average fall of 22 feet to the mile, turns abruptly SSW and eventually plunges into a wide gorge nearly 1,000 feet deep, where its gradient steepens so that it drops more than 600 feet to its junction with the Burrungubugge. The combined stream descends 250 feet in ¾-mile to meet the Snowy at 3,450 feet. From the point where the river enters the gorge Snowy Plains continue S for a mile to the low Kalkite Gap, through which the Gungarlin may eventually be captured by Kalkite Creek. Farther upstream the river's low eastern bank is being attacked by other Eucumbene tributaries.

The Burrungubugge rises in a broad, swampy col at 5,300 feet and occupies a wide grassy valley to the point of entry of its only substantial tributary, Dead Horse Creek. Downstream its walls close in and it flows in a wide straight early-mature valley 800 to 1,000 feet deep, with a very even gradient of 75 feet to the mile. In the ½-mile before its junction with the Gungarlin it descends 650 feet.

The general aspect of the tributary pattern on the right bank of the Upper Snowy is very different. Spencers, Perisher and Pipers Creek systems, gathering in the drainage of the Ramshead Range, all include longitudinal components parallel to the Summit road lineament, pierce a granite barrier at or near the convergence of the tributaries, and flow directly to the Snowy.

The upper components of the Spencers Creek system mostly occupy wide, open, swampy valleys with walls averaging perhaps 400 feet high, all exhibiting marks of glaciation. These converge to a wide gorge 600 to 800 feet deep, its floor covered with boulders almost all the way to the Snowy. Along the left bank is a terrace from 100 to more than 200 feet above the creek bed, composed of or veneered with boulders large and small, including glacial erratics. At 5,600 feet A.S.L. its very gentle gradient begins to steepen and in its last mile it drops through 270 feet (Fig. 5). The valley-walls of Upper and Lower Spencers Creek show a distinct break of slope at 6,000 feet.



Text-fig. 5. Longitudinal profiles of (*a*) Spencers Creek, (*b*) Perisher Creek, (*c*) Wilkinson Creek, (*d*) Cootapatamba Creek, and (*e*) Leatherbarrel Creek. Note the inflexions in all of them, attributed primarily to rejuvenation consequent on differential uplift. The very gentle gradients of the upper parts of (*a*) and (*b*) are related to glacial erosion.

Lower Perisher Creek is formed by the convergence of several tributaries including two longitudinal ones. The trunk valley, nearly 4 miles long, is more open than that of Spencers Creek, with walls from 400 to 1,200 feet high. The gently-sloping tract down from the Summit road ends abruptly with a rapid 300-foot descent from 5,600 feet to a lower tract which slopes with increasing gradient to the Snowy at 4,400 feet. In this lower tract tributary valleys on the left bank hang high above the main stream (Fig. 5).

The chief component of the Pipers Creek system is the longitudinal Upper Pipers Creek, which combines with the collinear Daners Creek to form Lower Pipers Creek. After breaching a low granite barrier and tumbling into a small basin this flows NW in a wide, straight, open valley contrasting with the gorges traversed by Spencers and Perisher creeks. The valley was evidently blocked by moraine at one point and the stream cut a diversion around the obstacle for nearly a mile. Traces of what look like old shorelines upstream may indicate temporary pondings of the creek. The head of rejuvenation is at 4,850 feet A.S.L. or 540 feet above the Snowy, and 1½ miles from it, and the flat floor of the glacial valley is cut into by a more rapidly deepening gorge. Farther down at ½-mile from the Snowy and 240 feet above it there is another steepening. The creek has a number of tributaries on both banks, some in bowl-shaped valleys probably hollowed by ice and hung as much as 100 feet above the floor of the trunk-valley.

These three creek-systems pose a problem. In each of them a series of tributaries or components with no great total volume of water (the Perisher components having the least) combine to form a single stream that makes its way to the Snowy through a barrier of granite, the first two helped by flowing in belts of shearing or intensified gneissosity. Quite possibly all the streams are antecedent and were able to keep cutting down against a slowly or intermittently rising fault-scarp. Pipers Creek appears to have had no aid from a shatter-zone, but may have carried a greater volume of water, and the barrier traversed by it was lower than elsewhere. The Pleistocene glaciers that occupied the valleys served to hasten erosion and perhaps to widen and deepen them. Griffith Taylor (1958, p. 228) briefly outlined a suggested explanation of these valleys that leans heavily on glacial action.

Farm Creek, collinear with Guthega River and cut in the same shear-belt, rises in a col in Perisher Range and follows a very straight course to the Snowy with a descent of 1,000 feet in almost 2 miles and a kink-point at 600 and another at 200 feet above the river. Diggers Creek flows north from Ramshead to join the Snowy below Island Bend at 3,750 feet. Its valley appears to have been glaciated down to at least 4,950 feet near the site of the old Hotel Kosciusko, where the creek begins to be entrenched in the glacial thalweg. A mile downstream a 50-foot waterfall possibly marks the head of a later rejuvenation, whence there is a drop of nearly 800 feet in 1½ miles to the Snowy. At ¼-mile from its mouth is a grassy flat, below which the creek tumbles down 100 feet into the river.

Crackenback.—The headwater stretch of this river makes a curious boathook bend, possibly related to a continuation of the fault along Jacobs River. In its long, straight course from Dead Horse Gap the river has cut a wide and deep gorge marking the course of the Crackenback fault. The disparity of surface altitude on either side is clearly apparent from Dead Horse Gap and Ramshead Range. It would seem that the present valley is incised 2,000 feet and more in a much older wide and shallow one, the traces of which are much lower on the Thredbo plateau than on the Ramshead Range. Incision of an inner valley to a depth of about 400 feet is well seen in the vicinity of Thredbo village, and successive rejuvenations within the main gorge are indicated by two inflexions in the thalweg, one at the exit from the Big Boggy marked by a descent of 600 feet in 3 miles, the other (200 feet in 1 mile) some 15 miles farther down. These inflexions may correspond with those in the Upper Snowy noted above.

The drainage-patterns of Crackenback and Upper Snowy rivers are in sharp contrast. The latter drains a roughly triangular area of approximately 200 square miles, the former a rectangular strip averaging probably less than

4 miles wide, with an area of 100 square miles. Nevertheless, with its remarkably straight course of 20 miles and its deep, wide valley the Crackenback is far more impressive than the Snowy; it is also rather more advanced in maturity, with a distinctly lower gradient—less than 85 feet to the mile below Dead Horse Gap—and a more alluviated floor. Apart from Little Thredbo River, which drops 1,700 feet in 8½ miles, the tributaries are short and steep, scoring the sides of the gorge, some of them on the left bank having gradients of about 900 feet to the mile. On the right bank gradients are not so steep and some tributaries have captured the waters of old shallow valleys on the Thredbo plateau; this may account for the inflexions shown by some of them. The Crackenback contrasts with the Wollindibby and Mowamba which, flowing at lower levels largely over medium-grained granite of Jindabyne type, are characterized by very gentle gradients and wide valleys over most of their courses. The peculiar course of China Creek, a tributary of Little Thredbo, is suggestive of structural control.

Indi.—The trend of this tortuous river though variable is in general NNW. For much of its length it is entrenched in a valley 2,000 feet and more in depth, but at Tom Grogin this opens out considerably, only to narrow again a few miles down to the Murray Gates defile. Some 15 miles up from its junction with Swampy Plain River it finally assumes an appearance of late maturity which persists beyond its junction with Tumbarumba Creek. South of Tom Grogin the steep banks of its gorge are deeply furrowed with consequent valleys and the rejuvenated parts of valleys that are mature on the plateau, such as those of Cascade Creek and Tin Mine Creek. At Tom Grogin Hut there are signs of two alluvial terraces, at about 20 and 60 feet above the river respectively. Near its head its course may have been determined in part by a fault (Crohn, 1950).

Swampy Plain River, formed by the confluence of Geehi River and Bogong Creek at 1,400 feet, is a considerable stream which, wide and alluviated at Geehi, plunges lower down into the impassable Devils Grip gorge, but a few miles farther downstream at Khancoban flows in a valley-plain over 3 miles wide which it has been suggested is a fault-trough. The Geehi River drains the most precipitous country of the whole region by consequent tributaries on its left bank which nearly all rise at or above 6,000 feet and are glaciated in their upper reaches. This river is formed by the confluence of Rocky Plain River and Back Flat Creek. The former, a late-mature or senile stream, rises at 6,500 feet on the southern slope of Jagungal and is joined at 4,850 feet by the Valentine, which tumbles over a 400-foot waterfall to meet it. Back Flat Creek, rising four miles south-west of Jagungal, takes a zigzag course with alternating gorge and flat, is joined by Straight Creek and meets Rocky Plain River in a valley 800 feet deep 200 yards above the mouth of Valentine River. The Grey Mare Range is deeply dissected by the Geehi tributaries on the east and those of Bogong Creek on the west and the Dargals Range is carved into a tangle of spurs and gorges by Bogong Creek on one side and Swampy Plain River on the other.

Both Geehi River and Bogong Creek show what appear to be vestiges of old outer valleys, and along the former Hall and Lloyd noted alluvial benches 50 feet above present river-level. Both have remarkably smooth and even gradients, averaging 160 and 190 feet to the mile respectively, due no doubt to the ease of erosion of the sedimentary belts in which their valleys are excavated, and perhaps to the presence of shatter-zones. By way of contrast Fig. 5 shows the thalwegs of three minor streams flowing down the western slope of the block. Two of these, Wilkinson and Leatherbarrel, appear to be consequent streams brought into being through the late-Pliocene uplifts, and both have cut deep gorges into the steep slope. The former crosses the scarp of the Geehi Creek fault and the gneissosity of the granite at a high angle, and below the scarp is eroding a much less resistant metasedimentary belt; this combination accounts for the marked change in gradient at 5,200 feet. The course of Leatherbarrel Creek lies east of the Geehi Creek fault and for 4 miles it traverses a metasedimentary belt at an acute angle; upstream it crosses two other fault-scarps obliquely and parallel to the gneissosity with only one small kink, and its upper course is in a belt of metasediments in which it is vigorously eroding a steep-sided gorge. The convex curvature of the profile near its mouth matches the progressive entrenchment of the Indi into which it flows.

The curious profile of Cootapatamba Creek betrays its immaturity. Like its affluent a little to the N it drains a cirquoid hollow cut in the riser of the 6,600-foot step and has had little success in sawing a way through fault-scarps and against gneissosity. The probable history of this creek has already been discussed (Browne *et al.,* 1955).

Tooma.—Much of the country W and NW of Jagungal is drained by Tooma River heading in a flat valley at 6,000 feet. Not far from its source it is diverted to the south by a meridional ridge and enters Bogong Swamp about a mile long, now partly drained and invaded by snowgrass; from this it emerges to the west by a gorge 400 feet deep, to flow for 4 miles obliquely across the Grey Mare step and join the mature, alluviated Pretty Plain Creek, the gorge deepening another 200 feet on the way. Four miles to the north of the swamp a smaller swamp is walled on the west by a continuation of the same scarp, here only 100 feet high. The topography suggests that the swamps on the east and the alluviated Pretty Plain valley on the west are related to the submeridional faults and shear-zones along the Geehi River and Bogong Creek respectively, or are contained in narrow local fault-troughs. From Pretty Plain the Tooma flows N for 15 miles, turns sharply W, crosses the Jagumba Range in a gorge more than 3,000 feet deep and traverses a lower block before emerging on to a wide valley at 900 feet A.S.L., where it is joined by Tumbarumba Creek.

Tumut.—This river rises a mile west of Jagungal on a flat at 5,400 feet and rapidly becomes entrenched in a little steep-sided, flat-floored grassy valley with a small hanging tributary on the right bank; farther down it is joined by Bogong Creek and Doubtful River, and according to Hall and Lloyd its course is influenced by two pronounced shear-zones. The gorge of the river deepens to more than 2,000 feet W of Kiandra and at Tumut Pond and elsewhere is seen to be deeply entrenched in an older valley. An important tributary from the SE is Happy Jacks River; this has carved out a broad, undulating valley-plain that narrows sharply downstream, in which it is entrenched ever more deeply as it nears the Tumut, which it meets at grade.

Glacial Sculpture

Many topographic features related to the Pleistocene glaciations have already been described (Browne and Vallance, 1957, 1963), and attention is here confined to a few of them. It is hoped to consider some aspects of the valley-glaciation more fully in a later paper.

In the glaciated country cirque-headed valleys are numerous. Typically they have curved heads and relatively steep walls at head and sides, giving rather abruptly on to a flat, swampy floor with gentle gradient containing some relics of moraine, and are most conspicuous and most deeply incised at the higher altitudes. Such a valley-form is most unlikely as a product of river-erosion alone, and it is clear that, whatever its original character, it has been greatly modified by ice. Most of the valleys are short and might be regarded as rather elongated cirques, but precisely similar forms occur at the heads of quite long valleys (Fig. 5).

Perhaps the best example is the Mawson cirque; another is the valley of Upper Spencers Creek heading in the multiple Charlotte cirque. South of The Paralyzer are the short circular-headed valleys of Amos Creek and the little unnamed creek east of it, both tributary to Betts Creek, and a mile to the east is the so-called Perisher cirque, really a small cirque-headed valley with a swampy floor 350 yards long. For all these the contour-pattern as shown on a large-scale map is essentially the same (see Browne and Vallance, 1963). Shallower examples are occupied by tributaries of Munyang River, Diggers Creek and Valentine River and probably also by tributaries of Tolbar Creek and the adjacent Burrungubugge River. Indeed the pattern is so constant and characteristic as to be tentatively diagnostic. In some instances the cirque-headed valley hangs above the floor of a trunk-valley, e.g., the Perisher cirque and some tributaries of Valentine River and Cascade Creek. The original steepness of the walls is apt to be lessened as the result of post-glacial weathering, and where river-erosion has been active the flat floors have been dissected and the valley-heads notched by tributary gullies. Cirque-heads modified in this way are to be seen around Mt. Anderson and elsewhere.

At the higher elevations hanging valleys are by no means rare, and in some instances erosion has pushed the hang a little way back from the mouth to form a kind of stepped valley. With normal river-erosion tributaries as a rule meet the parent stream at grade, but hanging valleys are familiar enough features in the Blue Mts. and other unglaciated parts of the State, the reason being inability of the tributary to keep pace with the deepening and/or widening of the parent owing to insufficient volume of water or the existence of a lithological, structural or other barrier. Some hanging valleys in the Kosciusko block are of this type and some are due to faulting, but there are others to which these explanations cannot logically apply, *viz.* those in which the valley has a catchment area equal to or greater than that above which it hangs. An outstanding example is afforded by Wrights Creek which, although it has a drainage-area more than twice the size of that of Upper Spencers Creek, empties into the latter with a sloping hang of more than 200 feet. In the same Spencers Creek system Guthrie Creek drops into the valley of an unnamed tributary of Betts Creek with a hang of more than 90 feet though their catchment-areas are approximately equal. Somewhat similar conditions obtain where the Perisher cirque drops more than 100 feet into the valley of Upper Perisher Creek, and where the main tributary of Upper Pipers Creek joins the parent stream between Pipers Gap and Smiggin Holes.

In the instances cited formation of the hang as a result of normal river-erosion is obviously out of the question, and one reasonable explanation seems to be that which postulates erosion of both valleys by ice, the normal volume of which in the lower valley may have been augmented by diffluence from adjacent glaciers. It is to be remembered also that when the possible volumes of glacier ice in two valleys are to be compared the cubic capacity of each valley, dependent in large measure on the height of its walls, must be taken into account no less than their respective catchment-areas.

In an earlier paper (Browne and Vallance, 1957, p. 129) it was noted that in a col at one of the heads of Rock Creek in the Ramshead Range there is a rather regular series of granite monoliths *in situ* of approximately accordant heights of 10 feet above the general surface, and it was suggested that the interspaces were at the onset of glaciation largely occupied by decomposed rock which when frozen hard behaved like solid rock towards the passage of ice and eventually vanished through erosion in post-glacial time. A number of somewhat similar occurrences have since been noted, e.g., east of the col at the head of Betts Creek, on the right bank of Little Diggers Creek some 1,200 yards S of Alpine View, and on the right bank of Diggers Creek a little below where it is crossed by the Summit road. A particularly interesting example is that on the right bank of Betts Creek a little way downstream from the site of the now demolished Betts Camp; here the accordant tops of the granite monoliths instead of being on a plane are on a gently domed surface and give the impression of having formed part of a large *roche moutonnée* smoothed by the glacier that passed down the valley of Betts Creek.

Rocks and Rock-Structures

The major features of the landscape were, as shown above, determined by crustal movements, but geology has also played another role in shaping the topography that cannot well be ignored, both the rock-types and their structures, primary and superimposed, having been important. Valuable accounts of the rocks of much of the area are given in the reports by Hall (1955), Hall and Lloyd (1954), Adamson (1955) and den Tex (1959), and only the broader features are dealt with here.

The *terrain* includes igneous and metasedimentary rocks, the former being dominant. The most widespread is a coarse-grained grey granite or granodiorite, generally somewhat gneissic and believed to be of epi-Silurian age; it has a meridional extent of 70 miles. Small intrusions of epi-Ordovician granite are known chiefly from the vicinity of Geehi and Tumut Pond. Medium-grained massive granites, thought to be Devonian, occur typically around Jindabyne and for several miles N and SW of it, and there are coarser and more salic types around Khancoban and in the far south in the Tin Mine plateau, some of which are, perhaps, even younger.

The chief basic rocks are basaltic, forming dykes and other small intrusions, and in the northern extension there are also considerable remnants of Oligocene terrestrial flows overlying sedimentary deposits.

The metasedimentary rocks are chiefly in the western half of the block in belts from a few hundred yards to 5 miles across, with a general NNE trend, separated by granite. They consist of highly-folded Ordovician slates, phyllites, schists and quartzites. In the east an irregular outcrop, mostly quartzitic, appears just west of the Eucumbene River near Eastbourne bridge and extends thence north through Munyang Range.

These rocks possess varying resistances to weathering and erosion. The survival of the monadnocks around Mt. Kosciusko is related in large measure to the very salic character of the granite-gneiss composing them as well as to the direction of its marked gneissosity, though Mt. Townsend is of grey granite. The prominent ridge of the Etheridge Range, also composed of siliceous gneissic granite, contrasts with the more easily eroded granodiorite forming the basin that fronts it at the main head of the Snowy River. The medium-grained granite forming the Big Boggy at the head of Crackenback River, the Snowy valley at Jindabyne, the locally widened Snowy valley at Island Bend, and the wide Wollindibby and Mowamba valleys, is in general more easily eroded than the coarser, rather gneissic granodiorite it invades, and a similar characteristic helps to explain the wide depression drained by Little Thredbo River, and perhaps also the wide Swampy Plain valley south of Khancoban.

The lowland corridor on the west of the Kosciusko block between Tom Grogin and Geehi may be a fault-trough, as suggested above, but the fact that it is excavated partly in somewhat biotitic epi-Ordovician granite which is fairly easily weathered, may have some significance. A coarse-grained massive granite also appears in this lowland and is accompanied on the east by a quartz-porphyry which, due to greater resistance, forms the higher foothills.

The belts of metasedimentary rock tend to erode easily except where composed of quartzite or where recrystallized to granulite or hornfels adjacent to granite intrusions. The collinear valleys of Upper Cootapatamba Creek and Upper Rawson Creek are in part excavated in soft phyllite, and the imminent recapture of the former by Leatherbarrel Creek (Browne *et al.*, 1955) is being facilitated by the fact that the latter is eroding its channel along the same narrow belt. The very straight course of Geehi Creek is contained within a belt of schist. Quartzitic rocks may form positive features like Nimmo Hill, Munyang Range and the country farther north, and the narrowing of the wide Happy Jacks valley downstream is due in part to its entering a belt of quartzite strengthened by igneous intrusions. Phyllite and old basaltic rocks recrystallized at a granite contact and laced with quartz veins compose the high ridge at the western end of Jagungal. In the SW the gorge of the Indi at Murray Gates and that of Swampy Plain River at Devils Grip Gorge are partly cut across a belt of resistant metasedimentary rocks that formed barriers resulting in the upstream widening of the valleys. Almost vertical slates form prominent features on Leatherbarrel Creek and near the falls on Tin Mine Creek, and in the far SW The Pilot ridge is of flinty quartzite.

Though the Kosciusko block contains several basaltic dykes, some of which are probably Tertiary, and basalt, as flow or intrusion, has been noted in the SW at 2,400 feet A.S.L. across the Indi from Tom Grogin Hut, only one small flow-remnant is definitely known, at 4,000–4,200 feet within the valley of Snowy Gap Rivulet, a tributary of the Eucumbene (Adamson, 1955). Most of the flows are in the northern extension, chiefly around Kiandra, and to the west of it in a belt running just east of Cabramurra township and south almost to Jagungal (Andrews, 1901; Hall and Lloyd, 1954). There are several flows, overlying deposits of Oligocene gravels, sands, clays, lignites, etc., and it is noteworthy that some are within the walls of existing valleys. In the valley of Tumut River up from its junction with Doubtful River the basalt is only 200 or 300 feet and in some places not more than 100 feet above the present valley-floor, and at Kiandra the base of the underlying sediments is some 400 feet below plateau level and perhaps 200 feet above the present Eucumbene. The Tumut and Eucumbene rivers thus date back to Oligocene time.

Farther down the Tumut the basalt, forming the Miocene peneplain, is as much as 2,500 feet above present river-level, giving some measure of the erosion since its uplift. The monadnocks of Tabletop and Round Hill are thought to mark centres of eruption (Andrews, 1901; Gill and Sharp, 1957). It is of interest that near Tooma on the down-faulted western side of the plateau the basalt is at 1,200 feet A.S.L., nearly 4,000 feet lower than at Kiandra.

The gneissic structure of the epi-Silurian granite is well developed in places but elsewhere virtually absent. The most common type is a primary foliation with a variable trend, generally NNW but changing to NNE, and with local curvature and a tendency near metasedimentary belts to strike parallel to the boundary. In certain zones the foliation has been accentuated, apparently by post-consolidation pressure, with some crushing and recrystallization, as on the top of The Perisher, Back Perisher and Blue Cow, near the head of Wrights Creek, in the Snowy valley at Charlottes Pass, on the Alpine Way at The Pilot Lookout, and elsewhere. The strongly gneissic rocks tend to form rough, craggy outcrops and to weather into flattish ellipsoidal slabs. In some rather narrow belts more intense pressure has produced crush-zones or shear-zones. A vertical section across one of these is exposed in a road-cutting on the south side of the Crackenback bridge on the new Jindabyne–Kosciusko road; here the granite is rather intensely sheared over a width of perhaps 300 yards, the sheared rock dipping at about 70° in a direction *ca.* 330° (true). In a cutting on the north side of the bridge the granite is much jointed vertically in several directions, with some slickensides and a few thin sheared bands. Though no sign of an upstream continuation is evident on air-photographs the coincidence of trend leaves little doubt that the Crackenback fault and river are in the shear-zone.

Both primary and secondary foliations have strongly influenced stream-directions, though not universally. For instance, Upper Snowy River where it turns SE below Island Bend seems to flow parallel to the foliation, but above the bend cuts directly across it. Lower Perisher Creek is in a belt of secondary foliation, but the summit of The Perisher is in the same belt and in the prominent Kangaroo ridge the granite is conspicuously sheared. Guthega River follows a rather narrow belt of shearing, which in its northward continuation meets the trend of a metasedimentary belt at an acute angle. The courses of some streams appear to have been determined by two or more shear-zones.

The primary foliation is presumably epi-Silurian; the belts of secondary foliation are younger but of the kind usually considered to result from the action of compressive or torsional stresses on solid rocks at great depth, and in some instances were evidently associated with upthrust, overthrust or transcurrent movement. The only field-evidence available suggests that they are pre-Oligocene, and they are almost certainly not younger than Palaeozoic.

The phyllites and other metasedimentary rocks are highly inclined as a rule, and where softer and more resistant types are interbedded stream courses have been influenced. Shearing and other forms of dislocation have been noted in several places, which may be related to the folding of the beds in late Ordovician time and/or to later orogenic movements. In some places, as at the head of the Tumut River (Hall and Lloyd, 1954), shearing has occurred along the boundary between metasedimentary and intrusive igneous rocks. Jointing and cleavage are very characteristic of the slates and quartzites, probably induced during folding. Under the influence of frost-weathering some of the quartzites, closely jointed in several directions, tend to form great surface accumulations of angular fragments.

Jointing is almost universal in the granite and very common in the metasediments. It may be vertical and horizontal, dividing the rock outcrops into cubical blocks, as at the main head of the Snowy, at the top of the chair-lift above Thredbo village, and at the falls on Munyang River and Diggers Creek; elsewhere there are concentrations of parallel vertical joints, such as are associated with normal faulting, as along Diggers Creek in various places, and on the Snowy at Long Corner below Island Bend. Close-spaced inclined jointing commonly accompanies shearing. Vertical jointing in two directions has induced a rude columnar structure on the southern side of The Blue Cow and the south-east face of Mt. Wheatley. Perhaps the commonest trend of vertical jointing is approximately NE–SW, but NS and EW directions are also important. Locally the granite has only wide-spaced jointing and then forms great tor-like monoliths as at The Porcupine and elsewhere on Ramshead Range, resistant *riegel*-like bars across creeks (e.g., in Dicky Cooper Creek at the head of rejuvenation and in Pipers Creek where crossed by the Summit road), or straight, massive valley-walls like those forming the right bank of Lower Betts Creek, the left bank of Little Diggers Creek where it descends steeply to join Diggers Creek, and the right bank of Carruthers Creek on the Blue Lake track from Charlottes Pass.

In certain places, e.g., the Snowy valley up from Jindabyne, the medium-grained massive granite is intersected by fairly close-spaced joints in three directions that seem to increase its natural tendency to weather.

Jointing has locally influenced stream-patterns, as along Diggers Creek between the old Kosciusko hotel and the Snowy and at the little hotel reservoir. Hall and Lloyd have noted the influence of well-developed joint-systems on stream-courses in the country drained by Valentine and Rocky Plain rivers, and air-photographs suggest stream control by two sets of vertical joints at right angles in the area between Lower Perisher and Lower Pipers creeks. Jointing has been an important factor in the formation of glacial cirques, as at Blue Lake and in the Clarke, Twynam and Etheridge Range cirques.

Of the age of this jointing nothing precise is known; some may be pre-Tertiary but probably most of it belongs to one or other of the Tertiary movements of uplift. Since the vanishing of the Pleistocene ice there has been, as the result of severe weathering, much manifestation of latent jointing.

Columnar jointing is common in the basalt flows, and in the deeply dissected country along the Tumut River has facilitated the formation of spectacular scree-slopes.

EVOLUTION OF THE TOPOGRAPHY

It is fairly well established that the entire highland belt of eastern New South Wales experienced significant movements of varying amplitude during three Kainozoic epochs. A Cretaceous peneplain was moderately elevated probably in the Eocene, during what may be called the *Kiandra Epoch* from the existence in the township and surrounding country of evidences of the uplift and its consequences. In the early Oligocene there was considerable dissection by rivers (cf. Voisey, 1942), with formation of deep valleys that became deeply alluviated, to be buried eventually beneath thick flows of basalt. A long interval of peneplanation and duricrusting was completed in Miocene time, the peneplain surface being cut indifferently out of Palaeozoic and Mesozoic strata, Palaeozoic granites and Oligocene basalts. The peneplain, much elevated and reduced largely to remnants, is now the most important and widespread surface in the State and perhaps indeed in the Commonwealth, and provides a useful reference datum for events in Kainozoic history. About the end of the Miocene, during what I have called the ***Macleay Epoch,*** elevation again took place, followed by a long Pliocene stillstand; during this some of the old drainage was dismembered, new rivers were formed and old ones were revived and brought to a condition of advanced maturity or even senility, giving rise to wide valleys and valley-plains like those of the Shoalhaven (Craft, 1931, 1932), Macleay (Voisey, 1957) and Murrumbidgee.* Later in the Pliocene episodic elevation on a grand scale occurred during the Kosciusko Epoch, and the cycle of river-erosion then established still continues.

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* Part of the Yass–Canberra Tableland of Sussmilch (1909).

The chronological scheme outlined above, based on the pioneer work of Andrews (1910), is believed on the whole to fit the known facts most satisfactorily. According to the generally accepted view, which the present study tends to confirm, differential elevation of the Kosciusko block above the surrounding country was an episode in the epeirogenesis of the Kosciusko epoch, though Craft (1933, p. 238) seems to regard the block as a kind of gigantic monadnock which may have existed since late Palaeozoic time and has survived many cycles of peneplanation.

In the Kosciusko block and its extensions no definite signs of the Cretaceous peneplain are known, but the residuals scattered over the surface may be relics or reduced remnants of it. Following the Kiandra uplift, with which, as with the later Macleay uplift, some faulting was doubtless associated, valleys more than 1,200 feet deep (Gill and Sharp, 1957) were cut in it and became wide and mature, with heavily alluviated floors. Possibly, as Andrews suggested for other parts of the State, some downfaulting or warping caused the valleys to be choked with fine alluvium before the outpouring of the Oligocene basalts began. Repeated lava outbursts, punctuated by quiescent intervals of alluviation and soil-formation, filled the valleys and built up a thickness of several hundred feet of basalt. The difference in altitude between the supposed volcanic plugs, Tabletop Mt. and Round Mt., and the present basalt surface gives a minimum value for original aggregate thickness of the flows, which may have been at least 800 feet. The Miocene peneplanation reduced the surface level considerably, wiping out all or most of the basalt in the Kosciusko block and leaving in the northern extension little beside remnants of valley-fillings. This peneplain is believed to form the extensive surfaces visible at different altitudes in the area, and some of the shallow, alluviated gutters on the surface may be relics of the Miocene drainage. However, wide valleys and valley-plains were excavated during the long earlier Pliocene stillstand following the Macleay uplift, and many of them were rejuvenated during the differential elevations of the Kosciusko Epoch. These must have been virtually completed before the Kosciusko glaciation (which affected only the highest parts of the uplifted block), and are therefore reasonably ascribed to late Pliocene and/or early Pleistocene time. Evidence of at least three stages of movement may be recognized in the Snowy and Crackenback valleys, and the small earth-tremors that are not uncommon in the region (Cleary *et al.*, 1964) show that minor adjustment of fault-blocks is still going on.

NATURE OF THE UPLIFT

The topography and the profile-sections across the area make it reasonably clear that there has been differential uplift and block-faulting, but the mechanism of movement is obscure. There may have been successive upfaultings of parallel crustal strips, with the highest reaching its present position last of all, or perhaps a kind of domal uplift with compensational adjustments leading to downfaulting in steps; the present superior elevation of the block would then be the algebraic sum of the movements, positive and negative, since the beginning of the Kosciusko epoch.

Block-faulting, trough-faulting and tilting of fault-steps are generally assumed to result from repeated normal or gravity faulting, and the appearance of the *terrain* is consistent with this explanation. On the other hand it has been shown that a curved or cylindrical fault, though definitely upthrust, may at the surface produce a scarp like that of normal fault: from the repetition of such faults the appearance of normal step-faulting might arise, but it is hard to see how this mechanism alone could produce a horst-like mass with the fault-pattern of the Kosciusko block.

den Tex (1959) found olivine-basalt dykes (?Tertiary) displaced by revived normal faults and alluvial sediments along Geehi and Swampy Plain rivers apparently affected by normal faulting.

Cleary *et al.* (1964) have reported that the epicentral points and depths calculated for recent earth-tremors just outside the Kosciusko area suggest overthrusting from the north-west, but it is known that minor adjustments on normal faults may result in small reversals of movement, such as are seen, for example, in the monoclinal flexure and faulting where the Blue Mts. plateau gives on to the lowland Cumberland Basin. To sum up, the topographical evidence is quite consistent with, and even suggestive of, normal faulting but does not actually prove it.

Whatever the mechanism involved in the uplift of the Kosciusko block, it seems clear that the crustal strains generated were largely relieved by differential movements upward and/or downward on fault-planes situated in pre-existing zones of weakness of appropriate azimuth. This appears to be the only way of accounting for the paradox that post-Miocene fault-blocks are bounded by zones of pre-Tertiary foliation and shearing.

Evolution of the Drainage

The region must have had its quota of rivers long before the dawn of Tertiary time, but the earliest drainage of which recognizable traces survive is that of the early Oligocene, represented now in the dissected basalt-capped alluvial leads at Kiandra, Cabramurra and elsewhere, and in the valleys of Fryingpan, Buckenderra and a few other creeks. These formed part of north-flowing systems that took their rise on an arcuate watershed 20 miles SSW and 30 miles SE of Kiandra. It is very probable that within the Kosciusko block proper there were Oligocene ancestors of the present stream-systems and that these survived into the Miocene, when they meandered across the peneplain in senile fashion, themselves and their tributaries largely adjusted to rock-structures. During the late Miocene Macleay epoch of uplift they were revived, and in the Pliocene stillstand their valleys attained a state of very advanced maturity. To this time we may assign the outer valleys of the Eucumbene, Snowy, Crackenback, Indi and Tumut and many of their tributaries, Happy Jacks Plain and Snowy Plains, also the shallow valleys and valley-remnants on the plateau S of Jagungal, in the Ramshead Range and on the Thredbo plateau. It may have been during this epoch of revived activity that the Eucumbene captured by headward extension a number of north-flowing tributaries of the Murrumbidgee at Kiandra and south of it, relics of the Oligocene drainage. In respect of the movements of the Kosciusko epoch many of these Pliocene rivers and creeks are antecedent, as their engorged stretches testify, but towards the original zones of dislocation they are, of course, subsequent.

With the differential Kosciusko movements came rejuvenation and entrenchment of the rivers and the initiation and development of the inner gorges of the Upper Snowy, Crackenback, Indi and other rivers and of the steep consequent tributaries of some of the main streams, with the establishment of the present cycle of erosion. Among the last streams to be brought into being were some of those draining cirques, e.g., Club Lake Creek and Blue Lake Creek, which seem to belong to the interval between the valley- and cirque-glaciations. The diversion of Upper Cootapatamba Creek to Lower Cootapatamba valley must have taken place at this time or at the very end of the Pleistocene.

Conclusion

The casual study of a topographical map or a scale-model of the Kosciusko area leaves one with the impression that the boundaries of the fault-steps, the courses of the main streams and many of their larger tributaries, and the topographic pattern generally, have been determined entirely by the late-Tertiary faulting. If, however, the interpretation given in these notes is correct it would seem rather that the tectonic pattern was in its essentials worked out far back in geological time during one or more Palaeozoic orogenies. Most of the Kainozoic movements may thus belong to the category of resurgent tectonics (Hills, 1963) and the epeirogen may really be part of a rejuvenated orogen. To reverse a venerable dictum, the past is here the key to the present, and the existing topography exemplifies the principle of what may be called *physiographic predestination,* a principle that doubtless holds elsewhere in the Palaeozoic *terrain* of the eastern highlands.

References

Adamson, C. L., 1955.—Geology of Snowy Mts. area. Prog. Rept. No. 4. Ann. Rept. Dept. of Mines, N.S.W., for 1951, 78.

Andrews, E. C., 1901.—Kiandra lead. Geol. Surv. N.S.W. min. Res., 10.

————, 1910.—Tertiary unity of E. Australia. *Journ. Proc. roy. Soc. N.S.W.*, 44: **420–480.**

Browne, W. R., 1952.—Our Kosciusko heritage. *Aust. Journ. Sci.*, 15 (Supplt.).

————, Dulhunty, J. A., and Maze, W. H., 1944.—Notes on geology &c. of the Kosciusko area and the country N. of it. Proc. Linn. Soc. N.S.W., 69: 238–252.

————, Vallance, T. G., and Rutledge, H., 1955.—Some examples of stream derangement in the Kosciusko area. Proc. Linn. Soc. N.S.W., 80: 267–273.

————, and Vallance, T. G., 1957.—Notes on some evidences of glaciation in the Kosciusko region. Proc. Linn. Soc. N.S.W., 82: 125–144.

————, ————, 1963.—Further notes on glaciation in the Kosciusko area. Proc. Linn. Soc. N.S.W., 88: 112–129.

Cleary, J. R., Doyle, H. A., and Moye, D. G., 1964.—Seismic activity in the Snowy Mts. region &c. *Journ. geol. Soc. Aust.*, 11: 89–105.

Craft, F. A., 1931, 1932.—Physiography of the Shoalhaven R. IV and V. Proc. Linn. Soc. N.S.W., 56: 412–430 and 57: 197–212.

————, 1933.—The surface history of Monaro. Proc. Linn. Soc. N.S.W., 58: 229–244.

Crohn, P., 1950.—The geology &c. of the Omeo district. *Proc. roy. Soc. Vict.*, 62: 1–70.

David, T. W. E., 1908.—Geological notes on Kosciusko. Proc. Linn. Soc. N.S.W., 33: 657–668.

Gill, E. D., and Sharp, K. R., 1957.—Tertiary rocks of the Snowy Mts. *Journ. Geol. Soc. Aust.*, 4: 21–40.

Hall, L. R., 1955.—Geology of Snowy Mts. area. Prog. Repts. Nos. 2 & 3. Ann Rept. Dept. Mines, N.S.W., for 1951, 76–78.

————, and Lloyd, J. C., 1954.—Geology of Snowy Mts. area. Prog. Rept. No. 1. Ann. Rept. Dept. Mines, N.S.W., for 1950, 96–104.

Hills, E. S., 1964.—"Elements of structural geology." (London: Methuen.)

Hobbs, W. H., 1911.—Repeating patterns in the relief and structures of the land. *Bull. geol. Soc. Amer.*, 22: 123–176.

Noakes, L. C., 1946.—Preliminary geological report on the Kosciusko area. Cwlth Dept. of Supply & Shipping, Min. Resources Survey, Rept. 1946/33.

Sussmilch, C. A., 1909.—Notes on the physiography of the southern tableland of N.S.W. *Journ. Proc. roy. Soc. N.S.W.*, 43: 331–354.

Taylor, T. Griffith, 1910.—Physiography of the Federal Capital Territory. *C'w'lth Bur. Meteorology, Bull. 6.*

————, 1914.—The evolution of a Capital [Canberra]. *Geograph. Journ.*, 378–554.

————, 1958.—"Sydneyside Scenery." (Sydney: Angus & Robertson.)

den Tex, E., 1959.—Geology of Grey Mare Range. *Proc. roy. Soc. Vict.*, 71: 1–24.

Voisey, A. H., 1942.—The Tertiary land-surface in southern New England. *Journ. Proc. roy. Soc. N.S.W.*, 76: 82–85.

————, 1957.—Erosion surfaces around Armidale. *Journ. Proc. roy. Soc. N.S.W.*, 90: 128–133.

EXPLANATION OF PLATE

Map of the Kosciusko Block and its northern and southern extensions showing lineaments and postulated Kainozoic faults.

NEW SPECIES AND NEW RECORDS OF FISH FROM QUEENSLAND

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[Read 26th April, 1967]

Synopsis

Aulopus curtirostris, n. sp. (Aulopidae, Scopeliformes), and *Kanekonia aniara*, n. sp. (Aploactidae, Perciformes), are described and figured, and, together with the shark *Parascyllium collare*, are recorded from Queensland for the first time. The Australian species *Sirembo everriculi* and *Allotaius spariformis* are regarded as synonyms of *S. imberbis* and *Taius tumifrons* from Japanese waters and, together with the shark *Squalus megalops*, are here recorded for the second time from Queensland waters.

The six species recorded in this paper were taken in two hauls of a prawn otter trawl in 35 fathoms of water, approximately 20 miles north-east of Cape Moreton on 16th August, 1966.

ORECTOLOBIDAE

PARASCYLLIUM COLLARE Ramsay and Ogilby, 1888

This collared cat shark has not been recorded previously from Queensland. Munro (1956) indicated its distribution as being the waters of Tasmania, Victoria and southern New South Wales. This specimen (T.L. 46·6 cm.) agrees with diagnoses by Whitley (1940) and Munro (1956) except in the details of the colour pattern. Compared with Whitley's figure the present specimen has fewer spots; the lower caudal has three diffuse splotches of black rather than sharply delineated spots; the upper caudal lobe has two black splotches superimposed on the dark brown band and has none of the small spots figured by Whitley; the second dorsal fin has a dark smudge on the lower three-quarters of the anterior edge and a very small black spot just below the tip of the fin; in front of the first dorsal the back is decorated by six median black spots, two of which are superimposed on the brown band running to the base of the ventral fins; the ventrals are marked by only one dark spot instead of the three shown in Whitley's figure (Queensland Museum Reg. No. I.9054).

SQUALIDAE

SQUALUS MEGALOPS Macleay, 1881

About 30 specimens, ranging in size from 12·5 to 28 cm., were taken in a single haul. Previously the species has been reported from Western Australia, Victoria, Tasmania and southern New South Wales (Munro, 1956) and in a single instance from southern Queensland (Ogilvie, 1965).

APLOACTIDAE

KANEKONIA ANIARA, n. sp.

(Fig. 1)

D. X, 14 A III, 11 P. 13 V. I, 2 C. 3, 7, 3 Ll. 11–12

Head length 4·5 and depth 4·1 in total length or respectively 3·8 and 3·2 in length to the hypural. Caudal peduncle 6·0 in depth; eye 5·0, snout 4·0 in head length; interorbital 2·0 in eye. The snout is short, steep-profiled, body deepest at the dorsal origin, elongate and tapering posteriorly. Head length less than head depth, snout longer than eye. Interorbital medianly depressed and surrounded by sunken areas bounded by ridges, the depression not triangular in outline, being very similar in appearance to the condition in *Kanekonia queenslandica* Whitley. Maxilla expanded posteriorly, reaching the base of the anterior preopercular spine but not the eye. A prominent symphysial knob on the dentary; tongue deep and keeled anteriorly. A flat band of teeth in each jaw, very small patch on vomer, none on palatine. Gill rakers obsolescent, wider than long, 3/6 on the first arch, the dorsalmost separated by a long gap from the next two which are at the axil; a trace of one or two vestigial rakers below those counted.

The head armed with spines, most of which are blunt and covered by velvety skin; preopercle with 4 marginal spines, the largest dorsalmost; from its base a ridge runs in the direction of the front edge of the pupil, but turns forward before reaching the eye to end in a swollen spine just in front of and a little below the lower edge of the eye; three spines on the preorbital, one pointing slightly posteriorly of ventral, one antero-ventrally and the shortest anteriorly; bases of preorbital spines connected by ridges which combine into one ridge running to a swollen protruberance in front of the eye; this protruberance connects via a low ridge with the dorsal preorbital spine, the system of ridges enclosing a depression between the bases of the spines.

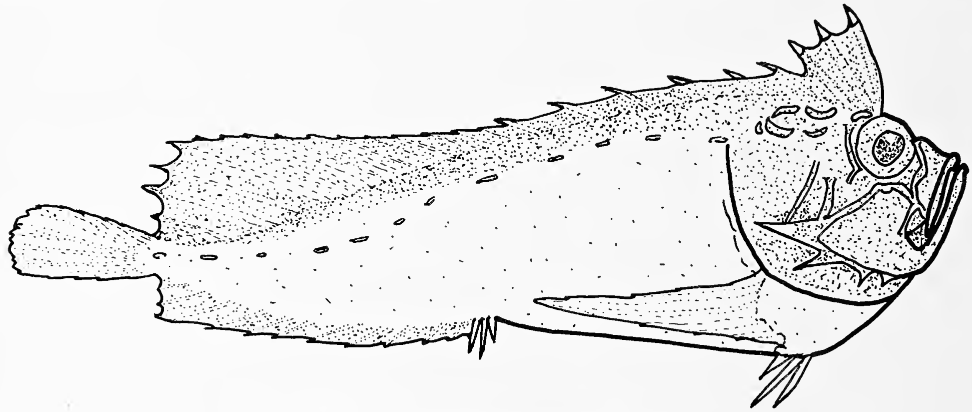


Fig. 1. *Kanekonia aniara*, n. sp.

Above the eye a slender supraorbital ridge, protruding laterally to overhang the eye in its posterior portion; between the supraorbital ridges a median ridge divides both posteriorly and anteriorly to enclose predorsal and frontal depressions; superior and inferior postorbital ridges in the form of rows of misshapen flat-topped spines; from the base of the anteriormost spine of the inferior postorbital ridge two low ridges run ventrally the anterior to the base of the posteriormost preopercular spine, and the posterior ending ventrally on the operculum at the level of and obscured by the same preopercular spine.

The dorsal fin origin over the posterior third of eye; anal origin opposite origin of soft-rayed part of dorsal; dorsal and anal separate from the broadly-rounded caudal, pectoral origin in line with posterior edge of opercle; ventrals jugal, origin in line with hind edge of pupil; a weak spine and two rays. Fin rays and spines covered by skin, spines pushing through under pressure. The raised tubes marking the lateral line well-spaced, 11 on one side, 12 on the other in the holotype, difficult to locate because skin covering blends with general body colouring.

Colour (freshly preserved in formalin): to the naked eye a dull metallic blue; under a low-power microscope the background a greyish-white freckled by velvety projections variously coloured dark blue, purple or black, widely spaced on sides, close together between lateral line and dorsal; a cobalt blue suffusion spreads as a small patch about occasional freckles. Fins dusky, ventral spine and first two anal spines buried in white-coloured swollen epidermis.

Holotype: 9·9 cm. total length. Registered number I 9053, Queensland Museum. *Type locality*: 20 miles north-east of Cape Moreton in 35 fathoms.

This species has only 10 dorsal spines instead of the 12 of *K. florida* Tanaka or *K. queenslandica* Whitley, but otherwise is very similar; I can see no point in erecting a monotypic genus on this characteristic. Tanaka's (1918) diagnosis of the genus applies in all other points. Whitley's (1952) description of *K. queenslandica* shows differences in fin counts, which he gives as A, 9 P. 14 and C 3, 11, 2. On examination of the holotype I counted these as A I, 8, P. 14 and C 2, 11, 3. Whitley also gives a ventral fin count of I, 3 but the holotype has I, 2 which is characteristic of the other species. *K. queenslandica* has a lateral line count of 8 or 9; *K. florida* has 9 or 10 and *K. aniara* 11 or 12. Whitley's *K. queenslandica* has the head length equal to the depth; Tanaka's *K. florida* has the depth slightly less than head length whereas *K. aniara* has the depth slightly greater than head length.

AULOPIDAE

AULOPUS CURTIROSTRIS, n. sp.

(Fig. 2)

D. 16 A. 9 P. 11 V. 9 Ll 38 (+4–5) tr. 6, 1, 6

Head 4·2, depth 6·5 in total length and respectively 3·4 and 5·2 in length to hypural. Body in front of first dorsal deeper than broad; dorsal anterior profile steep and scalloped; the snout short (5·1 in head), shorter than the eye (3·5 in head); interorbital (2·0 in eye length) flattened between slight supraorbital ridges; nostrils close together near orbit in the postero-ventral corner of a slight preorbital depression; mouth oblique, maxillary expanded posteriorly, reaching past posterior edge of eye; lower jaw entirely included laterally, its symphysis swollen anteriorly into a lobe projecting beyond the premaxillaries.

Lower jaw with an inner row of widely spaced elongate and depressible teeth and 2 to 3 indefinite outer rows of similar shape but smaller size, on the symphysis a small patch of larger teeth; in the upper jaw an inner row of teeth right around the jaw and a second outer row on the anterior half, the outer teeth increasing in size approaching the symphysis; teeth on vomer in flattened arc, about 4 large teeth each side with smaller teeth scattered between them; palatine toothed to well behind angle of jaw, a single row of large teeth being interspersed with smaller irregularly spaced teeth; tongue broadly rounded; gill-rakers long and slender, 4/13 (+2 vestigial) on first gill arch; branchiostegals 12. Hind edge of preopercle almost vertical sharply curved below; opercle more broadly rounded and without a lobe projecting over the pectoral base; interorbital space, snout and opercles without scales. Scales on breast cycloid, elsewhere ctenoid, those below lateral line larger than those above.

Dorsal origin over ventral origin; origin of small adipose second dorsal over the base of the 8th anal ray; 4th ventral ray reaches beyond anus, 3rd reaches anus; outer and inner rays of ventral simple, the others branched.

D_1 origin 3·8 in total length (3·1 in hypural); D_2 origin 1·6 (1·2); interdorsal distance 6·0 (4·8); distance between dorsal origins 2·6 (2·1); ventral origin 3·7 (3·0); anal length 4·1 (3·4); anal origin 1·7 (1·3); anal origin to anus 8·7 (7·0); base of D_1 1·1 in head.

Colour (fresh): silvery below, grey-green above, a series of brown splotches down back and sides; cheeks silvery; eye silvery with a greenish tinge; jaw and interorbital dusky; a marked yellow splash across first dorsal fin, about a third of the fin height anteriorly, curving slowly at first and then more rapidly to the back at the 9th ray; another small yellow patch higher on dorsal between the first two rays; caudal brown at base and at tip of upper lobe; otherwise fins colourless. After some weeks in formalin the yellow fin patches were not visible and the brown on body and caudal had faded. Distinguished from other species of the genus by the number of dorsal rays and the short snout.

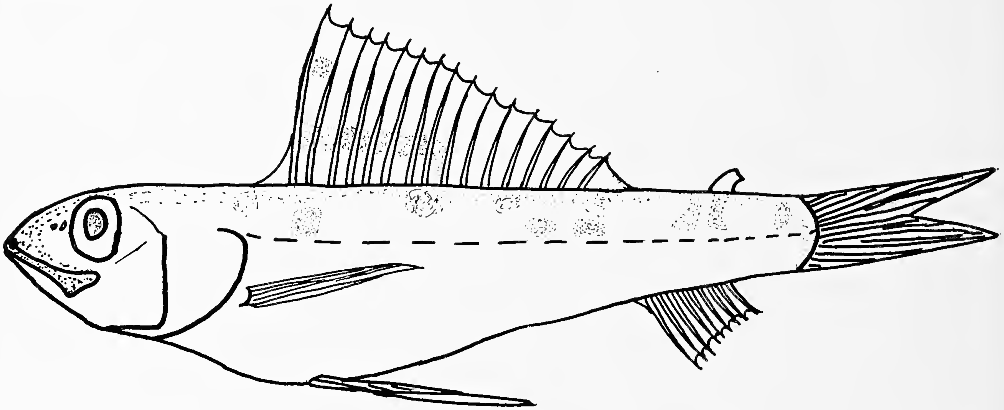


Fig. 2. *Aulopus curtirostris*, n. sp.

Holotype: 12·9 cm. T.L., Queensland Museum Reg. No. I.9051. *Paratype*: 14·0 cm. T.L., Queensland Museum Reg. No. I.9052. *Type locality*: 20 miles north-east of Cape Moreton in 35 fathoms.

The genus *Aulopus* was erected by Cloquet (1816) for a species which occurs in the Mediterranean and the adjacent Atlantic. Richardson (1843) added the Australian species *A. purpurissatus* and from the other side of Australia Cuvier and Valenciennes (1849) added *A. milesii* which has generally been regarded as a synonym of *A. purpurissatus,* though not by Whitley (1931), who erected the genus *Latropiscis* with *milesii* as type species. Whitley stated that "the differences between these two forms" (Atlantic and Australian) "as given by these authors" (i.e., Cuvier and Valenciennes) "seem to be of generic importance". But he did not enumerate the differences, and the only ones that are apparent to me are the number of dorsal fin rays which is greater in the Mediterranean species than in the Australian. This seems to me to be a specific rather than a generic characteristic. *A. curtirostris* has an intermediate number of dorsal spines. Deploring the trend to monospecific genera I refer the present species together with *A. purpurissatus* to the genus *Aulopus.*

BROTULIDAE

SIREMBO IMBERBIS Temminck and Schlegel, 1843

Brotula imberbis Temminck and Schlegel, 1843, p. 253, pl. 3, fig. 3; *Sirembo imberbis* Bleeker, 1958, p. 22; *Brotella imberbis* Kaup, 1858, p. 92;

Sirembo everriculi Whitley, 1936, p. 47, pl. 6, fig. 2, Marshall, 1964, p. 398. Two specimens, 23·1 and 19·6 cm. T.L. (21.4 and 17·9 S.L.), agree with Whitley's (1936) description except that the gill rakers are 1/3 with 2 obsolescent rakers above and 8 below, a count which was confirmed by inspection of the holotype of *S. everriculi* (Australian Museum Reg. No. IA 6564).

In the preserved specimens the rows of golden spots on the body and the golden brown line on the operculum did not show but the narrow pinkish brown band along the lateral line was distinct. As well as the dark anterior blotch described by Whitley the dorsal fin has a second large dark blotch rather less than half way back.

In the collection of the Australian Museum are three specimens of *Sirembo imberbis* from Japan (Australian Museum Reg. No. I 6910). I can detect no differences between these and the Australian specimens.

SPARIDAE

TAIUS TUMIFRONS Temminck and Schlegel, 1843

Chrysophrys tumifrons Temminck and Schlegel, 1843, p. 70, pl. 34; *Taius tumifrons* Jordan and Thompson, 1912, p. 571, fig. 8; *Dentex spariformis* Ogilby, 1910, p. 91; 1916, p. 169, pl. 21; *Allotaius spariformis* Whitley, 1937, p. 139; 1954, p. 28; Marshall, 1964, p. 205, pl. 36. (For a full synonymy of non-Australian references see Fowler (1933).)

A single haul made by the Endeavour in 1910 produced several specimens of this species. The only record since was that by Whitley (1954) who recorded a specimen from Nambucca Heads. Several other specimens from the coast of New South Wales are in the collection of the Australian Museum. Two dozen small specimens were taken in the two hauls mentioned in the introduction, ranging in size from 5·0 to 9·1 cm. T.L. They accord in all particulars with Ogilby's (1916) description of *Dentex spariformis* except that the gill rakers are 8/13 of which the lowermost two are obsolescent. The description by Jordan and Thompson of *Taius tumifrons* is almost identical with that of *Dentex spariformis* by Ogilby. Fowler (1933) relying on Ogilby's description and figure kept the species separate, keying them apart on the number of rows of cheek scales. But although in his key he places *tumifrons* in a section having "at least 7 or 8 scales above opercle ridge" in his specific description he attributes to *tumifrons* "5 or 6 rows on cheek to opercle flange". Five rows are attributed to *spariformis* by Ogilby. In his specific description of *tumifrons* Fowler gives the coloration as "Back pale to light brown, sides and below white, washed with silvery . . . . Fins pale." Yet in the key he states "Reddish with golden sheen", which accords with the description given by Kishinouye (1901) and with the plate in Anonymous (1931). His duller colour pattern was probably taken from stored material for it accords with the Australian specimens after storage, though when fresh they also are a pinkish-gold colour.

Whitley (1937) differentiated his genus *Allotaius* from *Taius* on the shape of the head and the number of anal rays. The anal ray number is the same being 8 in both species; the bump on the head is not a very convincing generic characteristic as it varies with age and size. In the specimens in the collection of the Australian Museum the smaller specimens have the eye impinging on the profile; in the largest the bump has developed sufficiently for the eye to be well away from the profile line.

Although there are no Japanese specimens available to me it would seem that there is no justification in separating *Allotaius* from *Taius* and no valid reason to separate *T. spariformis* from *T. tumifrons.*

Specimens in the Australian Museum include: I 12538 (*Co-type*) Cape Moreton to Double Island Point; IB 2987 Nambucca Heads; IB 3531 Newcastle; IB 3800-1 Nambucca; IB 5299 N.E. of Coffs Harbour; IB 6452 Northern New South Wales; IB 7315 Mosman Bay.

Acknowledgements

Thanks are due to the Director of the Australian Museum, Dr. F. H. Talbot for access to the relevant collections and to the Research Committee of the University of Queensland for financial support.

References

Anonymous, 1931.—"Illustrations of Japanese Aquatic Plants and Animals", Vol. I. Fisheries Society of Japan. (Tokyo.)

Bleeker, P., 1858.—Vierde bijdrage tot de kennis der ichthyologische fauna van Japan. *Act. Soc. Sci. Ind. Neerl.*, 3: 1–46.

Cloquet, H., 1816.—"Dictionnaire des Sciences Naturelles", Ed. 2, Suppl. 3. (Quoted from Whitley, 1931.)

Cuvier, G. L., and Valenciennes, A., 1840.—"Histoire Naturelle des Poissons", 22: 1–590.

Fowler, H. W., 1933.—The fishes of the families Banjosidae etc. collected by the United States Bureau of Fisheries steamer "Albatross" chiefly in Philippine seas and adjacent waters. *Bull. U.S. natn. Mus.*, 100: 1–465.

Jordan, D. S., and Thompson, W. F., 1912.—A review of the Sparidae and related families of perch-like fishes found in the waters of Japan. *Proc. U.S. natn Mus.*, 41: 521–601.

Kaup, J. J., 1858.—Uebersicht der Familie Gadidae. *Arch. Naturgesch.*, 24 (1): 85–93.

Kishinouye, K., 1901.—The Japanese species of the genus *Pagrus*. *Journ. Fish. Bur. Tokyo*, 10 (3): 31–42.

Marshall, T. C., 1964.—"Fishes of the Great Barrier Reef and coastal waters of Queensland." (Angus & Robertson, Sydney, 566 pp.)

Munro, I. S. R., 1956.—Handbook of Australian Fishes No. 1. *Fish. Newsl.*, 15 (7): 13–20.

Ogilby, D. J., 1910.—"New Fishes from the Queensland Coast." (Brisbane.)

————, 1916.—Edible fishes of Queensland Parts IV to IX. *Mem. Qd. Mus.*, 5: 127–177.

Ogilvie, P. S., 1965.—New records of southern fish in Queensland waters. *Qd. Nat.*, 17: 105–106.

Ramsay, E. P., and Ogilby, D. J., 1888.—Descriptions of two new Australian fishes. Proc. Linn. Soc. N.S.W., 3: 1310–1312.

Richardson, J., 1843.—"Icones Piscium." (London.)

Tanaka, S., 1918.—"Figures and descriptions of the fishes of Japan", 28: 500–531.

Temminck, C. J., and Schlegel, H., 1843.—"Fauna Japonica" (ed. P. F. von Siebold): 1–323.

Whitley, G. P., 1931.—New names for Australian fishes. *Aust. Zool.*, 6: 310–334.

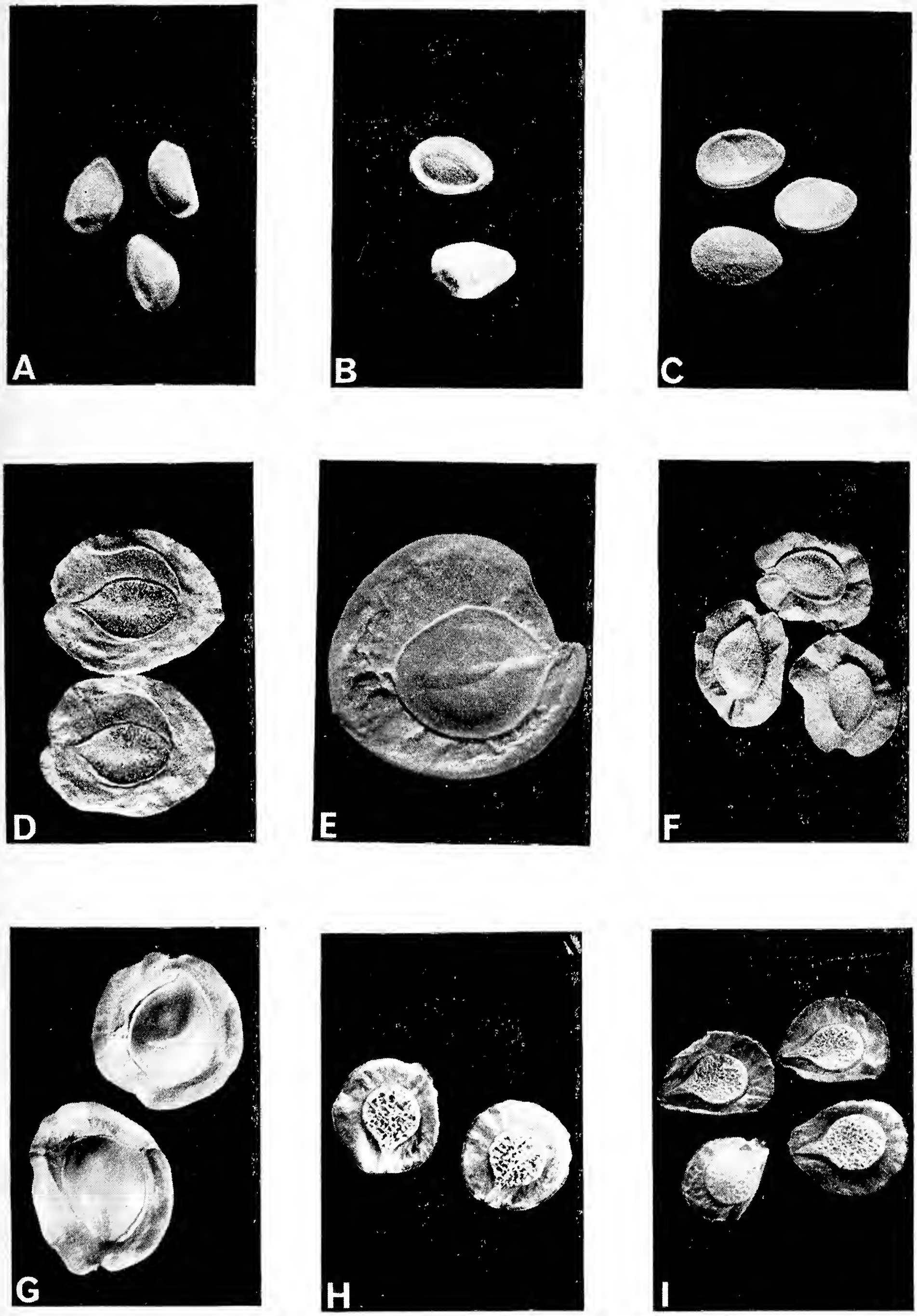
————, 1936.—More ichthyological miscellanea. *Mem. Qd. Mus.*, 11 (1): 23–51.

————, 1937.—Further ichthyological miscellanea. *Mem. Qd. Mus.*, 11 (2): 113–148.

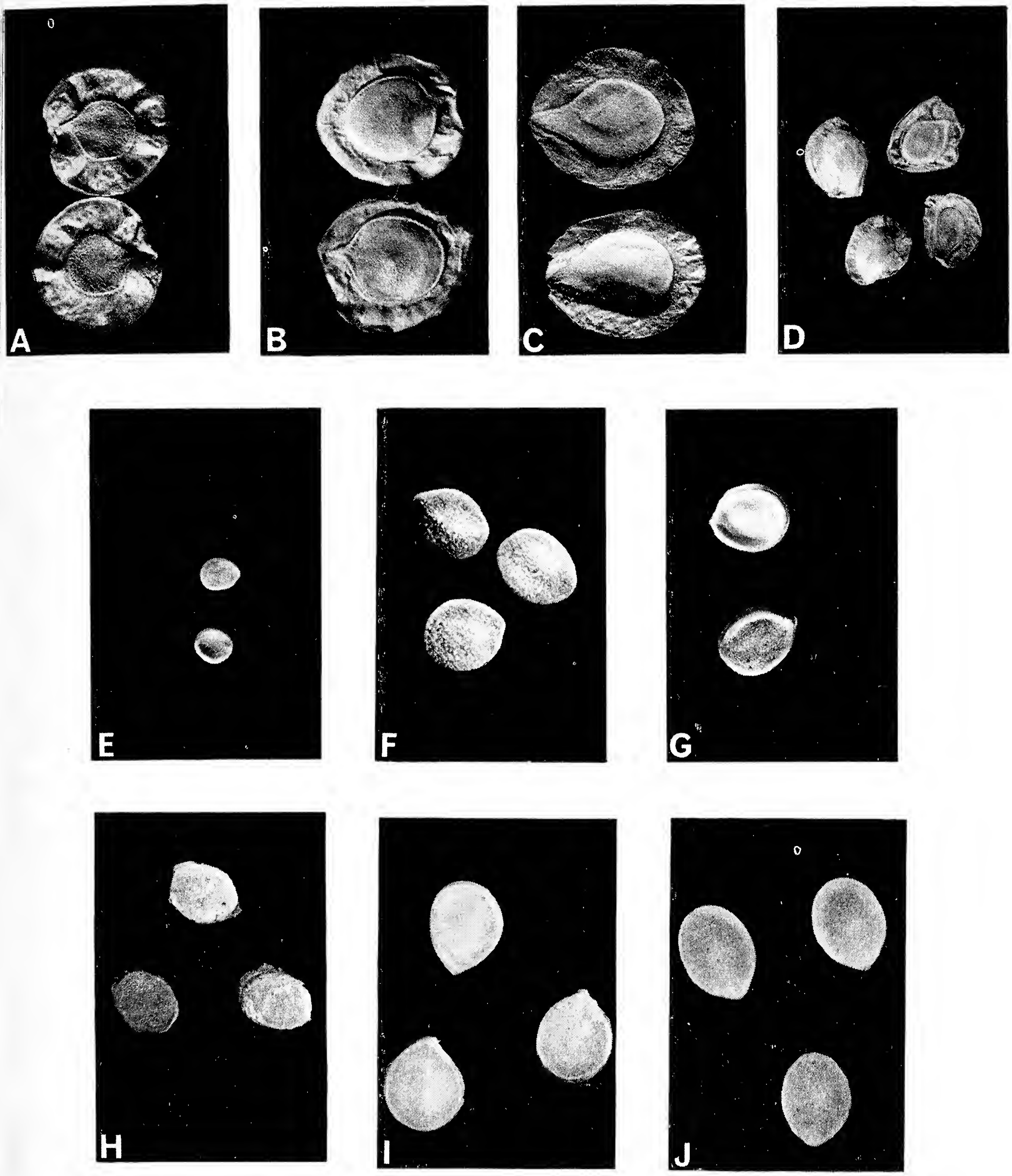
————, 1940.—"The Fishes of Australia", Part 1. Sharks. Royal Zoological Society of New South Wales, Sydney. 280 pp.

————, 1952.—Some noteworthy fishes from eastern Australia. *Proc. R. zool. Soc. N.S.W.*, 1950–51: 27–32.

————, 1954.—New locality records for some Australian fishes. *Proc. R. zool. Soc. N.S.W.*, 1952–53: 23–30.



Seeds of *Velleia*.



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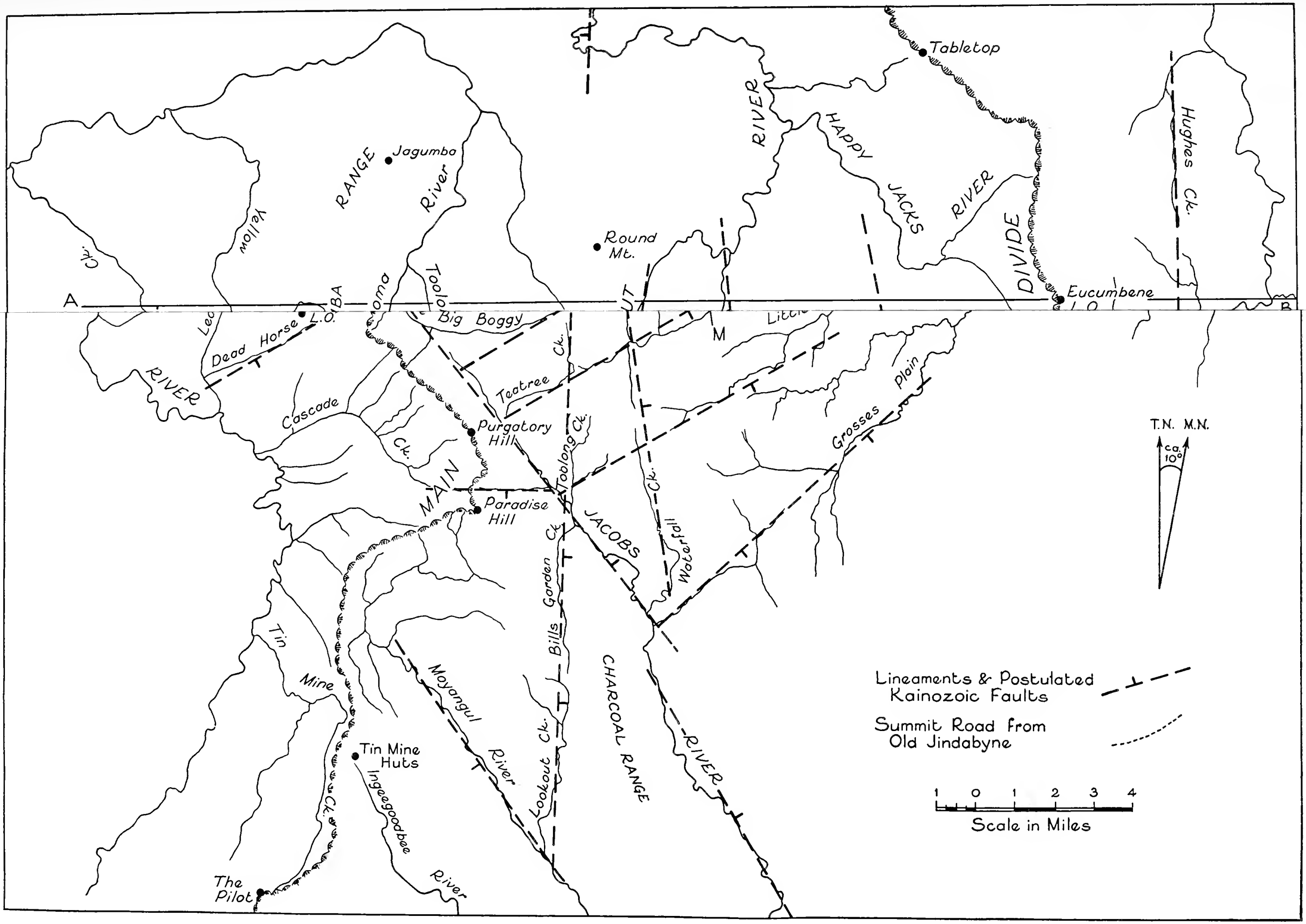
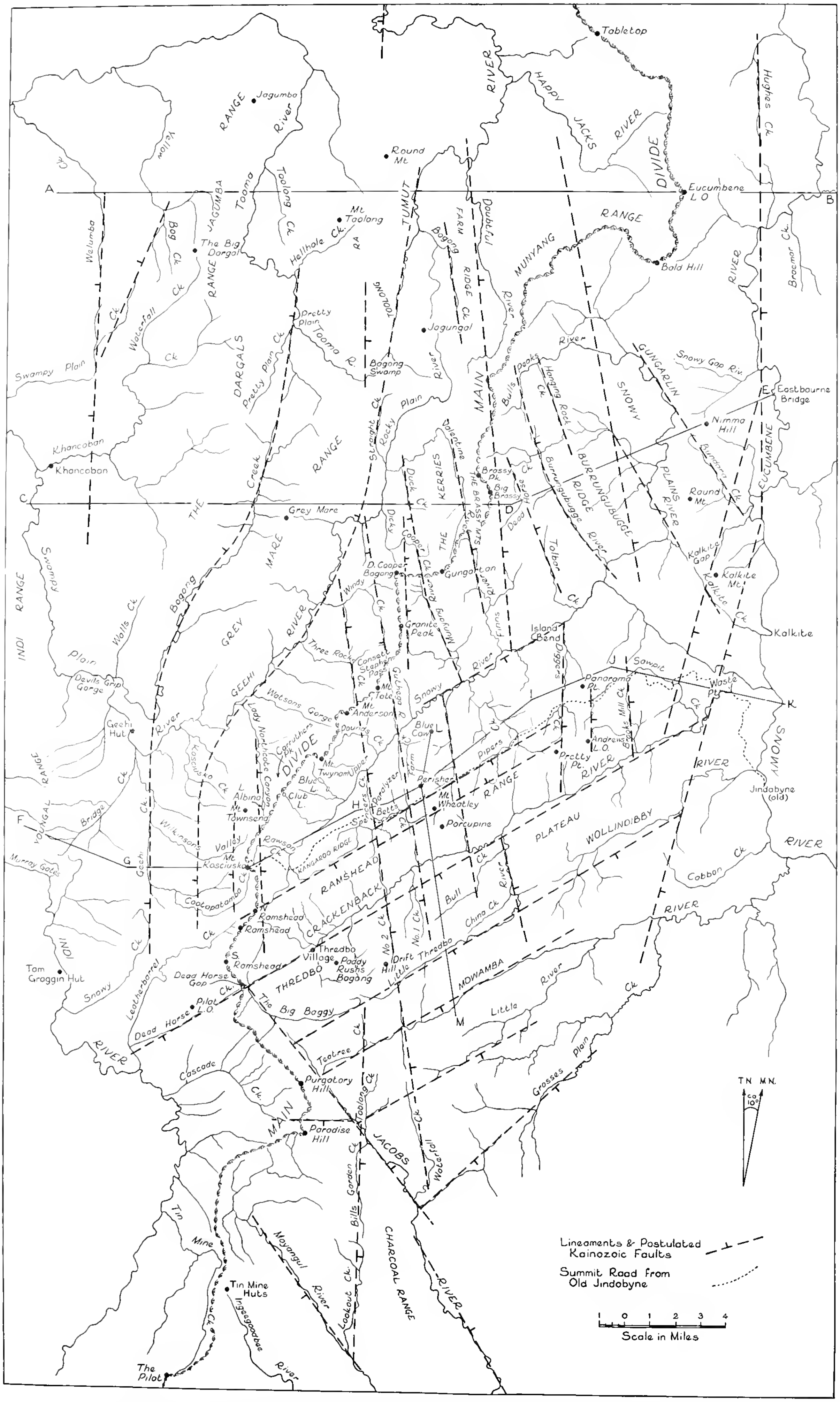


Map of Kosciusko Block and its north and south extensions.



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THE RHAPHIDOPHORIDAE (ORTHOPTERA) OF AUSTRALIA. PART 5. THE RHAPHIDOPHORIDAE OF FLINDERS ISLAND.

AOLA M. RICHARDS
Department of Zoology, University of New South Wales, Sydney

[Read 28th June, 1967]

Synopsis

The species *Speleotettix flindersensis* Chopard is re-described and placed in the genus *Cavernotettix* Richards as *Cavernotettix flindersensis* (Chopard). A key is given for the species in the genus *Cavernotettix*.

INTRODUCTION

Flinders Island is situated in Bass Strait, about 30 miles off the north-eastern coast of Tasmania. The Strzelecki Peaks occur in the south-western corner of the island, and are formed in granite. It was from a cave on Strzelecki Peak that the type material of *Speleotettix flindersensis* (Chopard) was collected by H. H. Finlayson around 1930. This is the only species of Rhaphidophoridae known to occur on the island. Gabriel (1894) refers to " weird cavernous openings " on the side of Strzelecki Peak, but it is not known if rhaphidophorids occur there, or if this is the type locality. There is no other known reference to caves on Strzelecki Peak.

Dune limestone is widespread on the western coastal plains of Flinders Island. Considerable depths of limestone occur in some areas, and sink holes are common (Kershaw and Sutherland, in press). Only one cave of any size is known. This is located on the property of Mr. A. Dart, near Ranga in the south-western part of the island. It occurs at an altitude of about 150 feet above sea level. This cave is directly below Strzelecki Peaks, and so is probably the cave referred to by Finlayson. The cave has a long, low entrance on the north bank of a creek, about three-quarters of a mile west of Barclay's Hill, and opens into a large rectangular-shaped chamber. *S. flindersensis* occur on the wall above the entrance, and on nearby formation (J. Partridge, pers. comm.). No rhaphidophorids have been observed in the small sinkholes near the cave. Thus the cave is the only known habitat for the species on Flinders Island.

Examination by the author of the type specimen of *S. flindersensis* had shown that the species did not belong to the genus *Speleotettix* Chopard, but until the recent collection of more material from Flinders Island, its exact taxonomic position could not be determined. It can now be shown that the species *flindersensis* should be placed in the genus *Cavernotettix* Richards.

The range of the genus *Cavernotettix* (Richards, 1966) is now extended from the Southern Highlands of New South Wales to Flinders Island. So far no representatives of the genus have been recorded from Tasmania. Thus *C. flindersensis* is more closely related to Mainland Rhaphidophoridae than to any known Tasmanian forms. Migration must have been from the north, presumably via the land bridge which extended from Wilson's Promontory to Flinders Island during the Pleistocene. *C. flindersensis* is considerably larger than the other three species in the genus, possibly due to the isolation of its island habitat.

Genus Cavernotettix Richards, 1966

Pacific Insects, 8 : 619

Cavernotettix flindersensis (Chopard, 1944) n.comb.

(Text-fig. 1, figs 1–6)

1944. *Speleotettix flindersensis* Chopard, *Bull. Soc. ent. Fr.* XLIX : 54-55.

In 1944, Chopard erected the genus *Speleotettix*, and placed in it two new species, *Speleotettix tindalei* and *S. flindersensis.* Examination of paratype and recent material of *S. tindalei*, the type species for the genus, confirm Chopard's generic description of *Speleotettix*, and this genus will be considered in detail in a later paper.

S. flindersensis was described from a single male specimen, the female being unknown. It was collected by H. H. Finlayson from a cave on Strzelecki Peak, Flinders Island, and deposited in the South Australian Museum. No date of collection is given on the labels, but the Museum records indicate that Finlayson was collecting in the Bass Strait area in January 1930. The labels belong to the A. M. Lea period at the Museum and, as Lea died in 1931, the specimen was definitely collected before then. In Chopard's description Strzelecki Peak is spelt as " Etreglecki Peak ", and Finlayson is referred to as " Frulagsen ". The spelling is correct on the specimen label.

Table I

Comparison of leg length (millimetres) in specimens of Cavernotettix flindersensis *(Chopard)*

	Type Male			Other Finlayson Male			Adult Male			Adult Female		
	Femur	Tibia	Tarsus	Femur	Tibia	Tarsus	Femur	Tibia	Tarsus	Femur	Tibia	Tarsus
Fore leg	13	14	—	14	15·5	11	17	18	11	11	12·5	9
Middle leg	12	14	8	14	16	—	15	18	11·5	11	12	8
Hind leg	26	32	10	30	36	—	34	41	14	22·5	27	10

Comparison of Chopard's type material of *S. flindersensis* with his generic description for *Speleotettix* has revealed a major point of difference. He says the fore coxae are unarmed, whereas there is a well-developed spine present.

Comparison of the type specimen with the specific description of *S. flindersensis* has shown that Chopard missed the presence of linear spines on both fore and middle femora. He also gives the number of linear spines on the hind femora as 12 prolateral and 15 retrolateral, whereas the author has counted 13 and 14 prolateral, and 23 and 24 retrolateral. Neither of these points are as important as the generic difference.

Another male specimen of this species, collected by Finlayson at the same time as the type, and also housed in the South Australian Museum, was not examined by Chopard. This insect is larger than the type, and the shape of its suranal plate is different. Apart from this, it agrees with the type in all its characters.

In May 1963, Mr. A. Dart collected more specimens of *S. flindersensis* from a cave on his property near Ranga. Three immature males and an adult female from this sample have been examined by the author.

In December 1966, 13 further specimens were collected by Miss J. Partridge from the same cave on Mr. Dart's property. This sample included two more adult females and the first adult male to be collected, showing that both Finlayson's specimens are nymphs. Thus the total material before the author consists of 19 specimens including the type, 15 of which are nymphs, three are adult females, and one an adult male. All specimens possess a well developed spine on the fore coxa. The adult is a large insect, and sexual dimorphism is strongly developed. A comparison of leg length in the type, other Finlayson male and adult specimens is given in Table I.

The shape of the suranal plate of the adult male (Text-fig. 1, Fig. 4) differs markedly from the type, which is illustrated by Chopard in his description. It lacks the large lateral lobes he refers to, and the distal margin is membranous and only slightly emarginate. Chopard was working with pinned material which had shrunk and become distorted over the years. The parameres had become hooked over the suranal plate changing its shape by very deeply invaginating the medio-distal margin. As a result, the shape of the plate had come to closely resemble that of *S. tindalei*. This shape is not repeated in the other pinned specimen collected by Finlayson. Here the genitalia more closely resemble those of the adult specimen. The parameres have dried out and project over the suranal plate slightly distorting the distal margin, but not to the same extent as in the type specimen.

TABLE II

Variability in number of linear spines on the legs of Cavernotettix flindersensis (*Chopard*)

		Mean		Number of Specimens		Standard Deviation		Range	
		L	R	L	R	L	R	L	R
Fore Femur	Pro.	1·6	1·5	16	16	0·6	0·6	1–3	0–2
Inf.	Retro.	0	0	16	16	0	0	0	0
Fore Tibia	Pro.	3·8	4	16	16	0·4	0	3–4	4
Inf.	Retro.	3·8	3·9	16	16	0·4	0·3	3–4	3–4
Mid. Femur	Pro.	0	0	16	15	0	0	0	0
Inf.	Retro.	1·2	1·1	16	15	0·5	0·7	0–2	0–2
Mid. Tibia	Pro.	3·9	4	16	15	0·3	0	3–4	4
Inf.	Retro.	3·9	4	16	15	0·2	0	3–4	4
Hind Femur	Pro.	12·6	13·1	11	9	1·6	1·7	11–17	10–16
Inf. ♂	Retro.	25·8	26·3	11	9	4·6	5·1	17–32	16–34
Hind Femur	Pro.	7·8	7·3	5	3	0·4	0·9	7–8	6–8
Inf.♀	Retro.	5	5	5	3	0·9	0·6	4–6	4–6
Hind Tibia	Pro.	33·5	33·6	16	12	3·3	2·9	28–41	28–39
Sup.	Retro.	38·1	38·8	16	12	2·3	2·3	34–44	37–43
Hind Tarsus	Pro.	2·3	2·3	16	12	0·7	0·6	2–4	2–4
1 Sup.	Retro.	2·9	2·6	16	12	0·7	0·5	2–4	2–3
Hind Tarsus	Pro.	1·1	1·1	16	12	0·4	0·3	0–2	1–2
2 Sup.	Retro.	1·3	1·2	16	12	0·6	0·4	0–2	1–2

Comparison of male and female adult specimens of *S. flindersensis* with adults of *S. tindalei* show there is no close similarity in the shape of the suranal plate of the male or the subgenital plate of the female.

In 1966, the author erected the genus *Cavernotettix* and placed in it three new species from south-eastern Australia, extending in range from the Southern Highlands of New South Wales to just north of Lakes Entrance, on the southern coast of Gippsland in Victoria (Richards, 1966). This genus has similar apical spination of the legs to *Speleotettix*, but differs from it in the shape of the genitalia, and the possession of a spine on the fore coxa. *S. flindersensis* shows much closer affinities with the genus *Cavernotettix* than with *Speleotettix*. Apart from the presence of linear spines on the fore and middle femora, all its generic characters agree with those of *Cavernotettix*, and, as this difference is considered of specific and not of generic importance, the author proposes to place the species *flindersensis* in the genus *Cavernotettix* as *C. flindersensis* (Chopard).

The species *Cavernotettix flindersensis* is now redefined as follows:

Colour—Basic colour mid brown, with pronotum, mesonotum, metanotum and abdominal terga irregularly mottled with dark brown, light brown and ochreous; femora and tibiae mottled or banded with mid brown, light brown and ochreous; tarsi ochreous; antennae light brown; ovipositor reddish-brown.

Body—Length 22 mm. in male, and 20 mm. in female. Body clothed with setae. Antennae broken. Fastigium as high as long. Ovipositor 0·75 length of body; ventral valves armed distally 0·2 of total length to apex with five small teeth, gradually decreasing in size towards apex (Fig. 1).

Antennae—As in generic description. Segment three in male on dorsal aspect 1·4 as long as pedicel, and on ventral aspect 1·6 as long; in female on dorsal aspect 1·6 as long as pedicel, and on ventral aspect 1·5 as long. Sexual dimorphism present, male possessing longer, stouter antennae than female. No spines present on flagellum of either male or female.

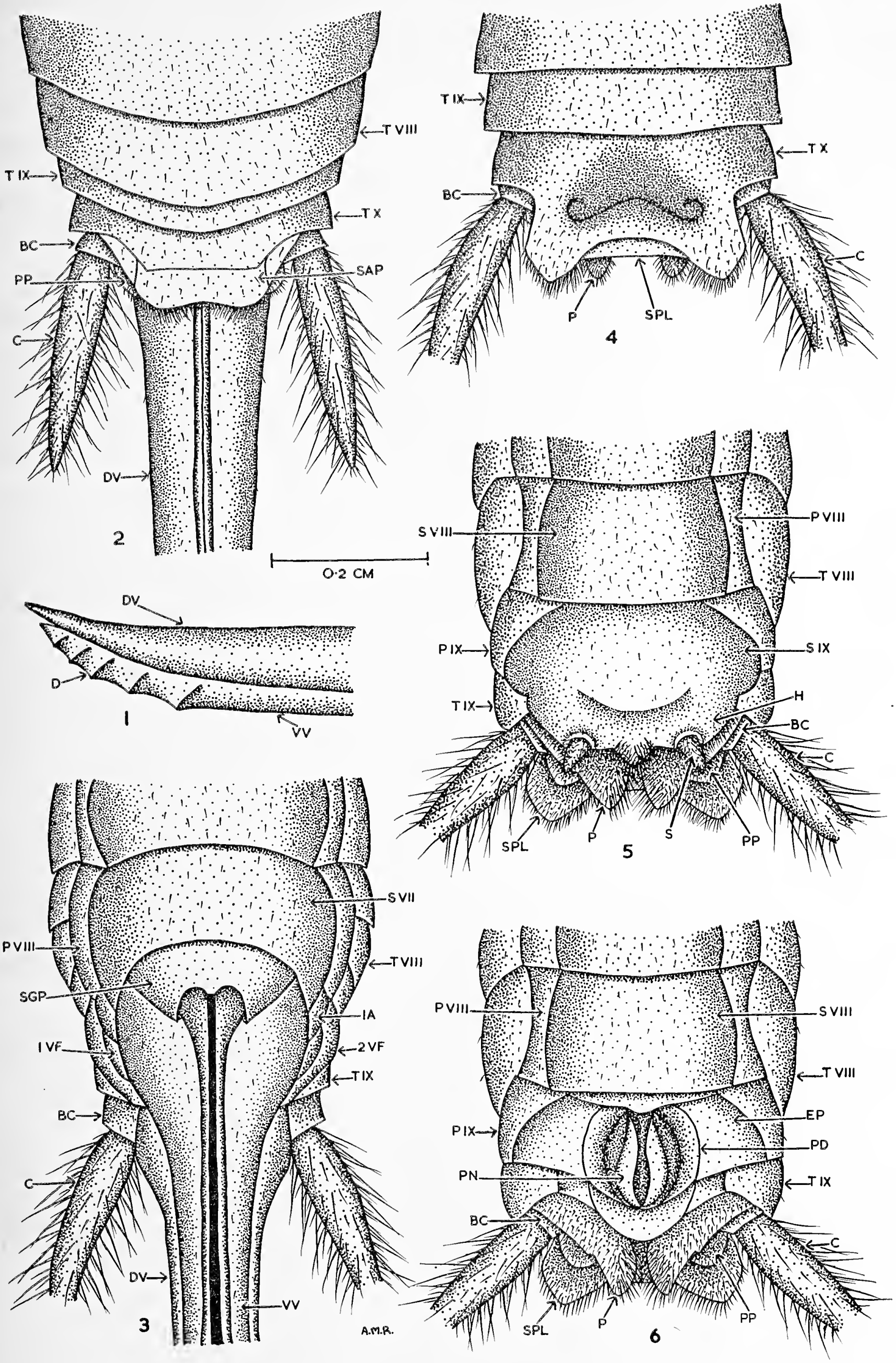
Legs—Fore and middle legs subequal in length, with hind leg twice length of fore and middle legs. Sexual dimorphism is shown by fore, middle and hind legs of female being 0·7 as long as male. All femora, tibiae and proximal two segments of hind tarsi armed with variable numbers of linear spines (Table 2). Apical spines constant in number, as in generic description. Ratio of length of legs to length of body: Fore leg, male 2·1 : 1; female 1·6 : 1. Middle leg, male 2 : 1; female 1·6 : 1. Hind leg, male 4 : 1; female 3 : 1.

Genitalia—Female: Suranal plate, Fig. 2 (SAP), distal margin emarginate and clothed with two groups of long setae; rest of plate sparsely clothed with short setae. Subgenital plate, Fig. 3 (SGP), 2·3 as wide as long; distal margin trilobed, two lateral lobes with an acute apex, median lobe truncated distally; median lobe 0·7 length of lateral lobes; whole plate glabrous.

Male: Suranal plate, Fig. 4 (SPL), concave laterally; distal margin with two lateral lobes clothed with long and short setae, medianly membranous, emarginate and glabrous; rest of dorsal surface sparsely clothed with setae. Subgenital plate, Fig. 5 (H), 1·6 wider than long, deeply convex proximolaterally changing to sharply indented 0·3 up from distal margin, then slightly convex; distal margin rounded laterally and medianly produced into a lobe with an acute apex; disto-lateral margin and dorsal and ventral surfaces of median lobe thickly clothed with long setae; rest of plate sparsely clothed with short setae. Medianly the plate is raised into a small tubercle. On ventral surface plate curves over anteriorly, and pseudosternite and penis are located under this flap. Two styli, Fig 5 (S), short, conical, thickly clothed with short setae, length of styli being 0·2 length of sternite IX (S IX). Parameres, Figs. 4, 5, 6 (P), elongate with rounded apex, outer lateral border indented 0·4 from apex, 2·6 as long as broad, distal portion thickly clothed with long and short setae. Pseudosternite, Fig. 6 (PD), subequal in length to width, distal margin rounded, laterally the plate partly covers each lobe of the penis. Penis, Fig. 6 (PN), two-lobed, each lobe 2·5 longer than wide. Paraprocts, Fig. 6 (PP), partly hidden between suranal plate and parameres, sparsely clothed with setae.

Locality—In cave, Strzelecki Peak, Flinders Island, Tasmania (type locality), coll. H. H. Finlayson, ? January 1930. Cave near Ranga, Flinders Island, coll. A. Dart 23/5/63; J. Partridge 10/12/66.

Type—The type of *C. flindersensis* (Chopard) is housed in the South Australian Museum, Adelaide. Fresh study material used in the redescription of the species has been deposited in the Australian National Insect Collection, Canberra, and in the Australian Museum Collection, Sydney.



Text-Figure 1—*Cavernotettix flindersensis* (Chopard)

1, Distal portion of ovipositor showing teeth on ventral valve; 2, Female genitalia, dorsal view; 3, Female genitalia, ventral view; 4, Male genitalia, dorsal view; 5, Male genitalia, ventral view; 6, Male genitalia, ventral view, subgenital plate removed to expose structures beneath.

Cavernotettix flindersensis is most closely related to *C. montanus* Richards (Richards, 1966), but differs from it in:

1. Presence of linear spines on fore and middle femora.
2. Shape of suranal plate of male.
3. Occurrence of five teeth on ventral valves of ovipositor.
4. Length of body, and ratio of length of legs to length of body larger in both male and female.

As four species have now been placed in the genus *Cavernotettix* Richards, a key to the genus is given below.

Key to the Species of Cavernotettix

1.	Fore and middle femora without linear spines	2.
	Fore and middle femora with linear spines	*C. flindersensis* (Chopard)
2.	Suranal plate of male with distal membrane; suranal plate of female sparsely clothed with setae	3.
	Suranal plate of male without distal membrane; suranal plate of female thickly clothed with setae	*C. buchanensis* Richards
3.	Lateral lobes of suranal plate of male thickly clothed with setae; retrolateral linear spines on hind femur of female over 30 ..	*C. wyanbenensis* Richards
	Lateral lobes of suranal plate of male sparsely clothed with setae; retrolateral linear spines on hind femur of female under 27 ..	*C. montanus* Richards

Acknowledgements

I should like to thank Miss J. Partridge, Department of Zoology, Monash University, for collecting and sending me specimens of the rhaphidophorids. I am also grateful to her for supplying me with information about the cave near Ranga, and the geology of the south-western part of Flinders Island. I am indebted to Dr. P. Crowcroft, Director of the South Australian Museum, Adelaide, for the loan of Chopard's type material of *Speleotettix flindersensis*, and other material in the Museum Collections. I am very grateful to Mr. G. F. Gross for checking the Museum records to determine the date of collection of the type material.

References

Chopard, L., 1944.—Description de deux Stenopelmatides cavernicoles d'Australie. *Bull. Soc. ent. Fr.*, XLIX(4): 52–55.

Gabriel, J., 1894.—Report of Expedition to Furneaux Group. *Vic. Nat.*, X(11): 167–184.

Kershaw, R. C., and Sutherland, F. L. (in press).—Cainozoic History of Flinders Island. *Rec. Q. Vic. Mus.*

Richards, Aola M., 1966.—The Rhaphidophoridae (Orthoptera) of Australia. Part 3. A new genus from south-eastern Australia. *Pacific Insects*, 8(3): 617–628.

Index to Table 2

Inf., Inferior; L., Left leg; Mid., Middle; Pro., Prolateral; R., Right leg; Retro., Retrolateral; Sup., Superior.

Index to Text-Figure

BC., basal segment of cercus; C., cercus; D., teeth; DV., dorsal valve; EP., endoparamere; H., subgenital plate, male; IA., intersegmental apodeme; MT IX., membrane of tergite IX; P., paramere (ectoparamere); P VIII, P IX., pleurite VIII, IX; PD., pseudosternite; PM., perianal membrane; PN., penis; S., stylus; S VII, S VIII, S IX., sternite VII, VIII, IX; SAP., suranal plate, female; SGP., subgenital plate, female; SPL., suranal plate, male; T VIII, T IX, T X., tergite VIII, IX, X; 1 VF., first valvifer; 2 VF., second valvifer; VV., ventral valve.

A DEVONIAN ECHINOID FROM TAEMAS, SOUTH OF YASS, N.S.W.

IDA A. BROWN (MRS. W. R. BROWNE)

(Plate IV)

[Read 28th June, 1967]

Synopsis

The paper describes a Lepidocentrid echinoid as a new genus and new species (*Cavanechinus warreni*) from the Middle Devonian Cavan Bluff Limestone near Taemas Bridge over the Murrumbidgee River, south of Yass, New South Wales. This is the first record of a Devonian echinoid from Australia.

INTRODUCTION

Echinoids are very rare Palaeozoic fossils in any part of the world. None is known from the Cambrian; three genera have been reported from the Upper Ordovician of Scotland, and about five genera are known from the Silurian of the British Isles, Gotland and North America. Six genera have been described from the Devonian; two of these are from the Lower Devonian of Germany, the others are from the Middle and Upper Devonian of North America and Europe.

There is a marked increase in the number and variety of forms in the Carboniferous and Permian of North America and Europe, with the remains of Cidaroida gradually replacing the earlier fossil Echinoidea.

In a paper on evolutionary trends shown by Palaeozoic echinoids Kier (1965) gives an analysis of the numbers of specimens, species and genera known up to date, proving the rarity of this group in the fossil record.

In Australia there are still scanty records of any Echinodermata from the Palaeozoic; representatives of most of the major groups have been found, but, except for crinoids, few individuals have been collected. Recent Australian discoveries include carpoid echinoderms from the Silurian and Devonian of Victoria (Gill and Caster, 1960), a Silurian edrioasteroid from Victoria (Philip, 1963), a Silurian cystoid from New South Wales (Brown, 1963), an Ordovician cystoid from Western Australia (Brown, 1964) and a Carboniferous echinoid from Western Australia (Thomas, 1965).

Palaeozoic echinoids are particularly rare. Etheridge (1892) described a specimen of a cidaroid (*Archaeocidaris selwyni*) from the Upper Marine (Permian) at Nowra, N.S.W., which had been rescued from the debris of the Garden Palace fire in Sydney in 1882, also an indeterminate species of about the same age from near Maitland, N.S.W.

Mitchell (1897) described a specimen from the Silurian shales at Bowning, N.S.W., as *Palaechinus* sp. The specimen is an external mould of about a dozen plates of an echinoderm, either an echinoid or a cystoid (Brown, 1963); the hexagonal plates are arranged in four rows, each plate showing fine tubercles in rows parallel to the sutures. No ambulacra are visible, but the specimen might possibly be part of the interambulacrum of an echinoid similar to the Silurian palaechinoid *Gotlandechinus* described by Regnéll (1957).

Apart from the recent paper by Thomas (1965) describing a specimen of *Oligoporus* (?) sp. from Western Australia, other records of Australian Palaeozoic echinoids are confined to notes on spines and fragments (Chapman, 1907; Jones, 1958, *etc.*).

The echinoid specimen now under consideration was collected by Dr. J. Warren of Monash University, Victoria, and was sent to me by Dr. J. A. Talent of the Geological Survey of Victoria. I am grateful to both of them for permission to describe and record it. It comes from the Devonian Cavan Bluff Limestone near the northern end of Taemas Bridge over the Murrumbidgee River at the head of Burrenjuck Reservoir, about 13 miles south of Yass, N.S.W.

An account of the stratigraphy and a map of the area have already been published (Browne, 1954, 1959) and the detailed palaeontology is still under consideration. On account of the rarity of Palaeozoic echinoderms in this country this form is being described separately.

The specimen is a block of limestone exposing fragments of several individuals of a Lepidocentrid echinoid associated with brachiopods (*Spirifer* spp. and *Atrypa* sp.), crinoid ossicles and other shell fragments. All the echinoid plates are of calcite; they are firmly cemented to the limestone matrix and could not be extracted from the rock. The limestone is black when fresh and weathers to a yellowish residue.

Comparison of the Taemas specimen with the published records of Palaeozoic echinoids indicates that it most closely resembles Devonian species of *Lepidechinoides* Olsson and *Leptocentrus* Müller from North America and Germany respectively.

In view of the geographical distances between these occurrences and the fact that some of the distinguishing characters of the genera from the northern hemisphere are not seen in the specimen under consideration it is proposed that a new genus be erected for the species from the Cavan Bluff Limestone.

It is of some interest to note that, although so few specimens of Australian Palaeozoic Echinoidea have been recognised up to the present, three Orders of the Sub-class Perischoechinoidea are represented by unique specimens; the Palaechinoida Haeckel, 1866, by *Oligoporus* (?) sp. (Thomas, 1965); the Cidaroida Claus, 1880, by *Archaeocidaris* sp. (Etheridge, 1892); and the Echinocystitoida Jackson, 1912, by the present species. There can be little doubt that many more specimens will be obtained in future collections here.

The classification of the Echinoidea has been discussed by Jackson (1912), Mortensen (1935), Durham and Melville (1957), Philip (1965), Kier (1965) and others. In the present paper the classification used in the "Treatise on Invertebrate Paleontology, Part U, Echinodermata 3(1)" (Moore, 1966) has been adopted.

SYSTEMATIC DESCRIPTION

Class ECHINOIDEA Leske, 1778
Sub-class PERISCHOECHINOIDEA McCoy, 1849
Order ECHINOCYSTITOIDA Jackson, 1912
Family LEPIDOCENTRIDAE Lovén, 1874
Genus CAVANECHINUS, new genus

Diagnosis—Lepidocentroid test, possibly spherical. Ambulacra narrow, composed of two columns of primary plates imbricating adorally and under the adradial columns. The height of four or five ambulacral plates equals the height of one adradial plate. Pore-pairs uniserial and situated midway between the perradial and adradial sutures; pores completely enclosed by the ambulacral plates.

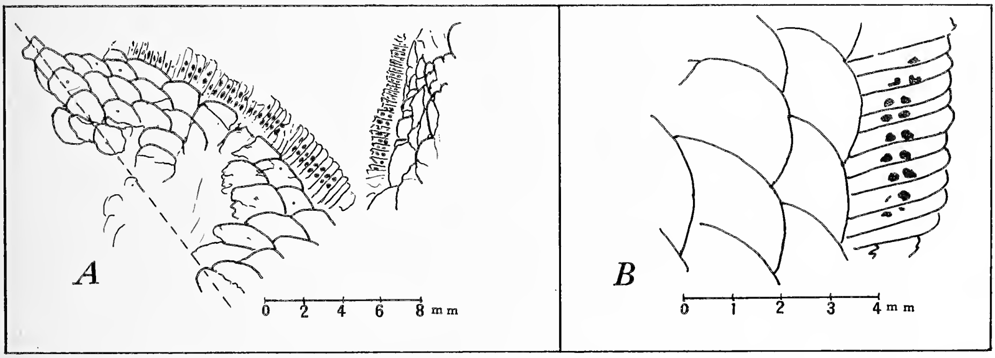
The interambulacra are at least four times the width of the ambulacra at the ambitus, with about nine (9) columns of plates strongly imbricating adapically and from the centre outwards over the ambulacra. Plates fan-shaped or polygonal, each with a small central tubercle. Small hollow spines associated. Apical, adoral and internal characters unknown.

Type Species—*Cavanechinus warreni*, gen.n. *et* sp. n.

Comparison with other genera—*Cavanechinus* is a typical member of the family Lepidocentridae, most closely resembling Devonian members.

Palaeodiscus Salter, 1857, from the Silurian of England is still imperfectly known as the specimens are poorly preserved. The pore-pairs in the peristomal region are closer to the perradial suture than in *Cavanechinus*, and according to Gregory (1897) there are no pores through the plates of the aboral surface. The lantern of *Palaeodiscus* has been studied by MacBride and Spencer (1938).

" *Koninckocidaris* " *silurica* Jackson from the Silurian Niagara Limestone, the oldest known echinoid in America, is probably not congeneric with the type species from the Mississippian (Kier, 1965, p. 450), but Jackson's (1912) figs. 5–6, Pl. 20, show a general resemblance to *Cavanechinus*. There are seven or eight columns of plates in the interambulacral areas and three ambulacral plates are equal in height to one adradial plate. As in *Palaeodiscus* the pores are closer to the perradial suture than in *Cavanechinus*.



Cavanechinus warreni gen. n. et sp. n. A. Sketch of Holotype (Aust. Mus. No. F. 52154), showing apical portion of interambulacrum and ambulacrum. Compare with Plate IV, fig. 1. B. Enlargement of ambulacral plates showing position of the pore-pairs. *cf.* Plate IV, fig. 2.

Porechinus Dehm, 1961, from the Rhine Valley, Germany, the only known early Devonian member of the Lepidocentridae, is based on a poorly preserved specimen, but differs from *Cavanechinus* in that the inner pore (nearer the perradial suture) is not completely enclosed by the ambulacral plate.

Lepidocentrus mülleri Schultze from the Middle Devonian of Germany as figured by Jackson (1912) Pl. 20, fig. 8, has a much larger test, but the shape, arrangement and ornamentation of the interambulacral plates are similar to those of *Cavanechinus* ; however, there are nearly twice the number of ambulacral plates to the height of one adradial plate.

Lepidechinoides Olsson, 1912, from the Middle Devonian of North America, most closely resembles *Cavanechinus* in so far as comparable characters are revealed. The genus was revised by Cooper (1931). It differs from *Cavanechinus* in that the ambulacra are relatively wider, being one-third to one-half the width of an interambulacrum, and the ambulacral plates are relatively larger, the height of two to four ambulacral plates equalling the height of one adradial plate.

Albertechinus Stearn, 1956, from the Upper Devonian of the Canadian Rockies, northwest of Calgary, Alberta, differs from *Cavanechinus* in that the interambulacra consist of numerous large and small irregularly arranged plates.

The only other known well-preserved specimen of an echinocystitoid from the Devonian is *Rhenechinus* Dehm, 1953, from the Lower Devonian Hansrückschiefer of Germany. It differs from *Cavanechinus* fundamentally in having four columns of plates in each ambulacrum, the occluded plates alternating with the primaries. There are seven or eight rows of plates in the interambulacra.

CAVANECHINUS WARRENI, sp. n.

Plate IV, Figs. 1 and 2 ; Text-fig.

Diagnosis—As for the genus.

Type Specimen—Holotype, Australian Museum, Sydney, No. F. 52154.

Material—The echinoid remains consist of numerous fragments embedded in a block of limestone about 10 cm. by 8·5 cm. by 2·5 cm. The largest specimen is that illustrated in Plate IV, fig. 1 (chosen as the holotype) covering an area of approximately 20 mm. by 20 mm. It consists of the adapical portions of two interambulacral areas and the intervening ambulacrum. The limestone block also shows several patches of imbricating ambulacral and interambulacral plates as illustrated in Plate IV, fig. 5, as well as scores of isolated plates, small spines (Plate IV, figs. 3 and 4) and possibly fragments of Aristotle's Lantern.

Shape—The holotype has been flattened but the curvature of the median suture of the ambulacrum indicates that the test must have been approximately globular, with an estimated diameter of 30 mm.

Ambulacra—The specimen shows two columns of primary ambulacral plates, which have been separated along the perradial suture. The plates are imbricating adorally and under the interambulacra. All the exposed plates are about the same size, each being about 2 mm. wide and 0·4 mm. high. The exposed height of four or five ambulacral plates equals the height of one adradial plate.

The ambulacrum is almost one quarter of the width of the interambulacrum at the widest part exposed.

The pore-pairs are uniserial ; each pore-pair is situated approximately in the centre of the plate and each pore is completely enclosed by the ambulacral plate. No tubercles have been observed ; the specimen is on the weathered surface of the limestone and any fine ornamentation may have been lost : in fact the edge of the ambulacrum figured at the left of Plate IV, fig. 1 has been partly eroded.

Interambulacra—These consist of at least nine columns of plates. The holotype shows portion of the central row and four lateral rows of plates on one side and a few plates on the other side. At its widest part it is nearly four times the width of the ambulacrum. The plates are strongly imbricating adapically and laterally away from the central column over the ambulacral plates. On account of weathering no fine ornamentation is preserved and the exposed edges of the plates appear rounded. Some of the plates show a low tubercle near the centre, others show a perforation in the same position.

The reverse side of the specimen shows many isolated plates, both ambulacral and interambulacral, the latter frequently hexagonal in outline (Plate IV, figs 3, 4), with a central perforation.

Spines—No spines have been seen attached to the plates of the holotype, but numerous hollow, simple spines are associated with the plates on the reverse side of the specimen (Plate IV, figs. 3,4).

Lantern, *apical* and *adoral systems* are not known. A few isolated fragments show some resemblance to portions of echinoid teeth.

Occurrence—Cavan Bluff Limestone, Murrumbidgee Series. Middle Devonian.

Locality—On the north side of Burrenjuck Reservoir, within a quarter of a mile to the west of the northern end of Taemas Bridge over the Murrumbidgee River, 13 miles south of Yass, N.S.W. Collected by Dr. J. Warren.

References

BROWN, IDA A., 1963.—A new Cystoid (Pelmatozoa, Echinodermata) from the Silurian of New South Wales. PROC. LINN. SOC. N.S.W., 88(3) : 386–391.

————, 1964.—An Ordovician Cystoid (Pelmatozoa, Echinodermata) from Western Australia. *Jour. roy. Soc. W.A.*, 47(1) : 3–7.

Browne, Ida A., 1954.—Pres. address. A study of the Tasman Geosyncline in the region of Yass, N.S.W. *Jour. and Proc. roy. Soc. N.S.W.*, 88(1): 1.

————, 1959.—Stratigraphy and structure of the Devonian rocks of the Taemas and Cavan areas, Murrumbidgee River, south of Yass. *Jour. and Proc. roy. Soc. N.S.W.*, 92: 115.

Chapman, F., 1907.—Rec. geol. Surv. Vict., II(1): 77.

Cooper, G. A., 1931.—*Lepidechinoides* Olsson, A genus of Devonian Echinoids. *Jour. Paleont.*, 5(2): 127–142.

Dehm, R., 1953.—*Rhenechinus hopstätteri* nov. gen. sp., ein seeigel aus rheinischen Unter-Devon. *Notizblatt Hessischen Landes Amtes Bodenforschung Wiesbaden*, 81: 88–95.

————, 1961—Ein zweiter Seeigel, *Porechinus porosus* nov. gen. nov. spec., aus dem rheinischen Unter-Devon. Bayerische Staatssammlung Palaeontologie Histerische, Mitteilungen, München, 1: 1–8.

Durham, J. W., and Melville, R. V., 1957.—A classification of Echinoids. *Jour. Paleont.*, 31(1): 242–272.

Etheridge, R., Jnr., 1892.—A monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales, Part II. *Mem. Geol. Surv., N.S.W., Palaeontology*, 5: 678, Pl. XV.

Gill, E. D., and Caster, K. E., 1960.—Carpoid Echinoderms from the Silurian and Devonian of Australia. *Bull. Amer. Paleont.*, 41(185): 5–70.

Gregory, J. W., 1897.—On *Echinocystis* and *Palaeodiscus*—two Silurian genera of Echinoidea. *Quart. Jour. geol. Soc. London*, 53: 123–134.

Jackson, R. T., 1912.—Phylogeny of the Echini, with a revision of Palaeozoic species. *Mem. Boston Soc. nat. Hist.*, VII: 1–443, Pl. 1–76.

Jones, P. J., 1958.—Preliminary report on Ostracoda from Bore B.M.R. No. 2, Laurel Downs, Fitzroy Basin, Western Australia. *Bur. min. Resour. Aust. Rept.*, 38: 37–52.

Kier, P. M., 1965.—Evolutionary trends in Paleozoic Echinoids. *Jour. Paleont.*, 39(3): 436–465.

MacBride, E. W., and Spencer, W. K., 1938.—Two new Echinoidea, *Aulechinus* and *Ectinechinus*, ... from the Upper Ordovician of Girvan, Scotland. *Royal Soc. London*, Philos. Trans., Ser. B., 229, 558: 91–136.

Mitchell, J., 1897.—On the occurrence of the genus *Palaechinus* in the Upper Silurian rocks of New South Wales. Proc. Linn. Soc. N.S.W., 22(2): 258–259.

Moore, R. C. (Editor), 1966.—Treatise on Invertebrate Paleontology, Part U, Echinodermata 3, Vol. 1, p. U295. Geol. Soc. Amer. N.Y., and Univ. of Kansas Press.

Mortensen, T., 1935.—" A Monograph of the Echinoidea, Vol. 2 ". (C. A. Reitzel, Copenhagen).

Philip, G. M., 1963.—The first recorded Australian Edrioasteroid. *Aust. Jour. Sci.*, 26(1): 25.

————, 1965.—Classification of Echinoids. *Jour. Paleont.*, 39(1): 45–62.

Regnéll, G., 1957.—Silurian Echinoids from Gotland. *Arkiv. för Mineralogi och Geologi*, Bd. 2, 7: 155–178.

Stearn, C. W., 1956.—A new Echinoid from the Upper Devonian of Alberta. *Jour. Paleont.*, 30(3): 741–746.

Thomas, G. A., 1965.—An Echinoid from the Lower Carboniferous of north-west Australia. *Proc. roy. Soc.* Vic., 79(1): 175–178.

EXPLANATION OF PLATE IV

Figs 1–5

Cavanechinus warreni Brown, gen. n. et sp. n. from Cavan Bluff Limestone, Murrumbidgee Series; near Taemas Bridge, 13 miles south of Yass, N.S.W. Middle Devonian. *Photo. I.A.B.*

Fig. 1

Adapical view of holotype (Aust. Mus., No. F. 52154) showing apical portion of ambulacrum and adjacent interambulacrum. Mag. ×4.

Fig. 2

Adapical view of portion of ambulacrum and adjacent interambulacrum showing imbrication and position of the pore-pairs. Mag. ×10.

Fig. 3

Isolated plates and spines. Mag. ×10.

Fig. 4

Isolated hexagonal plates and spines. Mag. ×4.

Fig. 5

Patches of imbricating plates—interambulacral on the left, and side view of ambulacral plates in the upper centre. Mag. ×4.

PERMIAN POLYZOA FROM THE PORT KEATS DISTRICT, NORTHERN TERRITORY

Robin E. Wass
Department of Geology and Geophysics, University of Sydney

(Plate V)

[Read 28th June, 1967]

Synopsis

A polyzoan fauna from two localities in the Port Keats District is described and discussed. *Polypora* sp. nov. Crockford, 1957, is named *Polypora bruteni* and the identity of *Streblascopora browni* (Etheridge) and *Streblascopora marmionensis* (Bretnall) is considered. The faunas are Lower Permian in age and occur in strata correlative with the Noonkanbah Formation. Numerous type localities are revised.

Introduction

Polyzoa from Port Keats were recorded first by Etheridge (1907). From the No. 3 Bore he described three species which were revised and redescribed by Crockford (1943). The present specimens were collected from two localities: a B.M.R. (Bureau of Mineral Resources, Geology and Geophysics) surface sample, 627/1, on the Port Keats 1 : 253,440 Geological Series Sheet D52-11, Lat. 14°26′, Long. 129°43′, 7·2 miles north-north-west of Table Hill and from an A.A.P. (Australian Aquitaine Petroleum Pty. Ltd.) seismic hole, SP. 323, at a depth of 144 feet, on the same map at Lat. 14°26′, Long. 129°34′, 8 miles north-north-east of Fossil Head, Northern Territory.

Ages of rock units deduced previously by Dickins (1964, Ms.) using brachiopods and molluscs are related to the standard sequence in the Ural Mountains and on the Russian Platform. All specimens are housed in the Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Canberra.

Abbreviations of repositories used throughout the text are: A.M., Australian Museum Palaeontological Collection, Sydney; C.P.C., Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Canberra; U.W.A., University of Western Australia, Department of Geology, Perth.

Systematic Descriptions

Order Cyclostomata Busk, 1852

Family Hexagonellidae Crockford, 1947

Genus Evactinostella Crockford, 1957

Type Species—(by original designation) *Evactinospora crucialis* Hudleston, 1883, p. 593, pl. 23, figs. 2*a-c*, possibly from the Callytharra Formation, in the "Fossil Range, north of the Lyons River", Western Australia.

Diagnosis—See Crockford, 1957, p. 27.

Remarks—Hudleston's specimens cannot be found in any museum in the world and the locality quoted is from Hudleston (1883). The stratigraphic horizon has been deduced by the writer.

Evactinostella crucialis (Hudleston), 1883

Evactinopora crucialis Hudleston, 1883, p. 593, pl. 23, figs. 2*a-c*.

Hexagonella crucialis (Hudleston); Hinde, 1890, p. 200.

Evactinopora crucialis Hudleston; Etheridge, 1914, p. 18, pl. 2, fig. 7, pl. 5, figs. 1-2.

Meekoporella crucialis (Hudleston); Moore and Dudley, 1944, p. 305.

Evactinostella crucialis (Hudleston); Crockford, 1957, p. 28, pl. 7, figs. 1-5.

Holotype—A single specimen described by Hudleston was the holotype. Crockford (1957) did not select a neotype because of the uncertain nature of the type locality making selection of topotype material difficult.

Diagnosis—See Crockford, 1957, p. 28.

The specimens recorded from Port Keats are typical of this species, possessing four bifoliate rays which diverge out and up from the centre of the zoarium. Maculae may be developed on the surface. Crockford (1957) mentions the presence in Western Australia of an undescribed species of the genus in which the rays diverge horizontally from the centre of the zoarium. A thorough search of Port Keats material in an attempt to locate this species has been unsuccessful.

The change in zoarial habit from diverging up and out to horizontal may be related to the depositional environment. Crockford (1957) has stated that the enclosing sediment for *E. crucialis* is usually a coarse sandstone or sandy limestone. The undescribed species of *Evactinostella* is much smaller than *E. crucialis*. Small species of *Evactinopora* in the Mississippian of the United States are found in shale whereas larger species occur in sandier sediments. Specimens catalogued from locality 627/1 are C.P.C. 7703–5.

Genus FISTULAMINA Crockford, 1947.

Type Species—(by original designation) *Fistulamina inornata* Crockford, 1947, p. 28, pl. 4, figs. 5–6, text figs. 33–36, from the Visean, Burindi Series, 1·5 miles north of Clarencetown, New South Wales; 806734 Paterson 1 : 63,360 military map, on the ridge west of the Clarencetown-Glen William Road, New South Wales.

Diagnosis—Zoarium bifoliate; branches straplike, possibly with non-celluliferous edges; surface without maculae or hexagonellid ridges; internally, zooecial tubes are long and thin, with lunaria and without vestibules; zooecial tubes separated by vesicular tissue near mesotheca and dense tissue near the surface.

Remarks—*Fistulamina* is a characteristic genus from the Carboniferous, but not the Permian, of Eastern Australia. Crockford (1957) first recorded the genus from the Permian of Western Australia where it is associated with two other strap-like forms, *Liguloclema* Crockford and an undescribed polyzoan of cryptostomatous affinities. From *Liguloclema*, species of *Fistulamina* may be separated as they possess long, thin zooecial tubes which are not hook-shaped as in *Liguloclema*; from the undescribed cryptostome, *Fistulamina* may be distinguished by the nature of the zooecial tubes and the absence of vestibules.

FISTULAMINA sp.

(Pl. V, fig. 1)

Description—The zoarium is strap-like, bifoliate and ramose. Branching occurs at intervals of 5·80 mm.–6·60 mm. Stable width of the zoarium ranges from 1·68 mm. to 1·88 mm.; proximal to branching it may be 2·40 mm. wide while distally it may be 2·10 mm. Thickness of branches is 0·75 mm. to 0·95 mm. Surface features such as maculae are absent.

Zooecia are arranged in seven or eight longitudinal rows but diagonal rows are evident, making an angle of 35° to 45° with longitudinal rows. The number of zooecial rows may increase to ten proximal to branching. Zooecial diameter is 0·14 mm. to 0·19 mm. and centres of successive zooecial apertures in the same longitudinal row are separated by 0·48 mm. to 0·72 mm.

Internally the zooecia are long and narrow and for most of their growth they lie close to the mesotheca but then diverge to the surface. No diaphragms were observed.

Remarks—From *Fistulamina lata* Crockford, this species can be distinguished by its smaller size and closer spacing of zooecia. The specimen catalogued from Port Keats is C.P.C. 7706 from 627/1.

Genus HEXAGONELLA Waagen and Wentzel, 1886.

Type Species—(by subsequent designation of Bassler, 1929, p. 51) *Hexagonella ramosa* Waagen and Wentzel, 1886, pp. 909, 911, possibly from the Permian, Middle Productus Limestone of the Salt Range, India.

Diagnosis—See Crockford, 1944*b*, p. 149.

HEXAGONELLA DENSA Crockford, 1944*b*

Hexagonella densa Crockford, 1944*b*, p. 151, pl. 4, fig. 2, text figs. 21–22*a*.

Holotype—22131 U.W.A. Collection from the Artinskian, Bulgadoo Shale, Lat. 23°58′20″, Long. 114°31′20″, Minilya 1 : 253,440 Geological Series Sheets F49–16 and F50–13, 5·6 miles at 230° from Billamberry Dam, " Wandagee ", Western Australia.

Remarks—The locality tabled by Crockford (1944*b*, p. 151) is not shown on the Minilya Sheets. Mr. T. Nicholas, Bureau of Mineral Resources, has forwarded the grid references to me and from them the foregoing locality has been compiled. Discussion relating to the stratigraphic horizon can be found in Teichert (1952).

Diagnosis—Broad, frond-like species ; surface with well developed maculae and few hexagonellid ridges ; zooecia small with indistinct lunaria, diaphragms few ; zooecia separated by vesicular and dense tissue ; mesotheca thin with coarse median tubuli.

The Port Keats material is similar to zoaria described by Crockford (1944*b*), being broad and bifoliate with solid maculae and faint hexagonellid ridges. Diaphragms are present in places. The development of tissue in this material is the same as outlined in the original description of *H. densa*. Specimen C.P.C. 7707 from 627/1 has been catalogued from Port Keats.

Order CRYPTOSTOMATA Shrubsole and Vine, 1882

Family RHABDOMESIDAE Vine, 1883

Genus SAFFORDOTAXIS Bassler, 1952

Type Species—(by original designation) *Rhombopora incrassata* Ulrich, 1890, p. 652, pl. LXX, figs. 12–12*d*, from the Lower Mississippian, Keokuk Formation, at King's Mountain, near Louisville, Kentucky, U.S.A.

Diagnosis—Zoarium, slender, ramose ; zooecia tubular, diverging from a central axis, thin walled in mature zone ; diaphragms may be developed ; apertures oval, in longitudinal and diagonal rows ; megacanthopores surround each zoarium, usually in one row, but occasionally in more rows ; mesopores absent.

Remarks—A perusal of the literature has shown that although many species of *Saffordotaxis* do possess more than one row of acanthopores this fact is rarely mentioned by workers. In his original diagnosis of the genus, Bassler (1952, p. 385) recognises this feature as does Ulrich (1890, p. 652 and pl. LXX, fig. 12*b*). Bassler (1953, p. G134) mentions only one row of megacanthopores.

SAFFORDOTAXIS ELEGANS Crockford, 1957

Saffordotaxis elegans Crockford, 1957, p. 77, pl. 21, figs. 1–4.

Holotype—C.P.C. 1185E from the Artinskian, Noonkanbah Formation, approximately 22 miles south-east of " Cherrabun ", Western Australia ; Lat. 18°46′, Long. 125°33′, Noonkanbah 1 : 253,440 Geological Series Sheet E51–12, approximately 7·5 miles west-south-west of Brutens Yard, " Cherrabun ", Western Australia (Crockford, 1957, p. 77).

Diagnosis—Fine ramose zoaria with approximately ten rows of oval, widely separated apertures ; usually from 14 to 16 acanthopores, arranged in one row or in a few places, two rows, surround each aperture.

In view of the modification of the specific diagnosis it seems that *Saffordotaxis multigranulata* (Bretnall) and *S. elegans* are similar in acanthopore arrangement. Crockford (1957, p. 77) stated that there were two rows of acanthopores in the former species and that *S. elegans* had a more regular acanthopore arrangement. The widely spaced zooecial apertures in the latter species is the main means of separating the two species. Specimens C.P.C. 7708–9 from 627/1 referred here to *Saffordotaxis elegans* agree in all respects with those of Crockford (1957). Two rows of acanthopores are present in places and the zooecial apertures are widely spaced.

Genus STREBLASCOPORA Bassler, 1952.

Type Species—(by original designation) *Streblotrypa fasciculata* Bassler, 1929, p. 66, from the Permian Bitaeoni Beds of Timor.

Diagnosis—Zoaria ramose with an axial bundle of parallel tubes ; zooecia tubular, thin walled in immature zone, thick walled in mature zone, often with hemisepta ; apertures arranged in longitudinal and diagonal rows with mesopores separating apertures in longitudinal rows ; small acanthopores may be present near apertures.

STREBLASCOPORA MARMIONENSIS (Bretnall), 1926.

(Pl. V, figs. 2–3)

Streblotrypa marmionensis Etheridge ; Bretnall, 1926, p. 22, pl. 1, figs. 1, 7, pl. 2, fig. 3.

cf. *Streblotrypa germana* Bassler, 1929, p. 67, pl. CCXXXIX, figs. 6–10.

Streblotrypa marmionensis Etheridge ; Hosking, 1931, p. 14, pl. 4, fig. 1, text fig. 1.

Streblotrypa marmionensis Etheridge ; Crockford, 1944*b*, p. 168, pl. 5, figs. 10, 11, text figs. 31–34.

Streblascopora marmionesis (sic) (Etheridge) ; Crockford, 1957, p. 80.

Holotype—F. 17548 A.M. Collection from the Artinskian, Noonkanbah Formation, near Mount Marmion, Western Australia ; Lat. 17°23′, Long. 124°21′, Derby 1 : 253,440 Geological Series Sheet E51–7, at the base of Mount Marmion, " Kimberley Downs ", Western Australia (Crockford, 1944*b*, p. 168, pl. 5, fig. 11).

Neotype—(chosen Crockford, 1957, p. 80) F. 17551 A.M. Collection from the above locality.

Diagnosis—Ramose *Streblascopora* with cylindrical branches having usually 16 to 20 longitudinal rows of zooecial apertures and with distinct areas of pits marked off by longitudinal ridges ; each area contains from 4 to 14 mesopore pits.

A full discussion of the locality, specimen numbers and change of author of the species are included in Wass (in prep.) and no elaboration need be made here.

Crockford (1943) redescribed *Streblotrypa browni* Etheridge from Port Keats and designated a neotype. This species contains a central bundle of parallel tubes and should be referred to as *Streblascopora browni* (Etheridge). Crockford considers it to be separate from *S. marmionensis* because of the arrangement of mesopores into hexagonal areas. However, the two species are of similar size and measurements of both species are tabled below. In most morphological features there is overlap. Examination of more specimens from Port Keats has strengthened the possibility that the two species may be identical. Specimens are in different states of preservation and in one zoarium, C.P.C. 7710, a change from the hexagonal arrangement of *S. browni* to the longitudinal arrangement of *S. marmionensis* can be observed. The arrangement of mesopores may be due to preservation. Until the lectotype of *S. browni* is studied a final statement on the identity of the two species cannot be made. Specimens of *Streblascopora marmionensis* catalogued from locality 627/1 at Port Keats are C.P.C. 7710–14.

TABLE I

	S. marmionensis (Crockford, 1944*b*)	*S. browni* (Crockford, 1943)
D	1·0–1·6 mm.	about 1·35 mm.
Zr	15–24	about 24
Z–Z	0·32–0·68 mm.	0·38–0·62 mm.
Mp	4–12	9–12
Z/10	about 22	about 22
Zd	0·14–0·21 × 0·10–0·14 mm.	about 0·18 × 0·24 mm.

D, Zoarial Diameter ; Zr, rows of zooecial apertures ; Z–Z, interval between centres of successive zooecial apertures ; Mp, number of mesopore pits proximal to aperture ; Z/10, number of zooecial apertures in 10 mm. ; Zd, measurement of zooecial aperture.

Family FENESTELLIDAE King, 1849.

Genus FENESTELLA Lonsdale, 1839

Type Species—(by subsequent designation of Riley, 1962) *Fenestella subantiqua* d'Orbigny, 1850, p. 180, from the Silurian Wenlock Limestone at Dudley, England.

Diagnosis—Zoarium fan or funnel shaped ; zooecia in two rows on branches, commonly increasing to three proximal to bifurcation ; rows of zooecia separated by a nodose carina on the obverse surface ; reverse surface of varying orientation.

FENESTELLA HOROLOGIA Bretnall, 1926.

The detailed morphology of this species and its identity with *Minilya duplaris* have been discussed recently by Wass (1966) and no elaboration is made here. Specimens recorded from Port Keats are C.P.C. 7715–6 from 627/1.

FENESTELLA LENNARDI (Crockford), 1944*a*.

(Fig. 1)

Fenestrellina lennardi Crockford, 1944*a*, p. 171, text fig. 1A.

Holotype—20948 U.W.A. Collection from the Artinskian Noonkanbah Formation, on the south side of Mount Marmion, " Kimberley Downs ", Lat. 17°23′, Long. 124°21′, Derby 1 : 253,440 Geological Series Sheet E51–7, east of Derby, Western Australia (Crockford, 1944*a*, p. 171, text fig. 1A).

Diagnosis—*Fenestella* with narrow branches and dissepiments ; one zooecium per fenestrule, apertures stabilized on dissepiments ; carina slight, nodes small and numerous ; zooecial base shape triangular with flange, becoming pentagonal in upper levels of the branch.

The specimen from Port Keats referred to this species has morphology and measurements similar to those tabled by Crockford (1944*a*, Table II). However, Crockford states that the nodes are small and not well shown. Observations by the writer on the holotype did not reveal any pertinent information. On the specimen from Port Keats, centres of successive nodes are from 0·22 mm. to 0·28 mm. apart and 21 to 24 nodes occur in 5 mm. These measurements, together with the zooecial base shape enable the following micrometric formula to be compiled.

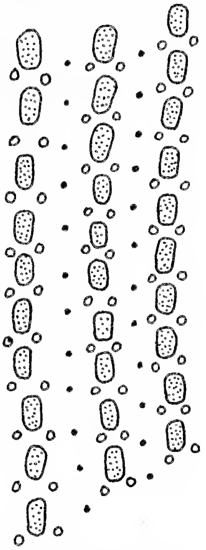
20–23/ 30–32// 15–16/ 21–24// 0·24–0·32/ 0·1/ T

One feature immediately revealed is the relation between the first and second parameters in the formula. Comparisons effected at a specific level show that, to the writer's knowledge, no known species of *Fenestella* has a similar mesh-work formula. The large number of fenestrules per 10 mm. compared with the number of branches per 10 mm. is considered unique in this species. The specimen recorded from locality 627/1 at Port Keats is C.P.C. 7717.

Genus POLYPORA McCoy, 1844.

Type Species—(by subsequent designation of Vine, 1884, p. 194) *Polypora dendroides* McCoy, 1844, p. 206, from the Tournaisian of Ireland.

Diagnosis—See Miller, 1963, p. 166.



Text fig. 1.—*Fenestella lennardi* (Crockford). Drawing from a photograph to show the position of nodes on the branch relative to the zooecial apertures. ×20.

POLYPORA RECTIFIS Crockford, 1944*a*.

Polypora rectifis Crockford, 1944*a*, p. 176, pl. 2, fig. 4.

Holotype—20951 U.W.A. Collection from the Artinskian Wandagee Formation, Minilya Syncline, Minilya River, Western Australia; Lat. 23°44′, Long. 114°25′, Minilya 1 : 253,440 Geological Series Sheets F50–13 and F49–16, half a mile west of Coolkilya Pool, Minilya River, Western Australia. (Crockford, 1944*a*, p. 176, pl. 2, fig. 4).

Diagnosis—*Polypora* with narrow branches and fenestrules; dissepiments of similar width to fenestrules; three or four rows of zooecia per branch with three or four zooecia per fenestrule; nodes large and infrequent.

The specimen from locality 627/1 at Port Keats, C.P.C. 7718, is distorted slightly but the relatively fine meshwork with narrow branches and fenestrules enable it to be attributed confidently to this species. *Polypora fenestelloides* Shulga-Nesterenko, 1941, and *P. brinensis* Shulga-Nesterenko, 1951, have similar meshwork formulae to *P. rectifis* but differ in that they have much narrower dissepiments and usually narrower branches and fenestrules.

POLYPORA WADEI Crockford, 1957.

Polypora wadei Crockford, 1957, p. 65, pl. 17, fig. 4.

Holotype—C.P.C. 1080B from the Artinskian Noonkanbah Formation, 21 miles south-east of "Cherrabun", Western Australia; Lat. 18°43′, Long. 125°32′, Noonkanbah 1 : 253,440 Geological Series Sheet E51–12, 2·9 miles at 70° from Chestnut Bore, "Cherrabun", Western Australia.

Diagnosis—Straight branches with oval or rectangular fenestrules separated by narrow dissepiments; five or six rows of apertures per branch with six or seven apertures per fenestrule; nodes not developed.

The specimens catalogued from Port Keats, C.P.C. 7719 from 627/1 and C.P.C. 7720 from SP. 323, agree in all respects with the specimens described by Crockford (1957). Species with similar meshwork formulae to *P. wadei* are *P. maccoyana* Ulrich, 1890, and *P. vereyensis* Shulga-Nesterenko, 1951. Both species have narrower branches. *P. simulatrix* Ulrich, 1890, usually has narrower branches together with narrower dissepiments and fenestrules. Of the other Russian species, *P. variocellata* Nikiforova, 1938, has wider dissepiments as has *P. remota* var. *russiensis* Shulga-Nesterenko, 1941, with the latter species usually having narrower branches. *P. abundans* Shulga-Nesterenko, 1951, has narrower branches and dissepiments whereas *P. martis* var. *laxata* Trizna, 1939, and *P. panteleevi* Morozova, 1955, have longer fenestrules, narrower dissepiments and generally narrower branches.

POLYPORA BRUTENI sp. nov.

Polypora sp. nov. Crockford, 1957, p. 66, pl. 17, fig. 3.

Holotype—C.P.C. 1250 from the Artinskian Noonkanbah Formation, approximately 23 miles south-east of "Cherrabun", Western Australia; Lat. 18°42′, Long. 125°35′, Noonkanbah 1 : 253,440 Geological Series Sheet E51–12, 4 miles at 260° from Chestnut Bore, "Cherrabun", Western Australia.

Diagnosis—Straight branches; short rounded fenestrules with dissepiments of similar dimensions; five or six rows of zooecia with four or five zooecia per fenestrule; nodes present, but indistinct.

Description—Micrometric Formula:

R/B	B/10	D/10	Z/5	N/5	Bw	Zd
5–6	7–10	6–8	13–14	?	0·50–1·25	0·11–0·14

The species has been described previously by Crockford (1957). Measurements tabled for B/10 and D/10 are new but otherwise no change is made from the original description. Specimen C.P.C. 7721 from 627/1 is catalogued from Port Keats.

Species with similar meshwork formulae to *P. bruteni* are *P. halliana* Prout and *P. stellispinata* Shulga-Nesterenko, 1955, but they both have narrower dissepiments. *P. subvaricellata* Shulga-Nesterenko, 1952, usually has wider fenestrules with narrower branches and dissepiments and *P. timorensis* var. *darashamensis* Nikiforova, 1933, has narrower fenestrules and dissepiments. *P. vereyensis* Shulga-Nesterenko, 1951, has longer fenestrules of different shape to those in *P. bruteni*.

Genus PROTORETEPORA de Koninck, 1877.

Type Species—(by original designation) *Fenestella ampla* Lonsdale, in Strzelecki, 1845, p. 268, pl. 9, fig. 3*b* only, from the southern part of Tasmania.

Diagnosis—Branches non-carinate, non-nodose, with more than two rows of zooecial apertures on the branches; dissepiments celluliferous to the exclusion of dissepimental tissue.

PROTORETEPORA AMPLA (Lonsdale), 1844.

Fenestella ampla Lonsdale, in Darwin, 1844, p. 163.

Fenestella ampla Lonsdale, in Strzelecki, 1845, p. 268, pl. 9, fig. 3*b*.

Protoretepora ampla (Lonsdale); de Koninck, 1877, p. 180, pl. 8, fig. 5.

Protoretepora ampla (Lonsdale); Crockford, 1941, p. 406, pl. 19, fig. 4, text fig. 2A.

Protoretepora ampla (Lonsdale); Crockford, 1944*b*, p. 160.

Protoretepora ampla (Lonsdale); Crockford, 1957, p. 68.

Holotype—Lost; from the southern part of Tasmania.

Neotype—A suitable neotype has never been selected.

Diagnosis—Wide branches connected by celluliferous dissepiments of similar width; oval fenestrules; zooecia in four to eight rows on the branches, two to three rows on dissepiments; four to six zooecia per fenestrule.

This species is widespread geographically and stratigraphically in Permian rocks and has been discussed previously by many authors. Smith (in prep.) has a discussion of the species and its type locality in the Bundella Mudstone at Lower Sandy Bay, Hobart, Tasmania. Specimens collected from this locality by the writer show more variation than is mentioned by Crockford (1941). The specimen from 627/1 at Port Keats, C.P.C. 7722, exhibits all the characteristics of *Protoretepora ampla*.

Also found in the fauna from both localities are small fragments of ?*Etherella* sp., ?*Prismopora* sp., ?*Liguloclema* sp., and ?*Rhombopora* sp. An uncatalogued specimen of ?*Liguloclema* cf. *typicalis* Crockford is recorded from SP. 323. Small ramose stenoporids have been recorded also and these, together with others from Western Australia, will be the subject of another paper.

CONCLUSIONS

From field evidence the stratigraphical relationship of the samples is not clear. However, both faunas contain forms which suggest they are equivalent to the Noonkanbah Formation. It would be difficult, using only the polyzoans, to determine whether or not there is a time break between the two localities. 627/1 could be stratigraphically higher than SP. 323 because of the occurrence of *Fenestella lennardi*, *Evactinostella crucialis* and *Streblascopora marmionensis*. These species also occur lower down in the Noonkanbah. The fauna from SP. 323 is Lower Permian and is, in my opinion older than the fauna in the Port Keats No. 3 Bore which is apparently Upper Permian.

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References

BASSLER, R. S., 1929.—The Permian Bryozoa of Timor. *Paleont. Timor*, 16(28): 37–90.

————, 1952.—Taxonomic notes on genera of Recent and fossil Bryozoa. *J. Wash. Acad. Sci.*, 42: 381–385.

————, 1953.—*Bryozoa in* "Treatise on Invertebrate Paleontology", Part g. Ed. R. C. Moore, Lawrence, Kansas, Univ. Kansas Press for Geological Society of America.

BRETNALL, R. W., 1926.—Palaeontological contributions to the geology of Western Australia, 7(13): Descriptions of some Western Australia fossil Polyzoa. *Bull. geol. Surv. West. Aust.*, 88: 7–33.

CROCKFORD, J. M., 1941.—Permian Bryozoa from eastern Australia, Part 1: A revision of some previously named species of Fenestrellinidae (Fenestellidae). *J. Proc. R. Soc. N.S.W.*, 74(4): 397–418.

————, 1943.—Bryozoa from the Port Keats Bore, Northern Territory. PROC. LINN. SOC. N.S.W., 68: 145–148.

————, 1944*a*.—Bryozoa from the Wandagee and Noonkanbah Series (Permian) of Western Australia. *J. Proc. R. Soc. West. Aust.*, 28: 165–185.

————, 1944*b*.—Bryozoa from the Permian of Western Australia, Part 1: Cyclostomata and Cryptostomata from the North-west Basin and Kimberley District. PROC. LINN. SOC. N.S.W., 69: 139–175.

Crockford, J. M., 1947.—Bryozoa from the Lower Carboniferous of Queensland and New South Wales. *Ibid.*, 72 : 1–48.

————, 1957.—Permian Bryozoa from the Fitzroy Basin, Western Australia. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*, 34.

Darwin, C., 1844.—" *Geological Observations* ". (Elder Smith, London).

Dickins, J. M., 1964., Ms.—Correlation and subdivision of the Permian of Eastern and Western Australia. 22nd Int. geol. Congr.

Etheridge, R., 1907.—Official contributions to the palaeontology of Western Australia, 19. Fossils of the Port Keats Bore, thirty miles north of Fossil Head, Treachery Bay. *Suppl. Parl. Pap.*, 55.

————, 1914.—Palaeontological contributions to the geology of Western Australia, 5(10) : Western Australian carboniferous fossils chiefly from Mount Marmion, Lennard River and West Kimberley. *Bull. geol. Surv. West. Aust.*, 58.

Hinde, G. J., 1890.—Notes on the palaeontology of Western Australia, corals and polyzoa. *Geol. Mag.*, N.S., 3, 7, 194.

Hosking, L. F. V., 1931.—Fossils from the Wooramel district, Western Australia. *J. Proc. R. Soc. West. Aust.*, 27 : 7–52.

Hudleston, W. H., 1883.—Notes on a collection of rock specimens and fossils from Western Australia, north of the Gascoyne River. *Q. Jl geol. Soc. Lond.*, 39 : 582–595.

de Koninck, L. G., 1877.—Recherches sur les Fossiles Paleozoiques de la Nouvelle-Galles du Sud (Australie) ; Texte et Atlas. *Mem. R. Soc. Sci. Liege*, 2nd Ser., II.

McCoy, F., 1844.—" *Synopsis of the carboniferous limestone fossils of Ireland* ". (Univ. Press. Dublin).

Miller, T. G., 1963.—The bryozoan genus *Polypora* McCoy. *Palaeontology*, 6(1) : 166–171.

Moore, R. C., and Dudley, R. M., 1944.—Cheilotrypid Bryozoans from Pennsylvanian and Permian rocks of the Mid-Continent Basin. *Bull. geol. Surv. Kans.*, 52(6) : 235–408.

Morozova, I. P., 1955.—Carboniferous Bryozoa of the Middle Don Basin. *Trudy pal. Inst.*, 58.

Nikiforova, A. I., 1933.—Upper Paleozoic Bryozoa from the Djulfa Region. *Trudy vses. geol-razv. ob''ed NTKP*, 364.

————, 1938.—Types of carboniferous Bryozoa in the European part of the U.S.S.R. *Paleontologiya SSSR*, 4(5) : 1.

d'Orbigny, A., 1850.—" Prodome de Paleontologie Stratigraphique ". Vol. 1, (Paris).

Riley, N. D., ed., 1962.—Opinion 622 : *Fenestella* Lonsdale, 1839 (Class Bryozoa) : Validation under the Plenary Powers in accordance with the accustomed usage. *Bull. Zool. Nom.*, 19(2) : 76–79.

Shulga-Nesterenko, M. I., 1941.—Lower Permian Bryozoa of the Urals. *Paleontologiya SSSR*, 5(5) : 1.

————, 1951.—Carboniferous Fenestellids from the Russian Platform. *Trudy Pal. Inst.*, 32.

————, 1952.—New Lower Permian Bryozoa from the Uralian Region. *Ibid.*, 37.

————, 1955.—Carboniferous Bryozoa from the Russian Platform. *Ibid.*, 57.

Smith, E. M., in prep.—A review of the first six Polyzoa recorded from Australia.

Strzelecki, P. E. de, 1845.—" *Physical Descriptions of New South Wales and Van Diemen's Land* ". (Longman *et al.*, London).

Teichert, C., 1952.—Carboniferous, Permian and Jurassic in the North-west Basin, Western Australia. 19th Int. geol. Congr., Algiers, Symp. on Gondwanaland, 115–135.

Trizna, V. B., 1939.—New species of Upper Palaeozoic Fenestellidae and Acanthocladiidae from the Bashkirian Urals. *Trudy neft. geol-razv. Inst.*, Ser. A., 115 : 102–144.

Ulrich, E. O., 1890.—Palaeozoic Bryozoa. *Bull. Ill. geol. Surv.*, 8(2) : 283–688.

Vine, G. R., 1884.—Further notes on new species and other Yorkshire carboniferous fossil Polyzoa described by Prof. John Phillips. *Proc. Yorks. geol. polytech. Soc.*, 8 : 377–393.

Waagen, W., and Wentzel, J., 1886.—Salt Range fossils 1, Productus limestone fossils. *Mem. geol. Surv. India, Paleont. indica*, Ser. 13 : 854–892, 904–924, 963–966.

Wass, R. E., 1966.—On the species *Fenestella horologia* Bretnall and *Minilya duplaris* Crockford. Proc. Linn. Soc. N.S.W., 91(1) : 90–95.

————, in prep.—Permian Polyzoa from the Bowen Basin, Queensland.

EXPLANATION OF PLATE V

Fig 1

Fistulamina sp. C.P.C. 7706 from 627/1. ×5.

Figs 2–3

Streblascopora marmionensis (Bretnall). 2. C.P.C. 7710 from 627/1 showing hexagonal ridges represented by small black dots. ×20. 3. C.P.C. 7710 from 627/1 showing longitudinal ridges also represented by small black dots. ×20.

THE GENUS *VERRUCISPORA* GEN. NOV. (FUNGI IMPERFECTI) ON PROTEACEAE IN NEW GUINEA AND QUEENSLAND

DOROTHY E. SHAW* and J. L. ALCORN†

(Plate VI)

[Read 28th June, 1967]

Synopsis

Verrucispora proteacearum gen. nov., sp. nov., is described on *Finschia chloroxantha* in New Guinea. It has also been recorded on *Hakea florulenta* in Queensland.

In 1959 the senior author collected a leaf spotting fungus on *Finschia chloroxantha* Diels at Mount Hagen, New Guinea. This was subsequently recorded as *Stenella* sp. (Shaw, 1963) on the advice of Dr. M. B. Ellis of the Commonwealth Mycological Institute. Recently a collection of a fungus parasitic on *Hakea florulenta* Meissn. in south-eastern Queensland (tentatively listed as *Heterosporium* sp. (Simmonds, 1966)) was forwarded to the C.M.I. for identification. In his report (personal communication, 1965) Dr. Ellis indicated that this fungus was very similar to that on *F. chloroxantha* from New Guinea, which he now considered would be better placed in a new genus. Comparison of specimens from both localities has revealed no great morphological differences, and the fungi are regarded as conspecific. A new genus is proposed to accommodate this fungus.

VERRUCISPORA gen. nov.

Fungi Imperfecti, Hyphomycetes.

Mycelium immersum et superficiale, ex hyphis olivaceis ramosis laevibus septatis compositum. *Stromata* rufo-brunnea, ex hyphis dense intertextis in cavis substomatalibus compositum. *Conidiophora* ex stromatibus oriunda, fasciculata, fatula; simplicia, septata, primo recta, tandem geniculata.

Conidia apicalia cylindrica transverse multiseptata verrucosa, quasi inflatio supra apicem conidiophori oriunda.

Species Typica: Verrucispora proteacearum Shaw and Alcorn.

VERRUCISPORA PROTEACEARUM sp. nov.

Mycelium 2–4 μ diam., stromata 25–50 μ diam. *Conidiophora* usque 40-nim fasciculata, basi densa subito late divergentia, simplicia valde septata septis usque 13, ubique aequabilia cicatricibus exceptis, primo recta tandem geniculata, apicibus pallidioribus exceptis aeque rufo-brunnea, usque 290 μ longa, 4·5–8·5 μ lata, interatim post delapsu conidiorum sub cicatrice apicale proliferantia, his proliferationibus quoad longitudine variabilibus; cicatricibus etiam variabilibus, circa 5. *Conidia* singula rufo-brunnea primo globosa tandem cylindrica obtusa, 3–7 septata ad septas interdum constricta, ante septas factas verrucosa, cellula basali per cicatricem conspicuam truncata interdum subconica, 23–51 μ × 5·6–10·5 μ. *Habitat* in foliis vivis *Finschiae chloroxanthae* Dielsii in Nova Guinea, 21·VIII·59, D. E. Shaw, TPNG 2428 (IMI 77905), typus.

The mycelium is mainly immersed and ramifies through the host mesophyll. A very limited amount of growth over the leaf surface occurs. Hyphae are olivaceous, branched, smooth walled and septate. In the sub-stomatal region the hyphae aggregate into rounded stromatic bodies from the apices of which

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the conidiophores arise. The conidiophores emerge from the stomata in dense fascicles of up to 40 but are immediately widely divergent. They are simple, strongly septate (up to 13 septa), uniform in width except at scars, initially straight then becoming geniculate with sporulation, uniformly reddish brown except at paler apices, up to 290 μ long × 4·5–8·5 μ wide. Prolongations originate just below the apical scar which then assumes a lateral position as the conidiophore grows. The length of each prolongation is variable, as is the number of scars (approximately 5). The conidia arise singly as blown out apices of conidiophores, and are at first globose, becoming elongated and roughened before the septa are visible. They are reddish brown, cylindric with obtuse ends with the proximal cell truncated by a prominent scar and occasionally sub-conic, transversely multiseptate (3–7 septa), sometimes indented at septa, thick-walled, verrucose, and measure 23–51 μ × 5·6–10·5 μ (Plate VI, Figs. 1–6).

Leaf spots on *Finschia* are up to 1·5 cm., amphigenous, round to angular, centre dark brown to black, margin lighter brown with irregular, slightly diffuse edge; especially on the lower surface velvety effuse to tufted black patches occur in the centres of the spots. On *Hakea* leaf spots are up to 1 cm., amphigenous, dark brown to black, rounded, irregular or dendritic with diffuse irregular margins. Fruiting occurs on both surfaces of the leaf. Cultures of the fungus have been obtained from both hosts, and pathogenicity towards its original host demonstrated for the *Hakea* isolate. On potato dextrose agar medium colonies are very slow growing, grey to black, raised and somewhat convoluted, sometimes with a narrow white margin, and usually imparting a yellowish tinge to the medium, which later becomes dark brown. Conidiophores and conidia are formed and are fairly typical of those seen on naturally infected leaves.

The colonies on *Finschia* are much more luxuriant than those on *Hakea*, which is probably a reflection of the different environments. At Mount Hagen (altitude 5,350 feet, latitude 6°S) the average annual rainfall is 103 inches, while at Beerwah (altitude 107 feet, latitude 27°S) it is 63 inches. The genus *Hakea* does not occur in New Guinea, and *Finschia* is not known from Australia.

The fungus under study differs from *Acroconidiella* (Lindquist and Alippi, 1964) which has single conidiophores arising from extensive superficial mycelium. *Heterosporium* Klotzsch was considered for the genus but de Vries (1952) has shown that the lectotype species, *H. ornithogali*, is a good *Cladosporium* with conidia in chains and protruding conidial scars, a deliberation which has been accepted by Hughes (1958), Barron and Busch (1962) and Dr. M. B. Ellis (personal communication).

As mentioned previously, the New Guinea fungus was first ascribed to *Stenella* by Dr. Ellis, but after subsequent study he considered that it would be better placed in a new genus. *Stenella* Syd., until recently a monotypic genus with *S. araguata* Syd. as the type species, has extensive superficial mycelium, short narrow conidiophores and small 0–2 septate rod-shaped conidia (Sydow, 1930) and the authors agree that the fungus cannot easily be ascribed to this genus as originally described. Although the genus *Stenella* has recently been widened on the advice of Dr. Ellis to include *S. tristaniae* Huguenin (Huguenin, 1965), the same authority considered (personal communication, 1966) that the fungus under study would still be better placed in a new genus rather than in *Stenella*. The fungus differs from *S. tristaniae** in the lack of superficial, branched, recumbent filaments forming a conidiferous layer, and of acrogenous secondary conidia.

Stenellopsis Huguenin* (Huguenin, 1965) forms conidia in a similar manner to *Verrucispora* but the development of the conidiophores from the stroma-like subepidermal aggregations differs. In the former genus the closely packed

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* Authenticated specimen of *Stenella tristaniae* Huguenin (IMI 102775) and type of *Stenellopsis fagraeae* Huguenin (IMI 104087) have been examined through the courtesy of the Commonwealth Mycological Institute.

conidiophores burst through the epidermis in an erumpent mass, whereas in *Verrucispora* the conidiophores form in the stomata and emerge from them in fascicles. For this reason, and on Dr. Ellis's advice, the new genus is proposed for this species.

SPECIMENS EXAMINED

The following collections represent the distribution of this species as known at present.

Finschia chloroxantha TPNG 2428 (IMI 77905), 21·VIII·59, D. E. Shaw, Mount Hagen, New Guinea ; TPNG 2586A (IMI 79045A), 19·XI·59, R. Smythe, Mount Hagen, New Guinea ; TPNG 5151, 22·VII·66, K. J. White, Mount Hagen, New Guinea.

Hakea florulenta BRIP* 16731, 11·IX·65, J. L. Alcorn, Tewantin, Queensland ; BRIP 16732 (IMI 116146), 20·IX·65, K. G. Pegg, Beerwah, Queensland ; BRIP 16890, 27·XII·65, J. L. Alcorn, Beerwah, Queensland ; BRIP 16894, 31·XII·65, J. L. Alcorn, Sunnybank, Queensland ; BRIP 16955, 23·II·66, J. L. Alcorn, Beerwah, Queensland.

Acknowledgements

It is a pleasure to thank Dr. S. T. Blake, Queensland Herbarium, Brisbane, for the Latin diagnosis ; Dr. M. B. Ellis for his advice ; Mr. J. S. Womersley, Division of Botany, Lae, for the identification of *F. chloroxantha* ; and Mr. W. W. Manley, Department of Primary Industries, Brisbane, for the photomicrographs.

References

Barron, G. L., and Busch, L. V., 1962.—Studies on the soil Hyphomycete *Scolecobasidium*. *Can. J. Bot.*, 40 : 77–83.

De Vries, G. A., 1952.—Contribution to the knowledge of the genus *Cladosporium* Link ex Fr. Thesis, University of Utrecht.

Hughes, S. J., 1958.—Revisiones hyphomycetum aliquot cum appendice de nominibus rejiciendis. *Can. J. Bot.*, 36 : 727–836.

Huguenin, B., 1965.—Micromycètes du Pacifique Sud. III. *Bull. Soc. mycol. Fr.*, 81 : 686–698.

Lindquist, J. C., and Alippi, H. E., 1964.—Un nuevo género de hongo parásito de *Tropaeolum majus* : *Acroconidiella tropaeoli* (Bond) nov. comb., sinonimo *Heterosporium tropaeoli* Bond. *Darwiniana*, 13 : 607–614.

Shaw, Dorothy E., 1963.—Plant pathogens and other micro-organisms in Papua and New Guinea. Department of Agriculture, Stock and Fisheries, *Res. Bull.* No. 1.

Simmonds, J. H., 1966.—" Host index of plant diseases in Queensland ". (Govt. Printer, Brisbane).

Sydow, H., 1930.—Fungi venezuelani. *Ann. Mycol.*, 28 : 29–224.

EXPLANATION OF PLATE VI

Fig. 1

Fascicle of conidiophores emerging from stoma ; some superficial mycelium also present. ×350.

Fig. 2

Young conidiophores emerging through stoma from sub-stomatal aggregation. ×1400.

Fig. 3

Conidia showing septation and slight indentation at some septa. ×650.

Fig. 4

Young conidia still attached to conidiophores. ×850.

Fig. 5

Conidiophore tip with five scars. ×1000.

Fig. 6

Surface view of verrucose conidia, showing proximal cell truncated by prominent scar. ×1000.

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* BRIP—Plant Pathology Herbarium, Department of Primary Industries, Brisbane.

THE GEOLOGY OF THE WHITE CLIFFS–MT. JACK–PEERY LAKE AREA, NEW SOUTH WALES

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(Plate VII)

[Read 28th June, 1967]

Synopsis

The area lies north of the Darling River about 50 miles north of Wilcannia. Pleistocene to Recent, Tertiary, Cretaceous and Devonian sediments outcrop in the area. The hills in the Mt. Jack-Peery Lake area consist of Upper Devonian rocks. The Mulga Downs Group can be divided into the Momba Sandstone and the Paroo Sandstone. The main structural feature in the Mt. Jack-Peery Lake area is the Mt. Jack anticline. Two anticlines are present in the White Cliffs area. Palynological investigations show that the centre of the White Cliffs anticline consists of sediments belonging to Cretaceous Roma Formation, and the flanks of this anticline of Tambo Formation.

INTRODUCTION

The area considered in this paper lies in the north-western part of New South Wales, north of the Darling River and about 50 miles north of Wilcannia. Compared with the surrounding plains it is fairly hilly, the highest point being 725 feet above sea level. The average rainfall is nine inches per year, which produces semi-arid country with sand dunes; however, the country supports some sheep and cattle. On geological grounds it may be divided into two regions: the Mt. Jack-Peery Lake area characterized by Devonian sediments, and the White Cliffs area where Cretaceous sediments are dominant with Devonian rocks outcropping only near its eastern edge (Fig. 1).

Very little has been written about this area. Kenny (1934) mentioned it in describing the geology and sub-surface waters of the West Darling district; Relph (1959) described the White Cliffs opal field; the author (Rade, 1964) described fish from the Mt. Jack-Peery Lake area, fixing the age of the sediments there as uppermost Devonian. Mulholland (1940) described the geology and underground water resources of the East Darling district, which contains Devonian rocks similar to those of the Mt. Jack-Peery Lake area; the author (Rade, 1954) has described an area north of the Darling River between longitudes 145° E. and 149° E. which lies to the north-east of the area considered in this paper.

GEOLOGY

Pleistocene to Recent, Tertiary, Cretaceous and Devonian sediments outcrop in the area.

Pleistocene to Recent

These sediments consist of alluvium, clay, sand and gravel. Silt and mud are widely distributed on the plains and floodouts. Sand has accumulated in the flat valleys; red sand dunes have been formed locally where sand has been derived from the disintegration of Devonian sandstones. The conglomeratic layers encountered in the Upper Devonian sandstones weather to sub-rounded quartz gravels, and the more resistant Upper Devonian sandstones form hard sandstone blocks.

Tertiary

The Tertiary is represented by sediments of the " Eyrian Series ", mostly shales and secondary quartzites which cap the Lower Cretaceous deposits in the White Cliffs area; they are generally between 10 and 30 feet thick.

Lower Cretaceous

On the plains the Cretaceous sediments are usually masked by Pleistocene to Recent deposits. They are exposed in canyons 200 feet deep in the White Cliffs area, where they consist of shales with subordinate white, fine-grained sandstones.

Lower Cretaceous sediments are known also at Momba. Kenny (1934, p. 76) estimated the thickness of Lower Cretaceous sediments in the White Cliffs-Bootra-Momba area to be 750 feet, but a bore at Momba penetrated 2,000 feet of Cretaceous sediments without reaching their base (Pittman, 1895). Lower Cretaceous sediments occur as outliers on the western part of the Peery Hills, where they overlie Upper Devonian sediments. Here they are easily recognized by their dirty yellow to greyish-white colour on weathered surfaces. Sediments of this age also occur at the Round Hill four miles north of Peery Lake. Partly lateritized shales form the low, roughly east-west trending ridges to the east of the Round Hill.

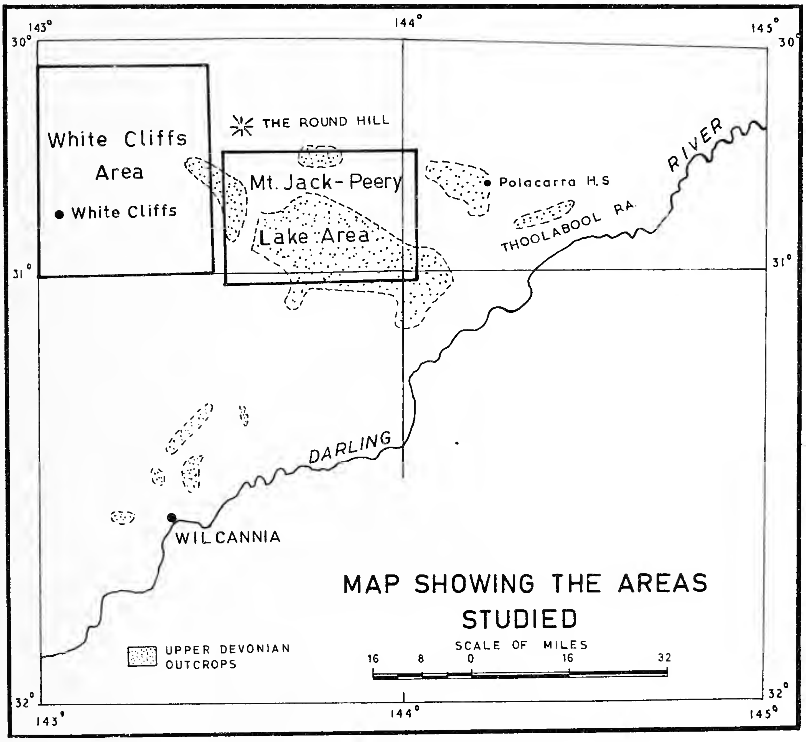

Fig. 1.

Upper Devonian

The hills in the Mt. Jack-Peery Lake area consist of Upper Devonian rocks. Kenny (1934) divided the Devonian sediments of the West Darling district into two stages: the Gnalta Stage (lower) and the Mootwingee Stage (upper). Mulholland (1940) divided the Devonian rocks of the Cobar area into the Amphitheatre (lower) and Mulga Downs (upper) stages. Kenny's Mootwingee Stage is approximately equivalent to Mulholland's Mulga Downs Stage. On its latest (1962) map of New South Wales, the Geological Survey of N.S.W. shows the Mulga Downs Group as Upper Devonian.

The *Mulga Downs Group* outcrops widely in the Mt. Jack-Peery Lake area. On lithological grounds, it can be divided into the Momba Sandstone and the Paroo Sandstone.

The Momba Sandstone is about 4,000 feet thick; its type locality is four miles south-west of the Mt. Pleasant homestead on the southern end of the Mt. Orr anticline. The name of the Momba Sandstone is taken from the Momba homestead, 40 miles north of Wilcannia. It extends from south-west of Peery Lake, lat. 30° 49′ S., long. 143° 30′ E., to the east end of the Thoolabool Range, lat. 30° 50′ S., long. 144° 30′ E. It represents the upper part of the Upper Devonian; it is overlain by Cretaceous rocks, and underlain by the Paroo Sandstone. It is exposed also to the north-east of Momba, and at the southern end of the Coorpooka Lake in the Black Hills. The Upper Devonian rocks at Polacarra, Thoolabool Range and south of Mt. McPherson belong to it. It consists of rather soft, friable, medium- to fine-grained quartz sandstones with sub-angular quartz pebbles; the pebbles range in size from one-eighth to one and a half inches in diameter. The basal part of the Momba Sandstone is decidedly conglomeratic. Higher up it is cross-bedded and often massive, with layers up to nine feet thick. Between the massive sandstones are flaggy fine-grained brown and white sandstones between one and five inches thick.

The Paroo Sandstone is typically exposed around the Mt. Jack homestead; the most widely exposed sediments on the Mt. Jack and Mt. Orr anticlines also belong to it. The name of the Paroo Sandstone is taken from the Paroo River north of Wilcannia. Its uppermost beds outcrop west of Peery Lake at lat. 30° 43′ S., long. 143° 25′ E.; its base was located in the Mt. Jack No. 1 Bore at 3,250 feet, lat. 30° 45′ S., long. 143° 45′ E. It is overlain by the Momba Sandstone and underlain by an unnamed sandstone found below 3,250 feet in the Mt. Jack No. 1 Bore. The Paroo Sandstone consists of brown, mostly fine- to medium-grained quartz sandstones with irregular clay inclusions and a few casts of salt crystals. The sandstones contain scattered sub-angular quartz pebbles and pebble layers in which the pebbles are up to three inches across. A few pebbles of sub-rounded quartzite occur in the conglomeratic layers; the pebbles of quartzite are more rounded and are generally larger than those of quartz. The sandstones are often cross-bedded and ripple marked, and often form flaggy bands between one-half and four inches thick. They are interbedded with shaly fine-grained quartz sandstones and brown shale. These rocks are very soft and easily eroded, forming valleys between resistant sandstone ridges.

The top of the Paroo Sandstone consists of a cross-bedded conglomeratic sandstone interbedded with brown, medium- to coarse-grained quartz sandstone lenses containing scattered sub-angular quartz pebbles between one and three inches in diameter. The lenses of sandstone are up to three feet three inches thick; the sub-angular quartz pebbles in them are generally about one inch across. The thickness of the Paroo Sandstone is estimated to be about 5,000 feet. Remains of fossil armoured fish found in the Paroo Sandstone by the author (Rade, 1964) include *Phyllolepis*, *Groenlandaspis*, *Holonema* and *Striacanthus*, showing it to be of Famennian age. The fossils were found in hard brown, flaggy, fine-grained quartz sandstones at three main localities, two of them on the Mt. Jack anticline and one on the Mt. Orr anticline (Fig. 2).

Silicification of the sediments of the Paroo Sandstone is common. Kenny (1934, p. 60) observed silicification in the sediments of the West Darling district: " Silica bearing solutions probably entering the sediments per medium of the fissure or fissures resulting from earth movement." Concerning the thin coating of siliceous material often found on slickensides in the area he says: " Many of the slickensided faces exhibit a thin coating of siliceous material; while small and irregular veins of similar composition are common within the sandstones in areas contiguous to some plane or locus of intense deformation. All these features, however, are by no means widespread." Very characteristic polygonal fracturing is widespread on surfaces of sandstones of the Paroo Sandstone which have been case-hardened by secondary silicification (Plate VII).

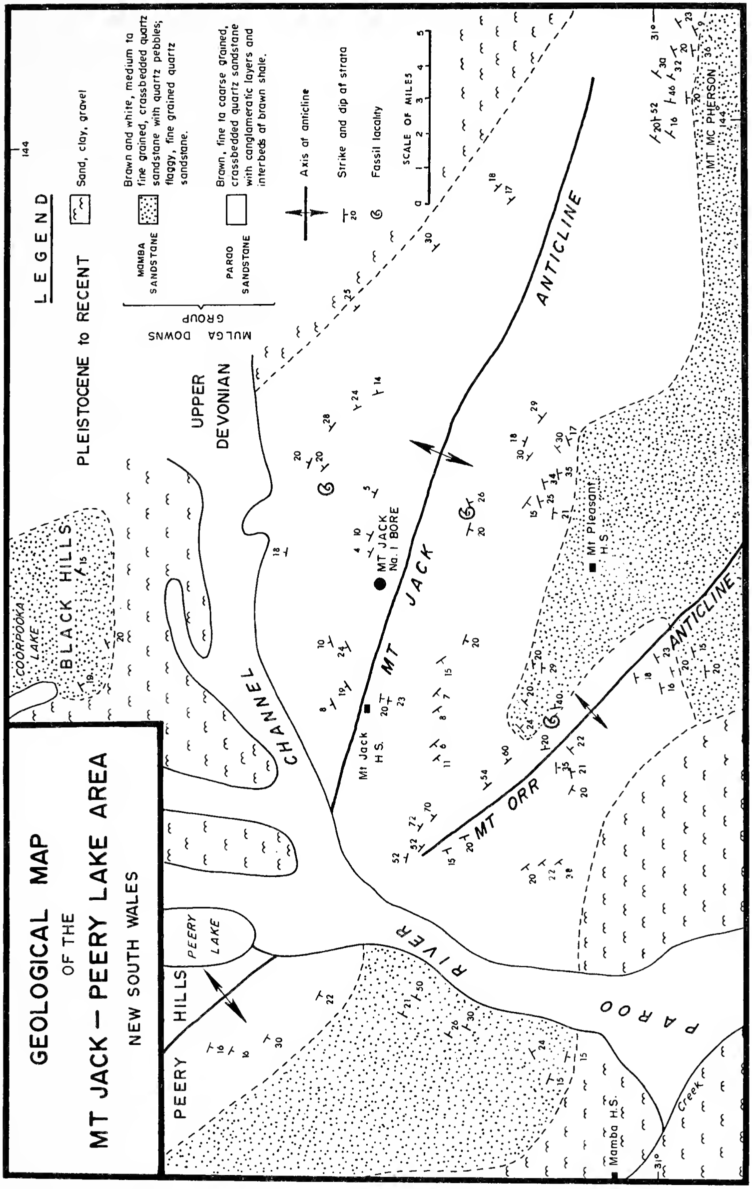

Fig. 2.

Structure

Mt. Jack-Peery Lake Area

Folding

The main structural feature in the area is the Mt. Jack anticline. Its axis trends approximately N. 80° W.; the Paroo Sandstone is exposed in its core. Both limbs of the anticline show average dips between 4° and 25°. Dips up to 52° occur north of Mt. McPherson. On the southern flank of the anticline about two and a half miles north-east of Mt. Pleasant homestead dips up to 35° were found.

The north-eastern limb of the Mt. Orr anticline is the steeper. Dips up to 72° were found on this limb at its north-western end, 68° in the middle and 42°

at the south-eastern end, where it dips under Pleistocene to Recent deposits. The south-western flank of the anticline is not as steep, with dips up to 25° at its north-western end, 20° to 38° in the middle, and 29° at the south-eastern end.

Both the anticlines in the Mt. Jack-Peery Lake area are closed structures. Although the north-eastern part of the east end of the Mt. Jack anticline is covered by younger deposits, the cover is apparently thin and the trend of the Upper Devonian rocks is clearly discernible on aerial photographs. These show that the Mt. Jack anticline is a well-closed structure.

TABLE 1

Distribution of Sporomorphs

Sporomorphs	White Cliffs Anticline		
	Western Flank	Centre	Eastern Flank
Cyathidites australis Couper	+	..	..
Stereisporites antiquasporites (Wilson and Webster)	+	..	+
Leptolepidites verrucatus Couper	+	+	+
Leptolepidites major Couper	+	..	..
Osmundacidites mollis (Cookson and Dettmann)	+	..	..
Baculatisporites comaumensis (Cookson)	+	+	+
Neoraistrickia truncatus (Cookson)	+	+	+
Tripartina cf. *T. variabilis* Maljavikina	..	..	+
Faveosporites canalis Balme	+	..	+
Lycopodiumsporites austroclavatidites (Cookson)	+	+	+
Reticulatisporites pudens Balme	+	..	+
Acanthotriletes levidensis Balme	+	+	..
Dictyotosporites complex Cookson and Dettmann	+	..	..
Cicatricosisporites australiensis (Cookson)	+	..	..
Cicatricosisporites pseudotripartitus (Bolkhovitina)	+	..	..
Ischyosporites crateris Balme	..	..	+
Cingutriletes clavus (Balme)	..	+	..
Contignisporites cooksonii (Balme)	+	..	..
Crybelosporites striatus (Cookson and Dettmann)	+	..	+
Laevigatosporites ovatus Wilson and Webster	+	..	+
Reticuloidosporites arcus (Balme)	+	..	..
Pilasporites marcidus Balme	+	..	..
Coptospora paradoxa (Cookson and Dettmann)	+	..	..
Rouseisporites radiatus Dettmann	+	..	..
Tsugaepollenites dampieri (Balme)	..	+	+
Vitreisporites pallidus (Reissinger)	+	..	..
Microcachryidites antarcticus Cookson	+	..	..
Cycadopites nitidus (Balme)	+	+	+
Classopollis cf. *C. torosus* (Reissinger)	..	+	..

The White Cliffs Area

Folding

Two anticlines affecting the Tertiary "Eyrian Series" sediments are present in this area. A large north-north-east trending anticline east of White Cliffs is here named the White Cliffs anticline. A smaller anticline south-east of White Cliffs, just east of the southern end of the White Cliffs anticline, is named the Bunker Hill anticline.

The *White Cliffs anticline* has been traced from eight miles south of White Cliffs to about 22 miles north-east of White Cliffs. At its southern end the limbs dip at between 10° and 20°; in the central part dips are between 7° and 16°; at the northern end dips are between 10° and 22°.

The *Bunker Hill anticline* is a small west-north-west trending structure. Its northern side dips at between 9° and 26°, and the southern side at 9° to 17°.

A north-south syncline west of White Cliffs extends for some distance to the north.

Faulting

A meridional fault, here named the *Pulpa Fault*, cuts the middle part of the White Cliffs anticline. It shows evidence of right lateral type horizontal movements which have displaced part of the White Cliffs anticline. The Pulpa Fault is quite long.

Palynology of White Cliffs Anticline

Twenty-nine sporomorphs (Table 1) were encountered in the five analysed samples from the different portions of the White Cliffs anticline (Fig. 3). Of the detected sporomorphs, four are of importance for closer dating of the exposed deposits on the White Cliffs anticline. These are as follows : *Laevigatosporites ovatus* Wilson and Webster, *Cicatricosisporites pseudotripartitus* (Bolkhovitina,) *Crybelosporites striatus* (Cookson and Dettmann) and *Acanthotriletes levidensis* Balme.

The occurrence of the sporomorph *Crybelosporites striatus* (Cookson and Dettmann) on both flanks of the White Cliffs anticline shows that the strata which are exposed there could not be older than the upper horizons of the Roma Formation. This conclusion is based on the vertical distribution of this sporomorph in the Great Artesian Basin where, according to Dettmann (1963, p. 81), it occurs in the upper horizons of the Roma Formation with a vertical extension into the Winton Formation.

The exposed sediments on both flanks of the White Cliffs anticline can be more closely dated by the occurrence of *Laevigatosporites ovatus* Wilson and Webster and *Cicatricosisporites pseudotripartitus* (Bolkhovitina), which do not occur below the Tambo Formation. *Laevigatosporites ovatus* Wilson and Webster is confined to the Tambo and Winton Formations in the Great Artesian Basin (Dettmann, 1963, p. 86). *Cicatricosisporites pseudotripartitus* (Bolkhovitina) also occurs there in the Tambo Formation according to Dettmann (1963, p. 55). The first of these abovementioned sporomorphs represents a very common form on the western as well as on the eastern flanks of the White Cliffs anticline. The second one has been found only on the western flank of this anticline.

It is clear that the strata exposed on both flanks of the White Cliffs anticline are not older than the Tambo Formation.

Leptolepidites verrucatus Couper, *Baculatisporites comaumensis* (Cookson), *Neoraistrickia truncatus* (Cookson), *Lycopodiumsporites austroclavatidites* (Cookson), *Acanthotriletes levidensis* Balme, *Cingutriletes clavus* (Balme), *Tsugaepollenites dampieri* (Balme), *Cycadopites nitidus* (Balme) and *Classopollis* cf. *C. torosus* (Reissinger) were found in the centre of the White Cliffs anticline. *Acanthotriletes levidensis* Balme has been recorded from the Lower Cretaceous in Western Australia and has not been found in the Jurassic (Balme, 1957, p. 18). The other recorded forms have a fairly wide vertical range in the Mesozoic sediments and for this reason they are not conclusive ; however, according to the occurrence of *Acanthotriletes levidensis* Balme and because no other forms were found which would be characteristic for the Tambo Formation, the strata exposed in the centre of the White Cliffs anticline were accepted as belonging to the Roma Formation.

Palaeozoic Palaeogeography and Sedimentation

The Middle Cambrian sea reached the area west of White Cliffs. This has been established by the presence of the Cambrian trilobites *Pagetia significans* and *Dorypyge* (*?*) *tenella* in the Mootwingee area (Warner and Harrison, 1961). Ordovician sediments have been found in the same area (Geol. Surv. N.S.W. 1962). Öpik (1957) has shown that the Cambrian tends to be characterized by north-south trends and the Ordovician by east-west trends in Central Australia. The author (Rade, 1957) has observed similar trends in the faulting of Cambrian and Ordovician sediments in the Amadeus Basin south-east of Alice Springs. A meridional fault lies in the central part of the White Cliffs area (Fig. 3).

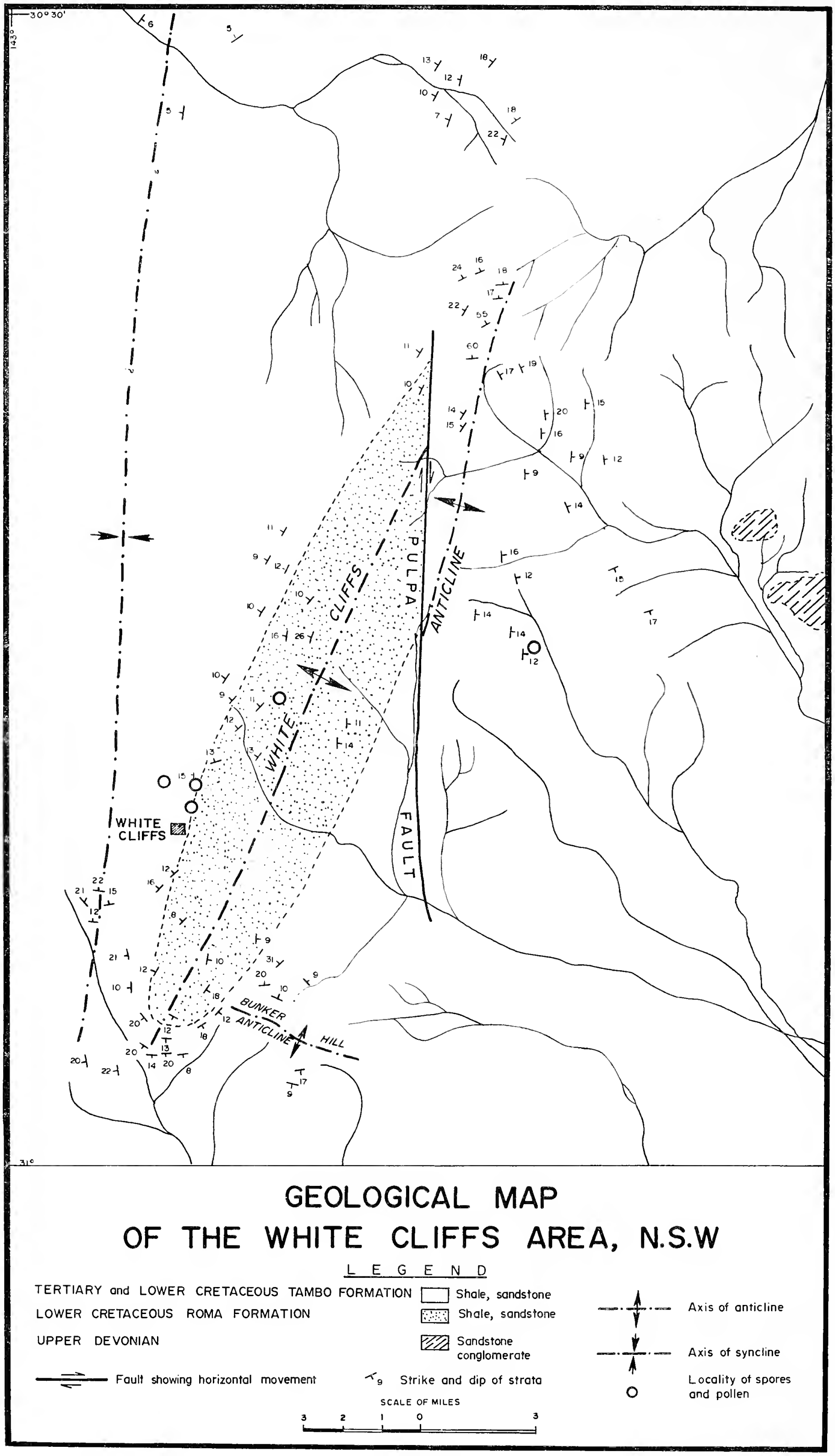
30°30'
143°
PULPA
ANTICLINE
WHITE CLIFFS
FAULT
WHITE CLIFFS
BUNKER ANTICLINE
HILL
31°
GEOLOGICAL MAP
OF THE WHITE CLIFFS AREA, N.S.W
LEGEND
TERTIARY and LOWER CRETACEOUS TAMBO FORMATION
Shale, sandstone
LOWER CRETACEOUS ROMA FORMATION
Shale, sandstone
UPPER DEVONIAN
Sandstone conglomerate
Axis of anticline
Axis of syncline
Fault showing horizontal movement
Strike and dip of strata
Locality of spores and pollen
SCALE OF MILES
3 2 1 0 3

Fig. 3.

Sprigg (1961, p. 54) has stated: "A deep graben extending NNW–SSE through the Darling district of N.S.W. (in line with the Cambro-Ordovician belt of the Georgina Basin) developed finally to accommodate more than 20,000 feet of Upper Devonian-Lower Carboniferous sediments." The Mt. Jack No. 1 Bore penetrated 4,044 feet of Devonian sediments without reaching their base; an aeromagnetic survey showed 6,000 feet of sediments between White Cliffs and the Mt. Jack-Peery Lake area, and 9,000 feet of sediments south of the Darling River in the area south-west of Cobar. Since Cambrian and Ordovician sediments were found to the west of the area, and since the aeromagnetic survey has shown the presence of a thick sedimentary sequence in the area, it is possible that the Devonian rocks in the area are underlain by Ordovician and Cambrian sediments. It may be added that a graben running north-south and containing about 8,000 feet of sediments has been revealed by the aeromagnetic survey north of Menindee, about 70 miles south-west of Wilcannia.

In the Mt. Jack No. 1 Bore the Devonian sediments are very fine and strongly silicified. Work by the author in the West Darling district has shown that the source of sedimentary material entering the Palaeozoic geosynclines was to the west; hence coarser Devonian sediments may be expected west of the Mt. Jack area.

In this paper the author has attempted to elucidate the geology of a part of New South Wales where not much geological work has been done. A primary task was to determine the age of the Palaeozoic sediments, which has been achieved with the aid of the armoured fish which the author has described elsewhere. It may be added that, in contrast with the area studied in this paper, the area immediately to the east of it contains mainly Mesozoic sediments, but some similarities exist in the geology of both areas.

References

BALME, B. E., 1957.—Spores and pollen grains from the Mesozoic of Western Australia. *C.S.I.R.O. Aust., Coal Res. Sect. T.C.*, 25: 1–48.

DETTMANN, M. E., 1963.—Upper Mesozoic microfloras from south-eastern Australia. *Proc. roy. Soc. Vic.*, N.S. 77, 1: 1–148.

Geological Survey of New South Wales, 1962.—Geological map of New South Wales. Department of Mines, Sydney.

KENNY, E. J., 1934.—West Darling district, N.S.W. Dept. Mines, Geol. Surv. Min. Res., 36.

MULHOLLAND, C. St. J., 1940.—Geology and underground water resources of the East Darling district. N.S.W. Dept. Mines, Geol. Surv, Min. Res., 39.

ÖPIK, A. A., 1957.—Cambrian geology of the Northern Territory: in The Cambrian geology of Australia. Commwlth. Bur. Min. Res. Geol. Geophys. Bull., 49: 25–54.

PITTMAN, E. F., 1895.—Report on a geological examination of the north-western portion of the colony, with special reference to the Cretaceous or artesian water bearing rocks. Annual Rept. Dept. Mines, N.S.W., 1894.

RADE, J., 1954.—Geology and sub-surface waters of the area north of the Darling River between longitudes 145° and 149° E, N.S.W. *Jour. roy. Soc. N.S.W.*, 88: 24–32.

————, 1957.—Geology and sub-surface waters of the area east of Deep Well, Alice Springs district, Northern Territory. *Transact. roy. Soc. South Aust.*, 80: 91–96.

————, 1964.—Upper Devonian fish from the Mt. Jack area, New South Wales, Australia. *Jour. Paleont.*, 38: 929–931.

RELPH, R. E., 1959.—The White Cliffs Opal Field, New South Wales. N.S.W. Dept. Mines, Technical Reports, 7: 7–17.

SPRIGG, R. C., 1961.—On the structural evolution of the Great Artesian Basin. Aust. Petr. Explor. Assoc. Pap. presented at the conference on the geology of South and Eastern Australia: 37–56.

WARNER, R. A., and HARRISON, J., 1961.—Discovery of Middle Cambrian fossils in New South Wales. *Aust. Jour. Science*, 23, 8: 268.

EXPLANATION OF PLATE VII

Polygonal fracturing on the surface of Upper Devonian sandstones in the Mt. Jack-Peery Lake area.

THE LIFE HISTORIES OF TWO BIRD TREMATODES OF THE FAMILY PHILOPHTHALMIDAE

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[Read 26th July, 1967]

Synopsis

Redial generations of *Cloacitrema narrabeenensis* n.sp. and *Philophthalmus burrili* n.sp. infect the digestive gland and gonad of the marine gastropod *Velacumantus australis*. These give rise to free-swimming megalurous cercariae which readily encyst on solid objects ; the cysts are oval in the case of *C. narrabeenensis* and flask-shaped in *P. burrili*. One experimental infection of *C. narrabeenensis* has been established in the bursa Fabricii of a young specimen of *Larus novaehollandiae* after feeding cysts ; *P. burrili* has been established experimentally in the ocular orbits of domestic chickens after feeding cysts, or direct inoculation of excysted metacercariae.

The natural definitive host of both species is *L. novaehollandiae*.

Introduction

At least six species of larval digenetic trematodes are known to infect the marine gastropod *Velacumantus australis* (Quoy and Gaimard) (Bearup, 1960). The life histories of three of these have been determined by Bearup (1956, 1960, 1961). The life histories of a further two species, which have very similar free encysting megalurous cercariae, but mature in widely different sites in the definitive host, *Larus novaehollandiae*, are reported here. A few details of both are as yet incomplete as free swimming miracidia, and experimental infections of snails with miracidia, have not been obtained. Further, excysted metacercariae of *C. narrabeenensis* have not been obtained.

Both species are members of the family Philophthalmidae and the taxonomy of this group has been recently discussed by Baugh (1962) and Penner and Fried (1963). *Philophthalmus burrili* n.sp. is of particular interest since its metacercaria could conceivably be infective to man. *P. lacrymosus*, which is normally parasitic in gulls, has been reported from the orbit of man in Belgrade (Markovic and Garzicic, 1939), and a further unnamed *Philophthalmus* species, from man in Ceylon (Dissanaike and Bilimoria, 1958).

Materials and Methods

Collections of *V. australis* were made at Narrabeen Lagoon, N.S.W., and Lake Burril, N.S.W. The snails were isolated in small plastic vials filled with sea water and infected specimens were detected by the presence of cercariae adhering to the surface film or swimming below the surface. Cercariae in the surface film readily encysted on small pieces of cellophane placed directly over them. Some specimens of *V. australis* released cercariae that formed oval cysts (cercariae of *C. narrabeenensis* n.sp.) while others released cercariae that formed flask-shaped cysts (cercariae of *P. burrili* n.sp.).

Twenty metacercariae enclosed in oval cysts were fed to a young silver gull, *Larus novaehollandiae*. Oval cysts were also fed to two mice, two pigeons, and two domestic ducklings.

Varying numbers of metacercariae enclosed in flask-shaped cysts were fed to domestic chickens. Excysted metacercariae, readily obtained from flask-shaped cysts on transfer to 0·85% saline at 37° C., were inoculated directly into the orbit with a Pasteur pipette.

Adult gulls were obtained for autopsy from the vicinity of Narrabeen Lagoon to determine natural fluke infections.

Redial stages of both species were recovered from naturally infected snails by cutting off the terminal whorls of the spire and teasing out the digestive gland and gonad into sea water.

All stages recovered were examined alive and 0·05% neutral red in sea water was used as an intra-vital stain. 0·05% phenol red in sea water stained gland cell material in recently dead redia and cercariae of *P. burrili.*

Permanent balsam mounts were made of all stages recovered after fixing in either 10% formalin or 70% alcohol and staining with Gower's carmine. For temporary stained mounts of larval stages, aceto-orcein was used.

Drawings were made with the aid of a camera lucida and all measurements are in mms.

OBSERVATIONS ON THE LIFE HISTORY of *Philophthalmus burrili*, n.sp.

The genus *Philophthalmus* was established by Looss (1899) for a single species, *P. palpebarum*, from the conjunctival sac of *Corvus cornix* and *Milvus parasiticus.* Many species were subsequently described by various authors. Ching (1961) considered that of the 21 species described up to that time only nine were valid ; those falling as synonyms showed differences to valid species that could be assumed to lie within the limits of variation, and the remainder required to be examined in far greater detail to determine their validity. Baugh (1962) described two new species from birds in India, and Penner and Fried (1963) described the first species known to have larval stages in a marine snail. The latter authors implied that *P. skrjabini* was valid on the basis of type of vitellaria, and by reducing the genus *Ophthalmotrema* to synonomy with *Philophthalmus*, added a further species, *P. numenii.* However, as *P. skrjabini* was described from immature specimens, and the type of vitellaria is not necessarily constant for all species, it must at present be considered a *species inquirendae.* Oshmarin and Parukhin (1963) (quoted in *Helminthological Abstracts*, 1966) described *P. macrorchis* from a single specimen, but in view of Ching's work (1961), it seems better to regard this species as a *species inquirendae* as well. Cable and Hayes (1963) have claimed that *P. gralli* as described by West (1961) and Alicata (1962), from the U.S. and Hawaii respectively, is probably distinct from *P. gralli* Mathis and Leger, 1910, and they renamed the North American species *P. megalurus* (Cort, 1914). Thus, there now appears to be 14 valid species in the genus, excluding that described here.

Fisher and West (1958) were the first to determine the life history of a *Philophthalmus* species. Several life histories have been described since by a number of workers, and some studies on the biology of the flukes have been made by West (1961) and Fried (1962*a*, *b* and *c*).

Adult
(Fig. 4)

Mature specimens of *P. burrili* n.sp. bearing eggs were recovered from the nictitating membrane of domestic chickens between 13 and 49 days after feeding encysted metacercariae or inoculating excysted metacercariae directly into the orbit.

The following description is based on 30 specimens ranging in age from 28 to 49 days, most of which had eggs containing miracidia with eyespots. The upper and lower limits of the measurements are the means for 28 and 49 days-old specimens respectively.

Description : Body elongate, slightly attenuated anteriorly, broadly rounded posteriorly. Cuticle lacking spines. In some specimens a slight constriction occurs near level of ventral sucker. Total length 2·8–3·7, greatest width 0·7–1·4 just posterior to ventral sucker. Forebody 30–35% of total length. Oral sucker subterminal, generally wider than long, 0·21×0·30–0·27×0·37 ; ventral sucker circular in outline, preequatorial, 0·4–0·55 ; ratio of transverse diameters of oral and ventral suckers, 1 : 1·33–1 : 1·38. No prepharynx ; pharynx muscular 0·25×0·24–0·30×0·28 ; gland cells (gc 2, Fig. 4) surround each end of pharynx ; oesophagus 0·15–0·25 but lacking in some specimens where forebody contracted ; caecal bifurcation 0·3–0·4 anterior to ventral sucker ; caeca long, extending to near posterior extremity.

Testes in hindbody, entire edges, tandem. Anterior testis oval, 0·30×0·35–0·40×0·55 ; posterior testis tends to be more pointed posteriorly, 0·25×0·40–0·50×0·55. Cirrus sac long and slender extending around left side of ventral sucker and reaching up to 0·2 into hindbody ; it contains a large seminal vesicle, long, extensible, finely spined cirrus, and some prostate cells. Genital pore median, close to caecal bifurcation.

Ovary spherical, median or displaced slightly to the left, 0·17–0·25 in diameter, may touch anterior testis. Uterus with many coils between anterior testis and ventral sucker ; distal portion runs alongside cirrus sac. Eggs non-operculate, slightly thickened at one pole ; dimensions given elsewhere (see p. 185). Vitellaria largely extracaecal, varying between tubular and follicular ; they form a conspicuous band along each side of body between 0·1 and 0·4 posterior to ventral sucker to ovarian level, where they run medially to terminate at a median vitelline reservoir. Large ovoid or sausage-shaped receptaculum seminis overlapping ovary and anterior testis seen in some specimens but apparently absent or not filled with sperm (thus not seen) in others ; its presence was correlated with presence of fertile eggs in uterus.

Excretory vesicle elongated, extending as far as anterior testis ; large longitudinal ducts extend anteriorly as far as oral sucker but finer excretory ducts not seen, and flame cell number not determined.

Hosts : Domestic chicken (Experimental), *Larus novaehollandiae* (silver gull) (Natural).

Localities : Lake Burril, N.S.W. (type locality) and Narrabeen Lagoon, N.S.W.

Type slides : Australian Museum, Sydney, Reg. No. W4158 (holotype and paratypes), School of Public Health and Tropical Medicine, Sydney, Reg. No. Mn 1567 (paratypes).

Remarks : Ching (1961) considered the following morphological characters of *P. gralli* fairly constant after examining more than 50 specimens from four different hosts : location of genital pore, ratio of transverse diameters of suckers, ratio of diameters of ovary and testes, type of vitellaria, extent of vitellaria, extent of seminal vesicle, and egg size. With the exception of type of vitellaria, which varies from follicular to tubular, and egg size, which differs between worms recovered from natural and experimental hosts, the same characters are essentially constant for *P. burrili* and have, therefore, been the main criteria used to distinguish *P. burrili* from other species. It is worth noting that the seminal vesicle may be transversely or vertically disposed posterior to the ventral sucker in *P. burrili*, and this results in some variation in its posterior extent. However, the overall length of the seminal vesicle remains constant.

Philophthalmus species described in which the extent of the vitellaria is for 80–85% of the ventral sucker-anterior testis distance are *P. gralli* Mathis and Leger, 1910; *P. anatinus* Sugimoto, 1928; and *P. halcyonis* Baugh, 1962. However, Ching (1961) considered *P. anatinus* a synonym of *P. gralli*. *P. burrili* is very similar to *P. gralli* but differs from it in having smaller eggs and lacking cuticular spines. With the life history of *P. burrili* now known, other features, particularly the number of flame cells in the cercaria, 24 as against 36, distinguish it from *P. gralli*. Moreover, its redial stages occur in a marine gastropod as opposed to a freshwater gastropod for the rediae of *P. gralli*. *P. burrili* differs from *P. halcyonis* in that the seminal vesicle extends posterior to the ventral sucker, the ovary is considerably smaller than the testes, and the genital pore is at the level of the caecal bifurcation.

It is noted elsewhere that the size of eggs containing fully developed miracidia differs between worms recovered from the natural host (*Larus novaehollandiae*) and experimentally infected chickens. However, in the absence of any other feature which permits a clear distinction to be made, worms from these two sources are regarded as the same species. The difference in egg size may merely be the result of development in a different host. Moreover, while the size of mature eggs may be a fairly constant feature for some species developing in different hosts, Penner and Fried (1963) have noted differences of up to 25μ in the length of the eggs of *P. hegeneri* from five experimental hosts. This is a similar difference in egg length noted between specimens of *P. burrili* from the two sources mentioned.

Some worms were found in which eggs had not commenced embryonation. This was most noticeable in infections where only one worm was recovered. Further, in all specimens with infertile eggs a receptaculum seminis was not seen. This evidence suggests that cross fertilization is a necessary prerequisite to egg embryonation in this species. A similar phenomenon was noted in *P. hegeneri* by Fried (1962*a*) but the presence of infertile eggs in this case was not correlated with the absence of the receptaculum seminis.

After inoculating excysted metacercariae into the orbit of chickens the worms are located for two to three days near the opening of the lachrymal duct. They then move out from this region and attach to the internal surface of the nictitating membrane. The cuticle spines, present in the metacercariae, have disappeared after 12 days. By the time egg laying commences (i.e., after 13 days) and subsequently, the worms are found attached to the external surface of the nictitating membrane. In heavy infections of 12–15 worms little pathological damage is found apart from slight pressure atrophy and oedema of the epithelial cells which are pinched into the ventral sucker for attachment.

It was found that metacercariae inoculated into one eye sometimes migrated to the other. Presumably, this migration is made before the worms become attached to the external surface of the nictitating membrane.

Eggs
(Fig. 8)

Eggs in the distal coils of the uterus of adult worms contain well developed miracidia with eyespots. From adults established experimentally in chickens, the eggs are 0·09–0·095 long by 0·05 wide; from adults in naturally infected *L. novaehollandiae* they are 0·110–0·115 long by 0·06 wide. In some adults, eggs are apparently infertile; this has been referred to above. Newly formed eggs in the proximal coils of the uterus are 0·06 long by 0·03 wide. The eggs are thin shelled, lack an operculum, and may be "egg"-shaped or "sausage"-shaped, depending on movements of the enclosed ciliated miracidium. A small teat-like projection is present at one end of the egg. Each miracidium contains an active, elongated body, presumed to be the mother redia. Further details of the morphology of the miracidium have not been obtained.

Rediae

(Figs 1 and 5)

The smallest rediae found in the digestive gland are about 1·5 long by 0·35 wide. A slight depression at the anterior end of each marks the position at the mouth; this is immediately followed by a mobile pharynx, 0·1 long. The caecum is prominent, approximately two-thirds the length of the redia, and contains yellow pigmented granules, probably derived from digestive gland tissue. The lumen of the redia is empty at this stage, apart from germinal tissue in the posterior region. A distinct prolongation of the posterior end, termed caudal appendage, is present. The birth pore is slightly elevated, 0·3 from the anterior end, while the lappets are more prominent, 0·4 from the posterior end. No collar was located.

Larger rediae, containing many developing cercariae and germ balls throughout the lumen, are up to 5 long by 0·8 wide. Slight yellowish pigmentation of the body wall is seen in some specimens. The caudal appendage is prominent and birth pore and lappets are at approximately the same relative levels as in small rediae. The pharynx and caecum are essentially the same size as in small rediae and the caecum is similarly pigmented and packed with solid matter.

Rediae are quite active when freed from snail tissue.

Cercaria

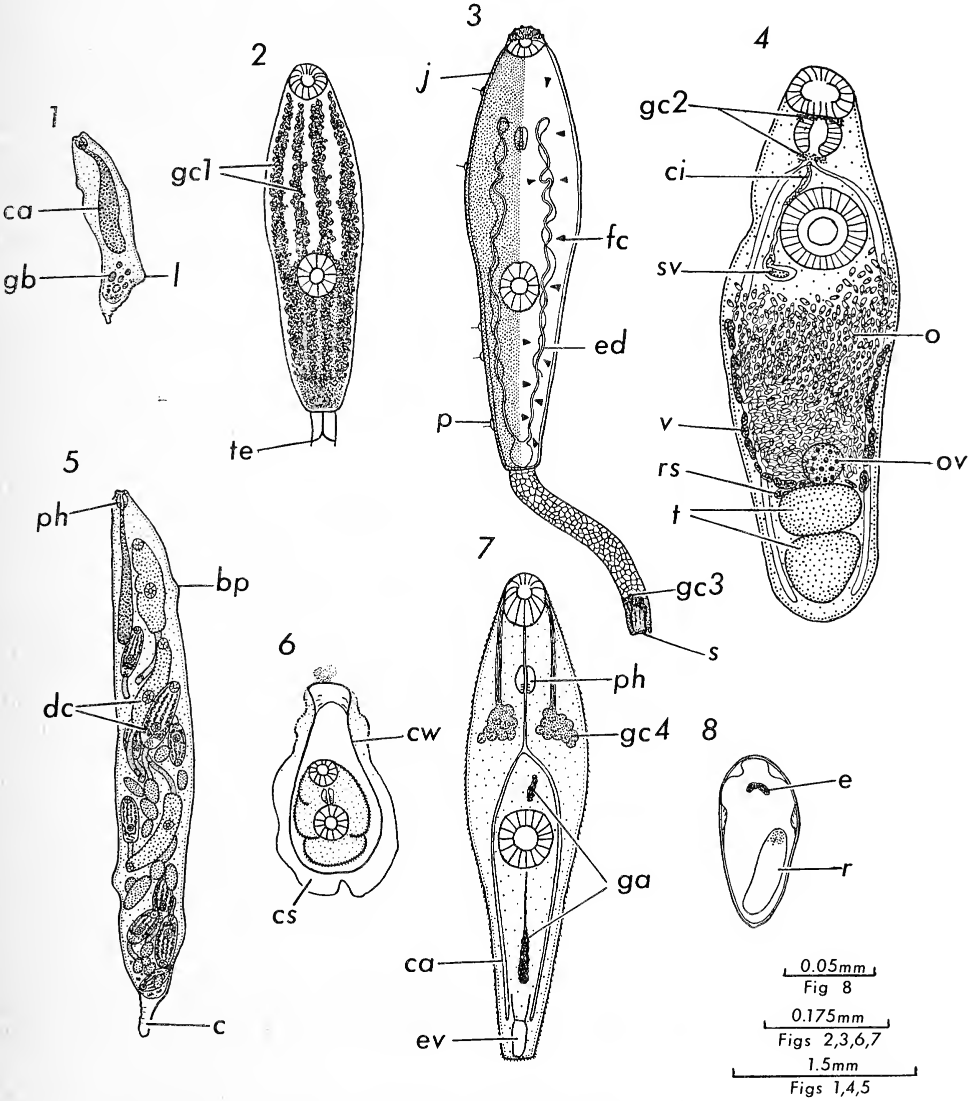
(Figs 2, 3, 17 and 18)

Infection rates of *V. australis* with *Philophthalmus* cercariae in Lake Burril were low (1–2%) over the study period (latter half of 1966 until March, 1967). The incidence was determined by natural emergence of cercariae which is probably below the true incidence for this locality. From Lake Narrabeen, 29 snails out of 3,565 were found infected with *P. burrili* between 1954 and 1959. These figures were obtained from examining crushed snails. Experiments to determine the effects of salinity on emergence have not been carried out. Rarely, double infections of *P. burrili* with either *Austrobilharzia terrigalensis* Johnston, 1917, or *Acanthoparyphium spinulosum* Johnston, 1917, were found, and on one occasion a triple infection of *P. burrili* with *Stictodora lari* Yamaguti, 1939, and *A. spinulosum* was encountered.

The cercariae are active but not progressive swimmers. Their chief movement is a flexing of the body and tail, which are then straightened by a sudden flick. This may elevate them slightly, but they never appear to progress in any particular direction. Most cercariae eventually reach the surface and they may hang there limply, supported by an air bubble enclosed by the ventral sucker (Fig. 17), or lie horizontally in the surface film either at rest, or swaying from side to side (Fig. 18). Some cercariae attach to the bottom of the container by the sucker-like organ at the tip of the tail. When drawn up into a Pasteur pipette the cercariae adhere to the inner glass wall and readily encyst.

In immature cercariae, gland cells (gc 1, Fig. 2), containing granular material, are arranged in four distinct longitudinal rows between the oral and ventral suckers. Posterior to the ventral sucker the rows are not as conspicuous and they appear to terminate abruptly 0·05 from the posterior end of the body. The remaining portion of the body contains less densely granular material. Prior to being released from the redia, the contents of these cells are secreted to form a jacket around the entire body apart from the suckers (Fig. 3). This makes the body of the cercaria considerably less opaque. It is interesting to note that dilute phenol red does not stain the jacket until the cercaria dies. This suggests that the jacket is enclosed by a living membrane (probably comparable with the embryonic epithelium in *Fasciola hepatica* cercariae described by Dixon, 1966) since these are impermeable to phenol red.

The average measurements of 10 free swimming cercariae, fixed in formalin, are: body, 0·60 long by 0·175 wide; tail, 0·300 long by 0·042; oral sucker, 0·05 in diameter; ventral sucker, 0·08 in diameter. The body is constricted slightly at the ventral sucker level, and this is more noticeable in contracted specimens. Small, inconspicuous spines cover the cuticle. A number of small papillae, associated with blocks of refractile material, occur at the anterior end of the body. Along each side of the body there are five papillae with sensory "hairs".



Philophthalmus burrili, n.sp.

1, Young redia; 2, body of immature cercaria showing arrangement of gland cells; 3, free swimming cercaria, body expanded, tail contracted; 4, dorsal view of 49-day-old adult from nictitating membrane of experimentally infected chicken; 5, mature redia containing developing cercariae; 6, metacercaria within flask-shaped cyst; 7, excysted metacercaria; 8, fully embryonated egg from terminal part of uterus.

The mouth, surrounded by the oral sucker, leads into a moderately long prepharynx, 0·095, oval muscular pharynx, 0·040 long, long oesophagus, 0·090, and the caecal bifurcation is approximately two-thirds the distance between the anterior end and ventral sucker. The caeca extend to near the posterior extremity.

A group of cells just anterior to the ventral sucker and a chain of cells between the ventral sucker and excretory vesicle represent the genital anlagen.

There is another group of cells on either side of the forebody between the pharynx and ventral sucker. Fine ducts from these cells run anteriorly and open on either side of the oral sucker. These cells are more clearly evident in excysted metacercariae (gc 4, Fig. 7).

The excretory system consists of a rectangular to ovoid excretory vesicle which varies in shape according to body movements. Lateral ducts extend anteriorly to the level of the oral sucker, where they turn back on themselves and run posteriorly into the hindbody. There appear to be 12 flame cells on each side, but finer excretory connections to these and the groupings of the flame cells were not determined. From the posterior end of the excretory vesicle a duct runs medially into the tail, forks 0·08 from the posterior end of the body, and each fork opens laterally.

The tail is occupied by vesicular parenchyma except at the posterior end. This is infolded to form a sucker-like organ, which is surrounded by four to six pear-shaped gland cells (gc 3, Fig. 3).

Metacercaria

(Figs 6 and 7)

Encystment of *P. burrili* cercariae is a relatively simple process as it involves, essentially, the body becoming free from the presecreted jacket and loss of the tail.

The cercaria attaches to the substrate by the oral and ventral suckers, flattens, and then contraction of the forebody commences. During the flattening process the so-called embryonic epithelium ruptures because the cyst material then stains with phenol red. Further, the rupture of this membrane probably allows mucoid substances to flow over the substrate, thereby cementing the jacket to the substrate. As the forebody contracts, the relatively fluid cyst material of the jacket, which overlies the body dorsally, is arched up and the open anterior end is closed off. During this process, the cyst material gels so that further contractions thus leave the forebody enclosed in a bulbous area. The hindbody then contracts into the bulbous area, the cyst material surrounding it having by this time gelled. Finally, the tail drops away. Thus, the resulting cyst is flask-shaped, the open end corresponding to the posterior end of the body of the cercaria. The metacercaria, as it can now be called, rotates in the bulbous area, but gradually becomes quiescent. There appears to be two layers to the cyst wall—one consisting of cementing substance, and the other making up the cyst wall proper. The former is indented at a point corresponding to the anterior end of the cercaria. Cysts are approximately 0·3–0·5 long by 0·175–0·234 at their widest point.

The enclosed metacercaria, which may remain alive for approximately three weeks, is identical to the cercaria but lacks the jacket, sensory papillae and tail. The cuticular spines and forebody gland cells (gc 4, Fig. 7) are more prominent.

Metacercariae excyst readily in sea-water or 0·85% saline at 35–37° C. Application of the temperature stimulus initiates very vigorous movements of the metacercaria which escapes from the open end of the cyst, anterior end foremost. By comparison with the cysts of *C. narrabeenensis*, cysts of this species do not tan.

OBSERVATIONS ON THE LIFE HISTORY OF *Cloacitrema narrabeenensis*, n.sp.

The genus *Cloacitrema* was established by Yamaguti (1935) for a single species, *C. ovatum*, from the cloaca of *Bucephala clangula clangula*. McIntosh (1938) added *C. michiganensis* from the cloaca of the sandpiper, *Actitus macularia* (type host) and stilt, *Himantopus mexicanus.* A third species is *C. oswaldoi* Travassos, 1940, in *Nyctanassa violacea.*

One life history of a *Cloacitrema* species has been reported. Robinson (1952) found megalurous cercariae developing in an estuarine snail, *Cerithidea californica*, and encysting on the shell surface. The metacercariae developed to *C. michiganensis* in *Larus californicus.*

Adult

(Figs 12 and 15)

Thirty-five days after feeding 20 oval cysts to a young gull, four adult worms bearing mature eggs were recovered from the bursa Fabricii. Three specimens were examined in detail and the measurements of each are given. Mice, pigeons and domestic ducklings proved refractory.

Description: Body elongate, oval, constricted in middle, 3·3, 2·5, 2·2 long by 1·4, 1·15, 1·0 at greatest width and 1·2, 1·0, 0·9 at constriction level with ventral sucker; cuticle without spines. Oral sucker subterminal, 0·37 long by 0·53 wide, 0·16×0·41, 0·24×0·33; ventral sucker slightly pre-equatorial, 0·8 long by 1·00 wide, 0·40×0·68, 0·56×0·64; sucker ratios 1 : 1·7–2. No prepharynx; pharynx muscular, 0·40 long by 0·50 wide, 0·33×0·37, 0·35×0·27; oesophagus very short, less than 0·05; caecal bifurcation midway between posterior border of oral sucker and anterior border of ventral sucker; caeca long, narrow, ending in testicular zone.

Testes oval, entire edges, parallel or slightly oblique, close together or touching. Left testis 0·5 long by 0·2 wide, 0·3×0·3, 0·2×0·2; right testis 0·6×0·3, 0·25×0·24, 0·21×0·18; vasa efferentia join near level of ventral sucker and continue along left side of ventral sucker with the terminal point functioning as an external seminal vesicle. Cirrus sac oval, 0·3 long by 0·25 wide, 0·18×0·14, 0·19×0·16, terminating at a common genital pore ventral to posterior region of pharynx; it contains the distal end of the seminal vesicle, prostate cells and finely-spined cirrus.

Ovary spherical, 0·15, 0·11, 0·12 in diameter, median, approximately midway between ventral sucker and testes; oviduct short, joining a small spherical receptaculum seminis at left of ovary and transverse vitelline duct, and then continues to uterus. Vitelline follicles compact, about five or six on each side between ovary and testes, dorsal to caeca. Uterus long, folded transversely to occupy posterior half of body but without coils in pre-ventral sucker zone; terminal portion thin walled, rugose, lying alongside seminal vesicle and opening at common genital pore. Eggs in last few coils have oculate miracidiae. Egg sizes given elsewhere (see p. 190).

Excretory vesicle elongate oval with short duct opening posteriorly. Two main anterior ducts leave antero-laterally and continue forwards around edges of testes to pharynx level. These ducts have several lateral outgrowths in this region. Finer excretory tubules not seen and flame cell number not determined.

Host: *Larus novaehollandiae* (silver gull) (Natural and Experimental).

Locality: Narrabeen Lagoon, N.S.W. (type locality) and Lake Burril, N.S.W.

Type slides: Australian Museum, Sydney, Reg. No. W4159 (holotype), School of Public Health and Tropical Medicine, Sydney, Reg. No. Mn 1377 (paratype).

Remarks: The closest relative of this species is *C. michiganensis* McIntosh, 1938, from which it differs in the following details:

(*a*) The close relation of the testes and their greater size;
(*b*) the wider separation of ovary from testes; and
(*c*) the larger pharynx. Similar differences exist between *C. narrabeenensis* and *C. oswaldoi* Travassos, 1940. In fact, the latter may well be a synonym of *C. michiganensis.*

Eggs

(Fig. 16)

In the distal end of the uterus, each egg contains a fully developed miracidium with a prominent eyespot ; one free miracidium was seen in this position. Eggs are 0·070 long by 0·035 wide when immature, but those containing a mature miracidium are 0·120 × 0·067. The eggs are thin shelled, colourless to slightly yellow, broadly oval. The X-shaped eyespot of the miracidium is composed of numerous black granules. Each mature miracidium is ciliated, and contains an active, elongated, mother redia. An oval body is often found alongside the miracidium but its significance is not clear. Further details of the morphology of the miracidium have not been obtained.

Rediae

(Figs 9 and 13)

Rediae of two size groups are usually present in the digestive gland and gonad of infected snails ; the smaller are slender 0·4 to 0·5 long, translucent, with a prominent pharynx and relatively long gut (about 80% of the total length), a birth pore on a small teat-like elevation, and two prominent lappets. The birth pore is at about 25%, and lappets at 80% of the body length. Rediae of this type, but slightly smaller, 0·2 long, were found in the mantle tissue of one snail. Developing daughter rediae and cercariae were not seen in these small rediae, but germinal tissue could be located in the posterior regions of the body.

Larger rediae are 2·0 to 4·0 long and may contain up to 10 well developed cercariae, several younger ones and germ balls. The mouth has shallow lips ; it is followed by a large muscular pharynx and a caecum packed with yellowish matter probably derived from the digestive gland. The caecum is now only one-quarter to one-half the body length. The birth pore and lappets are difficult to see, although by rolling the redia under a coverslip they can be located.

Rediae actively bend and extend when freed from snail tissue.

Cercaria

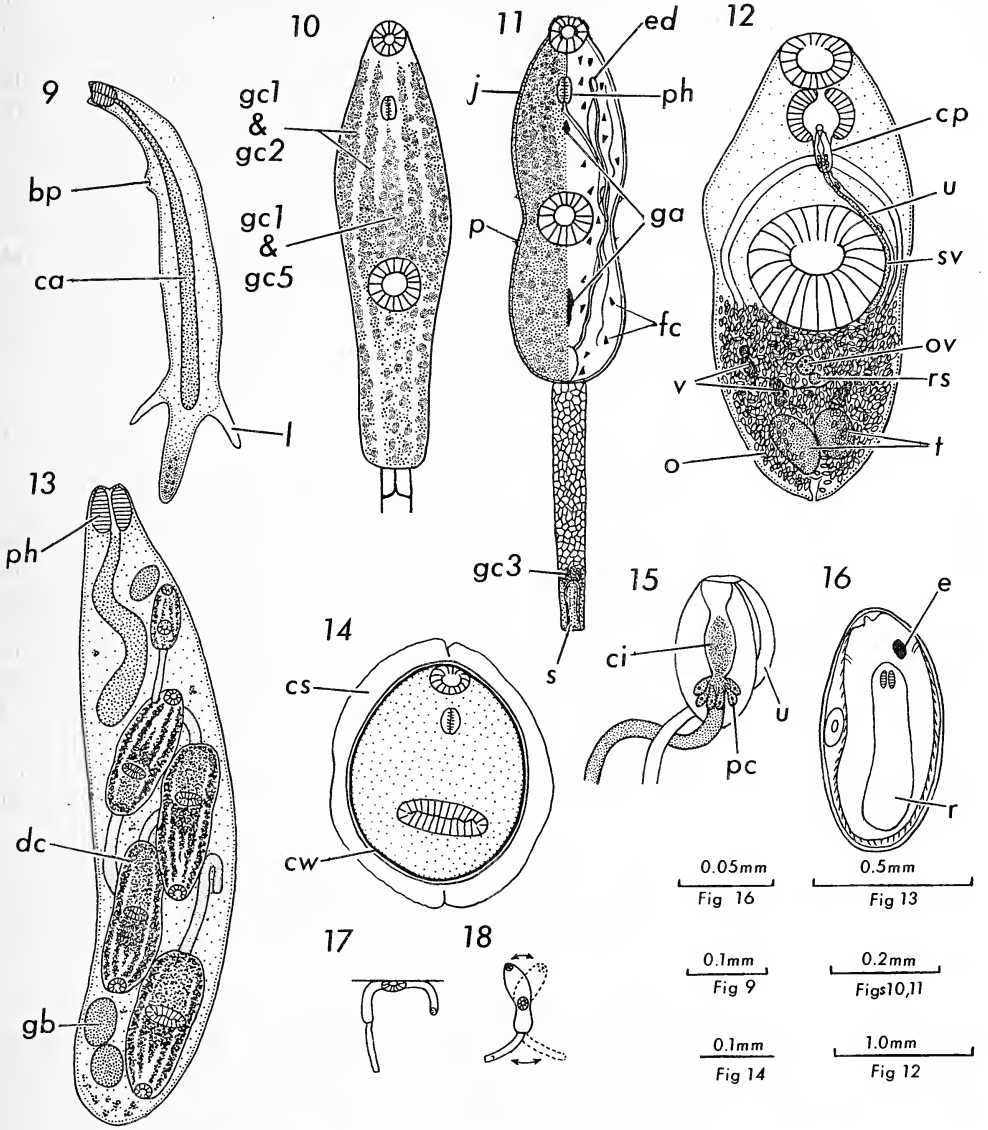
(Figs 10 and 11)

Infection rates of *V. australis* with megalurous cercariae of *Cloacitrema* in Narrabeen Lagoon have been followed for five years (1954–1959) and have shown no distinct seasonal pattern. Infection rates rose with those of other common parasites (schistosomes, echinostomes and heterophyids) and sometimes reached 10% ; then they remained high for several months while other rates fell, or vice versa. These results were based on examinations of crushed snails ; cercariae emerge spasmodically from infected snails and thus figures obtained by isolating snails in small glass tubes and searching for cercariae are below the true incidence. In Lake Burril, the incidence was found to be 2–4% during the latter half of 1966 until March, 1967. Infected snails were seldom less than 30 mm. long, which is the size of mature snails (Ewers, 1963). Rarely, double infections of *C. narrabeenensis* with *Austrobilharzia terrigalensis* or *Acanthoparyphium spinulosum* were found.

Variations in the salinity of the lagoon water (from 50–90% that of sea water) did not appear to affect emergence. Cercariae live for 48 hours in lagoon water but die within an hour of transfer to fresh water.

Swimming behaviour and method of attachment to the surface film in *C. narrabeenensis* cercariae is essentially identical to *P. burrili* cercariae. (See p. 186 and Figs 17 and 18.) Further, cercariae encyst readily on the inner wall of a Pasteur pipette when picked up.

Various types of gland cells filled with cystogenous material obscure much of the internal structure of the cercarial body. In immature cercariae the gland cells are clearly in four longitudinal rows between the oral and ventral suckers.



Figs 9–16 refer to *Cloacitrema narrabeenensis*, n.sp.,
Figs 17–18 apply to both species.

9, Young redia ; 10, body of immature cercaria showing arrangement of gland cells ; 11, free-swimming cercaria, body and tail slightly contracted ; 12, ventral view of 35-day-old adult from bursa of experimentally infected seagull ; 13, mature redia containing developing cercariae ; 14, metacercaria within oval cyst ; 15, terminal reproductive organs of adult ; 16, fully embryonated egg from terminal part of uterus ; 17, position which may be assumed by cercariae attached to surface film (lateral view) ; 18, swaying movements frequently made by cercariae attached to surface film (viewed from above).

The more medial rows tend to merge with a triangular mass of cells between the pharynx and ventral sucker. Posterior to the ventral sucker, two lateral rows and one medial area, which is slightly less dense, are evident. Within these areas the various types of gland cells are disposed as follows :

(*a*) In longitudinal rows in forebody and in hindbody, large gland cells containing either rods (gc 1, Fig. 10) or large granules (gc 2, Fig. 10) ;

(*b*) in the triangular area between pharynx and ventral sucker, gland cells with rods (gc 1, Fig. 10) or fine granules (gc 5, Fig. 10). Prior to the release of cercariae from the rediae, the gland cells containing large granules (gc 2) are secreted to form a jacket around the body of the cercaria apart from the suckers (Fig. 11). The gland cells containing rods (gc 1) and fine granules (gc 5) do not appear to alter in disposition after the release of this material.

The secretion of granules to form a jacket has also been noted in *Fasciola hepatica* cercariae by Dixon (1966). These granules in *C. narrabeenensis* cercariae subsequently contribute to the outer cyst wall and, as this part of the cyst wall " tans " three to four weeks after cyst wall formation, it seems likely that the granules are of a similar chemical composition to the corresponding granules in *F. hepatica* cercariae, namely, tanned protein (Dixon, 1966). Further, the rods (gc 1) in *C. narrabeenensis* are probably comparable to the keratin scrolls of *F. hepatica* cercariae described by Dixon and Mercer (1964).

The average measurements of 10 free-swimming cercariae fixed in formalin are : body, 0·7 long by 0·2 wide ; tail, 0·44 long by 0·05 wide ; oral sucker, 0·07 in diameter ; ventral sucker, 0·1 in diameter. The body is constricted at ventral sucker level, and this is more noticeable in partly contracted specimens. There is a row of papillae at the anterior end ; associated with blocks of refractile material, and at least two sensory " hairs " on each side of the body near the ventral sucker level. The latter are almost obscured by secreted cystogenous material. The mouth, surrounded by the oral sucker, leads into a short prepharynx, 0·05 long, an oval muscular pharynx, 0·05 long, short oesophagus, 0·015 long, and the caecal bifurcation is approximately midway between the ventral sucker and anterior end. The caeca pass round the ventral sucker and extend to near the posterior extremity.

A small group of cells just posterior to the caecal bifurcation, and another medial group between the ventral sucker and excretory vesicle, represent the genital anlagen.

There are groups of cells, mostly obscured by rods, on each side of the forebody just anterior to the ventral sucker and between the caecal limbs. Ducts from these cells, which are probably comparable with the forebody gland cells of *P. burrili* cercariae and metacercariae, run anteriorly and open on each side of the oral sucker.

The excretory vesicle and anterior longitudinal ducts are similar to those in *P. burrili* cercariae. Each posteriorly directed limb of the longitudinal ducts divides into two secondary ducts near the ventral sucker, one of which runs anteriorly and the other posteriorly. Smaller ducts were not traced to the flame cells, of which there are 18 on each side of the body.

The tail is identical to the tail of *P. burrili* cercariae.

Metacercaria

(Fig. 14)

The cercaria fixes itself to the subtrate by the ventral sucker and the cyst is rapidly formed by the secretion of material from the remaining gland cells in the body using the jacket as a mould. The tail drops away almost immediately cyst wall formation commences. The metacercaria moves around inside the cyst, apparently shaping or smoothing out the interior surface. The cyst wall eventually appears to have at least two layers : an inner cyst wall proper and an outer flared layer cementing the cyst to the substrate. The outer layer has indentations at points corresponding to the anterior and posterior ends of the cercaria. When infected snails are confined to glass tubes the liberated cercaria appear to favour the operculum for encystment.

The newly formed cyst is oval to round, 0·200 by 0·275. As mentioned above, the outer wall tans after three to four weeks, and once this has occurred the inner cyst can be separated from the outer cyst wall by compression with a coverslip.

The enclosed metacercaria appears to be very similar to the cercaria but lacks the cyst-forming gland cells. Excysted metacercariae have not been obtained.

DISCUSSION

Of the six trematode species known to infect *Velacumantus australis* at their sporocyst or redial stage, the life histories of five have now been described.

To our knowledge, this is the first time that the life history of a *Cloacitrema* species has been described in any detail. That of *C. michiganensis* was discussed by Robinson (1952) but only a few details, unsupported by figures, were given. It is interesting to note that *C. narrabeenensis* n.sp. has a very similar life history to *Parorchis* spp., and indeed it is difficult to separate the megalurous cercariae of each genus. The presence of collar spines in *Parorchis* is perhaps the greatest difference between the two, but these are difficult to see. A further difference is the longer oesophagus in *Parorchis.*

The life history of *P. burrili* parallels the life histories of other species of the genus. As its cercaria is very similar to that of *C. narrabeenensis* and both are derived from rediae which infect *V. australis*, means of distinguishing them warrant mention. The fact that both species of cercariae encyst readily and the cysts differ considerably in shape permits an easy distinction to be made. Further, *C. narrabeenensis* cercariae are slightly larger and more opaque due to the presence of gland cells containing rods. These rods appear some time before the cercariae are mature and this, along with the caudal appendage present in rediae of *P. burrili*, enables distinctions to be made between the two philophthalmid infections encountered in *V. australis.*

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References

ALICATA, J., 1962.—Life cycle and developmental stages of *Philophthalmus gralli* in the intermediate and final hosts. *J. Parasit.*, 48 : 47–54.

BAUGH, S. C., 1962.—Contributions to our knowledge of digenetic trematodes. Part V. On two new species of *Philophthalmus* Looss, 1899, and a discussion on the family Philophthalmidae. *J. Helminth.*, 36 : 243–258.

BEARUP, A. J., 1956.—Life cycle of *Austrobilharzia terrigalensis* Johnston, 1917. *J. Parasit.*, 46 : 470–479.

————, 1960.—Life history of *Acanthoparyphium spinulosum* Johnston, 1917 (Trematoda : Echinostomatidae). *Aust. J. Zool.*, 8 : 217–225.

————, 1961.—Observations on the life cycle of *Stictodora lari* (Trematoda : Heterophyidae). PROC. LINN. SOC. N.S.W., 86 (3) : 251–257.

CABLE, R. M., and HAYES, K. L., 1963.—North American and Hawaiian freshwater species of the genus *Philophthalmus* (Trematoda : Digenea). *J. Parasit.*, 49 : 41.

CHING, H. L., 1961.—The development and morphological variation of *Philophthalmus gralli* Mathis and Leger, 1910, with a comparison of species of *Philophthalmus* Looss, 1899. *Proc. helminth. Soc. Wash.*, 28 : 130–138.

Dissanaike, A. S., and Bilimoria, D. P., 1958.—On an infection of a human eye with *Philophthalmus* sp. in Ceylon. *J. Helminth.*, 32 : 115–118.

Dixon, K. E., 1966.—A morphological and histochemical study of the cystogenic cells of the cercaria of *Fasciola hepatica* L. *Parasitology*, 56 : 287–297.

Dixon, K. E., and Mercer, E. H., 1964.—The fine structure of the cyst wall of the metacercaria of *Fasciola hepatica*. *Q. Jl. microsc. Sci.*, 105 : 385–389.

Ewers, W. H., 1963.—Some observations on the life cycle of *Velacumantus australis* (Quoy & Gaimard) (Gastropoda : Potamididae). *J. Malac. Soc. Aust.*, 7 : 62–71.

Fisher, F. M., and West, F., 1958.—*Cercaria megalura* Cort, 1914, the larva of a species of *Philophthalmus*. *J. Parasit.*, 44 : 648.

Fried, B., 1962*a*.—Growth of *Philophthalmus* sp. (Trematoda) in the eyes of chicks. *J. Parasit.*, 48 : 395–399.

————, 1962*b*.—In vitro studies on *Philophthalmus* sp., an ocular trematode. *J. Parasit.*, 48 : 510.

————, 1962*c*.—Growth of *Philophthalmus* sp. on the chorioallantois of the chick. *J. Parasit.*, 48 : 545–550.

Looss, A., 1899.—Weitere Beiträge sur Kenntniss der Trematoden-Fauna Aegyptens, zugleich Versuch einer natürlichen Gliederung des Genus *Distomum* Retzius. *Zool. Jahrb. Syst.*, 12 : 521–784.

McIntosh, A., 1938.—A new philophthalmid trematode of the spotted sandpiper from Michigan and the black-necked stilt from Florida. *Proc. helminth. Soc. Wash.*, 5 : 41–47.

Markovic, A., and Garzicic, S., 1939.—Über *Philophthalmus lacrymosus* Braun. *Zool. Anz.*, 127 : 267–270.

Penner, L. R., and Fried, B., 1963.—*Philophthalmus hegeneri* sp.n., an ocular trematode from birds. *J. Parasit.*, 49 : 974–977.

Robinson, H. W., 1952.—A preliminary report on the life cycle of *Cloacitrema michiganensis* McIntosh, 1938 (Trematoda). *J. Parasit.*, 38 : 368.

Travassos, L., 1940.—Sobre una especie do genero *Cloacitrema* Yamaguti, 1935, Parasito de *Nyctanassa violacea* (L.). *Arq. Inst. Biol. Sao Paulo*, 11 : 589–591.

West, A. F., 1961.—Studies on the biology of *Philophthalmus gralli* Mathis and Leger, 1910 (Trematoda : Digenea). *Am. Midl. Nat.*, 66 : 363–383.

Yamaguti, S., 1935.—Studies on the helminth fauna of Japan. Part 5. Trematodes of birds, III. *Jap. J. Zool.*, 6 : 159–182.

List of Abbreviations for Text-figures

bp—birth pore
ca—caecum
cp—cirrus sac
cw—cyst wall proper
e—eyespot
ev—excretory vesicle
ga—genital anlagen
gc 1–gc 5—various types of gland cells referred to specifically in text
j—jacket
o—eggs
p—papilla with sensory " hair "
pc—prostate cells
r—mother redia
s—tail sucker
t—testes
c—caudal appendage
ci—cirrus
cs—cementing substance of cyst
dc—developing cercariae
ed—excretory duct
fc—flame cell
gb—germ ball
l—lappet
ov—ovary
ph—pharynx
rs—receptaculum seminis
sv—seminal vesicle
u—metraterm
v—vitellaria
te—terminal excretory pore

MIDDLE PALAEOZOIC BRACHIOPODS AND CORALS FROM KASHMIR

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(Plates VIII and IX)

[Read 26th July, 1967]

Synopsis

Two rugose and three tabulate coral species are described from the Naubug Beds of Upper Silurian age east of Islamabad (Anantnag), Kashmir, and nine brachiopod species and a rugose coral from the Muth Quartzite of the same area. This latter fauna is considered to indicate a Lower or lower Middle Devonian age.

Introduction

East of Islamabad (Anantnag), Kashmir, a succession of Ordovician and older deposits occupies the core of a broad gently north-west plunging anticline. It is conformably overlain by the Silurian succession, comprising shales, the Harpatnar Beds and the Naubug Beds. The Harpatnar Beds consist of buff-coloured graptolitic shales, and the Naubug Beds, blue grey to rusty calcareous sandy shales. Monograptids have recently been collected from the Harpatnar Beds, and suggest a Lower-Middle Ludlow age (Berry and Gupta, 1966). A large fauna of brachiopods, trilobites and nautiloids have been reported from the Naubug Beds by Reed (1912). A few corals have recently been collected from the uppermost part of the Naubug Beds of this area (Fig. 1), and are described in the palaeontological part of this paper. They include the following species: *Stewartophyllum* sp., *? Stereolasma* sp., *? Heliolites* sp., *Favosites gothlandicus* Lamarck forma *forbesi* Milne-Edwards & Haime and *Favosites* sp.

The Naubug Beds are succeeded, apparently conformably, by the Muth Quartzite. Devonian fish remains—probably an osteolepid and a dipterid—have been obtained from dark calcareous shales situated at the base of the Muth Quartzite south-west of Margan Pass (Gupta and Denison, 1966). Devonian fish material is most commonly found in non-marine Old Red Sandstone deposits, usually lacustrine or fluviatile in origin. However, they have occasionally been found in marine sediments—for example, in the Middle Devonian limestones of Taemas in New South Wales and Buchan in Victoria (Hills, 1958). The fish remains suggest a Lower or Middle Devonian age for the base of the Muth Quartzite. According to Middlemiss (1910, p. 217), a thickness of 3,000 feet of Muth Quartzite is developed in Kashmir.

Brachiopods, a trilobite, *Phacops rana* Green, a gastropod, *Diaphorostoma* sp., and a lamellibranch, *Modiomorpha* sp., have also recently been identified from a locality near Naubug situated stratigraphically towards the middle of the Muth Quartzite (Sahni and Gupta, 1964). The locality is one mile north of the village of Naubug (33° 40′ 30″ N.; 75° 23′ 30″ E.). The brachiopods, and also a solitary rugose coral, from this locality (Fig. 1) are described in the palaeontological part of this paper. The coral and brachiopod fauna is as follows: *? Stereolasma* sp., *Schizophoria* cf. *striatula* (Schlotheim), *Salopina* sp., *? Rhipidomella* sp., ? Davidsoniacea gen. indet., *Machaeraria* sp., *Plectatrypa* sp., *? Meristina* sp., *Athyris* aff. *spiriferoides* (Eaton), *Athyris* sp. and *Cyrtina* aff. *heteroclita*

(Defrance). The fauna seems to have a definite Devonian aspect, possibly representing a lower Middle or Lower Devonian horizon. The presence of *Schizophoria* cf. *striatula*, *Athyris* aff. *spiriferoides* and *Cyrtina* aff. *heteroclita* support a Middle Devonian horizon, and *Plectatrypa*, *Salopina* and *Machaeraria*, a Lower Devonian horizon. *Calceola sandalina* has, more recently, been found by one of us (V. J. G.) from another locality in the Muth Quartzite of this area, and tends to confirm an upper Lower Devonian or a lower Middle Devonian age. The Muth Quartzite in this area exhibits both an apparently conformable relationship with the overlying Syringothyris Limestone (Lower Carboniferous), and an unconformable relationship with the Panjal Volcanic Series of Upper Carboniferous age (Pascoe, 1959, p. 637).

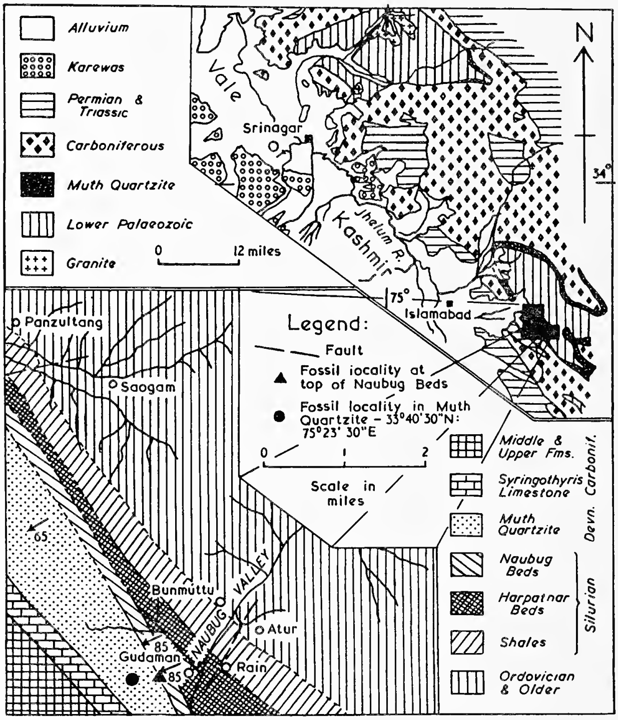

Fig. 1.—Detailed geological map of the Naubug valley area, showing the position of the fossi localities in the Naubug Beds and the Muth Quartzite. Inset map shows the generalized geology of the Vale of Kashmir and the location of the Naubug valley area, east of Islamabad (Anantnag).

Systematic Palaeontology

Numbers of specimens catalogued in the Museum of the Geology Department, Panjab University, Chandigarh, are prefixed PUGD.

Phylum COELENTERATA

Order Rugosa

Family Metriophyllidae

Genus *Stewartophyllum* Busch

Stewartophyllum sp.

(Plate 1, figs 1-2)

Material : One corallum (PUGD 1250). From the Naubug Beds locality.

Description : Corallum simple, small, trochoid, gently curved ; height 19 mm., attaining a maximum diameter of 12 mm. Exterior exhibits faint annulations and septal grooves. Calice moderately deep, at least 5 mm., with steeply inclined sides. Corallum wall 1 mm. thick. Septa of one order, dilated towards the periphery; united to form an axial structure in the neanic stage and withdrawing from the axis in the adult (ephebic) stage; up to 23 septa. Cardinal fossula on the concave side; alar fossulae also well developed. Tabulae not observed.

Remarks: The coral bears the closest comparison with the Middle Devonian genus *Stewartophyllum*. *S. intermittens* (Hall) has more dilated septa and lacks an axial structure in early growth stages (Busch, 1941), and *S. polonicum* (Sobelev) is smaller, and the septa tend to be rhopaloid (Fedorowski, 1965). It may also be compared with the Upper Silurian genus *Duncanella*, but differs in having well developed cardinal and alar fossulae, being larger with more septa, and apparently lacking the flanged septa (Sutherland, 1965). It shows quite remarkably close similarities to the Lower Carboniferous genus *Zaphrentites*.

Another specimen (PUGD 1278) from the Naubug Beds is even more doubtfully assigned to *Stewartophyllum*. It is a silicified coral with a simple, small, slightly curved form, 16 mm. in height and having a greatest diameter of 10 mm. The exterior shows a few widely spaced annulations, and the calice is moderately deep with steeply inclined sides. The septa exhibit vague structures resembling carinae near the periphery, or they may represent septal flanges, such as those observed by Sutherland (1965, p. 41) in *Duncanella pontotocensis*. Minor septa also occur in this specimen.

Genus *Stereolasma* Simpson

? STEREOLASMA sp.

(Plate 1, figs 3-4)

Material: Five coralla preserved as internal moulds, two of which also exhibit parts of their external moulds. From the Naubug Beds (PUGD 1251-54) and the Muth Quartzite (PUGD 1255) localities.

Description: Corallum solitary, very slightly curved, trochoid. Height of 11 mm. and greatest diameter of 9 mm. is attained in specimen PUGD 1251. Another specimen has a greatest diameter of 15 mm. and a least diameter of 10 mm. (average of 12.5 mm.). Exterior exhibits septal grooves. Calice deep. Short major and minor septa in the upper two-thirds of the corallum; major septa seem to reach the axis in the lower one-third; 24-27 major septa. Structures seen in the internal moulds linking septa probably represent tabulae.

Remarks: An axial structure is not preserved, but may have been developed near the apex. The specimens seem to bear the closest similarities to *Stereolasma gallicalar* (Davis) from the Middle Devonian of Ohio (Stumm, p. 14), but differ in being shorter (more obviously trochoid) and having shorter septa.

Order TABULATA

Family HELIOLITIDAE

Genus *Heliolites* Dana

? HELIOLITES sp.

(Plate 1, figs 5-7)

Material: Part of a compound corallum, exhibiting the external mould of part of the calicular surface. Preserved in recrystallized dark grey limestone. From the Naubug Beds (PUGD 1256).

Description: Tabularia have average diameters of 1 mm. and are from 0·5 to 2 mm. apart (with 4-8 rows of tubuli between). Walls of the tabularia not clearly differentiated in thin sections. In oblique lighting of the transverse section, 12 radiating elements (septa) can be seen. The calicular surface shows the sunken tabularia with the frequent occurrence of a raised columella surrounded by the elevated coenenchymal tissues (reticulum). The reticulum consists of tubuli, variable in size and many-sided; outgrowths resembling carinae are developed where a tubulus is at the point of dividing. In longitudinal section tubuli exhibit a tendency to arch inwards towards the tabularia. Sola closely and evenly spaced.

Remarks : The coral is doubtfully assigned to *Heliolites*, because of the lack of well-defined walls and the inward curvature of the tubuli towards the tabularia. It may in fact represent a new heliolitid genus characterized by the frequent division and inward curvature of the tubuli. Heliolitids are not known later than the Givetian (Jones and Hill, 1940, p. 186).

Family FAVOSITIDAE

Genus *Favosites* Lamarck

FAVOSITES GOTHLANDICUS Lamarck forma FORBESI Milne-Edwards & Haime

(Plate 1, figs 8-9)

Material : A small hemispherical colony measuring 13 mm. in diameter. From the Naubug Beds (PUGD 1257).

Description : Polygonal corallites of variable size, attaining a diameter of 1·8 mm.; walls of intermediate thickness. A few septal spines and mural pores observed. Tabulae flat to concave, six every 4 mm.

Remarks : This small specimen seems to be most closely comparable to the Silurian form *Favosites gothlandicus* forma *forbesi* (see Hill and Jones, 1940, p. 193). It is also quite similar to the Devonian form *F. goldfussi* d'Orbigny forma *pyriformis* Lecompte, showing a somewhat thicker wall structure and a closer spacing of tabulae (see Lecompte, 1939).

FAVOSITES sp.

Material : Portion of a poorly preserved, weathered colony measuring 6 cm. across. From the Naubug Beds (PUGD 1258).

Description : Polygonal corallites reaching a diameter of 2·2 mm. Impressions of tabulae faintly shown.

Remarks : This coral may also belong to the *F. gothlandicus* group.

Phylum BRACHIOPODA

Order ORTHIDA

Superfamily ENTELETACEA

Family ENTELETIDAE

Subfamily SCHIZOPHORIINAE

Genus *Schizophoria* King

SCHIZOPHORIA cf. STRIATULA (Schlotheim)

(Plate 1, figs 10-12)

Material : A single specimen preserved as an external mould. From the Muth Quartzite locality (PUGD 1264).

Description : Brachial valve convex, pedicle valve resupinate ; narrow dorsal fold and ventral sulcus. Outline subcircular to transversely elongated ; greatest width of shell 30 mm., measured midway from hinge line to anterior commissure ; anterior commissure uniplicate ; length of valve 25 mm. and hinge line measures 15 mm. Numerous fine costellae which are crossed by faint concentric growth lines.

Remarks : Apart from exhibiting a more acute and more narrowly uniplicate anterior commissure, the specimen agrees closely with Biernat's (1959) description of the exterior of *Schizophoria striatula*. Biernat considered the species to have a widespread distribution in the Devonian of Europe, Asia, North America and Australia, whereas Struve (1965) restricted *S. striatula* to the Frasnian of Germany. Specimens labelled " Schizophoria striatula " from the Hackberry Beds (Upper Devonian) of Iowa in the University of Sydney Geology Department reference collection (USGD 1485) are very similar in external form to the Kashmir specimen, and the larger specimens also show a relatively narrow uniplicate commissure.

Genus *Salopina* Boucot

Salopina sp.

(Plate 1, figs 13-16)

Material : Five samples from the Muth Quartzite (PUGD 1259-63) containing disarticulated internal moulds of both valves.

Description : Outline from transversely elongated to subcircular ; ventribiconvex ; hinge-line straight, greatest width posterior to the middle ; numerous fine unequal costellae ; weakly developed sulcus in brachial valve.

Impressions of prominent slightly diverging dental plates in the pedicle interior ; muscle field is not preserved. Simple, divergent brachiophores and dental sockets with faint impressions of fulcral plates in brachial interior, together with small, subrounded (tear-drop shaped) cardinal process.

Measurements : (in millimetres)

	Width	Length	
PUGD 1259 (pedicle valve)	18	13	
„ 1260 „ „	14·5	13	
„ 1261 „ „	14	18	(possibly distorted)
„ 1262 (brachial valve)	17	12	

Estimated thickness of adult shell (both valves) = 7 mm.

Remarks : This morphologically simple orthid is assigned to *Salopina*, a genus which ranges from the Upper Silurian to the Lower Devonian. It cannot be determined specifically, because details of the muscle impressions are not preserved. However, it seems to be close to *S. lunata* (J. de C. Sowerby), as recently described by Walmsley (1965), but has a somewhat larger shell and coarser costellae. It may be distinguished from *Isorthis* with its median ridge in the pedicle valve and more prominent cardinalia in the brachial valve (Walmsley, 1965), from *Sphenophragmus* with its proportionally shorter hinge line and more strongly divergent dental plates (Imbrie, 1959), and from *Mendacella* with its thick brachiophores and convex brachial valve (Boucot, Johnson and Walmsley, 1965).

Family Rhipidomellidae

Genus *Rhipidomella* Oehlert

? Rhipidomella sp.

(Plate 2, figs 1-2)

Material : One poorly preserved internal mould from the Muth Quartzite locality (PUGD 1265).

Description : Subcircular, planoconvex ; 11 mm. wide ; short dental plates in pedicle valve and short, divergent brachiophores in brachial valve.

Remarks : The specimen seems to be a rhipidomellid, but it is too poorly and incompletely preserved for more positive assignment.

Order Strophomenida

Suborder Strophomenidina

Superfamily Davidsoniacea King

? Davidsoniacea gen. indet.

(Plate 2, figs 3-4)

Material : Two samples from the Muth Quartzite, exhibiting part of the internal mould of the brachial valve (PUGD 1266) and the exterior mould of another (probably the brachial) valve (PUGD 1267).

Description : Gently convex shell, finely costellate with dichotomous branching ; length of shell 28 mm. and width 27 mm. measured along the hinge line. Brachiophores divergent, and cardinal process poorly preserved.

Remarks : The lack of diagnostic features prevents a definite assignment of these specimens. From general characters, they may represent a species of *Schuchertella*.

Order RHYNCHONELLIDA
Superfamily RHYNCHONELLACEA
Family RHYNCHOTREMATIDAE
Genus *Machaeraria* Cooper

MACHAERARIA sp.

(Plate 2, figs 5-12)

Material : Four specimens consisting of three complete internal moulds and a brachial impression from the Muth Quartzite (PUGD 1268-71).

Description : Small, subpentagonal in outline ; length less than width ; uniplicate, with well developed fold and sulcus ; costae strong, angular ; commissure serrate.

Dental plates short, not markedly divergent. Crural plates present ; tiny cardinal process connected to a relatively short median septum.

Remarks : The specimens seem to be closest to *Machaeraria formosa* (Hall) from the Lower Devonian of North America (Cooper, 1955, p. 55), though they show a somewhat more prominent median septum.

Order SPIRIFERIDA
Suborder ATRYPIDINA
Superfamily ATRYPACEA
Family ATRYPIDAE
Subfamily CARINATININAE
Genus *Plectatrypa* Schuchert & Cooper

PLECTATRYPA sp.

(Plate 1, figs 17-20)

Material : One external mould of both valves from the Muth Quartzite (PUGD 1272).

Description : Subequally biconvex, costate with dorsal fold and ventral sulcus ; costae bifurcate anteriorly ; growth lines prominent especially across costae ; beak incurved ; greatest width of shell 15 mm. midway from hinge line to anterior margin ; internal features unknown.

Remarks : Although somewhat poorly preserved, the specimen resembles in external appearance *Plectatrypa imbricata* (Sowerby) from the Silurian of Gotland (Schuchert and Cooper, 1930, p. 278), except that it is proportionally longer and thinner. According to Boucot, Johnson and Staton (1964), *Plectatrypa* ranges from Ashgillian to Gedinnian.

Suborder ATHYRIDIDINA
Superfamily ATHYRIDACEA
Family MERISTELLIDAE
Genus *Meristina* Hall

? MERISTINA sp.

(Plate 2, figs 13-15)

Material : External mould of one complete shell from the Muth Quartzite (PUGD 1273).

Description : Medium sized, smooth, biconvex, subpentagonal ; gentle dorsal fold and ventral sulcus. Greatest width posterior to anterior margin, measuring 18 mm. Internal features unknown.

Remarks : In the absence of internal features, the specimen can only be tentatively assigned to the genus *Meristina*. Another specimen (PUGD 1274 ;

Plate 2, fig. 16) from the Muth Quartzite is about the same size, but lacks a fold and sulcus. It possibly belongs to the same family.

Family ATHYRIDIDAE

Subfamily ATHYRIDINAE

Genus *Athyris* McCoy

ATHYRIS aff. SPIRIFEROIDES (Eaton)

(Plate 2, figs 17-19)

Material : One external mould of a complete shell from the Muth Quartzite locality (PUGD 1275).

Description : Subequally biconvex, transverse, subcircular shell with a shallow ventral sulcus and dorsal fold. Greatest width midway between umbo and anterior margin, measuring 37 mm.; concentric growth lines. Internal features not known.

Remarks : The Kashmir shell is similar to larger specimens of *Athyris spiriferoides* from the Hamilton Beds of Eighteen Mile Creek, New York, in the Sydney University Geology Department reference collection (USGD 1500), but seems to be proportionally slightly thicker.

ATHYRIS sp.

(Plate 2, figs 20-22)

Material : External mould of one complete shell from the Muth Quartzite (PUGD 1276).

Description : Shell small, biconvex, subtrapezoidal ; shallow ventral sulcus and dorsal fold ; fine concentric growth lines ; greatest width 12 mm., a little anterior to the midline ; apical angle 88°. Internal features unknown.

Remarks : The specimen seems to be comparable with *Athyris concentrica* (von Buch) from the European and Asian Devonian, although smaller in size.

Suborder SPIRIFERIDINA

Superfamily SUESSIACEA

Family CYRTINIDAE

Genus *Cyrtina* Davidson

CYRTINA aff. HETEROCLITA (Defrance)

(Plate 2, figs 23-25)

Material : One small, virtually complete shell from the Muth Quartzite locality (PUGD 1277).

Description : Small, subpyramidal, spiriferoid ; relatively large, gently incurved triangular area with convex pseudodeltidium and foramen near apex ; faint longitudinal and transverse striations on interareas ; hinge line straight ; greatest width of shell 12 mm. measured a little anterior to hinge line ; weakly developed plications on lateral slopes ; fold raised, and sulcus depressed and rounded ; faint concentric growth lamellae observed in sulcus.

Remarks : The specimen differs from *Cyrtina heteroclita* in being somewhat smaller and having weakly developed plications. *C. heteroclita* is a moderately common Middle Devonian species in Europe and Asia. According to Talent (1963, p. 28), it ranges from Middle Siegenian to Givetian.

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References

Berry, W. B. M., and Gupta, V. J., 1966.—Monograptids from the Kashmir Himalayas. *Jour. Paleont.*, 40 : 1338–44.

Biernat, G., 1959.—Middle Devonian Orthoidea of the Holy Cross Mountains and their Ontogeny. *Palaeont. polon.*, 10 : 1–78.

Boucot, A. J., Johnson, J. G., and Staton, R. D., 1964.—On Some Atrypoid, Retzioid, and Athyridoid Brachiopoda. *Jour. Paleont.*, 38 : 805–22.

————, ————, and Walmsley, V. G., 1965.—Revision of the Rhipidomellidae (Brachiopoda) and the Affinities of *Mendacella* and *Dalejina*. *Jour. Paleont.*, 39 : 331–40.

Busch, D. A., 1941.—An ontogenetic study of some rugose corals from the Hamilton of Western New York. *Jour. Paleont.*, 15 : 392–411.

Cooper, G. A., 1955.—New genera of Middle Paleozoic Brachiopods. *Jour. Paleont.*, 29 : 45–63.

Fedorowski, J., 1965.—Lindstroemiidae and Amplexocariniidae (Tetracoralla) from the Middle Devonian of Skaly, Holy Cross Mountains, Poland. *Acta palaeont. polon.*, 10 : 335–64.

Gupta, V. J., and Denison, R. H., 1966.—Devonian fishes from Kashmir, India. *Nature*, 211 : 177–8.

Hill, D., and Jones, O. A., 1940.—The corals of the Garra Beds, Molong district, New South Wales. *Jour. Proc. roy. Soc. N.S.W.*, 74 : 175–208.

Hills, E. S., 1958.—A brief review of Australian fossil vertebrates, 86–107. In T. S. Westoll, edit., *Studies on Fossil Vertebrates*, xii+263 pp. Athlone Press, Univ. London.

Imbrie, J., 1959.—Brachiopods of the Traverse Group (Devonian) of Michigan. Part 1. Dalmanellacea, Pentameracea, Strophomenacea, Orthotetacea, Chonetacea and Productacea. *Bull. Amer. Mus. nat. Hist.*, 116 (4) : 345–410.

Jones, O. A., and Hill, D., 1940.—The Heliolitidae of Australia, with a discussion of the morphology and systematic position of the family. *Proc. roy. Soc. Queensland*, 51 : 183–215.

Lecompte, M., 1939.—Les Tabulés du Dévonien moyen et supérieur bord sud du Bassin de Dinant. *Mém. Mus. Hist. nat. Belg.*, 90 : 1–229.

Middlemiss, C. S., 1910.—A revision of Silurian-Trias sequence in Kashmir. *Rec. geol. Surv. India*, 40 (3), 206–60.

Pascoe, E. H., 1959.—" A Manual of the Geology of India and Burma." Vol. II. 3rd Edit. xxii, 485–1343 pp. Calcutta.

Reed, F. R. C., 1912.—Silurian fossils from Kashmir. *Rec. geol. Surv. India*, 42 (1) : 16–33.

Sahni, M. R., and Gupta, V. J., 1964.—Graptolites from the Kashmir Himalayas, also a note on the discovery of fossils in the Muth Quartzite. *Nature*, 204 : 1081–2.

Schuchert, C., and Cooper, G. A., 1930.—Upper Ordovician and Lower Devonian stratigraphy and paleontology of Percé, Quebec ; Part 2, New species from the Upper Ordovician of Percé. *Amer. Jour. Sci.*, ser. 5, 20 : 265–88.

Struve, W., 1965.—Beiträge zur Kenntnis devonischer Brachiopoden. 11. *Schizophoria striatula* und *Schizophoria excisa* in ihrer ursprünglichen Bedeutung. *Senck. leth.*, 46 : 193–215.

Stumm, E. C., 1964.—Silurian and Devonian corals of the Falls of the Ohio. *Mem. geol. Soc. Amer.*, 93 : 1–184.

Sutherland, P. K., 1965.—Rugose corals of the Henryhouse Formation (Silurian) in Oklahoma. *Bull. Okla. geol. Surv.*, 109 : 1–92.

Talent, J. A., 1963.—The Devonian of the Mitchell and Wentworth rivers. *Mem. geol. Surv. Victoria*, 24 : 1–118.

Walmsley, V. G., 1965.—*Isorthis* and *Salopina* (Brachiopoda) in the Ludlovian of the Welsh Borderland. *Palaeontology*, 8 : 454–77.

EXPLANATION OF PLATES

Plate viii

Coral specimens figured 1–9 from the Naubug Beds, and the brachiopod specimens figured 10–20 from the Muth Quartzite. All figured specimens $\times 1\frac{1}{3}$ unless otherwise stated.

Figs 1–2. *Stewartophyllum* sp. 1, PUGD 1250, $\times 2\frac{2}{3}$, transverse section 11 mm. above the base, showing well-developed fossulae. 2, PUGD 1250, $\times 2\frac{2}{3}$, transverse section 6 mm. above the base. Figs 3–4. *? Stereolasma* sp. 3, PUGD 1252, side view of internal mould. 4, PUGD 1251, oblique-side view of corallum. Figs 5–7. *? Heliolites* sp. 5, PUGD 1256, view of calicular surface. 6–7, PUGD 1256, $\times 4$, transverse and longitudinal sections. Figs 8–9. *Favosites gothlandicus* Lamarck forma *forbesi* Milne-Edwards and Haime. 8, PUGD 1257, view of outer surface. 9, PUGD 1257, $\times 2\frac{2}{3}$, oblique section. Figs 10–12. *Schizophoria* cf. *striatula* (Schlotheim). 10–12, PUGD 1264, pedicle, brachial and side views. Figs 13–16. *Salopina* sp. 13, PUGD 1259, view of internal mould of pedicle valve. 14, PUGD 1260, view of internal mould of pedicle valve. 15, PUGD 1261, view of internal mould of pedicle valve. 16, PUGD 1262, view of internal mould of brachial valve. Figs 17–20. *Plectatrypa* sp. 17–20, PUGD 1272, brachial, pedicle, side and posterior views.

PLATE IX

All figured specimens × $1\frac{1}{8}$; from the Muth Quartzite locality.

Figs 1–2. *? Rhipidomella* sp. 1–2, PUGD 1265, pedicle and side views. Figs 3–4. ? Davidsoniacea gen. indet. 3. PUGD 1267, external mould of ?brachial valve. 4, PUGD 1266, internal mould of brachial valve. Figs 5–12. *Machaeraria* sp. 5–8, PUGD 1268, pedicle, brachial, posterior and anterior views. 9–12, PUGD 1269, pedicle, brachial, posterior and anterior views. Figs 13–16. *? Meristina* sp. 13–15, PUGD 1273, brachial, pedicle and side views. 16, PUGD 1274, brachial view. Figs 17–19. *Athyris* aff. *spiriferoides* (Eaton). 17–19, PUGD 1275, brachial, pedicle and side views. Figs 20–22. *Athyris* sp. 20–22, PUGD 1276, brachial, pedicle and side views. Figs 23–25. *Cyrtina* aff. *heteroclita* (Defrance). 23–25, PUGD 1277, brachial, pedicle and side views.

INHERITANCE OF PURPLE PERICARP IN WHEAT

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Synopsis

Purple pericarp colour transferred to a hexaploid wheat derivative from *Triticum durum* Desf. C.I.7809 was conditioned by duplicate dominant gene pairs. The intensity of pigmentation was modified both by genotype and environment and appeared to be enhanced by a gene(s) for red pericarp colour. Although a white grained hexaploid parent was used in the initial cross, all non-purple segregates in hexaploid derivatives segregating for purple pericarp were red indicating that a gene(s) for red pericarp also had been transferred from the *durum* parent. Studies involving C.I.7809 at the tetraploid level indicated duplicate dominant genes for purple pericarp as well as at least one gene for red pericarp colour.

Introduction

Grain colour in wheat is generally determined by the constitution of the pericarp and in cultivars of the hexaploid bread wheat (*Triticum aestivum* L. ssp. *vulgare* (Vill.) MacKey) is restricted to red and white types. However, Knott (1958) reported that a wheat-*Agropyron* substitution line showed blue endosperm due to a gene(s) carried on the single pair of *Agropyron* chromosomes. Red pericarp colour is controlled by one, two or three gene pairs acting cumulatively. Hence red grained cultivars may have from one to three factors. For example, red colour in Chinese Spring is due to a gene located on chromosome 3D (XVI) (Sears, 1953). Traditionally commercial cultivars grown in Australia have white pericarp.

In a programme designed to incorporate stem rust and leaf rust resistances from a purple grained resistant selection (C.I.7809) of *T. durum* Desf. into hexaploid wheat derivatives, a number of rust resistant *vulgare*-type F_3 selections were observed to segregate for purple coloured grain. Some lines segregated for a range of purple and brown grained types in addition to red. This paper reports an analysis of segregation in later generations within one line indicating that purple pericarp was conditioned by duplicate dominant gene pairs.

Literature Review

Copp (1965) reported the transference of purple grain colour from the tetraploid, *T. dicoccum* Schübl. var. *arraseita* Perc. to the hexaploid level. He reported that backcrossing to the white grained cultivar Arawa progressively weakened the purple colour. However, after backcrossing to the red grained cultivar Hilgendorf, fully purple pericarp derivatives were obtained.

From a study of inheritance at the tetraploid level, Sharman (1958) interpreted segregation on the basis of a single dominant gene pair difference ; however he based his conclusions on the extremely small F_2 population of forty plants.

Materials and Methods

In the initial cross involving C.I.7809, made in 1959, the white grained rust susceptible hexaploid cultivar Steinwedel W199* was used as the female parent. Steinwedel, thought to have been introduced from Africa prior to 1900, has been used successfully in interspecific hybridisation by Australian workers. Although F_1 plants exhibited low fertility, a large number of F_2 embryos were obtained from twenty F_1 hybrids. These were screened for resistance to stem rust

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* Refers to the Sydney University Wheat Accession Register.

Puccinia graminis var. *tritici* Erikss. and Henn.) in the glasshouse. Resistant plants were transplanted to the field and, as adult plants, selected for high fertility and *vulgare* spike characteristics as well as high levels of adult plant resistances to stem rust and leaf rust (*Puccinia recondita* Rob. ex Desm.). Homozygous seedling stem rust resistant F_3 lines were selected and certain of these were transplanted to the field. Lines were harvested on a single plant basis and a number segregated for purple and red grain colour.

In 1965 small populations of progenies from the above F_3 lines were grown and classified for grain colour. These preliminary studies indicated that purple pericarp was conditioned by a single dominant, or in certain instances, duplicate dominant factor pairs. In 1966 larger progeny populations were scored from plants within an F_4 line segregating in a ratio which conformed statistically to 15 purple : 1 red, indicating the action of duplicate genes.

Segregation for grain colour in an F_2 population from a cross between Glossy Huguenot W304, a white grained accession of *T. durum*, and C.I.7809 was studied to enable a comparison of results at the different levels of ploidy.

Anatomical studies of caryopses indicated that purple colour was due to pigmentation in the pericarp tissue which is of maternal origin. This aspect was investigated further from observations on grain colour following reciprocal crosses between a homozygous purple grained line and varieties with both red and white pericarps respectively.

EXPERIMENTAL RESULTS

Analyses following reciprocal crosses involving a purple grained hexaploid line confirmed that purple grain pigmentation was maternally inherited and determined by the pericarp. Hence the segregating generations referred to previously apply to maternal tissue. For example, F_2 pericarp phenotypes were determined from observations on lines at the F_3 embryo generation. The phenomenon of maternal inheritance means that the pericarp of all grains produced on a single plant will be of the same genotype, and variation within this unit must be due to non-genetic causes. Attempts were made to score progenies on the basis of a set of arbitrarily selected standards ranging from purple to light brown ; however in most instances only the limits of variation could be defined, continuous variation occurring within this range. Plumpness of grain affected colour ; in all cases plants with shrivelled grain were lighter in pigmentation than their plumper sibs. Similarly intra-plant variation was shown due to this cause. The time of the year at which the seed ripened also affected intensity of pigmentation. Grain on progenies from the same parental plant maturing in autumn was classified as purple whilst that maturing in late spring and summer was classified as dark brown. The modifications were apparently also in part genetical, the range of variation between pigmented progenies being usually less in pure breeding than in segregating lines. Because of difficulties in consistent and accurate classification between different degrees of brown and purple pericarp pigmentation, only two classes were considered in the final analyses—purple (including all shades of brown) and red. Despite the fact that a white grained hexaploid cultivar was used in the initial cross, all segregating lines which were studied possessed plants with red grain as the only contrasting phenotype to purple (or brown).

Data from progeny tests (relating to pericarp genotypes) of an F_4 generation of 36 plants which segregated in a ratio of 34 purple : 2 red grained individuals are presented in Table 1. The grain colour of each parental plant is also indicated. The F_4 segregation obviously conformed statistically to 15 purple : 1 red grained plant, suggesting the action of dominant duplicate factors. On this basis the expected F_5 behaviour would have been 7 homozygous purple lines : 4 lines segregating in a ratio of 15 purple to 1 red : 4 lines segregating in a ratio of 3 purple to 1 red : 1 homozygous red line. The families are grouped in the Table according to their apparent classification into one or another of these categories. It was intended originally to grow sufficient plants in each population to distinguish lines segregating in a ratio of 15 purple : 1 red pericarp from those segregating in a respective ratio of 3 : 1. At the P = 0·05 level 50 plants are required for this purpose when, if the number of recessives is more than 7, the segregation is considered to fit a 3 : 1 ratio. This family size would also distinguish homozygous purple lines from those segregating in a 15 : 1 ratio, where 47 plants are required at the same probability level. However a number of populations were less than the required size due to low grain numbers on parental plants and/or greater than anticipated plant losses during growth.

Table 1

Pericarp colour of progenies of F_4 classified plants in family segregating 34 purple : 2 red

Family number	Parental pericarp colour	Progeny numbers		χ^2 3 : 1 ratio	P value (homozygosity versus 15 : 1 segregation)	Classification
		Purple	Red			
1	Purple	30	—		0·14	Homozygous purple
5	,,	51	—		<0·05	,,
8	,,	47	—		0·05	,,
13	,,	81	—		<0·05	,,
14	,,	69	—		<0·05	,,
16	,,	56	—		<0·05	,,
20	,,	59	—		<0·05	,,
21	,,	68	—		<0·05	,,
22	,,	35	—		0·10	,,
23	,,	56	—		<0·05	,,
26	Dark brown	51	—		<0·05	,,
30	Purple	61	—		<0·05	,,
34	,,	26	—		0·19	,,
2	Purple	45	3			Segregating 15 : 1
4	,,	74	3			,,
11	,,	70	3			,,
24	Dark brown	49	1			,,
28	Purple	64	1			,,
29	,,	49	7			,,
31	,,	51	2			,,
33	,,	36	5[1]			,,
3	Purple	52	30	5·87[2]		Segregating 3 : 1
6	,,	37	21	3·88		,,
7	,,	52	14	0·51		,,
9	Brown	63	27	1·20		,,
12	,,	21	6	0·11		,,
18	Purple	21	11	1·50		,,
19	Dark brown	55	27	2·75		,,
25	Purple	38	17	1·03		,,
32	Brown	41	23	4·08		,,
35	Purple	44	20	1·33		,,
36	,,	19	20	1·33		,,
10	Red	—	42			Homozygous red
27	,,	—	62			,,
15	Purple	6	—			Unclassified
17	,,	6	—			,,

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[1] P value for family size in distinguishing 15 : 1 and 3 : 1 ratios=0·08. For P=0·08, r=5·3 plants.

[2] χ^2 values for significance—P=0·05, 3·84 ; P=0·01, 6·63.

Thirteen families did not segregate for red grain colour and were placed in the homozygous purple group. Of these 10 contained 47 or more plants, sufficient to distinguish homozygosity statistically at the $P = 0{\cdot}05$ level from the alternative 15 : 1 segregating ratio. Eight segregating families were placed in the category of 15 purple : 1 red. Segregation in family " 33 " did not deviate significantly from either a 3 : 1 or 15 : 1 ratio but as the r value for the family size of 41 plants was 5·3, it was included in the latter group as the number of recessives was 5.

Of eleven segregating families which deviated from a 15 : 1 ratio, eight conformed to single factor segregation ; the remaining three families had a statistically significant excess of red grained segregates for this ratio and thus the segregation observed could not be confused with that based on a 15 : 1 ratio. Due to low population numbers families " 15 " and " 17 " were not placed in any of the above categories. Both red grained plants yielded progenies homozygous for red pericarp colour. Table 2 presents a summary of observed and expected frequencies of progeny behaviour on the basis of dominant duplicate factor pairs. There is obviously close agreement with this hypothesis.

TABLE 2

Comparison of observed and expected behaviours of F_5 lines for pericarp colour on duplicate dominant gene action

Behaviour	Number observed	Number expected
Homozygous purple or brown ..	13	14·9
Segregating 15 purple : 1 red ..	8	8·5
Segregating 3 purple : 1 red	11	8·5
Homozygous red	2	2·1
Total	34	34·0

In the cross between C.I.7809 and Glossy Huguenot, 209 F_2 plants possessed purple or brown pericarp whilst 17 were scored as red or white. This agrees well with a 15 : 1 ratio ($X^2 = 0{\cdot}62$; $0{\cdot}25 < P < 0{\cdot}50$). Attempts to further classify within the pigmented class were again unsuccessful, shrivelled grain contributing largely to this difficulty. Among the 17 lines scored as red or white, definite red types were observed suggesting that the purple grained *durum* had contributed at least one gene pair for red colour in addition to two factor pairs for purple pericarp.

DISCUSSION AND CONCLUSIONS

In the hexaploid derivative studied, purple pericarp was conditioned by duplicate dominant genes. Further classification into discrete classes within the pigmented group was unreliable due to continuous variation, created largely by environmental or non-genetic modifications. However, genetic control of the intensity of purple pigmentation was also indicated, plants with brown or dark brown pericarp being frequently heterozygous for a single factor pair on the basis of progeny tests. Homozygous lines tended to show less variation in their progenies than segregating lines, indicating incomplete dominance of the genes. Despite the fact that the maternal hexaploid parent in the initial cross possessed white grain the contrasting recessive phenotype in segregating lines bore red pericarp. Copp (1965) found that purple pericarp colour could be more easily transferred to a red grained than a white grained genotype by backcrossing. In the current investigation the most deeply pigmented F_3 lines were selected for further study and it is possible therefore that these particular lines possessed a gene(s) for red colour. Segregation at the tetraploid level also indicated that a gene(s) for red colour was present in the *durum* parent in addition to duplicate genes conditioning purple pericarp. Presumably three factor pairs affecting pericarp colour were transferred to the hexaploid derivatives.

The recovery of non-purple segregates in certain F_2 populations when purple lines homozygous for a single factor pairs are crossed will show more conclusively that duplicate gene pairs condition purple pericarp in specific hexaploid derivatives. Homozygous purple grained hexaploid lines have been crossed with varieties possessing red and white pericarps to study more closely the effect of these different genetic backgrounds on the purple phenotype. From such crosses the possibility of obtaining lines segregating for purple and white pericarp can be explored. Studies to date have not shown whether red pericarp is a prerequisite background into which purple grain colour can only be established.

The commercial role of grain possessing a distinctive purple pigmentation requires further study. Seed of a quality suitable only for a specific purpose could be easily identified at time of marketing.

Since purple pigmentation is restricted to the pericarp it cannot be used directly in investigations on the extent of cross pollination in wheat, where endosperm markers are of value.

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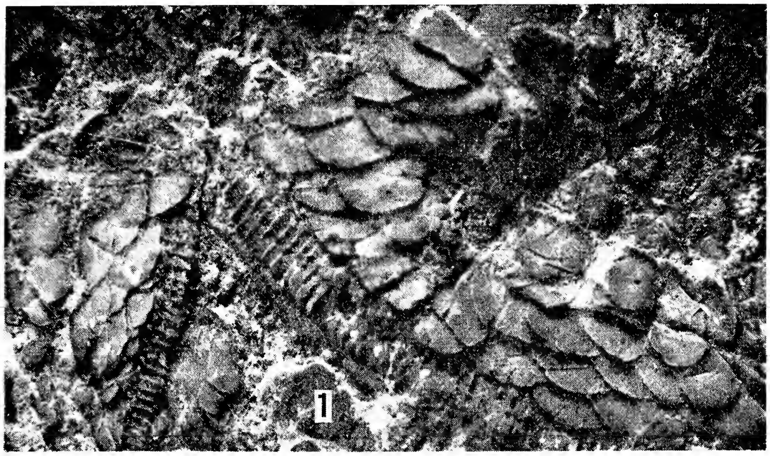
References

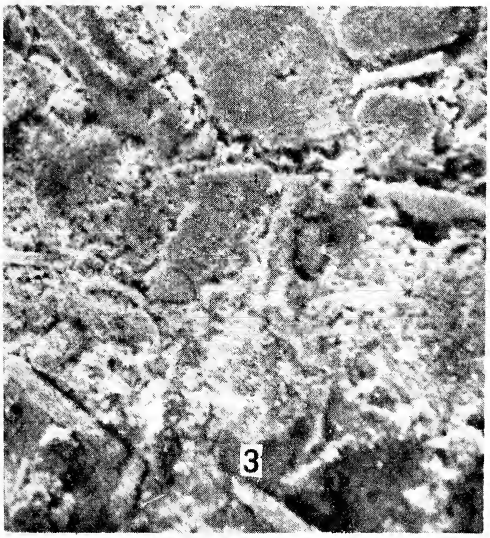
Copp, L. G. L., 1965.—Purple grain in hexaploid wheat. *Wheat Information Service*, 19, 20 : 18.

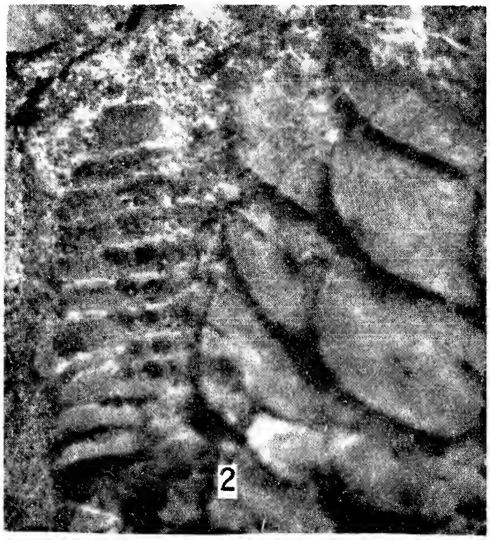
Knott, D. R., 1958.—The inheritance in wheat of a blue endosperm colour derived from *Agropyron elongatum*. *Can. J. Botany*, 36 : 571-574.

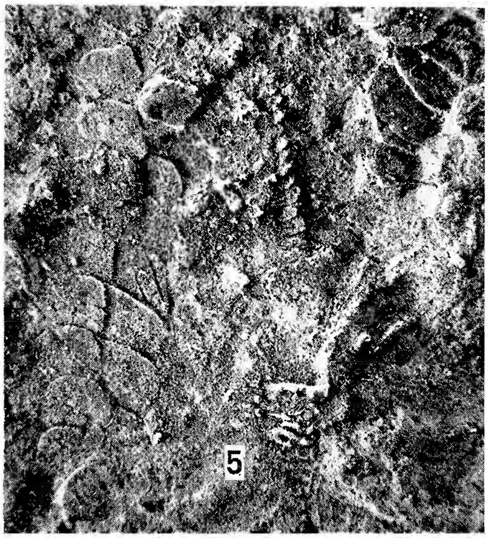
Sears, E. R., 1953.—Nullisomic analysis in common wheat. *Amer. Naturalist*, 87 : 245-252.

Sharman, B. C., 1958.—Purple pericarp : a monofactorial dominant gene in tetraploid wheats. *Nature*, 181 : 929.









A Devonian Echinoid from Taemas, South of Yass, N.S.W.

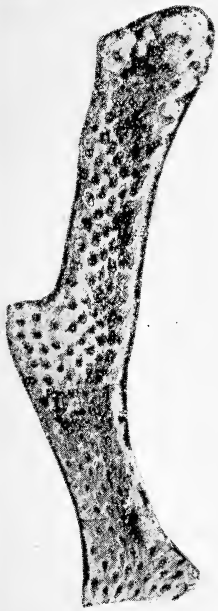


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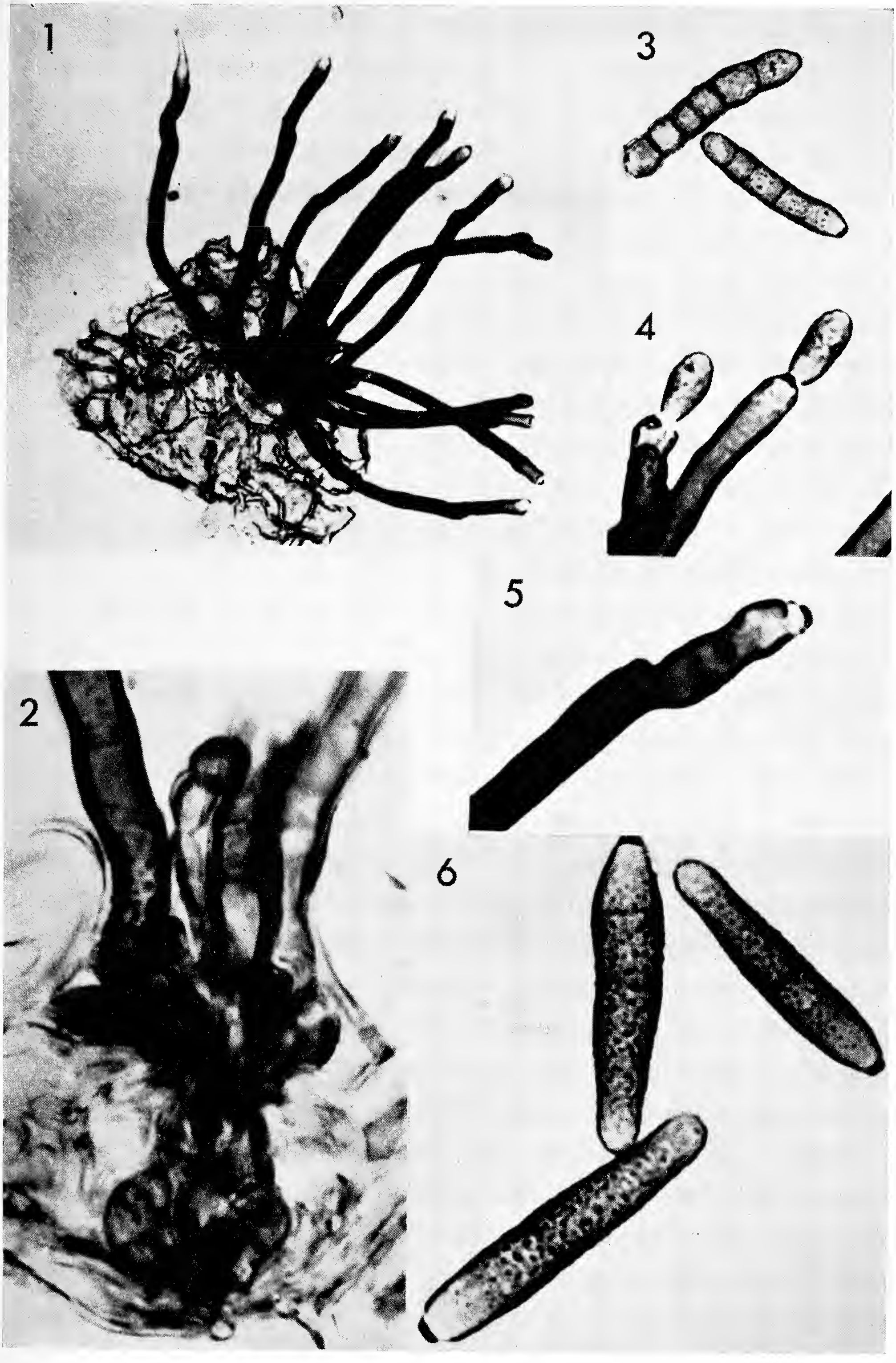
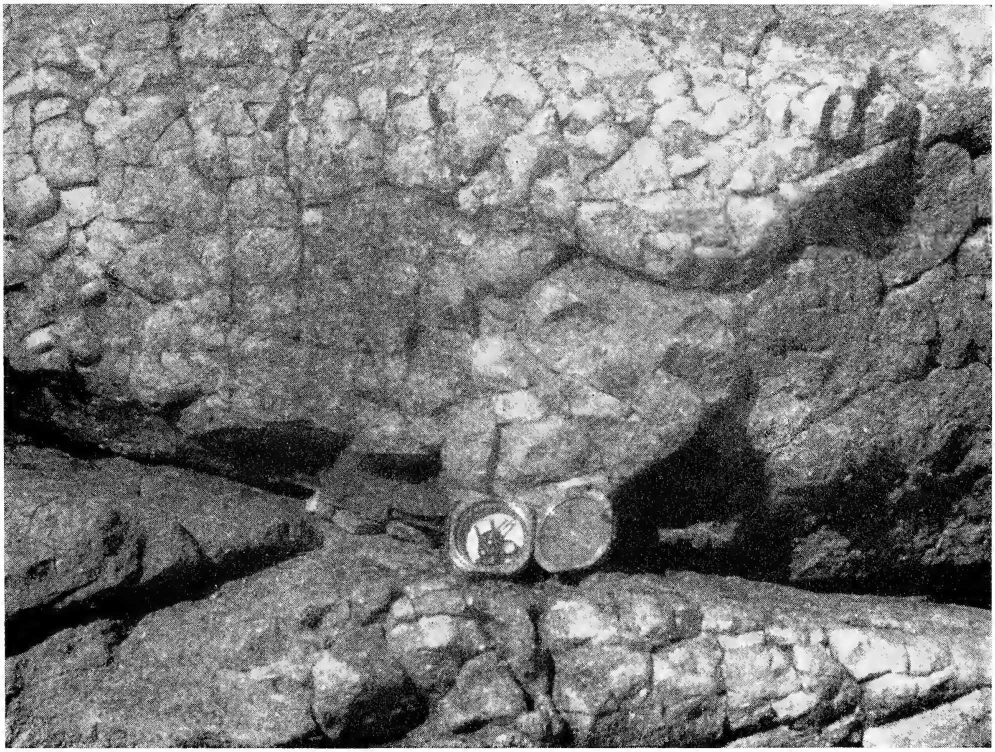
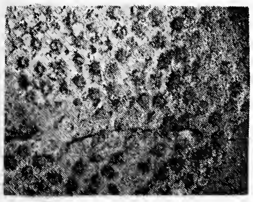
Fig. 1.—*Fistulamina* sp.
Figs 2–3.—*Streblascopora marmionensis* (Bretnall).



Verrucispora proteacearum Shaw & Alcorn.



Polygonal fracturing of Upper Devonian sandstones.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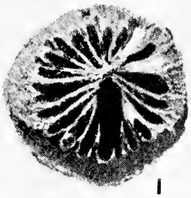
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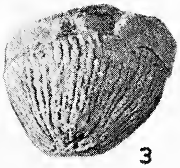
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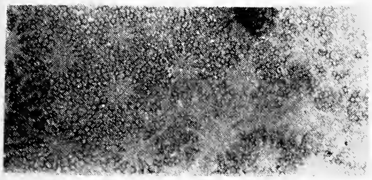
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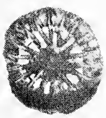
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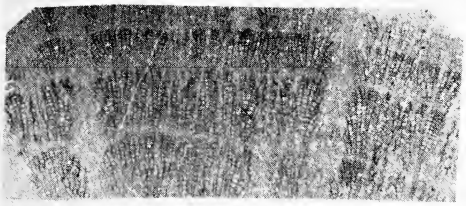
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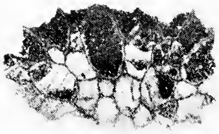
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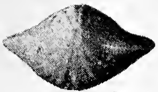
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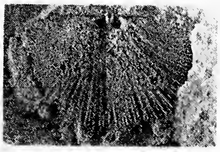
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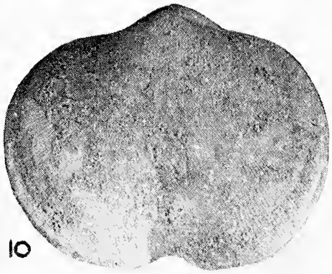
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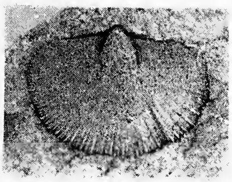
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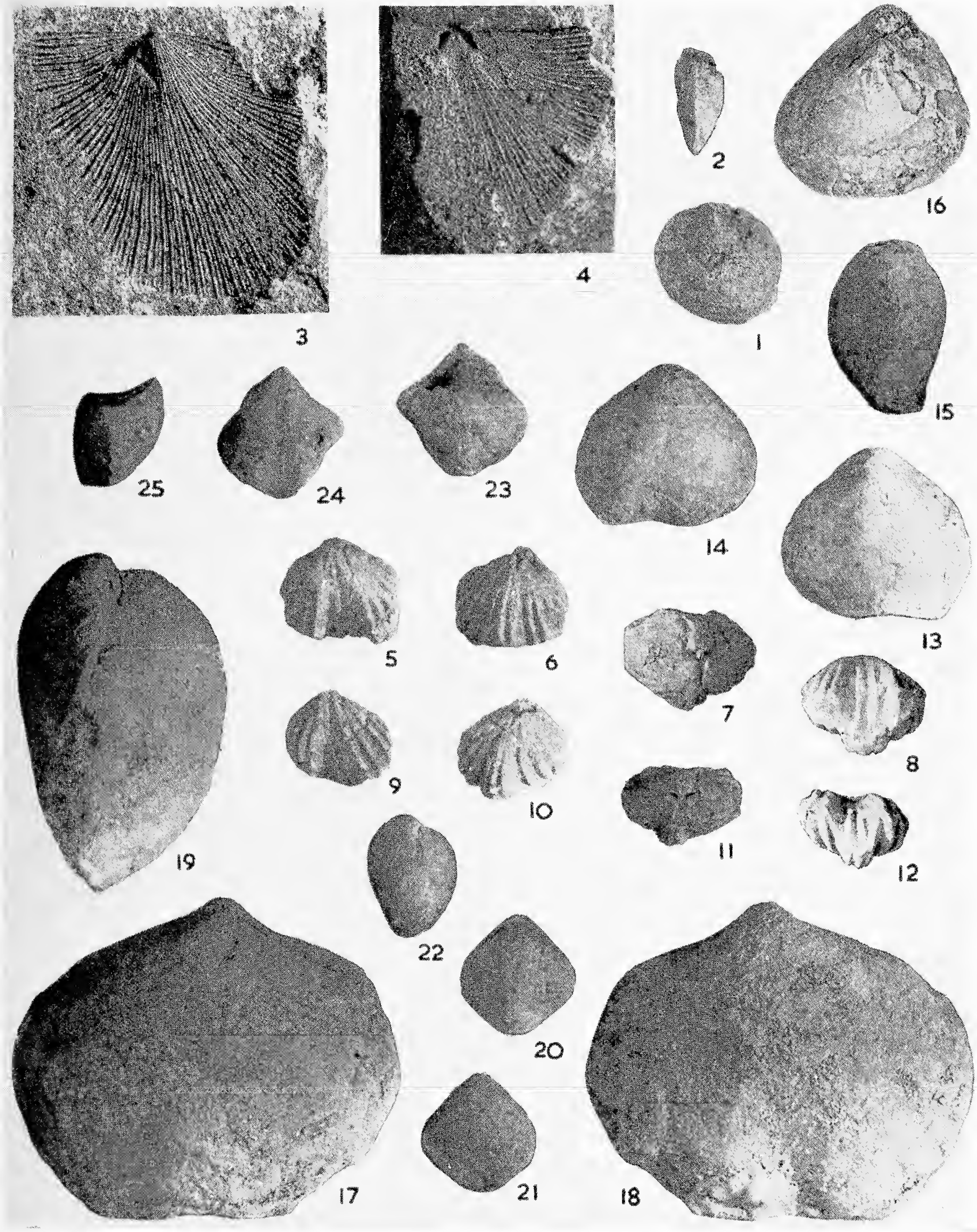
Middle Palaeozoic brachipods and corals from Kashmir.



Middle Palaeozoic brachipods from Kashmir.

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(Papers read June–July, 1967)

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COOPERNOOKIA: A NEW GENUS OF *GOODENIACEAE*

R. C. Carolin
School of Biological Sciences, University of Sydney

(Plate X)

[Read 27th September, 1967]

Synopsis

A new genus is described with the type species *C. barbata*, based on *Goodenia barbata*. It is distinguished from *Goodenia* by the ovoid, scarcely compressed, strophiolate seed; the stellate hairs on the vegetative parts of the plant; a basic chromosome number of 7, and the enate-barbulate corolla. A key is provided to the species with descriptions, specimen citations and distribution maps.

In previous communications (Carolin, 1966; Peacock, 1963) the differences between the group of species showing affinity with *Goodenia barbata* and the rest of that genus have been emphasized. These differences seem to be of the same order as those that separate *Goodenia* and *Scaevola* and certainly of a greater order than separate *Goodenia* from *Calogyne*, *Selliera*, *Catosperma*, etc. In fact, in some ways this new genus stands in an intermediate position between *Scaevola* and *Goodenia*. The seeds in particular (Carolin, 1966) and the long enations from the surface of the corolla which seems to be homologous with the " penicillate hairs " occurring in the same position in *Scaevola*, seem to indicate this. Both hair types are multicellular and the sole difference seems to be in the cluster of cells at the top of those in *Scaevola*. The difference in chromosome number, however, seems to preclude any very close affinity between *Coopernookia* and either *Goodenia* or *Scaevola* (Peacock, 1963).

Krause (1912) dealt with three of the five species; *G. chisholmii* was described later. The three species are dispersed between sect. *Monochila* (*G. phylicoides*) and his sect. *Eu-goodenia* ser. *Suffruticosae* (*G. strophiolata*, *G. barbata*). In *Monochila*, Krause emphasized the arrangements of the corolla lobes (" Digitatem patentes ") and the fact that they are almost all the same length; the corolla is not " bilabiate " as in the other sections. In the face of the more numerous distinguishing features outlined above these two characters based on one organ seem of little diagnostic value. Bentham's (1869) treatment is essentially the same although his series are different. Terminology for the corolla parts is the same as given in the previous communication on *Velleia* (Carolin, 1967).

Coopernookia, gen. nov.

Fructuli erecti vel effusi. Folia alterna pilis glandulis et stellatis, saepe ub movella viscida ubique vetustioria vernicosa. Flores in racemis vel thyrsis inflorescentiis partialibus paucifloris dispositi, bracteolati: bracteae herbaceae. Corolla caerulea vel rosea vel alba pilis stellatis et extus interdum glandularibus, obscure saccata, enationibus barbata. Dissepimentum ovarii breve ovulas paucas gerens. Semina ovoidea vix compressa nec alata nec incrassato-marginata. Embryo teres in endospermia inclusus.

Perennial undershrubs, erect or spreading. *Stems* ± woody, sometimes echinate. *Leaves* simple, spirally arranged, stellate and usually glandular hairy, ±viscid when young, often varnished when mature. *Flowers* arranged in terminal racemes or few-flowered thyrses, bracteolate, sessile or shortly pedicellate; bracts leafy. *Sepals* 5, linear, all united to the inner floral whorls for about half the height of the ovary, glandular—and/or stellate-hairy, free from each other. *Corolla* tubular at the base, often very shortly so, with an obscure anterior pocket, epigynous ; lobes 5, equal or unequal, broadly winged, stellate—and glandular-hairy on the outside, enato-barbulate on the inside especially towards the throat, auricle scarcely differentiated. *Stamens* 5, free from each other but epigynous ; anthers minutely apiculate. *Ovary* with a short basal dissepiment bearing 2 to 8 ovules ; style simple ; indusium depressed obovate, usually ± curved, ciliate on the margin, entire ; stigma bifid. *Fruit* a 2-valved inferior capsule with each valve often 2-fid. *Seeds* 2-6, ovoid, scarcely compressed, shiny with a thick-walled epidermal pallisade, strophiolate and without a wing or thickened rim. *Embryo* terete, embedded in endosperm.

The name *Coopernookia* is derived from the Coopernook State Forest on the northern coast of New South Wales where one of the species, *C. chisholmii* (Blakely) Carolin is common.

Type Species : C. barbata (R.Br.), comb. nov. *Basionym : Goodenia barbata* R.Br.

1. C. POLYGALACEA (De Vriese), comb. nov.

Nomenclatural Synonym : Dampiera ? polygalacea De Vriese, Gooden., 115 (1854). *Taxonomic synonym : Goodenia phylicoides* F. Muell., Fragm., 1 : 206 (1859) ; Benth., Fl. Austr., 4 : 55 (1869) ; Krause, Pflrch., 54 : 42 (1912).

Erect or spreading undershrubs up to 60 cm. tall. *Stems* up to 6 mm. diam., woody, tomentose when young with mainly stellate hairs, glabrescent, usually much branched, echinate. *Leaves* deciduous and therefore chiefly present towards the ends of the branches, spirally arranged, linear or narrow-oblong to elliptic, narrowing gradually towards the base but sessile, 12-30 mm. long, 3-6 mm. wide with revolute entire margins, obtuse, stellate-tomentose on both surfaces when young but with the upper surface glabrescent leaving scurfy scars, minute glandular hairs also present, frequently varnished when mature ; the lower surface remaining tomentose. *Flowers* in compact terminal leafy racemes, sessile within two linear tomentose bracteoles c. 7 mm. long, articulate above bracteoles. *Sepals* linear or very narrow-elliptic, 6-8 mm. long, 1 mm. wide, stellate-tomentose with one or two branches of each hair often longer than the others, acute, entire. *Corolla* lilac-pink to white, 14 mm. long with a very short obscure anterior pocket, stellate-hairy on outer surface with similar hairs to those of the calyx, enate-barbulate and sparsely villous-hairy inside ; tube almost obsolete ; lobes equal, ± digitately spreading, narrow-elliptic to narrow-oblong, 8-9 mm. long, 1·5-2 mm. wide with broad (2-3 mm.) lateral wings on either side, the wings on the lower margin of the superior lobes slightly larger and sub-auriculate. *Stamens* 5, free ; filaments narrow-linear, c. 3 mm. long ; anthers narrow-oblong, c. 1 mm. long, obtuse. *Ovary* with a very short dissepiment bearing 6-8 ovules arranged in two rows on either side ; style villous, c. 5 mm. long, ± curved, not folded, depressed-ovate, c. 1·5 mm. wide ; indusium villous on both surfaces with a slightly curved orifice beset with short white bristles (0·5 mm.) on both lips ; stigma bilobed. *Capsule* ovoid, tomentose, 4-valved. *Seeds* several per calsule, ovoid, strophiolate (mature seeds not seen).

Range : South-western Australia between Albany and Esperance.

Habitat : Sandy heaths.

Chromosome number : $n=7$ voucher specimen marked with an asterisk below).

Typification : Dampiera ? polygalacea De Vriese—*Holotype*—S.W. Australia, Drummond 356 (K. *Isotype*—MEL 18329). *Goodenia phylicoides* F. Muell.—*Holotype*—Gardiner River, Australiae Occidentalis, Maxwell (MEL 1963).

Discussion : According to Article 34 of Internat. Code Bot. Nomencl. (1961), which deals explicitly with question marks published with taxa, the binomial *Dampiera ? polygalacea* was validly published by De Vriese and, since the type belongs to the species under consideration, this provides the specific epithet (Art. 55).

This species shows some variation in leaf width which may have a geographical basis but the other features seem to be remarkably constant.

Selected specimens examined. Between Salmon Gums and Grass Patch, W. E. Blackall no. 1011, Nov. 1931 (PERTH) : 48 mls. Nth Esperance, P. G. Wilson no. 3016, 12.9.64 (AD96528102. PERTH. CANB) : Near Cape Arid, Maxwell (MEL 18324) : Jerdacuttup River, Ravensthorpe, T. E. H. Aplin no. 26806, 27.10.63 (PERTH) : Jerramungup, J. S. Beard no. 3642, 18th Oct. 1964 (PERTH) : Young River, R. Carolin no. 3375 11.9.61 (SYD) : Hopetown to Ravensthorpe 20 miles from Ravensthorpe, W. J. Peacock no. 60954, 1.9.1960 (SYD)*: Upper Kalgon River, F. Muell., Oct. 1867 (MEL 18321. MEL 18322): Kalgon Plains, J. H. Maiden, Nov. 1909 (NSW 80793) : Kalgon River, Oldfield (MEL 18328).

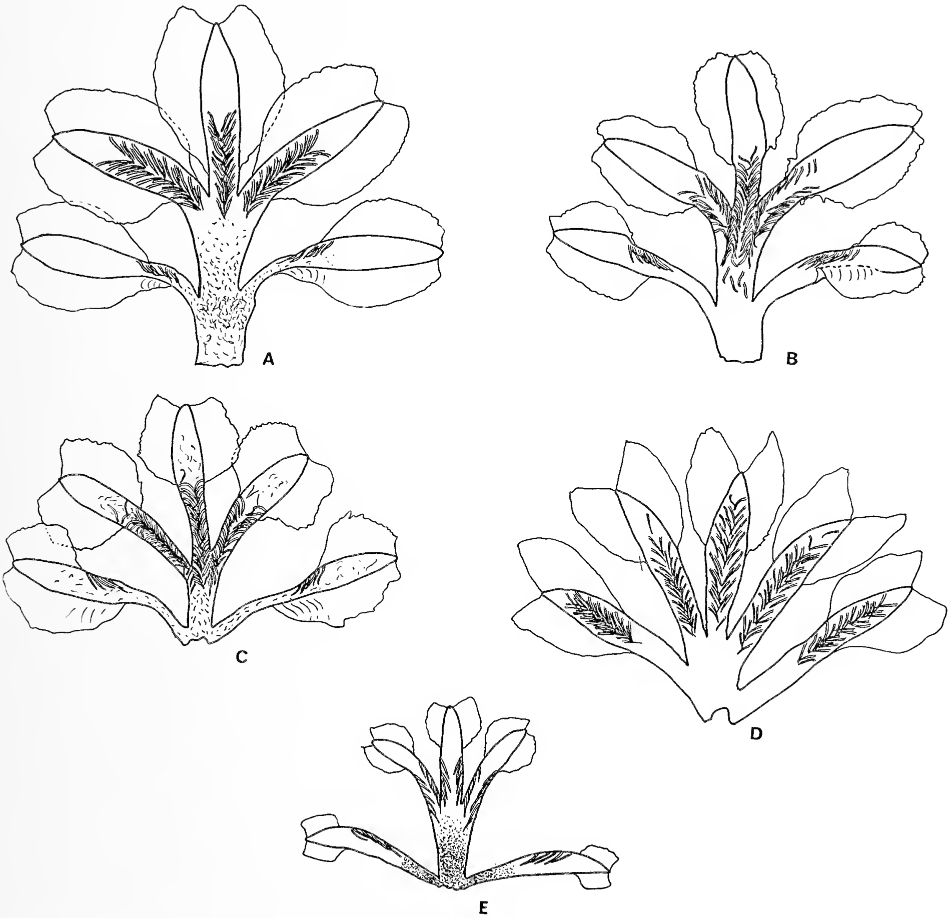

Fig. 1. Corollas of *Coopernookia* species. A, *C. georgei* ; B, *C. chisholmii* ; C, *C. barbata* ; D, *C. polygalacea* ; E, *C. strophiolata*.

2. C. STROPHIOLATA (F. Muell.), comb. nov.

Nomenclatural synonym: Goodenia strophiolata F. Muell. Fragm., 1: 119 (1859) ; Benth., Fl. Austr., 4 : 60 (1869) ; E. Pritzel in Engl. Bot. Jahrb., 35 : 550 (1905) ; Krause in Pflrch., 54 : 60 (1912) ; Robertson in Black, Fl. S. Austr., 4 : 822 (1957).

Viscid, diffuse to divaricate undershrub up to 1 m. tall. *Stems* woody, angular when young but becoming rounder with maturity, shortly stellate and glandular-pubescent when young but ± glabrescent. *Leaves* spirally arranged, obovate to narrow-obovate or spathulate or elliptic, 10-35 mm. long, 2-15 mm. wide, narrowing very gradually towards the base into an indistinct linear petiole with a few scattered stellate hairs when young and glandular hairs buried under the varnish at maturity, viscid, dentate or serrate, the margin sometimes slightly recurved, terminated by an acute tooth or obtuse. *Flowers* arranged in terminal leafy thyrses or racemes ; bracts leafy ; pedicels 8-12 mm. long, viscid, with linear bracteoles c. 2 mm. long above the middle, articulate immediately above the bracteoles. *Sepals* linear-lanceolate to ± elliptic, (2-) 4-7 mm. long, c. 1 mm. wide, adnate to the inner whorls only close to the base, entire, acute, viscid-varnished. *Corolla* bluish-white to white, 7-12 mm. long, stellate-pubescent outside, villous or almost glabrous inside, enate-barbate and with a ± prominent pocket almost as long as the ovary ; tube c. 1 mm. long : superior lobes falcate-narrow-obovate, 5-7 mm. long, 1-2 mm. wide with narrow (0·5 mm.) ± equal wings on either side, not auriculate ; inferior ones narrow-obovate, 4-8 mm. long, 1-2 mm. wide with wider (1 mm.) equal wings on either side : connate part of inferior lobes 3-5 mm. long. *Stamens* 5, free : filaments filiform, 4-5 mm. long ; anthers oblong, 1-5 mm. long, obtuse. *Ovary* viscid except for the glabrous or slightly villous beak and with an almost obsolete dissepiment bearing 4-6 ovules ; style villous, 4-5 mm. long ; indusium truncate-obtriangular 1-5 mm. long, 2 mm. wide, slightly villous to glabrous, curved not folded with a ± straight orifice beset with short (0·5 mm. or less) white bristles on both lips. *Capsule* globular, 5-7 mm. diam., viscid, 2- or tardily 4-valved. *Seeds* oblong, 3 mm. long, slightly compressed but not flat, yellow-brown, smooth, shining, strophiolate and with no wing or thickened rim.

Range : Western South Australia, into southern Western Australia.

Habitat : Sandy heaths.

Chromosome number : Unknown.

Typification : G. strophiolata F. Muell.—*Lectotype*—Fitzgerald Ranges, no collector (probably Maxwell) no. 286 (MEL 18346). There are two specimens attached to this sheet and two labels ; I am selecting the lower left-hand specimen as the *lectotype.*

Discussion : Differs from *G. polygalacea* in the almost complete lack of stellate indumentum on the broader mature leaves and in the narrower wings. It is the most viscid and varnished member of the genus. There is some considerable variation in the shape and length of leaves, sepals and bracteoles. One specimen, " Wyalkatchem, S. B. Rosier no. 353, 2 Oct. 1963 (PERTH) ", has elliptic dentate sepals. It is not thought advisable to recognize these variations as taxa.

Selected specimens examined : Western Australia, 98 miles east of Norseman, T. E. H. Aplin no. 1751, 5.9.1962 (PERTH) : north of Gibson's Soak, J. S. Beard no. 2338, 5 Nov. 1962 (PERTH) : Pingrup, W. E. Blackall no. 3026, 21 Sept. 1963 (PERTH) : 20 miles south of Norseman, N. T. Burbidge no. 2700, 20.9.1947 (CANB 15298. PERTH) : Doodlakine, W. V. Fitzgerald, Nov. 1903 (NSW 80810) : Gnowangerup, C. A. Gardner no. 2121, 4 Oct. 1928 (PERTH) : 2 miles east of Young River Station, J. W. Green no. 1236, 15 March 1957 (PERTH) : 30 miles north-west of Fraser Range, R. Helms, 4.11.1891 (AD 96620139. NSW 80808) : Merredin, M. Koch no. 2866, 19.10.1923 (NSW 80812) : 32 miles north of Salmon Gums, M. E. Phillips, 6.11.1962 (CBG 011597. SYD) : 20 miles south of Queen Victoria Spring, R. D. Royce no. 5333, 27 Jan. 1956 (PERTH) : 2 miles south of Cundeelee, D. E. White no. W631004, Oct. 1963 (PERTH). *South Australia.* Mt. Beadell near Maralinga, H. Turner, 4.9.1960 (AD 96221150) : Maralinga, T. W. Shilling no. 45, 23.9.1957 (AD 96010029. NSW 80811.K) : Maralinga, F. L. Hill no. 830, 20.10.1953 (NSW 80809. CANB 117343. BM).

3. C. GEORGEI, sp. nov.

Frutex ascendens usque ad 1·5 m. altae. Folia sessilia vel subsessilia, elliptica vel anguste elliptica, 2-5 cm. longa, 0·8-2·5 cm. lata, dentata, glabrescentia. Flores in racemo disposti; pedicellus pedunculum aequans, articulatus proxime super bracteolas lineares. Corolla malvina fauce alba, 15-20 mm. longa, extus stellato-pubescens intus enationibus barbata; lobi alis latis sine auriculis. Ovarium cum dissepimento brevissimo bi-ovulato. Semina oblonga strophiolata, 5 mm. longa.

Slender, ascending shrub up to 1·5 m. tall, probably slightly viscid on the young branches. *Stems* up to 5 mm. diam. with a few scattered sessile glandular hairs when young but becoming glabrous. *Leaves* sessile or very shortly petiolate, spirally arranged, elliptic to narrow-elliptic, 2-5 cm. long, 0·8-2·5 cm. wide, dentate, very slightly recurved with a few scattered almost sessile glandular hairs on both surfaces when young but becoming glabrous. *Flowers* in terminal leafy racemes; pedicel and peduncle together 8-15 mm. long, glabrous or with a few scattered sessile glandular hairs, the pedicel about as long as the peduncle and articulate immediately above the bracteoles; bracteoles linear to narrow-oblong, 3-4 mm. long. *Sepals* linear to very narrow-ovate, 7-8 mm. long, up to 1 mm. wide, adnate to the inner whorls for more than half the length of the ovary, acute, entire, almost quite glabrous outside but with a few small simple hairs towards the apex on the inside. *Corolla* mauve with a white throat, 15-20 mm. long, stellate-pubescent outside, villous pubescent towards the base and enatebarbate inside and with an indistinct pocket almost as long as the ovary; tube c. 2·5 mm. long; superior lobes narrow-elliptic, 10-12 mm. long, 2 mm. wide with broad (2 mm.) ± equal wings on either side, not auriculate; inferior lobes narrow-elliptic, 10 mm. long, 2 mm. wide with broad (2-2·5 mm.) wings on either side; connate part of inferior lobes c. 5 mm. long. *Stamens* 5, free; filaments narrow-linear, 3-4 mm. long; anthers narrow-oblong, 1·5 mm. long, obtuse or emarginate. *Ovary* covered with scattered, sessile, glandular hairs and with an almost obsolete dissepiment bearing 2 ovules; style villous, 6-7 mm. long; indusium depressed-obovate, 2 mm. long, 2-2·5 mm. wide, slightly villous, slightly folded with a curved orifice beset with long (almost 0·5 mm.) white bristles on both lips. *Capsule* oblong, c. 10 mm. long and 2 mm. diam., 2- or tardily 4–valved. *Seeds* oblong, 5 mm. long, 2 mm. wide, slightly compressed but not flat, yellow-brown, smooth, shining, prominently strophiolate and with no wing or thickened rim.

Range: Very limited distribution some 30-40 miles south-west of Ravensthorpe, Western Australia.

Habitat: Sheltered gullies on ranges.

Chromosome number; Unknown.

Typification: *C. georgei* sp. nov. *Holotype* north-eastern side of Whoogarup Range 30 miles south-south-west of Ravensthorpe, A. S. George no. 7201, Nov. 1, 1965 (PERTH)—*Isotypes* SYD. K.B.

Discussion: A distinctive species differing from *C. strophiolata* in the larger flowers and leaves which are scarcely viscid or varnished, the fewer (2) ovules per ovary, the more elongated capsule and the longer corolla tube.

Specimens examined: *Western Australia.* Western side of Thumb Peak Range, 40 miles south-west of Ravensthorpe, A. S. George no. 7168, Oct. 31, 1965 (PERTH): Phillip's Ranges, no collector, (Maxwell ?) no. 139 (MEL 18343): Drummond no number (MEL 18342): Drummond, no. 355 (MEL 18340): Drummond, no number (MEL 18341).

4. C. BARBATA (R.Br.), comb. nov.

Nomenclatural synonym: *Goodenia barbata* R.Br., Prodr. 576 (1810): DC., Prodr. 7: 514 (1839): De Vriese, Gooden., 145 (1854): Benth., Fl. Austr. 4: 61 (1869): Moore et Betche, Hbk. Fl. N.S.W. 307 (1893): Rodway, Tas. Fl. 102

(1903) : Krause, Pflrch., 54 : 62 (1912) : Ewart, Fl. Vict. 1068 (1931) : Curtis, Stud. Fl. Tasm., 2 : 401 (1963) : Beadle, Evans & Carolin, Handb. Vasc. Plts. Syd. Dist. & Blue Mts. 367 (1962).

Taxonomic synonyms : Goodenia cistifolia A. Cunn. ex DC., Prodr. *7* : 516 (1839) : De Vriese, Gooden., 150 (1854) ; F. Muell., Fragm. *2* : 110, 176 (1861). *Scaevola scaberula* Summerhayes in Kew Bull. 1927 : 356 (1927).

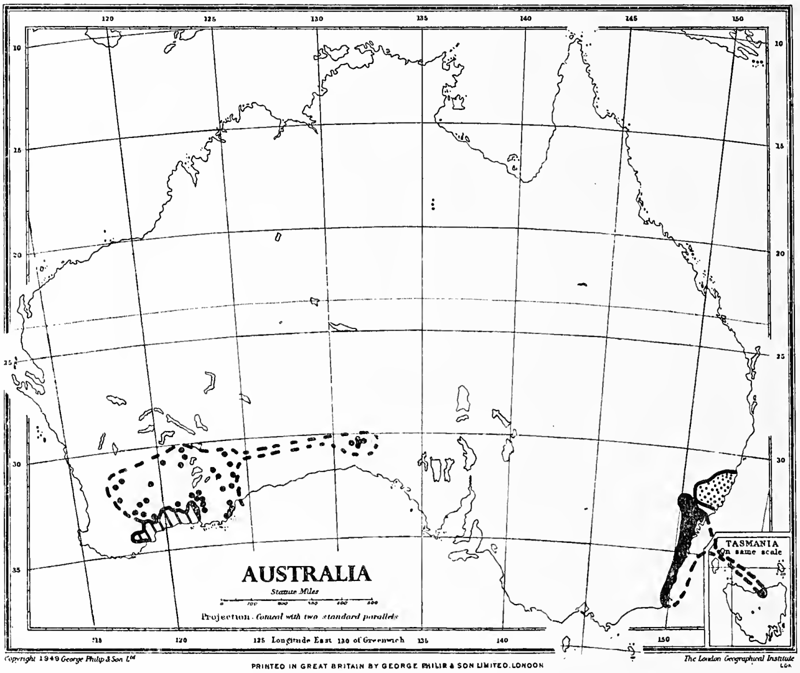

Fig. 2. Distribution of *Coopernookia* species. *C. chisholmii*, stippled area ; *C. barbata*, solid black area ; *C. polygalacea*, diagonally hatched area ; *C. strophiolata*, large black dots indicate localities.

Erect or ascending ± viscid undershrub up to about 1 m. tall with a thin tap-root. *Stems* up to 4 mm. diam., usually weak, glandular-hairy and with scattered stellate hairs when young becoming ± scabrous when old, ridged. *Leaves* spirally arranged, linear or very rarely narrow-oblong, sessile, 1-3 cm. long, 1-2(-5) mm. wide with revolute and entire or obscurely dentate margin, acute or obtuse, glandular-pubescent becoming scabrid on both surfaces with an occasional stellate hair, particularly on the lower surface. *Flowers* in loose terminal leafy racemes, the lowest partial inflorescences rarely 2-flowered : pedicels up to 20 mm. long, glandular-pubescent with two linear bracteoles 3-5 mm. long above the middle, articulated just above the bracteoles. *Sepals* very narrow-ovate to narrow-elliptic, 3-4 mm. long, 0·5-1 mm. wide, adnate to lowest part of ovary, glandular-pubescent with some stellate hairs, entire, acute. *Corolla* blue to pinkish-blue, 11-14 mm. long, glandular- and stellate-pubescent outside, villous towards the base inside, enate-barbate and with a pocket almost as long as the ovary ; tube c. 1 mm. long ; superior lobes narrow-elliptic, ± falcate, 9-11 mm. long, 2 mm. wide with wings (1 mm. broad) on either side, scarcely auriculate ; inferior lobes narrow-ovate to elliptic, 8-10 mm. long, 1·5-2 mm. wide with wings about 1·5 mm. wide on either side ; connate part of inferior lobes 3-5 mm. long. *Stamens* 5, free : filaments filiform, 4-5 mm. long ; anthers elliptic, 2 mm. long, obtuse. *Ovary* glandular-pubescent with an almost obsolete dissepiment bearing 2 ovules ; style covered with long villous hairs, 7-9 mm. long ; indusium depressed obovate, 1 mm. long, 2 mm. wide, villous, geniculate, not folded with an almost straight orifice beset with white bristles (c. 0·5 mm. long) on both lips. *Capsule* obovoid to oblong-elliptical, 5-7 mm. long, 3 mm. wide, glandular-pubescent except for the tip, 2-valved to the base. *Seeds* ellipsoid or oblong, 4-5 mm. long, scarcely compressed, yellow-brown, smooth, shining, strophiolate.

Range : South-eastern Australia including northern Tasmania.

Habitat : Dry sclerophyll forest and scrub.

Chromosome number : n=7 (voucher specimens marked with an asterisk below).

Typification : G. barbata R.Br.—*Lectotype*—Brown, Port Dalrymple (BM. photo SYD). Brown gives two localities in his Prodromus, ' J ' and ' D ', and states ' v.s.', whilst in his manuscript notes (BM. photo CANB) he gives " Blue Mts., Barralier and Port Dalrymple, Paterson ". I have, so far, been unable to locate any specimen agreeing with the former locality. Brown apparently was at the new settlement at Port Dalrymple at the same time as Paterson who was commander there. Thus Paterson may actually have collected the specimen but it became included in Brown's collection. There seems little doubt that this was one of the specimens that Brown used to write his diagnosis in the Prodomus. *G. cistifolia* Cunn. ex DC.—*Holotype*—In Novae Hollandiae collibus ad Hunter's River, A. Cunningham (GEN. *Isotypes*—K.P). *Scaevola scaberula* Summerhayes—*Holotype*—Ettrema River, south-west of Nowra on poor sandstone country, F. A. Rodway, Feb. 1927 (K. *isotype* NSW 100989).

Discussion : Can be distinguished from *C. chisholmii* by the leaf-shape. Not a particularly variable species except with regard to the indumentum. Some specimens are almost glabrous whilst generally glandular hairs are fairly abundant.

Selected specimens examined : New South Wales, New England, F. Campbell, Oct. 1882 (MEL 18315) : Howes Valley to Putty, L. A. S. Johnson, 20 Sept., 1951 (SYD. NSW 18752) : Khyber Pass, Rylstone, J. Peacock no. 6011, 26.2.1960, 28.11.1960 (SYD)* : Putty, J. Peacock no. 6012.5.1, 4.12.1960 (SYD)* : Mt. Wilson, O. D. Evans, 5.3.1927 (SYD) : Camden, Leichhardt (MEL 18313) : Yerranderie, R. H. Cambage no. 3107, 2.12.1911 (SYD. NSW 81204) : Robertson District, S. Smith-White & H. Lancaster, Oct. 1951 (SYD) : Nowra Rd. c. 3 miles north-east of Nerriga, L. G. Adams no. 1515, 24 Nov. 1965 (NSW 81195. MEL 183002) : Moruya, J. L. Boorman, 11.1911 (NSW 81209) : Bateman's Bay, J. L. Boorman, 6.1906 (BRI 062916) : Clyde Mountain, lower slopes eastern side, O. D. Evans, 16.9.1926 (SYD) : The Clyde, W. Bäuerlen no. 10, Oct. 1884 (MEL 18308) : Eden, E. Cheel, 17.2.1903 (NSW 81230) : Twofold Bay, no collector (MEL 18314) : *Victoria*, Foot of Genoa Peak, E. F. Constable, 2.11.1964 (NSW 78631) : Genoa and Howe Range, no collector (MEL 18319) : Mallacoota, ex herb. T. S. Hart, 7.1.1936 (MEL 18317) : *Tasmania*, Port Dalrymple, R. Brown. (This is the only specimen which I have seen that is supposed to have been collected in Tasmania).

5. C. CHISHOLMII (Blakely), comb. nov.

Nomenclatural synonym : Goodenia chisholmii Blakely in PROC. LINN. SOC. N.S.W., *54* : 684 (1929).

Erect or ascending, few-stemmed shrub up to 1·5 m. tall. *Stems* weak, up to 8 mm. diam., woody towards the base, stellate-tomentose particularly when young with very few short glandular hairs or none. *Leaves* spirally arranged, narrow-elliptic to elliptic, almost sessile, 4-9 cm. long, 1-2·5 cm. wide, stellate-tomentose to pubescent on both surfaces, irregularly dentate to entire with the margin almost flat, obtuse. *Flowers* arranged in terminal leafy racemes the lowermost branches rarely 2-flowered ; pedicels up to 2 cm. long, stellate-pubescent with two linear bracts 4-5 mm. long close under the flower, articulate immediately above the bracteole. *Sepals* linear-elliptic, 4-6 mm. long, 0·1 mm. wide, stellate- and glandular-pubescent, acute, entire, adnate to the base of the ovary. *Corolla* mauve-pink 11-14 mm. long, stellate- and glandular-pubescent on outside, glabrous or with a few villous hairs towards the base inside, enate-barbate and with an obscure pocket about half as long as the ovary: tube < 1 mm. long; superior lobes very narrow-obovate, falcate, 9-11 mm. long 1 5-2 mm. wide with a narrow wing 1 mm. broad on both margins, scarcely auriculate; inferior lobes 3-4 mm. long. *Stamens* 5, free; filaments filiform, 4-5 mm. long; anthers narrow-elliptic-oblong, 1·5-2 mm. long, obtuse. *Ovary* glandular- and stellate-pubescent with an obsolete dissepiment bearing two ovules; style villous, 5-6 mm. long; indusium depressed obovate to truncate—obtriangular, 1 mm. long, 1·5 mm. wide, villous, slightly geniculate, not folded, with a ± straight orifice beset with short white bristles less than 0·5 mm. long and even shorter on the lower lip. *Capsule* obovoid, 5-6 mm. long, 3 mm. wide, stellate and glandular pubescent, 2-valved almost to the base. *Seeds* oblong, 4-5 mm. long, slightly compressed but not flat, yellow-brown, smooth, shining, strophiolate.

Range: N.S.W. coast from the Hunter Valley to Port Macquarie.

Habitat: Wet sclerophyll forests.

Chromosome number: n=7 (voucher specimen marked with an asterisk below).

Typification: G. chisholmii—Lectotype—Kendall, F. M. Bailey, 9.1929 (NSW 76616). Blakely cites two specimens with the type description, viz., this lectotype and "Comboyne, E. C. Chisholm, Jan. 1925". There are two specimens in NSW. labelled Comboyne collected by E. C. Chisholm, one dated "2.1925" and the other "1.1926" I have therefore selected the only specimen which corresponds to both Blakely's description and citation.

Discussion: Distinguished from *C. barbata* by the leaf shape and margins, more numerous stellate and less numerous glandular hairs.

Selected specimens examined: New South Wales. Port Macquarie, E. R. Brown, 2.1897 (NSW 81401): The Comboyne, E. C. Chisholm, 1.1926 (NSW 76617. MEL 18320): Lorne via Kendall, A. W. Munro, 11.1950 (NSW 81398): Middle Camp, Coopernook State Forest, J. Peacock no. 6012.4.1, 3.12.1960 (SYD)*: near Wollombi Creek Ford, Broke Rd., C. Burgess, 12.1961 (CBG 005512).

Key to the Species

1. Lower surface of leaves at least tomentose with stellate or sub-stellate hairs.
  2. Leaf margins revolute; upper surface of leaves glabrescent .... 1. *C. polygalacea*
  *2. Leaf margins flat or slightly recurved; upper surface of leaves tomentose .... 5. *C. chisholmii*
*1. Lower surface of leaves glabrous or glandular hairy with very few stellate hairs.
  3. Leaves linear with revolute margins .... 4. *C. barbata*
  *3. Leaves elliptic to obovate with flat or slightly recurved margins.
    4. Corolla 15-20 mm. long .... 3. *C. georgei*
    *4. Corolla 7-12 mm. long .... 2. *C. strophiolata*

References

Carolin, R. C., 1966.—Seeds and fruit of the Goodeniaceae. Proc. Linn. Soc. N.S.W., 91: 58.
Carolin, R. C., 1967.—The genus *Velleia* Sm. Proc. Linn. Soc. N.S.W. 92: 27.
Krause, K., 1912.—"Das Pflanzenreich"—54: Berlin.
Peacock, W. J., 1963.—Chromosome numbers and cytoevolution in the Goodeniaceae. Proc. Linn. Soc. N.S.W., 88: 8.

EXPLANATION OF PLATE

Seeds of *Coopernookia* species. A, *C. georgei*; B, *C. barbata*; C, *C. strophiolata*.

CORRIGENDA

In the previous contribution of this series "The genus *Velleia* Sm.", Proc. Linn. Soc. N.S.W. 92: 27-57, in Fig. 2 read G, *V. arguta*, and I, *V. discophora*. In Fig. 9 read *V. paradoxa* (●), *V. glabrata* (+).

MONOGRAPTUS CF. *ULTIMUS* PERNER AND *MONOGRAPTUS FORMOSUS* BOUČEK FROM THE HUME SERIES OF THE YASS DISTRICT, NEW SOUTH WALES

G. H. Packham

(Plate XI)

[Read 27th September, 1967]

Synopsis

Monograptus cf. *ultimus* and *M. formosus* described in this paper have not previously been recorded from Australia. The fauna represents the highest graptolite zone so far recorded from the Yass district and is correlated with the Bohemian zone of *M. ultimus* at the base of Přidoli Schichten (Upper Budňany Stufe, Eβ2).

Introduction

The graptolites described here, *Monograptus formosus* Přibyl and *M.* cf. *ultimus* Perner, were collected from a small shale quarry on the northern side of the Hume Highway approximately fifty yards west of the bridge across Derrengullen Creek, four miles north-west of Yass. The locality, which is in the shales of the Hume Series on the eastern side of the Yass Basin (Brown, 1941), was first discovered by Dr. A. N. Carter in 1957. A specimen collected by him was figured by Thomas (1960) as *Cyrtograptus insectus.* The material described here in addition to Carter's specimen was collected by me in 1959.

The geological map of the Yass district (in Brown, 1941) indicates that the horizon of this graptolite locality is higher than the Dalmanites bed but within a hundred feet of it. The Dalmanites bed is an important marker horizon which extends around all but the northern part of the basin at about the middle of the 700 to 800 feet of sediment comprising the Hume Series. Brown and Sherrard (1952) have previously recorded a variety of graptolites from the Hume Series. Their most significant fauna is from immediately below the Dalmanites bed. It contains forms Sherrard identified as *M. bohemicus*, *M. nilssoni*, *M. roemeri*, *M. crinitus* and *Linograptus* sp. and attributed to the zone of *M. nilssoni.* In sandstones above the Dalmanites bed, six miles south of the locality at which *M.* cf. *ultimus* and *M. formosus* were found, the same authors recorded *M. salweyi*, a species occurring in the British zone of *M. scanicus.* It appears from what they say that the same species occurs in beds up to 200 feet above the Dalmanites bed. *M. salweyi* has been identified by Sherrard in the same paper from a locality near Silverdale and 2½ miles north-north-west of the Derringullen Creek locality. This locality for *M. salweyi* is also apparently stratigraphically above the Dalmanites bed and also above the level of the *M. formosus* and *M.* cf. *ultimus* locality.

In Europe, the stratigraphic range of *M. ultimus* is from the zone of *M. leintwardinensis* (*M.* cf. *ultimus* of Elles & Wood, 1910, and Tomczyk, 1956) to the Bohemian zone of *M. ultimus* at the base of the Upper Budňany Stufe (basal Eβ2) and its equivalents (Přibyl, 1944, E. & H. Tomczyk, 1962). The species *M. formosus* is confined to the Bohemian zone of *M. ultimus.* Although there seems to be no general agreement amongst European workers about the exact zonal succession between the zones of *M. leintwardinensis* and *M. ultimus*, it is agreed that there are at least two intervening zones. The graptolites from Derrengullen Creek can be referred to the zone of *M. ultimus* which is at least four zones higher than the *M. scanicus* zone (and five zones above the *M. nilssoni* zone !). If the stratigraphic relationship of the *M. formosus* beds to those containing the graptolite identified as *M. salweyi* is as suggested above, the ages assigned to the two horizons present a contradiction. The difficulty may be resolved by a re-identification of the *M. salweyi* material. This occurs in sandstone and its mode of preservation in the specimens studied by Sherrard renders the interpretation of its morphology difficult. Recently this suggestion has been independently confirmed by Dr. H. Jaeger (pers. comm.) who has made extensive collections of Sherrard's *M. salweyi* from the Silverdale locality and reidentified it as *M. bouceki* Přibyl, a species found a little higher than the *M. ultimus* zone in the upper part of the Budňany Stufe of Bohemia. The identification of *M. formosus* presents little difficulty since its morphology is extremely distinctive amongst late Silurian graptolites. The recognition of the zone of *M. ultimus* at this level of the Hume Series raises the possibility that the highest beds of the series may be Lower Devonian. (For a discussion of the correlation of the higher parts of the Silurian and the Silurian-Devonian boundary, see Jaeger 1965 and 1966).

All specimens mentioned in this paper are in the palaeontological collection of the University of Sydney.

MONOGRAPTUS FORMOSUS Bouček

(Plate XI, figures 4, 7)

1931, *Monograptus formosus* Bouček, pp. 301, 311, text-fig. 9 b, c.
1931, *Monograptus purkynei* Bouček, pp. 301, 311, text-fig. 9 a.
1941, *Monograptus* (*Spirograptus*) *convexus* Přibyl, p. 73, pl. 1, fig. 12.
1946, *Spirograptus formosus* (Bouček) ; Přibyl, p. 36, pl. 9, fig. 4.
1960, *Cyrtograptus insectus* Bouček ; Thomas, pl. 13, fig. 180.
1962, *Monograptus formosus* Bouček ; Willefert, p. 33, text-pl. fig. 8, pl. 2, fig. 18.

Material and preservation—Twelve fragmentary specimens, three of which are preserved in very low relief and the remainder are flattened films lacking internal detail. Specimen numbers S.U.P. 23,620-1 & 23,626-35.

Description—The largest specimen is 17 mm. long (measured around its arcuate length. The rhabdosomes are arcuate with a varying radius of curvature, in two of the specimens with the sicula preserved, the initial portion (1 mm. in one specimen and 3 mm. in the other) is almost straight, the curvature increases rapidly then diminishes gradually distally. The radius of curvature of the more strongly curved portions is as small as 3 mm. The most distal parts are again almost straight. The largest rhabdosome bends through 120 degrees. The width at the first theca is about 0·8 mm. increasing gradually distally to a height of 1·4 mm. The hooked portion of the thecae make up approximately $\frac{3}{4}$ of the rhabdosome width proximally decreasing to $\frac{1}{2}$ distally.

The sicula is visible but poorly preserved in several specimens, it is almost straight on the ventral side and gently convex on the dorsal side. Its length is around 1·0 to 1·2 mm. and its width at the aperture 0·15 mm. in relief and up to 0·3 mm. in flattened specimens. Only about 0·1mm. of the sicula is exposed below the base of the first theca. The apex of the sicula is at about the distal extremity of the first theca or slightly distal to it.

The thecae are initially triangular with negligible overlap but distally the overlap becomes significant as the free portion of the theca occupies a smaller proportion of the rhabdosome width. In the initial thecae the free proximal thecal wall (proximal to the aperture) is nearly straight before curving into the hook, and is inclined to the dorsal side of the rhabdosome at about 20 degrees. The angle of inclination is more variable but generally higher distally, ranging from 20 to 35 degrees. The angle of inclination of the thecal margin increases where it passes proximally into the interthecal septum in the overlapping distal thecae. Although the amount of overlap is not readily determinable, in specimen S.U.P. 23,620 (Pl. 1, fig. 4) it reaches approximately 0.5 mm. The distal free walls of the thecae are also inclined to the rhabdosome length at an acute angle throughout the rhabdosome so that the axis of the thecae proximal to the hook proper is directed strongly distally. The angle of inclination of this distal wall to the dorsal side of the rhabdosome is around 60 or 70 degrees. In some specimens this wall is straight for up to 0·4 mm. in others it is gently curved, passing into the hook. The thecae narrow to 0·2 to 0·3 mm. where the hook commences. The appearance of the hook varies tremendously with aspect. In specimen S.U.P. 23,620 (pl. 1, fig. 4) most of the thecae are preserved in profile view and appear to be tightly bent through 180 degrees. In specimen S.U.P. 23,621 (pl. 1, fig. 7) the rhabdosome is twisted and thin lateral prolongations on the apertures can be seen. The various aspects preserved give the impression that the thecae strongly resemble Sudbury's reconstruction of the thecae of *M. planus* (Sudbury, 1958, pl. 22, fig. 92), except that the angle through which the hook bends is slightly greater and the lateral prolongations of the apertural region are longer. The interthecal distance measured at the deepest points of incision between the thecae, give a measurement of about 1·1 mm. proximally (9 thecae per cm.) and about 0·8-1·0 mm. distally (10-12 thecae per cm.).

Remarks—The morphology of this species is most distinctive amongst Upper Silurian graptolites. From an examination of the literature and the present material, the chief diagnostic features are the arcuate rhabdosomes with hooked thecae, with the initial thecae high (well over ½ mm.) and not overlapping, the later thecae overlapping about ⅓, the incisions between thecae occupying ¾ of the width of the rhabdosome proximally and ½ distally. Distal thecae are 10 to 12 per cm., the proximal ones are spaced at 7-9 per cm.

The present specimens differ slightly from those described from Bohemia by Přibyl (1946) in two main respects, the thecae are slightly more closely spaced (8 to 10 in the Bohemian specimens with occasional proximal measurements of 7 per centimetre) and the rhabdosomes are more distinctly curved. However the sample of specimens from Yass is very small and may not be entirely representative of the population.

The largest specimen, S.U.P. 23,620 (Pl. 1, fig. 4), is the one collected by Dr. A. N. Carter and figured by Thomas (1960) as *Cyrtograptus insectus* Bouček. *C. insectus* is an early Wenlockian species which has far less isolate thecae in which the incision between the proximal thecae is half the width of the rhabdosome and ⅓ to ¼ distally (Bouček, 1933). Thomas interpreted the fragment adjacent to the eighth theca of the specimen as a branch.

MONOGRAPTUS sp., cf. MONOGRAPTUS ULTIMUS Perner

(Plate XI, figs 1-3, 5, 6)

1899, *Monograptus ultimus* Perner, pp. 13-14, text-figs 14a, b, pl. 14, figs 4, 5, 11a, 11b.
1900, *Monograptus ultimus* Perner ; Wood, p. 461, text-fig. 13, pl. 25, figs 9A, 9B.
1910, *Monograptus* cf. *ultimus* Perner ; Elles and Wood, pp. 383-384, text-figs 253a-c, pl. 37, figs 14 a-d.
1935, *Monograptus* cf. *ultimus* Perner ; Decker, p. 443, fig. 25.
1941, *Monograptus* (*Pristiograptus*) *ultimus* Perner ; Přibyl, pp. 69-70, pl. 1, figs 9-11.
1944, *Pristiograptus ultimus* (Perner) ; Přibyl, pp. 35-36, text-fig. 2, A, B, pl. 4, figs 7-11.
1947, *Monograptus* cf. *ultimus* Perner ; Ruedeman, p. 488, pl. 84, fig. 35.
1956, *Monograptus* cf. *ultimus* Perner ; Tomczyk, p. 54-55, 116-117, text-fig. 15c, d, pl. 7, fig. 3 a-c.
1962, *Monograptus ultimus* Perner ; Willefert, p. 33, text-pl. fig. 7, pl. 2, fig. 7.

Material and preservation—Approximately 60 specimens which are fairly complete are available, eleven of them are preserved in half relief. These latter, which were originally pyritised, but now weathered to limonite, show traces of half rings in the partially preserved periderm. The remainder of the specimens are preserved as thin flattened films possessing little internal detail. Specimen numbers S.U.P. 23,622-5 & 23,636-97.

Remarks—The form identified as *M.* sp. cf. *M. ultimus* is small with specimens reaching 17 mm. in length but mostly about 7 or 8 mm. long with a gentle dorsal curvature extending over 5 to 6 mm. The rhabdosomes have a maximum width of 1·0 to 1·1 mm. in most specimens.

Several of the better preserved specimens have morphological features worthy of special comment. A section ground through a weathered pyritised specimen from Yass, preserved in half relief (Pl. 1, fig. 6) has revealed the shape of the thin interthecal septum. The septum ends proximally in a rod-like thickening approximately 0·05 mm. in diameter. The common canal occupies just a fraction under half of the width of the rhabdosome. The basal thickening of the interthecal septum has resulted in the formation of a raised boss on incompletely compressed specimens and a thicker carbonaceous impression in many of the flattened specimens. Associated with this boss in many of the partially compressed specimens is a groove running from the point of emergence of the interthecal septum thickening towards the dorsal surface (Pl. 1, fig. 5). The groove becomes shallower dorsally, but in its ventral part there is a thick carbonaceous deposit, presumably marking a thickening and possibly an indentation of the periderm at the junction of two thecae. This structure is oblique to growth rings when they can be detected. The interthecal thickening can be recognised in many of the flattened specimens.

There are two species, *M. haupti* Kühne and *M. praeultimus* Münch have close morphological affinities with *M. ultimus* and closely resemble each other. *M. haupti* is recorded only from isolated material and *M. praeultimus* only from shale material. Both occur in the zone of *M. scanicus*. Urbanek (1958) has made the suggestion that they might be conspecific. *M. haupti* as described by Urbanek (1958) differs from the Yass specimens of *M.* cf. *ultimus* in three respects. 1. The sicula is shorter (1·4 to 1·76 mm. as against 1·7 or possible 1·5, to 2·0 mm.). 2. There are more thecae in 5 mm. (7 as against 5 to 7 but mostly 5½ or 6). 3. The curvature of the ventral thecal wall is greater in *M. haupti* (compare pl. 1, fig. 6 with Urbanek, 1958, fig. 64). The shape of the siculae in Urbanek's illustrations is similar to that of the present specimens of *M.* cf. *ultimus* and less ventrally curved than the siculae of the original specimens of *M. haupti* described by Kühne (1955). The data available in Münch's description and illustrations of *M. praeultimus* (Münch, 1942), are very incomplete, but it would appear that the rhabdosomes are shorter and the thecae may be more closely spaced and have a stronger sigmoidal curvature of the ventral wall.

The description given by Přibyl (1944) in his revision of the Bohemian representatives of *M. ultimus*, compares closely in many respects with the Yass material. The degree of curvature of the thecal wall is similar, so too are the overall dimensions of the rhabdosomes, but the first theca of Bohemian specimens seems to be more prominent and of rather different shape in some illustrations. A length of 2·0 mm. is quoted for the sicula, some of the present specimens have rather shorter siculae, but longer ones than *M. haupti*. Some of the Yass specimens have more distant thecae than the Bohemian ones but most fall within the range of 11 to 14 thecae per centimetre quoted by Přibyl. I am unsure how he made his measurements, possibly it represents the range in number of thecae in any centimetre of rhabdosome. The British specimens described by Elles and Wood (1910) as *M.* cf. *ultimus*, from a lower horizon (the zone of *M. leintwardinensis*), has slightly more distantly spaced thecae and in this respect comes closer to the Yass material. Similar too is the rather lower angle of inclination of the thecae, but the sigmoidal curvature is more gentle in the British material. By inclusion of Elles and Wood's *M.* cf. *ultimus* in his synonymy, Přibyl (1943) is presumably accepting a good deal of morphological variation within the species. The relationship of this Yass form to *M. ultimus* should be left provisional until the Bohemian type material is more fully described and better figures are published.

Acknowledgements

I am grateful to Dr. A. N. Carter for the donation of the specimen of *M. formosus* he collected and the information which enabled me to make further collections from the locality he discovered. My field expenses were paid from a Sydney University Research Grant. I also wish to thank Mr. G. Z. Foldvary for photographing the specimens and drawings figured in the plate and Dr. Hermann Jaeger for telling me of his identification of *M. bouceki.* Financial assistance from the Australian Research Grants Committee is also gratefully acknowledged.

References

Brown, I. A., 1941.—The stratigraphy and structure of the Silurian and Devonian rocks of the Yass-Bowning district, New South Wales. *J. Proc. roy. Soc. N.S.W.*, 74 : 312-341.

————, and Sherrard, K. M., 1952.—Graptolite zones in the Silurian of the Yass-Bowning district of N.S.W. *J. Proc. roy. Soc. N.S.W.*, 85 : 127-134.

Bouček, B., 1931.—Communication preliminaire sur quelques nouvelles especès de Graptolites provenant du Gothlandien de la Bôheme. *Věst. geol. ústav. Cesk.*, 7 : 293-312.

————, 1933.—Monographie der silurischen Graptolithen aus der Familie Cyrtograptidae. *Práce geol.—paleont. ústav. Karlovy. Univ.*, 1 : 1-81.

Decker, C. E., 1935.—Graptolites from the Silurian of Oklahoma. *J. Paleont.*, 9 : 434-446.

Elles, G. L., and Wood, E. M. R., 1910.—A monograph of British Graptolites. Part 8. *Palaeontogr. Soc. London*, 64 : 359-414.

Jaeger, H., 1965.—Symposiums—Band der 2. Int. Arbeitstagung über die Silur/Devon-Grenze und die Stratigraphie von Silur und Devon, Bonn-Bruxelles 1960 (Review). *Geologie*, 14 : 348-364.

————, 1966.—Two late *Monograptus* species from Victoria, Australia and their significance in dating the *Baragwanathia* flora. *Proc. roy. Soc. Vict.*, 79 : 393-413.

Kühne, W. G., 1955.—Unterludlow-Graptolithen aus Berliner Geschieben. *Neues Jb. Geol. Paläont.*, 100 : 350-401.

Münch, A., 1942.—Die Graptolithenfauna des unteren Ludlow von Ronneburg und Umgebung. *Beit. Geol. Thuringen*, 6 : 241-266.

Perner, J., 1899.—Études sur les Graptolites de Boheme. Pt 3B. *Paleont. Bohemiae*, 1-24.

Přibyl, A., 1941.—Die Graptolithenfauna des mittleren Ludlows von Böhmen (oberes eβ). *Zprávy Geol. Úst. Cechya Moravu*, 16 (1940) : 63-73.

————, 1944.—Revision aller Vertreter der Gattung *Pristiograptus* aus der Gruppe *P. dubius* und *P. vulgaris* aus dem böhmischen und ausländischen Silurs. *Bull. inter. de l'Acad. tchèque de Science*, 44 : 33-81.

————, 1946.—The Middle-European Monograptids of the genus *Spirograptus* Gür. *Bull. inter. de l'Acad. tchèque de Science*, 45 : 185-231.

Ruedeman, R., 1947.—Graptolites of North America. *Geol. Soc. Amer. Mem.*, 19 : 1-652.

Sudbury, M., 1958.—Triangulate Monograptids from the *Monograptus gregarius* zone (Lower Llandovery) of the Rheidol Gorge (Cardiganshire). *Phil. Trans. roy. Soc. London*, B 241 : 485-555.

Thomas, D. E., 1960.—The zonal distribution of Australian Graptolites. *J. Proc. roy. Soc. N.S.W.*, 94 : 1-58.

Tomczyk, E., and H., 1962.—Das Problem der Silur/Devon-Grenze in Polen. *Sym. Bd. 2 Int. Arbeitstagung Silur/Devon-Grenze* 274-280.

Tomczyk, H., 1956.—Wenlock and Ludlow in the Kielce Syncline of the Swiety Krzyz Mts. *Inst. Geol. Prace* 16.

Urbanek, A., 1958.—Monograptidae from erratic boulders of Poland. *Paleont. polon.*, 9 : 1-105.

Willefert, S., 1962.—Quelques Graptolites du Silurien Supérieur du Sahara Septentrional. *Bull. Soc. géol. France* (7) 4 : 24-40.

Wood, E. M. R., 1900.—The Lower Ludlow Formation and its graptolite fauna. *Quart. Jour. geol. Soc. London*, 56 : 415-492.

EXPLANATION OF PLATE XI

Fig. 1. Flattened specimen of *Monograptus* sp. cf. *M. ultimus* Perner, S.U.P. 23,622.

Fig. 2. *Monograptus* sp. cf. *M. ultimus* Perner preserved in low relief (portion of the sicula is missing), S.U.P. 23,623.

Fig. 3. *Monograptus* sp. cf. *M. ultimus* Perner with well preserved sicula, S.U.P. 23,624c.

Fig. 4. *Monograptus formosus* Bouček. S.U.P. 23,620.

Fig. 5. Drawing of two distal thecae of *Monograptus* sp. cf. *M. ultimus* Perner specimen preserved in low relief. S.U.P. 23,625.

Fig. 6. Drawing of oblique section through specimen of *Monograptus* sp. cf. *M. ultimus* Perner, preserved in low relief. The section shows the gentle curvature of the ventral thecal wall and the basal thickening of the interthecal septum. S.U.P. 23,625.

Fig. 7. Twisted rhabdosome of *Monograptus formosus* Bouček showing a variety of profiles of the thecae. S.U.P. 23,621.

All figures × 10 except figure 5 which is × 25.

THE OCCURRENCE AND COMPOSITION OF THE SUGARS IN THE HONEYDEW OF ERIOCOCCUS CORIACEUS (MASK.)

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[Read 27th September, 1967]

Synopsis

The honeydew secreted by the Blue Gum Scale, *Eriococcus coriaceus* (Mask) contains, inter alia, seven sugars. One of these has not been previously reported, two have not been found previously occurring in nature and one is a relatively rare sugar. These sugars all have the unusual (1→3) glycoside linkage between portions of the molecule. The sugars and the method of their identification are described.

Eriococcus coriaceus (Mask.) is a scale insect which lives almost exclusively on eucalypts. Tillyard (1926) states that nearly thirty species of *Eriococcus* are known in Australia. The commonest is *Eriococcus coriaceus* (Mask.) which infests the branches of gum trees. It does little harm in Australia but when accidentally introduced into New Zealand it killed off many thousands of acres of blue gum (*Eucalyptus globulus*) until controlled by the introduced Australian ladybird beetle *Rhizobius ventralis* Er.

Froggatt (1921) says " This is the commonest species of the genus, and it is widely distributed over Australia upon many different species of *eucalyptus*. There are many variations in colour but the general form is regular unless massed together. We always find it more vigorous upon all kinds of cultivated gums in gardens and avenues, than in the native bush, where it has many enemies among the ladybird beetles and scale-eating moths ".

Hoy (1963) reports it as occurring on *E. amygdalina*, *E. cladocalyx*, *E. coccifera*, *E. globulus*, *E. gunnii*, *E. regnans*, and *E. stuartiana*. The material used in this investigation was obtained from *E. maculata* and *E. punctata*. No other species of *Eucalyptus* in this, the Hunter River district, appeared to be attacked.

The insect was first described by Maskell in 1893 but an apparently more reliable description is given by Froggatt (1921).

Eriococcus secretes a honeydew which is much sought by ants. In many cases the trail of ants up a tree and along a branch leads to the discovery of a colony of scale. In some cases the secretion of honeydew is so copious that all the leaves and most of the twigs below the colony are thickly covered with the honey. The material used in this investigation was obtained by washing it from the leaves and twigs, filtering and then concentrating the solution under reduced pressure. The dilute solution had a pH 5·8. This acidity was considered to be too low to induce any appreciable hydrolysis during concentration but as a further safeguard the solution was concentrated under reduced pressure. A second sample of honeydew extracted and evaporated under atmospheric pressure showed no significant difference in composition from the first sample. This indicated the precaution was an additional safeguard against hydrolysis. The concentrated honeydew had the colour and consistency of treacle and when fully dehydrated under vacuum looked like dark toffee.

A complete analysis of the dehydrated material was not made, as only the sugars in the honeydew formed the subject of this investigation. However, Table 1 gives the results of some analyses that were made.

The secretion of *Eriococcus coriaceus* is of considerable interest in that it contains a sugar which has not been previously described, two sugars which have been known previously only as prepared in the laboratory and have not been reported as occurring naturally, and as a third feature of interest, the above mentioned sugars together with a rare one which occurs naturally, all contain only glucose and fructose units joined by one or more (1→3) glycosidic linkages.

TABLE 1

Ash..	11·4
Total sugars (as glucose) ..	33·15
Protein	2·6
Esters and acids	5·0
Not determined	47·85

Analysis of Ash	
Na_2O	25·76
K_2O	12·12
CaO	6·95
MgO	9·87
SiO_2	2·86
P_2O_5	13·36
SO_4	21·76
Fe, Al, Cl, CO_2	not determined
	92·68

An examination of the mixed sugars by paper chromatography revealed the presence of seven. These have been identified as eriose, raffinose, melezitose, laminaribiose, turanose, glucose and fructose.

The first named sugar has not, as far as I am aware, been reported before and the name eriose is proposed for it. Laminaribiose and turanose have not previously been reported as occurring in natural products, they having been prepared in the laboratory by the hydrolysis of laminarin and melezitose respectively.

The method of identification of the sugars is detailed below.

The only sugar of the seven shown to be present, which has not a character common with the rest is raffinose. An explanation of the reason for its presence is offered below.

The names of the sugars, their systematic names and some of their chromatographic data are given in Table 2.

TABLE 2

Sugar	Systematic name	R_G *	Colour of stain †
Eriose	O-D-glucopyranosyl (1→3)-O-D fructo furanosyl (2→1) O-D-glucopyranosyl (3→1) O-D-glucopyranoside	0·19	Victorian mauve C.C.297
Raffinose	O-D-galactopyranosyl (1→6) O-D-glucopyranosyl (1→2) O-D-fructofuranoside	0·24	Olive drab C.C.362
Melezitose	O-D-glucopyranosyl (1→3) O-D-fructofuranosyl (2→1) O-D-glucopyranose	0·36	Victorian mauve C.C.297
Laminaribiose	O-D-glucopyranosyl (1→3) O-D-glucopyranose	0·54	Lavender mauve C.C.296
Turanose	O-D-glucopyranosyl (1→3) O-D- fructofuranoside	0·64	Verbena mauve C.C.157
Glucose	D-Glucopyranose	1·0	Lavender grey C.C.343
Fructose	D-fructofuranose	1·20	Apricot buff C.C.44

* The R_G was determined on Whatmans No. 1 paper using Butanol:acetone:water 3:4:1 as eluent. The paper was dipped in aniline-diphenylamine phosphate solution in acetone.

† The colours and colour code refer to the British Colour Council Dictionary of Colours.

The presence of raffinose amongst the sugars secreted by *Eriococcus* seems anomalous, but it might be explained as having been sucked up in the sap by the insect which is unable to assimilate it and it is then excreted unchanged together with the other sugars. It has been shown Basden (1965) that the phloem sap of eucalypts contains from 5% to 10% raffinose together with about 80% sucrose and 10% glucose and fructose. Raffinose is present as about 10% of the honeydew so that this assumption is not improbable. No galactose nor galactoside other than raffinose is present among the sugars. If the raffinose absorbed by the insect were hydrolysed in the digestive tract one would expect it to reappear in the secretion in some other form as is the case in the secretion of *Eurymela distincta* (Signoret) (Basden 1966).

The remaining sugars secreted by the insect are composed of glucose and fructose molecules united in various combinations to yield those listed in Table 2.

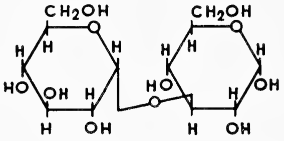

Fig. 1

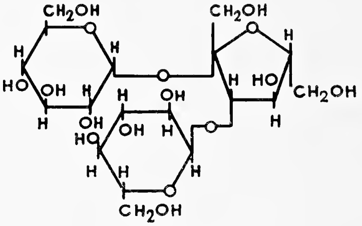

Fig. 3

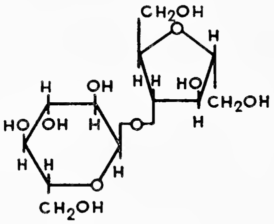

Fig 2

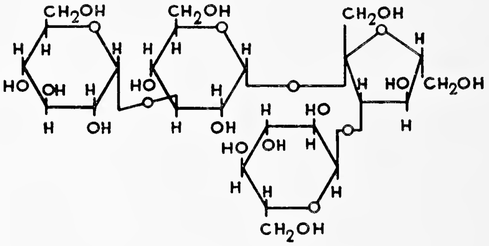

Fig. 4

Eriose is a tetrasaccharide which, as far as the author is aware, has not been previously identified nor described. It comprises about 20% of the sugars of the honeydew. Not sufficient of the sugar has yet been obtained to permit its physical properties to be examined but it has been extensively examined chemically and its formula determined. It is O-α-D-glucopyranosyl (1→3) fructofuranosyl (2→1) O-α-D-glucopyranosyl-(3→1)-O-D-glucopyranoside. Its structure is shown in Fig. 4. It will be observed that its molecule consists of a laminaribiose moiety Fig. 1 joined to a turanose molecule Fig. 2 by a (1→2) linkage as in sucrose. Also it will be seen from the formula that if one of the glucose molecules of the laminaribiose portion is removed the remainder is melezitose Fig. 3, and if the second molecule of glucose is removed the remainder is turanose. Thus these four sugars belong as it were to the same family. The weakest link between the four portions of the molecule is the (1→2) linkage in the middle and is the point of cleavage of the molecule during hydrolysis. It is because this bond is so vulnerable that it has not been possible to obtain melezitose as one of the products.

The position of the spot on the chromatogram of eriose is consistent with its being a tetrasaccharide. Further experimental work is now being done in an effort to synthesize this new sugar.

Melezitose was first described by Morninglane, Duponchel and Bonastre (1822) during the examination of a secretion from the larch tree (*Larix europaea* DC.). They called the secretion Manne de Briançon. Many years later interest in this manna was revived by Alekhine (1889). He hydrolysed the sugar obtained by recrystallising the manna from glacial acetic acid. By using 1% sulphuric acid and heating on a steam bath he found that its molecular rotation changed from +87·5° to +64° in half an hour. It remained nearly constant during the next half hour, but then the rotation fell slowly and became constant at about +50°. The first stage resulted in the formation of a monosaccharide and a disaccharide. The former was shown to be D-glucose and the latter a new sugar which he named turanose from Turan, the old Persian name of the general region north-east of Persia from which the manna had come. Four years after Alekhine's paper was published, Maquenne (1893) reported the presence of melezitose in honeydew from *Tilia.* In later years other writers have reported its occurrence in poplar (*Populus nigra* L.) in *Laburnum anagyroides* Griseb. and *Pinus virginiana* Mill.

This sugar is now obtained from the manna of Douglas Fir (*Pseudotsuga menziesii* (Mirb.) Franco) and in larger quantities from " melezitose honey " in which the sugar has been gathered by bees and incorporated in the honey. In some seasons it constitutes 10% to nearly 20% of the honey. Hudson (1946) states " The melezitose of the honey is not made by the bees ; the trisaccharide was found in honeydew that was taken from pine branches." Arnhart (1926 and 1930) stated that the saccharine material of honeydew is to be attributed to the activity of plant lice of several kinds.

The formula for melezitose was established by Georges Tanret (1906) as $C_{18} H_{32} O_{16}$ $2H_2O$ (Fig. 3).

In the honeydew of *Eriococcus coriaceus*, melezitose constitutes about 15% of the sugars present. It was identified by hydrolysing a specimen with 1% sulphuric acid at 100° for 30 minutes and then chromatographing the resultant sugars. These were glucose and turanose in equal quantities. The sugar was further identified with melezitose by subjecting it to a two dimensional chromatogram using an authentic specimen of melezitose as a control. The R_G and the colour derived from a spray reagent were identical with those of the control.

Laminaribiose has not, so far, been reported as occurring in nature. It was obtained (Barry 1941) as one of the products of the partial hydrolysis of laminarin, a reserve polysaccharide of some brown seaweeds. Barry used the enzymes of the digestive juice of the snail *Helix pomata*, to achieve the hydrolysis. He determined the structure of laminaribiose to be as shown in Table 2 and Fig. 1. In eriococcus honeydew it is present as about 10% of the total sugars. It has been identified by its yielding only glucose on hydrolysis with normal sulphuric acid and also by the presence of the (1→3) linkage as indicated by the mauve colour of its chromatogram when sprayed with aniline diphenylamine phosphate reagent. Its chromatographic behaviour places it among the disaccharide group of sugars.

The disaccharide turanose constitutes about 10% of eriococcus honeydew. It has not been reported as occurring in nature. It was first prepared by Alekhine (1889) by the partial hydrolysis of melezitose from larch manna. Five years later Emil Fischer (1894) prepared turanose phenylosazone and reported many of the properties of the osazone and of the sugar. However another fifty years elapsed before the structure of the sugar was proved. (Hudson 1944 and 1950).

Turanose was identified in eriococcus honeydew by its yielding equal amounts of glucose and fructose when hydrolysed with normal sulphuric acid at 100° for thirty minutes. Its phenylosazone was identical with that of an authentic sample of turanose and a two dimensional chromatogram was also identical with that of turanose.

Acknowledgement

Grateful acknowledgement is made of the help by Dr. D. F. Waterhouse Chief of the Division of Entomology, C.S.I.R.O. for the identification of the insect and for several references to its description and distribution.

References

Alekhine, A., 1889.—*Ann. chim. phys.*, (6) 18 : 532.

Arnhart, L., 1926.—*Z. angew. Entomol.*, 12 : 457.

————, 1930.—*Z. angew. Entomol.*, 16 : 392.

Barry, V. C., 1941.—*Sci. Proc. roy. Dublin Soc.*, 22 : 423.

Basden, R., 1965.—The occurrence and composition of manna in *Eucalyptus* and *Angophora*. Proc. Linn. Soc. N.S.W., 90 : 154.

————, 1966.—The composition, occurrence and origin of Lerp, the sugary secretion of *Eurymela distincta* (Signoret). Proc. Linn. Soc. N.S.W., 91 : 45.

Boudier, G., 1884.—*Assoc. franç. pour l'avancement des Sciences. Congres de Blois.*, 2 : 289.

Fischer, E., 1894.—*Ber.*, 27 : 2486.

Froggatt, W. W., 1921.—Descriptive catalogue of the scale insects of Australia. *Sci. Bull.*, 18 : 76. Dep. Agric. N.S.W.

Hoy, J. M., 1963.—A catalogue of the Eriococcidae of the world. *N.Z. D.S.I.R. Bulletin*, No. 150 : 82.

Hudson, C. S., 1944.—Theory of a method for comparing the structures of certain compound sugars. *J. org. Chem.*, 9 : 117.

————, 1946.—Advances in carbohydrate chemistry, 2 : 12.

————, 1950.—A direct proof of the equivalence of carbon atoms 1 and 6 in D-Mannitol. *J. Am. chem. Soc.*, 72 : 3880.

Maquanne, L., 1893.—*Bull. soc. chim.*, 9 : 723.

Maskell, W. M., 1893.—*Trans. N.Z. Inst.*, 25 : 229.

Morninglane, Duponchel and Bonastre, 1822.—*J. Pharm.*, 8 : 329.

Tanret, G., 1906.—*Bull. soc. chim.*, 35 : 816.

Tillyard, R. J., 1926.—" Insects of Australia and New Zealand ", 174.

AN ANNOTATED LIST OF AUSTRALIAN LEECHES

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[Read 25th October, 1967]

Synopsis

Some 45 " species " are listed with a brief description of essential characters and critical comment so far as possible. The species are distributed in 5 families (Piscicolidae, 19 ; Glossiphonidae, 9 ; Erpobdellidae, 3 ; Hirudidae, 9 ; Haemadipsidae, 5) and 21 genera. Since less than half are adequately described, keys cannot yet be constructed, but the list is a first and essential step to the further study of the leech fauna of Australia.

INTRODUCTION

The leeches of Australia have not previously been assembled or surveyed as a group. Ingram (1957) gives the only account of a regional fauna. Otherwise, the literature is scattered, widely varied in nature and often difficult to assess or interpret accurately. Not half of the recorded species are described in such manner as to permit them to be recognised again, other than in material from the original locality. Accordingly, reliable keys cannot be constructed at this time, nor for a matter of some years as, even at this point, at least 10 undescribed species are known to exist, additional to the following list. The list provides condensed essential descriptions and critical comment, so far as possible, for some 45 " species " in 5 families (Piscicolidae, 19 spp.; Glossiphonidae, 9 spp.; Erpobdellidae, 3 spp.; Hirudidae, 9 spp.; Haemadipsidae, 5 spp.) and contained in 21 genera of which 5 genera were based on Australian species.

The purpose of the list is to enable others to reach at least a provisional identification of any material coming to hand, to assist their entry to the literature more readily than is at present possible and, in this way, to encourage further studies on our leech fauna which is relatively rich, varied, and valuable zoologically. Of equal importance, the list provides overseas workers with an appreciation of the need for caution in their consideration of many of the elements in the Australian leech fauna as at present known.

There has been some progress since the paper was originally submitted. More recent information has been inserted in the text between double brackets.

In spanning a period of 100 years, the literature on the Australian leeches exhibits the stages in the development of descriptive techniques. Earlier descriptions are essentially external, concerned with colour and pattern and give a count of annuli. The latter is constant in the species, but some authors count the annuli as on the venter and others as seen on the dorsum, so that the data given for the one species may differ by 6 to 10 and more annuli. For example, the male genital pore may be described as in the 24th annulus in one account, and the 30th in another.

Whitman (1886) followed Moquin-Tandon (1846) in recognising the annulus containing the ganglion of the ventral nerve cord and marked externally by a transverse row of cutaneous somital sense-organs, as being the anterior annulus of the morphological somite, and the annulus bearing the following nephropore as the last of the same somite. He recognised only 26 preanal somites.

Moore and Castle, independently and from different material, established in 1900 that the ganglion of the nerve cord is placed in the middle annulus of the

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* 4 Bacon Street, Grafton, N.S.W.

somite, and that the nephridium anterior to it is the nephridium of the same somite. They demonstrated that there were 27 preanal somites. Some descriptions of our leeches are clearly and simply based on Whitman's method, others on that of Castle and Moore; but, unfortunately, there are some descriptions which, while they appear to be based on the method of Castle and Moore, in fact contain a confusion between the two systems. This particularly affects the annulation of the first eight and the last four or five somites and the location of the genital pores. The confusion in this respect may now continue in a third form. Mann 1953 reviewed the theories of the somital morphology of leeches, concluding in agreement with the somital morphology as recognised by Castle and Moore. Recently (1962) he revises this to a preanal morphology of 26 somites. There is no adequate reason for this change. I have attempted where helpful to indicate in the list the method on which a description has been based.

Order RHYNCHOBDELLIDA

Having a small circular pore-like mouth on the anterior sucker through which the pharynx can be everted as a proboscis. Freshwater and marine.

Family Piscicolidae

The body consisting of an anterior sucker, commonly disc-like and wider than the neck of which the posterior portion forms the greater part of the clitellar region; the neck narrower than the following abdomen which terminates in a well-formed posterior cupped sucker. The body regions may not be obviously distinct in the young or in some small species. These are the "fish-leeches", best known attached to the exterior or to the gills of fish, turtles, crustacea, bivalve molluscs, etc. and less commonly taken free-living. Marine and freshwater. Knight-Jones (1962) and Soos (1965) give keys to genera and catalogues of the species in this family.

1. Austrobdella translucens Badham 1916

Badham described a new species and established a new genus for small (13·0 mm. long) transparent leeches found as ectoparasites on sand-whiting (*Sillago ciliata*) taken near Port Jackson, N.S.W. The body regions are well-defined; eyes, one pair; somites, 6-annulate; a continuous longitudinal contractile vessel along each side of the abdomen external to the muscular envelope; testes, 5 pairs; crop caeca, 6 pairs. The type is in the Australian Museum.

The species is recorded also from *Notothenia* at the Kerguelen Islands. The genus is recorded also from Greenland.

2. Austrobdella bilobata Ingram 1957

Large, up to 35·0 mm.; transparent to opaque; blue-blackish above; no eyes; crop caeca, 12 pairs; testes, 5 pairs. From the common flounder, *Rhombosolea tapirina*, Pittwater, Tasmania.

Genus Branchellion

Marine fish-leeches having flat plate-like gills on nearly all somites of the abdomen.

3. Branchellion australis Leigh-Sharpe 1916

Up to 35·0 mm. long; 31 pairs of gills on the abdominal region with 11 pairs of pulsatile vesicles; testes, 6 pairs. On *Raja lemprieri*, Port Victor, S.A.

4. Branchellion lineare Baird 1869

Inadequately described from a specimen ½ inch long from *Mustelus*, King George Sound, North Australia, and not recognisable again from the description. Gills simple, not "puckered"; 32 abdominal annuli. The original specimen is stated to be no longer available at the British Museum.

5. BRANCHELLION PARKERI Richardson 1949

Twenty to 40·0 and exceptionally up to 75·0 mm. long ; 31 pairs of gills but only 10 pairs of pulsatile vesicles ; testes, 5 pairs. Known (Ingram, 1957) from *Raja lemprieri*, *Pristiophorus*, and *Dasyatis*, and originally from New Zealand. Type, Dominion Museum, Wellington, N.Z.

6. BRANCHELLION PUNCTATUM Baird 1869

Up to 1½ inches long. The description is generalised and the species not recognisable again unless Baird's statement that " the gills are larger on the posterior portion of the body, simple, not puckered on the margin " does describe a distinctive feature of a leech having " about 32 segments in the body ". From *Myliobatis*, King George Sound, North Australia. The original specimen is said to be no longer available at the British Museum. Blanchard identified the leech figured by MacDonald (1877) from Shark Bay, W.A., as *B. punctatum*, but MacDonald's leech shows 29 pairs of gills, which would be a low number for a leech having about 32 abdominal annuli.

7. ICHTHYOBDELLA AUSTRALIENSIS Johansson 1911

Known from one specimen 1·9 mm. long. The body regions not distinct ; eyes, two pairs on the expanded anterior sucker ; typical somite possibly 4-annulate ; posterior crop caeca apparently united but briefly bilobed distally ; testes, probably 6 pairs. From shallow water, sandy bottom with plants, near Geraldton, Champion Bay, W.A. Inadequately known and possibly unrecognisable again with certainty in the absence of a known host. The size given is curiously small.

8. "ICHTHYOBDELLA" PLATYCEPHALI Ingram 1957

Length, 23·0 mm.; body regions distinct ; two transverse dark bands across the disc-like excentrically attached anterior sucker ; body elongate, smooth, brown above with three pairs of longitudinal light bands ; the wider posterior sucker mottled above ; somites, 14-annulate, the annulations faint ; posterior crop caeca united, with (?) two fenestrae ; testes, 5 pairs. From *Platycephalus bassensis*, Catamaran, South Tasmania.

Miss Ingram was faced with the difficulty that her leech more closely resembles *Johanssonia abditovesicula* Moore 1952 of Hawaii, than Moore's species resembles the genotypic species and *J. pantopodium* which are the only two other species in this genus. It is quite likely that " *I* ". *platycephali* and *J. abditovesicula* together constitute a new genus which would resolve a current difficulty in *Johanssonia*. Ingram's reference of her species to " *Ichthyobdella* " follows a practice for new species of fish-leech which are, in general, simple in form and of confused generic relationship.

9. OZOBRANCHUS BRANCHIATUS Menzies 1791

A small white leech about 25·0 mm. long with distinct body regions ; eyes, one pair ; 7 pairs of filiform gills crowded on the lateral margins of the anterior half of the abdomen ; found as ectoparasites on marine turtles of warmer waters, possibly on dolphins, etc. MacDonald (1877) figures this species from Shark Bay, W.A. but without identification. Referred to by Goddard (1910b) but not in such manner as to make definite that he had handled a specimen from Australian waters.

((Through Mr. John Goode, I now have specimens of an ozobranchid from Murray River turtles. It has simple elongate undivided gills. It is a new species requiring a new genus. Otherwise, ozobranchs are known in freshwater by only a single species in North India.))

10. PLATYBDELLA MICHAELSENI Johansson 1911

Known from two small leeches taken in the vicinity of Fremantle, Cockburn Sound, and others at Warnbro Sound, W.A. Length 6·9 mm.; longitudinally striped; elongate; the regions distinct; posterior sucker very large; somites, 6-annulate; testes, 5 pairs. No host given.

Moore (1938) suggested that this species might be based on juveniles of the antarctic *Cryobella levigata* Harding 1922. He examined material taken from " behind the gills " of *Trematomus hansoni*, finding these leeches to be 12-annulate and accordingly placed *C. levigata* in the genus *Platybdella*. Harding's leech was uniform brownish above and below; up to 29.0 mm. long; testes, 4 pairs; posterior crop caecum single, terminating in two distal pouches. Knight-Jones (1962) and Soos (1965) retain *Cryobdella*.

G. Pontobdella. Tapering cylindrical leeches; regions not distinct; 2-annulate to 5-annulate; strongly tuberculate; 6 to more tubercles per annulus. Leeches of such description are so strongly characterised that the genus now includes a range which would not be acceptable in another genus of leeches. (The New Hebridean *Stibarobdella superba* Leigh-Sharpe 1925 is known only from the original incompletely described specimen. It is 4-annulate but distinct in having only 4 major tubercles on the dorsal aspect of the abdominal somite and only lesser ones below. It can well be expected in Australian waters.)

11. PONTOBDELLA AUSTRALIENSIS Goddard 1910

A 3-annulate uniformly tuberculated cylindrical leech, 20·0 mm. long; host unknown; possibly collected in the vicinity of Sydney. Inadequately described and the description confused by reference to a resemblance to *P. muricata*, a 4-annulate species of the Atlantic.

12. PONTOBDELLA BIANNULATA Moore 1957

A small leech up to 20·0 mm. in length taken at southern sea-stations by the BANZARE and remarkable as a cylindrical leech with the neck finely annulate (3-annulate) and lacking tubercles and the abdomen 2-annulate, coarsely tuberculate with the tubercles appearing as though arranged in spiralling rows. No eyes or eye-spots. No record of host.

13. PONTOBDELLA LEUCOTHELA Schmarda 1861

Small, 18·0 mm. long; apparently 3-annulate, the middle annulus the wider and with 4 large tubercles; the first and third annuli with 13 small tubercles; the neck of 15 annuli; yellowish-grey. From Port Jackson, N.S.W. Figured but this is not helpful. The tuberculation does have some agreement with that of Harding's *S. superba*.

14. PONTOBDELLINA MACROTHELA Schmarda 1861

This common pontobdellid of warmer oceans, an ectoparasite of hammer-head sharks was recognised by Goddard (1910a) on material from the Brisbane River. It is known from 50·0 mm. to 95·0 mm. in length. The neck and body are strongly distinct with an obvious clitellum of 5 uniformly tuberculated annuli and a sixth short naked annulus; neck and body strongly tuberculate; the abdominal somites with 4 large and 2 small tubercles above and 6 below on the middle annulus, the first and last annuli with 16 tubercles. There are good specimens in the collection of the Australian Museum. *Pontobdellina* is given only subgeneric status by some authors.

15. PONTOBDELLA RAYNERI Baird 1869

Baird briefly characterises a pontobdellid found on *Rhinobatis* at Shark's Bay, as: a small leech, one inch long contracting to three-quarters of an inch in spirit; the neck and body almost continuous, covered with tubercles, separated by a clitellum of 5 tuberculated annuli; 3-annulate, with the middle annulus on the body somite carrying larger tubercles; the anterior sucker small, with 6 papillae and two subtriangular brown areas.

Johansson (1911) recognised this species in a further specimen also from *Rhinobatis* at Shark's Bay. This is 3-annulate, the middle annulus the longer and with 4 large tubercles above and below, where there are also 3 small tubercles in the middle area (11 in all), and 18 on the shorter first and third annuli; clitellum of 5 tuberculated annuli. This specimen was 10·0 mm. long. Moore (1957) identified 5 specimens from a Port Jackson shark caught off Hobart as belonging to this species. Small 3-annulate pontobdellid leeches are well-represented in the collection of the National Museum of Victoria. Where noted, these are from the Port Jackson shark.

16. PONTOBDELLA RUGOSA Moore 1938

A 4-annulate pontobdellid of medium size (40·5 mm.), having 8 equivalent tubercles on all fully developed annuli of the abdomen and few if any median tubercles; neck continuous with the abdomen; poorly defined clitellum of 5 (6 or 7) tuberculated annuli. Described first from Commonwealth Bay, King George V Land, host not recorded; later from stations at sea, and with some doubt from *Trigonorhina fasciata* caught near Hobart, Tasmania.

17. PONTOBDELLA TASMANICA Hickman 1942

Originally named *P. verrucosa* (nom. preoc.). A 3-annulate pontobdellid having 8 tubercles on the middle annulus of the abdominal somite and 12 on the first and last annuli; clitellum of 5 tuberculated annuli. Up to 80·0 mm. From Sandy Bay, Hobart, Kingston, Tasmania, and (Ingram, 1957) from a skate at King Island. The type is in the Australian Museum.

18. SEMILAGENETA HILLI Goddard 1908

A freshwater leech for which Goddard established a new genus in the Glossiphonidae, later (1910b) suggesting it should be in the fish-leeches and noting that it might even require a new Family, so that its position here is doubtful; but if it is a piscicolid it will be the only fish-leech known from our freshwaters. The single specimen taken free-living near Oberon N.S.W. was destroyed. No size is recorded. A pale-green leech, broadly pear-shaped; distinct papillae on somites i to iv, smaller on v to xi, and absent posteriorly. The genital apertures apparently united into a single aperture on the posterior portion of annulus 21. Goddard originally considered that the posterior sucker consisted of 14 fused somites (not the usual 7), but departed from this view later on.

The data is now incomprehensible. No such animal is known elsewhere. Knight-Jones (1962) does not refer to it in his review of the Piscicolidae, nor does Soos (1965). Mann (1962) regards it as a glossiphonid of uncertain subfamilial status.

19. TRACHELOBDELLA LEPTOCEPHALI Ingram 1957

Up to 20·0 mm. in length, taken from the gills of *Leptocephalus conger*, Tasmania. Elongate with distinct body regions; 13 pairs of pulsatile vesicles on each side of the abdomen, the anterior vesicles the larger and the few last posterior much reduced; genital pores separated by 2 annuli; testes, 5 pairs; posterior crop caeca fused and extending nearly to the anus; anterior sucker about equal to the width of the neck and bearing 2 or 4 pigmented patches which may be eyes; 6-annulate.

Pinto (1923) records *Trachelobdella australis* Blanchard 1900 as from Australia. The one specimen then known came from off Tierra del Fuego. Moore (1957) established a new genus *Trachelobdellina* for *T. glabra*, n. sp., a leech of

29·0 mm. in which the narrow neck is equal in length to the abdomen ; 6- or 8-annulate ; 12 pulsatile vesicles ; the skin smooth except for numerous sensory papillae ; genital pores separated by 3 annuli. This was taken in our southern ocean waters and it can be expected to be near our coasts.

Family GLOSSIPHONIDAE

Freshwater leeches commonly of small size ; characteristically depressed, convex above ; the body without distinct regions, appearing somewhat ovate, tapering anteriorly to a narrowly rounded head with a shallow open ventral sucker ; the mouth, a small circular pore within the sucker or on the anterior rim ; the dorsum roughened by obvious papillae, or smooth ; the body generally obviously 3-annulate. Most commonly found attached to the lower surface of stones, submerged logs, lily-pads, etc., or sheltering in the submerged axils of bulrush and other aquatic plants. When removed, roll up lengthwise. Eggs and young carried on the venter which is then shallowly concave to contain them.

1. CLEPSINE, n. sp. Johansson 1911

Described from a single small (3·5 mm.) leech from Broome Hill, W.A., having two pairs of eyes arranged in transverse pairs, an eye on either side of the mid-line and the second pair closely follows the other ; testes, 6 pairs. Otherwise described so that it may only be recognised again from a specimen of nearly similar size from the original locality. The reference of the animal to *Clepsine* is not helpful, as the genus operated somewhat as a catchpot and species have been transferred from it to five other genera. There is only mention of the similarity of the internal anatomy to *Helobdella stagnalis* as a guide to possible generic standing.

2. CLEPSINE OCTOSTRIATA Grube 1866

I do not have Grube's original account, but later (1871) it seems that the species is based on only a single specimen from Rockhampton, of small size, the length not given but at least 10·0 mm.; 58 obvious annuli, each carrying a transverse row of 10 or more tiny papillae ; eyes, two, separated by a distance equal to the diameter of the eye and placed as far from the anterior margin as from the lateral edge ; greyish-yellow dorsally with 8 longitudinal dark red stripes, the median four narrow and of equal width and separated by about half their width ; the other stripes paler and wider, and the most lateral separated from the edge of the body by a faint grey stripe, so that if the latter are excluded, there are 8 stripes ; ventral surface paler than the dorsum ; the whole somewhat translucent as the crop pouches can be seen as green ; genital apertures not observed.

It appears that Goddard (1909) was aware of some such leech in the vicinity of Brisbane and considered that " the genus is extremely abundant throughout Eastern Australia ", but this is now confusing in meaning. It is quite likely that *C. octostriata* can be recognised again.

3. GLOSSIPHONIA AUSTRALIENSIS Goddard 1908

Described from specimens up to 15·0 mm. long from a creek near Oberon, N.S.W. and, more recently (1957), by Ingram from 2·5 mm. to 39·0 mm. from the lower surface of stones and wood in Lake Dulverton, Oatlands, Tasmania. Soos (1966) recognises this as a species in the g. *Glossiphonia* characterised in having : a single annulus between the genital pores ; 3 pairs of eyes situated in annuli 2, 3, and 4 ; one post-anal annulus ; testes, 6 pairs ; the sixth pair of crop caeca elongated posteriorly and with many (10 or 11) simple lateral diverticula.

Ingram reports that the last crop caeca appear late and that small specimens may show only 5 pairs of simple caeca ; somewhat larger specimens, simple sixth caeca which may actually be asymmetrical ; but large specimens always have six pairs of diverticulate crop caeca. She describes her specimens as having a greenish tinge, lacking conspicuous patterning; flesh-coloured, opaque; segmental papillae absent.

4. GLOSSIPHONIA HETEROCLITA Linn. 1761

This leech of America, Europe, Asia, Central and East Africa was recognised in Australia on the evidence of a single specimen taken from the lower surface of a floating timber from Narara Creek in the vicinity of Gosford by Goddard (1909), but with some doubt on the certainty of this identification.

His specimen was small (8·8 mm. contracted); the skin smooth, lacking papillae; the body clear, gelatinous; crop and crop caeca appearing as yellowish-brown structures; annuli, 68 to 72, inconspicuous; eyes, 3 pairs, in the form of an arc, the most anterior being small and close together in annulus 4; the intermediate pair large and further separated, in 5/6; the third pair equal to the second and close to them in 6.

This sparse data, so far as it goes, conforms to *G. heteroclita*, but there seems to be no further account of Australian material. Soos (1966) does not refer to this record.

5. GLOSSIPHONIA INFLEXA Goddard 1908

Described from a single specimen, 14·0 mm. long, collected near Waverley, Sydney, as being: broad; flat; pale sage-green in colour; semi-translucent; smooth; indistinctly annulate, with 70 annuli; lacking eyes; sense-papillae obvious in the middle region of the body; anus on the dorsal surface of the last annulus; the genital pores united as a common pore on annulus 28; 3-annulate.

There is little certainty in this description which might lead to recognition of the species again. Soos (1966) lists this as a *species inquirenda*. He groups three species as having a common pore for the reproductive systems; *G. tasmaniensis*, *G. heteroclita*, and *G. weberi*. Of these only *G. heteroclita* lacks a post-anal annulus and the number and arrangement of the eyes is highly variable in this species.

6. GLOSSIPHONIA INTERMEDIA Goddard 1909b

Described from two leeches taken attached to submerged timber in the bed of Orphan School Creek, Fairfield. A leech capable of remarkable extension. Goddard described it as 14·0 mm. contracted, 4·6 mm. wide in the posterior part of the body, but capable of extending the anterior half of the body to give a maximum length of 33·0 mm.; eyes, typically 4, a pair each in annuli 5 and 6, the eyes of a pair being spaced out somewhat more than half the width of the annulus (and an eye-like structure at 3/4 in one specimen); mouth in annulus 4; crop with 6 pairs of caeca, the posterior elongated and each with three simple lateral diverticula; anus followed by 2 annuli; testes, 6 pairs; genital pores separated by one annulus in xii; blue-grey over the dorsum of the anterior half of the body and dirty yellow over the posterior half; prominent sensory papillae lacking; unornamented.

Soos (1966) sustains this as a valid species. There seems to be no record other than the original account and the species needs careful re-examination. As for example, Goddard wrote " The anus lies between the second and third last annuli ". This can be read that two annuli follow the anus, as in the above account, but this is unique among the ten species now retained in the genus so that the statement may be ambiguous.

7. GLOSSIPHONIA TASMANIENSIS Ingram 1957

A small leech, 7·0 mm. to 10·0 mm. long; colourless to grey-white; transparent in life attracting attention by the pattern of the dark crop diverticula. Taken attached to the lower surface of stones in the creek entering Curryjong Rivulet in the vicinity of Antill Ponds, Tasmania. Eyes as a pair on each of annuli 5, 6, 7, arranged in divergent longitudinal lines ; 70 annuli ; surface very finely granular ; no segmental papillae ; genital pores united at 27/28 ; testes, 4 or 5 pairs ; 6 pairs of crop caeca, last pair elongated posteriorly with a small number (4 or 5) of large simply lobed lateral diverticula ; one annulus behind the anus ; egg-bearing in March.

Ingram suggested the possibility that this might be only a variety of *G. heteroclita*, but Soos (1966) sustains this as a valid species.

8. Placobdella bancrofti Best 1931

Originally located in the genus *Helobdella*, this species was based on three small specimens, 6·8 mm. long, removed from the turtle *Emydura krefftii* at the Burnett River, Queensland.

There is no record of colour, and much general external detail is lacking, as the description was taken from two leeches prepared as whole mounts and the third in transverse serial sections. The mouth, subterminal, a perforation in the second annulus ; one pair of eyes separated by less than their diameter ; genital apertures separated by a single annulus immediately anterior to ganglion xii ; testes, 6 pairs ; crop caeca, 7 pairs, the last pair extending posteriorly with a few (3) broadly open lateral diverticula ; anus opens (?) in the centre of the disc of the posterior sucker as seen in the whole mount.

A known locality and host give the promise that this species might be recognised again. With the mouth in the second annulus and with 7 pairs of crop caeca, these leeches fall outside of *Helobdella* as at present understood. It is more suitable at this time to refer the species to *Placobdella*, following a practice of others for leeches parasitic temporarily on reptiles and amphibia. This is a simple provisional convenience.

((Placobdellid leeches are common on Murray River turtles and may well be Best's species. Elsewhere turtle-leeches have a wide distribution.))

9. Placobdella bdellae Ingram 1957

A small, coarsely papillate, almost colourless, transparent leech, 11·0 to 13·0 mm. long ; one pair of pigmented eyes at 3/4 ; mouth in ii ; middle annulus longer and more coarsely tuberculated than the contiguous annuli so that the 3-annulate condition is obvious ; large papillae in 4 distinct longitudinal rows with a fifth median row in the mid-region of the body ; 70 annuli ; genital apertures separated by 2 annuli, located at 27/28 and 29/30 ; testes, 6 pairs ; crop caeca, 7 pairs all with many small diverticula and the seventh pair directed posteriorly.

Described from specimens taken from the buccal cavity of the lamprey *Geotria australis* in Tasmania. The leeches survive apart from the host. The location is unusual. Other leeches known from cyclostomes are entirely ectoparasitic, attached to the open skin.

Order ARHYNCHOBDELLIDA

Most commonly elongate, more or less somewhat depressed or some cylindroid leeches ; broader posteriorly ; tapering anteriorly to a head consisting mostly of a shallow scoop-like ventrally directed oral sucker with well-formed ventral and lateral margins overhung by a flexible upper " lip " of several annuli ; the mouth a slit-like or three-cleft opening leading into a buccal chamber in which for most there are 3 muscular ridges (median dorsal, paired ventrolateral) terminating in jaws which may be unarmed, equipped with a cutting plate of chitin, or with chitinous or calcareous teeth, but in some few there are only two jaws ; the ridges continue into the fixed muscular pharynx ; essentially 5-annulate but often with secondary or further subdivision of these annuli ; a clitellum, the eggs being deposited in a cocoon attached to sticks, stones, plants, etc. Freshwater and terrestrial.

Family Erpobdellidae

Slender, linear in form, somewhat rounded in section anteriorly, commonly flattened posteriorly and even sharply flanged when swimming ; eyes variable in number and arrangement, even absent, but never as a nearly continuous arch of 10 eyes ; more typically an anterior pair or two pair of eyes and a more posterior two pairs transversely arranged and widely spaced and these may be followed by other eyes ; jaws simple, reduced, lacking teeth or with only one or two simple stylets on each jaw ; pharynx elongate, reaching into x and beyond ; crop lacking caeca, or with only a single small pair. Freshwater, secretive, carnivorous, feeding on worms, snails, larvae, etc.

((I now have three species of this Family additional to those below. These show considerable novelty.))

1. Genus Barbronia Johansson 1918

Not yet reported in Australia although the genus is now known to be widespread in East Asia, India, Malay Archipelago, New Guinea and I had specimens in New Zealand. I now have specimens from Sydney and elsewhere.

These are small (up to 35·0 mm.), slender, reddish, translucent worm-like leeches ; a copulatory pore is situated some 5 annuli anterior to the male pore and another posterior to the female pore but these may be small and the posterior difficult to detect ; the jaws armed each with a small coarse stylet which is very easily displaced.

Such leeches can be found beneath stones in streams, but more readily in submerged rooted vegetation in shallow pools on slow-running streams when the vegetation is examined in water in a white pan.

2. Dineta cylindrica Goddard 1909a

Known from a single contracted specimen about 25·0 mm. long by 2·0 mm. wide, collected from a freshwater pool in the vicinity of Oberon, N.S.W. A cylindrical elongate leech having 115 annuli, but the annulation somewhat obscured by a roughness due to many fine longitudinal lines which gives an appearance of tuberculation ; 5-annulate but many annuli superficially subdivided further ; genital apertures separated by 5 annuli ; 3 pairs of eyes on annuli 1, 3, and 6 ; 3 muscular ridges in the pharynx ; testes about 7 pairs.

Regarded by Goddard as possibly a species of the genus *Dina*. It is retained by Soos (1966) as *Dineta*, characterised as lacking stylets and accessory eyes and with $b_5 < b_6$ which is not further subdivided. It requires further examination, since among other features of interest, Goddard refers to a peculiar proboscis-like outgrowth of the oesophagus or pharynx which is a novelty. It may not be confused with *Barbronia sp.* where the eyes are arranged as an anterior median pair on the upper lip and two pairs each in a lateral position on about the third annulus following.

3. Erpobdella sp.

Goddard (1909b and 1910c) refers briefly to the occurrence of leeches, which he assigns to this genus, in the vicinity of Sydney and in the Maitland district, but gives no further data. Pope (1966) figures an erpobdellid cocoon (not *Barbronia*).

Family Hirudidae

Ten-eyed leeches with the eyes arranged as an ocular arch near to the margin of the upper lip and on the first few complete annuli with longer intervals between the third and fourth, and fourth and fifth eyes on each side ; some with a median longitudinal furrow on the lower surface of the upper lip ; nephridiopores ventral ; dorsal somital cutaneous sensillae in 8 longitudinal rows, ventrals in 6 rows ; jaws characteristically armed with a few too many teeth in one or two rows, or with a chitinous cutting plate, or unarmed ; pharynx bulbous, short, in vii and viii uncommonly reaching into ix ; crop with at least one and often more pairs of large caeca. Terrestrial (not yet known here) and freshwater, predators, scavengers, carrion eaters, and sanguivores.

1. AETHEOBDELLA HIRUDOIDES Moore 1935

Known from a single specimen, 107·0 mm. long and 11·6 mm. wide, collected in 1930 from a pond near Cambewarra, near Nowra, N.S.W., and deposited in the British Museum. Moore established a new genus for this leech.

Moderately elongate in form, widest posteriorly, but the lateral margins sub-parallel over the greater length of the body, which tapers abruptly at the anterior end ; generally depressed ; margins rounded ; surface smooth ; eyes, 5 pairs, small, obscure especially the last pair ; 5-annulate (17 such, viii to xxiv inclusive but the latter is incompletely divided on the venter) ; genital pores separated by 7 (possibly 8) annuli ; two postanal annuli ; apparently 11 pairs of testes ; male and female atria minute and embedded in the body-wall external to the longitudinal muscles ; nephridiopores very obvious, having swollen lips, close to the lateral margins on the ventral surface ; jaws small, low, broad, lacking a distinct dental ridge, lacking papillae, and with 21 relatively large blunt teeth having a bilobed base and in one row.

The leech is remarkable in the Hirudidae in lacking an obvious penis and in the minute size of the atria. Moore states that it is of the size and form of *Haemopis lateralis*, which could mean that the body is rather soft and the colouring plain in life.

A. hirudoides has now been recognised as the leech which perforates the conjunctival fold at the upper outer corner of the eye and takes up its position between the skin and skull in various bush-birds (White-eye, Bulbul, Yellow-faced Honeyeater, etc.). It is aquatic but its habits are not yet known.

2. HAEMOPIS sp.

In view of the reference above to *Haemopis*, it is interesting that McCarthy (1962) states that leeches removed from the teat-canal in cattle in Southern Queensland had been identified as *Haemopis* sp., and that the same species had been removed from the udders of cattle at the Townsville Abattoir.

Genus HIRUDO Linn. 1758

As the " classical " genus of 10-eyed jawed striped leeches, new species described from many countries were almost automatically placed in this genus during the last century and even more recently. European experience led to the view that there would be only one such species in each continent. This is now proven incorrect, but it resulted in the reduction of many species without reference to material to the level of synonyms of the first-named species. The genus is now more closely defined. Caballero (1956) lists 21 genera in the family. The true generic homes for the species listed here as " *Hirudo* " is still to be determined for any which may be recognised again and found valid as species.

3. HIRUDO ELEGANS Grube 1866

Described from a leech taken at Rockhampton, Q. The description provides little information beyond this being " *Hirudo* " in eyes, form, etc.; the colour pattern on the dorsum being a median wide, intense dark stripe and two other stripes of lesser intensity, all five each with a delicate black border ; the venter, pale olive.

There is nothing essential in the description which can give definite recognition of this species other than in a collection at the original location. I have seen specimens of " *L.*" *australis* with fine black borders on the dorsal stripes as described above.

((Grube (1871) was in error in crediting his original descriptions of *H. elegans* and *H. novemstriata* to his paper published in 1866. The descriptions are contained in his paper of 1867 on land-leeches. I have now recognised *H. elegans* in specimens sent me by the Rockhampton Field Naturalists' Club, and at Grafton. It is assigned to a new genus : Richardson, in press, *Mem. Queensl. Mus.*))

4. HIRUDO NOVEMSTRIATA Grube 1866

Described from a specimen from Rockhampton as being a most slender leech, 12 times as long as wide, the anterior end tapering and the sucker so narrow as to appear lumbricine ; annuli appear long and with a transverse row of about 10 papillae above and below giving the appearance of a low ridge. The dorsum is described as marked with 9 dark lines (or 8 light longitudinal stripes) of equal width excepting the unpaired darker stripe which is broader, and the spaces on either side, wider than the paired dark stripes ; lateral edgings, wider, light and not set off from the uniformly coloured plain venter. The paired stripes commence at the 10th annulus. Male pore at the rear edge of 24 ; female pore in annulus 29.

Goddard (1909) considered this a synonym of "*L.*" *australis* which Johansson (1911) regarded as quite incorrect. The latter figures the patterns in "*L.*" *australis* as known to him in specimens and from published figures of this and other species which strongly supports his opinion. I have not yet seen such a pattern in "*L.*" *australis*, where in all specimens I have so far seen, the dark stripes commence as such in annulus 6 and none show more than 5 dark stripes.

5. HIRUDO QUINQUESTRIATA Schmarda 1861

This large striped leech was described as being 150·0 mm. long ; with 80 annuli ; the dorsum, brown with a very narrow median longitudinal stripe and four other wider stripes which are narrower than the intervening light stripes ; small eyes forming an arch ; large jaws with 48 to 50 sharp-edged teeth of diminishing size ; the anterior genital pore behind annulus 25 ; the caudal sucker of the width of the body and narrowly attached. It was stated to be not unusual in the Cooks River, as well as in waterholes at the foot of the Blue Mountains.

This was made a synonym of *Hirudo australis* Bosisto by Grube in 1868 according to Benham (1907), but the name *quinquestriata* continued in use, for example Vaillant (1890), Blanchard (1893), Parker and Haswell (1897), and in the pharmacopeias until quite recently. McCarthy (1962) quotes Seddon (1950) as referring to a leech under this name taken from the teat-canal of a cow.

In establishing the genus *Limnobdella* for a new leech from Mexico, Blanchard (1893) remarked that other known species would be accomodated in this genus, and indicated *H. quinquestriata* as one such. Brandes (1901) following Grube and Blanchard accordingly lists *Limnobdella australis* (Bosisto), and follows this with the description and localities as given by Schmarda, excepting that he gives 103 as the total number of annuli. This was repeated in a reduced form by Pinto (1923), but with the addition of a comment that the length was 75·0 mm. in alcohol, obviously a figure derived from Goddard's account of *australis* (1909b).

Schmarda's account of the distribution of *quinquestriata* reads more like hearsay than personal experience, suggesting his specimen might have been an exceptionally large one obtained from a Sydney pharmacy. Recently with the help of the Pharmacy Board of New South Wales, I have been in touch with senior pharmacists but none have recalled a leech of this size.

It can be noted that Schmarda approximated closely in the counting of annuli. For example, he gives 96 annuli for his *H. multistriata* of Ceylon, almost certainly *Hirudinaria manillensis* (Lesson 1842) which has 102 annuli. The low figure of 80 annuli could only indicate an haemadipsid, but the illustration does not support this conclusion.

It continues difficult to accept that the great length and the unusually low count of annuli are both simple errors. If they are not such, the confusion between two possible species has been greatly augmented by the transfer of the description of *quinquestriata* to *australis* and there remains the possibility that a large uncommon sanguivore may be rediscovered presumably in the coastal belt.

((I have recently handled specimens of '*L.*' *australis* which reached an extended length of 120 mm. and cannot now sustain *quinquestriata* as a separate species, especially as the dentition figured by Schmarda agrees with *australis* where it has proven to be specific in value.))

6. HIRUDO TRISTRIATA Schmarda 1861

Described as differing from *H. quinquestriata* in having 3 black stripes on the dorsum which is a dirty-greenish colour, and the abdomen greenish-brown. From Bathurst but also supposed to be present in the Macquarie and Murray Rivers. The drawings were lost. Vaillant (1890) refers to this species, but in general it has been omitted from the literature. McCarthy (1962) quotes Seddon (1950) as referring to a leech under this name taken from the teat-canal of cattle, but I have not been able to find this in Seddon.

From the description and location, this is almost certainly '*L.*' *australis* in which in many specimens I have seen, the median black stripe is broad occupying a third and more of the width of the dorsum, but subdivided by two very narrow paler lines extending from iii to xxvi, passing through the paramedian sense organs and of no greater width than these structures, so that at first sight the animal shows only three stripes.

7. HIRUDOBDELLA sp. Goddard 1910c

Goddard writes of a species of this genus present in Australia but gives no other information. There is no later information.

The genus *Hirudobdella* was established by Goddard for *Hirudo antipodum* Benham 1903, which is remarkable for having the jaw much higher than wide, lacking teeth, but with a straight not curved distal margin where the cuticle is folded into a cutting edge with irregular rounded prominences and almost nothing of teeth of the usual pointed kind.

This leech is 48·0 mm. long, with 5 longitudinal dorsal black bands ; obvious dorsal somital sensillae ; genital pores separated by 5 annuli ; testes, 7 pairs. It was discovered among the wet roots of grasses and other material at the bottom of shearwater nests on Open Bay Island off the West Coast of the South Island of New Zealand. No type or other material exists, nor has it been found again at the type locality (W. Benham, pers. comm.).

We can only assume that Goddard handled leeches coming close to this description.

8. " HORSE-LEECH " of Bosisto and Becker 1859

Included here since from their accounts it would seem this is a rather common leech of large size which has not been further described since the original accounts, nor referred to in the literature, excepting by Johansson (1911) who considered it to be a variety of *Hirudo australis*. This seems improbable.

A 10-eyed leech having an elongate depressed body widest in the posterior third and tapering gradually to the narrow head ; annuli, 94 with ridged folds of no distinctive character ; dark rusty colour above and below with a longitudinal median dorsal black stripe and three faint brown (? narrow) parallel lines on either side. It becomes grey in spirit.

In lagoons, pools and creeks (? Victoria). As a pharmacist, Bosisto would be familiar with accounts of the european horse-leech, a non-sanguivore, at best only a moderate swimmer, found under stones, logs etc. in deeper pools and the littoral of lakes, with a preference for marshy ground. He could be expected to distinguish between his Australian medicinal leech and another of the " horse-leech " kind.

9. " LIMNOBDELLA " AUSTRALIS Bosisto 1859

This leech was loosely described by Bosisto, and well-figured by Becker (1859) in a separate paper, the material obtained from the Murray watershed which Bosisto refers to as yielding only this, the best blood-sucker for medicinal purposes. Bosisto used the name *Hirudo australis.*

Dark olive above, sometimes approaching black, with 4 well-marked yellow longitudinal stripes, the two outer wider than the inner ; the lateral margins being of the same colour as the venter which is deep ochre yellow sometimes spotted with olive-green. Eyes 8 ; body narrow, oval, about 100 annuli. From Becker, it is clear that the median dark stripe is the narrower, about equal to the light lines on either side of it, and half the width of the inner pair of dark lines, which are barely half the width of the light lines lateral to them. This conforms to the pattern of Schmarda's *quinquestriata.*

So far as I have been able to find, there was no further published description of a leech under the name *australis* until Goddard's account in 1909b, excepting in Brandes (1901) who, under this name, repeats Schmarda's description of *quinquestriata.* In this period of fifty years it was the latter name which was widely used (see above), as for example by Baird (1869), who footnoted that the few specimens preserved from a shipment of medicinal leeches from Australia to London were of Schmarda's species. It should be mentioned that Bosisto hoped for an export of leeches to England where the european medicinal leech was becoming scarce. The Australian leeches were liberated in the Thames.

Goddard accepted that *H. quinquestriata* was a synonym of *australis* and that the leech belonged in *Limnobdella* Blanchard (1893). He describes *L. australis* as a leech not exceeding 76·0 mm. preserved ; smooth surfaced ; lacking any trace of sensory papillae ; genital pores separated by 5 annuli ; testes, 10 pairs ; the jaws with 48 to 50 long strong pointed teeth as a series diminishing in height and diameter. He records the leech as the commonest leech in New South Wales, abundant in freshwater creeks and moist places and extending into Victoria and Queensland. He states, it is a vigorous biter and of much annoyance in bush travel. (It may well be this remark which has resulted in some small confusion between this aquatic leech and the haemadipsine bush-leeches.)

He described the somital annulation ; but gives essentially the formula as in Parker and Haswell (1897) which was stated to be based " Partly after Whitman ". Goddard gives the impression that he is following the method of analysis established by Castle and Moore. He makes it quite clear that he did not distinguish cutaneous somital sensory organs. The formula he presents is : uni-annulate, i and ii ; 2-annulate, iii, iv, xxiv, xxv, xxvi ; 3-annulate, v, vi ; 4-annulate, vii ; 5-annulate, viii to xxiii (a total of 16 such).

Johansson (1911) gives an account of colour pattern variation in *H. australis* on specimens from Western Australia for the most part, and from the figures of other authors. In 1918, he described *Hirudo catenulata* from New Caledonia, a leech which he considered was intermediate between *Hirudo* and *Limnobdella,* so that *Limnobdella* was invalid. This proposal has not been followed by others. Caballero (1930) redescribed in detail the genotype, *L. mexicana,* and subsequently established a new genus *Pintobdella* for most of the species of *Limnobdella* other than *L. mexicana,* from which *L. australis* differs in such manner that at present it is more proper to consider this a doubtful generic position for our species. For example, in *L. mexicana* the teeth are relatively few, spaced, somewhat low conical with a complex base, strongly contrasting with the tall, seemingly cylindroid, numerous, crowded teeth of *australis* which form a continuous cutting edge. Dr. Caballero has kindly sent me specimens of *mexicana.* These differ strongly in general facies from *australis.*

Goddard reduced *Hirudo mauiana* Benham 1907, a New Zealand leech, to synonymy with " *L.*" *australis* as a possible distinct variety which I now regret I followed myself (1947). Benham figured a jaw in which the teeth are spaced, low conical, so unlike the teeth of the Australian leech as I have now seen them that the two can hardly be regarded as the same species. Also, Benham did not detect somital sense organs in living or freshly prepared specimens which he could not have overlooked had these been " *L.*" *australis.*

I found it most difficult to identify leeches before me as " *L.*" *australis.* All reasonably prepared striped leeches showed obvious somital cutaneous sense organs on all somites. Goddard stated that these were lacking. Ingram (1957) partly remodelled Goddard's analysis of somital annulation. She observed these only in the anterior part of the body. The annulation of the incomplete somites in my specimens differed strongly from the formula as given by Goddard and Ingram. It was not until I recognised that Goddard had not properly followed Castle and Moore in his analysis of these regions, that I could bring my specimens into agreement with his account.

Pope gives photographs (1963) and a general account of this leech (1965).

((There is a second and new species congeneric with *australis* in New South Wales. It is highly aggressive. An account of both species is in preparation.))

Family HAEMADIPSIDAE

Three-annulate to 7-annulate ; the body elongate conical to almost cylindroid in full extension when the posterior sucker equals or exceeds the diameter of the body ; eyes, 10, prominent, arranged as a marginal arch on the dorsal aspect of the anterior sucker, with the 4th and 5th eye separated more widely (2 annuli) than the spacing between the others ; somital sense organs in 6 rows above, 4 below, laterals absent ; lacking a median furrow on the lower surface of the upper lip ; nephridiopores lateral, the first anterior near to the 5th eye, the 17th beneath a flap-like " auricle " above the posterior sucker or combined into a common median pore on the ventral surface ; somites xxv to xxvii inclusive, uni-annulate. Terrestrial. Bush or forest leeches.

The two genera of Eastern Australia, *Philaemon* (4-annulate) and *Chtonobdella* (5-annulate) are two-jawed, lacking the median dorsal jaw. Blanchard (1917) describes two species of the 5-annulate, 3-jawed genus *Haemadipsa* from New Guinea but their generic status is uncertain since he does not refer to the number of jaws. These may be *Chtonobdella* which is known also in the New Hebrides (*C. parva* Moore 1944). The 6-annulate genus *Phytobdella* is known from two species in New Guinea, but not yet in Australia.

((Soos, 1967, provides a key and catalogue of the Haemadipsidae (*Act. Zool. Acad. Hungar.* 13 (3/4). He accepts Augener's recognition of *tristriata* as a species of *Chtonobdella.*))

Genus CHTONOBDELLA Grube 1866

Two-jawed, 5-annulate haemadipsids. The Australian species appear in the literature also as *Hirudo*, *Chthonobdella*, *Geobdella*, *Moquinia*, *Haemadipsa* and *Trocheta.*

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* Included in the collections of the National Museum of Victoria is a specimen of *Philaemon* named specifically and labelled " Type ", and a second haemadipsid labelled as " Type " of a new genus and species from Fife Bay, N.G. The evidence on the label indicates that the latter specimen may be part of the collection made by Mr. T. Steel, who provided the specimen from the Fife Bay district, which Goddard (1910a) described as *Geobdella striata* n. sp. which is at present of uncertain generic status. The generic name on the label indicates the leech resembles *Haemadipsa.* I have failed to find any published description of these " Types ". Caballero (1956) does not list the generic name.

1. CHTONOBDELLA AUSTRALIENSIS Lambert 1899

Described as *Geobdella* from specimens from Moss Vale, N.S.W. as : preserved, some 48·0 mm. long ; 95 annuli (including the 1st to 3rd pairs of eyes) of which 5 is the first complete annulus and 92, the last ; male pore at 29/30, female at 36/37. In alcohol, the anterior region to annulus 39, dull brown and posterior to this is bluish black ; a distinct white line on each side encloses the nephridiopores ; on each side of the mid-dorsal line in 85 and 86, a small white oval patch, another in 84 and in line with this a white line extending from 89 to 92 ; on either side of the mid-line, a diamond shaped area in 90 extending into 89 and 91 ; a triangular patch at the posterior end, the apex in the mid-dorsal line of 93 and the base in 95 ; annulation (after Whitman), i to iii without furrows ; uni-annulate, xxiii, xxiv, xxv, xxvi ; 3-annulate, iv, v, vi ; 5-annulate, vii to xxii inclusive.

This was not referred to in Blanchard (1917). Pinto (1923) lists the species as *Trocheta* since *Geobdella*, in which Lambert placed it, was a synonym. Otherwise, so far as I have seen, there is no reference until this was made a synonym of *C. limbata* by Moore (1944), an action following Blanchard's view that all 5-annulate bush-leeches from Eastern Australia belonged to the one species.

Blanchard (1917) did not record colour nor pattern. The prominent mid-dorsal stripe and the absence of patches on the posterior part of the body of *C. limbata* contrast with the pattern described by Lambert. In the various collections of bush-leeches sent me from the vicinity of Sydney, the majority of specimens conformed to *C. limbata* in colour and pattern, but from time to time there would be a single specimen differing from this and conforming to Miss Lambert's *australiensis*. Most recently, Mr. H. Battam of Cronulla has sent me a collection of 20 specimens conforming to *australiensis*, and with them one *Philaemon* and one *C. limbata* ; and from Dr. R. E. Barwick, 6 specimens from Clyde Mt., N.S.W. conforming to *australiensis*. I have kept the two kinds of *Chtonobdella* together for some weeks without change in their distinctive colour patterns. Those conforming to *australiensis* show 6½ to 7 annuli between the genital pores, 7½ annuli in one specimen.

In reviewing the several accounts, it became apparent especially in Blanchard that specimens from Queensland and northern New South Wales were recorded as having 7½ annuli between the genital pores, while those having a separation of 7 annuli were from the vicinity of Sydney. This suggested the possibility of northern and southern species of *Chtonobdella*, and that *C. australiensis* might be the southern species. I have not yet seen bush-leeches conforming to *australiensis* in the Northern Rivers Region.

At this time it seems most highly probable that *C. australiensis* may prove to be a valid species.

Miss Lambert's type is in the National Museum of Victoria.

2. CHTONOBDELLA LIMBATA Grube 1866

The original account of *Hirudo limbata* from near Sydney includes the suggestion of *Chtonobdella* as a new genus. It described an elongate terrestrial leech of 30·0 mm. by 4·0 mm.; 5-annulate, with obvious transverse rows of papillae and the dorsum granular on the posterior sucker ; 89 annuli ; the genital apertures at 24/25 and 31/32 ; bottle green in colour and losing the green colour in spirit. In 1867, Grube still referred to this as *Hirudo limbata*, a name continuing with some other authors (e.g. Vaillant (1890), who lists the range as India, Philippines, Japan, Chile, etc. a confusion arising from a misunderstanding of a general statement on the distribution of haemadipsids made by Whitman, 1886).

Grube (1868) is not available to me, but it would appear that here he re-describes material under the name of *Chtonobdella*, which is the basis of the account of *Haemadipsa limbata* in Brandes (1901) : length, 30·0 mm. to 50·0 mm., width

4·0 mm. to 10·0 mm.; posterior sucker, 10·0 mm.; 95 annuli ; male genital pore at 30, or 30/31, and female at 37/38, separated by 7 or 7½ annuli ; median dorsal jaw absent ; ventrolateral jaws with 67 sharp teeth ; dark bottle green in life.

Haswell had sent specimens to Whitman, who (1886) decided that in the absence of the median dorsal jaw and with a separation of the genital pores by 7½ annuli, these required a new genus and he proposed the name *Geobdella*, although he was aware that this was preoccupied and that Grube had suggested *Chthonobdella* (Whitman's spelling) earlier. Because of this, Blanchard in 1887 proposed the generic name of *Moquinia* for *limbata*, but in 1917 he reduced all three to synonymy under *Haemadipsa*. Pinto (1923) removed *limbata* and Miss Lambert's two species to *Trocheta*, considering this to be a systematic equivalent of *Geobdella*.

So far as I find, Blanchard (1917) gives the first new description of *limbata* under this name since Grube. It was based on 17 specimens, including two from the Novara collection at the Vienna Museum. The annulation follows Whitman. There is no reference to jaws, colour, or pattern. Specimens came from near Sydney, from the Upper Richmond River northern N.S.W., and three were from Queensland. From these, he recognised the species as having the male pore constantly at 29/30 and the female pore separated from it by 7 to 7½ annuli.

Moore (1944) gives a full detailed account of the external features of *C. limbata* based on a single specimen (British Museum) from " Dorringo, New South Wales, W. Herron esq ". (Correctly Dorrigo, where I have confirmed locally that Mr. Heron was well-known).

Moore gives the annulation as : uni-annulate, i, ii, iii, iv, xxv, xxvi, xxvii ; 2-annulate, v, and xxiv ; 3-annulate, vi (2-annulate ventrally), vii ; 4-annulate, viii and xxiii ; 5-annulate, ix to xxii inclusive ; genital pores, xi b_5/b_6 and xiii b_2 ; a prehensile papilla on the anterior margin of the posterior sucker ; a median dorsal clear yellow line, lateral to this thickly and irregularly mottled black, yellowish marginal stripes ; venter mottled black.

3. CHTONOBDELLA WHITMANI Lambert 1899

Described as *Geobdella* and based on a specimen from Woombye, Queensland and others from New South Wales. Up to 40·0 mm. long ; male pore at 29/30, female in annulus 37 so having a separation of 7½ annuli ; annulation is given following Whitman ; body, rusty brown, a more or less distinct light band edged by a dark line on the dorsum with patches of darker pigment on either side with a light band in each occasionally forming a continuous lateral light band along most of the length of the body, excepting the last sixth which is then mottled with dark patches.

The colour pattern is obviously based on preserved material and conforms to *C. limbata* so that Moore is correct in considering this to be a synonym of Grube's species. Pinto (1923) lists this as *Trocheta*.

The type is in the National Museum of Victoria.

Genus PHILAEMON Blanchard 1898

Two-jawed, 4-annulate haemadipsids. Eastern Australia, New Guinea, Java, Samoa, Juan Fernandez, Madagascar. It should be noted that jaws have not been reported on for specimens from Java, Samoa, and Madagascar.

4. PHILAEMON PUNGENS Blanchard 1898

Baldwin Spencer sent specimens to Blanchard who provided the above name which Miss Lambert credited to Blanchard and used with her description of the species published in 1898 based on specimens from Victoria and Tasmania : 25·0 mm. to 30·0 mm. long ; two jaws with some 70 fine teeth each ; the median dorsal jaw lacking ; 79 annuli (including i to iii not indicated other than by eyes) ; genital pores in 26 and 30, separated by 4 annuli ; (following Whitman) uniannulate, xxiii, xxiv, xxv, xxvi, 3-annulate iv, v, vi, 4-annulate vii to xxii inclusive ; 12 equidistant prominent papillae. Colour, a narrow light brown median longitudinal band with pale green longitudinal stripes on each side broken by the paramedian papillae into patches outlined by dark brown, the remainder of the dorsum dark, the venter uniform light brown.

Miss Lambert's description was a major contribution to the morphology of the haemadipsine leeches. Blanchard (1917) adds nothing to this and recognises the species in material from Java. He places the genital pores at 26/27 and 29/30 in his figure, a separation of only 3 annuli, but describes their position as at the rear of 26 and of 30 in his text, and notes variation in the position of the female pore in 30. Some of his specimens were from the Upper Richmond River, Northern New South Wales. My own material from this area conforms to Lambert's account.

The type is in the National Museum of Victoria. Ingram (1957) detected differences in detail between Tasmanian and Mainland specimens. She described the cocoon as somewhat spherical, 7·0 mm. in diameter, pale yellow, an inner entire capsule with one perforation for eclosion, an outer honeycombed capsule of irregular hexagonal units. Thirteen leeches hatched over the period January 20 to March 4 at a length of 5·0 mm. The colour pattern established at 6·0 mm. and at 8·0 mm. the first blood meal was taken from a frog.

5. PHILAEMON GRANDIS Ingram 1957

From Western Tasmania and elsewhere in Tasmania ; up to 36·0 mm. long by 6·0 mm. wide ; area behind and between eyes 1 to 4 broken into an irregular pavement (rather transversely regular in *pungens*) ; 80 annuli ; uni-annulate i, ii, iii, iv, xxiv, xxv, xxvi, xxvii, 2-annulate v, 3-annulate vi and vii, 4-annulate viii to xxiii inclusive ; genital pores in 27 and 31 ; testes, 10 pairs ; jaws with 50 denticles. Colour : median longitudinal brown stripe paralleled on either side by segmental bright yellow patches fusing into irregular lines in the mid-region of the body ; the rest of the dorsum with brown bands ; a lateral marginal yellow stripe ; the venter uniform light brown.

The characters indicate a distinctive species.

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References

BADHAM, C., 1916.—On an ichthyobdellid parasitic on the Australian sand-whiting (*Sillago ciliata*). *Quart. Journ. micr. Sci.* (N.S.), 62 : 1-41.

BAIRD, W., 1869.—Descriptions of some suctorial annelides in the collections of the British Museum. *Proc. zool. Soc. Lond.* 1869 : 310-318.

Becker, L., 1859.—Art. iv. A few notes on two kinds of Australian leeches. *Trans. phil. Inst. Victoria,* 3 : 36-38.

Benham, W., 1903.—Art. xxi. On a new species of leech (*Hirudo antipodum*) recently discovered in New Zealand. *Trans. N.Z. Inst.* 36 : 185-192.

————, 1907.—Art. xvi. Two new species of leech in New Zealand. *Trans. N.Z. Inst.,* 39 (1906) : 181-193.

Best, Effie W., 1931.—The anatomy of an Australian leech, *Helobdella bancrofti*. *Trans. Proc. roy. Soc. S. Australia,* 55 : 23-31.

Blanchard, R., 1893.—Revision de hirudinees du Museu de Turin. *Boll. Mus. Zool. Anat. Comp. Univ. Torino,* N. 145. 8 : 1-32.

————, 1917.—Monographie des haemadipsines (sangsues terrestres). *Bull. Soc. Path. Exot.,* 10 (7) : 640-675.

Bosisto, Jos., 1859.—Art 3. On the *Hirudo australis*. *Trans. phil. Inst. Victoria,* 3 : 18-22.

Brandes, Gustav, 1901.—Leuckart, " Die parasiten des menschen und die von inhnen herruhreneden krankheiten." Hirudineen : 535-897. Leipzig. 1886-1901.

Caballero y C., Ed., 1930.—Contribucion al conocimiento de los hirudineos de Mexico. *Limnobdella mexicana* R. Blanchard. *Ann. Instit. Biol. Mexico,* 1 : 247-251.

————, 1956.—Hirudineos de Mexico. 20. Taxa y nomenclature de la Clase Hirudinea hasta generos. *Ibid.* 27 (1) : 279-302.

Castle, W. E., 1900.—No. 108. The metamerism of the Hirudinea. *Proc. Am. Acad. Arts & Sci.* 35 (15) : 285-303.

Goddard, E. J., 1908.—Contribution to our knowledge of Australian Hirudinea. Pt. i. Proc. Linn. Soc. N.S.W. 33 (2) : 320-342.

————, 1909a.—Pt. ii. *Ibid.* 33 (4) : 854-866.

————, 1909b.—Pt. iii. *Ibid.* 34 (3) : 467-486.

————, 1910a.—Pt. iv. *Ibid.* 34 (4) : 721-732.

————, 1910b.—Pt. v. Leech metamerism. *Ibid.* 35 (1) : 51-68.

————, 1910c.—Pt. vi. The distribution of the Hirudinea with special reference to Australian forms and remarks on their affinities, together with reflections on Zoogeography. *Ibid.* 35 (1) : 69-76.

Grube, ed., 1866.—Beschreibungen neuer von der Novara-Expedition mitgebrachter anneliden und neuen landplanarie. *Verh. Zool.-Bot. Ges. Wien.,* 16 : 173-184.

————, 1867.—Uber landblutegel. *Jahrb. Schles. Gesell. vaterl. cultur.,* 44 : 59-60.

*————, 1868.—Reise der osterreichischen fregatte Novara. Zool. T.2, Anneliden. Wien. 1-64.

————, 1871.—Beschreibungen einiger egel-arten. *Arch. Naturg.,* 37 : 87-121.

Hickman, V. V., 1942.—A new ichthyobdellid leech and its egg-capsules. *Pap. Proc. roy. Soc. Tasmania,* (1941) : 41-44.

Ingram, D. M., 1957.—Some Tasmanian Hirudinea. *Pap. Proc. roy. Soc. Tasmania,* 91 : 191-232.

Johansson, L., 1911.—Hirudinea. " Die fauna Sudwest-Australiens." Michaelsen and Hartmeyer, Bd. iii (12) : 409-431.

————, 1918.—Hirudineen von Neu-Caledonien und die Neuen-Hebriden. Sarasin and Roux. Zool. 2 : 373-396.

Knight-Jones, E. W., 1962.—Appendix B. The systematics of marine leeches : 169-186. In " K. H. Mann. Leeches (Hirudinea) " q.v.

Lambert, Ada M., 1898.—Art. 11. The structure of an Australian land leech. *Proc. roy. Soc. Victoria* n.s., 10 : 211-235.

————, 1899.—Art. 21. Description of two new species of Australian land leeches, with notes on their anatomy. *Ibid.* n.s. 11 : 156-163.

Leigh-Sharpe, W. H., 1916.—A new species of leech from South Australia. *Trans. Proc. roy. Soc. S. Australia,* 40 : 42-55.

McCarthy, P. H., 1962.—Infestation of the bovine udder and teat-canal by leeches. *Aust. vet. Journ.,* 38 : 355-356.

MacDonald, J. D., 1877.—11. A new genus of Trematoda and some new or little known parasitic Hirudinei. *Trans. Linn. Soc. Zool.,* (Ser. 2) 1 : 209-212.

Mann, K. H., 1953.—The segmentation of leeches. *Biol. Rev.,* 28 : 1-15.

————, 1962.—Leeches (Hirudinea). " Intl. Ser. Monogr. Pure Appl. Biol. Zool.", 11 : 1-201. Pergamon Press. Oxford.

Moore, J. P., 1900.—A description of *Microbdella biannulata* with special regard to the constitution of the leech somite. *Proc. Acad. nat. Sci. Phila.,* 5 : 50-73.

————, 1935.—A description of *Aetheobdella hirudoides*, gen. et spec. n. from New South Wales with notes on leeches collected by the Oxford University Sarawak expedition. *Ann. Mag. nat. Hist.,* Ser. 10, 16 : 296-304.

————, 1938.—Hirudinea. Australasian Antarct. Exped. 1911-1914. *Sci Rept.* C, 10 (3) : 5-15.

————, 1944.—Leeches in the British Museum, mostly Haemadipsinae from the South Pacific with descriptions of new species. *Ann. Mag. nat. Hist.,* Ser. 11, 11 : 383-409.

————, 1957.—Hirudinea. B.A.N.Z. Antarct. Exped. Ser. B, 6 (6) : 99-106.

Moquin-Tandon, A., 1846.—" Monographie de la famille Hirudinees." Ed. 2 : 1-448, and Atlas. Bailliere. Paris.

Parker, T. J., and Haswell, W. A., 1897.—" A text book of Zoology." (Hirudinea i : 465-481). Macmillan. London.

Pinto, C., 1923.—Ensaio monographico dos Hirudineas. *Rev. Museu Paulista*, 13 : 5-266.

Pope, E. C., 1963.—Photographs of *Limnobdella australis*. *Aust. nat. Hist.*, 14 (6) : 179.

————, 1965.—Australian leeches. *Ibid.*, 15 (1) : 6-11.

————, 1966.—Leech egg-capsules. *Ibid.*, 15 (5) : 165.

Richardson, L. R., 1947.—A review of New Zealand leeches. *N.Z. Sci. Congr.*, 1947 : 201-202.

Schmarda, L. K., 1861.—Neue wirbellose thiere beobachtet und gesammelt auf einer reise um die erde 1853-1857. Bd. Turbellarien, Rotatorien und Anneliden. T.2. (Hirudinea : 2-7) Leipzig.

Seddon, H. R., 1950.—Diseases of domestic animals in Australia. *Comm. Dept. Hlth. Serv. Publ.* No. 5 : 1-223.

Soos, A., 1965.—Identification key to the leech (Hirudinoidea) genera of the world with a catalogue of species. i. Family Piscicolidae. *Act. Zool. Acad. Sci. Hungar.*, 11 (3-4) : 417-463.

————, 1966.—*Ibid.* 2. Families Semiscolecidae, Trematobdellidae, Americobdellidae, Diestecostomatidae. *Ibid.* 12 (1, 2) : 145-160.

————, 1966.—*Ibid.* 3. Family Erpobdellidae. *Ibid* 12 (3, 4) : 371-407.

————, 1966. On the genus *Glossiphonia* Johnson 1816, with a key and catalogue to the species (Hirudinoidea, Glossiphonidae). *Ann. Hist. Nat. Hungar. Zool.*, 58 : 271-279.

Vaillant, L., 1890.—" Histoire naturelle des annelees marins et d'eau douce." 3 (2). Hirudiniens : 477-542. Roret, Paris.

Whitman, C. O., 1886.—The leeches of Japan. *Quart. Journ. micr. Sci.*, n.s., 26 : 317-416.

(* indicates paper not seen)

NOTES ON TWO NEW HETEROMORPHIC DEUTONYMPHS (HYPOPI) (ACARINA : SARCOPTIFORMES)

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(*Communicated by Mr. R. Domrow*)

[Read 25th October, 1967]

Synopsis

Two new hypopi are described : *Anoetostoma domrowi*, n. sp., from a small fly, *Scoliophthalmus* sp., from New Guinea, and *Marsupiopus trichosuri*, n. g., n. sp., from a marsupial, *Trichosurus vulpecula*, from the Australian Capital Territory.

The two new heteromorphic nymphs (hypopi) described below were kindly sent to me by Mr. R. Domrow, Queensland Institute of Medical Research, Brisbane.

They belong to two different families of Acaridiae. One, from a fly, is a new species of Anoetidae, but the second, from a marsupial, is more difficult to classify because of its very aberrant characters. It represents a new genus and species. Further, as it is not possible to place it in any known group of hypopi, I propose a new subfamily within the Glycyphagidae for its inception.

The holotype of each of these two new species is in the Australian National Insect Collection, C.S.I.R.O., Canberra, with paratypes in the Queensland Museum, Brisbane, the South Australian Museum, Adelaide, and the collection of the author.

Family Anoetidae

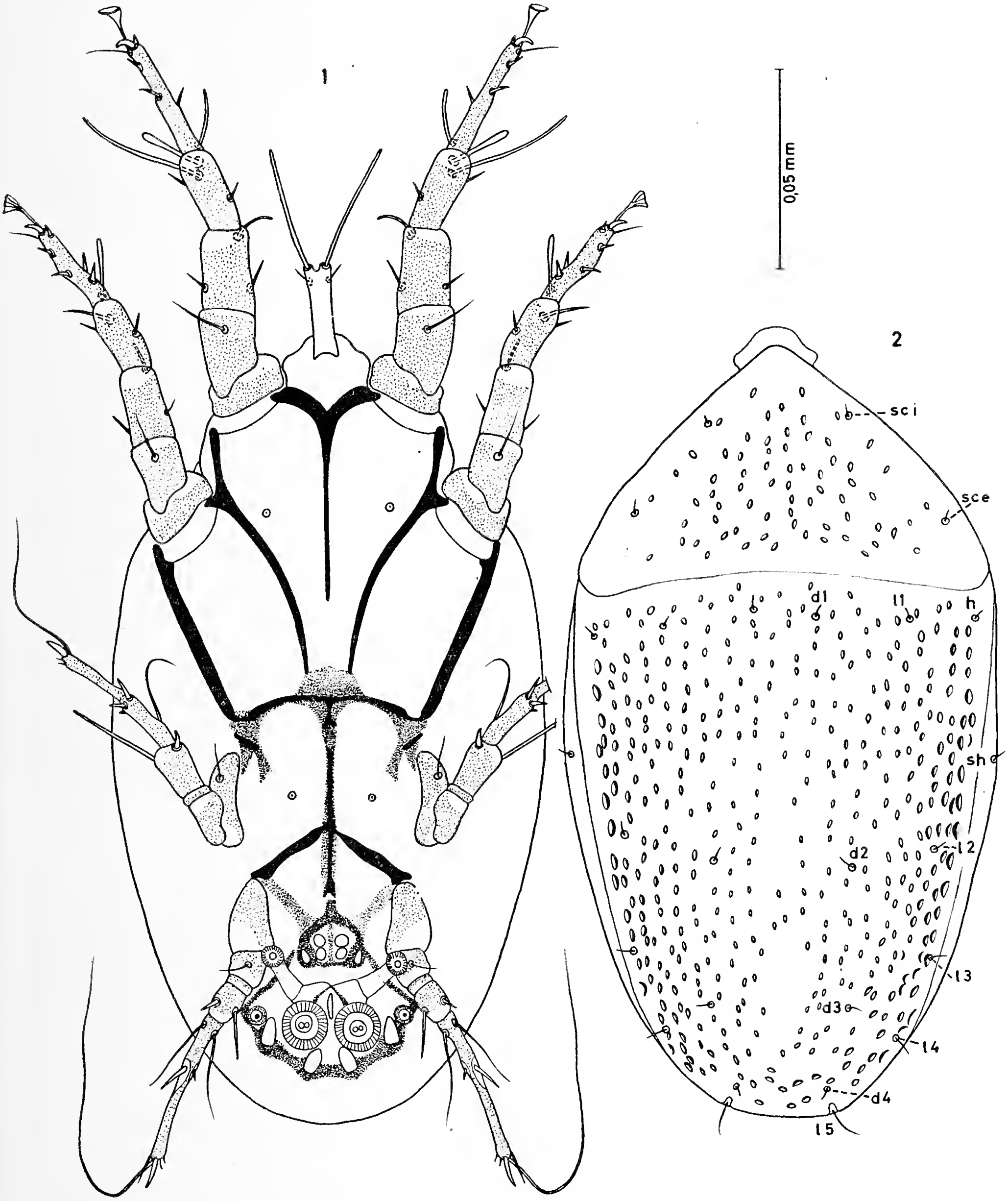
Genus Anoetostoma Womersley

Anoetostoma domrowi, n. sp.

This species does not fit exactly into any described anoetid genus, but it is assigned provisionally to *Anoetostoma*. It resembles *A. oudemansi* Womersley, the only known species (Scheucher, 1957 ; Hughes and Jackson, 1958), in having coxae I and III without setae or discs (small circles, representing vestigial setae, are, however, present) ; rather long legs ; all tarsi ending in a claw ; tarsi III and IV with a long, simple, subapical seta ; a small disc on each side of the vulva ; and the cuticle of the dorsum coarsely granular. However, it differs from that species in many characters : body more elongate ; well-developed sejugal furrow present ; dorsal cuticle with pits elongate and fewer in number ; ten discs on suctorial plate ; legs III and IV equal ; sternum and epimera II much longer ; and epimerites II fused posteriorly with epimera III.

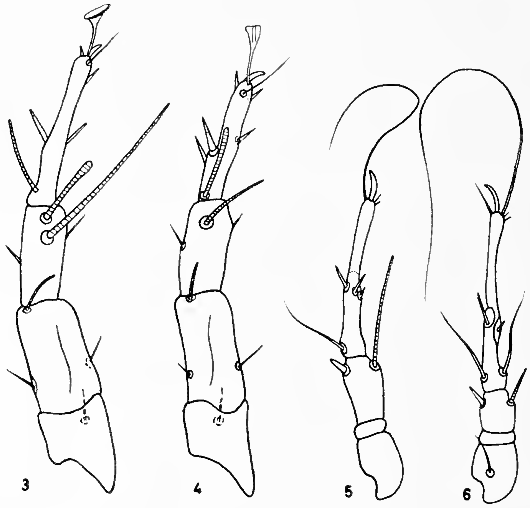
This species is named after Mr. Domrow, who kindly sent me this interesting material.

Deutonymph (holotype) (Figs. 1-6) : Idiosoma 180μ long, 96μ wide, and four paratypes 174 × 98μ, 177 × 93μ, 181 × 96μ, 186 × 96μ. Dorsum with well-formed sejugal furrow. Dorsal cuticle with numerous small pits, all longer than wide. Gnathosoma 22μ long, 4-5μ wide. Sternum 42μ long. Epimera II almost reaching epimeral bridge formed by fusion of epimera III. Suctorial plate with five pairs of discs; anterior pair with very faint radial striations, borne on elongated bases which may be protruded some distance; median pair much larger, also with radial striation; two pairs set posterolaterally, more or less conical, and without striation; remaining (exteriormost) pair obsolescent. Vulva with two pairs of genital suckers, flanked on each side by small, more or less conical, non-striate disc.



Figs 1-2. *Anoetostoma domrowi*, n. sp. Heteromorphic deutonymph. Ventral and dorsal views, respectively.

Chaetotaxy : Dorsal setae thin and very short (mostly 4-5μ long), comprising *sc i*, *sc e*, *h*, *sh*, *d 1* to *d 4*, *l 1* to *l 5*, of which *l 5* reach 10μ. I could not see *d 5*, and *sh* is ventrolateral. Gnathosoma with one pair of long solenidia (34μ) and one pair of short setae. Tarsi I and II each with leaf-like terminal seta, that on tarsus I somewhat sucker-like. Number of setae on tarsi I to IV (excluding solenidia) 6-7-7-8 ; tibiae 2-2-1-1 ; genua 2-2-0-0 ; femora 1-1-0-1 ; trochanters 0-0-1-0. *Solenidiotaxy* : Tarsi I and II each with one basal solenidion. Tibia I with two distal solenidia (one club-shaped, one strongly attenuated apically) ; tibia II with one well-developed, distal solenidion ; tibia III with long, distal solenidion (25μ) ; tibia IV with shorter solenidion. Genua I and II with one solenidion.



Figs 3-6. *Anoetostoma domrowi*, n. sp. Heteromorphic deutonymph. Legs I, II, III, and IV, respectively (tarsi-femora only).

Host and locality : All the specimens were attached around the base of the abdomen of a small fly, *Scoliophthalmus* near *micans* Lamb., Butemu Village, Finisterre Range (4200′), Madang Central District, New Guinea, x. 1964, R. Pullen. The fly was identified by Dr. B. H. Cogan, British Museum (Natural History), and the mites noted by Dr. D. H. Colless, C.S.I.R.O., Canberra.

Family GLYCYPHAGIDAE

Subfamily MARSUPIOPINAE, n. subf.

Definition (based only on heteromorphic deutonymph) : Sucker-like organs on opisthosoma considerably reduced, with suctorial plate lacking and only two very small sucker-like discs (one on each side of genital slit). Genital suckers well-developed. Gnathosoma short, wide, and divided into two rounded lobes ; with two pairs of setae and one pair of solenidia. Cuticle finely and uniformly punctate in mature specimens. Sejugal furrow poorly developed or absent. Legs I and II well developed, ending in strong claw mounted on rather long pretarsus. Legs III and IV directed forwards, short, but rather thick ; without claws. Tarsi III and IV with several short, strong spines, and two long, subterminal hairs. Trochanters III and IV each with very strong, forwardly directed ventral process, which probably serves to retain mite in hair-follicle, which seems to be its normal biotope. Posterior trochanters extended internally by large sclerites. Epimera I and II normally developed. Epimera III and IV poorly sclerotized. Anus absent.

Chaetotaxy : *v i*, *v e*, *s cx*, *sc i*, *sc e*, *h*, *sh*, *d 1* to *d 4*, *l 1* to *l 5*, *cx I*, *g a* (very short and thin) and *g m* present. Setae *g p* and *d 5* absent. Setae *cx III* represented by small sclerotized circles. Tarsi 8-9-8-8 ; tibiae 2-2-1-1 ; genua 2-2-1-0 ; femora 1-1-0-0 ; trochanters 1-1-1-0. *Solenidia* : Tarsi 2-1-0-0 ; tibiae 1-1-1-1 ; genua 1-1-0-0.

Type genus : *Marsupiopus*, n. g.

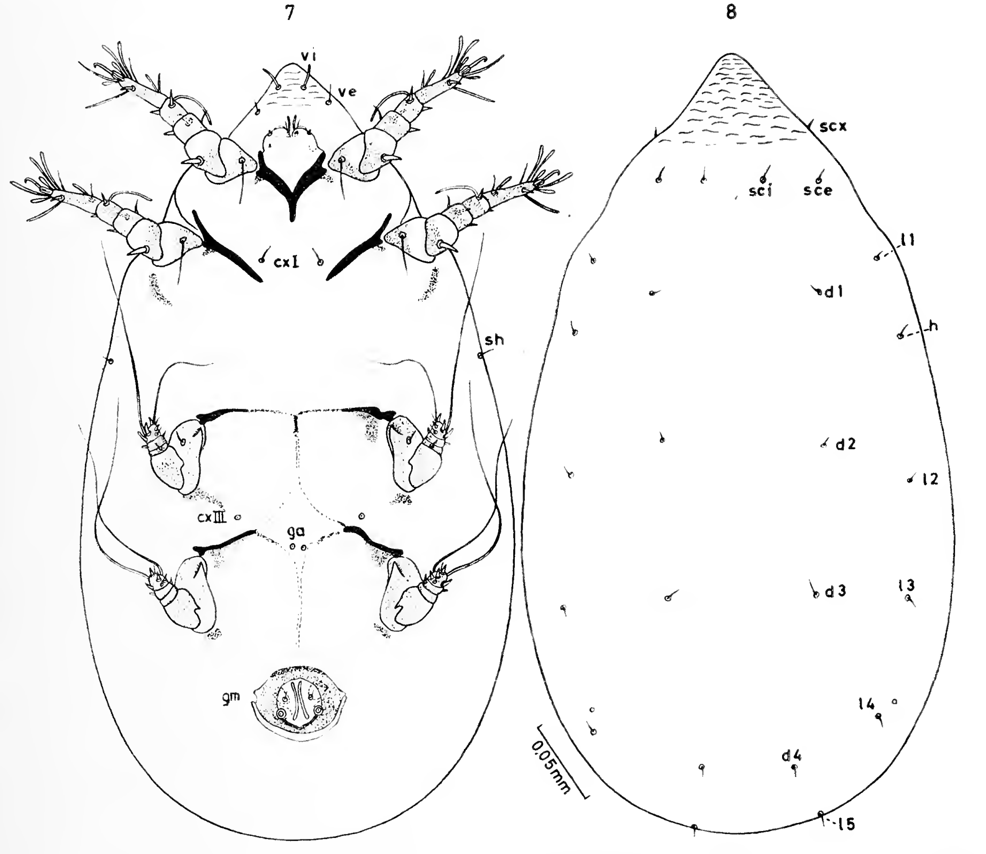
Genus MARSUPIOPUS, n. g.

Definition : As for the subfamily.

Type species : *Marsupiopus trichosuri*, n. sp.

MARSUPIOPUS TRICHOSURI, n. sp.

Deutonymph (holotype) (Figs. 7-12) : Idiosoma 430μ long, 240μ wide, and three paratypes 400 × 220μ, 395 × 210μ, 340 × 190μ. Body ovoid, with anterior extremity conical and more or less snout-like. Cuticle, in mature specimens, finely punctate except on anterior " snout " area, and laterally and ventrally behind genital region. Epimera I fused into short sternum. Epimera II and IV free. Epimera III thin, poorly sclerotized and united in midline. Genital area surrounded by sclerotized, punctate ring, which is heavier along its anterior margin.



Figs 7-8. *Marsupiopus trichosuri*, n. sp. Heteromorphic deutonymph. Ventral and dorsal views, respectively.

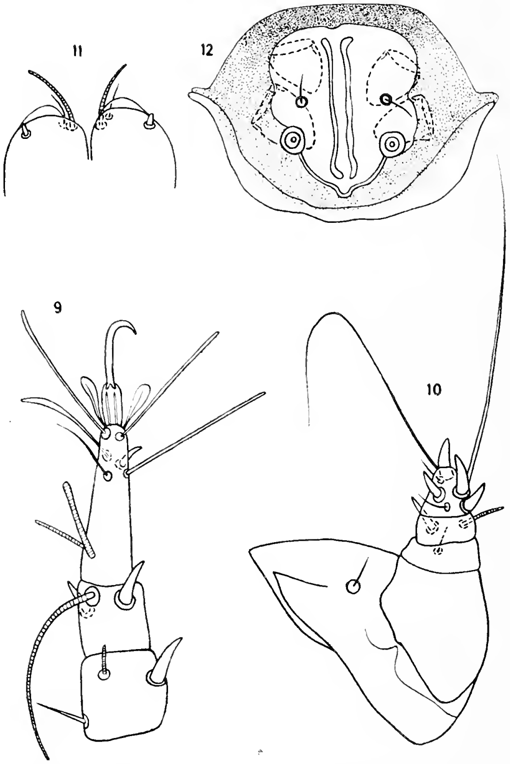
Chaetotaxy of legs consisting mainly of strong, but short spines (modified setae) except on anterior tarsi, which bear only one spine.

Other characters as defined above in subfamilial definition.

Host and locality : In the hair follicles of an adult brush-tailed possum, *Trichosurus vulpecula* (Kerr) (Phalangeridae), Weetangera Road, Australian

Capital Territory, 28. x. 1958, A. L. Dyce. The mange resulting from this infestation was rare in the A.C.T., and was not noted at all in one population studied. It was limited to the tail, except for a small patch on each ear, and was quite conspicuous by spotlight at night.

Remarks : The pilicolous habit of some hypopi was first noted by Fain (1965, 1967), who raised the genus *Rodentopus* for two species from rodents. These hypopi are characterized by the complete absence of suckers on the opisthosoma and the curious modification of the posterior legs. The fixation organs on these latter consists mainly of modified setae, which aid in attachment to the fur.



Figs 9-12. *Marsupiopus trichosuri*, n. sp. Heteromorphic deutonymph. 9, Leg I in dorsal view ; 10, Leg III in ventral view ; 11, Gnathosoma ; 12, Genital area.

The new hypopus described above (*Marsupiopus*) thus resembles that of *Rodentopus* both in biological and in morphological characters. Both live in the hair follicles, although in rather different hosts (a rodent *versus* a marsupial), and both show a drastic reduction of the opisthosomal suckers and a modification of the posterior legs. But in spite of these resemblances, which may perhaps be explained by convergence, I think these hypopi belong to two different groups. The structure of the posterior legs, of the gnathosoma and of the ventral genital plate differ basically in these two species, and justify their separation into different sub-families.

References

Fain, A., 1965.—Un nouveau type d'hypope, parasite cuticole de rongeurs africains (Acari : Sarcoptiformes). *Zeitschr. f. Parasitenk.*, 26 : 82-90.

Fain, A., 1967.—Les hypopes des Glycyphagidae nidicoles en Afrique au sud du Sahara (Acarina : Sarcoptiformes). *Ann. Mus. roy. Afr. cent., Tervuren*, 157 : 1-89.

Hughes, R. D., and Jackson, C. G., 1958.—A review of the Anoetidae (Acari). *Virginia J. Sci.* (N.S.), 9 : 1-198.

Scheucher, R., 1957.—Systematik und Oekologie der deutschen Anoetinen. In H.-J. Stammer, ed., 1957-9, "Beiträge zur Systematik und Oekologie mitteleuropäischer Acarina". (Akademische Verlagsgesellschaft Geest & Portig K.-G., Leipzig). Vol. I, pp. 233-384.

A NEW SPECIES OF *METAPENAEOPSIS* (CRUSTACEA-DECAPODA) FROM NORTHERN AUSTRALIAN WATERS

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(Plates XII–XIII)

[Read 25th October, 1967]

Synopsis

A new penaeid prawn from shallow waters of the continental shelf of Western Australia and the Gulf of Carpentaria is described. A number of unusual morphological features, in particular its aberrant petasma and thelycum, are of interest.

INTRODUCTION

The new species here described was first detected in a comprehensive series of penaeid prawns recently collected by Mr. Vernon Wells in the Exmouth Gulf area, Western Australia, and sent to the author for a routine examination. Just after the draft of its description was completed, the author received 2 additional specimens from the Gulf of Capentaria, Queensland, through the kindness of Mr. Donald Tuma, C.S.I.R.O., Division of Fisheries and Oceanography. Considering the increasing prawn trawling activities in both these regions during the past 10 years, and the voluminous material collected there for the most recent and extensive taxonomic revision (Racek and Dall, 1965), the discovery of a new penaeid species in rather shallow waters certainly is surprising. The new species of *Metapenaeopsis* has been named after Mr. Wells in recognition of his unflagging cooperation on many occasions. For the nomenclature of the various morphological criteria the reader is referred to Kubo (1949), Dall (1957) and Racek and Dall (1965).

TAXONOMY

METAPENAEOPSIS WELLSI, sp. n.

(Plate XII; Plate XIII, Figs. 1-3)

Material—Exmouth Gulf, Western Australia, 7-10 fm, mud, 9. August 1967, coll. Vernon Wells; *holotype* female 110 mm, carapace 30 mm; *allotype* male 103 mm, carapace 25 mm; *paratype* female 109 mm, carapace 29 mm.

Gulf of Carpentaria, Queensland, C.S.I.R.O. Grid 6800, 18, April 1966, coll. D. J. Tuma; male, 111 mm (approximate, rostrum broken), carapace 28 mm; female, 97 mm (approximate, rostral tip broken), carapace 26 mm.

Description—Rostrum short, almost straight, upper margin slightly convex, moderately wide at base, tapering to a sharp and somewhat upturned tip; reaching to anterior margin of basal antennular segment; armed dorsally with 5-7 teeth plus epigastric; penultimate tooth in level with frontal margin of carapace. Postrostral carina of females feebly developed for a very short distance behind epigastric tooth, altogether absent in males.

Carapace entirely covered with short tomentum except along pleural carinae, setae in sulci longer and dense; orbital spine minute though well-defined; orbito-antennal sulcus shallow and obscured by dense tomentum; hepatic spine moderately large, cervical and hepatic sulci distinct in spite of tomentum ; antennal spine well-developed, almost reaching cornea, carina ill-defined ; pterygostomial spine large and sharp. Branchiocardiac carina conspicuous and arcuate, ascending in anterior half, bending sharply ventrad at posterior 9/10 of branchiostegite, parallel to posterior margin of carapace. Between the branchiocardiac and pterygostomial carinae another glabrous ridge, extending from level of hepatic spine posteriorly to 8/10 of carapace. Stridulating ridges on branchiostegite absent.

Antennular flagella subequal, length of lower 9/10 of peduncle, slightly more than 1/2 carapace in both sexes ; lower flagella sexually dimorphic, with a dorsal bulbous swelling on proximal 1/3 length in male (see Plate i), of normal conical shape in female. Prosartema not quite reaching as far as eye, stylocerite reaching to tip of basal antennular segment. Distomedian spine of basal segment vestigial, distolateral spine long, slender, inclined slightly upwards.

Third maxillipeds reaching to middle of 2nd antennular segment; 1st pereopod reaching to, or slightly exceeding base of carpocerite, 2nd exceeding carpocerite by dactyl or entire propodus; 3rd not quite reaching to tip of basal antennular segment, 4th reaching as far as carpocerite, 5th exceeding it by dactyl. Ischial spine of 1st pereopods prominent.

Abdomen sculptured with extensive setose patches ; 2nd abdominal somite with a short dorsal carina in posterior half ; 3rd to 6th somites with a strong carina, that of the 3rd without a trace of a sulcus, the carina of the 6th ending in a small acute tooth. Length of 6th somite 1·3 that of 5th. Telson slightly shorter than inner uropods, armed with 3 pairs of mobile and 1 pair of fixed lateral spines ; 1st mobile spines 1/2 length of that of the posterior 2 pairs, the fixed spines the smallest of the series.

The petasma is shown on Plate ii, Figs 1 and 2. Right distoventral projection larger than left, broadly leaf-like, widest in distal 1/3, distally carrying 1–3 blunt tubercles ; distoventral flap large ; left distoventral projection flattish and dorsoventrally curved, distally carrying a triangular inward-bent projection with a series of very small spines. Inner and outer intermediate strips fused in form of a rounded and strongly calcified plate with a distal broad tooth ; distomedian lobule, covered by the " dust-cap " of right distoventral projection, with a sinuous and distinctly crenulated apical plate. Appendix masculina typical for the genus, one-segmented with a small soft process just inside of distal part of rim

The thelycum is shown on Plate ii, Fig 3. Sternum of female 2nd pereopods with 2 long spinous processes arising from a broad base, that of the 3rd with 2 rather closely set blunt tubercles. Thelycal plate subrectangular with a large acicular spine at centre of anterior margin, and with evenly rounded anterolateral corners ; arising from the posterior border of this plate a pair of parallel blunt ridges anteriorly converging to base of acicular spine. Intermediate plate strongly concave, semitubular, with raised blunt lateral ridges of sigmoid appearance ; posteriorly this plate is confluent with the anterior sternal plate which consists of a slightly curved transverse bar and laterally of a pair of strongly calcified projections ; the lateral parts of the transverse bar bent anteriorad and abutting lateral borders of intermediate plate ; the calcified projections kidney-shaped, inserted at about 45° to longitudinal axis of sternites, forming anteriorly and posteriorly a pair of broad and blunt teeth.

Colour in life—Not yet reliably assessed, freshly preserved specimens (in formalin) pinkish, without apparent mottlings, pereopods orange, posterior half of uropods maroon.

Location of types—In the Australian Museum Collection ; *holotype* Reg. No. P 15518, *allotype* P 15519, *paratype* P 15520.

DISCUSSION

In view of the comparatively limited material available, the intrageneric relationship of *M. wellsi* cannot as yet be fully assessed. While the stridulating species of *Metapenaeopsis*, as well as those with a long 6th abdominal somite, more or less form homogenous groups, the interrelationship of the remaining species is difficult to demonstrate. From most Indo-West Pacific congeners *M. wellsi* differs by having its right petasmal lobe longer than the left, a condition found only in *M. borradailei* (de Man), *M. sibogae* (de Man), and to a certain extent in *M. sinuosa* Dall. However, the petasma of *M. wellsi* is structurally quite different from and fully incomparable with that of any of these three species. In general form its thelycal plate is comparable with that of *M. borradailei*, *M. lamellata* (de Haan) and *M. insona* Racek and Dall, but the remaining thelycal structures are not shared by any other species of the genus.

In size, development of the branchiocardiac carina, and length as well as sexual dimorphism of the antennular flagella, *M. wellsi* on the other hand possesses some features found only in the *M. coniger* group of species; however, it does not share a number of other decisive criteria of that group: its 6th abdominal somite is comparatively short, its thelycum and petasma is strikingly different, there is no distomedian spine on the basal antennular segment, and its optimal habitat seems to be the shallow regions of the continental shelf.

The sudden appearance of *M. wellsi* in two distant and intensively trawled areas of Australia's northwest and north is difficult to explain. Its optimal habitat could well be the deeper parts of the shelf, from where trawling records remain extremely scarce. On the other hand it is possible that it normally occurs on " hard " bottoms which are difficult to trawl. It would seem that this latter assumption is supported by the fact that the trawl containing the two specimens from the Gulf of Carpentaria consisted of several baskets of dead mollusc shells covered with bryozoa.

References

DALL, W., 1957.—A revision of the Australian species of Penaeinae (Crustacea Decapoda: Penaeidae). *Aust. J. mar. freshw. Res.* 8 (2): 136-231.

KUBO, I., 1949.—Studies on the penaeids of Japanese and its adjacent waters. *J. Tokyo Coll. Fish.* 36 (1): 1-467.

RACEK, A. A., and DALL, W., 1965.—Littoral Penaeinae (Crustacea Decapoda) from Northern Australia, New Guinea and adjacent waters. *Verhand. koninkl. Nederlandse Akad. Wetensch.* 56 (3): 1-116.

EXPLANATION OF PLATES XII–XIII

Plate xii. *Metapenaeopsis wellsi*, allotype, male 103 mm.

Plate xiii. Fig. 1. *M. wellsi*, petasma, ventral view. Fig. 2. *M. wellsi*, petasma, dorsal view. Fig. 3. *M. wellsi*, thelycum and genital sterna.

MORDACIA PRAECOX, N. SP., A NONPARASITIC LAMPREY (PETROMYZONIDAE), FROM NEW SOUTH WALES, AUSTRALIA

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(*Communicated by Professor A. K. O'Gower*)

(Plate xiv)

[Read 25th October, 1967]

Synopsis

The adult of a new species of lamprey, *Mordacia praecox*, from the Moruya and Tuross rivers in southern New South Wales, is described. This species differs from the only other Australian species of *Mordacia*, *M. mordax* (Richardson), by being nonparasitic and having its life cycle entirely restricted to fresh water. It can be distinguished from the recently metamorphosed forms, or macrophthalmia, of *M. mordax* by its colour and dentition, and from the adults of this species by a difference in size.

Introduction

There are two genera of lampreys found in Australia, *Geotria* and *Mordacia*. *Geotria* is represented by the single species, *Geotria australis* Gray, 1851, which is found in Western Australia, South Australia, Victoria and Tasmania (Potter and Strahan, in preparation). *Mordacia mordax* (Richardson, 1846), the type species for *Mordacia* Gray, 1851, has until now been the only known Australian species of this genus. Although anadromous like *G. australis*, it is not as widely distributed, being found only in south-eastern Australia and Tasmania. The ammocoetes of both species metamorphose in the rivers and then feed parasitically at sea before returning to fresh water to breed.

Recently, however, a nonparasitic lamprey has been discovered in the Moruya and Tuross Rivers in southern New South Wales, where *M. mordax* is also found. This is the first example from the Southern Hemisphere of a lamprey with a life cycle entirely restricted to fresh water and lacking a parasitic phase. The adults can be distinguished from those of *M. mordax* by the great difference in length. It is also possible to separate, at any one time, the recently metamorphosed ammocoetes, or macrophthalmia, because metamorphosis of the two species occurs at entirely different times of the year (Potter, in preparation). The ammocoetes of the two species appear indistinguishable and there is no indication that they are found in different regions of the rivers, since at metamorphosis both species are found at all sites studied. The name *Mordacia praecox*, n. sp. is proposed because of the precocious nature of sexual development.

The macrophthalmia of *M. praecox* is very similar to that of *M. mordax* (fig. 1), which has been described by Strahan (1960). The description will therefore only apply to the adults of *M. praecox*, which are obviously different, and which show a marked sexual dimorphism.

Material

As only a few adults of *M. praecox* were caught, macrophthalmia were kept in the laboratory until they reached sexual maturity. Since no differences have been found between the measurements and morphology of these adults and those from the field, both have been used for the description. All measurements and counts were made on animals caught between the middle of April and end of July in the years 1965-67.

METHODS

Length Measurements. Length measurements were made on the left side of live animals, after they had been anaesthetised in M.S.-222 (Sandoz), and are expressed as a percentage of the total length in the style of Vladykov (1955).

Total Length (T.L.): distance from the most anterior tip of the disc to the end of the caudal fin.

Disc Length (d): distance from the tip of the snout to the posterior edge of the disc when closed.

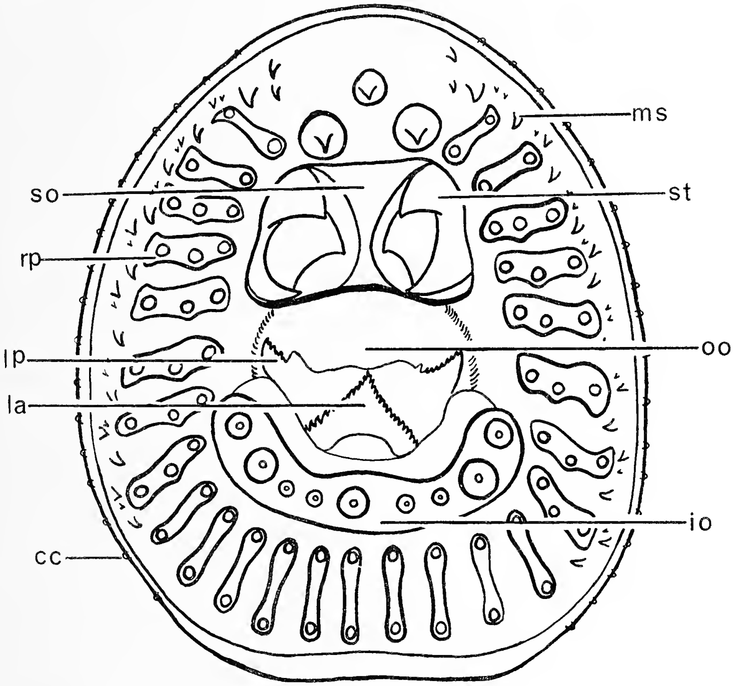

Fig. 1. Schematic drawing of the disc and dentition in the macrophthalmia of *Mordacia mordax.*

Prebranchial Length ($d\text{-}B_1$): distance from the most anterior edge of the oral disc to the anterior edge of the first gill opening.

Diameter of Eye (o): horizontal diameter of eye.

Branchial Length ($B_1\text{-}B_7$): distance from the anterior margin of the first gill opening to the posterior edge of the last (7th) gill opening.

Trunk Length ($B_7\text{-}a$): distance from the posterior edge of the last (7th) gill opening to the anterior edge of the cloacal slit.

Position of Anterior Dorsal Fin (P.ad.): point at which the anterior dorsal fin starts.

Length of Anterior Dorsal Fin (L.ad.): horizontal length of anterior dorsal fin along body.

Position of Posterior Dorsal Fin (P.pd.): point at which the posterior dorsal fin starts.

Length of Posterior Dorsal Fin (L.pd.): horizontal length of posterior dorsal fin along body.

Tail Length (a-c): distance from the anterior edge of the cloacal slit to the extremity of the caudal fin (see below).

Height of First Dorsal Fin ($h.D_1$): maximum height (see below).

Height of Second Dorsal Fin ($h.D_2$): maximum height (see below).

Vladykov (1955) measured the tail length from the posterior edge of the cloacal slit. However, as this edge is not always clearly visible in *M. praecox* the better defined anterior edge was taken (see also Hubbs and Trautman, 1937).

Since the measurements taken for the two dorsal fins were made on live specimens it was more convenient to measure the vertical distance from the body to the highest point of the fin. This differs slightly from Vladykov, who measured the length of the longest fin ray.

Myomere Counts. The trunk myomeres, on the left side of thirty formalin-preserved specimens, were counted between the posterior edge of the last gill opening and the anterior edge of the cloacal slit. The first myomere counted was the one whose posterior septum passes distinctly and entirely behind the groove, which surrounds the margin of the last gill opening (Hubbs and Trautman, 1937). The last myomere counted by Hubbs and Trautman was the one whose lower posterior angle lies in part, or wholly, above the cloacal slit but, as the myotomal septa of *M. praecox* converge in this region and do not extend completely down to the cloaca, it was not possible to establish the myomere whose posterior angle lies exactly above the cloacal slit (Plate XIV). To determine the last myomere, a vertical line was extended up to the mid-axis of the body and the myomere at this point was marked. The myomere immediately anterior to this one was the last one recorded for the trunk number.

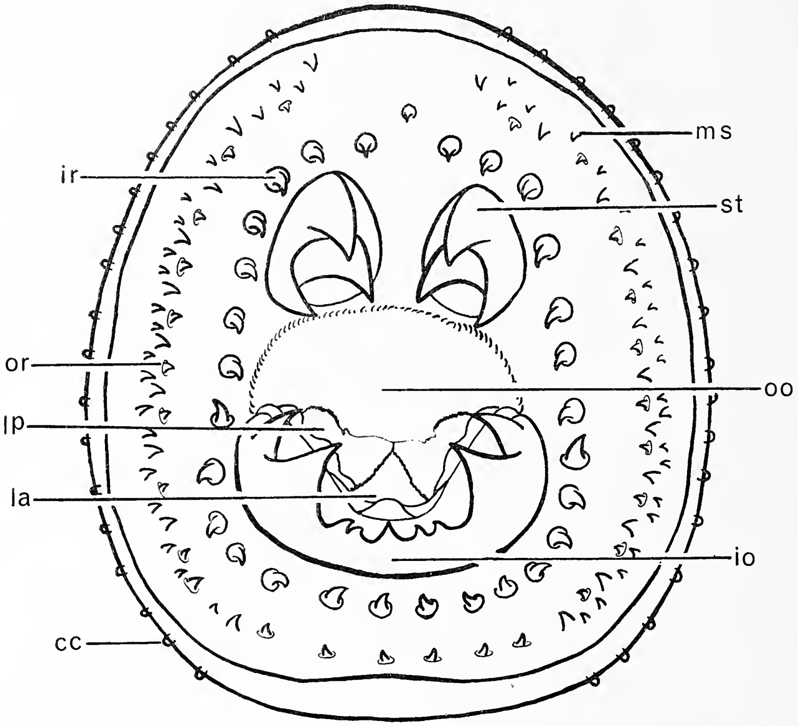

Fig. 2. Schematic drawing of the disc and dentition in the adult of *Mordacia praecox*, n. sp.

Cirri Counts. Small conical cirri are found around the perimeter of the oral disc, except for along a small anterior and posterior region (fig. 2). Counts of these cirri were made, under a dissecting microscope, on twenty preserved specimens.

Description of Adult MORDACIA PRAECOX

Total Length (Table I). The mean length of males examined for this description was greater than that of females. However, there is considerable variation in the size of the adults of *M. praecox*, due to the different growth rate of ammocoetes from different localities. Furthermore, the small numbers of this species have made it impossible to obtain large samples from one particular site and thus determine whether there is, in fact, a difference in length between the sexes. The longest adult, 172 mm., was caught in May 1967, and the shortest, 102 mm., in April 1965.

Table I

The range, mean and standard deviation of the body proportions of ten males and ten females of Mordacia praecox, *n. sp.*

	Males			Females		
	Range	Mean	S.D.	Range	Mean	S.D.
T.L. (mm.)	119 —160	136·4	13·95	119 —149	132·5	10·20
$\frac{\text{d}}{\text{T.L.}}$	6·7— 8·4	7·3	0·40	5·4— 6·3	6·0	0·26
$\frac{\text{d-B}_1}{\text{T.L.}}$	11·1— 12·6	11·6	0·31	9·4— 10·6	10·1	0·30
$\frac{\text{O}}{\text{T.L.}}$	1·3— 1·5	1·4	0·06	1·3— 1·5	1·4	0·08
$\frac{\text{B}_1\text{-B}_7}{\text{T.L.}}$	8·2— 9·9	8·9	0·43	8·4— 9·8	8·8	0·46
$\frac{\text{B}_7\text{-a}}{\text{T.L.}}$	59·6— 64·2	61·9	1·27	61·8— 64·1	63·2	0·76
$\frac{\text{P.ad}}{\text{T.L.}}$	56·7— 58·9	58·0	0·76	55·0— 58·0	56·8	0·76
$\frac{\text{L.ad}}{\text{T.L.}}$	6·4— 8·9	7·7	0·80	6·9— 9·0	7·9	0·58
$\frac{\text{P.pd}}{\text{T.L.}}$	67·4— 73·6	71·9	1·74	69·8— 74·2	71·7	1·10
$\frac{\text{L.pd}}{\text{T.L.}}$	15·0— 18·6	16·8	0·94	16·0— 17·6	16·8	0·67
$\frac{\text{a-c}}{\text{T.L.}}$	16·5— 20·4	17·6	1·23	16·7— 19·3	18·0	0·86
$\frac{\text{h.D}_1}{\text{T.L.}}$	1·6— 1·9	1·8	0·11	1·5— 1·9	1·7	0·16
$\frac{\text{h.D}_2}{\text{T.L.}}$	2·1— 2·5	2·3	0·16	2·0— 2·4	2·3	0·14

(Proportional body measurements are expressed as a percentage of the total length.)

Body Proportions (Table I). The only measurements in which there are significant differences between the sexes are the prebranchial and disc length ratios, which are greater for males in both cases. It should be noted that the prebranchial and disc length ratios of most of the males kept in the laboratory during August and September were greater than the maximum value shown in Table I. However, these have not been included in the description since animals were not obtained in the field after July.

Myomere Counts. The average number of trunk myomeres was 89·7 (Range 85-92, S.D.=1·75, N=30).

Cirri Counts. The conical cirri surrounding the oral disc become more prominent during the final stages of sexual development and the average number found in this region was 39·6 (Range 36-45, S.D.=2·68, N=20).

Dentition (Fig. 2). As the dentition of *Mordacia* differs from that of other lampreys, and also undergoes considerable changes during the life cycle of the animal, some alterations in the terminology generally used in taxonomic descriptions, have been necessary.

The marginal series consists of scattered lateral teeth, two or three deep, situated just inside the rim of the oral disc. The radial series, which lie within the marginals, comprise twenty-six pairs of teeth, which are formed by the breakdown of the middle part of radial plates present in the macrophthalmia. Both the outer and the inner teeth of the radially-arranged pairs each form a circle, which is continuous, except at the anterior part of the disc where there are three teeth arranged in the form of a triangle. There were twenty-seven and thirty pairs of teeth, instead of the normal twenty-six, in two of the ten specimens examined, but their dentition was normal in all other respects.

There are two separate supraoral tricuspid tooth plates, which, in the macrophthalmia, are joined by a thin plate. The only specimen which did not have supraoral teeth conforming to this pattern had an extra cusp between the two posterior cusps on each plate.

Typically the infraoral lamina bears nine cusps, arranged in two symmetrical groups of four on either side of a median cusp. Beginning with the cusp adjacent to the median one the series of four on the right is designated R_1 to R_4, and on the left L_1 to L_4. Cusps 1 and 2 are the same size and slightly smaller than the median cusp. Cusps 3 and 4 are larger than the median cusp, cusp 3 being the largest on the lamina.

It is only in the region of cusps 1 and 2 that supernumerary teeth have been found. Out of twenty-one specimens twelve contained at least one extra cusp, which was generally smaller than any of the others. In most cases it was clear that these were derived from the same base as either cusp 1 or 2.

The transverse lingual lamina has a V-shaped ridge bearing a row of very small cusps. The terminal cusp of each arm is the largest and the one at the apex of the V is smaller but slightly larger than the others, which are all of approximately the same size. There is a minute row of two or three cusps at rightangles to the main row, but in the same plane, which lie just below the large terminal cusp at each end of the V-shaped ridge. When the piston is projected forwards the transverse lingual lamina appears triangular (fig. 2).

On either side of the longitudinal lingual lamina are two prominences, with serrated edges, whose anterior edge is inclined downwards in attached animals (fig. 2) but upwards in preserved specimens.

Morphology. Both sexes have very dark blue dorsal surfaces, occasionally with a green tinge, but a marked difference exists in the colouration of the ventral area between the last gill slit and the cloaca. In the male this is mottled grey, but in the female the presence of eggs, which can be clearly seen through the body wall, gives this region a yellow appearance. The liver can only be clearly seen in the female and appears as a dark structure at the anterior end of the body cavity. The ventral surface below the gills has a reddish colouration which is more conspicuous in females.

There is greater growth of the tissue surrounding the oral disc of males, but in both sexes this area is of the same colour as the dorsal surface of the body.

Lateral Line System (Fig. 3). The external structures of the lateral line system, like the conical cirri, become more obvious in mature forms and can be seen as a series of papillae, which form a characteristic pattern under the eye and along the dorsal surface of the snout.

Eyes (Fig. 3). As in *M. mordax* the eyes are located dorsolaterally, rather than laterally as in all other genera.

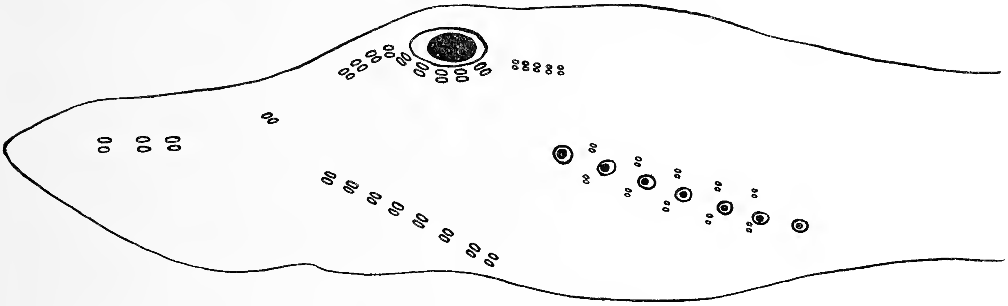

Fig. 3. Schematic drawing showing the arrangement of lateral line organs on the head region of *Mordacia praecox*, n. sp.

Fins (Plate XIV, Fig. 2). There are two dorsal fins, the second being separated by no more than a notch from the caudal fin. The base of each of the dorsal fins, and much of the dorsal region of the caudal fin, is dark blue and small patches of similar pigmentation can also occur throughout both dorsal fins.

Cloaca (Plate XIV, Fig. 1). The cloaca is located beneath the second dorsal fin. A cloacal papilla has not been found in any males but this may be due to the fact that none of these forms were fully mature, even though histological examination showed the testes were in an advanced state of development.

DISCUSSION

Although the great difference in size between the adults of *M. praecox*, 102-172 mm., and *M. mordax*, 300-420 mm., at the commencement of their spawning run (Potter and Strahan, in preparation) enables the species to be easily recognised at this stage of development, the adults of *M. praecox* and the macrophthalmia of *M. mordax* could be confused because of their similar size. The diagnosis will, therefore, contain a comparison of the adult of *M. praecox* with the macrophthalmia of *M. mordax*.

The macrophthalmia of both species are very similar, but it has always been possible to separate these forms in the Moruya and Tuross Rivers because of the different times of metamorphosis. The macrophthalmia of *M. praecox* metamorphoses in October to November and breakdown of the radial teeth plates is just starting at the time that *M. mordax* begins transforming in March of the following year. By April, sexual dimorphism is becoming apparent.

It has not been possible to study the dentition of the macrophthalmia of *M. praecox* in as great detail as that of *M. mordax*, but as far as can be seen they are very similar. This is not surprising since it is generally believed that non-parasitic lampreys have evolved from parasitic forms (Hubbs, 1925 ; Zanandrea, 1961), and thus it is probable that *M. praecox* has evolved from *M. mordax*.

DIAGNOSIS

Adult *M. praecox* can be most easily distinguished from the macrophthalmia of *M. mordax* on the following characters.

Character	*Adult* M. praecox	*Macrophthalmia of* M. mordax
1. *Colouration*		
Dorsal surface	Dark blue	Brownish grey
Ventral surface	Mottled grey in males. Yellow in females.	Silver in both sexes.
2. *Dentition*		
Radial teeth	Consist of an outer and inner row of teeth that are not joined by radial plates.	Teeth are borne on radially arranged plates.
Infraoral lamina	Cusps on lamina are large and point in towards the oesophageal opening.	Cusps on lamina are short and do not point directly in towards the oesophageal opening.

LOCALITY

Moruya River (type locality). Tuross River. Both rivers are in southern New South Wales.

TYPES

The *holotype* (IB.7936) a male of 147 mm., in total length, when measured alive under anaesthetic on 20/7/67 weighed 3·20 gms., and is deposited in the Australian Museum, Sydney. Its proportional measurements expressed as percentages of the total length are as follows: disc length, 8·2: prebranchial length, 12·6: eye diameter, 1·4: branchial length, 8·8: trunk length, 61·9: position of anterior dorsal fin, 58·5: length of anterior dorsal fin, 7·8: position of posterior dorsal fin, 72·8: length of posterior dorsal fin, 17·0: tail length, 17·0: height of anterior dorsal fin, 1·7: height of posterior dorsal fin, 2·4. There are 91 trunk myomeres. It was impossible to obtain a completely accurate count of the conical cirri, without damaging the specimen, as the edges of the oral disc have become involuted, but it appeared to have thirty-eight.

An *allotype* (IB.7937) a female of 129 mm., was also measured on 20/7/67 and placed with the holotype in the collection of the Australian Museum. It differs from the holotype in having a proportionally shorter prebranchial (10·4) and disc (5·8) region, and by having eggs visible through the body wall, which gives the ventral surface a yellow appearance.

Acknowledgements

I am indebted to Mr. R. S. Strahan, Director of Taronga Zoological Park, for help and encouragement throughout this study. I would like to thank members of the Zoology Department, University of New South Wales, who have assisted in the collection of specimens and given advice during the preparation of this manuscript. I am most grateful to Mr. G. Harris for the photographs, and to Miss R. McNeill who made the drawings.

References

GRAY, J. E., 1851.—List of the specimens of fish in the collection of the British Museum. Part 1. Chondropterygii: 1-160.

HUBBS, Carl L., 1925.—The life-cycle and growth of lampreys. *Pap. Mich. Acad. Sci., Arts and Letters*, 4, 1924: 587-603.

HUBBS, Carl L., and TRAUTMAN, M.B., 1937.—A revision of the lamprey genus *Ichthyomyzon*. *Misc. Publs. Mus. Zool. Univ. Mich.*, 35: 1-109.

RICHARDSON, J., 1846.—Fishes. In Zoology of the voyage of H.M.S. Erebus and Terror. 2: 53-74.

STRAHAN, R. S., 1960.—A comparison of the ammocoete and macrophthalmia stages of *Mordacia mordax* and *Geotria australis* (Petromyzonidae). *Pacif. Sci.*, 14: 4: 416-420.

VLADYKOV, V. D., 1955.—*Lampetra zanandreai*, a new species of lamprey from northern Italy. *Copeia* 1955 (3) : 215-223.

ZANANDREA, G., 1961.—Studies on European lampreys. *Evolution*, 15 : 4 : 523-534.

EXPLANATION OF PLATE XIV

1, Male and female of *Mordacia praecox*, n. sp., caught in July 1967 ; 2, Tail region in a female of *Mordacia praecox*, n. sp., showing the posterior and caudal fins, the position of the cloaca and the arrangement of myomeres.

Index to Text Figures

cc — conical cirrus
io — infraoral lamina
ir — inner radial tooth
la — transverse, or anterior, lingual lamina
lp — longitudinal, or posterior, lingual lamina
ms — marginal series tooth
oo — oesophageal opening
or — outer radial tooth
rp — radial plate
so — supraoral lamina
st — supraoral tricuspid tooth

TAXONOMIC NOTES ON AUSTRALIAN MALVACEAE

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(*Communicated by Mr. R. H. Anderson*)

[Read 29th November, 1967]

Synopsis

New combinations or changes of rank are made in the genera *Urena, Hibiscus* and *Alyogyne*. Three new taxa are described, all in varietal rank. A key to the varieties of *Hibiscus sturtii* Hook. is provided.

Examination of material from Central Australia has brought to light some new taxa, described below, and has indicated the necessity for certain nomenclatural changes.

1. URENA SPENCERI (Ewart) Fryxell, comb. nov.

Hibiscus spenceri Ewart in Ewart & Davies, Fl. N. Terr. 186 (1917).

When Ewart assigned this species to *Hibiscus*, he apparently overlooked its 10 styles and stigmas, which suggest its placement in *Urena*. Other morphological features support the suggestion. The most notable additional features are the elaborate foliar nectaries with prominent yellow borders (cf. Janda, Österr. Bot. Zeitschr. 86 : 81–130, 1937) and the pentamerous involucel, the lobes of which are alternate with those of the calyx. In *Hibiscus* the involucel is only rarely pentamerous (and then not uniformly so), and its divisions are independent of those of the calyx.

Northern Territory : 6 miles out from Daly River, C. S. Robinson R 87, 4 Feb. 1964, (NT 10928) : Cullen River, 40 miles N. of Katherine, N. G. Eddy 214 [with annotation : " Matches TYPE exactly (from Cullen Creek, 5/7/1911, Baldwin Spencer) G. Chippendale 18/1/1960 at Sydney Herb."], 6 Apr. 1958, (NT 5254) : South Plains area, Humpty Doo, D. Tulloch s.n., Mar. 1961, (NT 8030) : Holmes Jungle, 8 miles E. of Darwin, G. Chippendale s.n., 22 Mar. 1961, (NT 7909).

2. HIBISCUS MICROCHLAENUS F. Muell., Fragm. 2 : 116 (1861)

a. HIBISCUS MICROCHLAENUS F. Muell. var. MICROCHLAENUS.

Northern Territory : 10 miles N.E. of Alexandria Station, R.A. Perry, 1480 22 June, 1948 (NT) 1488 (NT) : 30 miles S.S.W. of Wavehill Station, R. A. Perry and M. Lazarides 2224, 21 June, 1949 (NT) : Haast's Bluff, R. E. Winkworth 1389 (NT) : Desert grazing area, Hamilton Downs, G. Chippendale s.n., 23 Sep. 1955, (NT 1749) : Tanami area, A. W. Banks s.n., July, 1948, (NT 2400, 2401) : 18 miles W. of Soudan, G. Chippendale s.n., 29 Mar. 1963, (NT 10659) : 3·2 miles E. of O.T. Downs H.S., G. Chippendale s.n., 11 Mar. 1959, (NT 5511, TAES) : The Granites, J. B. Cleland s.n., 14 Aug. 1936, (ADW 10113).

b. HIBISCUS MICROCHLAENUS F. Muell. var. LEPTOCLADUS (Benth.) Fryxell, stat. nov. *Hibiscus leptocladus* Benth. Fl. Austr. 1 : 214 (1863).

This taxon appears to be only varietally distinct from *H. microchlaenus* (F. Muell. Fragm. 2 : 116, 1861) and is therefore reduced to varietal rank. The two varieties may be distinguished by the length of the involucral bracts (5–9 mm.

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in var. *leptocladus* ; 1–2 mm. in var. *microchlaenus*). Also the very short seed hairs of var. *leptocladus* contrast with those of var. *microchlaenus*, which are 2–4 mm. long, and the overall pubescence is greater in var. *microchlaenus*. Var. *leptocladus* occurs from the Victoria River to the MacArthur River and northward ; var. *microchlaenus* occurs to the south of this region.

Northern Territory : 30 miles E. of O. T. Station, R. A. Perry 1865, 4 Aug. 1948 (NT) : King River, 25 miles S. of Katherine, H. S. McKee 8488, 15 Feb. 1961 (NT) : 24½ miles W. of Borroloola, G. Chippendale s.n., 12 Mar. 1959, (NT 5549, TAES).

3. HIBISCUS KRICHAUFFIANUS F. Muell. var. CHIPPENDALEI, var. nov.

Differt a var. *krichauffianus* pedunculis plus quam triplo longioribus, foliis magis subtiliter serratis, marginis 19–39 serratis vice 7–15 dentatis.

The present variety may be distinguished from var. *krichauffianus* by its much longer peduncles, which are more than thrice as long, and its more finely serrate leaves, the margins of which have 19–39 teeth rather than 7–15 as in the typical variety.

Northern Territory : Rare in grey sandy soil in woodland, 52·2 miles N.W. of Newcastle Waters, G. Chippendale s.n., 18 April 1959, (NT 5826, Holotype) : ¼ mile N. of Alice Springs trucking yards, A. Nicholls 519 (NT) 524 (NT) 525 (NT, TAES), 11 May 1967.

4. HIBISCUS STURTII Hook. in Mitchell, Trop Austr. 363 (1848)

Bentham (Fl. Austr. 1863) published five varietal names in *H. sturtii*, thus recognizing the variability of this species. Hochreutiner, in his revision of *Hibiscus* (Ann. Cons. Jard. Bot., Genève 4 : 70–71, 1900), differed from Bentham only in raising one of the varieties to specific status as *H. platychlamys* (Benth.) F. Muell. ex Hochr. The taxa recognized by Bentham are well-founded and discrete, but his descriptions are so abbreviated that it is often difficult to determine individual specimens.

The following treatment attempts to differentiate these five taxa more clearly and adds a sixth, var. *truncatus*. Bentham's var. *platychlamys* is provisionally retained in varietal rank.

Key to the varieties of H. STURTII

- A. Plant 1–3 feet tall ; all plant parts large, for example : calyx 17–25 mm. long ; capsule 12–17 mm. long .... var. *platychlamys*
- *A. Plant less than 2 feet tall ; calyx 6-19 mm.; capsule 8-12 mm. long.
  - B. Pedicel equalling or exceeding petiole ; petals purple .... var. *grandiflorus*
  - *B. Pedicel much shorter than to nearly equalling petiole ; petals usually pink
    - C. Calyx equalling involucel .... var. *sturtii*
    - *C. Calyx exceeding involucel.
      - D. Involucel subtruncate, nearly equalling calyx .... var. *truncatus*
      - *D. Involucel 6–8 toothed
        - E. Involucral teeth acuminate, 3–8 mm. .... var. *campylochlamys*
        - *E. Involucral teeth triangular, 1–3 mm. .... var. *muelleri*

a. HIBISCUS STURTII var. PLATYCHLAMYS Benth., Fl. Austr. 1 : 217 (1863)

Hibiscus platychlamys (Benth.) F. Muell. ex Hochr. Ann. Cons. Jard. Bot., Genève 4 : 71 (1900).

Pedicels exceeding petioles, 15–50 mm. (rarely shorter). Involucel not equalling calyx, 10–22 mm., 4–6 toothed ; teeth acuminate, reflexed, 6–10 mm. Calyx 17–25 mm., deeply 5-lobed ; lobes 10–15 mm. Petals 25–35 mm., pink with dark basal spot. Fruits 12–17 mm. long.

Northern Territory : 11 miles W. of Mt. Doreen H. S., G. Chippendale s.n., 9 Feb. 1955, (NT 1231) : 14 miles E. of Dalmore Downs, G. Chippendale s.n., 22 June 1960, (NT 7342, TAES) : 26 miles E. of Mt. Liebig Bore, G. Chippendale s.n., 6 Feb. 1955, (NT 828) : Devil's Marbles, G. Chippendale s.n., 8 Mar. 1955, (ADW 12235, NT 930) : Tanami area, A. W. Banks s.n., July 1948, (NT 2403).

b. HIBISCUS STURTII var. GRANDIFLORUS Benth., Fl. Austr. 1 : 216 (1863).

Pedicels equalling or exceeding petioles, 10–22 mm. Involucel not equalling calyx, 4–8 mm., 6–10 toothed ; teeth triangular, 1–2 mm. Calyx 8–13 mm., 5-lobed ; lobes 3–5 mm. Petals 15–35 mm., purple with dark basal spot. Fruits 8–10 mm.

South Australia : near Halowie Creek, Flinders Ranges, D. E. Symon 3091, 13 Oct. 1964, (ADW 28766) : *Northern Territory* : 4 miles N. of Alice Springs, R. Swinbourne 568, 8 Nov. 1962, (NT 9745) : 9 miles W. of Alice Springs, R. E. Winkworth 894, 16 Mar. 1955 (NT) : hill E. side of Undoolga Gap, G. Chippendale s.n., 9 Nov. 1954 (NT 430) : 16 miles S.E. of Alice Springs, R. E. Winkworth 684, 9 Nov. 1954 (NT) : 20 miles SE of Ringwood Station, Simpson Desert, R. A. Perry 5459, 9 Sept. 1955 (NT).

c. HIBISCUS STURTII var. STURTII

Pedicels shorter than petioles, 4–7 mm. Involucel equalling calyx, 6–8 mm., ca. 8-toothed ; teeth rounded-triangular, ½–2 mm. Calyx 6–8 mm., 5-lobed ; lobes ½–2 mm.

Northern Territory : Haast's Bluff Reserve, J. B. Cleland s.n., 29 Aug. 1957, (ADW 18462, NT 4016).

d. HIBISCUS STURTII var. TRUNCATUS var. nov.

Pedicelli 3–6 mm. longi, quam petioli breviores. Involucella truncata vel subtruncata, 6–10 mm., quam calyces aliquantum breviora. Calyces 9–12 mm., 5 lobati ; lobi calycum 2–3 mm. Petala erubescentia, basi sine maculis atratis, 15 mm. longa. Fructus 8 mm. longus.

Pedicels shorter than petioles, 3–6 mm. Involucel somewhat shorter than calyx, 6–10 mm., truncate or subtruncate. Calyx 9–12 mm., 5-lobed ; lobes 2–3 mm. Petals 15 mm., pink, without dark basal spot. Fruits 8 mm.

Northern Territory : Tropic of Capricorn, 13 miles S. of Kintore Range. Erect, perennial herb, 6″ high, flowers pale pink. Rare on roadway across deep red sand plain. D. J. Nelson 973, 12 Mar. 1964, (NT 10857, Holotype) : 27 miles W. of The Granites, A. W. Banks s.n., July 1948, (NT 2402).

e. HIBISCUS STURTII var. CAMPYLOCHLAMYS Benth., Fl. Austr. 1 : 217 (1863)

Pedicels shorter than petioles, 2–10 mm. Involucel not equalling calyx, 7–14 mm., 6–8 toothed ; teeth acuminate, 3–8 mm. Calyx deeply 5-lobed, 13–19 mm., lobes 10–12 mm. Petals 20–25 mm., pink or purple with dark basal spot. Fruits 8–12 mm.

Northern Territory : 3 miles S. of Daly Waters turnoff, G. Chippendale s.n., 10 Mar. 1955, (NT 1051) : 21 miles from Newcastle Waters, R. E. Winkworth 1060, 23 Mar. 1955 (NT) : 51 miles S. of Hooker's Creek Settlement, G. Chippendale s.n., 14 July 1956, (NT 2322) : 105 miles W. of Muckety (Long. 132° 29′, Lat. 18° 30′), H. A. Johnson s.n., 1 June 1965 (NT 11757) : 10 miles W. of Wonarah Telegraph Stn., G. Chippendale s.n., 25 Mar. 1956, (NT 1979).

f. HIBISCUS STURTII var. MUELLERI Benth. Fl. Austr. 1 : 217 (1863)

Pedicels shorter than petioles, 2–10 mm. Involucel not equalling calyx, 4–8 mm., 6–8 toothed ; teeth triangular, 1–3 mm. Calyx 5-lobed, 7–12 mm., lobes 3–5 mm. Petals pink without dark basal spot, 10–20 mm. Fruits 8–9 mm.

New South Wales : Broken Hill, South Hills, A. Morris s.n., 3 Apr. 1921, (ADW 7922) : *Northern Territory* : Winnecke Creek, 50·3 miles S.W. of Hooker Creek Settlement, G. Chippendale, s.n., 14 Apr. 1959, (NT 5724, TAES) : Storm Creek, 160 miles S.W. of Alice Springs, G. Chippendale s.n., 24 Nov. 1955, (NT 595) : Tobermorey, No. 7 bore paddock, G. Chippendale s.n., 2 Oct. 1954, (NT 408): ca. 2 miles W. of sewerage farm, Alice Springs, 11 May 1967, A. Nicholls 541 (NT, TAES).

5. ALYOGYNE HUEGELII (Endl.) Fryxell, comb. nov.

Hibiscus huegelii Endl. in Huegel, Enum. 10 (1837).

The features that distinguish *Alyogyne* from *Hibiscus* and allied genera include: a copious development of endosperm enclosing a correspondingly smaller and simpler embryo; the form of the involucel; and the structure of the flower. The anther mass is columnar in form, and rather narrowly so, as a result of having a columnar androecial column and filaments of equal length emerging from the column. The anthers are a characteristic rusty colour. The style is undivided. The corolla is a characteristic mauve. These several traits taken together indicate the necessity of transferring the present species to the genus *Alyogyne*, as suggested by Bates (Baileya 13: 69, 1965), as well as the following species, which shares these traits.

Western Australia: Mr. Ashby's garden, originally from Geraldton, G. H. Clark s.n., Oct. 1937, (ADW 3810A, 3810B), E. Ashby s.n., 17 Dec. 1932, (ADW 1599): *South Australia*: Lower Mambray Creek, Flinders Range, D. E. Symon 459, 11 June 1960, (ADW 22154): Lower Eyre Peninsula, A. E. Ophel s.n., Nov. 1939, (ADW 6654): Pt. Germain, Lower Flinders Ranges, A Morris s.n., 5 Sep. 1916, (ADW 17674): 3 miles along road to Koppio from turnoff along the Tunsby-Lincoln road, 14 km from Tumby Bay, Lower Eyre Peninsula, D. E. Symon 908, 12 Nov. 1960, (ADW 22731): head of Monnabie, (Mr. Moulds) part of Cooyerdoo Stn., S. of the Whyalla-Kimba road, W. S. Reid s.n., 2 Feb. 1962, (ADW 27924).

6. ALYOGYNE PINONIANUS (Gaud.) Fryxell, comb. nov.

Hibiscus pinonianus Gaud., Voy. Freyc. 476, t. 100 (1826).

a. ALYOGYNE PINONIANUS (Gaud.) Fryxell var. PINONIANUS.

South Australia: Mt. Moulden, between Blyth Range and Deering Hills, W. S. Reid s.n., 26 Sep. 1955, (ADW 19247): *Northern Territory*: 2 miles S. of Lake Amadeus G. Chippendale s.n., 29 June 1959, (NT 6398, TAES): 18½ miles N. of Lake Amadeus, G. Chippendale s.n., 28 June 1959, (NT 6357, TAES): Petermann Range area, 7½ miles W. of Shaw River, G. Chippendale s.n., 24 June 1958, (NT 4636): 25 miles S. of Angus Downs H.S., G. Chippendale s.n., 24 Nov. 1954, (NT 627): near Warburton Mission, near Mt. Charles, H. A. Johnson s.n., 16 May 1958, (NT 5129).

b. ALYOGYNE PINONIANUS (Gaud.) Fryxell comb. nov. var. MICROANDRUS Fryxell var. nov.

Differt a var. *pinonianus* statura minore, petalis minoribus (usque ad 3 cm. longis), basi sine maculis, filamentis quadruplo brevioris (usque ad ½ mm. longis), stigmatibus tantum 1 mm. diam., sed fructibus et seminibus idem.

The present variety may be distinguished from var. *pinonianus* by its smaller stature, its smaller petals (to 3 cm.) which lack a basal spot, its shorter filaments (to ½ mm.) that are one-fourth the length of those of the typical variety, and its smaller stigma of only 1 mm. diameter. In spite of the reduced flower parts, the fruits and seeds are of similar size.

South Australia: Eyre Peninsula: roadside near Midgee Rocks, on road to Mitchellville, N.E. of Cowell, R. Pearce s.n., Feb. 1965, (ADW 29591, Holotype; CANB, Isotype, n.v.).

It is possible that *Hibiscus drummondii* Turcz. (=*H. intraterraneus* Black) also belongs in *Alyogyne*. Bates (loc. cit.) suggested that *Hibiscus farragei* F. Muell, might be allied to *Alyogyne*, but I disagree. The embryo structure of *H. farragei* is quite distinctive and is unlike the majority of Malvaceae in that it is straight. If this species is to be removed from *Hibiscus*, its more natural position would seem to be in or near the genus *Radyera* Bull. (=*Allenia* Phill. non Ewart).

THE COMPOSITION OF TROPICAL LOWLAND PEAT SAMPLED AT KLANG, SELANGOR, MALAYSIA

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[Read 29th November, 1967]

Synopsis

The results of analyses of a tropical lowland peat from Klang, Selangor are given and the utilization of the peat is discussed.

INTRODUCTION

The distribution, location and mode of formation of tropical lowland peat on the Malayan Peninsula have been the subjects of a previous paper (Hewitt, 1967). The extensive occurrence of peat in tropical lowlands gives to this peat an importance because it is situated in areas suitable for padi cultivation although the peat itself is an extremely poor medium for crop plant growth. The continually waterlogged conditions and the fact that peat does not provide adequate mechanical support means that many crops and particularly tree crops such as rubber cannot be grown successfully on peat.

The chemical environment is also very unfavourable. For example, the low pH of the peat is probably responsible for the release of toxic amounts of some elements. There is in any case usually a low content of most essential nutrient elements and naturally a high carbon to nitrogen ratio. Furthermore, the anaerobic waterlogged conditions result in the formation of toxic substances such as di-hydrogen sulphide and of a very acidic ground water.

In this paper results of chemical analyses of peat are given together with a discussion of these results and of the utilization of peat.

METHODS AND RESULTS

The peat was sampled from an extensive swamp near Klang, Selangor, part of which carries extensive areas of the original peat swamp forest while other parts have been cleared, drained, burnt and put down to rubber and oil palm. Clearing, burning and draining has resulted in shrinkage of the peat so that the level has dropped by about 3 feet.

Sampling was carried out on both virgin and on cleared peat with a peat auger at 5 sampling points along a two-mile traverse. The depths of sampling 0–1 ft, 1 ft–2 ft and 2 ft–4 ft. Initially the analyses were done on individual samples but the results for each depth level were similar so that samples were bulked for the virgin and cleared peat to give three main samples, namely 0–1 ft, 1 ft–2 ft, 2 ft–4 ft. Since the top layers of the cleared peat had been burnt and drainage had resulted in further shrinkage the 2 ft–4 ft sample contained the underlying blue-grey clay.

The profile descriptions of the samples are :

VIRGIN PEAT

Coloured black, with leaves and other vegetable material distinguishable in the top layers together with some twigs, pieces of wood which graded into a more amorphous peat of reddish colour with depth. The lower portions still contained undecomposed pieces of wood.

Cleared Peat

This contained a thin layer of charcoal on the top and some of the underlying clay in the lower portions. Between these there was an amorphous peat of reddish brown colour.

The samples were transferred to the laboratory in polythene bags then air dried and passed through a 2·0 mm. sieve for analysis. In later work it was necessary to use finer size of sample and <0·5 mm. sized samples were obtained after the appropriate quartering of the <2·0 mm. samples. On drying all peat samples had a reddish brown colour except for the 2 ft–4 ft sample from the cleared peat which was grey in colour.

Analysis was carried out on individual samples as shown below in Table 1.

Table 1
pH, Loss on ignition (%) and ash (%) of Klang peat

Individual Virgin peat samples

Depth	Sample	pH	Loss on Ignition (%)	Ash (%)
0–1 ft	1	2·4	95·3	4·7
	2	2·5	95·8	4·2
	3	2·3	96·6	3·4
	4	2·3	92·3	7·7
	5	2·1	92·5	7·7
1 ft–2 ft	1	2·4	87·7	12·3
	2	2·5	98·2	1·8
	3	2·3	97·5	2·5
	4	2·3	96·2	3·8
	5	2·2	98·6	1·4
2 ft–4 ft	1	2·4	97·7	2·3
	2	2·4	97·5	2·5
	3	2·3	96·4	3·6
	4	2·3	97·7	2·3
	5	2·3	96·0	4·0

Individual cleared peat samples

Depth	Sample	pH	Loss on ignition (%)	Ash (%)
0–1 ft	1	1·8	95·5	4·5
	2	2·4	86·6	13·4
	3	2·8	91·9	8·1
	4	2·5	96·7	3·3
	5	2·4	94·8	5·2
1 ft–2 ft	1	2·5	83·4	16·6
	2	2·3	94·8	5·2
	3	2·6	96·2	3·8
	4	2·6	86·7	13·3
	5	2·8	52·3	47·7
2 ft–4 ft	1	2·9	44·0	56·0
	2	2·5	68·4	31·6
	3	2·7	80·7	19·3
	4	2·9	43·3	53·7
	5	3·4	29·1	70·9

The determination of moisture content on the field samples was meaningless and was not carried out. pH was measured on a 1 : 5 peat to 1M KCl suspension and loss of ignition by igniting at 800°C. for 4 hours. It was found that ignition for 1 hour was insufficient.

The samples from each depth showed similarity of results for pH and loss on ignition values except for the cleared peat in the 2 ft–4 ft samples where more or less of the underlying clay was taken in sampling. Therefore the samples for each depth were bulked and further analyses were carried out on these bulked samples. In the samples from the virgin peat the colours of the ashes from each depth were similar and graded from grey to yellow-grey in the top to pink in the 2 ft–4 ft depth and provided an additional reason for bulking the samples in this manner. This also occurred in the ash colour of the ignited cleared peat samples.

TABLE 2

pH, Loss on ignition (%) and ash (%) of bulked samples of Klang peat

Virgin peat						
Depth	Loss on ignition (%)	Ash (%)	pH	N %	Org. C %	C/N Ratio
0–1 ft	95·8	4·2	2·4	1·9	33·0	17·3
1 ft–2 ft	97·0	3·0	2·4	1·3	27·0	20·8
2 ft–4 ft	95·7	4·3	2·3	0·3	22·0	24·4
Cleared peat						
Depth	Loss on ignition (%)	Ash (%)	pH	N %	Org. C %	C/N Ratio
0–1 ft	91·6	8·4	2·7	1·1	23·5	21·4
1 ft–2 ft	84·7	15·3	2·7	0·8	22·5	28·1
2 ft–4 ft	55·8	44·2	2·7	0·6	13·0	21·6

ANALYSIS OF BULKED PEAT SAMPLES

In addition to loss on ignition and pH determination nitrogen was determined by the Kjeldahl method and organic carbon by the Walkley and Black method (Piper, 1950). These results are shown in Table 2. Further determinations were made according to the methods of Jackson (1958) and included determinations of sulphur (gravimetrically) and phosphorus, manganese, iron, copper, zinc, silica colorimetrically. These results are shown in Table 3 together with the aluminium results which were determined by the difference method according to Piper (1950). Further results are shown in Table 3 of sodium, chloride, potassium, calcium and magnesium contents which were determined by flame photometry while in Table 4 the results for cation and anion exchange capacities are given.

TABLE 4

Total Cation and Anion exchange capacities of Klang peat

Virgin peat		
Depth	Total Cation exchange capacity m.e. % of oven dried peat	Total Anion exchange capacity m.e. % of oven dried peat
0–1 ft	98	0·19
1 ft–2 ft	122	0·46
2 ft–4 ft	120	0·06
Cleared peat		
0–1 ft	76	0·77
1 ft–2 ft	125	0·32
2 ft–4 ft	72	0·63

TABLE 3

Principal inorganic ion analysis of Klang peat

Depth	Percentage B_2O_5 in dried peat	Percentage B_2O_5 in ash	Percentage K_2O in dried peat	Percentage K_2O in ash	Percentage Na_2O in dried peat	Percentage Na_2O in ash	Percentage CaO in dried peat	Percentage CaO in ash	Percentage MgO in dried peat	Percentage MgO in ash	Percentage Fe_2O_3 in dried peat	Percentage Fe_2O_3 in ash	Percentage Al_2O_3 in dried peat	Percentage Al_2O_3 in ash	Percentage SiO_2 in dried peat	Percentage SiO_2 in ash	Percentage CuO in dried peat	Percentage CuO in ash	Percentage ZnO in dried peat	Percentage ZnO in ash	Percentage SO_3 in dried peat	Percentage SO_3 in ash
Virgin peat																						
0–1 ft	0·15	3·8	0·002	0·05	0·018	0·42	0·010	0·25	0·020	0·46	4·62	11·10	0·06	1·53	3·42	82	0·02	0·45	0·05	0·88	0·42	8·30
1 ft–2 ft	0·09	3·1	0·001	0·05	0·018	0·57	0·009	0·27	0·016	0·12	0·57	9·30	0·06	1·87	2·10	70	0·01	0·41	0·09	2·65	0·62	20·87
2 ft–4 ft	0·04	0·8	0·001	0·07	0·015	0·33	0·006	0·15	0·020	0·46	0·12	2·40	0·06	1·47	3·21	75	0·01	0·32	0·01	2·01	1·07	21·00
Cleared peat																						
0–1 ft.	0·07	0·8	0·007	0·05	0·012	0·15	0·019	0·24	0·016	0·20	0·06	0·75	0·24	2·85	5·39	64	0·02	0·22	0·04	1·11	1·52	15·50
1 ft–2 ft	0·03	0·2	0·055	0·35	0·015	0·09	0·019	0·24	0·020	0·12	0·12	0·81	0·45	2·93	12·78	84	0·02	0·11	0·02	0·10	2·37	11·87
2 ft–4 ft	0·02	0·05	0·062	0·15	0·015	0·03	0·004	0·01	0·018	0·04	0·33	0·78	1·38	3·13	23·40	53	0·01	0·01	0·05	0·10	4·02	8·00

Peat fractions were determined according to the procedure of Konanova (1961) as

1. Humic substances insoluble in O.1N.NaOH—*humin*, *ulmin.*
2. Humic substances soluble in O.1N.NaOH and soluble in O.1N.HCl—*crenic* and *apocrenic acid.*
3. Humic substances soluble in both O.1N.NaOH and O.1N.HCl and
4. (*a*) soluble in alcohol—*Hymatomelanic acid.*
   (*b*) insoluble in alcohol—*humic* and *ulmic acids.*

These results are shown in Table 5.

TABLE 5

Fractions of Klang peat

Peat fractions as a percentage of the total when determined on an air dry basis

Depth	Humin and Ulmin	Humic and Ulmic acids	Hymatomelamic acid	Crenic and Apocrenic acids
Virgin peat				
0–1 ft	32	25	9	8
1 ft–2 ft	40	25	11	11
2 ft–4 ft	32	22	15	4
Cleared peat				
0–1 ft	30	21	14	12
1 ft–2 ft	31	15	6	10
2 ft–4 ft	21	12	3	10

When calculated on oven dried peat the percentages were :

Depth	Humin and Ulmin	Humic and Ulmic acids	Hymatomelamic acid	Crenic and Apocrenic acids
Virgin peat				
0–1 ft	43	33	12	12
1 ft–2 ft	47	29	13	11
2 ft–4 ft	42	29	19	8
Cleared peat				
0–1 ft	39	27	18	16
1 ft–2 ft	51	23	11	15
2 ft–4 ft	46	27	6	22

In further analysis the functional groups of peat and the peat fractions were determined according to the method of Konanova (1961). The total content of carboxyl and phenolic hydroxyl groups were determined by titration with barium hydroxide and carboxyl groups by reactions with calcium acetate. The results are tabulated in Table 6 for complete peat and for the peat fractions.

DISCUSSION

It is evident that the very low pH of Klang Peat is not particularly conducive to plant growth. This coupled with the usual low level of nutrients, the presence of often toxic concentrations of sulphur leading to the formation of sulphuric acid and the lack of mechanical support for plants makes the peat very unattractive as a medium for crop growth. Nevertheless, lowland peat occurs in areas which are otherwise ideal for the growth of padi so that the shallow peat in particular is being continually cleared and used for production.

However, the results show that clearing and draining have not resulted in any great accumulation of plant nutrients and, in fact, drainage has resulted in the leaching of most of the elements. The leaching of iron was shown by experi-

TABLE 6

Functional groups of Klang peat and of the peat fractions
Results are quoted in m.e. per 100 g of oven dried peat.

Depth	Functional groups			Humin and Ulmin fractions			Humic and Ulmic acids fraction			Crenic and Apocrenic acids fraction			Hymatomelanic acid fraction		
	Carboxyl + Phenolic hydroxyl groups	Carboxyl groups	Phenolic groups	Carboxyl + Phenolic hydroxyl groups	Carboxyl groups	Phenolic groups	Carboxyl + Phenolic hydroxyl groups	Carboxyl groups	Phenolic groups	Carboxyl + Phenolic hydroxyl groups	Carboxyl groups	Phenolic groups	Carboxyl + Phenolic hydroxyl groups	Carboxyl groups	Phenolic groups
Virgin peat															
0–1 ft	426	23	403	1840	90	1750	2020	290	1730	920	360	560	1660	270	1390
1 ft–2 ft	430	21	409	1840	90	1750	2200	330	1870	1120	260	860	1480	260	1220
2 ft–4 ft	465	22	443	1840	100	1740	2020	350	1650	1480	310	1170	1660	290	1370
Cleared peat															
0–1 ft	460	26	434	1660	80	1580	2020	260	1760	1660	220	1440	1280	280	1000
1 ft–2 ft	375	29	346	2020	90	1930	2020	340	1680	1660	220	1440	1480	290	1190
2 ft–4 ft	360	34	326	1660	90	1570	1660	260	1400	920	290	630	1480	180	1100

ment to be very rapid. Samples of virgin peat were shaken with water (2 g. of 2·00 mm. peat in 250 mls. of water) for 1/2 hour and the iron content determined colorimetrically after standing overnight. As shown in Table 7 the iron content of the peat was reduced to 1/3 of its initial value.

TABLE 7

Fe_2O_3 content of virgin peat before and after leaching
% Fe_2O_3 (dry basis)

Depth	Before leaching	After leaching
0–1 ft	2·85	0·91
1 ft–2 ft	0·21	0·10
2 ft–4 ft	0·13	0·06

The agricultural utilization of lowland peat has been the subject of a number of investigations including those of Coulter (1950), Coulter *et al* (1956), and van Wijk (1951). Although special cultivation methods have been used when growing padi on peat and a number of methods advocated for reducing the high acidity such as liming together with suggestions such as the growing of leguminous plants as green manure crops it is probable that only the shallow peat can be used advantageously. The shallow peat when cleared and drained has its depth reduced so that plants and particularly tree crops are able to penetrate to the underlying clay which affords mechanical support, is usually richer in plant nutrients and is less acid.

It is possible to use peat as a fuel and this possibility has been indicated by Fitch (1953). North Borneo peat had calorific values which ranged from 8,500 to 9,200 BTU/lb. (4,700—5,100 cal/g.). These values are comparable with those of peats from Europe but it is probable that peat extracted could only be used for power production in light industries and this is unlikely to be economic in a country where hydro-power and oil are readily available.

References

COULTER, J. K., 1950.—Peat formations in Malaya. *Malay agric. J.*, 33 : 63-81.

COULTER, J. K., MCWALTER, A. R., and ARNOTT, G. W., 1956.—Soil surveys No. 3. The Trans-Perak Swamp. *Malay agric. J.*, 39 : 99-120.

FITCH, F. H., 1953.—North Borneo mineral resources. Fuel value of peat near Papor. Brit. Borneo Geol. Survey Ann. Rept. 70-75.

HEWITT, B. R., 1967.—The occurrence, origin and vegetation of lowland peat in Malaya. PROC. LINN. SOC. N.S.W., 92 : 58-66.

JACKSON, M. L., 1958.—" Soil Chemical Analysis." Constable, London.

KONANOVA, M. M., 1961.—" Soil Organic Matter." Pergamon Press, Oxford.

PIPER, C. S., 1950.—" Soil and Plant Analysis." University of Adelaide.

VAN WIJK, C. L., 1951.—Soil survey of the tidal swamps of South Borneo in connection with agricultural possibilities. *Contrib. gen. agric. res. Sta. Bogor*, No. 123 : 1-49.

NOTES ON THE BIOLOGY OF TWO SPECIES OF RHAPHIDOPHORIDAE (ORTHOPTERA) IN TASMANIA

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[Read 29th November, 1967]

Synopsis

Environmental conditions are given for four Tasmanian caves containing populations of *Micropathus* Richards. Food preferences of *M. cavernicola* Richards and *M. tasmaniensis* Richards are discussed, and it is shown that both species are omnivorous scavengers. In both species seven pre-adult instars are passed through. In November, all instars were present in the populations.

INTRODUCTION

To date only two genera of Rhaphidophoridae, *Micropathus* Richards (Richards, 1964) and a new genus (Richards, in press), have been recorded from Tasmanian caves, and nothing is known of their biology and habits. The new genus is known only from the Mole Creek district in northern Tasmania; but *Micropathus* extends throughout the western half of Tasmania, and appears to be the dominant rhaphidophorid genus on the island.

Three species belong in the genus *Micropathus*. *Micropathus* n. sp. (Richards, in press) from Gunns Plains in north-west Tasmania, was discovered after the field-work in this paper had been completed, and appears to have a limited distribution. The other two species, *M. cavernicola* Richards and *M. tasmaniensis* Richards, occur throughout wide areas of the island (Richards, in press). In November 1966, a series of observations was made on their biology. Three areas in widely separated parts of Tasmania were selected for study. The caves examined were Marakoopa Cave and Little Trimmer Cave at Mole Creek, Cashion Creek Cave in the Florentine Valley, and Mystery Creek Cave at Ida Bay.

TABLE 1
Environmental conditions under which Micropathus *Richards occurred, November, 1966*

Locality	Latitude	Altitude (ft.)	Air Temperature in Caves (°F.)	Relative Humidity (%)	Species
Mole Creek ..	41·75	c.1400	48–49	86–92	*M. cavernicola*
Florentine Valley ..	42·60	c.1300	48–49	88–93	*M. tasmaniensis*
Ida Bay ..	43·25	c. 400	47–47·5	92–96	*M. tasmaniensis*

HABITAT

Environmental conditions under which the two species of *Micropathus* occur are summarized in Table 1. Temperatures show little variation throughout each cave system and are among the lowest recorded from Australian caves containing Rhaphidophoridae (Richards, 1966; in press). Any effect altitude may have on temperature is counteracted by latitude, as there is a difference of only 1·5°F. between Ida Bay and the other two areas. In all caves the relative humidity is very high. All four caves are situated in sclerophyll forest and contain streams which flood periodically.

FOOD PREFERENCES OF MICROPATHUS

In Tasmanian caves the food supply for cavernicolous arthropods is limited because of the absence of mammalian faeces with their associated guanobia. One of the main food sources is the large quantity of organic debris washed into caves during floods. Predation of one species on another also occurs.

Examination of crop content of both species of *Micropathus* collected from several different caves shows the insects appear to eat about equal proportions of plant and animal tissues, and are omnivorous scavengers. Crops contained large quantities of fungal hyphae and spores, as well as green algae, angiosperm tissues consisting of spiral, scalariform and pitted vessels, and unidentified chitinous arthropod remains. Algae can be obtained only round cave entrances ; but angiosperm tissues occur both inside and outside caves, as leaves and twigs are periodically washed into caves. At Marakoopa Cave, *M. cavernicola* was observed at night on vegetation outside the cave entrance.

In Cashion Creek Cave and Little Trimmer Cave partly eaten remains of *Micropathus* were found close to large aggregations of these insects. Rhaphidophorid mandible marks could be seen on several of the hind femora, which suggests cannibalism occurs. When placed alive in a confined space for several hours, small nymphs of *M. tasmaniensis* were attacked and eaten by large nymphs and adults.

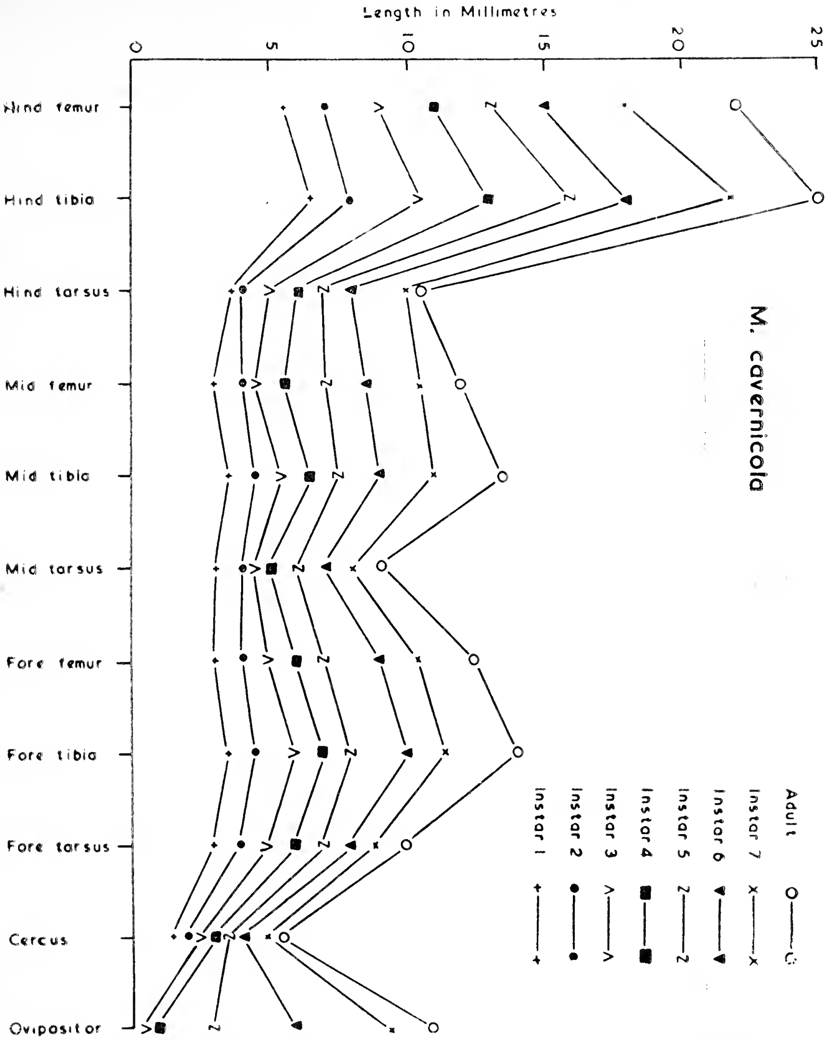
NUMBER OF INSTARS IN *Micropathus*

Neither *M. cavernicola* nor *M. tasmaniensis* have been reared under observation from egg to adult. In November 1966, field observations showed both species could be divided into a series of distinct groups ranging from first instar nymphs to adult insects. In all instars that could be sexed, there was a preponderance of females to males in a ratio of approximately 2 : 1. About 50 specimens of each species were collected. From these a series of measurements were made on the lengths of selected anatomical features in nymphs and adults. Sizes of individuals within each instar varied slightly so mean values have been used in all cases. These indicate that in both species seven pre-adult instars are passed through by male and female insects (Text-figs. 1, 2; Tables 2, 3).

TABLE 2

Percentage increase growth in length in each instar in Micropathus cavernicola

	I mm.	II	III	IV	V	VI	VII	Adult
Hind Femur	5·5	27·3	28·6	22·2	18·2	15·3	20·0	22·2
Hind Tibia	6·5	23·0	31·3	23·8	23·0	12·5	22·2	13·6
Hind Tarsus	3·5	14·3	25·0	20·0	16·7	14·3	25·0	5·0
Mid Femur	3·0	33·3	12·5	22·2	27·3	21·4	23·5	14·2
Mid Tibia	3·5	28·6	22·2	18·2	15·4	20·0	22·2	22·7
Mid Tarsus	3·0	33·3	12·5	11·1	20·0	16·7	14·3	12·5
Fore Femur	3·0	33·3	25·0	20·0	16·7	28·6	15·0	19·0
Fore Tibia	3·5	28·6	33·3	16·7	14·3	25·0	12·5	21·7
Fore Tarsus	3·0	33·3	25·0	20·0	16·7	14·3	12·5	11·1
Cercus	1·5	33·3	25·0	20·0	16·7	14·3	25·0	10·0
Ovipositor			0·5 mm.	100·0	200·0	100·0	58·3	15·8



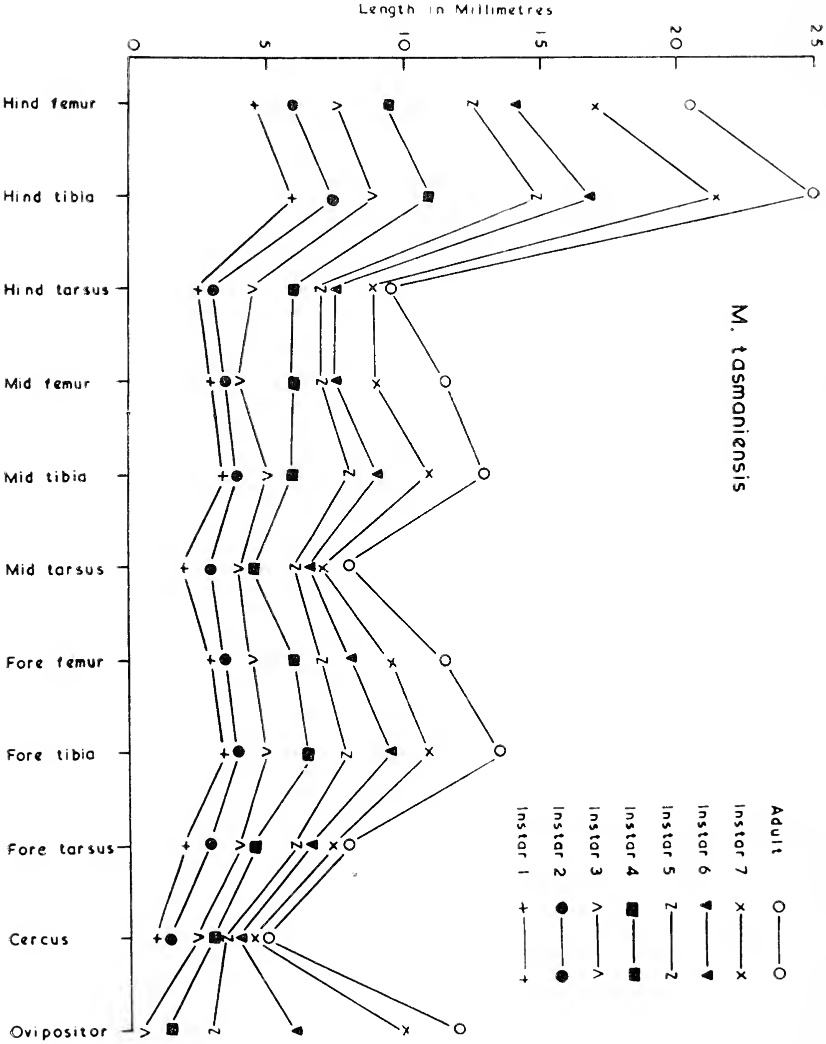
Text-fig. 1. Number of instars in *Micropathus cavernicola* Richards.

TABLE 3

Percentage increase growth in length in each instar in Micropathus tasmaniensis

	I mm.	II	III	IV	V	VI	VII	Adult
Hind Femur ..	4·5	33·3	25·0	26·6	31·6	12·0	21·4	20·6
Hind Tibia ..	6·0	25·0	20·0	22·2	36·3	13·3	26·5	16·3
Hind Tarsus ..	2·5	20·0	50	33·3	16·6	7·1	20·0	5·5
Mid Femur ..	3·0	16·6	14·3	50	16·6	7·1	20·0	27·7
Mid Tibia.. ..	3·5	14·3	25·0	20	33·3	12·5	22·2	18·2
Mid Tarsus ..	2·0	50	33·3	12·5	33·3	8·3	7·7	14·3
Fore Femur ..	3·0	16·6	28·6	33·3	16·6	7·1	18·7	21·0
Fore Tibia ..	3·5	14·3	25·0	30·0	23·0	18·7	15·8	22·7
Fore Tarsus ..	2·0	50	33·3	12·5	33·3	8·3	15·4	6·6
Cercus	1·0	50	66·6	20·0	16·6	14·3	12·5	11·1
Ovipositor ..			0·5 mm.	200·0	100·0	100·0	66·6	20·0

Observations were also made on the degree of development of male and female external genitalia. In all but the smallest nymphs, the stages in the development of the ovipositor in females proved a useful indicator in determining the number of instars present. The attempt to separate males into instars was less satisfactory.



Text-fig. 2. Number of instars in *Micropathus tasmaniensis* Richards.

To check whether an instar had been overlooked in either species, the logarithm of the linear measurements of the hind femora were plotted against the number of instars. Calculated values were obtained from fitted regression lines, and are given in Table 4. The approximation of the observed to the calculated measurements is sufficiently close to remove the possibility of an instar having been overlooked. It is suggested that this remarkably good fit is due to the unusual circumstances of all instars being present at the same time, thus being subjected to identical environmental conditions.

DISCUSSION

The vegetation surrounding Tasmanian caves, and the fauna occurring in them have closer affinities with New Zealand than with mainland Australia. Most caves in New Zealand and Tasmania are situated in rain forest or wet sclerophyll forest, and have underground streams ; algae and bryophytes grow in abundance round cave entrances ; bats do not occur in the caves ; and Rhaphidophoridae and Mycetophilidae (Diptera) are the dominant cavernicolous species. Organic debris washed into caves partially compensates for the absence of guano and guanobia, both of which are important food sources for Rhaphidophoridae in mainland Australia and other parts of the world.

TABLE 4

Fit of Dyar's law to instar measurements of hind femora in M. cavernicola *and* M. tasmaniensis

Instar	*M. cavernicola*		*M. tasmaniensis*	
	Observed Length (mm.)	Calculated Length *	Observed Length (mm.)	Calculated Length *
1	5·5	5·9	4·5	4·8
2	7·0	7·1	6·0	6·0
3	9·0	8·6	7·5	7·4
4	11·0	10·4	9·5	9·2
5	13·0	12·6	12·5	11·4
6	15·0	15·3	14·0	14·1
7	18·0	18·5	17·0	17·4
Adult	22·0	22·4	20·5	21·6

Proportionality constant : 1·21 for *M. cavernicola* ;
1·24 for *M. tasmaniensis*.

* From regression line.

In Europe, Trichoptera and Lepidoptera are the main arthropods eaten by rhaphidophorids (Remy, 1931 ; Chopard, 1938), while in New Zealand Hemiptera and Diptera are eaten (Richards, 1962). In Tasmanian caves no Lepidoptera occur as they breed in and are closely associated with guano, and no Hemiptera have been recorded. Trichoptera and Diptera both occur in the caves, but no arthropod remains from rhaphidophorid crops have yet been identified.

The simultaneous occurrence of all instars in both *Micropathus cavernicola* and *M. tasmaniensis* is unusual, and this is the first record among Rhaphidophoridae. However, it is known that the length of the developmental period in rhaphidophorids varies considerably within a species (Richards, 1961). This, together with the presence of two generations in the population, will to a large extent explain the full range of instars in *Micropathus* in November 1966. It is probable that all instars are present only during spring and early summer when hatching is occurring and overwintering nymphs are maturing into adults.

With the addition of *M. cavernicola* and *M. tasmaniensis*, the exact number of pre-adult instars has been determined for nine species of Rhaphidophoridae. The number of ecdyses in these species ranges from six to eleven, but is most commonly from six to eight (Ramsay, 1964). Both species of *Micropathus* pass through seven ecdyses. Sexual dimorphism does not occur in *Micropathus*, the same number of instars being present in both males and females. The two species are approximately the same size, which agrees with Hubbell's (1936) conclusion that the number of pre-adult instars in the life cycle of Rhaphidophoridae is related to the size of the adult insect.

Acknowledgements

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References

CHOPARD, L., 1938.—"*La Biologie des Orthoptères.*" Paul Lechevalier. Paris. 541.

GOEDE, A., 1967.—Tasmanian cave fauna: character and distribution. *Helictite,* 5: 71-86.

HUBBELL, T. H., 1936.—A monographic revision of the genus *Ceuthophilus. Univ. of Florida Publ.,* Vol. II, No. 1. 551.

RAMSAY, G. W., 1964.—Moult number in Orthoptera (Insecta). *N.Z. J. Sci.,* 7: 644-666.

REMY, P., 1931.—Observations sur les Moeurs de quelques Orthoptères Cavernicoles. *Ann. Sci. Nat.-Zool.* (10) 14: 263-274.

RICHARDS, Aola M., 1961.—The life history of some species of Rhaphidophoridae (Orthoptera). *Trans. roy. Soc. N.Z. Zoology,* 9: 121-137.

————, 1962.—Feeding behaviour and enemies of Rhaphidophoridae (Orthoptera) from Waitomo Caves, New Zealand. *Trans. roy. Soc. N.Z. Zoology,* 15: 121-129.

————, 1964.—The Rhaphidophoridae (Orthoptera) of Australia. 1: Tasmania. *Pacific Insects,* 6: 217-223.

————, 1966.—The Rhaphidophoridae (Orthoptera) of Australia 3: A new genus from south-eastern Australia. *Pacific Insects,* 8: 613-624.

————, (in press).—The Rhaphidophoridae (Orthoptera) of Australia. Part 6. Two new species from northern Tasmania. *Pacific Insects.*

GONIOCLADIA AND *DYSCRITELLA* FROM THE PERMIAN OF QUEENSLAND

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(Plates XV-XVII)

[Read 29th November, 1967]

Synopsis

In the Queensland Permian, the polyzoan genera *Goniocladia* and *Dyscritella* are represented by the species *Goniocladia immensa* sp. nov. and *Dyscritella corella* sp. nov. This is the first record of both genera from this area and the first record of *Goniocladia* from the Permian of Eastern Australia. Both have their closest affinities with species occurring in the Western Australian Permian.

INTRODUCTION

Recent collections by the writer from the limestone of the Buffel Formation, south of Cracow, Queensland, revealed numerous fragments of a cyclostomatous polyzoan. One specimen exhibited a definite fenestrate habit with an undulating obverse surface. The weathered nature of this surface and the habit of the colony prevented all pertinent morphological features being recorded but those obtained are considered adequate to enable the species to be assigned to *Goniocladia*. *Fistulipora* sp. has been described by Wass (in press) from a similar locality and horizon but because of insufficient information on this species it is not possible to state whether it and *Goniocladia immensa* are conspecific.

Runnegar (1963) mapped an area of Permian sediments in the Maryborough Basin, north-west of Gympie, Queensland. The rich Permian fauna contained some Polyzoa, amongst them being a fine, ramose species which has been assigned to *Dyscritella*. This is the first definite record of this genus from the Queensland Permian. Hill (1957) lists *Dyscritella* sp. in a faunal list from the Dilly Beds near Springsure in the Bowen Basin but it is unaccompanied by descriptions or figures.

Abbreviations of repositories used throughout the text are :

U.Q. University of Queensland, Dept. of Geology Collection, Brisbane.

S.U. University of Sydney, Dept. of Geology Collection, Sydney.

U.W.A. University of Western Australia, Dept. of Geology Collection, Perth.

C.P.C. Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Canberra.

SYSTEMATIC DESCRIPTIONS

Order CYCLOSTOMATA Busk, 1852
Family GONIOCLADIIDAE Nikiforova, 1938
Genus *Goniocladia* Etheridge, 1876

Carinella Etheridge, 1873, p. 433.

Goniocladia Etheridge, 1876, p. 522.

Goniocladia Etheridge ; Bassler, 1929, p. 88.

Goniocladia Etheridge ; Shulga-Nesterenko, 1933, p. 5.

Type Species.—(By monotypy) *Carinella cellulifera* Etheridge, 1873, p. 433, pl. 15, figs 1-3, from the Carboniferous Limestone Series of Scotland.

Diagnosis.—Zoarium reticulate with bifoliate branches bifurcating pinnately or irregularly and sometimes anastomozing, forming polygonal fenestrules; zooecia, separated by vesicular and dense tissue on both sides of median lamina, are tubular, without hemisepta and rarely developed diaphragms; zooecial apertures arranged in rows opening on obverse surface, sometimes with lunaria or peristomes of varying outline; median lamina with fine tubuli, expressed externally as a carina bordered by non-celluliferous tissue on both obverse and reverse surfaces.

GONIOCLADIA IMMENSA, sp. nov.

(Pl. XV, Figs 1-4; Pl. XVI, Figs 1, 2, 4)

Holotype.—S.U. 16413 from the Buffel Formation, at 32108453 Mundubbera 1 : 253,440 military map, three-quarters of a mile, north-west of "Cracow", six miles south of Cracow, Queensland.

Paratypes.—S.U. 16414-16416 from the above locality.

Diagnosis.—Coarse *Goniocladia*: branches wide and angular; fenestrules large, polygonal or elongate hexagonal; zooecial apertures in numerous rows on obverse surface; zooecia tubular, sometimes with diaphragms.

Description.—The zoarium is fenestrate with one incomplete specimen measuring 30 mm. square. Fenestrules are polygonal, 7·10 mm. to 13·90 mm. long and from 4·20 mm. to 5·70 mm. wide. Branch width varies from 2·90 mm. to 4·50 mm. Bifurcation occurs in a plane normal to the median lamina. Because of preservation the number of rows of zooecial apertures cannot be determined exactly but it is greater than four. Apertures are approximately 0·24 mm. in diameter, are surrounded by peristomes and possess small, inconspicuous lunaria in some places. Zooecial tubes are long and tubular; for a short distance they parallel the median lamina then diverge gradually to meet the periphery obliquely. They are crossed by sparse diaphragms separated by 0·60 mm. but in one exceptional case, three diaphragms are found in a space of 0·40 mm. Diaphragms are either straight or concave inwards. In all sections dense tissue is common adjacent to the median lamina and is replaced by vesicular tissue in the peripheral region. The vesicular tissue is coarse and occupies the greater portion of the interspaces.

An interesting feature is the pattern traced by the median lamina. In one area, repeated bifurcation enables the lamina to follow a polygonal pattern which results in it abutting against the periphery of an older branch.

Discussion.—*Goniocladia immensa* is a much larger species than *G. laxa* (de Koninck), 1877 and *G. parva* Crockford, 1947 from the Lower Carboniferous of New South Wales. These two species are also devoid of diaphragms. *Goniocladia americana* Girty, 1909, from the Guadalupian of U.S.A. has branches of similar width but possesses smaller fenestrules. None of the species described by Shulga-Nesterenko (1933) are comparable with the Queensland species; *G. cyclopora* var. *magnafenestrata* Shulga-Nesterenko, 1941, from the Lower Permian of the Pechora region seems to be the only Russian species to approach *G. immensa*. It has fenestrules of similar length but is smaller in other measurements. *G. timorensis* Bassler, 1929, from the Basleo Beds of Timor is a smaller species. C.P.C. 1111A assigned to this species by Crockford (1957) shows the reverse surface. Branches are of similar width but fenestrules are smaller than in *G. immensa*. *Goniocladia indica* Waagen and Pichl, 1887, described originally from the Salt Range is poorly known, but comparison of the Cracow material with that assigned to *indica* by Crockford (1957) from the Fitzroy Basin, Western Australia, reveals that the two species are most similar. Specimen 22336C, U.W.A. of *G. indica* has a branch width of 1·75 mm. and a fenestrule length and width of 7·90 mm. and 5·00 mm. respectively (Pl. XVI, Fig. 3). C.P.C. 1078B (Pl. XVI, Fig. 5) has comparable measurements together with three, and sometimes four rows of zooecial apertures. Only the type locality in the Buffel Formation which can be correlated with Fauna II of Dickins (in Dickins *et al.*, 1964) has yielded specimens of *Goniocladia immensa.* Additional specimens catalogued are S.U. 16417-16424.

Order TREPOSTOMATA Ulrich, 1882
Family STENOPORIDAE Waagen and Wentzel, 1886 rev. and emend. Duncan, 1949
Genus *Dyscritella* Girty, 1911

Dyscritella Girty, 1911, p. 194.

Dyscritella Girty ; Lee, 1912, p. 151.

Dyscritella Girty ; Bassler, 1941, p. 178.

Dyscritella Girty ; Crockford, 1943, p. 259.

Type Species.—(By original designation) *Dyscritella robusta* Girty, 1911, p. 193 from the Fayetteville Shale of Arkansas, U.S.A. (Bassler, 1941, p. 178, figs 18-20).

Diagnosis.—Zoarium ramose or encrusting; zooecia tubular, without diaphragms, thin walled in axial region, evenly thickened in peripheral region ; apertures oval or rounded ; mesopores and acanthopores present, the latter usually of two sizes.

DYSCRITELLA CORELLA, sp. nov.

(Pl. XVII, Figs 1-7)

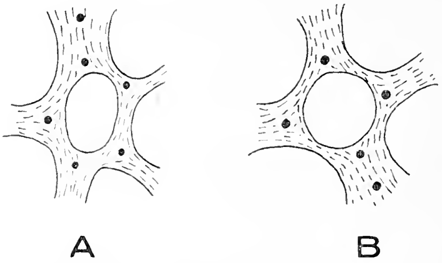
Holotype.—U.Q. 52939 from the middle part of the " upper limestone, Middle Gympie Formation ", at 752544 Gympie 1 : 63,360 military map, about one mile west of Mount Corella and 6·5 miles north-west of Gympie, Queensland.

Paratypes.—U.Q. 52940, 52941, 52945, 52948 from the above locality.

Diagnosis.—Fine, ramose species of *Dyscritella* with a few, small acanthopores which increase in number near the occasional mesopore.

Description.—Zoaria are ramose with a diameter of 1·30 mm. to 1·90 mm. Zoarial diameter increases from 1·44 mm. to 1·80 mm. proximal to widely spaced bifurcations. These occur immediately distal to a growing tip and brauches produced are mutually perpendicular. Measurement of their diameter cannot be effected because of poor preservation. Zooecial apertures are oval and arranged in irregular diagonal and longitudinal rows. They are 0·26 mm. to 0·32 mm. long and 0·12 mm. to 0·16 mm. wide. Centres of successive apertures in a longitudinal row are separated by 0·50 mm. to 0·80 mm. Mesopores, 0·12 mm. in diameter, are developed occasionally. They are associated with more acanthopores than the usual three or four surrounding an aperture. Acanthopores which are placed adjacent to, or at the proximal end of the zooecia develop in the axial region. Zooecial walls are thin in the axial region and diverge gradually at 25° to 30° from the growth direction. In the peripheral region they thicken rapidly and meet the periphery at 65° to 80°. Walls of the peripheral region are thickened evenly except if a growing tip is present. In this region an annulation is evident at the junction with the axial region. Growing tips have been observed 10 mm. apart. The peripheral region occupies from one-quarter to more than one-third of the zoarial diameter. In zoaria of diameter, 1·70 mm. and 1·90 mm., the width of the peripheral region is 0·65 mm. and 0·45 mm. respectively.

Discussion.—This new species can be distinguished from the other two species described from Eastern Australia, *Dyscritella restis* Crockford, 1943 (text fig. 2A, the larger of the diagrams labelled 3A) and *D. porosa* Crockford, 1943 by its almost complete absence of mesopores and the small acanthopores of one size. *D. tenuirama* Crockford, 1957 exhibits a diagonal rather than a longitudinal orientation of the zooecial apertures. This, together with the presence of more mesopores results in the acanthopore arrangement being more irregular than in *D. corella* (see Text Figure 1). Bending of zooecial tubes into the peripheral region is more gradual and the thickening of zooecial walls is less abrupt in *D. tenuirama.* Linear measurements of the two species are very similar.



Text-fig. 1. *Dyscritella tenuirama* Crockford, 1957, from the Noonkanbah Formation, Western Australia. C.P.C. 1161, drawing to show relation of acanthopores to zooecial apertures. (Not to scale).

Dyscritella corella was originally thought to belong to *Rhombopora* Meek, especially as in longitudinal section it showed the absence of hemisepta, diaphragms and a true vestibulum with an abrupt thickening of the walls in the peripheral region. These features are characteristic of " topotype " material of *Rhombopora lepidodendroides* Meek in the S.U. Collection but the most objective characters of this species are the form, nature and abundance of the acanthopores and the longitudinal and diagonal orientation of the zooecial apertures. Material studied is from the same horizon as *R. lepidodendroides* and as close as possible to the original locality. Features considered here can be observed also on " topotype " material in the United States National Museum.

The irregular orientation of zooecial apertures and nature of the acanthopores with the development of the occasional mesopore satisfy me that the species is best assigned to *Dyscritella.*

Dyscritella corella has been found only at the type locality. This stratigraphic horizon can be correlated probably with Fauna IV of Dickins (in Dickins *et al.*, 1964). Additional specimens catalogued are U.Q. 52942-44, 52946-47, 52949-51.

In addition to the above species, two specimens referable to *Saffordotaxis* sp. and ? *Ptylopora* sp. are catalogued as U.Q. 52952 and 52953 respectively from the locality of *D. corella.* 52952 is a transverse section which shows the zooecial tubes arising from a central point (Pl. xvii, Fig. 8). The specimen referred to ? *Ptylopora* sp. is a weathered surface with a main branch from which arise two secondary branches. The secondary branches are joined by a dissepiment (Pl. xvii, Fig. 9).

CONCLUSIONS

As palaeontological studies of Eastern Australian Permian faunas progress, many genera new to this area but common in the Permian of Western Australia emerge. Wass (in press) has recorded many polyzoan genera and species from the Bowen Basin which are common in the Permian of Western Australia. Their distribution and implications are being studied. Whereas some phyla also exhibit notable differences from the Western Australian faunas, studies of Polyzoa have shown the Eastern and Western Australian Permian faunas to be markedly similar. The occurrence of *Goniocladia* in the Eastern Australian Permian and the presence of *Dyscritella corella,* so similar to *D. tenuirama,* are considered to be of palaeogeographic significance. Further studies of Eastern

Australian polyzoans and of Western Australian Permian Polyzoa from the Lower Permian of the Canning Basin, and the Carnarvon and Perth Basins may continue to exhibit this similarity.

Acknowledgements

I wish to thank Dr. B. N. Runnegar, Department of Geology and Mineralogy, University of Queensland, who kindly lent his polyzoan specimens for study and Mr. T. N. Nicholas, Bureau of Mineral Resources, Canberra who made available C.P.C. material used by Crockford (1957). Mr. E. J. Armstrong sectioned some ot the material and Mr. G. Z. Foldvary assisted with photographic aspects. The study was financed by a Research Grant from the University of Sydney.

References

Bassler, R. S.,1929.—The Permian Bryozoa of Timor. *Palaont. Timor*, 16 (28) : 37-90.

————, 1941.—Generic descriptions of Upper Palaeozoic Bryozoa. *J. Wash. Acad. Sci.*, 31 : 173-179.

Crockford, J. M., 1943.—Permian Bryozoa from eastern Australia, Part III : Batostomellidae and Fenestrellinidae from Queensland, New South Wales and Tasmania. *J. Proc. roy. Soc. N.S.W.*, 76 (4) : 258-267.

————, 1947.—Bryozoa from the Lower Carboniferous of New South Wales and Queensland. Proc. Linn. Soc. N.S.W., 72 : 1-48.

————, 1957.—Permian Bryozoa from the Fitzroy Basin, Western Australia. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*, 34.

Dickins, J. M., Malone, E. J., and Jensen, A. R., 1964.—Subdivision and correlation of the Middle Bowen Beds, Queensland. *Rep. Bur. miner. Resour. Geol. Geophys. Aust.*, 70.

Duncan, H., 1949.—Genotypes of some Palaeozoic Bryozoa. *J. Wash. Acad. Sci.*, 39 (4) : 122-136.

Etheridge, R., 1873.—Description of *Carinella*, a new genus of Carboniferous Polyzoa. *Geol. Mag.*, 10 : 433-434.

————, 1876.—Carboniferous and Post Tertiary Polyzoa. *Ibid.*, N.S., 2 (3) : 522-523.

Girty, G. H., 1909.—The Guadalupian Fauna. *Prof. Pap. U.S. geol Surv.*, 58.

————, 1911.—New genera and species of Carboniferous fossils from the Fayetteville Shale of Arkansas. *Ann. N.Y. Acad. Sci.*, 20 : 189-238.

Hill, D., 1957.—Explanatory notes, Springsure 4-mile geological series. *Note Ser. Bur. miner. Resour. Geol. Geophys. Aust.*, 5.

de Koninck, L. G., 1877.—Recherches sur les fossiles Paleozoiques de la Nouvelle-Galles du Sud (Australie) ; Texte et atlas. *Mem. r. Soc. Sci. Leige*, 2nd Ser., II.

Lee, G. W., 1912.—The British Carboniferous Trepostomata. *Mem. geol. Surv. U.K.*, 1 (3) : 135-195.

Runnegar, B. N., 1963.—Unpub. Hons. Thesis, Dep. Geol. Univ. Qd.

Shulga-Nesterenko, M. I., 1933.—Bryzoa from the coal bearing and subjacent series of Pechora Land : *Goniocladia* Etheridge and *Ramipora* Toula, Carboniferous and Permian representatives of the family Cystodictyonidae. *Trudy vses. geol-razv. ob''ed. NTKP*, 259.

————, 1941.—Lower Permian Bryozoa from the Urals. *Paleontologiya SSSR*, 5 (5), 1.

Waagen, W., and Pichl, J., 1887.—Salt Range fossils 1, *Productus* limestone fossils. *Mem. geol. Surv. India, Palaeont. indica*, Ser. 13 : 771-814.

Wass, R. E., (in press).—Permian Polyzoa from the Bowen Basin, Queensland. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*

EXPLANATION OF PLATES XV–XVII

PLATE XV

Fig. 1. *Goniocladia immensa*, sp. nov.; S.U. 16413, before sectioning. X5.

Fig. 2. *Goniocladia immensa*, sp. nov.; S.U. 16413, after sectioning. X3.

Fig. 3. *Goniocladia immensa*, sp. nov.; S.U. 16416, showing median lamina and diaphragms across zooecial tubes. X10.

Fig. 4. *Goniocladia immensa*, sp. nov.; S.U. 16415, showing relation of zooecia to median lamina and closely spaced diaphragms across zooecia. X10.

PLATE XVI

Fig. 1. *Goniocladia immensa*, sp. nov.; S.U. 16413, showing shape of zooecial tubes in transverse section and diaphragms across tubes. X10.

Fig. 2. *Goniocladia immensa*, sp. nov.; S.U. 16414, showing bifurcation of median lamina, relation between dense and vesicular tissue and diaphragms across zooecial tubes. X10.

Fig. 3. *Goniocladia indica* Waagen and Pichl ; U.W.A. 22336C from the Noonkanbah Formation' Western Austral X4 approximately.

Fig. 4. *Goniocladia immensa*, sp. nov.; S.U. 16413, showing median lamina of branch abutting against lateral portion of an older branch (polished section). X10.

Fig. 5. *Goniocladia indica* Waagen and Pichl; C.P.C. 1078B from the Noonkanbah Formation, Western Australia. X3.

PLATE XVII

Fig. 1. *Dyscritella corella*, sp. nov.; U.Q. 52939, longitudinal section with annulations developed at the base. Cross structures in zooecial tubes result from structure of calcite. X10.

Fig. 2. *Dyscritella corella*, sp. nov.: U.Q. 52939, tangential section showing relation of zooecial apertures and acanthopores. X20.

Fig. 3. *Dyscritella corella*, sp. nov.; U.Q. 52945, longitudinal section showing branching developed distal to growing tip. X10.

Fig. 4. *Dyscritella corella*, sp. nov.; U.Q. 52939, transverse section. X20.

Fig. 5. *Dyscritella corella*, sp. nov.; U.Q. 52940, longitudinal section showing zooecia oblique to the periphery. X10.

Fig. 6. *Dyscritella corella*, sp. nov.; U.Q. 52944, longitudinal section. X10.

Fig. 7. *Dyscritella corella*, sp. nov.; U.Q. 52946, oblique longitudinal section. X10.

Fig. 8. *Saffordotaxis*, sp.; U.Q. 52952, transverse section. X20.

Fig. 9. ? *Ptylopora*, sp.; U.Q. 52953. X5.

ANTHONY REEVE WOODHILL, 1900–1965

(*Memorial Series No. 21*)

(With Portrait, Plate xviii)

With considerable pleasure, and without misgivings, we accepted the invitation to prepare a Memorial Notice in honour of the late Anthony Reeve Woodhill, for long a member, council member, and also a past President of the Linnean Society of New South Wales.

As time went on and we thought more deeply into this task, we found it easy to give a facile appreciation of our late teacher and friend and much more difficult to put the convictions we felt into the usual words used on such occasions. Our difficulties lay in the fact that Woodhill was not a flamboyant character about whom an endless string of anecdotes could be related, nor was he a spectacular teacher from whose lectures inspiring passages could be quoted, nor was he a controversial figure arousing the ire of some and the acclamation of others.

A. R. Woodhill had no airs or poses, he sought no favours for himself, there was no striving to impress. On these counts he might have been regarded as a colourless personality, but his personal appearance and austere reserve would dispel any such judgement on first meeting. Woodhill's students usually accepted him as a man standing on his own, essentially complete and independent, with no known ties and no need for such ties. When a man is accepted in this way it usually indicates a strength of character and individualism, and those who had close associations with Woodhill soon learned that he was indeed such a man.

There is no doubt that Woodhill was a strong character but perhaps not in the usual usage of this phrase. His strength lay in the complete and unswerving consistency of his thoughts and deeds ; this was certainly the case in the thirty years we knew him, and for fifteen years beyond that to some of our colleagues who knew him from the time he entered the University of Sydney as an undergraduate.

We might have left it at this and enlarged on his contributions to our Society, but as we thought and recollected, and fitted Woodhill into the pattern of entomological development and achievement in Australia during this century, we wondered, as have others, whether Woodhill was accidentally in the hub of this development or whether he personally played any important roles. He did not, as others in related disciplines of biology were able to do, persuade governments that this or that action should be taken, he did not campaign for particular things to be done, nor did he seek, or attract, finance to sponsor his own researches or develop his department. Yet he did give New South Wales, and Australia, many of the entomologists it needed in the 1930's to early 1950's. Was this inevitable ? Would it have happened no matter who was the teacher ? Or did Woodhill make a personal contribution through his students ?

To answer all this we must endeavour to understand Woodhill. What was his strength ? What was his contribution ?

We have said that students accepted Woodhill as an independent individual. Yet he had family ties and traditions ; these he must have accepted since he remained true to them throughout his life. Woodhill was a member of an English family whose records go back to about 1670. There must have been a sense of family pride, of tradition and of unity, which infused into Anthony Woodhill throughout his youth. As far as we can glean he must have accepted this as part of himself for he never mentioned it, not even the fact that the village of Woodhill, near Nowra, derived its name from his family.

His grandfather, Alfred Meredith Woodhill, was born in Birmingham, England, in 1835 and later migrated to Australia where he weathered a series of vicissitudes of fortune before he became established as a successful country merchant.

He placed on record the history of the Woodhill family in " The Woodhill Family Record " published June 2nd, 1905, by F. H. Booth, Sydney. The family copy we have seen has been kept up to the present date, as was intended, by various members of the family. In it appears the family genealogy, and an account of the fortunes of Alfred Meredith Woodhill in his endeavours to succeed in his adopted country. The family was traditionally English, royalist and conservative. This flowed with undiminished vigour to Anthony Woodhill whose loyalty to King and Queen was unswerving throughout his lifetime.

There was also a tradition of service, again best expressed by the grandfather, who published

The Hawkesbury and Shoalhaven
Calendar,
Cultural and Cookery Guide
and
Useful Household Compendium

With Some Sketches of Pioneer Residents and
Notes on Early Settlement

(Illustrated)

Presented by
Woodhill & Co., The Universal Providers,
To the People of
Richmond, Windsor, Kurrajong, Nowra,
Berry, Cambewarra, Kangaroo Valley
and Surrounding Districts

1905
Printed for the Publishers by
THE WOODHILL PRINTING WORKS
127 York Street, Sydney

This book of 128 pages, plus a 64 page Cookery Guide, was certainly a handsome Christmas present for the customers of Woodhill & Co. and merited the following review in the Sydney Mail, Nov. 30, 1904. " The Woodhill Printing Works, Sydney, forwards ' The Hawkesbury and Shoalhaven Directory ', a compilation dealing with two of the most interesting districts of the State, for which Mr. A. M. Woodhill is responsible. It is at once calendar, diary, ' cultural, and cookery guide ', and compendium of information regarding old settlers of the Hawkesbury and the Shoalhaven. And its value is increased by numerous portraits and illustrations of stock and of the beauty spots of the district. Mr. Woodhill's book reflects credit upon his industry, and should be of value, and the idea of preparing and presenting it to the friends of the firms branches at Richmond and Nowra was a happy one ".

Grandfather Woodhill was not only a merchant; he was interested in the people who gave service to the community, in the country itself and the means by which his customers earned their livings.

We have mentioned A. R. Woodhill's inheritance of a traditionally English conservative outlook, we can also suggest that a tradition of service to the community (not in the present day manner, but in a deeper and far less conspicuous way), an interest in the country, and in enlightened farming, may also have been part of this inheritance. But inheritance is seldom complete and no vestige of a merchant tradition ever reached him.

Grandfather Woodhill married Jane Kidd, born in 1836 at Launceston, Tasmania. They had seven sons and two daughters. Of these Alfred Robert Woodhill (born 1860) was Anthony's father. His mother was born Agnes Mary Pepper (1866, Richmond, Victoria). Anthony was their youngest child (born 1900) there being two others, Judith Gertrude (born 1890) and Geoffrey Guy (born 1895).

At the time of Anthony's birth his family was at Nowra, but owing to the ill-health of his father they moved to Wentworth Falls where his father recovered and lived to the age of 73. With his elder brother Geoffrey, of whom he was very fond, Anthony used to walk about the mountains and valleys, and for the rest of his life he had a special liking for the Grose Valley which he used to revisit to camp and fish even after his return from World War II.

Anthony was educated at the Woodford Academy on the Blue Mountains and his early ambition was to go on the land. On leaving school he spent two years at the Wagga Experiment Farm. However, family finances made this ambition impracticable so he came to the University of Sydney to do the course in Agriculture, entering the faculty in 1920 and graduating on 29th May, 1924.

His fellow students throughout this course were Charles Magee recently retired Chief of the Division of Biological Services, New South Wales Department of Agriculture, Professor J. R. A. McMillan recently retired Dean and Head of the Faculty of Agriculture at Sydney University, and M. L. G. Sheldon, now Deputy Principal of the Sydney Teachers' College.

From the time A. R. Woodhill graduated he was an entomologist, and at this point we have to pause to review the past history of the teaching and practice of this discipline and the changes that were commencing to take place and which continued with increasing tempo throughout most of Woodhill's professional career.

The Faculty of Agriculture had commenced operation in 1910, but none of the students of the first ten years emerged as practising entomologists. W. W. Froggatt, then Government entomologist in the New South Wales Department of Agriculture, taught the entomology course from the inception of the Faculty up to 1921. He is chiefly remembered, as was often recounted by Woodhill, for introducing insects as " bitin', chewin', or suckin' " as they went " hoppin', skippin' or jumpin' about " (he is also remembered for a vast series of publications on entomology).

Woodhill took Froggatt's course, but from 1922 onwards the course in entomology was given by A. J. Nicholson who later became Deputy Chief, later Chief, of the Division of Economic Entomology, CSIR (now Division of Entomology, CSIRO). However, Woodhill also took Nicholson's course during 1923. His fellow students remember that he was intensely interested in insects and perhaps gave more time to entomology than was wise. On graduation Woodhill entered the Department of Agriculture as entomologist, being the first graduate ento, mologist to be so appointed. His immediate chief, as Government Entomologist-was W. B. Gurney who, originally appointed to assist W. W. Froggatt in 1900, succeeded him in 1923. Gurney graduated in Science in 1925, the year after Woodhill's appointment.

W. W. Froggatt (appointed Government Entomologist in 1896) was the first official entomologist in New South Wales and, up to the time of Woodhill's appointment, both Froggatt and Gurney had published much on the insect pests of this State. However, the problems were treated largely empirically, and it was only about the time of Woodhill's entry to the department that the empirical approach was being superseded by investigation into the bionomics of individual pests. Woodhill, and others who joined the department shortly after (Allman in 1925, then Hely and Morgan in 1926 and Noble in 1928) were all involved in detailed investigations of the life histories, host relationships and seasonal influences of particular pests. Much of this work was done in exacting detail but little of it was published—only the details that had practical application in primary industry. This was traditional during this period. For one thing the only medium of publication was the Agricultural Gazette of N.S.W. and, although it was accepted in principle that the complete work might appear in a special bulletin, this was seldom achieved since once one problem had been solved for the time being there would be another one demanding investigation. This may well have had an influence on Woodhill's later career, in his concentration on one problem at a time and in his modest statements of his own achievements.

Woodhill worked on blowflies with Gurney, on Dicky Rice Weevil with Allman, on the Woolly Aphid, the Green Peach Aphid, Citrus Red Scale and the Fruit Tree Root Weevil. Zeck who had been appointed to the Entomology Branch in 1923 studied the life history of the Green Peach Aphid, and from this Woodhill developed the idea of a bud swell spray for stem mothers followed by an attack on the eggs. Woodhill did a lot of research on the bionomics of the Citrus Red Scale, but this was never published, partly because as a multivoltine species it was not as amenable to control as a univoltine species such as the White Wax Scale.

Forty years later it is difficult to separate the work of Woodhill, Allman and Hely during this period, nor does it particularly matter. This was the period when control recommendations were being based on careful and detailed observations. The profound influence this approach had on Woodhill's later teaching was shown by the great emphasis he placed on what was then popularly termed " the bionomics of the species ".

This then was the atmosphere of the time ; but what of the man himself ? He was undoubtedly handsome, over six feet tall, straight and with a natural dignity. His walk never varied and has best been described as a nonchalant saunter. He had become known as the " Count " during his undergraduate days and this cognomen remained with him. His hair was cut short and frequently. In those days he wore the very respectable black Indiana socks, smoked Chesterfield cigarettes and always carried an umbrella, or at least that is the impression that remains with his colleagues of this period. He always wore a hat but kept the brim turned up right around. Yet this picture is in part misleading since he was then, and remained until well into his fifties, an active and skilful tennis player. His service is well remembered for the extreme height to which he tossed the ball.

After six years in the Department of Agriculture he succeeded A. J. Nicholson as McCaughey Lecturer in Entomology at the University of Sydney.

Nicholson, a graduate of the University of Birmingham, had developed an excellent course in entomology for students of Zoology in the Faculty of Science and also for the Faculty of Agriculture. In Nicholson's words " the basis of both courses was general systematics, morphology, and general biology. Only sufficient of this was given to Agriculture students to provide a firm basis for an intelligent development of the subject of economic entomology, to which I naturally had to devote as much time as I could. With Science students I made little more than passing reference to insect pests and their control, treating entomology simply as a component of Zoology and going into greater detail with morphology, systematics and biology ".

At this time the only avenue of employment for entomologists in New South Wales was the Department of Agriculture; similar organisations existed in other States. It was not until the CSIR Division of Economic Entomology was formed in 1928 that the Commonwealth itself provided employment for entomologists. This is historically important and is the reason why the best of Nicholson's students (e.g. Allman, Hely, Morgan, Noble and McCulloch) entered the State department. One or two others went elsewhere, e.g., O'Connor. Nicholson taught relatively few students in the Faculty of Science, entomology being the alternative to two terms of Vertebrate Zoology. During Nicholson's tenure, there were only three students in Science who became entomologists; these were Mary Fuller, K. E. W. Salter and C. E. Chadwick.

Nicholson's course, according to the University calendar of the time, comprised 40 lectures and a minimum of 120 hours practical. His main contributions to the teaching of entomology were the design of a sound basic course, the building up of an extensive and very representative systematic collection of insects for teaching, a considerable amount of which still survives, and the institution of field collecting with students.

When Nicholson resigned, the Dean of the Faculty of Agriculture, then Professor R. D. Watt (later Sir Robert) wished to have a lecturer in entomology appointed in the Faculty[1] but the wishes of the Professor of Zoology, then Professor W. J. Dakin, to have both branches of Entomology combined in the Department of Zoology prevailed. When appointed, Woodhill taught the subject known as Economic Entomology to a combined class of Science and Agriculture students.

The change was a little more profound, in that an honours course in entomology which had not been available during Nicholson's tenure was now instituted. This meant that the basic course could be followed by a year of specialisation in the subject, and was of great benefit to the students Woodhill trained to become practising entomologists.

It is unlikely that Woodhill would have changed Nicholson's course in any major way in the early years of his teaching, nor indeed is it likely that there was any need for this. However, Woodhill started teaching at the beginning of the era of insect physiology, and the subject went through a period of vast expansion and development lasting most of his teaching life so that changes were eventually inevitable. Nevertheless, entomology has a broad basis which needs to be learnt by all who practice the discipline and this remained in essence, if not in detail, throughout both the Nicholson and Woodhill periods.

However, Woodhill came from a position as a field investigator to a University Laboratory. He could no longer pursue studies of orchard pests although it was obvious that this was his initial intention—witness the two citrus trees which were planted outside the Entomology building and the Fruit Tree Root Weevil cultures which survived in jars for a year or so. He must have decided that, to continue research, and this he did for the greater part of his teaching career, a type of insect suitable for continuous laboratory culture and experimentation would be necessary. He chose mosquitoes and for some reason no longer known[2] he was intrigued by a particular species restricted in its breeding to saline rock pools on the seashore (then *Aedes concolor*, now *Aedes australis*). This was in the beginning of the 1930's when overseas mosquito investigations were directed to studies of the physical and chemical properties of water likely to stimulate or inhibit the breeding of individual species. Instead of investigating

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[1] It was not until 36 years later (1966) that a lecturer in entomology was appointed in the Faculty of Agriculture.

[2] Miss Isobel Bennett has since informed us that the investigation was suggested by Professor W. J. Dakin who had become fascinated by the ability of this mosquito to exploit exposed rock pools on the sea shore, sometimes filled by rain and at others by seaspray, and sometimes encrusted with salt crystals.

the properties of natural waters Woodhill established laboratory cultures in a series of artificially varied water types. The results were probably a surprise to him. They indicated that the properties of the water were not likely to be the factors determining successful or unsuccessful breeding. He then turned his attention in a similar way to another laboratory species, *Culex fatigans*, and his results were similar in character in so far as larval development was concerned. Still he persisted and introduced *Aedes aegypti* to his experimental waters, adding more and more weight of evidence to the conclusions which, these days, we would regard as almost axiomatic.

Woodhill's work of this period was proof against, where elsewhere there was only dissatisfaction with, the then prevailing ideas of breeding requirements for individual species. Some of his students added to the weight of evidence (D. J. Lee with *Aedes vigilax*, R. H. Wharton with *Aedes aegypti*), but their results were never published. Woodhill started a chain of investigation which continued through several of his students to culminate eventually in the work of A. K. O'Gower who demonstrated the selectivity of the female for particular types of surfaces on which to oviposit. This was a definitive proof of the gradually and widely forming concept that the situations in which a particular mosquito species were to be found breeding were due to the selection of these places for oviposition by the female. In the meantime M. M. H. Wallace had made an important observation, confirmed experimentally by Wharton, of the oviposition requirements of *Aedes notoscriptus*. These are minor points, but their importance lies in the fact that Woodhill initiated a school of mosquito research from which important information emerged over a considerable period of years.

To the students who observed Woodhill undertaking his researches there was salutory example in particular and some stimulation as well. He was meticulous to a degree. He was also imbued with the recently developed ideas of statistically designed field trials and applied the same principles to his laboratory studies. He insisted on replicated experiments and he took into account the possible variables he could detect. He did the work personally, not because of mistrust for others, but because he had the conviction that his responsibility for the results obtained commenced with the inception of the experiment and continued throughout its duration. This was teaching by example and was perhaps the most important means whereby a heritage of scientific integrity and an insistence on a more than adequate weight of evidence was passed to his students.

Who were these students of this period 1930-1938 ? There were of course far more than in the time of Nicholson due to the natural growth of the undergraduate body, but there was also a growing demand for entomologists due, to some extent, to the State Departments expanding, but under the limitations imposed by the depression, and more particularly to the Commonwealth forming the CSIR Division of Economic Entomology in 1928. Many students in the Faculty of Agriculture took Woodhill's course but few majored in Entomology. For the first time a significant number of Science students specialised in Entomology, most of whom took the additional fourth year Honours course.

In 1931[1] F. J. Gay graduated in Science and was the first of Woodhill's students to gain first class Honours and to join CSIR where he remains to this day. J. A. Wright (1932), from Agriculture, went to the State Department first and later joined the old established pest control firm of Houghton & Byrne, eventually to become a director. G. S. Dun (1933), also from Agriculture, went to the New Guinea Service where he remained to retire as principal entomologist in 1967. R. V. Fyffe an Agriculture graduate of 1934 entered CSIR. In 1934 also H. F. C. Davis, with double Honours in Entomology and Botany, eventually initiated the teaching of Zoology in New England University College (now the University

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[1] From here on the year given is that of completion of the course, not the year in which the degree was confirmed.

of New England). D. J. Lee (1935) was next from Science and went initially to CSIR, then to the Department of Agriculture and Stock, Queensland, and later to the University of Sydney and later became Associate Professor in Medical Entomology at the School of Public Health and Tropical Medicine, University of Sydney. D. Gilmour, graduating in 1936, remained at the University of Sydney for a time, then went to Harvard on a James King of Irrawang scholarship and eventually entered CSIR in 1941 to which organization he still belongs. Perhaps the best of all years was 1937, with three honours graduates in Science, D. Margaret Cumpston who later taught in the New England University College and later still did entomological research on malaria vectors in New Guinea ; D. F. Waterhouse who went to CSIR to eventually become Chief of the Division of Entomology, succeeding Nicholson ; and M. F. Day who initially joined CSIR but shortly went to America for several years to finally rejoin CSIR and was later appointed a member of the executive of that organisation. In 1938 K. L. Taylor, from Agriculture, went to the Forestry Department of N.S.W. but later joined CSIRO where he remains.

Later students who pursued an entomological career were L. R. Clark (1938), now in CSIRO ; N. C. Lloyd (1939) of the N.S.W. Department of Agriculture ; G. Pasfield (1940), now Chief Entomologist, Division of Science Services, N.S.W. Department of Agriculture ; G. J. Shanahan (1941), now Senior Entomologist in the same organisation ; D. H. Colless (1942) delayed his honours course until after military service, then undertook malaria research in Borneo, later went to University of Malaya and finally joined CSIRO ; R. H. Wharton (1942), originally a student of H. F. C. Davis at New England, did his honours at Sydney under the guidance of Lee, worked on malaria and filariasis in Malaya for fifteen years and has recently become officer-in-Charge, Entomological Investigations, CSIRO Veterinary Research Station, Yeerongpilly ; M. M. H. Wallace (1942), also under the guidance of Lee, entered CSIRO where he remains ; J. G. Gellatley (1947), B. M. Braithwaite (1948) and E. L. Jones (1948) are in the N.S.W. Department of Agriculture ; A. K. O'Gower (1948), originally an entomologist at the School of Public Health and Tropical Medicine, is now Associate Professor in Zoology at the University of New South Wales ; E. Shipp (1949), is now Senior Lecturer in Entomology at the University of New South Wales ; J. H. Burden (1949), now teaches Entomology at Hawkesbury Agricultural College ; R. G. Lukins (1949) is with CSIRO ; A. L. Dyce (1950) joined CSIRO where he remains ; L. B. Barton-Browne (1950) again is an officer of CSIRO ; W. E. Wright (1950) is in the N.S.W. Department of Agriculture ; B. Johnson (1951) originally went to the Waite Institute but is now Professor of Zoology at the University of Tasmania. Between 1952 and 1957 the following professional entomologists graduated from the Zoology Department and joined the institutions listed : M. A. Bateman, 1952 (CSIRO) ; M. Casimir, 1952 (New South Wales Department of Agriculture ; T. D. C. Grace, 1953 (CSIRO) ; E. M. Reed, 1957 (CSIRO) ; T. V. Bourke, 1957 (N.S.W. Department of Agriculture).

There were, of course, later students, but from this time there was a reduction in the time available for the entomology course and Woodhill was not able to give the same solid grounding in the subject.

Those who benefited most from Woodhill's course were those who took his first course and followed this by sitting for Honours in Entomology in the succeeding year. In these two years the method of approach was quite different.

In the formal pass course Woodhill's success lay in his careful preparation of lecture and practical courses. " Careful " must be emphasized for what he lacked in colourful presentation was more than counterbalanced by his unfaltering delivery of all the information he imparted with professional dignity. He just never stumbled, never forgot a detail nor omitted a pertinent fact. The course itself, as Nicholson's must have done, drew heavily on Imms' " Textbook of Entomology " since this was such an excellent source book on basic entomology. Woodhill added enough of the recent advances in the subject to arouse the interest of students, and also a survey of the more important pests of New South Wales, drawing heavily on the researches of his former colleagues in the State Department.

The result of this was a very solid basis to entomology, both pure and applied, upon which his students could build with confidence either in research or in applied fields.

Woodhill's personal influence was greatest in his Honours course. In this he did not teach but provided guidance and example. Teaching and students dominated his professional life, research he pursued during vacations although some would also be underway in term time. Yet he was always available to his students with never more than an hour or two delay.

The organisation of his department was austere but efficient. His collection of books, selected journals and fairly extensive reprints, together with important specimens of all major groups of insects, were housed in one room. There was seldom a student question which could not be answered within that room.

By the time his students had entered their honours year they were usually capable of selecting their own research project. Woodhill allowed a great deal of freedom of choice, although he did give guidance on what he considered would or would not merit an Honours degree. He was not over concerned with a successful conclusion of the project, possibly because some of his own early work had had no satisfactory outcome. His assessments were based on observation of the student's ability to handle and develop his project. Guidance was given when asked for but the student definitely had to establish his ability to stand on his own feet. The project was not all; students were thoroughly grounded in the use of literature sources, there were more advanced exercises in anatomical dissection of insects, microtomy, and anything else the student might desire to do, and perhaps the most important of this miscellany, identification in most orders by means of keys. Woodhill stressed the use of keys and insisted that his students should be able to use the best of those available. He was also adamant that there should be complete absence of ambiguity in keys prepared by his students or colleagues.

One important point has so far been overlooked. From the time of Lee it became common practice to combine senior Zoology with Physiology (then a combined course of Physiology and Biochemistry). This was out of Woodhill's field, but in keeping with the overseas trends of that period—notably the developing emphasis on insect physiology. Inevitably some of his students became interested in the investigation of physiological problems and Woodhill was pleased to have students tackling problems for which he himself lacked the basic training. Whether it was insect physiology or any other specialization in entomology there is no doubt that he derived great satisfaction from seeing the subject he taught being extended into new fields.

The essence of all this is really that Woodhill provided a very sound basic training in entomology from which could emerge any type of entomological specialisation suited to the individual student.

In his thinking Woodhill was conservative and at times inflexible, but in his dealings with students he could be convinced if the student was able to produce strong arguments—nay, more than that, real evidence. A student who could convince Woodhill had every reason to be confident in his ideas !

Woodhill had certain other attitudes to students. He did not actively seek to take advanced students, as he felt it was a violation of his trust to train more students than could reasonably hope to gain employment in a relatively small field. He discouraged women students for he realised that they had no chance of employment in State departments and few prospects elsewhere if they continued with entomology.

Woodhill realised his need to know more of insect physiology, so in 1939 he took his only sabbatical leave to visit England and work with Wigglesworth. This visit was prematurely terminated because of the outbreak of World War II. He chafed to get home and enlist partly because of his strong feelings for the British Empire, and partly because he had lost his well-loved brother Geoffrey, killed at Poziers in 1916 during World War I.

On his return to Australia he found that because of manpower restrictions he would not be able to enlist as a private but had to wait until 1941 when he was accepted as a commissioned officer.

While a member of the armed services he undertook teaching and research activities, mostly on mosquitoes but at one point, and rather to his disgust, also on mites but this only briefly.

His first major task was to assist in the investigation of the 1942 outbreak of malaria in the civilian population of Cairns. Prior to this no vector had been incriminated for any part of the mainland of Australia. This was a particularly interesting and important exercise with most of those most competent to solve the problem present. G. M. Heydon and A. J. Bearup were there on the parasitological side, F. H. Taylor, Woodhill and F. H. S. Roberts on the entomological, with I. M. Mackerras and N. H. Fairley also present part of the time. The important entomological result was the identification of *Anopheles farauti* (then *An. punctulatus moluccensis*) as the vector at Cairns. This species had not previously been identified from Queensland, although later checks in collections showed that it had been previously collected but misidentified.

Despite published records to the contrary we are quite certain from our perusal of Army documents of that period, and from those present at the time, that the credit for this identification goes to Woodhill. Taylor, who was the recognised authority at that time would make no identifications other than of the two species known to occur (*annulipes* and *amictus*). Heydon cast doubt on some of these identifications, and the situation although probably rather bitter at that time, is amusing in retrospect. It is easy to imagine Woodhill, using keys and the scanty literature available, ploughing doggedly towards an identification at variance with the categorical determination of the expert. Woodhill had no time for unsubstantiated opinions, he would have insisted on verification, almost scale by scale. Heydon's personal diaries are interesting for this period. He was apparently convinced all the time, from his considerable experience in Rabaul, that the culprit was indeed *An. farauti* as he referred to it throughout his diaries for this period by the then current name *moluccensis*. However, probably from professional loyalty to his fellow worker, Taylor, he made no such reference in his official correspondence.

At this point Woodhill embarked on a study of a section of the genus *Anopheles*, for which he undertook extensive field work in the Northern Territory, followed by laboratory studies at the University of Sydney and in the field in New Guinea, much of this being done in collaboration with Lee working at the University of Sydney.

Woodhill was not a systematic entomologist and would probably never have embarked on any systematics if it had not become necessary in the course of his Army duties. Nevertheless, he was quite capable of solving taxonomic problems. He did this, not by recognising a species intuitively, but by meticulous attention to detail and the exacting examination of precisely the same features in hundreds, and later thousands, of individual specimens. He never let himself be unduly influenced by the work of others and in the course of this work gave a salutory demonstration of the real value of his approach. Woodhill collected a species in the Northern Territory which he was unable to identify. Lee who had been studying exotic species was able to make a positive identification of *Anopheles novaguinensis* from the original description. Woodhill later studied this species in Sydney and discovered a most striking character by which this species could be identified. This had been overlooked in the original description and had passed unnoticed by Lee.

Woodhill was in Salamaua during May-July 1944. While there he concentrated on the *Anopheles punctulatus* complex trying to resolve the status of the frequently observed morphological intermediates between what were then known as *Anopheles punctulatus punctulatus* and *Anopheles punctulatus moluccensis* (now *An. punctulatus* and *An. farauti*). This study was published (Woodhill, 1946) and the original hypothesis of Lee and Woodhill (1944), that these intermediate forms were a result of hybridization, while not confirmed, was strongly supported by the evidence obtained.[1]

Woodhill's findings at Salamaua were conservatively stated in his 1946 paper. Here he presented the observations he considered clinched the hypothesis that intermediate forms were hybrid in origin. Much of his labour went unrecorded. He does not mention for example that he bred 15,000 adults from larvae collected in a particular area to establish the purity of the *An. punctulatus* population at this locality. This, and other evidence, usually massive and never trivial, he outlined in correspondence to D. J. Lee.

The above is an example of Woodhill's insistence, in his own work, on an overwhelming weight of evidence. This did not fail to make its impression on his students even though they may have considered it as scientific integrity carried to the extreme.

Was this insistence on weight of evidence, followed by a modest presentation of results, an inherent part of Woodhill's individuality? Certainly it was in keeping with his character but it was also a likely result of his training in the New South Wales Department of Agriculture, possibly due to the influence of Gurney, but possibly simply a product of the circumstances of the times.

Woodhill considered his work on *Anopheles* was the best he had done and only he could fully realise the effort it cost him. Hence he decided to submit his research papers for a doctorate and was awarded a D.Sc. Agr. in 1951. To his students this was an occasion for celebration and all available former students, and their wives, gave Dr. and Mrs. Woodhill a congratulatory dinner at the Sydney University Union.

His finding of a new subspecies of *Aedes scutellaris* (*Ae. scutellaris katherinensis*) in the Northern Territory, together with his study of subspeciation in *Anopheles punctulatus* led him to embark, in the post-war years, on a further line of mosquito investigation, the crossing of related species and subspecies. This he proceeded to do with precisely the same attention to meticulous detail and incorporation of controls in his experiments as he had always used. Because of this he was more likely to be right than others who sometimes produced contrary results. In this work the organisation of his colonies was more exacting than before; a single mosquito placed in the wrong cage could produce false results and this worried Woodhill at times, hence his insistence on doing everything himself.

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[1] This was despite the fact that a new species, *An. koliensis* Owen, had been described from the Solomon Islands, this species being indistinguishable from some of the presumed hybrid forms observed in New Guinea. To this day, despite a period of insistence on the separate specific identities of *punctulatus, farauti* and *koliensis*, the controversial issue has not been resolved to the satisfaction of all. Metselaar (1957) while adopting the three closely related taxa as species, as established by Belkin, Knight and Rozeboom (1945) also remarked on the preference for Australian workers to regard them as subspecies conceding that " the problem still awaits solution ". Few would be adamant that one or other of the extreme views is the only answer. Probably both are correct but the circumstances under which either one obtains remains to be explained and no doubt complex problems of genetics and ecology are involved.

At the time this work was a contribution to the general body of knowledge on the cross-mating potentialities of closely related species, but one important finding was a peculiar kind of non-reciprocal fertility within the *Aedes scutellaris* complex (Woodhill, 1949, 1950, and Smith-White and Woodhill, 1954). One type of crossing resulted in normal fertility but its reciprocal was sterile. It was suggested that this sterility might be due to a factor in the cytoplasm of the egg of one species which is incompatible with the sperm of the other, killing the latter before karyogamy.

The dramatic success of the release of mass-reared males of the screw-worm fly, after irradiation to produce dominant lethal genes and other changes, has led to this technique being thought of as the ultimate in pest eradication. For mosquitoes it suffers the disadvantage of interfering with mating competitiveness and hence is not likely to be successful. Woodhill's sterility phenomenon is not an alternative to the use of irradiation to produce sterility or genetic death but a parallel technique with considerable chances of success, especially in the *Aedes scutellaris* complex with which Woodhill was working. The implications of this non-reciprocal fertility have recently been discussed by a WHO Scientific Group and reported in " Genetics of Vectors and Insecticide Resistance " (WHO Technical Report Series, no. 268, 1964, pp. 34-38).

After his return from Army service Woodhill unbent a little. He was still the well-dressed, well-groomed handsome man but the umbrella was not always present and the hat disappeared. To one of us he said " Dave, I came to realise that as I left home in the morning I picked up my hat, walked out the door, put on my hat, walked to the bus, got in the bus, took off my hat, got out of the bus, put on my hat and walked to the ferry, took off my hat, got off the ferry, put on my hat, walked to the tram, got in the tram, took off my hat, got out of the tram, put on my hat, walked down Science Road, entering the Zoology building and took off my hat, and when I realised this, I thought the hat was not really necessary ".

Woodhill continued to teach entomology in much the same way in the post-war years but modified his course giving, for example, considerable attention to DDT in the early years of its usage. In 1952 we find that the University Calendar records the course in entomology as consisting of 50 lectures and 135 hours practical, an increase over the previous 20 years. Then came a dramatic reduction in 1953 to 20 lectures and 30 hours practical in the Faculty of Agriculture.

This reduction was a blow to Woodhill, especially since the subject had expanded enormously during his teaching career and several of his former students had already gained world reputations in entomological research. The effect of this blow to himself and his subject, together with the difficulties he had had over the previous two years in his candidature for a Readership, must have had their repercussions on his health and in 1956 he suffered a very severe heart attack from which he recovered slowly but never fully regained his former vigour. In this period he was also subject to periodic attacks of diverticulitis. He continued to teach, but with reducing force, up to the time of his retirement in 1965, and perhaps it was his sheer doggedness that kept him alive to this point as his death occurred some five months later.

One of the enigmas of Woodhill's tenure was the fact that his department never expanded when all other comparable sections did so, especially with the institution of Teaching Fellows. Woodhill certainly preferred to do everything himself, apart from the laboratory assistance given him by Miss Gwen Burns for much of the early teaching period, later by K. E. W. Salter and later still by J. Henry, his wartime staff sergeant. Whether he ever sought to expand and met with refusal, we do not know, but the fact remains that he never took one of his own graduates into his section. Knowing the man, we are inclined to think that he sought better things for his students and there is no doubt that he did all he possibly could, and much more than many of his colleagues, to place each of his students. In this he was very fair and made an equal attempt to place the occasional student he was not very keen about as for those he considered had a bright future in entomological research or practice.

" Following his retirement, an appeal was made to his former students to establish an A. R. Woodhill Fund. It is hoped now to use this fund to endow an annual prize in Entomology or to establish some other fitting memorial to honour his memory " (L.C.B. in Union Recorder, September 8, 1965). This fund was finalised in 1966 and an annual prize established for Entomology in the Faculty of Agriculture.

Woodhill's professional career was separate from his family life so that there has so far been no suitable place to record his marriage, in1926, to Gwyndoline Smith. Although taking no part in her husband's research or teaching activities Gwyn Woodhill provided him with a social life of mutual interest. She had also a long standing and active interest in the University of Sydney's traditional charity, the University Settlement. For this Mrs. Woodhill annually arranged a Chrysanthemum Tea and Tony gave much time to, and had much pleasure in bringing on their garden to look its very best for this occasion.

For the first twelve years of their married life they lived at Northwood and here their son Rodney was born. Later they moved to Hunters Hill, and with more leisure, found a congenial group of friends with whom they played tennis, bridge and in Tony's later years, bowls.

This then was Tony Woodhill, a man of the highest integrity who followed his chosen career throughout his adult life, a man who sought no favours nor entered into intrigues of any kind. He was a man who had a job to do, and did it faithfully and well. That job was not just the teaching of entomology, but rather was to supply Australia with promising young graduates in Science or Agriculture ready to embark on a rewarding career of entomological research. This was a need Australia had, and there is no doubt that the achievements of his students are a continuing reflection of the sound instruction and admirable example of their mentor.

D. J. Lee
D. F. Waterhouse

List of Publications by A. R. Woodhill

1926. Gurney, W. B. and Woodhill, A. R. Reports of the external parasites in Sheep Committee of the Departmental Research Council. No. 2—Range and longevity of sheep Blow-flies. *Agric. Gaz. N.S.W.*, 37, (January) : 49-64, 10 text-figs.

1926. Woodhill, A. R. Insect scavengers found on the North-west Plains. With some observations on *Saprinus lactus*. *Aust. Nat.*, Sydney, 6, (February) : 14-15.

1926. Gurney, W. B. and Woodhill, A. R. Reports of the external parasites in Sheep Committee of the Departmental Research Council. No. 3—Biological notes on sheep blow-flies in the Moree district. *Agric. Gaz. N.S.W.*, 37, (February) : 135-144, 2 graphs.

1926. Gurney, W. B. and Woodhill, A. R. Investigations on sheep blow-flies. Part I—Range of flight and longevity. Part II—Notes on bionomics and parasites. *Dept. Agric. N.S.W., Sci. Bull.*, No. 27 (May) : 1-28, text-figs.

1927. Woodhill, A. R. and Allman, S. L. The Dicky rice weevil. *Maleuterpes* (*Prosayleus*) *phytolymus* Olliff. *Agric. Gaz. N.S.W.*, 38, (October) : 791-799, figs.

1928. Woodhill, A. R. Spring versus autumn spraying for red scale of citrus. *Agric. Gaz. N.S.W.*, 39, (July) : 561.

1928. Woodhill, A. R. Spraying for woolly aphis. The addition of miscible oil to summer tobacco sprays. *Agric. Gaz. N.S.W.*, 39, (August) : 613-614.

1928. Gurney, W. B. and Woodhill, A. R. White ants (Termites). *Dept. Agric. N.S.W., Insect Pests Leaflets*, No. 17.

1929. Woodhill, A. R. The apple root weevil (*Leptops squalidus* Boh) as a pest of citrus. *Agric. Gaz. N.S.W.*, 40, (November) : 813-817, figs.

1930. Woodhill, A. R. The citrus red scale (*Chrysomphalus aurantii*). Progress report on fumigation and spraying experiments. *Agric. Gaz. N.S.W.*, 41, (February) : 125-130.

1930. Woodhill, A. R. The green peach aphid (*Myzus persicae*). *Agric. Gaz. N.S.W.*, 41, (April) : 311-314, 2 figs.

1936. Woodhill, A. R. Observations and experiments on *Aëdes concolor*. *Bull. ent. Res.*, 27 : 633-648.

1938. Woodhill, A. R. Salinity tolerance and pH range of *Culex fatigans* Weid., with notes on the anal papillae of salt-water mosquitoes. Proc. Linn. Soc. N.S.W., 63 : 273-281.

1941. Woodhill, A. R. and Pasfield, G. Illustrated key to some common Australian Culicine mosquito larvae, with notes on the morphology and breeding places. Proc. Linn. Soc. N.S.W., 64 : 201, 11 text figs.

1941. Woodhill, A. R. The oviposition responses of three species of mosquitoes (*Aëdes* [*Stegomyia*] *aegypti* Linnaeus, *Culex* [*Culex*] *fatigans* Wiedemann, *Aëdes* [*Pseudoskusea*] *concolor* Taylor) in relation to the salinity of the water. Proc. Linn. Soc. N.S.W., 66 : 287-292.

1941. Woodhill, A. R. Development of *Aëdes* (*Pseudoskusea*) *concolor* in relation to small quantities of salts in solution and to the temperature of the water. Proc. Linn. Soc. N.S.W., 66 : 396-400.

1942. Woodhill, A. R. Comparison of factors affecting the development of three species of mosquitoes, *Aëdes* (*Pseudoskusea*) *concolor* Taylor, *Aëdes* (*Stegomyia*) *aegypti* Linnaeus and *Culex* (*Culex*) *fatigans* Wiedemann. Proc. Linn. Soc. N.S.W., 67 : 95-97.

1942. Pasfield, G. and Woodhill, A. R. Ground Derris root as a mosquito larvicide. Proc. Linn. Soc. N.S.W.,67 : 343-348.

1944. Woodhill, A. R. and Lee, D. J. Some new records and new synonymy of Australian species of *Anopheles* (Diptera, Culicidae). Proc. Linn. Soc. N.S.W., 69 : 67-72.

1944. Woodhill, A. R. and Lee, D. J. The subspecies of *Anopheles amictus* Edwards (Diptera, Culicidae). Proc. Linn. Soc. N.S.W., 69 : 62-66, 8 text figs.

1944. Lee, D. J. and Woodhill, A. R. The Anopheline mosquitoes of the Australasian region. *Publ. Univ. Sydney. Dept. Zool.* Monogr. No. 2. Australasian Medical Publishing Co. Ltd., Sydney, December 1944.

1946. Woodhill, A. R. Observations on the morphology and biology of the subspecies of *Anopheles punctulatus* Dönitz. Proc. Linn. Soc. N.S.W., 70 : 276-287, 3 text figs, 1 map.

1947. Woodhill, A. R. A brief review of progress in the control of some major agricultural insect pests in New South Wales. Extract of Presidential Address. Proc. Linn. Soc. N.S.W., 72 : iv-xi.

1949. Woodhill, A. R. Observations on the comparative survival of various stages of *Aëdes* (*Stegomyia*) *scutellaris* Walker and *Aëdes* (*Stegomyia*) *aegypti* Linnaeus at varying temperatures and humidities. Proc. Linn. Soc. N.S.W., 73 : 413-418.

1949. Woodhill, A. R. A new subspecies of *Aëdes* (*Stegomyia*) *scutellaris* Walker (Diptera, Culicidae) from northern Australia. Proc. Linn. Soc. N.S.W., 74 : 140-144.

1949. Woodhill, A. R. A note on experimental crossing of *Aëdes* (*Stegomyia*) *scutellaris scutellaris* Walker and *Aëdes* (*Stegomyia*) *scutellaris katherinensis* Woodhill. Proc. Linn. Soc. N.S.W., 74 : 224-226.

1950. Woodhill, A. R. Further notes on experimental crossing within the *Aëdes scutellaris* group of species (Diptera, Culicidae). Proc. Linn. Soc. N.S.W., 75 : 251-253.

1954. Woodhill, A. R. Experimental crossing of *Aëdes* (*Stegomyia*) *pseudoscutellaris* Theobald and *Aëdes* (*Stegomyia*) *polynesiensis* Marks (Diptera, Culicidae). Proc. Linn. Soc. N.S.W., 79 : 19-20.

1955. Smith-White, S. and Woodhill, A. R. The nature and significance of non-reciprocal fertility in *Aëdes scutellaris* and other mosquitoes. Proc. Linn. Soc. N.S.W., 79 : 163-176, 3 text figs.

1959. Woodhill, A. R. Experimental crossing of *Aëdes* (*Stegomyia*) *aegypti* Linnaeus and *Aëdes* (*Stegomyia*) *albopictus* Skuse (Diptera, Culicidae). Proc. Linn. Soc. N.S.W., 84 : 292-294.

Notes and Exhibits

1937. Specimens of mosquito larvae and notes on the habitat and salinity tolerance of the various spp. of larvae. *Aëdes* (*Pseudoskusea*) *concolor*, *Culex fatigans*, *Aëdes* (*Ochlerotatus*) *vigilax* and *Megarhinus speciosus*. Proc. Linn. Soc. N.S.W., 62 : xliii.

1959. Lantern slide showing mosaic between green and brown forms of a Scarab Beetle. *Anoplostethus opalinus* from Western Australia. Proc. Linn. Soc. N.S.W., 84 : 418.

1960. Photograph of a Nemestrinid fly hovering in mid-air taken by Dr. A. J. Nicholson in the late 1920's and coloured by hand by Miss Burns. Proc. Linn. Soc. N.S.W., 85 : 385.

ABSTRACT OF PROCEEDINGS

ORDINARY MONTHLY MEETING

29th March, 1967

Mr. L. A. S. Johnson, President, in the chair.

The minutes of the last Ordinary Monthly Meeting (30th November, 1966) were taken as read and signed.

The following were elected Ordinary Members of the Society: Dr. E. G. H. Manchester, M.B., B.S., Vaucluse, N.S.W.; A. O. Nicholls, B.Sc., Animal Industry and Agriculture Branch, Alice Springs, Northern Territory; Miss Jean M. Pulley, B.Sc.Agr., Dip.Ed., Newtown, N.S.W.; and S. A. South, B.Sc., Turramurra, N.S.W.

The Chairman announced that library accessions amounting to 40 volumes, 336 parts or numbers, 2 bulletins, 14 reports and 9 pamphlets, total 401, had been received since the last meeting.

The Chairman offered congratulations to Dr. D. F. Waterhouse on his election as a Fellow of the Royal Society, London.

PAPERS READ

(By title only, an opportunity for discussion to be given at the April Ordinary Monthly Meeting."

1. The genus *Velleia* Sm. By R. C. Carolin.

A systematic treatment of the genus is provided. All species recognized are described. The types, together with other specimens, are cited. Two species are described as new. A key for the identification of these species is given.

2. The occurrence, origin and vegetation of lowland peat in Malaya. By B. R. Hewitt.

The extent, origin, distribution and vegetation of the lowland peat of Malaya are described. Some reference is made to similar peat formations in adjacent areas in south-east Asia and factors responsible for the development of peat are discussed.

3. New species of Permian gastropods from Queensland. By R. E. Wass.

Three new species of gastropods are described and figured from Permian sediments at Cracow, Queensland.

4. The Australian species of *Diplogeomyza* and allied genera (Diptera, Heleomyzidae). By D. K. McAlpine.

The Australian species of the genus *Diplogeomyza* Hendel and 3 related new genera are described, and keys are given for their identification. Of these species 17 are described as new, 2 having been previously described. One of the new species is divided into 2 subspecies. It is pointed out that these genera, together with the New Zealand genera *Allophylopsis* Lamb and *Allophylina* Malloch, form a compact monophyletic group to which may be attributed the status of a tribe.

ORDINARY MONTHLY MEETING

26th April, 1967

Mr. L. A. S. Johnson, President, occupied the chair.

The minutes of the last Ordinary Monthly Meeting (29th March, 1967) were read and confirmed.

Mr. R. L. Hardwick, B.Sc., Kingswood, N.S.W., was elected an Ordinary Member of the Society.

The Chairman announced that the Council had elected the following office-bearers for the 1967-68 session : *Vice-Presidents* : Professor R. C. Carolin, Dr. D. T. Anderson, Miss Elizabeth C. Pope and Mr. G. P. Whitley ; *Honorary Treasurer* : Dr. A. B. Walkom ; *Honorary Secretary* : Mr. R. H. Anderson.

The Chairman announced that library accessions amounting to 21 volumes, 154 parts or numbers, 2 bulletins, 2 reports and 2 pamphlets, total 181, had been received since the last meeting.

The Chairman drew the attention of members to the notice notifying that the Australian Research Grants Committee is at present calling applications for support for research projects in 1968.

PAPERS READ

1. The early development of Tasmania's endemic Anura, with comment on their relationships. By A. A. Martin.

2. Geomorphology of the Kosciusko Block and its North and South Extensions. By W. R. Browne.

3. New species and new records of fishes from Queensland. By J. M. Thomson.

NOTES AND EXHIBITS

Mr. A. G. Khan exhibited embryos of *Podocarpus spinulosus* R.Br. grown in agar culture under various conditions. Full-grown green seeds were collected from Warrah Sanctuary at Pearl Beach on 20th February, 1967, and, after being kept for two days at 4° C, their embryos were aseptically excised and put in sterile culture on agar slopes. One half of the culture tubes was kept in an out-of-door shady glasshouse (temperature range 20-25° C) with natural light (photoperiod of approx. 12 hours light and 12 hours dark) and the other half in a constant temperature room (22° C) with photoperiods of 16 hours light and 8 hours dark. Significant growth occurred in the embryos kept in the glasshouse whereas the embryos which were kept in the room remained dormant. Embryos from the same collection of seeds, when cultured on the medium containing extract from the swollen, fleshy, purple-coloured arils (or receptacles) on which seeds are borne, showed no growth under both the above-mentioned climatic conditions. They remained dormant and turned brownish in colour. Embryos from the same collection of seeds when cultured after giving the seeds 7 days of low temperature treatment at 4° C also remained dormant.

SYMPOSIUM

A symposium entitled " Marine Sciences of the Central Coast of New South Wales—Recent Researches " was held under the leadership of Miss Elizabeth C. Pope. The speakers included Dr. Charles V. Phipps, Sydney University (Geology), Dr. John McIntyre, Division of Fisheries and Oceanography, C.S.I.R.O. (Biology), and Mr. C. Lawler and Mr. W. Deas (members of the Underwater Research Group of New South Wales).

ORDINARY MONTHLY MEETING

28th June, 1967

Mr. L. A. S. Johnson, President, occupied the chair.

The minutes of the last Ordinary Monthly Meeting (26th April, 1967) were read and confirmed.

Dr. Laurence Robert Richardson, M.Sc., Ph.D., F.R.S.N.Z., Grafton, N.S.W., and Mr. A. N. Rodd, Cheltenham, N.S.W., were elected Ordinary Members of the Society.

The Chairman announced that library accessions amounting to 34 volumes, 429 parts or numbers, 12 bulletins, 9 reports and 13 pamphlets, total 497, had been received since the last meeting.

The Chairman drew the attention of members to a Symposium on Insect Abundance to be held in London by the Royal Entomological Society of London, 21st–22nd September, 1967.

The Chairman announced that there will be no Ordinary Monthly Meeting in August.

PAPERS READ

1. The geology of the White Cliffs-Mt. Jack-Peery Lake area, New South Wales. By J. Rade.
2. Description of a new genus (Fungi imperfecti) on Proteaceae in New Guinea and Queensland. By Dorothy E. Shaw and J. L. Alcorn.
3. Permian polyzoa from the Port Keats District, Northern Territory. By Robin E. Wass.
4. The Rhaphidophoridae (Orthoptera) of Australia. Part 5. The Rhaphidophoridae of Flinders Island. By Aola M. Richards.
5. A Devonian echinoid from Taemas, south of Yass, N.S.W. By Ida A. Brown (Mrs. W. R. Browne).

DISCUSSION

The address of the immediate Past President, Professor R. C. Carolin, entitled " The Concept of the Inflorescence in the Order Campanulales ", was discussed.

ORDINARY MONTHLY MEETING

26th July, 1967

Mr. L. A. S. Johnson, President, occupied the chair.

The minutes of the last Ordinary Monthly Meeting (28th June, 1967) were read and confirmed.

Mr. R. J. T. Holland, M.A. (Syd.), M.A.C.E., c/- Sydney Grammar School, Sydney ; Miss Jan C. Morrow, B.Sc. (Q'ld.), Woollahra, N.S.W. ; and Mr. M. J. Wallace, B.Sc. (Syd.), Beverly Hills, N.S.W., were elected Ordinary Members of the Society.

The Chairman announced that library accessions amounting to 16 volumes, 130 parts or numbers, 3 bulletins, 3 reports, and 2 pamphlets, total 154, had been received since the last meeting.

The Chairman announced that there will be no Ordinary Monthly Meeting in August.

The Chairman drew the attention of members to the Stony Range Flora Reserve, Pittwater Road, Dee Why.

PAPERS READ

1. Middle Palaeozoic Brachiopods and Corals from Kashmir. By B. D. Webby and V. J. Gupta.

2. The life histories of two bird trematodes of the family Philophthalmidae. By M. J. Howell and A. J. Bearup.

3. Inheritance of purple pericarp in wheat. By R. A. McIntosh and E. P. Baker.

LECTURETTE

A lecturette entitled "Geological Aspects of the Great Barrier Reef" (illustrated) was given by Professor W. G. H. Maxwell, Department of Geology and Geophysics, University of Sydney.

ORDINARY MONTHLY MEETING

27th September, 1967

Mr. L. A. S. Johnson, President, occupied the chair.

The minutes of the last Ordinary Monthly Meeting (26th July, 1967) were read and confirmed.

The Chairman announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1968, 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 $A3,200 per annum. Applications should be lodged with the Honorary Secretary, who will give further details and information, not later than Wednesday, 1st November, 1967.

The Chairman announced that library accessions amounting to 28 volumes, 303 parts or numbers, 10 bulletins, 9 reports, and 23 pamphlets, total 375, had been received since the last meeting.

The Chairman announced that a Special General Meeting of the Society will be held on Wednesday, 25th October, 1967, at 7.30 p.m., to consider the recommendations of Council regarding the alterations to the Rules of the Society.

The Chairman drew the attention of members to a pamphlet entitled "Field List of Birds of Queensland's South-East Corner", compiled by Mr. Robin Elks, "Midyim", Orvieto Terrace, Caloundra, Queensland. Price: 25c.

PAPERS READ

1. A new genus of the family Goodeniaceae. By R. C. Carolin.

2. *Monograptus* cf. *ultimus* Perner and *Monograptus formosus* Bouček from the Hume Series of the Yass District, New South Wales. By G. H. Packham.

3. The occurrence and composition of the sugars in the honeydew of *Eriococcus coriaceus* (Mask.). By R. Basden.

EXHIBIT

Dr. Ida A. Browne exhibited specimens of fossiliferous limestone from the Upper Hume Series in the neighbourhood of Bowning, N.S.W. The fossils include forms tentatively recognized as species of *Lyrielasma*, *Cystiphyllum* and other simple Rugosa, *Pseudamplexus*, *Tryplasma*, *Thamnopora* and other corals, Bryozoa, Brachiopoda, etc. The fauna suggests a correlation with formations of eastern Victoria, generally considered to be Lower Devonian. The limestone lies conformably above the Silurian Middle Trilobite (Dalmanites) bed and the *Monograptus salweyi* quartzite bed (of Mrs. K. M. Sherrard), and is thought to underlie the Upper Trilobite Bed at Bowning. It is unconformably overlain by the Devonian tuffaceous agglomerate at the base of the volcanic rocks of

Bowning Hill. This would indicate that the Bowning Orogeny occurred here during the Lower Devonian rather than at the close of the Silurian.

SYMPOSIUM

A symposium entitled " Some recent studies on intertidal animals " was held under the leadership of Dr. D. T. Anderson. The speakers included Dr. V. B. Morris, Mr. David Tracy, Miss Angela Frecker and Brother G. Rossiter.

SPECIAL GENERAL MEETING

25TH OCTOBER, 1967

The recommendations from the Council regarding alterations to the Rules, of which the required notice had been given to members, were considered. After a brief explanation by the President it was unanimously resolved that the suggested alterations be approved.

ORDINARY MONTHLY MEETING

25TH OCTOBER, 1967

Mr. L. A. S. Johnson, President, in the chair.

The minutes of the last Monthly Meeting (27th September, 1967) were read and confirmed.

Mr. Alan J. Dartnall, B.Sc., Hobart, Tasmania, was elected an Ordinary Member 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, 1968, from qualified candidates.

The Chairman announced that a Special General Meeting will be held on 29th November, 1967, to consider the confirmation of the approval of the alterations to the Rules, passed at the Special General Meeting of the Society on 25th October, 1967.

The Chairman announced that library accessions amounting to 18 volumes, 141 parts or numbers, 6 reports, and 2 pamphlets, total 167, had been received since the last meeting.

The Chairman referred to the death, on 24th September, 1967, of Dr. E. G. H. Manchester, who had been elected a member of the Society on 29th March, 1967.

PAPERS READ

1. An annotated list of Australian leeches. By L. R. Richardson.
2. Notes on two new heteromorphic deutonymphs (hypopi) (Acarina: Sarcoptiformes). By A. Fain. (*Communicated by Mr. R. Domrow.*)
3. A new species of *Metapenaeopsis* (Crustacea-Decapoda) from northern Australian waters. By A. A. Racek.
4. A new species of *Mordacia*, a non-parasitic lamprey (Petromyzonidae) from New South Wales, Australia. By I. C. Potter. (*Communicated by Professor A. K. O'Gower.*)

LECTURETTE

An illustrated lecturette entitled " Some observations on the status of Rainforest " was delivered by Mr. G. N. Baur, Forestry Commission of N.S.W.

SPECIAL GENERAL MEETING

29th NOVEMBER, 1967

Mr. L. A. S. Johnson, President, in the chair.

The minutes of the Special General Meeting of 25th October, 1967, were read and confirmed.

The recommendation of the Council of the alterations to the Rules, as approved at the Special General Meeting of 25th October, 1967, was confirmed, and carried unanimously.

ORDINARY MONTHLY MEETING

29th November, 1967

Mr. L. A. S. Johnson, President, in the chair.

The minutes of the last Monthly Meeting (25th October, 1967) were read and confirmed.

Mr. E. J. Edwards, Faulconbridge, N.S.W., was elected an Ordinary Member of the Society.

The Chairman announced that the Council had re-appointed Miss Alison K. Dandie, B.Sc.(Hons.), to a Linnean Macleay Fellowship in Botany for one year from 1st January, 1968.

The Chairman referred to the death on 20th August, 1967, of Mr. D. S. North, who had been a member of the Society since 1912.

The Chairman announced that library accessions amounting to 27 volumes, 146 parts or numbers, 10 bulletins, 3 reports and 6 pamphlets, total 192, had been received since the last meeting.

PAPERS READ

1. Taxonomic notes on Australian Malvaceae. By P. A. Fryxell. (*Communicated by Mr. R. H. Anderson.*)

2. The composition of tropical lowland peat sampled at Klang, Selangor, Malaysia. By B. R. Hewitt.

3. Notes on the biology of two species of Rhaphidophoridae (Orthoptera) in Tasmania. By Aola M. Richards.

4. *Goniocladia* and *Dyscritella* from the Permian of Queensland. By R. E. Wass.

NOTES AND EXHIBITS

Dr. A. R. H. Martin exhibited specimens of an apparently unrecorded species of *Gentiana* from Wingecarribee Bog, near Robertson, N.S.W. An interesting feature of this species is the strongly stipitate capsule which elongates to about 2·5 cm. beyond the persistent corolla after pollination and fertilization.

Mr. J. T. Waterhouse showed slides illustrating the structure of the inflorescence of species of *Xanthorrhoea*. The suggestion was made that the inflorescences in this genus are highly contracted branch systems in comparison with the open-branched systems of genera of the Agavaceae with which *Xanthorrhoea* is co-ordinal.

Dr. I. V. Newman gave a further report (see these *Proceedings*, Vol. 88, 1963, p. 398) on exploratory investigations into the habit of the prostrate mutant of *Acacia spectabilis*. A sowing of seed from open pollination in the absence of " erect " pollen resulted in 241 viable seedlings, all of which were prostrate, thus confirming the previous inference that the parent plant was homozygous recessive for the prostrate factor. Seedlings, emerging in December with " vertical " sun, grew erect for a while before becoming prostrate. Seedlings, grown in a root-observation box in the dark from seeds placed horizontally, began with the normal tropic response to gravity—root turned down, shoot turned up—but, later, after potting out into the light, became prostrate after the manner of such seedlings normally grown. Seedlings growing at the bottom of black-surfaced tubes with uniform top lighting, though thin and drawn, grew erect till overcome with damping-off. Seedlings growing on a klinostat revolving about a vertical axis at a rate of about once per hour began as perfectly erect, but later became prostrate, with indiscriminate direction. Controls, growing at the same time as the two previous sets, immediately on appearing above ground began to bend uniformly towards the winter sun, low in the northern sky—this was a sowing in June. Though the sun is now, in November, nearly " vertical ", the seedlings are maintaining the prostrate growth.

It may be inferred from the above that the seedlings are at first normally photo- and geo-tropic in the shoot ; that an event takes place that brings them prostrate ; and that therewith either they lose tropism and grow in the direction they happen to be pointing or become strictly dia-tropic.

The mechanism of the bend may be complex, but one clue is from starch and cell-wall distribution in the region of bending. Lantern slides of transverse sections showed the inner part of the curve to have fewer cells, with the fibres thick-walled and packed with starch, while the outer part of the curve had many more cells with the " fibres " thin-walled and devoid of starch. It is suggested that the bend results from the osmotic distension of the thin-walled cells due to an excess of soluble carbohydrate. The explanation of the phenomenon of the prostrate habit would thus lie in the cause of the differential distribution of the enzymes involved.

Dr. Newman's foregoing note was illustrated with photographs and lantern slides of seedlings and photomicrographic lantern slides of stem sections.

Mr. A. G. Khan exhibited photomicrographs and photographs of the nodulation of roots in *Podocarpus falcatus* R.Br., *P. lawrencei* Hook,f., and *Microstrobos fitzgeraldii* F.Muell. Photomicrographs showed the anatomy and regeneration of root nodules which are morphological features of podocarp root systems. The nodules, as compared with lateral roots, lack an apical meristem pattern and have an endodermis over-arching their vascular tissues, whereas the lateral roots show an apical meristem pattern of cells and have an open-ended endodermis. Photomicrographs also showed that the nodules may be spherical or occasionally elongated like a lateral root but anatomically unlike the latter.

Photographs of root segments, cleared in lacto-phenol, showed the renewal of growth of both spherical and elongated nodules. A dark collar against a lighter background represents the distended dead tissue of previous nodules and marks the beginning of the new growth period.

Like nodules, lateral roots also exhibit the phenomenon of renewal of growth. Photographs showed that, when dormant, the root tip is dark brown. A beaded appearance can be seen in the root due to renewal of growth for several times, and the beginning of each renewal of growth is marked with a dark collar against a lighter background.

The origination of nodules on the lateral roots seems to be related to the state of growth. Photographs showed that in an actively growing lateral root, nodules appear at a greater distance from the root apex as compared with a slow-growing root. A photograph of cleared segment of a slow growing root reveals a developing root nodule within a few mm. of the apical meristem.

Professor T. G. Vallance exhibited two original water-colour sketches of *Banksia serrata* bound in his copy of J. E. Smith's *A Specimen of the Botany of New Holland* (London, 1793–5). The sketches, on paper with the water-mark JWHATMAN, are initialled " F.P.N. 89." and are clearly related to two plates in John White's *Journal of a Voyage to New South Wales* (London, 1790)—also exhibited. In the latter work these two plates (listed as nos. 18 and 20) are inscribed " F.P. Nodder, delin." and dated Dec. 29, 1789. One of the sketches exhibited bears the title in pencil " Banksia serrata in Fruit " and agrees exactly with White's plate no. 20. The other sketch is not identified, but is evidently a variant of plate 18 in White's *Journal.*

It seems clear that the two sketches are by Frederick Polydore Nodder, Botanic painter to Queen Caroline and one of the artists employed at times by Sir Joseph Banks. Professor Bernard Smith has argued that many of the plates in White's book were based on originals made in New South Wales, but the slight differences between plate 18 and Nodder's unlabelled sketch suggest that the artist had access to botanical specimens. Commenting on other early illustrations of Australian plants and animals, the exhibitor noted that Rex and Thea Rienits (*Early Artists of Australia*, Sydney, 1963) suggest the convict artist Thomas Watling was responsible for the original sketches on which the plates in George Shaw's *Zoology of New Holland* (London, 1794) were based. An extract from a letter by Shaw to his artist Sowerby (see these *Proceedings*, vol. 91, p. 239) will suffice to indicate that living specimens were available in London.

Mr. D. R. Selkirk exhibited photographs of a fossil epiphyllous moss from Tertiary deposits at Kiandra, N.S.W. The fossils have been ascribed to the genus *Ephemeropsis*, which today consists of two species, one in Java, Malaya and Thailand, and the other in New Zealand and Tasmania. The fossil specimens appear to differ from both the modern species, and may belong to a third species, together with specimens from the Eocene brown coals of Germany which have been ascribed to this genus.

Dr. B. D. Webby exhibited an Ordovician edrioblastoid from the lower part of the Cliefden Caves Limestone, west-north-west of Mandurama, New South Wales. It is considered to be a new species of *Astrocystites*, and represents the first record of an edrioblastoid outside North America. Hitherto, the sole representative of the group was *Astrocystites ottawaensis* Whiteaves, from the Trenton Limestone of Ottawa. Study of serial sections and broken plate fragments of some New South Wales specimens reveals details of internal structures not previously known in the group, and helps to elucidate the relationships between edrioblastoids, edrioasteroids and blastoids. It is concluded that *Astrocystites* is more closely related to *Edrioaster* than any other form, and can only be most doubtfully regarded as the ancestral form of blastoids.

LIST OF MEMBERS

(*15th December, 1967*)

ORDINARY MEMBERS

(An asterisk (*) denotes Life Member)

1940 Abbie, Professor Andrew Arthur, M.D., B.S., B.Sc., Ph.D., c/- University of Adelaide, Adelaide, South Australia, 5000.
1940 *Allman Stuart Leo, B.Sc.Agr., M.Sc., 99 Cumberland Avenue, Collaroy, N.S.W., 2097.
1965 Anderson, Derek John, Ph.D., School of Biological Sciences, Botany Building, Sydney University, 2006.
1959 Anderson, Donald Thomas, B.Sc., Ph.D., School of Biological Sciences, Department of Zoology, Sydney University, 2006.
1964 Anderson, Mrs. Jennifer Mercianna Elizabeth, B.Sc.Agr., 51 Ocean Street, Woollahra, N.S.W., 2025.
1922 Anderson, Robert Henry, B.Sc.Agr., 19 Kareela Road, Chatswood, N.S.W., 2067.
1965 Andrew, Mrs. Phillipa Audrey, M.Sc. (*née* Croucher), Royal Melbourne Institute of Technology, 124 Latrobe Street, Melbourne, Victoria, 3000.
1963 Ardley, John Henry, B.Sc.(N.Z.), Messrs. William Cooper and Nephews (Australia) Pty. Ltd., P.O. Box 12, Concord, N.S.W., 2137.
1927 *Armstrong, Jack Walter Trench, " Cullingera ", Nyngan, N.S.W., 2825.
1952 Ashton, David Hungerford, B.Sc., Ph.D., 92 Warrigal Road, Surrey Hills, Victoria, 3127.
1912 Aurousseau, Marcel, B.Sc., 229 Woodland Street, Balgowlah, N.S.W., 2093.

1962 Bailey, Peter Thomas, B.Sc., C.S.I.R.O., Division of Wildlife Research, P.O. Box 109, City, Canberra, A.C.T., 2601.
1961 Bain, Miss Joan Maud, M.Sc., Ph.D., 18 Onyx Road, Artarmon, N.S.W., 2064.
1949 Baker, Professor Eldred Percy, B.Sc.Agr., Ph.D., Department of Agricultural Botany, Sydney University, 2006.
1962 Ballantyne, Miss Barbara Jean, B.Sc.Agr., N.S.W. Department of Agriculture, Private Mail Bag No. 10, Rydalmere, N.S.W., 2116.
1959 Bamber, Richard Kenneth, F.S.T.C., 113 Lucinda Avenue South, Wahroonga, N.S.W., 2076.
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., 2033.
1960 Barber, Ian Alexander, B.Sc.Agr., School of Biological Sciences, Department of Zoology, Sydney University, 2006.
1955 Barlow, Bryan Alwyn, B.Sc., Ph.D., School of Biological Sciences, The Flinders University of South Australia, Bedford Park, South Australia, 5042.
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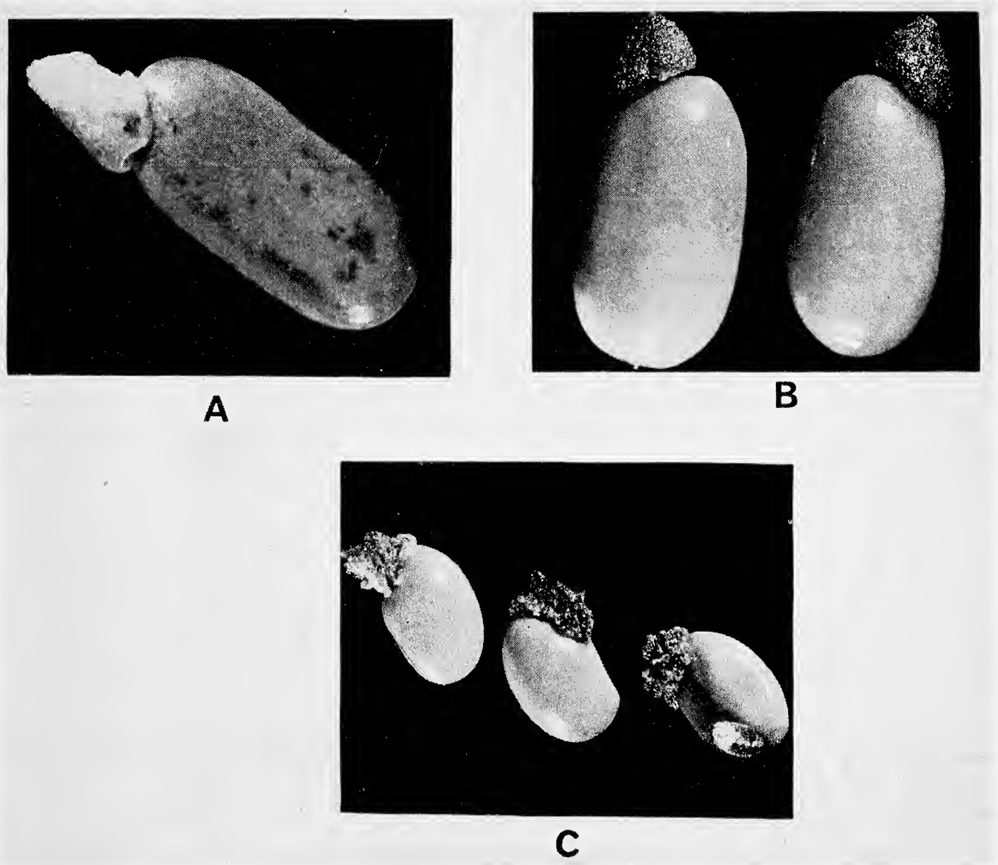
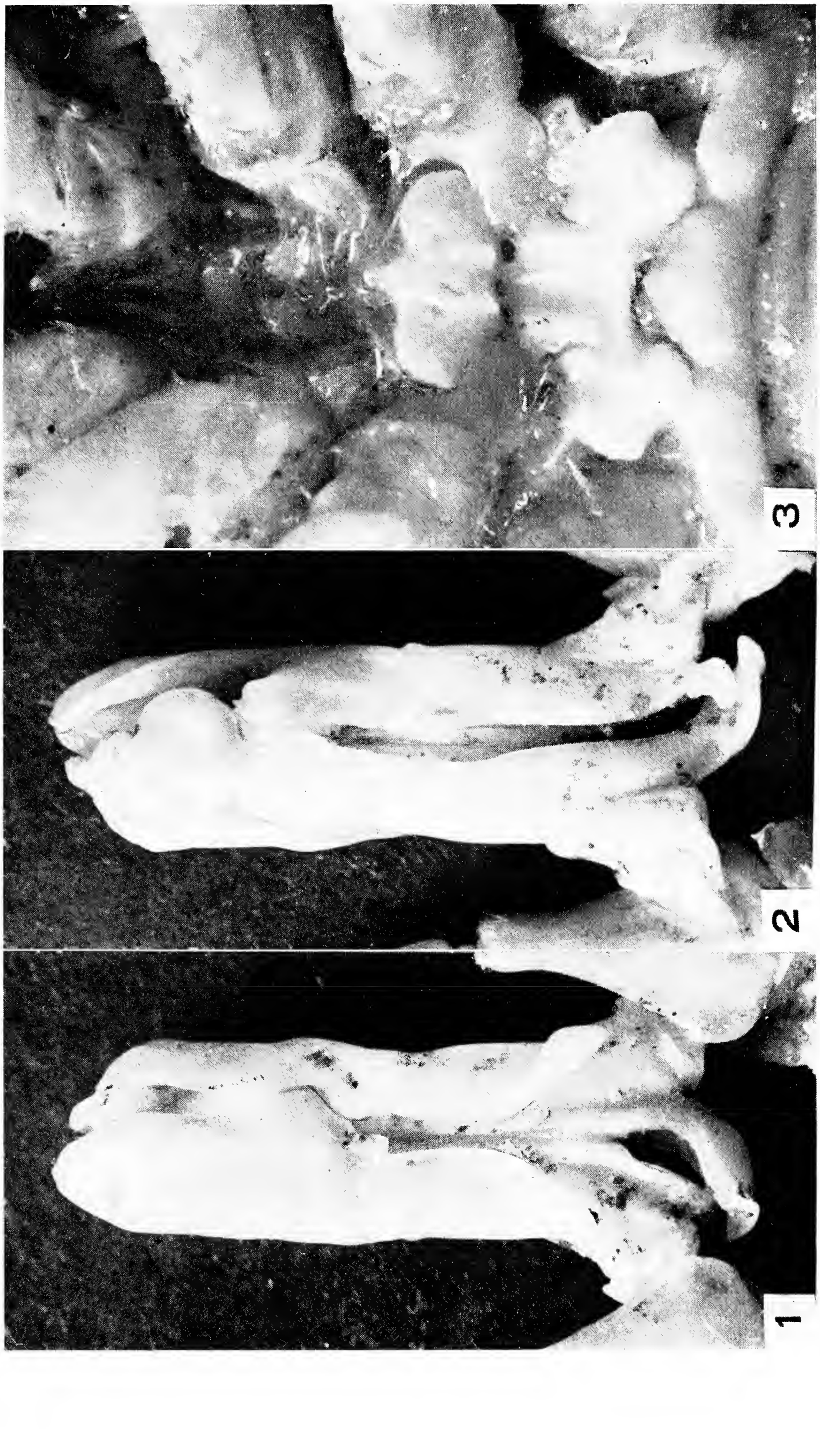


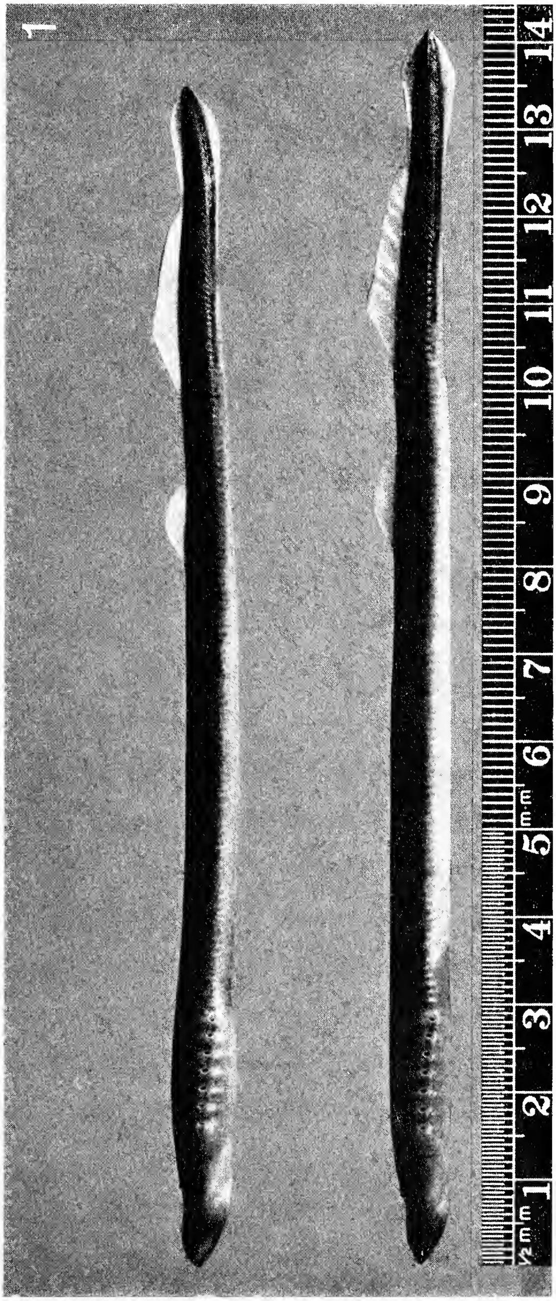
Seeds of *Coopernookia* species.

Monograptus sp. cf. *M. ultimus* and *Monograptus formosus*

Metapenaeopsis wellsi



Metapenaeopsis wellsi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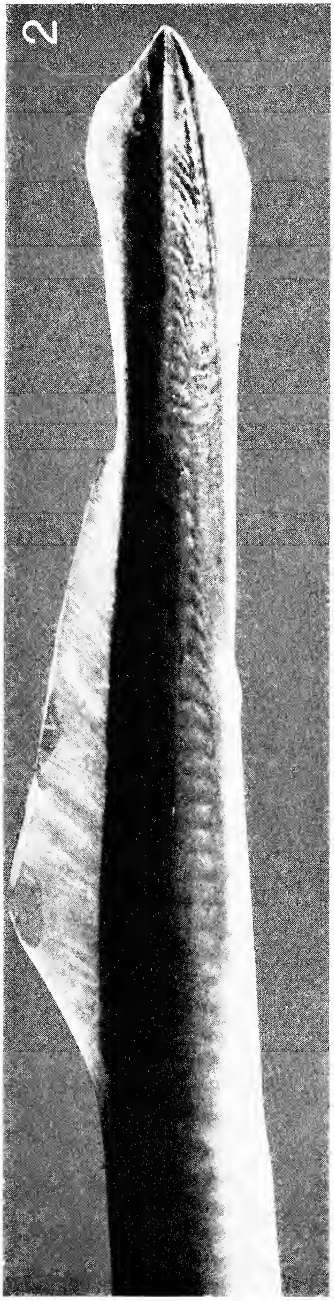
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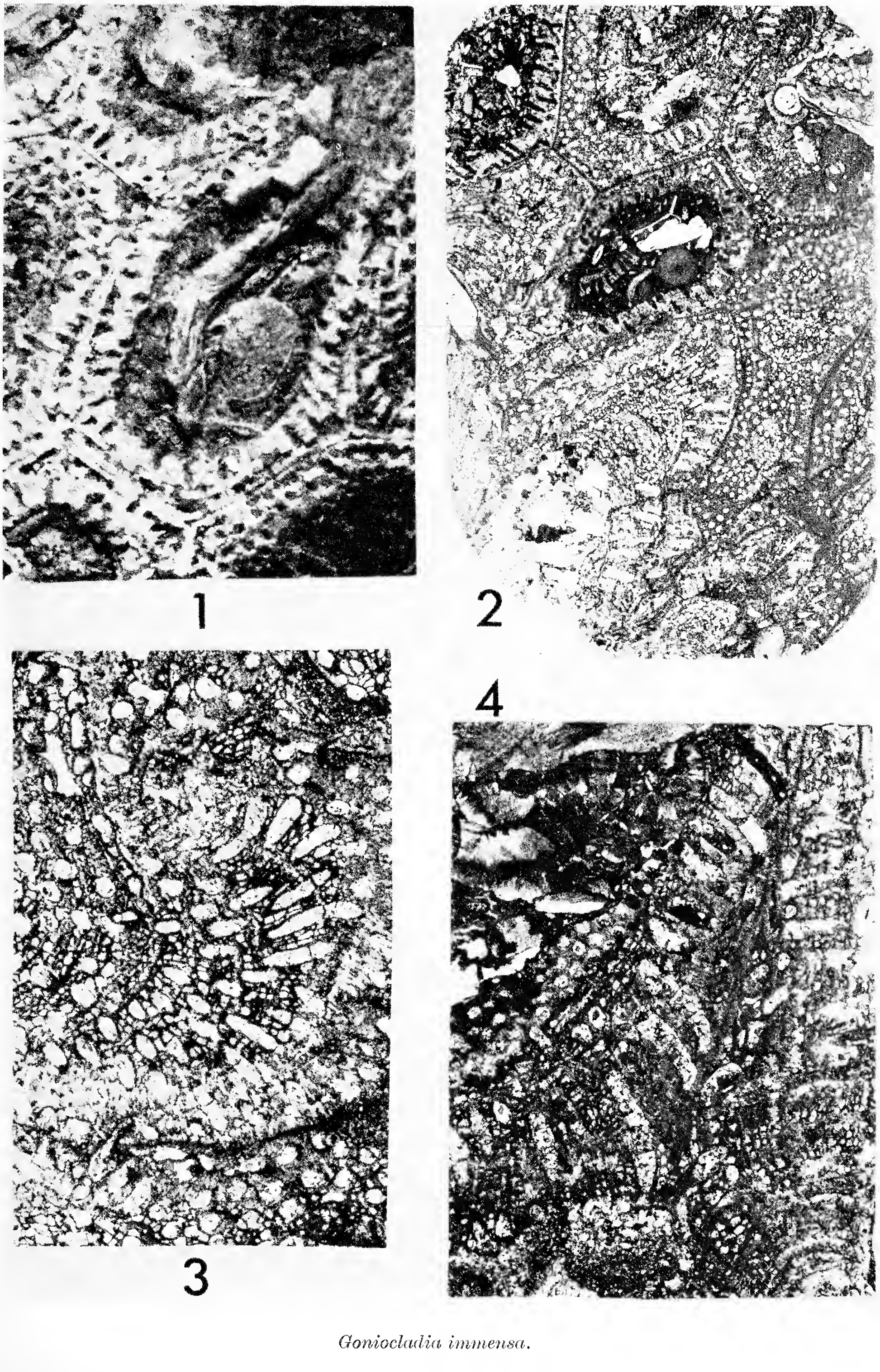
Mordacia praecox, n. sp.



Goniocladia immensa.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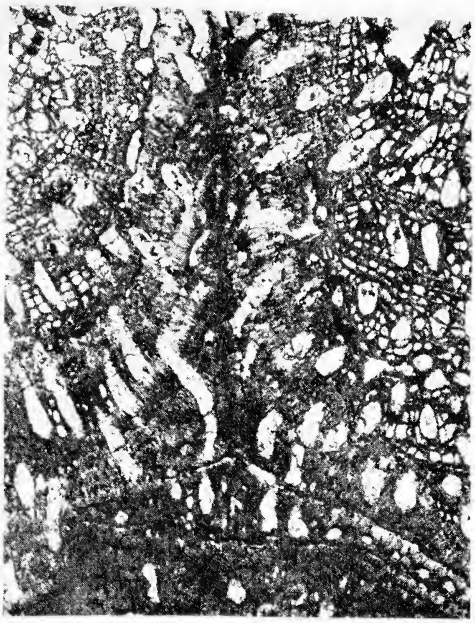
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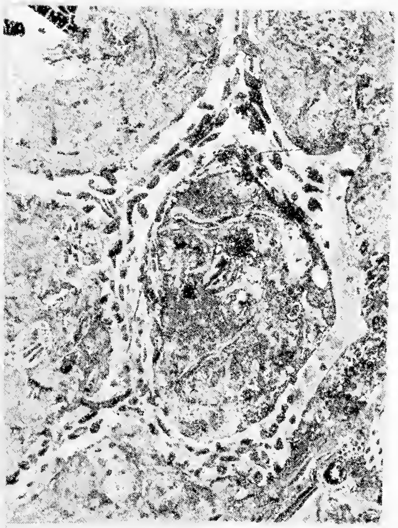
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Goniocladia immensa and *Goniocladia indica*.

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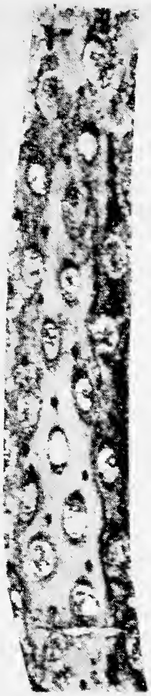

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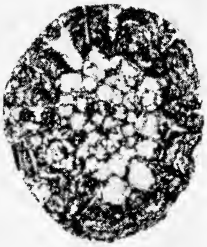

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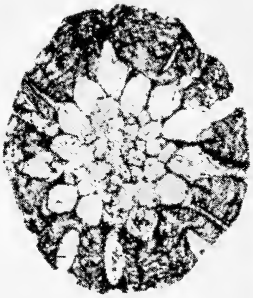

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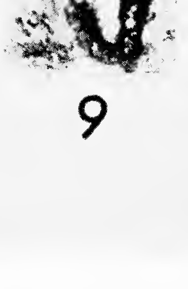

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Dyscritella corella, *Saffordotaxis* sp and ? *Ptylopora* sp.

A. R. Woodhill

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