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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 "

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Linnean Macleay Lecturer in Microbiology, University of Sydney

K. Y. Cho, Ph.D.

Linnean Macleay Fellow of the Society in Vertebrate Palaeontology as from 1st June, 1970

Dr. A. Anne Warren (*née* Howie), B.Sc., Ph.D. (Cantab.)

The Society's Headquarters are in Science House, 157 Gloucester Street, Sydney, N.S.W. 2000, Australia

Proceedings of the Linnean Society of New South Wales

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ANNUAL GENERAL MEETING

31st March 1971

The Ninety-sixth Annual General Meeting was held in the Society's Rooms, Science House, 157 Gloucester Street, Sydney, on Wednesday, 31st March 1971, at 7.30 p.m.

Professor N. G. Stephenson, President, occupied the chair.

The minutes of the Ninety-fourth Annual General Meeting (25th March 1970) were read and confirmed.

Report on the Affairs of the Society for the Year

1970 has seen a considerable number of changes and new developments in the Society's affairs. So that members may be fully informed, this report will be more comprehensive than usual.

Publication

The Society's Proceedings for 1969, Parts 2 and 3 were published on 1st June and 28th September, and for 1970, Parts 1 and 2 on 30th November and 23rd December 1970.

In order to retain registration with bulk postage facilities, the Proceedings will be published four times a year from 1971 onwards ; during March, June, September and December.

Donations totalling $1,000 were made during the year towards the cost of publication of three papers ; net cost involved in publishing the Proceedings was $4,873.60.

Membership

During the year 11 new members were admitted to the Society, 1 died, 10 resigned and 2 were removed from the list of members. The numerical strength of the Society at 1st March 1971 was : Ordinary Members, 272 ; Life Members, 30 ; Corresponding Member, 1 ; total, 303.

The death of Dr. H. S. Halcro Wardlaw in Singapore on 6th June 1970 is recorded with great regret. Dr. Wardlaw had been a member of the Society since 1911, a member of Council from December 1924 until March 1970, and President during 1929/30.

Administrative Changes

At the beginning of the year Council decided to appoint a full-time Secretary to the Society. Mrs. Ruth J. Inall took up her appointment on 18th May 1970, combining the duties of administrator and editor of the Proceedings.

Papers Read

Papers read at Ordinary General Meetings totalled 18. Addresses were given at the following meetings : March, Early History of Australian Zoology from earliest times up to and including Cook's Voyages, by Mr. G. P. Whitley; April, Carl Linnaeus, his personality, his relationships with contemporary botanists and students, his published works, his discovery of the sexual system of plant reproduction, and his introduction of the binomial system to scientific nomenclature by adapting the colloquial method of defining each material article by a general (generic) and a descriptive or qualifying (specific) word, by Dr. William T. Stearn; June, The biology of Nectaries, by Professor F. V. Mercer; September, The search for Australian fossil vertebrates, by Dr. A. Ritchie and Dr. Anne Howie; October, Cattle grazing and butterfly conservation—an exercise in conservation research in England, by Mr. O. B. Williams. Notes and exhibits were a feature of the November meeting.

The Seventh Sir William Macleay Memorial Lecture was delivered by Sir Otto Frankel, D.Sc., F.R.S., F.A.A., on 27th July 1970, and was entitled " Variation—the Essence of Life ".

Archives

The Society's records have been sorted with the help of the Senior Archivist of the Archives Authority of New South Wales and a trained archivist from the Mitchell Library. The material is now housed, on permanent loan, at the Mitchell Library, where it will be catalogued, repaired and prepared for binding, and eventually available for reference to interested research workers.

Science House and Future Developments Concerning the Society's Activities

The Sydney Cove Redevelopment Authority first informed this Society in June 1970 that it was intended to resume the property known as Science House at an early date; subsequently notice of resumption was received in November allowing 21 days for appeal against this action.

During a cordial two-hour discussion at the North Sydney offices of the Redevelopment Authority, a number of matters relating to the possible future of the Society were discussed. It was necessary to ascertain whether the Sydney Cove Redevelopment Authority would give any encouragement to the Linnean Society or any other Learned Societies to remain in the eastern Rocks Area. In other words, we wished to determine whether or not the Authority, having threatened to destroy a Science Centre by resumption, would facilitate the redevelopment of a Science Centre in the area, either on the present or another site.

In the meantime the Linnean Society had indeed been fortunate in that the Director of the Australian Museum, Dr. F. H. Talbot, had generously offered to provide, through the Australian Museum, accommodation for the Linnean Society and its Library in a new multi-storied block which is currently being planned as part of the Australian Museum complex of buildings. It is necessary for the Linnean Society to make a decision, without undue delay, as to whether it wishes to take advantage of this offer.

It is important to clarify the relationship between the Sydney Cove Redevelopment Authority and the Government, as well as the nature of the assistance which might be sought from either of these bodies. The Authority is an independent body, set up by the Government to develop a particular area. It hopes to do so under financially advantageous terms, but any profits made from the redevelopment are apparently to be returned to the Government by being paid into Consolidated Revenue. Thus, the Linnean Society could approach the Authority on matters concerning the resumption, or the provision of an alternative site, or for concessions of one type or another, but it would need to approach the Government directly for financial support if the changing circumstances necessitated grants or loans to maintain or develop the established activities of the Society.

The Chairman of the Authority was extremely sympathetic to the Linnean Society's needs, and to the problems posed by the resumption order. These needs were elaborated by the Secretary and Honorary Treasurer of the Linnean Society, who were fully conversant with the details and were able to provide a solid factual backing to our case.

The primary question raised was, whether or not the Sydney Cove Redevelopment Authority would provide, in the east Rocks Area under its control, a site for a scientific centre. The answer was that this question could be safely answered in the affirmative even now. The project, of course, would be dependent on Government approval and support, but it could be phased so as to cause the minimum inconvenience during change-over operations to the societies primarily concerned. One important point emerging from the discussion was that no land would be sold by the Authority after its resumption, but would be made available by the Authority under lease. No doubt the terms could be favourable if the cause for which the site would be developed was a worthy one and of public interest.

On the assumption that a suitable site could be provided for a Science Centre, the question then arose as to the conditions under which it could be developed. The resumed land of the area is to be made available under lease from the Authority. Once a site is allocated, it seems that the occupant or occupants may make proposals for its development and execute an approved plan. Presumably there would be no objection to the provision in a multi-storied block of office space for sub-letting, comparable to the present tenancy arrangements in Science House.

The next step in the proceedings is likely to be a direct discussion with the State Government. The Linnean Society, with the goodwill of the Sydney Cove Redevelopment Authority and the enthusiastic interest and support of other societies, may approach this period of negotiation with confidence.

A survey was taken by a market research consultant to ascertain the support of other professional and scientific organizations. In view of the response, it was decided to hold a meeting of possible co-owners as soon as possible, with a view to establishing an organization to proceed with the planning for a Science Centre.

The Secretary will also press for an early meeting with the Deputy Premier, Mr. Cutler.

Library

Council, at its last meeting, discussed the implications of the last month's developments, with particular reference to the Library.

After considerable discussion, it was decided to retain the Library if at all possible, and that work on the Library proceed accordingly. It was agreed that a librarian would have to continue to be employed from now on (on a part-time basis).

Library accessions from scientific institutions and societies on the exchange list from 1st March 1970 to 28th February 1971 amounted to 1,802.

The total number of borrowings from the Library of books and periodicals by members and institutions for the year was 290.

Linnean Macleay Fellowship

Dr. A. Anne Howie was appointed Linnean Macleay Fellow in Vertebrate Palaeontology for one year as from 1st June 1970. During the year Dr. Howie has been undertaking field trips to Rewan Station in Queensland which, among other material, yielded a skull of the first labyrinthodont found in that State.

Linnean Macleay Lectureship in Microbiology

Dr. K. Y. Cho, Linnean Macleay Lecturer in Microbiology, University of Sydney, as from 1st January 1969, reported as follows on his work for the year to December 1970. Previous work on the extremely halophilic bacteria was accepted for publication in the *Journal of General Microbiology* (62 : 267–270, 1970). Purification and characterization of the exoprotease in these extreme halophiles are still in progress. The information obtained may be helpful in understanding the evolution of enzymes. Other projects under investigation are the use of spermine for preserving fine structure in bacteria and the effect of vinca alkaloids on *Azotobacter vinelandii*.

Annual Elections

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 : Barbara G. Briggs, Ph.D. ; H. G. Cogger, M.Sc., Ph.D. ; Elizabeth C. Pope, M.Sc., C.M.Z.S. ; P. G. Valder, B.Sc.Agr., Ph.D. (Camb.) ; T. G. Vallance, B.Sc., Ph.D. ; G. P. Whitley, F.R.Z.A.

Auditor : W. Sinclair & Co.

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

A vote of thanks to the retiring President, Professor N. G. Stephenson, was moved from the Chair and carried by acclamation.

LINNEAN SOCIETY OF NEW SOUTH WALES

GENERAL ACCOUNT

BALANCE SHEET AS AT 28th FEBRUARY, 1971

1970 $		$	$
	Accumulated Funds		
	Balance, 1st March, 1970		
	Amount received from Sir William Macleay	40,000.00	
	Transfers from Income Account	10,669.69	
			50,669.69
	Add Surplus for the Year		3,147.03
50,669	Balance, 28th February, 1971		53,816.72
	Reserves		
68,344	Contingencies	68,344.13	
1,153	Bookbinding	1,152.66	
			69,496.79
$120,166			$123,313.51

1970 $		$	$
	Fixed Assets		
30,097	Commonwealth Loans—At Cost		30,097.00
	Debentures—At Cost		
41,689	Metropolitan Water, Sewerage and Drainage Board		39,688.75
6,000	Sydney County Council		6,000.00
31,470	Science House—At Cost (one-third Interest)		31,470.43
—	Loan on Mortgage		4,750.00
109,256	Total Fixed Assets		112,006.18
	Current Assets		
40	Cash on Hand	40.00	
10,870	Commercial Banking Company of Sydney Limited	11,267.33	
10,910	Total Current Assets		11,307.33
$120,166			$123,313.51

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 28th FEBRUARY, 1971

1970 $	EXPENDITURE	$
105	Audit Fees	105.00
169	Cleaning	151.40
472	General Expenses	314.92
980	Illustrations	754.05
25	Insurance	34.77
251	Library	249.21
14	Light and Power	22.91
215	Linnean Society of London	—
52	Office Renovations	196.77
443	Postages	287.99
5,187	*Proceedings*—Printing Costs	5,042.55
—	Proof Reading	57.00
—	Presentations	128.34
323	Printing and Stationery	323.01
—	Referee's Fees	55.00
660	Reprints	841.13
—	Sir William MacLeay Lecture	232.60
3,735	Salaries and Honorarium	5,952.06
3,556	Science House Rent	3,556.00
93	Telephone	59.66
16,280	Total Expenditure	18,364.37
5,356	Surplus for the year, transferred to Accumulated Funds	3,147.03
$21,636		$21,511.40

1970 $	INCOME	$	$
	Subscriptions		
1,579	1970–1971	1,526.00	
147	Arrears	117.61	
42	Advance	28.00	
			1,671.61
200	Contributions		1,000.00
4,349	Interest Received		4,514.11
3,497	Fellowships Account—Surplus Income for the year ended 28th February, 1971		3,722.59
800	Grant—N.S.W. Government		800.00
43	Rents Received		29.50
1,227	Reprints Sales		585.46
—	Sir William Macleay Lecture Dinner Receipts		51.75
2,048	Sales		1,920.18
7,704	Science House—Share of Surplus		7,216.20
21,636	Total Income		21,511.40
$21,636			$21,511.40

AUDITOR'S REPORT

We have audited the Books and Records of the Linnean Society of New South Wales for the year ended 28th February, 1971, and are of the opinion that the above Balance Sheet and accompanying Income and Expenditure Account correctly sets forth the position of the financial affairs as at 28th February, 1971, according to the explanations given to us and as disclosed by the books.

Dated at Sydney this Fifteenth day of March, 1971.
G. N. Baur, Hon. Treasurer.
15th March, 1971.

(Sgd.) W. Sinclair & Co.,
Chartered Accountants,
Registered under the Public Accountants
Registration Act 1945, as amended.

LINNEAN SOCIETY OF NEW SOUTH WALES

BACTERIOLOGY ACCOUNT

BALANCE SHEET AS AT 28th FEBRUARY, 1971

1970		$	$	1970 $		$
	Accumulated Funds				Fixed Assets	
	Balance, 1st March, 1970			30,636	Commonwealth Loans—At Cost	30,636.25
	Amount bequeathed by Sir William Macleay	24,000.00		1,800	Debentures—Metropolitan Water, Sewerage and Drainage Board—At Cost	1,800.00
	Transfers from Income Account	13,251.38		3,900	Loan on Mortgage	3,400.00
	Research Fund	20.00	37,271.38	36,336		35,836.25
	Less Deficiency for the Year		7.16		Current Assets	
37,271	Balance, 28th February, 1971		37,264.22	935	Commercial Banking Company of Sydney Limited	1,427.97
$37,271			$37,264.22	$37,271		$37,264.22

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 28th FEBRUARY, 1971

1970 $		$	1970 $		$
1,910	University of Sydney—Salary of Lecturer	1,950.00	1,964	Interest Received	1,942.84
54	Surplus	—	—	Deficiency for the Year	7.16
$1,964		$1,950.00	$1,964		$1,950.00

AUDITOR'S REPORT

We have audited the Books and Records of the Linnean Society of New South Wales for the year ended 28th February, 1971, and are of the opinion that the above Balance Sheet and accompanying Income and Expenditure Account correctly sets forth the position of the financial affairs as at 28th February, 1971, according to the explanations given to us and as disclosed by the books.

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Dated at Sydney this Fifteenth day of March, 1971.
G. N. Baur, Hon. Treasurer.
15th March, 1971.

LINNEAN SOCIETY OF NEW SOUTH WALES

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT
BALANCE SHEET AS AT 28th FEBRUARY, 1971

1970 $		$	$
	ACCUMULATED FUNDS		
	Balance, 1st March, 1970		
	Amount bequeathed by Sir William Macleay	70,000.00	
	Transfers from Income Account	51,472.98	
			121,472.98
	Transfers from Income and Expenditure Account		800.00
121,473	Balance, 28th February, 1971		122,272.98
$121,473			$122,272.98

1970 $		$
	FIXED ASSETS	
60,886	Commonwealth Loans—At Cost	59,885.50
	Debentures—At Cost	
5,000	Electricity Commission of New South Wales	6,000.00
42,297	Metropolitan Water, Sewerage and Drainage Board	37,896.98
1,745	Rural Bank of New South Wales	17,45.50
11,000	Loans on Mortgage	15,750.00
120,928		121,277.98
	CURRENT ASSETS	
545	Commercial Banking Company of Sydney Limited	995.00
$121,473		$122,272.98

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 28th FEBRUARY, 1971

1970 $		$
2,667	Salary of Linnean Macleay Fellow	2,400.00
533	Transfer to Capital Account	800.00
3,497	Surplus for the year, transferred to General Account	3,722.59
$6,697		$6,922.59

1970 $		$
6,697	Interest Received	6,922.59
$6,697		$6,922.59

AUDITOR'S REPORT

We have audited the Books and Records of the LINNEAN SOCIETY OF NEW SOUTH WALES for the year ended 28th February, 1971, and are of the opinion that the above Balance Sheet and accompanying Income and Expenditure Account correctly sets forth the position of the financial affairs as at 28th February, 1971, according to the explanations given to us and as disclosed by the books.

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Dated at Sydney this Fifteenth day of March, 1971.
G. N. BAUR, Hon. Treasurer.
15th March, 1971.

THE TRICHOMES OF THE GOODENIACEAE

R. C. Carolin
School of Biological Sciences, University of Sydney

[Accepted for publication 9th December 1970]

Synopsis

A survey of trichomes in the Goodeniaceae is reported. It is concluded that there are seven distinct types of trichome: (1) stellate-simple; (2) uniseriate multicellular; (3) branched multicellular; (4) T-shaped; (5) glandular; (6) dendritic; (7) Brunonia-type. Types (1), (5) and (6) are subdivided into subtypes. Each type is morphologically distinct and therefore has had a long, separate evolutionary history. The hair types confirm previous suggestions in systematic rearrangement and again call into question the groupings made by the most recent monographer (Krause).

Introduction

The trichomes of the Goodeniaceae have not been examined in detail before. Krause (1912) makes passing references to them in his introductory paragraphs but gives few illustrations. He uses the indumentum type in his species descriptions and keys but only distinguishes between glandular, stellate and simple types, and in *Dampiera* provides some illustrations of different sorts of dendritic hairs. In some cases he refers to a species as being glabrous when, in fact, it does have numerous microscopic hairs (e.g. *G. ovata*). Colloza (1907, 1908) mentions the trichomes in a very few cases and illustrates only those of *Brunonia*. Hummel (1962) does not appear to mention the family.

The use of trichomes in taxonomic studies is well established by a long line of investigators, particularly in the family Gramineae. In other families the taxonomist is usually content to describe the macroscopic appearance and texture of the indumentum. Uphof (1962) draws attention to a few cases in which more detailed investigations have been carried out. It is primarily because of their potential use in the taxonomy of the family that the present investigation has been undertaken.

Material and Methods

Most of the observations have been carried out on herbarium material. Thin, surface sections of the dry material were cut by hand with a sharp razor blade; the section bleached and soaked in a mixture of commercial bleaching agent and weak detergent. The sections were then mounted in Gurr's water-mounting medium without staining. In the few cases where fresh material was available the soaking in the bleach was omitted. In addition, transverse sections of the leaves and corollas were prepared by embedding in paraffin wax in the usual manner. These two sets of preparations were further supplemented by observations on the whole specimen, scraping the hairs off the epidermis with a razor blade and mounting in Gurr's water-mounting medium.

Some of the sections were stained to distinguish the cuticle; the stains used were ammoniacal fuchsin and Auromine. The former stains the cuticle red and also shows a brilliant fluorescence, whilst the latter is visible only with fluorescence microscopy.

OBSERVATIONS

Coopernookia: Three basically different types of trichomes are found in this genus. Uniseriate multicellular hairs (Fig. 5) are almost restricted to the leaf axil. They consist of a basal cell with a prominent cuticle and a varying number of other cells with thin walls and a cuticle that is only visible using fluorescence microscopy. The so-called stellate hairs (Carolin, 1968) consist of a basal group of cells without outgrowths but with heavily cutinized surfaces, surmounted by a series of thick-walled, thin-cuticled cells with long, stiff, pointed outgrowths (Fig. 1, F). Furthermore, there are glandular hairs present and, whilst the two former hair-types are more or less uniform throughout the genus, these latter show some variation. In *C. barbata* the head of the hair is unicellular (Fig. 6). *C. chisholmii* also has this form of glandular hair but they are much less frequent. In *C. strophiolata*, *C. polygalacea* and *C. georgei* the head is four-celled and so flattened as to appear almost peltate (Fig. 3, E).

Fig. 1. Stellate and simple hairs. A. *Goodenia ovata.* B. *Diaspasis filifolia.* C. *Goodenia pinnatifida.* D. *Goodenia stelligera.* E. *Goodenia subintegra.* F. *Coopernookia polygalacea.* G. *Scaevola tomentosa.*

Velleia: Only simple unicellular hairs are found in this genus, except for some uniseriate multicellular hairs in the leaf axils. The former have thick cell walls which extend down into the basal part; the cuticle is very thin, and scarcely visible using normal staining and lighting. The only variation in the microscopic form of the hairs is in the degree to which the surrounding epidermal cells are raised up into a sheath around the base of the hair. This is fairly conspicuous in *V. hispida* (as in Fig. 1, C) but much less so in *V. paradoxa* and *V. trinervis* with *V. rosea* and *V. daviesii* showing intermediate conditions. Indeed, the size of the sheath is variable in the one species to some extent, although *V. hispida* in particular shows a constantly well-developed sheath.

Goodenia: This large genus displays a wide variety of trichomes; most species have tufts, however minute, of uniseriate multicellular hairs in the leaf axils; it is, however, the surface trichomes to which we should divert attention.

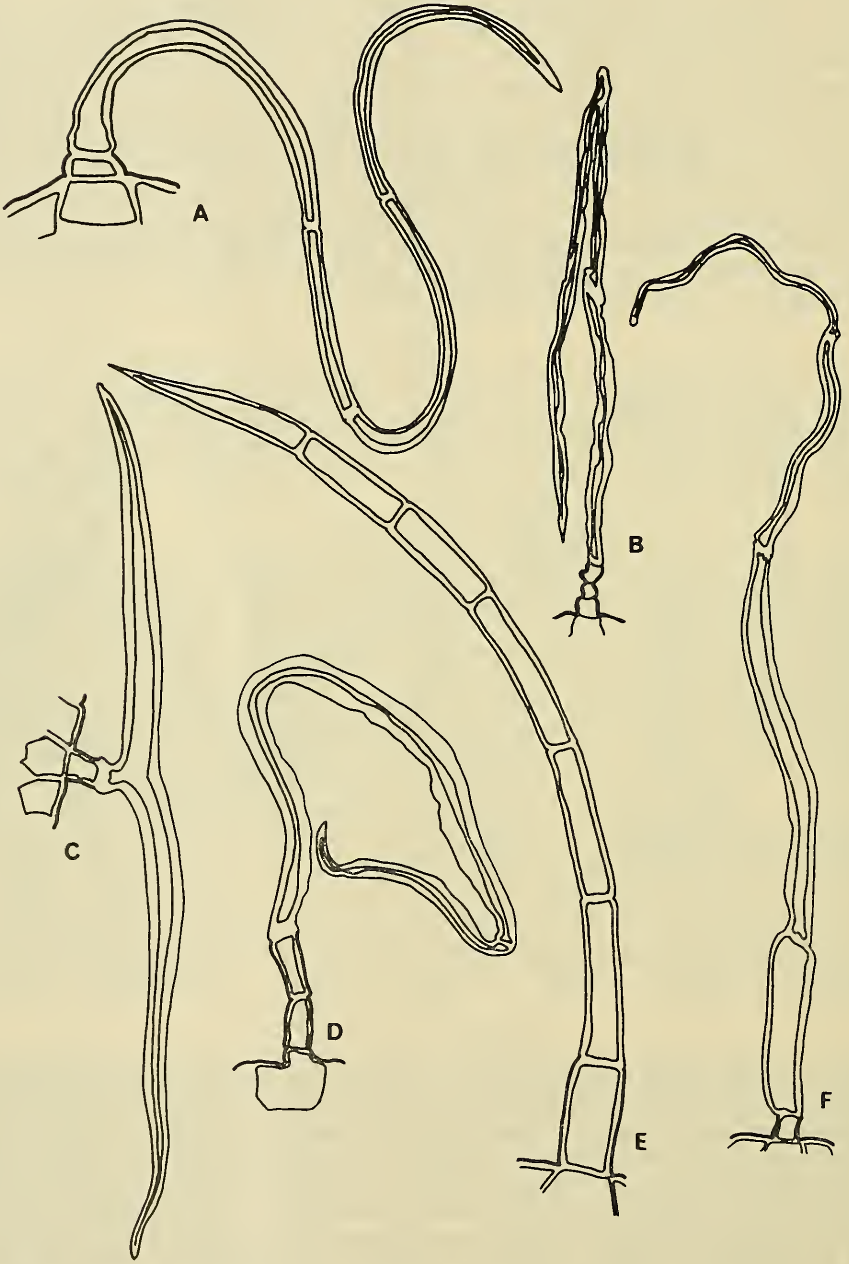

Fig. 2. Uniseriate multicellular and T-shaped hairs. A. *Goodenia incana*. B. *Goodenia hederacea*. C. *Goodenia mueckeana*. D. *Goodenia primulacea*. E. *Pentaptilon careyi*. F. *Goodenia heterochila*.

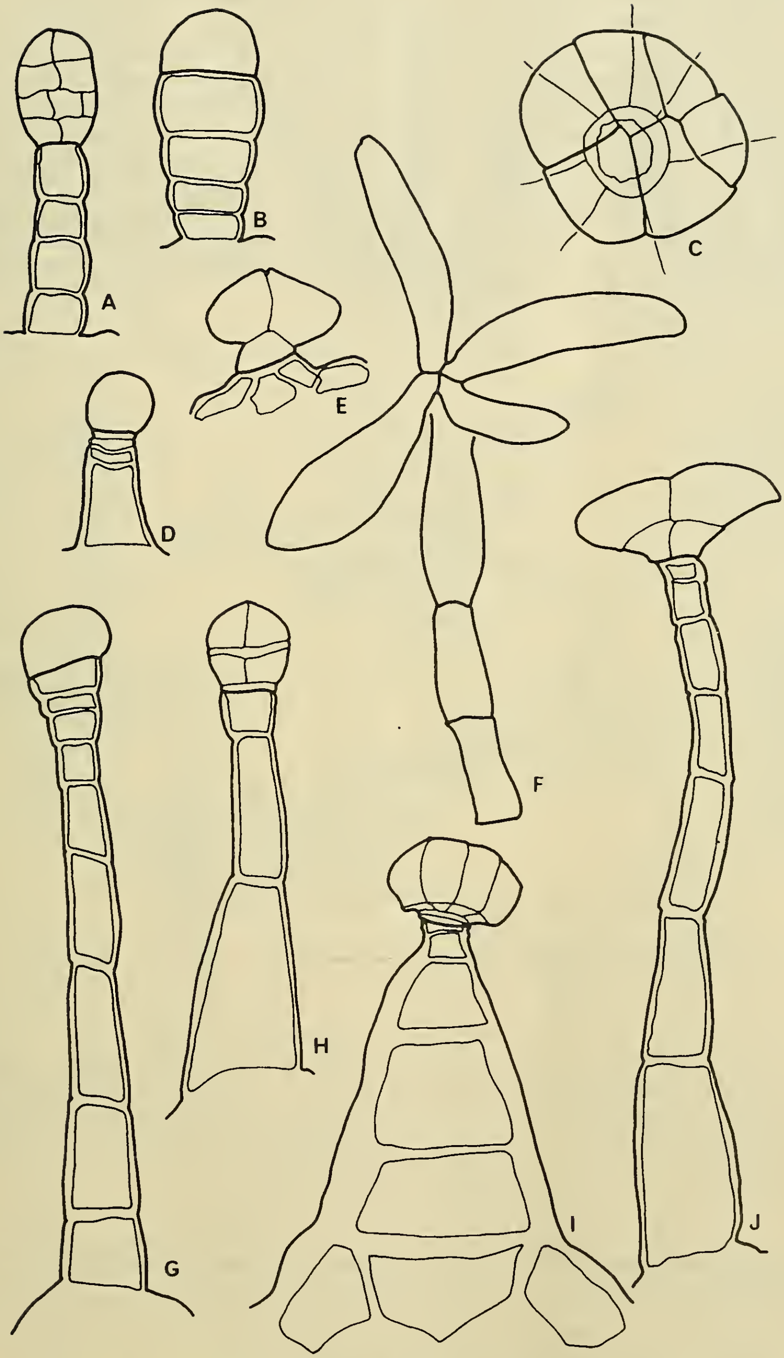

Fig. 3. Glandular hairs. A. *Calogyne* sp. B. *Goodenia decurrens*. C. *Goodenia ovata*. D. *Goodenia concinna*. E. *Coopernookia polygalacea*. F. *Scaevola coriacea*. G. *Goodenia stephensonii*. H. *Pentaptilon careyi*. I. *Goodenia barilletii*. J. *Leschenaultia hirsuta*.

Despite the inadequacies of Krause's (1912) treatment (see Carolin, 1959, 1968), it seems best to use this as a basis for reporting these findings.

The various forms of the trichomes are shown in Figs. 1, 2 and 3, and Table 1 indicates their occurrence in the species examined. The stellate type is virtually the same, although generally shorter, as the stellate type in *Coopernookia*. Submerged stellate can be looked upon as the stellate type which has lost the basal column of more heavily cutinized cells, or as a cluster of simple trichomes. The simple and ensheathed simple trichomes have the same form as those found in *Velleia*. The one-sided simple hairs appear to be unique to *Goodenia* ; these hairs are appressed and apparently ensheathed on one side, but this is obscured by an outgrowth of the trichome more or less overlapping and obscuring the basal sheath (Fig. 1, E). *G. mueckeana* appears to have a unique form of simple hair in that it is T-shaped (Fig. 2, C).

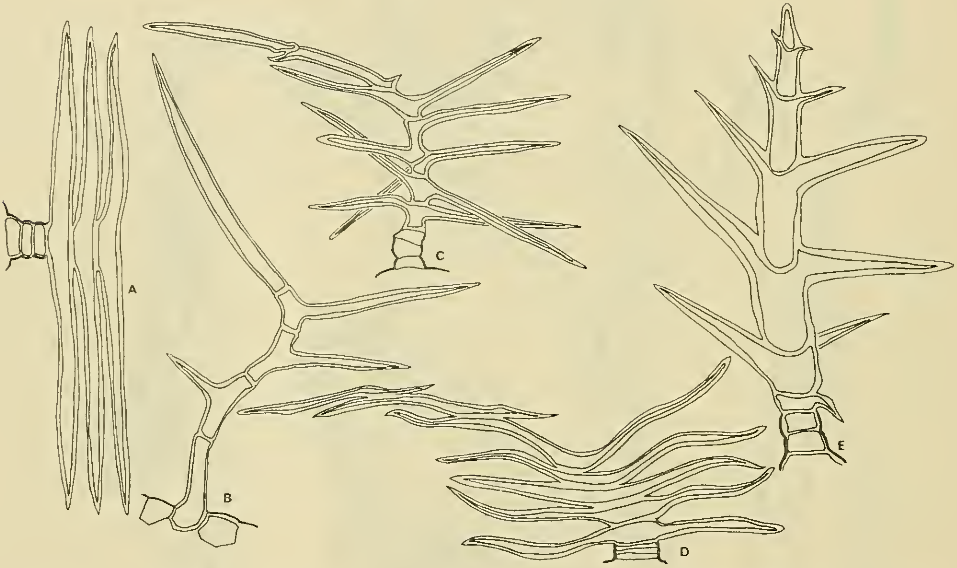

Fig. 4. Dendritic hairs and branched multicellular hairs. A. *Dampiera coronata*. B. *Verrauxia reinwardtii*. C. *Dampiera tomentosa*. D. *Dampiera stricta*. E. *Dampiera purpurea*.

The glandular hairs can be divided into those with a single-celled head and those with a multicellular head (Fig. 3, A-E). In a few multicellular headed hairs the head is flattened to give the peltate hair (Fig. 3, C), but in others the the number of tiers of cells in the head is multiplied considerably and the head is oval or spherical in shape. This latter type may have a stalk which is uniseriate to the base (Fig. 3, A) or multicellular at the base (Fig. 3, I).

Calogyne: This genus falls into two fairly well defined groups on the basis of hair type, although at first they appear similar in that both have glandular and simple hairs.

C. berardiana has simple hairs more or less ensheathed on one side only (as in Fig. 1, E) and glandular hairs with single-celled heads.

C. holtziana and *C. purpurascens* have simple, practically sheathless cells and glandular hairs with multicellular heads (Fig. 6, V, 2).

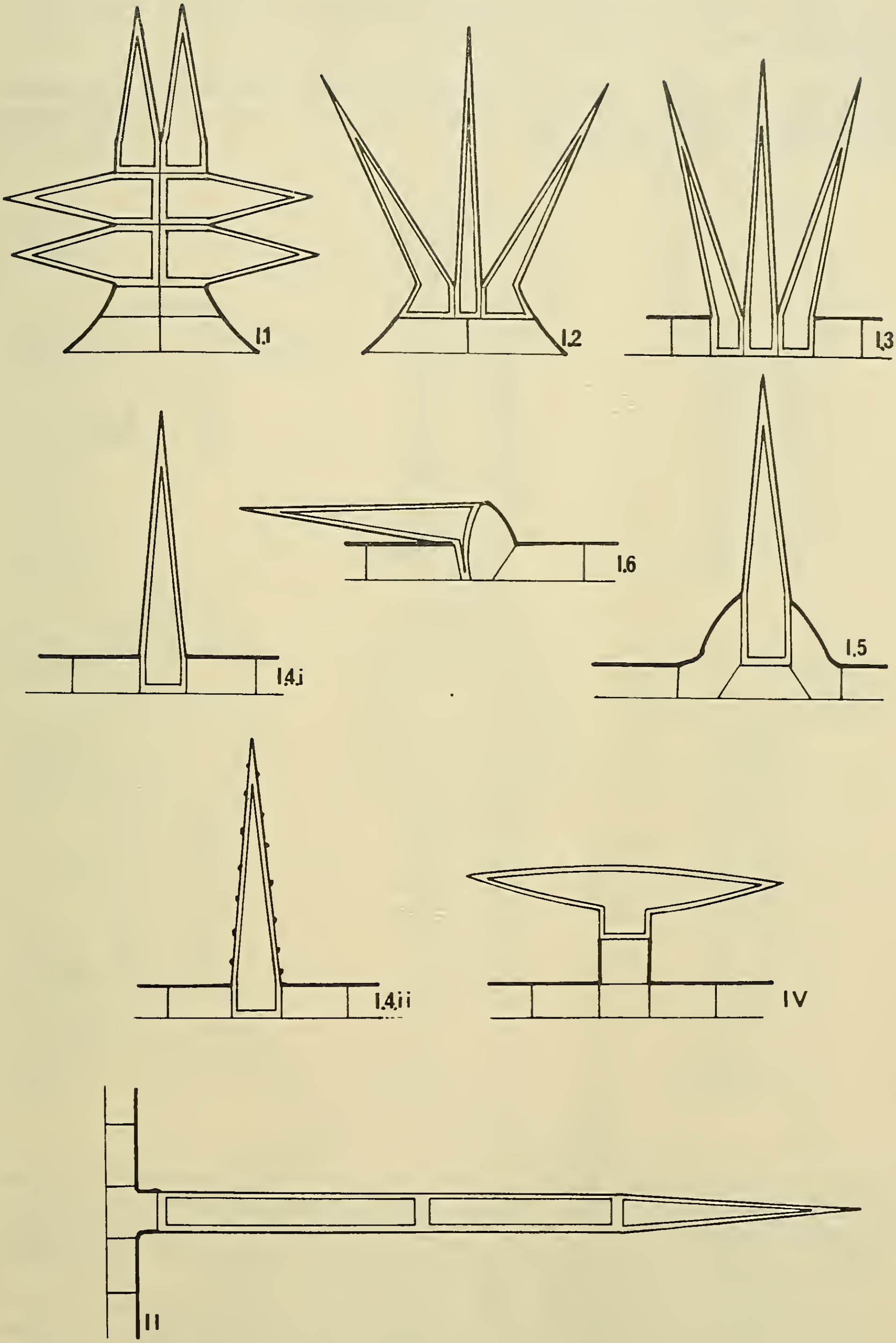

Fig. 5. Hair types, see Table III.

Catosperma: The single species *C. goodeniaceum* has a few short simple hairs, particularly on the sepals, and rather more numerous cottony, multicellular hairs.

Diaspasis: The single species *D. filiformis* has very thick-walled unsheathed simple hairs in which the cuticle is raised into numerous warty outgrowths; the wall is conspicuously striated.

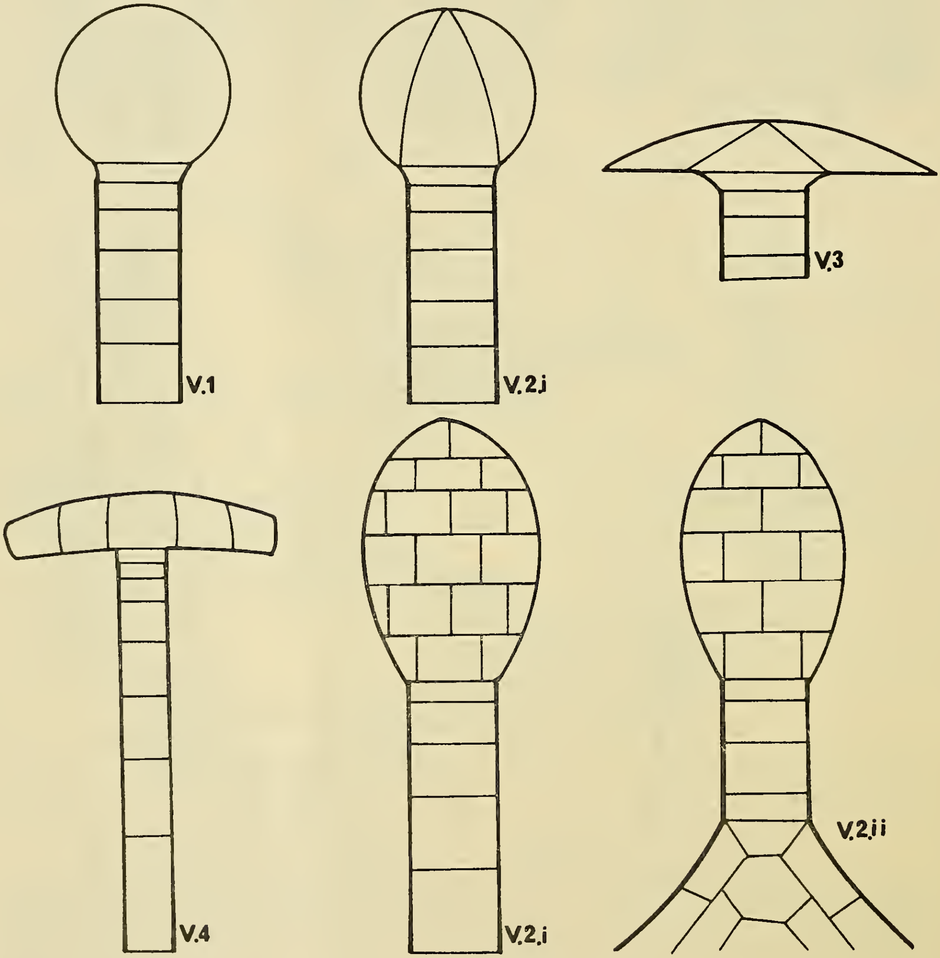

Fig. 6. Hair types, see Table III.

Scaevola: This genus shows rather fewer hair types than the other large genus *Goodenia*. In fact, however, another subtype is found which is almost a characteristic feature of the genus, i.e. the simple hair with an uneven, warty surface (Fig. 1, B). The occurrence of hair types in *Scaevola* and its supposed relative *Diaspasis* is shown in Table 2.

It can be seen from this that stellate hairs are very infrequent, found only in *S. tomentosa* (Fig. 1, G) of the species examined. Simple, smooth hairs are also rare, being found only in *S. mollis*. The glandular and peltate types have apparently the same construction as those of *Goodenia*.

TABLE 1
Distribution of Hair Type in Goodenia *and Related Genera*

Name	Stellate I.1 and I.2	Submerged Stellate I.3	Simple I.4.i	Ensheathed Simple I.5.i	One-sided Simple I.6	Multicellular II	T-shaped IV	Glandular V.1	Glandular with Multicellular Head V.2.i	Glandular with Multicellular Head and Multicellular Base V.2.ii	Peltate V.3
GOODENIA											
Sect. Monochila											
G. viscida R.Br.		—	—	—		—	—		—		+
G. xanthotricha De Vriese			—	—	—	—	—	+	—	—	—
G. watsonii F. Muell.				—		—	—	+			—
G. sericostachys Gardner		—	—			—	—		—	—	—
Ser. Racemosae											
G. quadrilocularis R.Br.			—	—				—		—	—
G. eremophila E. Pritzel					—	—	—	—	+	—	
G. stapfiana Krause	—		—						—	—	
G. ramellii F. Muell.	—		—			—		—	—	—	
G. decurrens R.Br.	(—)		—			—	—	—		—	—
G. bellidifolia Sm.	—		—		—	+	—	—	—	—	—
G. stelligera R Br.	—	—	—		—	+		—		—	—
G. rostrivalvis Domin			—	—	—	+	—	+	—		
G. dimorpha Maiden et Betche	—	—	—	—	—		—	—	—	—	
G. geniculata R Br.	—	—	—	—	—	—	—	—	—	—	
G. primulacea Schlechtd.			—	—		—		—	—	—	—
G. robusta (Benth.) Krause	—	—	—	—	—	+	—	—	—	—	—
G. affinis De Vriese	—	—	—	—	—	+	—			—	—
G. heterophylla Sm.	—		+			—		+		—	—
G. hederacea Sm.	—	—	—	—	—	+		—			—
G. rotundifolia R.Br.	—		+	—	—	(+)			—	—	—
Ser. Suffruticosae											
G. ovata Sm.		—	(+)	—	—	—	—	—	—	—	+
G. varia R.Br.	—	—	—	—	—	—	—	—	—		+
G. mueckeana F. Muell.	—	—	—	—	—	—			—	—	—
G. amplexans F. Muell.	—	—	+	—	—	—	—	+	—	—	—
Ser. Coeruleae											
G. azurea F. Muell.		—	(+)	—	—						—
G. incana R.Br.	—		—	—				—	—	—	—
G. horniana F. Muell. et Tate	—	—	+	—			—	+	+	—	—
G. scaevolina F. Muell.	—		—	—	—		—		—	—	—
G. coerulea B.Br.	—	—	(—)	—	—				—	—	—
G. trichophylla De Vriese ex Benth.	—	—	—	—	—	—	—				—
Ser. Foliosae											
G. mitchellii Benth.	—		—	(+)	—		—	+			—
G. heterochila F. Muell.	—	—	—		—		—	+	—	—	—
G. hispida R.Br.	—	—		+	—	—	—				—
G. grandiflora Sims	—	—	—	—	—		—	—	—	—	—
G. chambersii F. Muell.	—	—			—	—	—	+	—		—
G. macmillanii F. Muell.		—	—	—	—		—	+	—	—	
G. armstrongiana De Vriese	—	—	—	+	—	—	—	—			
Ser. Pedicellosae											
G. cycloptera R.Br.	—	—	+	—	—			—			—
G. pinnatifida Schlechtd.	—	—	—	+			—	—	—		—
G. pusilliflora F. Muell.	—	—	—	+	—	—	—	+	—	—	—
G. elongata Lahill.	—	—	+	—	—	—	—	—	—		—
G. glauca F. Muell.	—	—	—	—	+	—	—	—			—
G. subintegra F. Muell. ex Black	—	—	—		+	—	—	±			—
G. lunata Black	—	—	—	—	+	—	—	±			
G. heteromera F. Muell.	—	—	—	—	+	+	—	+	—		
G. pulchella Benth.	—	—	—	—	+	—	—	+			—
G. concinna Benth.	—		—	—	+	—	—	+	—	—	—
G. micrantha Christ. et Ost.	—	—	—	—	+	—	—	+		—	—
G. cirrifica F. Muell.	—	—		+		—	—	+	—	—	—
G. vilmorinae F. Muell.	—	—	—	—	—	—	—	+			—
Sect. Amphichila											
G. paniculata Sm.	—	—	—		—	—	—	+	—		
G. gracilis R.Br.	—	—	+	—			—	+	—		
G. pumilio R.Br.	—	+	—				—	—	—	—	—
Incertae Sedis											
G. tenuiloba F. Muell.	—				—		—	+			—
COOPERNOOKIA											
C. polygalacea (De Vriese) Carolin	+	—		—		—		—		—	—
C. barbata (B.Br.) Carolin	+		—		—		—	+	—	—	—
C. strophiolata (F. Muell.) Carolin	+	—	—		—	—	—			—	+
VELLEIA											
V. hispida Fitzg.	—	—	—	—	—						—
V. paradoxa R.Br.	—	—	+	—	—		—	—			—
V. trinervis Lahill.	—	—			—	—					—
V. rosea Sp. Moore	—	—	—	+	—			—		—	—
V. daviesii F. Muell.	—		—	+		—	—				—

Pentaptilon : This monospecific genus has very much the same indumentum as *Verreauxia*, all the same types of hair are present, simple, unbranched multicellular, branched multicellular, glandular with multicellular heads.

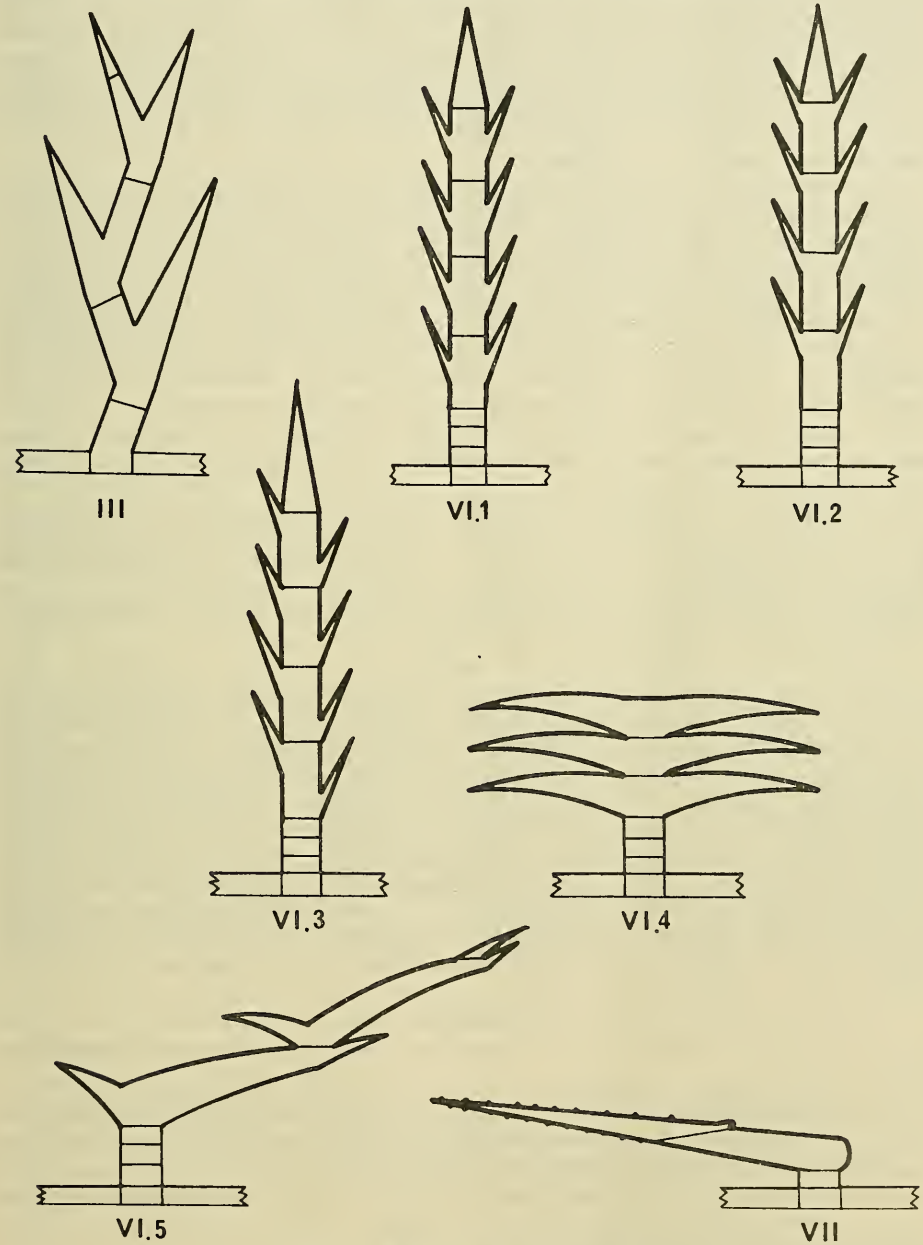

Fig. 7. Hair types, see Table III.

Leschenaultia : Few species of this genus appear to have trichomes except on the inner floral parts. *L. hirsuta* has glandular hairs with flattened multicellular heads on multicellular stalks. The heads are frequently knocked off and consequently trichomes on the older parts of the plant often appear to be simple (Fig. 3, J).

Dampiera: This large genus appears to show only the dendritic hair-types These hairs at first sight appear to be similar to those of *Verreauxia* but differ in that they have two short arms instead of one to each cell, except the basal two or three and the terminal cell. There is some variation on the basic theme of this hair-type in *Dampiera* which will no doubt prove of taxonomic value in the future. The variation is concerned mainly with the position of the two branches of each cell with regard to each other, the length of the cells and the number of the cells in the trichome.

In *D. discolor* the arms are situated opposite each other and more or less in the middle of the cell (Fig. 7, VI.1), whilst in *D. hederacea*, *D. incana* and *D. luteiflora* they are situated at the top of the cell opposite each other (Figs. 4, E, 7, VI.2). In many species there is a tendency for the upper cells to be attached to the hair somewhat laterally rather than terminally on the preceding cell of the trichome, e.g. *D. spicigera* (Fig. 4, C). In *D. coronata*, *D. lindleyi* and *D. eriantha* there are only one to three armed cells, and the body of each cell is very short (Figs. 4, A ; 7, VI.4). There is a tendency also for each cell to be displaced laterally, as in *D. stricta* (which see) but this is usually very slight.

D. eriocephala and *D. adpressa* show the condition when the arms of each armed cell are not opposite but one is placed at the top of the cell and one at the bottom (Figs. 4, C ; 7, VI.3).

In *D. stricta* the arms are also displaced but, in addition, each succeeding cell of the trichome is bent horizontally at its base, thus giving a series of steps (Figs. 4, D ; 7, VI.5).

Brunonia: This genus has, at first sight, a hair-type entirely different from that found in any other genus in the family.

The hairs are multicellular and closely appressed to the epidermis. The basal cell is thin-walled and quite obviously cutinized, whilst all the succeeding cells are very thick-walled with a very thin cuticle. The first of these latter cells turns the trichome through 90° since it is attached horizontally to the basal cell (Fig. 7, VII). Moreover, it has a prominent groove in the upper surface, particularly towards the base. The next cell of the trichome is attached diagonally to the apex of the first and frequently the two spiral around each other for some distance (Fig. 7, VII). There are two subtypes, both found on the same plants. In one this second cell is the terminating cell and has large warty projections on the surface. In the second subtype, which is much longer, there are usually still more cells in the file, all attached to each other in much the same manner as indicated above, and none of them has prominent warty projections.

DISCUSSION

On the basis of these results it is possible to distinguish seven main trichome types :

(i) Stellate-simple type in which one or several unbranched cells are arranged side by side in short multicellular files (Fig. 5, I.1–I.5).
(ii) Uniseriate multicellular type (Fig. 5, II).
(iii) Branched multicellular type in which each cell, except the basal and terminal ones, branch once (Fig. 7, III).
(iv) T-shaped type (Fig. 5, IV).
(v) Glandular type (Fig. 6).
(vi) Dendritic type in which each cell except some basal ones and sometimes the terminal one has two side-arms (Fig. 7, VI.1–VI.5).
(vii) *Brunonia*-type (Fig. 7, VII), which may be a derivative of (ii).

Each of these trichome types appears to have had its own independent phylogenetic history within the family ; independent that is, as far as any part of the organism can be independent of any other part. There is, moreover, probably no significant phylogenetic link between the main types, i.e., we cannot look upon any of the seven types outlined above as being derived from each other, with the possible exception of the *Brunonia*-type. They all differ from each other fairly significantly. For instance, it is improbable that the thick-walled stellate-simple trichome of horizontally arranged cells gave rise to the single-file multicellular hair or to the thin-walled secretory glandular hairs.

The dendritic type does show some similarity to the unbranched multicellular type in that they both consist of uniseriate files of cells with a basal group of heavily cutinized cells. It is felt, however, that any such derivation must have occurred at a very early stage in the history of the family since their appearances are now so different. There is a slight resemblance to the branched multicellular type, but this would appear to be rather superficial since there are no basal cells more heavily cutinized than the upper ones ; in fact, the insertion of these basal cells on the epidermis is more like that of simple hairs.

The most complex of the stellate-simple type is found in *Coopernookia* (Fig. 5, I.1). It has been indicated previously that this genus has a number of features that may be considered primitive in the genus (Carolin, 1966). This is really the only evidence that is available for suggesting a phylogenetic starting point for the various forms of this trichome type. It is easy enough to arrange these types in a series (Fig. 5), but to determine whether it is a reduction series or compounding series other evidence is necessary. For the reason given it will be considered as a reduction series in which first the individual units are contracted into a submerged, unilayered, stellate form (I.2) then submerged in the epidermis (I.3) and then reduced to a single unit forming a simple trichome (I.4). Type I.5 is similar but is ensheathed at the base by a raised plinth of cells.

The appressed hairs of *Goodenia glauca* and its allies are derived from the simple form by the excessive growth of the plinth cells on one side (I.6). The warty type might almost be considered a subform of the simple trichome. In many ways the T-shaped trichomes of *G. mueckeana* (Fig. 5, IV) could be mistaken for suppressed dendritic trichomes. However, it does not have the full complement of basal cells for the dendritic type. Furthermore, this latter type is completely unknown in *Goodenia*, to which *G. mueckeana* undoubtedly belongs, or any of its close relatives. If, in fact, this trichome type is genetically related to the dendritic type, it is either a phylogenetic " throw-back " of some significance or a feature which has been retained from the ancestral Goodeniaceae in only this one species over a very considerable period of time. In the absence of any further evidence probably the best course is to recognize it as a separate type. The presence of a basal cutinized cell may link this cell type to the unbranched multicellular type.

The unbranched multicellular type shows relatively little variation in form throughout those genera in which it occurs. The variation that does occur is confined to differences in length and straightness of the hair, features possibly significant taxonomically but not particularly so in a general survey of the type being reported here.

The dendritic type shows almost as much formal variation as the stellate-simple type. Again, it is almost impossible to decide which form is primitive ; possibly the equal-armed type with the arms at the mid-point of the cell could be taken as a starting point (Fig. 7, VI.1). Changes have been firstly the arms occurring at the top of each cell (Fig. 7, VI.2) and secondly one arm occurring at the top and one at the bottom (Fig. 7, VI.3). The suppression of the lower part of each cell and the extension of the arms leads to Fig. 7, VI.5, whilst VI.5 has lead to form VI.6 by the whole trichome becoming appressed.

The *Brunonia* type could have been derived from this last form, i.e., 6, by suppression of both arms or their connation, or from type II. The evidence available does not allow a decision to be made.

Again, the glandular hair-type shows very considerable variation, and whilst it is easy enough to draw a series, the designation of the primitive condition is not so simple. Since the stalk is a file of cells, it seems reasonable to conclude that in the primitive condition the head will continue this sequence and also be unicellular. Thus this series can be looked upon as a compounding series, the head increasing in complexity. The first step is a double division of the terminal cell to give the situation in 2. In one line of change this becomes flattened into the peltate form of 3 and in another the multicellular form of 4 (all Fig. 6). The subforms of V.2 are based on the single or multicellular base. The form found in *Leschenaultia* is sub-peltate but with a long stalk.

Any sort of overall concept of evolution within the family must await more complete evidence. This survey of trichome form and phylogeny is an attempt to determine the homologies of the various trichomes, a task which has to be performed before any overall taxonomic or phylogenetic assessment can be made.

Functionally, it is possible that all these trichomes have a bearing on the adaption of these plants to the hot, dry, sunny climates in which many of them live. The non-glandular trichomes reflect incident light and heat and thus may restrict water loss. Various species have developed the appressed habit of trichomes, but using different types, thus in *Goodenia glauca* they are simple, in *Goodenia hederacea* they are uniseriate multicellular, in *Dampiera stricta* and *D. coronata* they are still another type ; the same apparent condition is achieved by non-homologous structures in these cases.

The glandular hairs may likewise function in decreasing water loss since they secrete a resin which covers the epidermis and frequently even obstructs the stomata.

More information is obviously necessary with regard to the physiology of these plants, but it is reasonable to assume that the trichomes do, in fact, have a significance in the adaptation of these organisms.

It seems clear that these trichomes will be important taxonomic characters. The last monograph of the family (Krause, 1912) made relatively little use of them.

In some ways this investigation indicates that adjustments may be needed in previous suggestions (Carolin, 1959, 1966, 1967 ; Peacock, 1963), although they promise to be relatively minor.

Verreauxia and *Pentaptilon*, otherwise clearly agreeing with *Goodenia* and its satellite genera, stand apart in their possession of branched multicellular hairs. *Leschenaultia*, likewise, shows an aberrant trichome type resembling those of the *Goodenia* group more than those of the *Dampiera* group.

On the other hand the trichome types of *Coopernookia*, *Goodenia*, *Velleia*, *Scaevola*, *Diaspasis*, *Catosperma* and *Calogyne* are all very similar and, apart from the presence of branched multicellular types, those of *Verreauxia* and *Pentaptilon* are also similar to those of *Goodenia*. This 7- and 8-chromosome group (Peacock, 1963), with " polytelic " inflorescences (Carolin, 1967), " Goodenioid " floral morphology (Carolin, 1959) and with a single ovular strand and frequently winged seeds (Carolin, 1966) has distinct similarities when the trichomes are considered. *Diaspasis* is clearly very close to *Scaevola* in its trichome type.

The other genera, in the 9-chromosome group (Peacock, 1963), are less similar, as indeed has been shown in other previous studies (Carolin, 1959, 1966.)

The trichomes of *Brunonia* may show certain similarities with those of *Dampiera* but they are not close (see above).

The trichome type also promises to be of some use in the subdivision of the larger genera, particularly in *Goodenia*, and less so in *Dampiera* and *Scaevola*. A glance at Table 1 will show the occurrence of multicellular hairs to be concentrated in the ser. *Rosulatae* and ser. *Racemosae* and peltate hairs occur in *G. ovata* and its relatives *G. vernicosa* and *G. varia*. The one-sided simple type likewise is concentrated in *G. glauca* and its relatives, whilst the other forms tend to be scattered.

Table 3

Refer to Figures. Standardized Hair Types in Goodeniaceae

Description	Type	Form	Subform	Figure
Stellate	I	1	i	5
Reduced stellate	I	2	i	5
Submerged stellate	I	3	i	5
Submerged stellate, warty surface ..	I	3	ii	
Simple	I	4	i	5
Simple, warty surface	I	4	ii	5
Ensheathed simple	I	5	i	5
Ensheathed simple, warty surface ..	I	5	ii	
One-sided simple	I	6	i	5
Multi-cellular unbranched	II	—	—	5
Multi-cellular branched	III	—	—	7
T-shaped	IV	—	—	5
Glandular	V	1	—	6
Glandular with multi-cellular head ..	V	2	i	6
Glandular with multi-cellular head and multi-cellular base	V	2	ii	6
Peltate	V	3	—	6
Leschenaultia type	V	4	—	6
Dendritic, branched at mid-cell ..	VI	1	—	7
Dendritic, branched at top of cell ..	VI	2	—	7
Dendritic, one branch at top and one bottom of cell	VI	3	—	7
Dendritic with very short cells and long arms	VI	4	—	7
Dendritic with unequal arms	VI	5	—	7
Brunonia-type	VII	—	—	7

It is clear once again that Krause's subgeneric divisions have as little bearing on trichome distributions as they have on seed type and inflorescence type (Carolin, 1959, 1966). Little more can be said until a monograph is completed.

In *Scaevola* there are few distinctions, but peltate forms occur in a fairly compact set of species grouped around *S. porocarya*.

In *Dampiera* the only striking grouping of similar trichomes is type IV.5 in Sect. *Camptosperma*.

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THE REPTILES OF LORD HOWE ISLAND

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(Plates I, II)

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Synopsis

Three species of lizards are the only terrestrial reptiles recorded from Lord Howe Island. Of these, only the gecko *Phyllodactylus guentheri* Boulenger and the endemic skink *Leiolopisma lichenigera* (O'Shaughnessy), both of which are redescribed, are currently known to occur on the island.

Although both lizards are abundant on the small islands lying off-shore from Lord Howe Island (including Ball's Pyramid, from which both species are here recorded for the first time), they are now uncommon on the main island and confined to a small specialized habitat. The latter is described.

Records of the gecko *Gehyra oceanica* (Lesson) from Lord Howe Island are shown to be in doubt.

Introduction

Lord Howe Island (Fig. 1, Pl. I, A, B) is a crescent-shaped island roughly 7½ miles long and averaging about one mile in width, and is located approximately 440 miles east-north-east of Sydney, New South Wales. Its highest point (Mount Gower) rises to 2,836 feet above sea-level. The island is the central portion of a platform which has an average depth of about 50 fathoms. Standard (1961) considered that this platform was formed by wave action during the Pleistocene.

Lord Howe Island has long held great interest for the biologist, largely because of its isolation and the relatively high order of endemicity of its plants and animals. Until its discovery by Lt. Henry Lidgbird Ball in 1788 (only two weeks after the founding of the first Australian settlement at Port Jackson), Lord Howe Island had not known human occupation.

The history of the island has been well documented by Nicholls (1938) and Hindwood (1940). Oliver (1917) gives an excellent account of the plants of the island, while Standard (1963) gives a full account of its geology. Standard (1961) discusses Lord Howe Island in relation to the submarine geology of the Tasman Sea. Excellent general accounts of the island and its natural history are given by McCulloch (1921), Pope (1949, 1959, 1960) and Paramonov (1958, 1960 and 1963). The latter discussed briefly the status and habits of the island's reptiles. More recent treatment of the birds is given by Hindwood and Cunningham (1950) and McKean and Hindwood (1965). Squires (1963) provided Carbon-14 datings of 20,700 years and more than 38,500 years for two samples from the Fossil Dune Sequence on Lord Howe Island, from which specimens of the large extinct turtle *Meiolania platyceps* have been taken.

Significant changes have been wrought in the original environment of Lord Howe Island since European occupation. Eight species of land birds have become extinct (Hindwood, 1940 ; McKean and Hindwood, 1965). The endemic phasmid *Dryococelus australis* was also believed to be probably extinct (Gurney, 1947), but this insect was recently rediscovered on Ball's Pyramid, south of Lord Howe Island (McAlpine, 1966). There seems little doubt that this insect is extinct on the main island.

The major disruption to the ecology of the island is thought to have been brought about by the chance introduction of the Black Rat (*Rattus rattus*) in 1918. The Burns Philp steamship *Makambo* ran aground on 14th June of that year and rats apparently accompanied the loads of fruit and copra which were thrown overboard and washed ashore. At least, it was immediately after this event that the islanders first noticed the presence of rats. Within a short time the numbers of these animals had reached plague proportions and were having a disastrous effect on the island's principal industry, the harvesting and export

Fig. 1. Map of Lord Howe Island showing topography and principal localities. Contour lines are at 500 ft. intervals.

of the seeds of the endemic palms (*Howea* spp.). For many years a bounty was offered on rats, but at the time of writing the number of rats is maintained at a relatively low level due to systematic poisoning by the Island Board.

Prior to the introduction of the Black Rat, goats and pigs had been released and these were soon running wild (and still do) in the uninhabited parts of the island.

Hindwood (1940) records that only three species of land birds were extinct when rats were first introduced in 1918, but by 1935 an additional five species had vanished. The extent to which rats were responsible for eliminating these birds is difficult to assess, but there seems little doubt that on the main island rats exterminated the endemic phasmid mentioned above.

One of the aims of the author's visit to Lord Howe Island was to determine whether the reptile fauna had been influenced significantly by any of those factors which had brought about changes in other animal groups. There was, in fact, some evidence to suggest that changes had occurred in the reptile population, for recent reports from the island suggested that lizards were only infrequently seen and difficult to collect on the main island, despite the fact that they were extremely common on Rabbit Island (Pl. I, C). The latter is a low island, about 250 yards long and 118 feet high, lying within the lagoon less than half a mile off-shore.

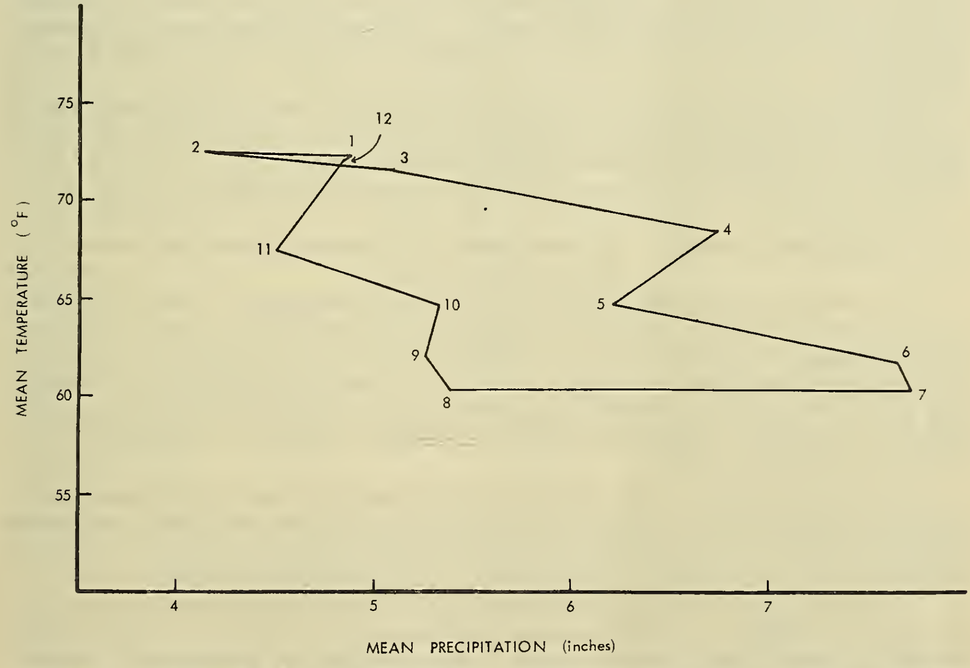

Fig. 2. Climatograph for Lord Howe Island based on data supplied by the Commonwealth Bureau of Meteorology. Months are indicated by numbers.

No attempt has been made to treat the marine reptiles of Lord Howe Island. The sea-snake fauna of north-eastern Australia is a rich one, and although many species probably occur in the waters near Lord Howe Island, I can find no reliable records. Indeed, such records would probably bear little relationship to the number of forms occurring in the area.

Similarly, all of the marine turtles known from the Great Barrier Reef probably frequent the waters of Lord Howe Island from time to time, but no reliable records are available. However, it is interesting to note that turtles, presumably the Green Turtle (*Chelonia mydas*), once nested on Lord Howe Island and provided a valuable source of food for the early visitors and colonists. Phillip (1789) notes that turtles were nesting in abundance in March 1788.

Turtles no longer breed on the island and they are only infrequently seen in the surrounding seas. The disappearance of the turtle colony is generally attributed to excessive hunting, but this explanation is not entirely satisfactory. Turtles have been hunted intensively at their breeding sites for many years in many places throughout the world, and although serious depletion of breeding populations has often resulted, the total extermination of such populations has not proved to be readily accomplished. However, it may be that the isolation of Lord Howe Island prevented recolonization after its relatively small breeding community was reduced to a level which was no longer viable.

Situated some 10 nautical miles to the south of Lord Howe Island is Ball's Pyramid, a large eroded remnant of volcanic rock (of the same series as the Mt. Lidgbird volcanics of Standard, 1963) which rises to a height of 1,811 feet. This rock is still virtually unexplored biologically and was first scaled in 1965 by a party from Sydney Rock Climbing Club. Two earlier attempts by the same club were unsuccessful, and although no biological collections were made, on the second of these trips photographic records of the " extinct " Lord Howe Island phasmid *Dryococelus australis* (McAlpine, 1966) and the scincid lizard *Leiolopisma lichenigera* (see later discussion) were made. Another climbing party in February 1969 collected specimens of both *Leiolopisma lichenigera* and *Phyllodactylus guentheri*.

Ball's Pyramid sits on a shallow platform which is separated from that of Lord Howe Island by depths of more than 2,000 feet and was probably never connected to Lord Howe Island (Standard, 1963).

Basic climatological data for Lord Howe Island is presented in Fig. 2.

THE PRESENT STATUS OF THE RECENT REPTILES RECORDED FROM LORD HOWE ISLAND

The only recent terrestrial reptiles recorded from Lord Howe Island are three species of lizards, only one of which—the skink *Leiolopisma lichenigera* (O'Shaughnessy)—is believed to be endemic. The other two species are the geckos *Phyllodactylus guentheri* Boulenger and *Gehyra oceanica* (Lesson). The former has been recorded only from Lord Howe Island, Norfolk Island and north-western Australia, whereas the latter is widely distributed throughout the south-west Pacific region.

Loveridge (1934) considered that *Leiolopisma lichenigera* (O'Shaughnessy), described originally from Lord Howe Island, was conspecific with *Leiolopisma cuprea* (Gray). The latter species was described from a specimen without locality data. The validity of Loveridge's action is discussed below.

The first record of the gecko *Gehyra oceanica* from Lord Howe Island is that of Boulenger (1885), who listed a male specimen in the British Museum (Natural History) from " Lord Howe's Island ", collected by J. Macgillivray. Subsequently Etheridge (1889) and Ogilby (1889) included *Gehyra oceanica* in the fauna of Lord Howe Island, but apparently based their record solely on the Macgillivray specimen listed by Boulenger. The Australian Museum expedition about which Etheridge and Ogilby were writing did not obtain specimens of this species.

Paramonov (1960), presumably following Etheridge and Ogilby, included *Gehyra oceanica* in the Lord Howe Island fauna, while Mitchell (1965) records this species from Lord Howe Island on the basis of Zietz's (1920) record and " specimens in the Australian Museum collection ". Zietz appears to have based his record on the British Museum specimen recorded by Boulenger, while there is one specimen (no. 4931) in the Australian Museum which is ostensibly a *Gehyra oceanica* from Lord Howe Island. However, as this specimen has apparently been lost (it was collected in the late 1800's) and as its identification and locality are based on a series of ambiguous ditto marks below entries for *Gehyra oceanica* from Fiji and *Phyllodactylus guentheri* from Lord Howe Island, I regard the record as suspect.

As *Gehyra oceanica* has been recorded from New Zealand (McCann, 1955) it might seem that excessive pains are being taken to discredit the Lord Howe Island record for this species. However, as it is normally common wherever it occurs, its apparent absence from Lord Howe Island appeared to the author to be sufficient grounds for questioning the validity of the earlier records.

Macgillivray, as naturalist on the voyage of the *Herald*, spent some months on Lord Howe Island (Macgillivray, 1852–55). However, as there were, at the time of the *Herald's* voyage, three other islands known as " Lord Howe Island " in the area covered by the ship's travels (one, now known as Ontong Java in the Solomon Islands ; one, now known as Mopeha Island, in the Society Islands ; and one in the Santa Cruz Islands), a request was made to Miss A. G. C. Grandison of the Herpetology Department of the British Museum (Natural History) to examine the original record of Macgillivray's specimen. Miss Grandison (*in litt.*) reports : " In our collection are four specimens given as coming from (a) Fiji, (b) Lord Howe Island, (c) two specimens from Fiji ; but reference to the original register indicates that the specimen (a) has no locality, was part of the Macgillivray collection but was purchased from Cuming. The specimen (b) is given as having been collected on the Isle of Pines (New Caledonia) and not Lord Howe Island and only the two specimens (c) seem to be correct in their locality." Hence the Macgillivray specimen, on which is based virtually all Lord Howe Island records of this species, did not in fact come from that island. For this reason it seems advisable to remove *Gehyra oceanica* from the list of the island's fauna until such time as it is clearly shown to occur there. The remaining two species are redescribed below ; S.D. represents the standard deviation of the sample.

Leiolopisma lichenigera (O'Shaughnessy)

(Plate II, C)

Mocoa lichenigera O'Shaughnessy, 1874. *Ann. Mag. Nat. Hist.*, Series 4, 13 : 298.

Holotype—British Museum (Natural History) No. $\frac{55.8.16.12}{1946.8.16.27}$ from Lord Howe Island, N.S.W.

Description : Habitus moderate ; mean adult snout-vent length 78 mm., maximum recorded snout-vent length 96 mm. (♀, R26037) ; the snout-vent/axilla groin ratio averages 1·93 (range 1·74–2·33, S.D. = 0·079) ; limbs well-developed, the snout-vent/forelimb length ratio averages 3·90 (range 3·50–4·35, S.D. = 0·192) while the snout-vent/hindlimb length ratio averages 2·99 (range 2·51–3·48, S.D. = 0·167) ; the adpressed limbs fail to meet ; snout moderately angular ; the head is distinctly swollen posteriorly due to the well-developed muscles in the quadrate region ; lower eyelid with an undivided transparent disc ; supranasals absent ; nostril pierced in a partly divided nasal, a deep groove dividing the scale posterior to the nostril ; frontonasal much broader than long, in contact with the rostral anteriorly and the frontal posteriorly ; prefrontals widely to narrowly separated ; frontal only slightly longer than broad, about as long as frontoparietal and interparietal together, and in contact with the two anterior supraoculars ; 4 supraoculars, although in one specimen the two anterior supraoculars on one side are partially fused ; 2 loreals ; 7 supralabials, the 4th, 5th and 6th below the eye but totally or partially excluded from the granules of the lower eyelid by a series of small suboculars ; 5–6 infralabials ; either a single pair of nuchals or no discernible nuchals (of 44 specimens examined for this character, 59% possessed one pair of enlarged nuchal shields, 9% possessed an enlarged nuchal on one side only, and 32% lacked any enlarged nuchals); 36–46 scale rows around the middle of the body (mean 42·7, S.D.=1·96); 86–109 rows of scales along the mid-dorsal line from the parietals to the base of the tail (mean 99·4, S.D.=3·90); 15–21 lamellae under the fourth toe (mean 18·0, S.D.=1·05); ear-opening vertically elliptic, its long axis from 1⅓–2 times the diameter of the transparent disc in the lower eyelid.

Dorsal surface, including the head and limbs, rich bronzy brown to olive with scattered dark brown and light brown flecks and streaks. The darker flecks tend to disappear in adult animals, so that the lighter ones predominate in large individuals. A narrow (usually less than 1 scale in width) brown band on either side commencing at the nostril and extending below the canthus to the eye. This band continues behind the eye and extends above the ear and along the dorso-lateral surface of the body to the tail, and, where the latter is original, along the length of the tail.

This dark dorso-lateral band may continue with equal intensity to the base of the tail, but in some specimens it becomes obscure posterior to a point about midway between snout and vent.

The narrow dark dorso-lateral band is bordered below by a dark brown area, about 3–4 scales in width, in which scattered groups of light-coloured scales form irregular blotches or indistinct oblique bars that are directed downwards and backwards. This region fades into the light grey or brown ventro-lateral colour, which in turn merges with the cream ventral surface. The latter, in living specimens, is often brilliant orange or lemon-yellow. The throat, especially in the labial region, is usually flecked with light grey or brown. The upper labials, especially in juveniles, may be alternately barred with brown and light grey. In life, regenerated tails are usually bright orange.

Distribution: *Leiolopisma lichenigera* is known only from Lord Howe Island and the small islands lying off-shore from it (including Ball's Pyramid).

Material Examined: Australian Museum, Sydney: R26033–R26037, R26057, R26074, R26086, Roach Islet, Lord Howe Island; R18919–R18920, R18979–R18983, R26048–R26052, Rabbit Island, Lord Howe Island; R2546, R7923–R7928, R10942–R10946, R26058–R26071, Lord Howe Island; R29052–R29057, Ball's Pyramid. Dominion Museum, Wellington: R599, Lord Howe Island; R768, north end of Lord Howe Island. Museum of Comparative Zoology, Harvard: 35459–62, 35464–69, 93776–80, Lord Howe Island.

Remarks: Loveridge (1934) placed *L. lichenigera* in the synonymy of *Leiolopisma cuprea* (Gray), a species whose type locality is unknown. Boulenger (1887), who had the holotypes of both species before him, differentiated the two species on the following characters:

lichenigera	*cuprea*
4 supraoculars	3 supraoculars
42 mid-body scale rows	36 mid-body scale rows

Loveridge had a series of 18 specimens, all of which possessed 4 supraoculars and with mid-body scale row counts ranging from 36–46 (mean 42). He suggested that the 3 supraoculars in the type of *cuprea* were abnormal. As *L. lichinigera* is known only from Lord Howe Island, Loveridge's action implied that the type of *L. cuprea* came from this locality.

Of the 69 specimens listed above, only one shows any deviation from the four supraoculars count. This specimen (R18919) has only 3 supraoculars (caused by partial fusion of the first and second) on the right-hand side. The mid-body scale row count varies from 36 to 46, averaging 42·7.

In the scincid genus *Emoia*, Brown (1953, 1954) made good use of the number of scale rows along the mid-dorsal line, from parietals to tail base, as a taxonomic character. This count was made on all of the above specimens of *L. lichenigera* and averaged 99·7 (range 85–109, S.D. of sample 3·93).

The holotype of *L. cuprea* has three supraoculars on each side, 36 rows of scales around the middle of the body and about 84 rows of scales from the parietals to the base of the tail (damaged parietal region prevents a precise count). It is in poor condition, being so badly discoloured that the original colour and pattern are not discernible. The nostril is pierced in an otherwise immaculate nasal, whereas the nasal is strongly grooved or divided posteriorly in all specimens of *L. lichenigera* examined.

A specimen (M.C.Z. 35460) cited by Loveridge (1934) is the only one found to possess a mid-body scale row count below 40. This specimen has only 36 rows of scales around the middle of the body, and has only 86 rows of scales from parietals to base of tail. Loveridge considered that this exceptional individual bridged the gap between *cuprea* and *lichenigera*, but as the latter is known only from the one island locality it seems unlikely that either geographic or individual variation could account for the differences between this species and the type specimen of *cuprea*.

In view of this decision to regard *L. cuprea* and *L. lichenigera* as distinct species, an attempt was made to determine with what other known species *L. cuprea* might be conspecific. In its colour, pattern, the undivided nasal and the shape and disposition of many head scales (notably the labials, loreals and preoculars) it appears to be most closely allied to the Leiolopismas of New Zealand. However, it differs from the described species in enough features (especially its supraocular count) to cast considerable doubt as to its relationships. It is therefore relegated to the status of a *nomen dubium*.

Phyllodactylus guentheri (Boulenger)
(Plate II, D)

Phyllodactylus guentheri Boulenger, 1885. *Cat. Liz. Brit. Mus.*, 1 : 90, pl. 7, fig. 3.

Syntypes : (5), British Museum (Natural History) from Champion Bay, N.W. Australia (67.2.19.18), Lord Howe's Island (56.7.7.19) and Norfolk Island (62.1.6.29–31).

Description : Habitus stout ; mean adult snout-vent length 71·2 mm., maximum recorded snout-vent length 91 mm. (R29193) ; limbs well developed ; the snout-vent/forelimb length ratio averages 3·09 (range 2·66–3·70, S.D. = 0·223) while the snout-vent/hindlimb length ratio averages 2·47 (range 2·00–2·75, S.D. = 0·155) ; the adpressed limbs overlap ; head relatively deep ; canthus rounded ; eye moderate, its diameter equal to about half the distance from eye to tip of snout ; rostral rectangular, about twice as wide as deep and lacking a median crease ; nostril directed backwards and upwards and surrounded by the rostral, first labial and four other scales, the upper one or two of which are considerably enlarged ; several small scales between these enlarged " supranasals " ; scales on top and sides of snout larger than dorsals ; but the latter and the scales on the head are subequal ; 7–9 supralabials ; 7–9 infralabials ; the anterior labials are largest, and all are much larger than the adjacent scales ; mental roughly pentagonal, about the same size as adjacent infralabials ; anterior and lateral gular scales much larger than the remainder ; a distinct gular fold ; ear-opening relatively small, its maximum diameter about two-thirds that of the eye ; dorsal and lateral surfaces of body covered with small, juxtaposed conical scales which are much smaller than the flat, slightly-imbricate ventrals ; more than 10 scales in the middle of the back in a distance equal to the diameter of the eye ; number of scale rows around middle of body averages 138·4 (range

119–160, S.D. = 7·87); limbs covered above with conical scales somewhat larger than those on the dorsum; lower surfaces of limbs with flat, slightly imbricate scales like those on the venter; digits moderately dilated, the distal expansion of the 4th toe greatest, its width about equal to the maximum diameter of the ear-opening; each digit with a pair of enlarged pads or lamellae distally, between which is a large claw; the sheath from which each claw projects extends to the edge of the distal lamellae or beyond; there are 9–12 undivided lamellae under the 4th toe (mean 10·23, S.D. = 0·815); these are largest basally and are separated from the enlarged distal lamellae by from 3–7 rows of small scales; tail covered with flat, slightly imbricate scales which are arranged in fairly regular rings and are largest ventrally; the latter are about twice as large as those on the upper surface of the tail, these latter more or less equaling in size the scales on the venter; preanal and femoral pores absent; males with a swollen post-cloacal region on each side of which is a cluster of 3–4 slightly enlarged rounded tubercles.

Colour and pattern extremely variable. Dorsal surface medium grey or brown (the latter colour predominates in preserved specimens) usually with a dull orange (in life) or light brown vertebral stripe which extends from the nape to the base of the tail. This stripe usually divides a series of irregular, transverse dark grey or dark brown bands which typically number six between the nape and the base of the tail. In many specimens this vertebral stripe may be indistinct or absent, while the irregular transverse bands may break up to such an extent that the dorsal surface is simply variegated with light and dark grey or brown. The head is often darker than the ground colour of the body. Labials mottled with light grey or brown; sides and upper surfaces of the limbs are usually grey or brown mottled with irregular darker markings, while the ventral surface is grey or off-white, each individual scale peppered with dark grey. The scales of the throat are more richly peppered than those of the body.

The tail, where original, is usually alternately banded with irregular dark and light grey or brown, the bands not extending on to the ventral surface; in some specimens these bands break up to form irregular mottling. Regenerated tails are usually light brown or grey with scattered darker scales. Underside of tail light grey.

No major differences in colour and pattern can be observed between the Lord Howe Island and Norfolk Island populations. However, there is a definite tendency for the darker transverse markings to be narrower and less conspicuous in the Norfolk Island specimens, while old adults from the latter locality tend to have the pattern reduced to scattered dark flecks or spots.

The colour and pattern of hatchlings from Lord Howe Island appear to be fairly constant. The dorsal ground colour is rich olive-brown, speckled with darker brown; there is a light salmon-coloured patch over each eye and an indistinct, broken vertebral stripe of a rich salmon colour; the tail, especially distally, is rich salmon with dark brown bands; the venter is white with numerous grey flecks; the ventral surface of the tail is salmon-coloured.

Distribution: *Phyllodactylus guentheri* is known from Norfolk Island and Lord Howe Island and their small off-shore islands. In his original description Boulenger lists one of the type series from " Champion Bay, N.W. coast of Australia ", but this record appears to be in error. Champion Bay lies within the known range of *Phyllodactylus marmoratus* and is far removed from the other localities in which *P. guentheri* is known to occur. No specimens of the latter have subsequently been recorded from mainland Australia. However, Miss Grandison has checked the original data associated with this specimen and can find no reason for doubting its validity.

Material Examined: Australian Museum, Sydney: 4930, R360, R3350, R4542, R5581, R5583–4, R8043, R26072–3, Lord Howe Island; R26038–47, R26085, Roach Island, Lord Howe Island; R18984–6, R19298–9, R26053–6, Rabbit Island, Lord Howe Island; R4270–3, R4275–7, R4919, R5594, R19301, R29192–4, Norfolk Island; R29058–9, Ball's Pyramid, Lord Howe Island. Dominion Museum, Wellington: R1–8, R780–2, Norfolk Island.

Remarks: This species has long been in the synonymy of *Phyllodactylus marmoratus*, the only other Australian member of this genus (Loveridge, 1934). However, *P. guentheri* is very distinct from *P. marmoratus*, and can be readily distinguished from the latter:

Phyllodactylus marmoratus: Width of distal expansion of 4th toe at least twice the maximum diameter of the ear-openings; scales relatively large and regular; 84–96 mid-body scale rows (mean of 21 specimens 90·4, S.D. = 3·7); sheath of claw on each digit does not extend to edge of distal lamellae (Fig. 3).

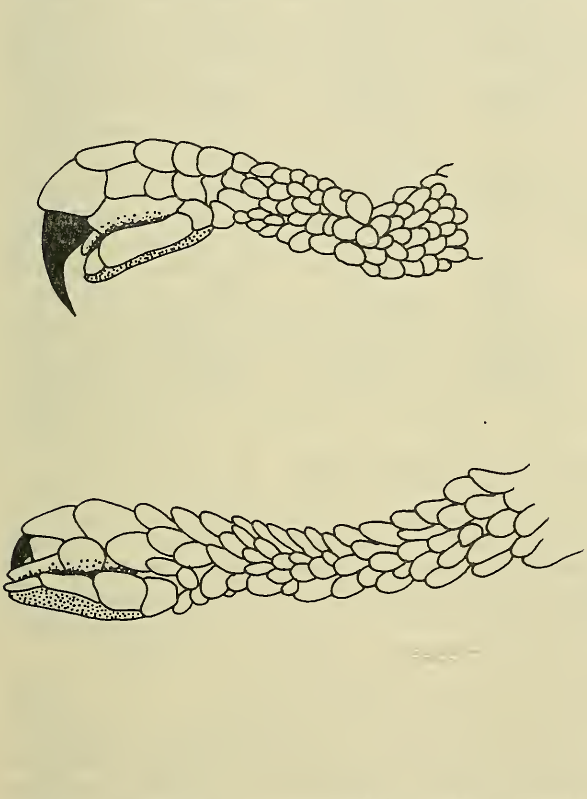

Fig. 3. Lateral and dorsal views of distal portions of the fourth toes of *Phyllodactylus guentheri* (upper) and *P. marmoratus* (lower).

Phyllodactylus guentheri: Width of distal expansion of 4th toe about equal to the maximum diameter of the ear-opening; scales on most parts of body small, tubercular; 119–160 mid-body scale rows (mean 138·4); sheath of claw of each foot extends to edge of distal lamellae or beyond (Fig. 3).

Unfortunately the material available for study is inadequate for an effective analysis of intraspecific variation in meristic and other characters. Nevertheless, there are indications that the populations on the different islands do differ from one another at a measurable level. For example, the two specimens from Ball's Pyramid have much longer limbs than specimens from other localities. The data in Table 1 are presented, therefore, with a view to indicating the potential value of using these island populations for micro-evolutionary studies. There seems little doubt that barriers to dispersal and interchange between the various island populations are so effective that gene flow is reduced to a mere trickle, if any, and that each island population is evolving almost entirely independently of the others.

TABLE 1

	Mid-body Scale Rows	Lamellae under Fourth Toe	Snout-vent/ Axilla-groin	Snout-vent/ Forelimb	Snout-vent/ Hindlimb
Ball's Pyramid (2)	145–147 (146·0)	9–11 (10·0)	2·29–2·47 (2·38)	2·58–2·71 (2·64)	2·00–2·28 (2·14)
Roach Island (10)	135–160 (146·3) S.D.=7·44	9–10 (9·9) S.D.=0·38	2·16–2·44 (2·32) S.D.=0·064	2·75–3·04 (2·89) S.D.=0·102	2·27–2·54 (2·39) S.D.=0·058
Rabbit Island (9)	136–153 (142·2) S.D.=6·97	10–12 (11·0)	2·17–2·43 (2·27) S.D.=0·059	2·91–3·70 (3·27) S.D.=0·261	2·41–2·74 (2·58) S.D.=0·233
Lord Howe Island(1) (8)	137–147 (139·2) S.D.=4·38	10 (10·0)	2·18–2·90 (2·40) S.D.=0·225	2·66–3·17 (2·94) S.D.=0·154	2·28–2·58 (2·44) S.D.=0·088
Lord Howe Island(2) (28)	135–160 (143·7) S.D.=6·79	9–12 (10·14) S.D.=0·77	2·16–2·90 (2·33) S.D.=0·132	2·58–3·70 (3·01) S.D.=0·255	2·00–2·74 (2·45) S.D.=0·294
Norfolk Island (24)	119–140 (133·7) S.D.=4·82	9–12 (10·24) S.D.=0·90	2·00–2·51 (2·19) S.D.=0·111	2·84–3·59 (3·13) S.D.=0·181	2·14–2·75 (2·50) S.D.=0·163

(1) Main island only.

(2) Lord Howe Island and off-shore island specimens pooled.

The relationship between *P. guentheri* and *P. affinis* (the latter known only from the New Hebrides) is obscure. Miss Grandison kindly examined the holotype of *P. affinis* and found numerous differences in scalation between the two species. It would therefore seem advisable to leave any assessment of these differences until additional specimens of *P. affinis* are available.

LOCAL DISTRIBUTION AND ECOLOGY

The first report on the habits of the lizards of Lord Howe Island was that of Etheridge (1889), who stated of *Phyllodactylus guentheri* and *Lygosoma lichenigera* that they " . . . may be sought for on dry stony ground, under stones, amongst dry leaves, and at the feet of low scrubby trees." Ogilby (1889) states simply that both species are " . . . much more abundant in the vicinity of the coast than on the more elevated districts inland." Etheridge (1889) goes on to say that " . . . so far as our researches enabled us to judge, *Phyllodactylus guentheri* is the commonest, the distribution of this and the other species (*L. lichenigerum*) being very general, not only on the main island, but also on Goat (=Rabbit) Island and the Admiralty Islets."

No further general account of the reptiles was given until that of Paramonov (1960), who, although he did not mention Etheridge's paper, nevertheless quoted the latter precisely. However, in doing so he made the error of applying Etheridge's comments on habitat to all three species, instead of the two species to which Etheridge originally and correctly referred. For reasons outlined above the inclusion of *Gehyra oceanica* was probably in error.

It is significant that despite the fact that no zoologist had previously visited Lord Howe Island for the express purpose of collecting reptiles, small collections have nevertheless been obtained apparently with little difficulty. The Australian Museum possesses several small series of specimens collected at various times between 1888 and 1963. Except for the series collected in 1962–63 from Rabbit Island, all earlier specimens have the locality of " Lord Howe Island ". As the prime reason for the visit of an Australian Museum party in 1909 was to obtain bird specimens from the Admiralty Islets for a Museum exhibit, it seems likely that at least some of our lizards were taken from those islets and not from the main island.

Loveridge (1934) states that a series of specimens of *L. cuprea* (=*L. lichenigera*) in the Museum of Comparative Zoology was collected by Mr. R. Baxter in 1932. These specimens were taken when they fell into a drum set into the ground and baited with fish oil, and K. R. Hindwood (*in litt.*) reports that Baxter informed him that these specimens were taken on Rabbit Island after unsuccessful attempts to collect lizards on the main island. A specimen (R768) of *L. lichenigera* in the Dominion Museum, Wellington, collected by W. R. B. Oliver in 1913, has the notation " north end Lord Howe Island ".

From this scant evidence there seems little doubt that both species—*Phyllodactylus guentheri* and *Leiolopisma lichenigera*—were once common and easily procured on the main island, as well as on the off-shore islands, and it was with this background information that the writer set out to assess the present distribution of reptiles on Lord Howe Island.

The results were disappointing. Despite a search of all major available habitats, especially those in which earlier workers had reported finding lizards, not a single specimen was obtained. Although some habitats, such as the leafy heads of the *Howea* palms, were virtually inaccessible, all terrestrial habitats were examined. Three major saxicoline environments are present on the main island :

(1) Covering the greater portion of the island are outcrops of basaltic volcanic rocks, in the form of either solid rock faces or boulder slopes. All of the major topographic features are made up of this rock, as are all of the off-shore islands.

(2) Recent sediments, which form a stratified " sandstone ", outcrop in several places, the most prominent being above Ned's Beach on the eastern side of the island.

(3) The only other rock consists of large clumps of old " beach rock ", which may be loosely or firmly embedded in soil, and which outcrop in several places on the lower parts of the island.

The first of these three rocky environments corresponds with the " North Ridge Volcanics " and " Mt. Lidgbird Volcanics " of Standard's (1963) geological map of the island. The second corresponds with his " Ned's Beach Calcarenite " and the third with his " Alluvium, including beach and talus deposits ". The age and distribution of each of these are shown on Standard's map.

On the main island a search of the basalt rock faces and slopes failed to reveal a single lizard. Collecting efforts were concentrated at four points :

(1) The boulder slopes below Mt. Lidgbird, immediately behind Salmon Beach.
(2) The slopes of Dawson Ridge, between Old Settlement Bay and North Bay.
(3) The lower, eastern slopes of Malabar.
(4) The northern slopes of Intermediate Hill.

Also, although the search was far from exhaustive, a search was nonetheless carried out along the track from Salmon Beach to the summit of Mount Gower and in the " moss forest " which occupies several hundred acres on the summit of that mountain.

All of these searches failed to find any trace of lizards, either among rocks or in or under fallen logs. No sloughs were found ; nor eggs or egg shells.

Following reported sightings of lizards, the area behind Ned's Beach was also searched carefully, especially in the stratified " sandstone " which makes up much of the headland (Stevens Point) between Ned's Beach and Middle Beach. No lizards were found.

During the time that this work was being carried out, a cyclone prevented the author from reaching any of the off-shore islands. As soon as the weather cleared a visit was made to Rabbit Island, where both *Phyllodactylus guentheri* and *Leiolopisma lichenigera* were found commonly under loose basalt boulders. Small slopes of these loose boulders occurred mainly on the leeward (northern) side of the island, especially around the bases of low, windswept trees. On the windward side of the island few loose boulders occurred but an examination of large crevices in outcrops of rock revealed traces (a mummified body and sloughed skins) of both species.

As the island is so small, and as the Australian Museum already possessed samples from Rabbit Island, only a small number of specimens were actually taken. Although unlikely, it is nevertheless quite possible that the removal of large numbers of lizards could have a decimating effect on the total population. Of the lizards found, the ratio of *L. lichenigera* to *P. guentheri* was 4 : 1.

Subsequently, attempts were made to land on two of the other off-shore islands—Mutton Bird Island, off the eastern shore, and Roach Island, the largest of the Admiralty group of islands off the southern point of the main island. Both of these islands are surrounded by rocky shores, and although heavy seas prevented a landing on Mutton Bird Island, the author was put ashore on Admiralty Islet, where collecting was carried out for about an hour before rising seas forced a hurried and wet return to the boat. During this hour 19 specimens were collected among large basalt boulders, in the ratio of 11 *P. guentheri* to 8 *L. lichenigera*. Both species were evidently extremely abundant.

It should be stressed that the lizards taken on Rabbit Island and on Admiralty Islet were found in a habitat which had proved completely barren of lizards on the main island.

About half-way through the author's visit to Lord Howe Island he was presented with a live specimen of *L. lichenigera* by Mr. R. Payton, whose cat had apparently caught the lizard in the vicinity of the Payton house. The latter is situated behind Lagoon Beach, just below Signal Point. In the following week the cat produced three more specimens of the same species. The area in which these lizards were taken consists of dense *Howea* palm forest with leaf-litter and scattered clumps of weathered " sandstone " embedded in the soil. The nature and origin of this rock is discussed below.

In a similar area, at the base of Malabar, the author searched among similar " sandstone " boulders and found a specimen of *P. guentheri* which entered one of the numerous finger-sized tunnels in a massive clump of the rock. The gecko could not be extricated from the rock but in some of the shallow holes clusters of eggs were found, some of which contained advanced living embryos of *P. guentheri*.

Subsequently, a sledge-hammer and crowbar were used unsuccessfully in an attempt to break up some of these sandstone clumps in the areas below Malabar and behind Lagoon Beach. Only the thinner surface layers of the stone could be broken up, leaving intact the massive bases, with their network of tunnels. No adult lizards were obtained but some hundreds of old and new gecko eggs were found, some with well-developed living embryos.

This habitat warrants description in greater detail, as it is apparently the only habitat on the main island in which both species of lizards now occur. It consists of large irregularly-shaped boulders of honeycombed " rock " which may be either superficially or deeply embedded in the soil (Pl. I, D).

These boulders almost invariably outcrop in dense *Howea* palm forest, in which there is a thick mat of humus formed by palm and other leaf-litter. The matrix of the boulders consists of a " sandstone " or conglomerate sediment, and there seems little doubt that the outcrops are of weathered " beach rock ", a common formation of many coral reefs and the structure and origin of which is discussed fully by Wiens (1962). According to Standard (1963) these outcrops represent recent beach alluvium.

Of special significance in the ecology of the lizards on Lord Howe Island is the mode of weathering of these alluvial boulders. Their surfaces are deeply pitted with small holes, averaging only 1–2 cm. in diameter. These are the entrances to tunnels which enter deeply into the matrix of the rock. Such tunnels may coalesce to form larger chambers, as shown in Pl. II, A, B. The origin of these tunnels is uncertain, but they so closely resemble in structure the " subaerial solution potholes " observed in some limestones (Cotton, 1948, p. 448) that their origin might well be identical, especially as buried portions of these boulders are as strongly weathered as the exposed portions. Lord Howe Island has a relatively high average annual rainfall (68 inches) and the deeply-shaded floor of the *Howea* forests is normally quite moist. The exposed surfaces of the outcropping beach rock are covered with a layer of algae which imparts a distinctive green colour to the rock.

The role of the weathered tunnels or potholes in the ecology of the two lizards on Lord Howe Island seems to be that they provide a niche which is safe from virtually all predators, for the size of the openings precludes the entry of any of the island's predatory vertebrates. The tunnels offer an ideal site for the safe deposition of eggs (Pl. II, A) while insect food, both in the tunnels and in the surrounding leaf-litter, is abundant. The eggs of *Phyllodactylus guentheri* may be found in large numbers within the tunnels, recent clutches being deposited upon the hatched, empty shells of earlier seasons (Pl. II, B).

Apart from those eggs broken or immediately preserved, a series of five intact and apparently fertile eggs were brought back to the Australian Museum. There they were placed on paper in a dry glass jar, and left on a laboratory bench, where they were subject to a mean temperature of approximately 70° F. (range 66° F.–84° F.). As none had hatched by the end of December 1966 (the eggs having been collected in June 1966), they were no longer examined regularly and were put to one side. When next examined on 18th January 1967 two of the eggs had hatched. Both hatchlings were dead, one freshly so but it was possible to place the date of hatching within the two-week period preceding the 18th. Another egg hatched on 8th February, another on 13th February and another on 14th March. The mean snout-vent length of hatchlings was 30·25 mm.

The eggs of *P. guentheri* have thick, brittle calcareous shells which are apparently quite soft when laid, for they take the shape of the surfaces with which they come into contact when laid. Eggs are often found firmly adhering to one another or to the surface of a rock.

The significance of this long incubation time is not known. As it was not possible to know how long the eggs had been laid when collected, the minimum incubation time for those eggs collected varied from 30 to 39 weeks. Although overwintering of eggs is a relatively common phenomenon in lizards, the observations made above are not explicable in normal overwintering terms. The eggs were collected in mid-winter (when no gravid females were collected) and continued to develop throughout the spring and summer. Indeed, the last egg to hatch did so at the end of summer. The temperature of development in the laboratory was probably not very different from that experienced by eggs in the field during this period.

From these meagre observations it would be unwise to draw any general conclusions regarding incubation times or their roles in the biology and ecology of this lizard. These observations do indicate, however, that the reproductive habits of Lord Howe Island reptiles may differ radically from those of related forms on the Australian mainland.

On returning to Sydney, the author contacted Mr. David Rootes, a member of several climbing parties which attempted to scale Ball's Pyramid. Mr. Rootes advised that one species of lizard had been seen, and produced several photographs showing clearly an individual of *L. lichenigera.* This individual was observed to roll a tern egg down a rock slope until it broke, then fed on the contents.

Mr. Rootes' observations were made in November, whereas no lizards were active in the open during the author's visit to Lord Howe Island in winter (June).

SUMMARY

(1) The recent reptile fauna of Lord Howe Island comprises two species of lizards, the gecko *Phyllodactylus guentheri* and the endemic skink *Leiolopisma lichenigera.* The latter is resurrected from the synonymy of *Leiolopisma cuprea*, which is in turn relegated to the status of a *nomen dubium.* It has been shown that earlier records of the gecko *Gehyra oceanica* from Lord Howe Island were probably in error.

(2) On the small islands lying off-shore from Lord Howe Island the lizards occur commonly in the rocky habitat described by earlier workers. On the main island, however, both species appear to have virtually disappeared from the habitat in which they were once common and are now to be found only in a very restricted and specialized habitat consisting of weathered boulders of " sandstone " or " beach rock ". It seems likely that this habitat is the only one which offers protection from such introduced predators as rats.

(3) Slight differences in the proportions of the two lizards on different islands, differences in size, and the prolonged incubation period of the eggs of *Phyllodactylus guentheri* indicate the potential value of the reptile fauna of Lord Howe Island for future ecological and evolutionary studies.

ADDENDUM

Since this paper was submitted for publication the types of *Phyllodactylus guentheri* and *P. affinis* have been examined in the British Museum (Natural History). The *P. guentheri* syntype from Champion Bay is indeed conspecific with the other syntypes, and I therefore regard its locality data as incorrect. The holotype of *P. affinis* (B.M.N.H. 55.8.16.5.) appears to be a typical example of the Australian *Phyllodactylus marmoratus*, for which reason I suggest that its type locality (New Hebrides) is also incorrect.

Further to my comments on the ecology of *Leiolopisma lichenigera*, Dr. H. Recher reports (pers. comm.) that in summer this species is abundant and active at night among supralittoral rocks and other ground cover on Rabbit Island.

ACKNOWLEDGEMENTS

The author is grateful to the Trustees of the Australian Museum and the Museum's Director, Dr. F. H. Talbot, for making possible a visit to Lord Howe Island, and to the Lord Howe Island Board for permission to undertake the work here reported upon. Mrs. Kirby (then of " Pine Trees "), Mr. R. Payton, Mr. E. Rhodes, Mr. R. Schick and Mr. C. Wilson were especially kind and helpful during the author's stay on the island. Miss A. G. C. Grandison of the British Museum (Natural History), Dr. Ernest Williams of the Museum of Comparative Zoology at Harvard University, and Dr. J. Moreland of the Dominion Museum, Wellington, kindly examined and/or lent specimens under their charge.

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EXPLANATION OF PLATES

Plate I

A. Lord Howe Island viewed from Malabar, showing Mt. Lidgbird (left) and Mt. Gower.

B. Northern, low-lying parts of Lord Howe Island viewed from the summit of Mt. Gower ; Rabbit Island is seen lying in the lagoon while the Admiralty Islands are in the right upper corner.

C. Rabbit Island from Lagoon Beach.

D. Clump of " beach rock " riddled with tunnels in which the eggs of *Phyllodactylus guentheri* are laid.

Plate II

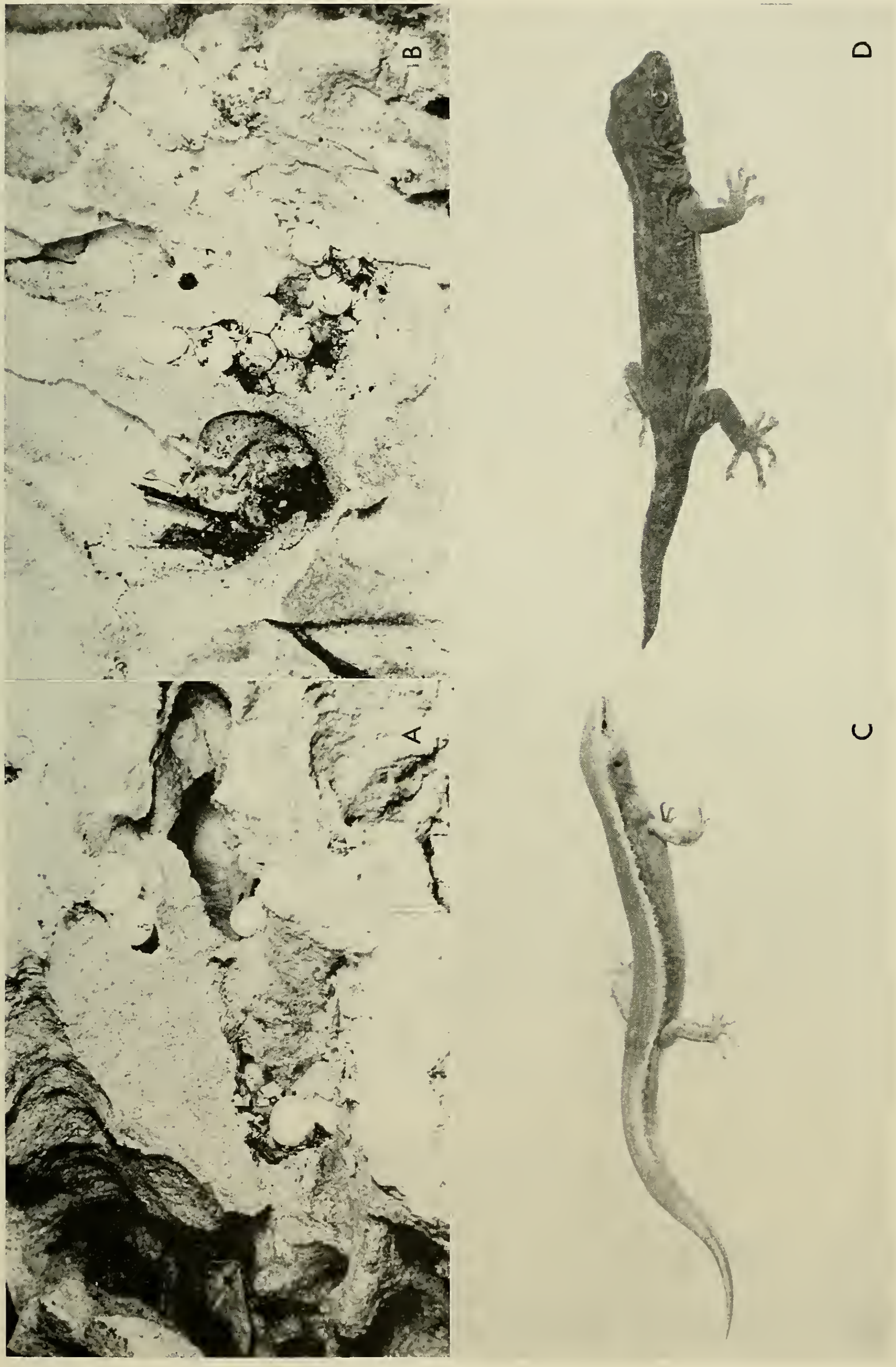
A and B. Sections of " beach rock " showing successive clutches of eggs of *Phyllodactylus guentheri* laid within tunnels.

C. *Leiolopisma lichenigera.*

D. *Phyllodactylus guentheri.*


A
B
C
D

PLATE II



AUSTRALIAN SEA STARS OF THE GENUS *PATIRIELLA* (ASTEROIDEA, ASTERINIDAE)

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(Plates III, IV)

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Synopsis

Including the two new species described in this paper ten species of *Patiriella* are known from Australia. The Lamarckian species *Patiriella exigua* is shown to contain a tropical and temperate species. A neotype is erected to validate the identity of *P. exigua sensu stricto*. A key to the Australian species of *Patiriella* is provided. An account of the biogeography of the genus in relation to known marine zoogeographic boundaries is given.

Introduction

The present paper deals with asterinid sea stars of the genus *Patiriella* from Australia. *Patiriella* comprises a group of sea stars whose members are a conspicuous feature of the intertidal fauna of temperate and cool temperate shores in the Southern Hemisphere. Although the primary concern here is the fauna of Australia, some reference is also made to the asterinid faunas of South Africa, the Indo-west-Pacific area and New Zealand.

Australia and Tasmania possess eight species of *Patiriella* and two further species are described in this paper. *Patiriella exigua* (Lamarck) is common to South Africa and Australia and a New Zealand species (*Patiriella regularis* (Verrill)) is known as an introduced member of the Tasmanian marine fauna (Dartnall, 1969*a*).

Abbreviations used in the text are as follows : A.M., Australian Museum, Sydney ; B.M., British Museum (Natural History), London ; M.C.Z., Museum of Comparative Zoology, Harvard ; M.N., Museum für Naturkunde, Berlin ; N.M.V., National Museum of Victoria, Melbourne ; Q.M., Queensland Museum, Brisbane ; T.M., Tasmanian Museum, Hobart ; U.S.N.M., United States National Museum, Washington, D.C. ; W.A.M., Western Australian Museum, Perth. The material quoted is housed in the institution indicated by the initial preceding the registration numbers given. The number of specimens in each lot is indicated in parentheses after the registration number.

R is the greater radius of the specimen measured along the ambulacral groove ; *r* is the lesser, interambulacral radius. Body proportions are expressed as a ratio *R : r* and the height of the body is given as *vh*.

Systematic Account

Genus Patiriella Verrill 1913

Type Species : *Asterina* (*Asteriscus*) *regularis* Verrill, 1867.

Asterinid sea stars with a plane actinal surface, short rays and a body outline varying from a blunt star to nearly pentagonal. Actinal intermediate spines rarely more than two, most often paired or single. Oral plates may carry one, two or no suboral spines. The inferomarginal plates and their spines form a fringing edge to the body and the superomarginal plates are not distinct. Abactinal spines are short, granular and bluntly capitate. The carinal row of abactinal plates is doubly notched to accommodate two rows of papulae. Papuael are confined to the abactinal surface, along the rays, on the centre of the disc and the interradial, abactinal areas near the disc centre. The plates of the sides of the rays and the outermost interradial areas are apapulate. Pedicellariae are absent.

Species of this genus are found on rocky shores in the intertidal zone of southern and eastern Australia. Populations of some species may be found on mud, sand or gravel and can be taken below tidemarks to about 15 metres and occasionally at greater depths.

The genus *Patiriella* is most closely related to the predominantly northern hemisphere genus *Patiria*; to *Paranepanthia* which contains three nominal species in Australia, and to part of the heterogeneous genus *Asterina* from which *Patiriella* was originally removed.

In a previous account (Dartnall, 1970*b*) the genus was subdivided into " *exigua* ", " *regularis* " and " *gunni* " groups. There are distinct morphological differences between these groups; within them are species of very similar morphology whose isolation is geographic, ecological or reproductive. In the following account the groups concerned are defined first, and thus the descriptions of species offered are concise, depending more on evidence of species isolation than indefinite morphological differences.

(a) " exigua " group

Small species of *Patiriella* in which *R* rarely exceeds 15 mm. The number of rays is usually five and actinal intermediate spines are usually single. Abactinal spines from the centre of the disc are from 0·2 to 0·3 mm. in length.

Patiriella exigua (Lamarck, 1816)
(Plate IV (*c*))

Restricted synonymy: Asterias exigua Lamarck, 1816; *Asterina krausii* Gray, 1840; *Asteriscus pentagonus* Müller and Troschel, 1842 (in part); *Asterina exigua* Perrier, 1876; *Patiriella exigua* Verrill, 1913 (in part); *Asterina exigua* Mortensen, 1921; *Patiriella exigua* H. L. Clark, 1938, 1946 (in part); Endean, 1956 (in part); Shepherd, 1968; Dartnall, 1970*b*.

Non: Asteriscus pentagonus Müller and Troschel, 1842 (in part); *Asterina exigua* H. L. Clark, 1908; Koehler, 1910; Fisher, 1919; H. L. Clark, 1921; *Patiriella exigua* Livingstone, 1932; *Asterina* (*Patiriella*) *exigua* Mortensen, 1933*a*; Domantay and Roxas, 1938; Engel, 1938.

Asterina minuta of various authors has not been included in the synonymy because of lack of precise information about localities. However, Gray (1840) was clear that the specimens he attributed to *A. minuta* were from the " West Indies, St. Vincents ". If those details are correct then those specimens are probably Lütken's *Asterina folium* or a related form. Information about *A. folium* with which to compare Gray's *A. minuta* is available in a paper by de Roa (1967). As far as synonymy is concerned the complex of asterinids from South Africa has also been ignored in this paper as it is commented upon by both H. L. Clark (1923) and Mortensen (1933*a*).

Asterias exigua Lamarck was described from material whose provenance was suggested to be the Americas (Perrier, 1876). Perrier examined Lamarck's seven type specimens and also noted that a further series of nine specimens, collected from the Cape of Good Hope in 1829 by M. Raynaud, were labelled *Asterias exigua* by Lamarck. Perrier (*loc. cit.*) and Koehler (1910) both recognized *Asterias exigua* as a valid species containing the synonyms *Asterias minuta* de Blainville, 1834; Agassiz, 1834 (in Agassiz, 1838) and Gray, 1840; *Asteriscus pentagonus* Müller and Troschel, 1842 and *Asterina pentagona* von Martens, 1866.

Patiriella exigua is recorded in the literature from throughout the Australo-Indo-west-Pacific from South Africa to the Philippines, the New Hebrides and the eastern and southern coasts of Australia including Tasmania. Whitelegge (1889) was the first to note the orally directed gonoducts of the adult and the shortened development of the larvae. Mortensen (1921) confirmed Whitelegge's observations and suggested that *P. exigua* might contain more than one species, quoting Ludwig that *Asterina pentagona*, an accepted synonym, possessed genital pores opening on the abactinal surface. Since that time abbreviated development has been accepted as characteristic of the species and an account is incorporated in at least one standard textbook of zoology (Parker and Haswell, 1962).

In September, 1967, Dr. J. R. Grindley obtained for me material attributed to *Patiriella exigua* from Port Elizabeth, South Africa. This material can be divided into two groups :

(1) Asterinid sea stars with abactinally directed gonoducts, attaining 18 mm. *R* in these samples and whose actinal surface is not consistently blue-green in colour. Miss A. M. Clark of the British Museum (Natural History) was kind enough to compare some of these specimens with material in her care and informs me that they agree best with *Asterina dyscrita* H. L. Clark, 1923.

(2) Asterinids with actinally directed gonoducts, attaining a maximum *R* of approximately 12 mm. and whose actinal surface is always blue-green in colour.

The latter group is identical to that species of sea star from south-eastern Australia commonly determined as *Patiriella exigua* and it was decided to investigate that species throughout its known range. Through the co-operation of many individuals and institutions, material was obtained from areas throughout most of the recorded distribution of the species and all the specimens were examined to determine the position of the gonopores and the orientation of the gonoducts. Morphological differences between the samples were slight and gonopore position remained the one constant character for investigation in preserved material. The map (Fig. 1) shows the localities from which material was obtained. Orientation of gonoducts in the samples is indicated by the arrowheads and the following distribution is clear.

North of about 28° S. in Australia all the samples attributed to *Patiriella exigua* possessed abactinally orientated gonopores.

In Australia the form with actinally directed gonopores is found along the east coast, south of approximately 28° S., to Port Lincoln on the south coast at approximately 136° E. The range of this form extends southwards to encompass the coasts of Tasmania and eastward of the continent to Lord Howe Island at about 159° E. This form is also found in South Africa and the isolated islands of St. Paul and New Amsterdam.

Application to Dr. G. Cherbonnier revealed that Lamarck's types of *Asterias exigua* are no longer in Paris. Dr. E. Binder of Geneva and Dr. W. Vervoort of Leiden inform me that neither of their institutions hold Lamarckian echinoderm types. Further enquiries suggest that Lamarck's specimens no longer exist and in order to preserve the name " *exigua* " for this well-documented animal it appears necessary to erect a neotype for the species.

The Cape of Good Hope has been accepted as the type locality by various authors, but without a locality for Lamarck's specimens this is very uncertain. Among those specimens available to me the two from the Cape do not demonstrate adequately the key character to the species, namely the gonopores, so I have chosen a recent specimen from False Bay, South Africa, which lies to the east of the Cape of Good Hope and is now designated the type locality.

Details of neotype: T.M. H508. $R=11{\cdot}5$ mm., from the type locality, False Bay, South Africa (34° S./18° E.); 10.x.1969; don. J. G. Field.

Other material examined:

A.M. J7762 (6), City of Melbourne Bay, King Is., Tasmania, June 1968, S. Kerrison.

B.M. 1840.11.25.1 and 1840.11.25.5, Cape of Good Hope. Both specimens are syntypes of *Asterina kraussii* Gray.

M.N. 6682 (35), St. Paul Island, 26.iv.1903, Deutche Südpolar-Expedition 1901–1903; 6683 (6), Amsterdam Is., 27.iv.1903, Deutche Südpolar-Expedition.

N.M.V. H151 (6), Flinders, Victoria, 6.vi.1969, A. J. and P. J. Dartnall.

Q.M. G3765 (4), Currumbin, Queensland, 8.viii.1953, R. Endean.

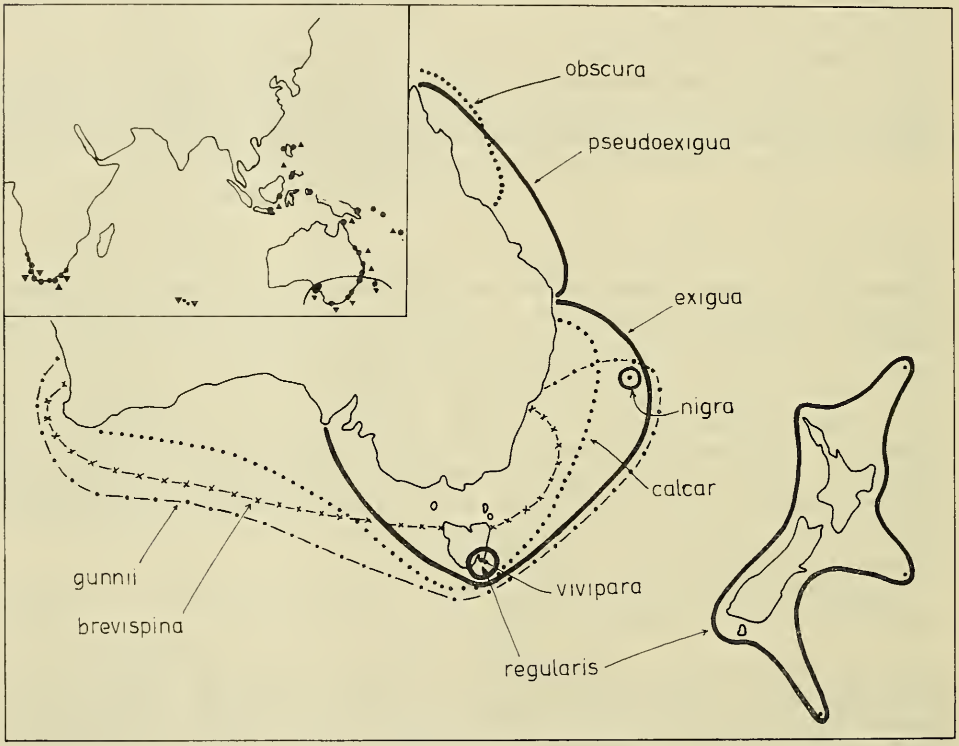

Fig. 1. Contemporary distribution of the species of *Patiriella* found in Australia. *P. inornata* from Western Australia is omitted.

Inset: Map showing the localities from which material of the "*exigua*" group has been obtained. Orientation of gonopores is shown by the solid triangles— ▲ abactinal; ▼ actinal.

T.M. H212 (2), Roaring Beach, Port Davey, Tas., Feb. 1937, C. Davies; H222 (12), Stanley, Tas., Oct. 1937, A. W. G. Powell; H332 (31), Nubeena, Tas., 14.v.1967, L. Jenkins; H345 (2), Murdunna, Tas., 12.i.1967, A. J. Dartnall; H349 (8), Port Arthur, Tas., 20.iv.1967, A. P. Andrews and E. Aves; H365 (12), Granville Harbour, Tas., 6.xi.1967, A. J. Dartnall; H392 (6), Dennes Pt., Bruny Is., Tas., 24.i.1968, A. J. Dartnall; H409 (13), South Australia, 1967, S. A. Shepherd; H452 (4), Maria Is., Tas., 15.iv.1968, A. J. Dartnall; H456 (4), Swan Is., Tas., Sept. 1968, F. L. Sutherland; H458 (9), Cape Portland, Tas., 2.iii.1969, A. J. Dartnall; H479 (18), Salmon Reef, Lord Howe Is., 6.xi.1968, W. G. Thornton; H480 (6), Trouser's Point, Flinders Is., Tas., 7.i.1969, T.

Goede ; H483 (7), Marrawah, Tas., 1.xii.1968, B. J. Smith ; H484 (5), Greens Beach, north Tas., 13.viii.1969, R. H. Green ; H485 (10), Stevens Bay, Port Davey, Tas., 8.i.1969, D. Milledge ; H486 (10), Long Reef, near Sydney, N.S.W., 1.viii.1969, E. C. Pope ; H496 (5), Salt Creek, Port Lincoln, S. Australia, 10.xi.1969, J. Veitch ; H494 (6), Port Elizabeth, South Africa, Sept. 1967, J. R. Grindley ; H498 (8), False Bay, South Africa, 34° S./18° E., 10.x.1969, J. G. Field.

UNIVERSITY OF CAPE TOWN : ECOLOGICAL SURVEY COLLECTIONS. All from South Africa. L10 (8), East London, 32° S./28° E., 6.vii.1937 ; LB112 (4), Langebaan Lagoon, 33° S./18° E., 15.vii.1946 ; N35 (6), Port Nolloth, 29° S./16° E., 27.x.1935 ; LU3A (13), Luderitz, 26° S./15° E., 15.vii.1946 ; D24 (8), Durban, 29° S./15° E., 27.vi.1935 ; A7 (10), Oudekraal, 34° S./18° E., 2.i.1934 ; E3 (9), Port Elizabeth, 33° S./28° E., 3.vii.1936 ; S9 (10), Still Bay, 34° S./21° E., 4.i.1932.

W.A.M. 37–69 (1), Sydney, N.S.W., late 1963, C.S.I.R.O. Fisheries ; 39–69 (3), Gunnamatta Bay, Port Hacking, N.S.W., 31.x.1963, C.S.I.R.O. Fisheries.

Description : As above, in the description of " *exigua* " group. Oral spines 5–6 ; suboral spines 1 ; furrow spines 2 to each adambulacral ossicle and basally webbed ; subambulacral spines 1. Actinal intermediate spines 1, 2 towards the disc margin, absent proximal to the mouth plates. In preserved specimens the plate at the apex of the chevron which defines the actinal intermediate area may " float " clear of its fellows on a sheet of membrane. A pair of gonopores are present in each actinal intermediate area about level with the third ambulacral ossicle and between the second and third chevrons of actinal intermediate plates (Plate IV, C).

R : r about 1·2–1·3 : 1.

Diagnosis : A small species of *Patiriella* with actinally directed gonoducts and abbreviated larval development.

Colour in life : The actinal surface is consistently blue-green. The ground colour of the abactinal surface is dull green or brown. Red, orange, purple, brown or pastel greens or browns on the spines grouped at the inferomarginal fringe, along the top of the rays and at the disc centre, often produce an attractive geometric pattern against the ground colour. The tissues of the circum-oral ring are blue-green. The tube feet are blue-green and the suckers off-white. The papulae are transparent, showing blue-green coloration at their exit from the papular pores.

Distribution : South Africa, St. Paul group, Australia south of 28° S. and E. of 136° E., Tasmania, Lord Howe Island.

Habitat : Mid-tide level on rocky shores. In areas where wave splash is consistent the species may be found high on the shore. Specimens from South Australia were taken under rocks on a muddy substrate and the species has been collected on sand at Anson's Bay, N.E. Tasmania. In Australia *Patiriella exigua* is often associated with the alga *Hormosira banksii.*

Patiriella pseudoexigua sp. nov.

(Plate IV (*a*))

Synonymy : ? *Asteriscus pentagonus* Müller and Troschel, 1842 (in part), ? *Asterina pentagona* von Martens, 1866 ; *Asterina exigua* H. L. Clark, 1908 ; ? Koehler, 1910 ; *Patiriella exigua* Verrill, 1913 (in part) ; *Asterina exigua* Fisher, 1919 ; *Asterina exigua* H. L. Clark, 1921 ; *Patiriella exigua* H. L. Clark, 1938 (in part) ; ? *Asterina* (*Patiriella*) *exigua* Domantay and Roxas, 1938 ; Engel, 1938 ; *Patiriella exigua* H. L. Clark, 1946 (in part) ; Endean, 1956 (in part).

Ludwig (*in* Mortensen, 1921) observed that *Asterina pentagona* von Martens possessed genital pores opening on the abactinal surface of the animal in contrast to *Patiriella exigua.* Thus it would appear that the name *pentagonus* of Müller and Troschel is available to accommodate the species of *Patiriella* found north of 28° S. in Australia. However, two species of *Patiriella* are present in north-eastern Australia and I find it impossible to decide which is actually *pentagonus* of past authors. Accordingly both this species and one belonging to the "*regularis*" group are described as new. Future workers in the Indo-west-Pacific may need to place one of these species in synonymy if further information validates the status of Müller and Troschel's species name. The alternative is to declare formally that *pentagonus* is invalid, but this must await further studies on the species of *Patiriella* in the waters north of Australia.

Holotype: T.M. H499. A dried specimen, $R=12 \cdot 5$ mm., Airlies Beach, Proserpine, Queensland (type locality), 12.iv.1970, A. J. Dartnall.

Paratypes: T.M. H500 (6), Airlies Beach, Proserpine, Queensland, 12.iv.1970, A. J. Dartnall; A.M. J7761 (2), Airlies Beach, Queensland, September/October 1968, K. Deacon.

Other material examined:

B.M. 1890.5.7.581–584 (4), Zamboanga, Philippines; 1968.6.14.156–160 (5), Solomon Islands.

M.C.Z. 2297 (1), Murray Is., Mer., Oct. 1913, H. L. Clark, Carnegie Expedition; 2083 (15), Espiritu Santo, Malo, New Hebrides, January 1911, Rev. J. Annand; 2296 (23), Erub, Torres Strait, 19.ix.1913, H. L. Clark; 2298 (1), Erub, Torres Strait, 19.ix.1913, H. L. Clark.

N.M.V. H116 (1), Aola, Guadalcanal, 1901, G. Officer; G114 (1), Bora Bada, New Guinea, March 1891, J. Exton; H110 (1), Bingal Bay, Queensland, July 1964, J. Kerslake.

Q.M. G3767 (2), Port Curtis, Queensland, 16.viii.1961, R. Endean; G3762 (26), South Yeppoon, Queensland, 15.i.1953, R. Endean; G3764 (22), Airlies Landing, Proserpine, Queensland, 21.iv.1953, R. Endean.

T.M. H501 (32), Airlies Beach, Proserpine, Queensland, 12.iv.1970, A. J. Dartnall; H502 (4), one mile N.E. Airlies Beach, Proserpine, Queensland, 12.iv.1970, A. J. Dartnall; H503 (6), south end of King's Beach, Bowen, Queensland, 13.iv.1970, A. J. Dartnall.

U.S.N.M. 38088 (12), Philippine Islands, E. A. Mearns; 40261 (7), Port Binang, Subic Bay, Philippines, 8.i.1908, Albatross Philippines Expedition 1907–1910; 40254 (4), Borneo, 2.iii.1908, Albatross Expedition.

W.A.M. 43–69 (3), Real Point, Villa Carmen, Cabcaben, Bataan, Philippines, 24.vii.1965, Western Australian Museum Luzon Expedition 1965.

Description of holotype: A small asterinid sea star very similar in morphology to *Patiriella exigua.* $R:r$ about $1 \cdot 3:1$. Rays five. Each oral plate with five oral spines and one suboral spine. Most furrow spines are paired except near the mouth plates, where two or three adambulacral plates carry three furrow spines. The subambulacral and actinal intermediate spines are each placed singly to an actinal plate. There are no pairs of spines towards the edge of the disc and spines are absent near to the mouth plates. The inferomarginal plates carry seven to nine spines; the abactinal plates four to 20 spinelets.

The gonoducts are orientated abactinally and the gonopores open on the abactinal surface.

Diagnosis: A small species of *Patiriella* with abactinally directed gonoducts.

Colour in life: The actinal surface is a dull brownish-green; the abactinal surface dull brown and green. Most specimens are darker on the centre of the disc and along the crest of the rays, forming a five-rayed star pattern on the abactinal surface. Variants show some russet and orange patches in the interradial areas. The circum-oral ring is bluish, the tube feet pale straw coloured, and the suckers off-white.

Distribution : The east coast of Australia north of about 28° S., Torres Strait, New Guinea, the New Hebrides, the Philippines and Borneo.

Habitat : Under rocks at mid-tide level.

Patiriella vivipara Dartnall, 1969

Diagnosis : A small species of *Patiriella* with no gonoducts ; coelomic incubation of young ; viviparous.

Distribution : Restricted to S.E. Tasmania.

(*b*) "*regularis*" *group*

Species of *Patiriella* resembling the "*exigua*" group morphologically, in which *R* exceeds 15 mm. and the abactinal spinelets are longer than in the "*exigua*" group (between 0·4 and 0·9 mm. in length).

Patiriella regularis (Verrill, 1867)

Restricted synonomy : Asterina (*Asteriscus*) *regularis* Verrill, 1867 ; *Patiriella regularis* Verrill, 1913 ; *Patiriella mimica* Livingstone, 1933 ; *Patiriella regularis* Dartnall, 1970.

Diagnosis : A species of *Patiriella* with five rays. $R : r = 1 \cdot 5 – 1 \cdot 8 : 1$.

Distribution : New Zealand and S.E. Tasmania.

Patiriella inornata Livingstone, 1933

Diagnosis : A species of *Patiriella* with five rays, short furrow spines and the innermost oral spine notched at the tip.

Distribution : Western Australia.

Remarks : This species is known only from the holotype.

Patiriella nigra H. L. Clark, 1938

Diagnosis : Five rays. Actinal intermediate area with dense spinulation ; many plates towards the inferomarginal fringe carrying two or three spines. On the abactinal surface the spinulation of the papulate areas is distinct, approaching the condition described for species of *Paranepanthia*. Colour in life black. The gonopores open on the abactinal surface.

Distribution : Lord Howe Island.

Patiriella obscura sp. nov.

(Plate IV (*b*))

Synonymy : ? *Patiriella exigua* Livingstone, 1932 ; *Patiriella exigua* Endean, 1956 (in part).

Museum samples showed that a large species of *Patiriella* was present in north-eastern Australia and probably extended to the Philippines. When I first collected this animal alive I considered it to be the adult of *Patiriella pseudoexigua* sp. nov. However, examination showed that the gonads of *P. obscura* were not mature until 13 mm. *R* was attained and *P. pseudoexigua* possesses mature gonads at 11 mm. *R*.

Holotype : T.M. H504. A dried specimen, $R = 18$ mm., Rose Bay, Bowen, Queensland (type locality), 13.iv.1970, A. J. Dartnall.

Paratypes : T.M. H505 (6) and A.M. J7791 (6), Rose Bay, Bowen, Queensland, 13.iv.1970, A. J. Dartnall.

Other material examined :

Q.M. G5330 (2), Rowe's Bay, Townsville, Queensland, August 1967, R. Monroe; G3763 (5), Low Island, Queensland, 13.viii.1954, R. Endean.

T.M. H506 (15), Rose Bay, Bowen, Queensland, 13.iv.1970, A. J. Dartnall; H507 (23), Rowe's Bay, Townsville, Queensland, 14.iv.1970, A. J. Dartnall.

COLL. ZOO. DEPT., UNIVERSITY OF THE PHILIPPINES. Two dried specimens from the vicinity of Port Galera Bay.

Description of holotype: A species of *Patiriella* with five rays. $R:r=1\cdot2:1$. Each oral plate carries five or six oral spines and one or two suboral spines. Most furrow spines are arranged in pairs, but two adambulacral plates near the mouth carry three spines. Subambulacral spines are single with occasional pairs. Actinal intermediate spines are mainly single with occasional pairs near the edge of the disc. Fringing spinelets are in groups of seven to 13. The abactinal spinelets range from four to 20 to an abactinal plate.

The gonopores open on the abactinal surface.

Diagnosis: A species of *Patiriella* of $R > 15$ mm. with abactinally directed gonoducts. Suboral spines often paired.

Colour in life: The actinal surface is dull brownish-green; the abactinal surface dull brown, reddish and purple. Dull, pale colours show indistinct geometric patterns against the ground colour. Tube feet greenish-blue; suckers off-white. Circum-oral ring bluish.

Distribution: N.E. Australia to the Philippines.

Habitat: Under rocks at mid-tide level. This species will feed over the surface of mud surrounding rocks at low tide and the body colour provides very effective camouflage at this time.

Patiriella calcar (Lamarck, 1816)

Restricted synonymy: *Asterias calcar* Lamarck, 1816; *Asterina calcar* McCoy, 1890; *Patiriella calcar* Verrill, 1913; H. L. Clark, 1946; Endean, 1953; Shepherd, 1968; Dartnall, 1970*b*.

Diagnosis: A species of *Patiriella* with seven to 11 rays, usually eight. Apart from the number of rays this species falls most naturally into the "*regularis*" group.

Distribution: From the south coast of Western Australia to southern Queensland and the coasts of Tasmania.

Remarks: It appears that Lamarck's types of *Asterias calcar* no longer exist. I have not erected a neotype for this species because I am not aware that the identity of this well marked species has been questioned.

(*c*) "*gunni*" *group*

Species of *Patiriella* with six rays and the spines of the actinal intermediate area arranged in pairs. Abactinal spines near centre of the disc between 0·2 and 0·4 mm. in length.

Patiriella gunnii (Gray, 1840)

Restricted synonymy: *Asterina gunnii* Gray, 1840; *Patiriella gunnii* Verrill, 1913; H. L. Clark, 1946; A. M. Clark, 1966; Shepherd, 1968; Dartnall, 1970*b*.

Diagnosis: A flattened form with paired subambulacral spines. Maximum *R* about 39 mm.

Distribution: Known from Tasmania, Western Australia to New South Wales, Lord Howe Island.

Patiriella brevispina H. L. Clark, 1938

Diagnosis : An arched form with single subambulacral spines attaining about 52 mm. *R*.

Distribution : Western Australia to New South Wales, the north coast of Tasmania.

Key to the Australian Species of *Patiriella*

1\. Actinal intermediate spines paired ; rays six........................ " *gunnii* " group (2)
Actinal intermediate spines single ; rays usually five or more than six..................(3)

2\. (1) Flattened ; subambulacral spines usually paired ; Colour in life varied....*Patiriella gunnii*
Arched ; subambulacral spines usually single ; colour consistently and uniformly purple .... *Patiriella brevispina**

3\. (1) Small ; $R<15$ mm., actinal spines $<0\cdot4$ mm. in length " *exigua* " group (4).
Large ; $R>15$ mm., actual spines $>0\cdot4$ mm. in length " *regularis* " group (6).

4\. (3) Gonoduct absent ; coelomic incubation of young.................. *Patiriella vivipara*
Gonoduct present...(5)

5\. (4) Gonoducts directed actinally. Actinal surface blue-green..............*Patiriella exigua*
Gonoducts directed abactinally. Actinal surface dull brownish green *Patiriella pseudoexigua*

6\. (3) Rays 7–11...*Patiriella calcar*
Rays 5 .... (7)

7 (6) Spinulation of apapulate and papulate abactinal areas distinct ; colour black (Lord Howe Is.)...*Patiriella nigra*
Spinulation of abactinal interradial areas not as dense as above ; colour not black.. ..(8)

8\. (7) Innermost oral spine flat, very wide notched at tip...................*Patiriella inornata*
Innermost oral spine not as above...(9

9\. (8) Suboral spines single ; colour of actinal surface off-white............*Patiriella regularis*
Suboral spines often paired ; colour of actinal surface dull brownish-green *Patiriella obscura*

* In a previous key to the Asterinidae of Tasmania (*Proc. Roy. Soc. Tas.*, 1970) this section runs down to *P. calcar*. The opportunity is taken to rectify this mistake here.

DISCUSSION

The distribution of species within the " *exigua* " group shows a sequence in which each species is separated from the next by a reproductive mechanism. These observations reinforce the concept of sibling pairs of species mooted in a previous paper (Dartnall, 1970*b*) except that a triple sequence is now discernible. *Patiriella pseudoexigua*, with upwardly directed gonoducts and presumably free-swimming larvae, is found north of 28° S. in eastern Australia. South of 28° S. and isolated from *P. pseudoexigua* by a reproductive " inversion " is *Patiriella exigua*. The third species in the sequence is the hermaphrodite, viviparous form, *Patiriella vivipara*, which is restricted to the cool coasts of S.E. Tasmania.

The discovery of a " *regularis* " form (*Patiriella obscura*) in N.E. Australia adds weight to the concept that the precursors of *Patiriella* came from the Indo-west-Pacific area. It is suggested that the " *regularis* " forms have contributed to the New Zealand fauna (*Patiriella regularis*) by way of the Lord Howe Rise (*Patiriella nigra*) and to south-eastern Australia through evolution of *Patiriella calcar*. It is possible that the " *exigua* " forms represent an older invasion as the contemporary distribution of *P. exigua* encompasses the temperate and cool temperate waters of both Australia and South Africa and the intervening St. Paul group of islands (see Fig. 1).

Figure 1 shows the present distribution of the Australian species of *Patiriella*. The limits of distribution of *P. exigua* and *P. pseudoexigua* at about 28° S. roughly correspond with the biogeographic boundary defined amongst others by Endean (1957) when he considered the biogeography of the shallow water echinoderm fauna of Queensland. When the distribution of the species belonging to the " *gunnii* " group is also considered it can be seen that the agreement with the marine zoogeographic provinces of Bennett and Pope (1953, 1956) is marked and that the distributional limits accord well with those postulated by George (1969) for the tropical and subtropical Palinuridae.

In an earlier paper (Dartnall, 1970*a*) the distributions of the hermaphrodite forms known within the Asterinidae were shown to lie in widely separate areas around 40° of latitude, both north and south. This evidence must now be restricted to the non-fissiparous asterinids because Dr. R. Kenny has sent me samples of hermaphrodite individuals of *Nepanthia belcheri* (Perrier) from Moreton Bay, Queensland. When the distribution of the species belonging to the " *exigua* " sequence is considered, the speculations which follow are of interest.

(*a*) The distributions of the " *exigua* " species are defined by thermal tolerance alone, the observed sequence of reproductive mechanisms being fortuitous.

(*b*) Each kind of reproductive mechanism is limited by temperature, higher latitudes and lower temperatures directing the success of hermaphrodite forms, species with abbreviated development, or a combination of both.

It is probably not possible to test these speculations. However, it may be possible to find out whether similar reproductive sequences occur in other groups of Asteroidea along the long eastern seaboard of Australia.

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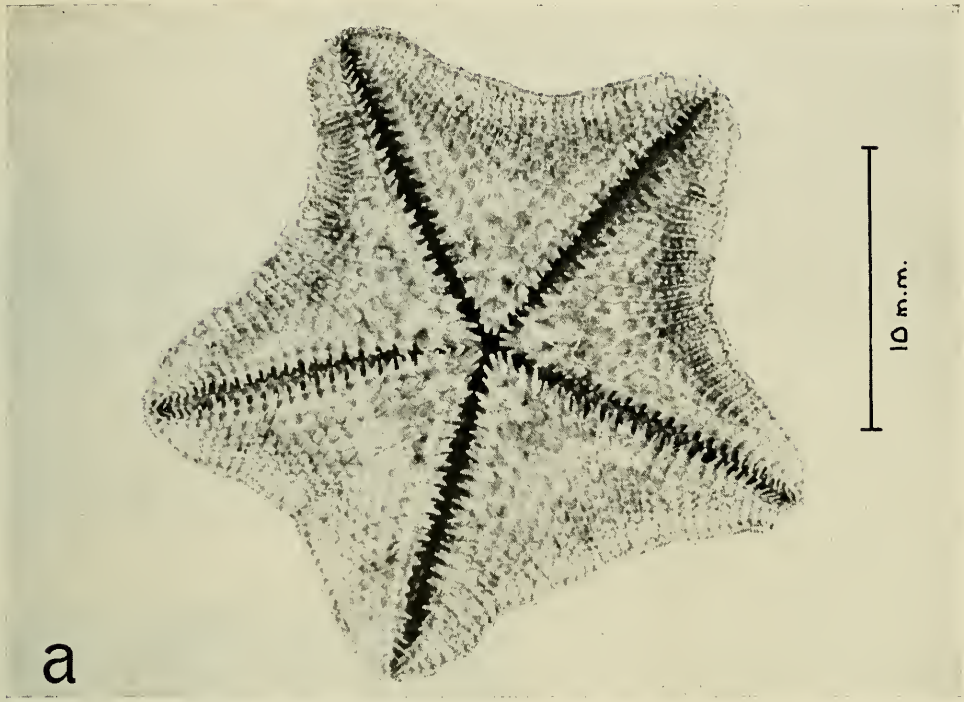
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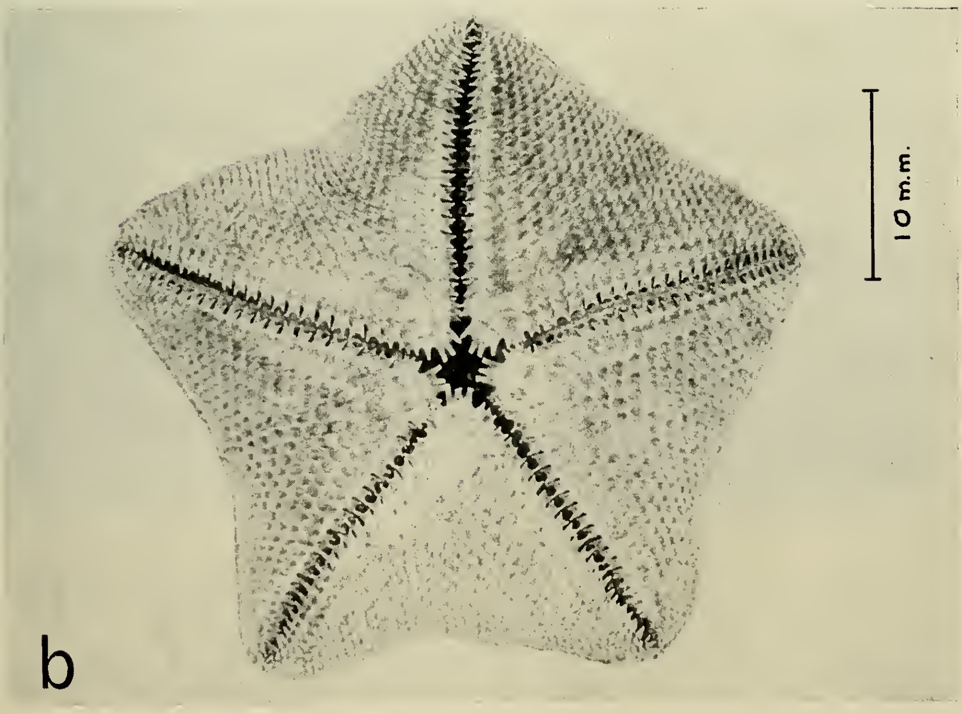
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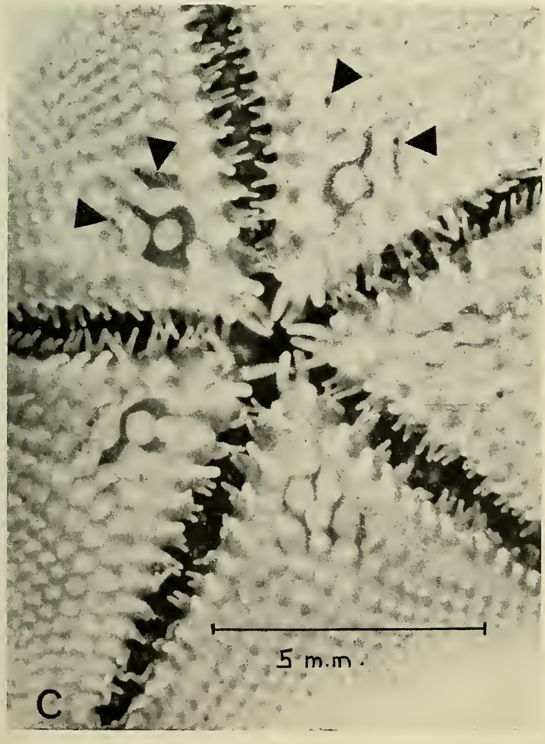
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b

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EXPLANATION OF PLATES

Plate III

(*a*) *Patiriella pseudoexigua* sp. nov. Actinal surface of holotype (T.M. H499).

(*b*) *Patiriella obscura* sp. nov. Actinal surface of holotype (T.M. H 504).

Plate IV

(*a*) Airlie's Beach, Proserpine, Queensland. Type locality of *P. pseudoexigua* sp. nov.

(*b*) Rose Bay, Bowen, Queensland. Type locality of *P. obscura* sp. nov.

(*c*) *Patiriella exigua* (Lamarck). Actinal surface of neotype (T.M. H499). The positions of the gonopores in two interradii are indicated by the arrowheads.

A SEA STAR OF GENUS *CTENODISCUS* FROM TASMANIA

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[Accepted for publication 23rd September 1970]

Synopsis

A single specimen from deep water off northern Tasmania constitutes the first record of the sea star family Goniopectinidae from Australian waters.

Introduction

The sea star genus *Ctenodiscus* of the family Goniopectinidae is represented by two species in the Southern Hemisphere. *Ctenodiscus australis* Lütken is known from waters off the east coast of South America and *C. procurator* Sladen from the west (Bernasconi, 1964). *Ctenodiscus orientalis* Fisher is tropical Indo-Malay in distribution and *C. crispatus* (Retzius) is an arctic-boreal form with a circumpolar distribution (D'yakonov, 1950).

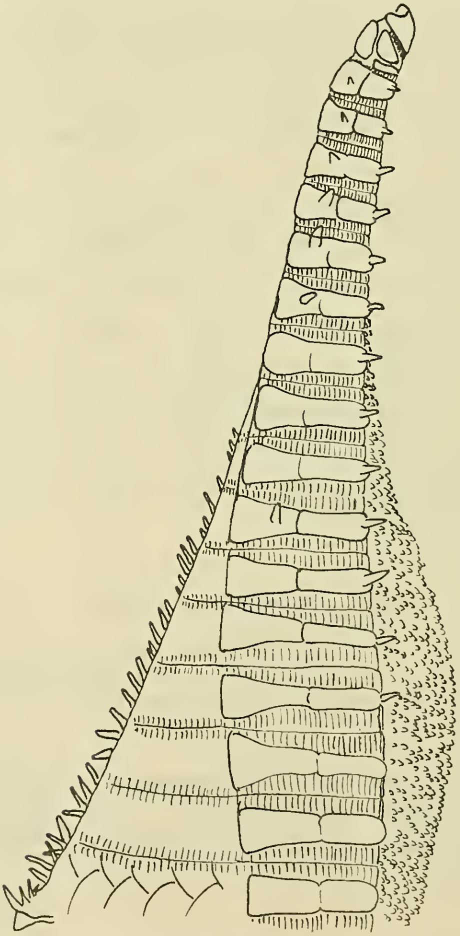

Fig. 1. *Ctenodiscus* sp. Side view from tip of ray to midline of the interradius.

The single specimen discussed here was taken on the 24th September, 1953, from the F.R.V. *Derwent Hunter* 45 miles E.N.E. of Stokes Point, King Island, in 300–240 fathoms (546–436 metres). I am grateful to Mr. A. M. Olsen, who collected the specimen, which is now housed in the collections of the Tasmanian Museum.

Ctenodiscus sp. (cf. *C. orientalis* Fisher)

One dried specimen. Tasmanian Museum Reg. No. H497. $R = 19 \cdot 5$ mm., $r = 8 \cdot 0$ mm., *br* at base of ray$= 7 \cdot 0$ mm., $R : r$ $2 \cdot 43 : 1$.

Description: A sea star with five pointed rays and deep interbrachial arcs. The aboral surface is flattened and the oral surface is inclined at a steep angle, the mouthplates being the lowest point (Fig. 1).

The actinal surface is covered with small paxillae that have no central spinelets and four to eight peripheral spinelets. Near the disc centre a small area (about 2·5 mm. across) is more closely covered with paxillae. This may be a retracted epiproctal cone.

The madreporite is some 2 mm. across and placed close to the margin. The furrows of the madreporite are roughly parallel and aligned along the radial axis of the body in which the madreporite lies.

The body is bordered by two rows of marginal plates forming an upright wall. Opposite inferomarginal and superomarginal plates are approximately equal in height, there being 16 marginals along the side of each ray. The largest pairs of inferomarginal and superomarginal plates are the third, fourth and fifth from the interradial line, the height of the marginal wall being reduced from those plates both to the tip of the ray and the mid-line of the interradius. Fascioles are present between all the marginal plates. The fasciolar spines are longer on the superomarginals and become progressively narrower along the borders of the inferomarginal plates. Each superomarginal plate carries a single pointed spine at its apex and 10 to 12 fasciole spinelets on each side. A single spine is present on most inferomarginal plates near to the upper edge. The terminal plates of this specimen are much abraded, but probably carry a single large spine either side of the terminal groove with a smaller spine set below and outside the former.

Fig. 2. *Ctenodiscus* sp. Mouth plate, proximal fascioles and adambulacral spinulation.

The fascioles run across the actinal surface to the ambulacrum. The fasciole in the mid-line of the interradius divides behind the mouth plates (Fig. 2). The actinal plates between the first fascioles from the mid-line are made up of two rows of overlapping, sub-rounded plates. The other actinal plates are obscured by membrane. The adambulacral plates carry four to five furrow spines. Up to four spines may be present on the actinal surface of the adambulacral plates, amongst which a pair of spines may be distinct, especially near to the mouth. Occasional single spines are present on the actinal plates.

The mouth plates are prominent, carry three or four oral spines and between 10 and 12 suboral spines (Fig. 2). The innermost oral spines are the largest of that series. The second suboral spine is the largest of the suboral series.

The tube feet are in two rows, pointed and without sucking discs.

Discussion

The single specimen available is not adequate to confirm the existence of a further species of *Ctenodiscus*. However, some comparisons may be drawn with the species already ascribed to the genus. Sources of comparative information are given throughout the discussion.

The paxillae of the specimen described are similar to those described as characteristic of *C. procurator*, being less than 0·5 mm. in height and without central spinelets (A. M. Clark, 1962). Fisher (1911) demonstrated the morphological variability of *C. crispatus* and noted that the extremes of the paxillae and of body form of that species came within the variation shown by both *C. procurator* and *C. australis*. Fisher's table of measurements showed that 16 marginal plates were present in *C. crispatus* at R of approximately 36 mm. The specimen under discussion has 16 marginal plates at about half that size.

The number of furrow spines observed here comes well within the range given by Fisher for *C. crispatus*, i.e. three to five.

C. orientalis is the only other form known with a large number of marginal plates (26–27 when $R=52$ mm.) and the number of fasciole spinelets are similar to the Tasmanian specimen. Comparison with Fisher's (1919) figures of *C. orientalis* shows that the oral spinulation of the Tasmanian specimen differs from that species in that the second suboral spine is larger and there are more suboral spines (10–12 against 5–8). Fisher's figures also show that central spinelets are present on the paxillae of *C. orientalis*.

On the basis of size and numbers of marginal plates, this specimen has been referred to *Ctenodiscus orientalis* Fisher. A similar Indo-Malay relationship has already been inferred by A. M. Clark (1962) for a species of *Marginaster* from deep water off eastern Tasmania. A number of hypotheses are available to fit the distribution observed.

(1) All the attributed species of *Ctenodiscus* are but one species showing a wide range of morphological variation and bipolar distribution.

(2) Two species of *Ctenodiscus* exist with north and south polar distributions.

(3) The Tasmanian form shares its relationships with the tropical Indo-Malay fauna and is most closely related to *Ctenodiscus orientalis*.

Without further material available, I have chosen the latter hypothesis. The specimen is also of interest as it adds another family to the known Australian asteroid fauna.

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THE GENUS *NUNCIELLA* ROEWER (OPILIONES, LANIATORES) WITH DESCRIPTION OF A NEW SPECIES FROM KANGAROO ISLAND, SOUTH AUSTRALIA

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Synopsis

The genus *Nunciella* Roewer is redefined and the genus *Cinuna* Hickman is synonymized with it. A new species, *N. kangarooensis* n. sp., is described from Kangaroo Island, South Australia. A new key is given for the twelve species of *Nunciella*. The male genitalia of *N. aspera* (Pocock), *N. badia* (Hickman), *N. dentata* (Hickman), *N. tasmaniensis* Hickman and *N. tuberculata* Forster are described.

INTRODUCTION

The genus *Nunciella* Roewer is one of the largest groups of triaenonychid harvestmen in Australia. Five species have been described from eastern Australia south of Canberra, three from Tasmania, and two from the south-west of Western Australia. The new species from Kangaroo Island fills a gap in this distribution.

The genus is of considerable interest because of the complex structure of the male genitalia, and sexual dimorphism in the chelicerae, pedipalps and coxae of leg 1.

Family TRIAENONYCHIDAE Soerensen, 1886

Subfamily TRIAENONYCHINAE Pocock, 1903

Tribe TRIAENONYCHINI Pocock, 1903

Genus *Nunciella* Roewer, 1929

Nunciella Roewer, 1929 : 96 ; Roewer, 1931 : 162 ; Forster, 1952 : 26 ; Hickman, 1958 : 35.

Cinuna Hickman, 1958 : 37, new syn.

Although early authors have regarded the number of segments in tarsus 1 as a reliable generic character, more recent work has shown that it must be used with caution in some genera (Goodnight and Goodnight, 1953). Forster (1954) allowed a variation of 2–4 tarsal segments in leg 1 for *Nuncia* and 5–7 for *Hendea* in his comprehensive revision of the New Zealand Laniatores. Recently, Forster (1965) described a cave species of *Hendea* with eight segments in tarsus 1, and remarked, " emphasis is placed on the tarsal formula for the separation of genera . . . and it is of considerable interest to find that it may be influenced so readily by adaptation to a different environment ". Furthermore, Hickman (1958) has noted that variation (including asymmetry within an individual) is common in some Australian genera.

All the species of *Nunciella* described by Roewer possessed three tarsal segments in leg 1, a character he used in his description of the genus. Forster (1949), however, noted that the male of *N. tuberculata* possessed four segments in tarsus 1, whilst the female had three.

In his diagnosis of *Nunciella*, Hickman (1958) retained Roewer's diagnostic character of three segments in tarsus 1 while noting the situation in *N. tuberculata*. On the basis of the segment number in tarsus 1 and the position of the eyemound, Hickman erected the closely related genus *Cinuna* and placed in it *C. badia* (type species) and *C. dentata* from Tasmania. *Cinuna* possessed four segments in both sexes and an eyemound removed from the anterior margin of the carapace. The latter character is not valid because in males of *N. aspera* and *N. tuberculata* the eyemound also rises from behind the anterior margin.

It is obvious that the dimorphic variation in tarsus 1 in *N. tuberculata* (and *N. kangarooensis*, n. sp.) causes problems in separating *Cinuna* from *Nunciella*. Because of the similarity in the genitalia of the two genera (Figs. 1–18) and the apparent absence of any clear-cut distinguishing characters, the limits of *Nunciella* must be extended to include species with four segments in tarsus 1. Thus *Cinuna* must be synonymized with *Nunciella* and the genus *Nunciella* redescribed.

Too little emphasis has been placed on the systematic importance of the male genitalia. Descriptions of genitalia have been given in only four of the 11 previously described *Nunciella* species. Kauri (1955) described those in *N. aspera* and *N. karriensis*, and Forster (1955) those in *N. montana* and *N. woolcocki*. Descriptions are given for species which have been examined by the author and whose genitalia had not been described previously. The penis of *N. aspera* is redescribed, as Kauri's drawing is partly inaccurate.

The genus *Nunciella* Roewer is now redefined as follows.

Anterior margin of carapace unarmed or with row of tubercles or granules above. Eyemound low, generally rounded, rising from or behind anterior margin, unarmed except for small granules in some species. Tergites without spines or large tubercles, but with rows of granules. Chelicera of male with proximal retrodorsal boss on first segment. Pedipalp femur in male with a large modified proximoventral bifid tooth which is laterally flattened and directed backwards. With pedipalp lowered this tooth abuts another modified bifid tooth on coxa of leg 1. Calcaneus of each metatarsus much shorter than astragalus and that of leg 1 in male without notch below. Tarsal formula 3–4, 8–15, 4, 4. Distitarsi 1 and 2 with two and mostly four segments respectively. Claw of both tarsus 3 and 4 three-pronged, middle prong larger than laterals. Apical portion of penis complex and usually compact. One superior and three inferior setae usual number on each ventral plate (*N. tasmaniensis* with two and five respectively).

Type species: *Nunciella aspera* (Pocock).

Nunciella is closely related to the Tasmanian genus *Nuncioides* Hickman and the New Zealand genus *Neonuncia* Roewer. The males of these genera possess a strong proximal boss on the first segment of the chelicera, a highly modified bifid tooth placed proximoventrally on the pedipalp femur, and a calcaneus of leg 1 without notch below. *Nunciella* differs from *Nuncioides* in having 3–4 segments rather than 5–6 in tarsus 1, and 4–5 compared with 6–8 in distitarsus 2. In *Neonuncia* the scute, including the anterior margin, is smooth, without tubercles or granules, and there are only two inferior setae on each ventral plate of the penis. The structure of the genitalia and other characters suggest *Nunciella* is also related to *Calliuncus* Roewer.

The 12 species in the genus *Nunciella* may be distinguished by the following key. Females are not known for all species, so the key is based on male characters with the possible exception of *N. parvula* Roewer, which Forster (1952) believes is a female, not a male as stated by Roewer (1931). *N. frontalis* Roewer is omitted as it is probably a synonym of *N. aspera* (Forster, 1952).

KEY TO SPECIES OF NUNCIELLA (MALES)

1. Tarsus of leg 1 with four segments .... (2)
Tarsus of leg 1 with three segments.. (5)
2. Distal portion of first segment of chelicera unarmed.................. *N. tuberculata* Forster
Distal portion of cheliceral first segment with spine or prominent tubercle.......... (3)
3. Pedipalp tibia with four strong retrolateral teeth........ *N. dentata* (Hickman), new comb.
Pedipalp tibia with three strong retrolateral teeth.................................. (4)

4. Pedipalp femur with five mediodorsal teeth.......................*N. kangarooensis*, n. sp.
Pedipalp femur with four mediodorsal teeth..............*N. badia* (Hickman), new comb.
5. Prolateral surface of pedipalp femur with two distal teeth........................(6)
Prolateral surface of pedipalp femur without two distal teeth.....................(9)
6. Prolateral surface of pedipalp patella armed sub-distally with strong tooth..........(7)
Prolateral surface of pedipalp patella armed sub-distally with small tubercle........(8)
7. Mediodorsal surface of pedipalp femur with four strong teeth..........*N. cheliplus* Roewer
Mediodorsal surface of pedipalp femur with four teeth, 1 and 3 very small, 2 and 4 strong.... .... *N. granulata* Roewer
8. Penis with a rounded distally oriented swelling ventral to the inferior setae............ ....*N. karriensis* Kauri
Penis without a prominent swelling ventral to the inferior setae..........*N. aspera* (Pocock)
9. Femur of leg 3 with strong spine near proventral surface..............*N. woolcocki* Forster
Femur of leg 3 without such a spine...(10)
10. Mediodorsal surface of pedipalp femur with five teeth................*N. parvula* Roewer
Mediodorsal surface of pedipalp femur with three teeth in proximal half..........(11)
11. Ventral surface of pedipalp femur with strong tooth in distal half and the prolateral surface unarmed..*N. tasmaniensis* Hickman
Ventral surface of pedipalp femur with tubercle in distal half and spinous tubercle at two-thirds on prolateral surface...................................*N. montana* Forster

Of the species in *Nunciella*, *N. aspera* and *N. karriensis* are from Western Australia, *N. tasmaniensis*, *N. badia* and *N. dentata* are from Tasmania, *N. cheliplus* and *N. parvula* from Victoria, *N. montana* from New South Wales, *N. woolcocki* from the Australian Capital Territory, and *N. kangarooensis*, n. sp., from Kangaroo Island, South Australia. Roewer (1931) recorded *N. granulata* from New Zealand, but according to Forster (1954) it is probably an Australian species.

Nunciella aspera (Pocock)

Triaenonyx aspera Pocock, 1903 : 404 ; Loman, 1910 : 133.

Nuncia aspersa (Pocock) : Roewer, 1915 : 80 ; Roewer, 1923 : 592.

Nunciella aspera (Pocock) : Roewer, 1929 : 96 ; Forster, 1952 : 27–29 ; Kauri, 1955 : 3–4.

Nunciella frontalis Roewer, 1931 : 163.

Structure of Penis (Figs. 1–3) : Penis complex and compact. Glans arising dorsally but curving ventrad, with terminal portion ventral (Fig. 2). Arising from glans, and flanking it on either side, two large curved plates. These plates present in all species, but relationship with glans not as evident in the eastern Australian forms. In these, the curved flanking plates meet dorsally and presumably obscure the line of fusion with the glans. The glans and flanking plates constitute the aedeagus.

Ventral plates fused and enlarged basally, but not with a pronounced distally-oriented swelling ventral to inferior setae. Plates tapering rapidly distal to inferior setae, separated by deep notch. Each ventral plate with one superior and three inferior setae.

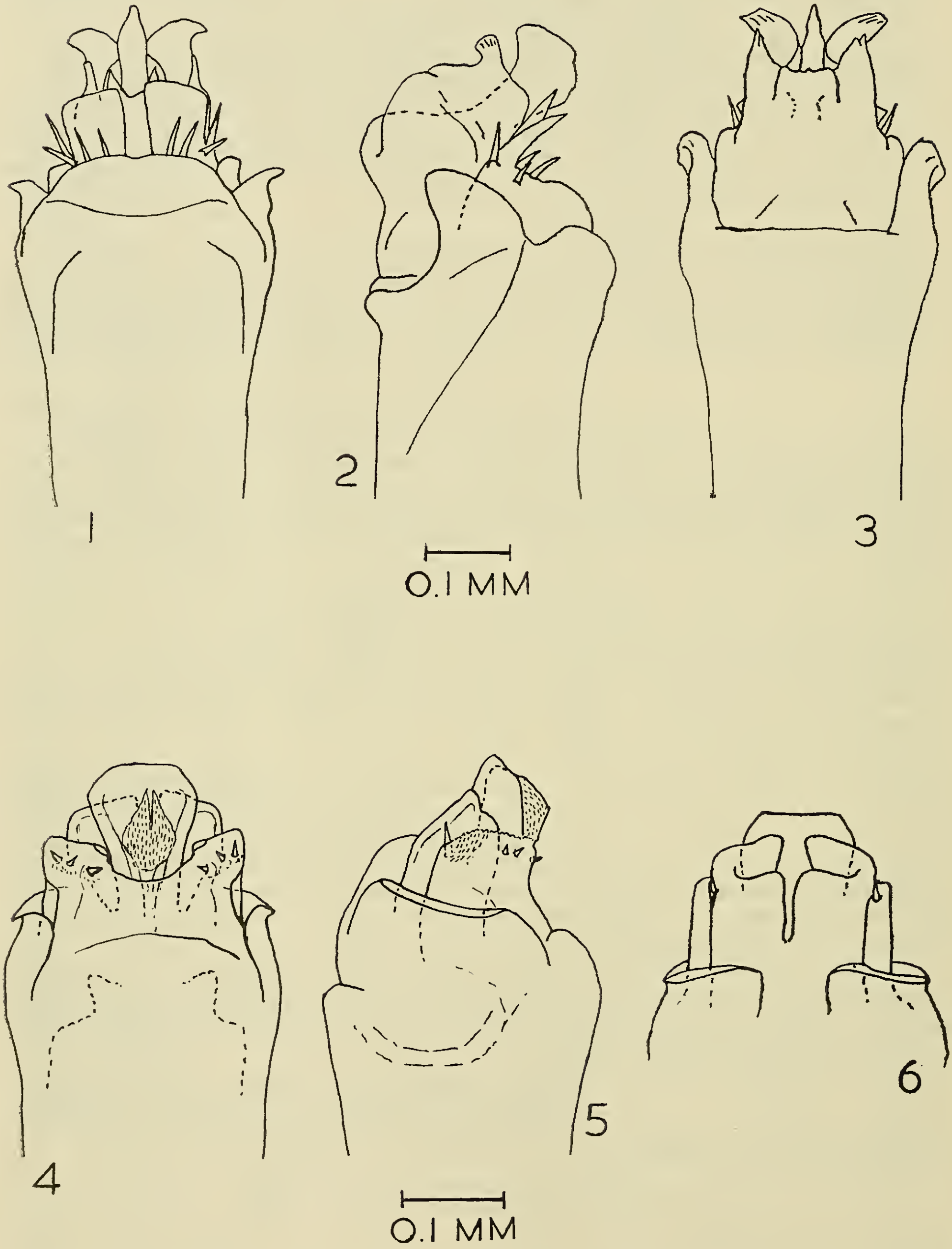
Material Examined : Ten males, three females (type material not examined).

Locality : Strong's Cave, near Margaret River, Western Australia : under loose rocks and debris in entrance doline. Coll. G. S. Hunt 5.i.65.

Nunciella badia (Hickman), new comb.

Cinuna badia Hickman, 1958 : 38–40.

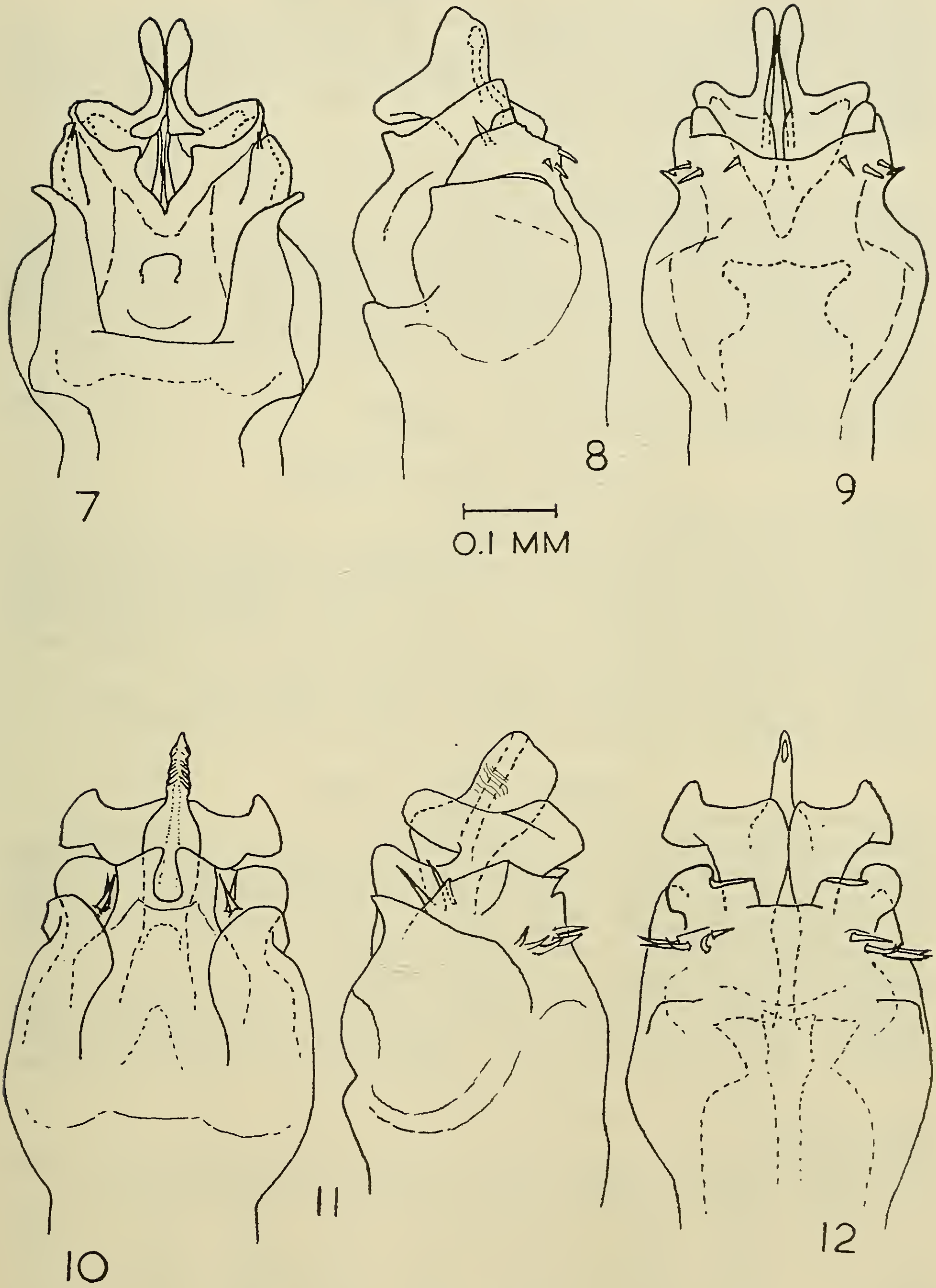
Structure of Penis (Figs. 4–6) : Apical portion complex and compact. Glans rugose and swollen sub-apically (Fig. 4), protected dorsally by curved hood-like process. Two curved plates dorsal to hood, fused along mid-dorsal line except for narrow cleft. Each ventral plate with one superior and three minute inferior setae. Distal edge of plate serrated and distodorsal region rugose (Fig. 5). Plates fused except for shallow indentation.



Text-fig. 1

Figs. 1–3. *Nunciella aspera* (Pocock). 1, Apical portion of penis, ventral view ; 2, lateral view ; 3, dorsal view.

Figs. 4–6. *Nunciella badia* (Hickman), new comb. 4, Apical portion of penis, ventral view ; 5, lateral view ; 6, extreme apical portion, dorsal view.



Text-fig. 2

Figs. 7–9. *Nunciella dentata* (Hickman), new comb. 7, Apical portion of penis, dorsal view; 8, lateral view; 9, ventral view.

Figs. 10–12. *Nunciella tasmaniensis* Hickman. 10, Apical portion of penis, dorsal view; 11, lateral view; 12, ventral view.

Material Examined: Holotype male and allotype female.

Localities: Holotype male from near Lake St. Clair, Tasmania: under rotting log. Coll. V. V. Hickman 7.ii.45. Australian Museum, Sydney, Cat. No. K68133. Allotype from side of Lyell Highway, 23 miles from Queenstown, Tasmania: under rotting log. Coll. V. V. Hickman 23.v.54. Australian Museum, Sydney, Cat. No. K68134.

Nunciella dentata (Hickman), new comb.

Cinuna dentata Hickman, 1958: 40–42.

Structure of Penis (Figs. 7–9): Apical portion complex and compact. Glans apparently lying between two curved plates, appearing narrow and tubular with an apical expansion. Curved plates flared out laterally, fused along mid-dorsal line except for indentation. Ventral plates fused except for wide smoothly curved shallow indentation, each with one superior and three inferior setae.

Material Examined: Holotype male.

Locality: Slopes of Mt. Wellington, Tasmania. Coll. C. Oke Sept., 1949. Australian Museum, Sydney, Cat. No. K68135.

Nunciella tasmaniensis Hickman

N. tasmaniensis Hickman, 1958: 35–38.

Structure of Penis (Figs. 10–12): Apical portion complex. Glans laterally flattened, narrowed sub-apically, directed slightly ventrally and striated subdistally with lateral ridges (Fig. 11). Flanking plates wing-like, joining medioventrally and mediodorsally. Ventral plates fused except for wide sharply cornered indentation, each with two strong superior and five strong inferior setae.

Material Examined: Holotype male and allotype female.

Locality: Weldborough Pass, Tasmania: under rotting logs. Coll. V. V. Hickman 25.viii.53. Australian Museum, Sydney, Cat. No. K68132.

Nunciella tuberculata Forster

N. tuberculata Forster, 1949: 71, 73–75, 78.

Structure of Penis (Figs. 13–15): Glans ventrally placed and narrowed apically. Flanking plates large, flared out laterally and fused along mid-dorsal line except for very deep and narrow notch. Ventral plates fused except for a sharply cornered indentation, each with one superior and three inferior setae. Portion of plates distal to inferior setae relatively enlarged.

Material Examined: Holotype male, allotype female and four paratype males.

Localities: Holotype, allotype and three paratypes from Diamond Creek, Victoria. Coll. J. A. Kershaw 11.iv.05. Paratype male from Kallista, Victoria: under log. Coll. A. N. Burns 18.ix.46. National Museum of Victoria, Melbourne.

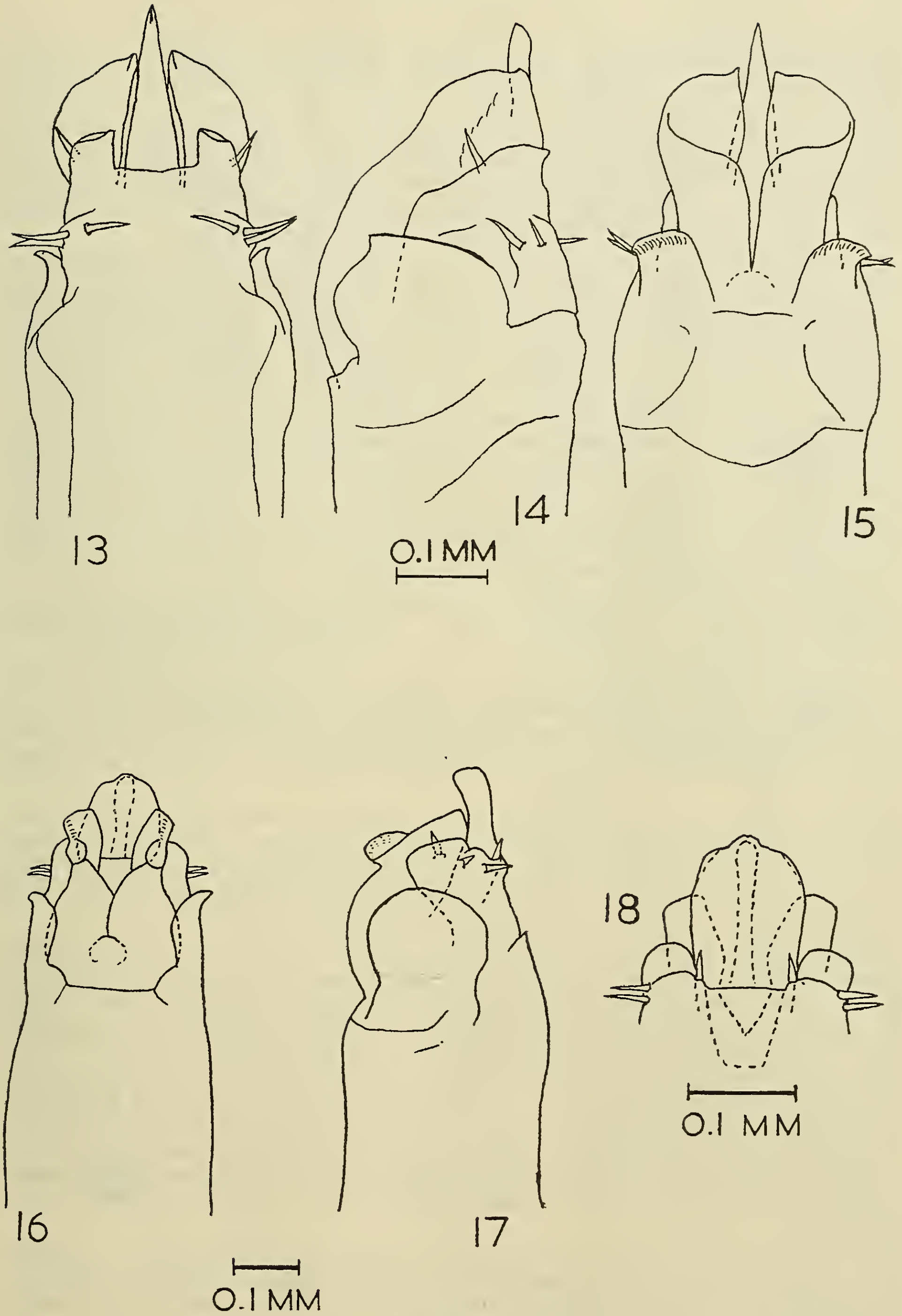
Nunciella kangarooensis, n. sp.

Holotype male.

Measurements (mm.): Length scute 3·90, width scute 3·62, length carapace 1·64, length genital operculum 0·43, width genital operculum 0·42.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tar.	Total
Leg 1 ..	1·44	0·68	1·96	0·91	1·52	1·95	1·28	9·74
Leg 2 ..	1·99	0·74	2·74	1·15	2·31	2·77	2·70	14·40
Leg 3 ..	1·49	0·78	2·02	0·85	1·54	2·13	1·35	10·16
Leg 4 ..	1·96	0·94	2·77	1·18	2·16	3·34	1·60	13·95
Pedipalp ..	1·18	0·61	2·02	1·16	1·42	—	1·42	7·54

Chelicera: First segment 1·55, second segment 1·59, total 2·88.



Text-fig. 3

Figs. 13–15. *Nunciella tuberculata* Forster. 13, Apical portion of penis, ventral view; 14, lateral view; 15, dorsal view.

Figs. 16–18. *Nunciella kangarooensis*, n. sp. 16, Apical portion of penis, dorsal view; 17, lateral view; 18, extreme apical portion, ventral view.

Colour: Dorsal body pattern as in Fig. 19. Carapace with background colour orange-brown superimposed with darker red-brown markings, including reticulations lateral to eyemound and distinct markings posterior to eyemound. Tergites generally darker than carapace, overall colour dark brown to black. Lighter markings down sides. Prominent club-shaped stripe posterior to scutal groove. Yellowish circular patch surrounding each of the two mesial granules in areas 2 and 3, less distinct patches in areas 1, 4 and 5. Row of patches along each free tergite. Pedipalps and chelicerae orange-brown with darker reticulations. Legs yellow-brown with dark brown and black markings.

Body (Figs. 19, 21–23)*:* Eyemound low, less than half as high as long, directed slightly forward, rising abruptly from just behind anterior margin of carapace and sloping back gently posterior to apex (Figs. 21–22). Apex with small setose granule. Six small tubercles directed obliquely forward and some small granules along anterior margin of carapace. Five other processes lower on anterior margin: one mesially placed and curved slightly upwards, one abutting retroproximal boss of each chelicera, one outside each pedipalp. Each tergal area and free tergite with transverse row of setose granules, mesial ones larger. Most of scute with minute granulations but free tergites more sparsely covered. Scutal groove prominent mesially, groove between areas 4 and 5 distinct, extending towards lateral margins, that between areas 1 and 2 faintly indicated mesially, others indistinct. Free tergites tending to be fused to each other and to scute, a condition approaching that of *N. tasmaniensis.*

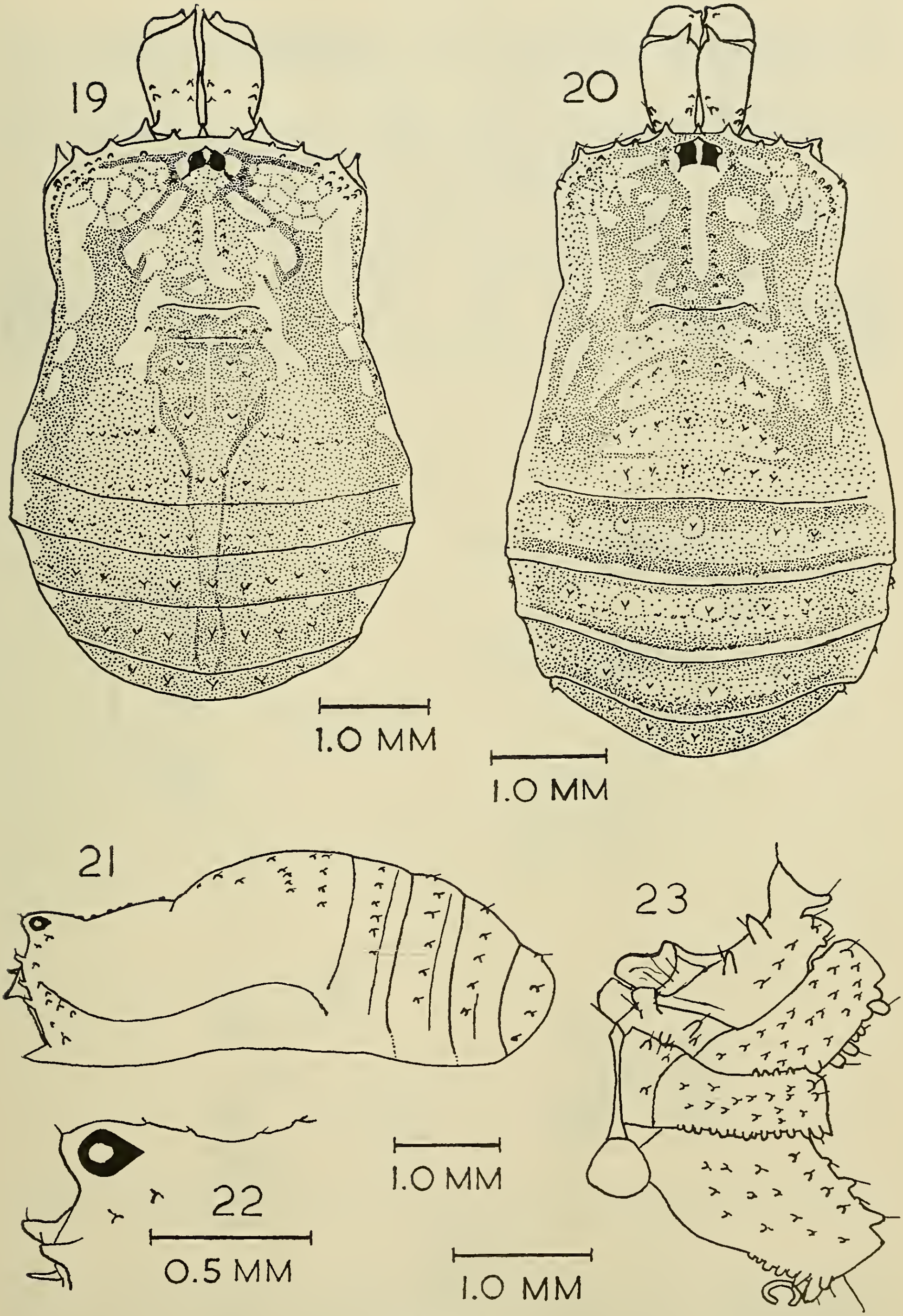
Sternites each with row of tiny setose granules. Margin of spiracle only obscured by one or two tubercles on coxa 4. Genital operculum smooth except for scattered hairs.

Penis (Figs. 16–18)*:* Apical portion complex and compact. Glans ventrally placed and dorsoventrally flattened, with pair of curved plates dorsal to it. Plates fused mid-dorsally except for large V-shaped notch. Ventral plates fused except for broad shallow indentation, each with one superior and three inferior setae.

Chelicerae (Figs. 19, 27)*:* Strong retroproximal boss on dorsal surface of first segment abutting process on anterior margin of carapace. Dorsal surface with a few small granules and prodistal spine directed obliquely forward. Dorsal surface of second segment with small inner sub-proximal spine, retrodorsal tubercle at two-thirds and small spine at retrodistal corner.

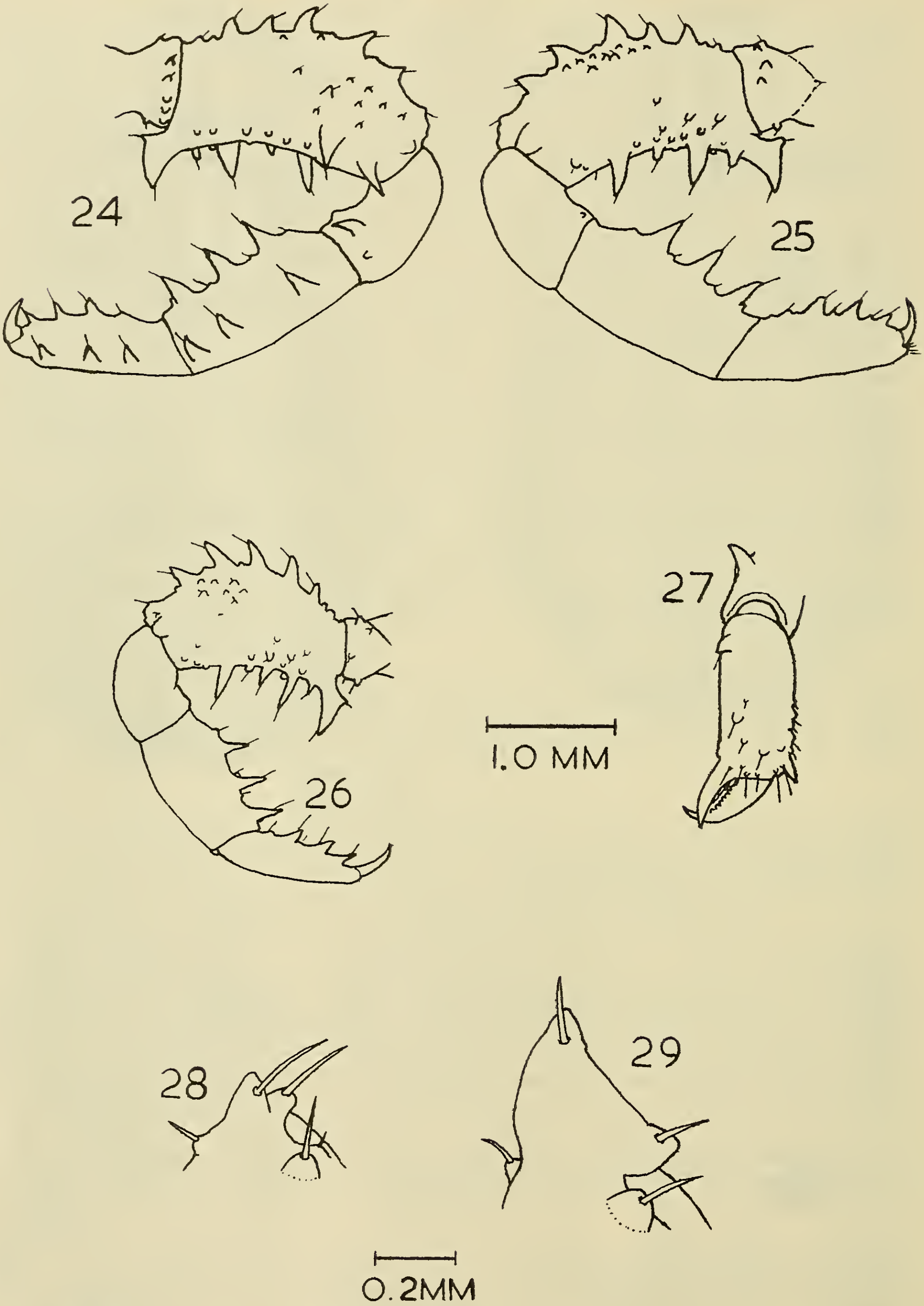
Pedipalps (Figs. 24, 25)*:* Moderately large. Trochanter with a few granules· Dorsal surface of femur with row of five prominent teeth, third and fourth largest· On ventral surface median proximal tooth modified into large laterally compressed process directed obliquely backwards (Fig. 25). With pedipalp lowered, posterior edge of this process in contact with modified cup-like process on coxa 1. Four other teeth along ventral surface, second and fourth strong, first and third weak. Two large sub-distal teeth low on prolateral surface. Granule at two-thirds high on prolateral surface enlarged into denticle. Patella with large sub-distal tooth low on prolateral surface. Tibia with three teeth down each ventrolateral margin. Tarsus with small denticle followed by three teeth down retroventral margin and three teeth down proventral margin. Claw about 0·25 length of tarsus.

Legs: Coxa 1 with large cup-like process in prodistal corner (Figs. 23, 29) and two spines near proventral margin, more distal stronger. Retroventral edge with sub-distal tubercles. Coxa 2 with small sub-distal spine on retrolateral surface and small tubercles more proximally. Maxillary lobe with three setose tubercles. Coxa 4 with pro- and retrolateral tubercles. Trochanter of each leg with small tubercles or granules, femora with rows of small tubercles and/or granules, those on leg 1 ventral surface largest. Each calcaneus much shorter



Text-fig. 4

Figs. 19–23. *Nunciella kangarooensis*, n. sp. 19, Dorsum of male showing colour pattern, with first segment of chelicerae also shown ; 20, dorsum of female showing colour pattern, with first segment of chelicerae also shown ; 21, male body, lateral view ; 22, eyemound of male, lateral view ; 23, sterno-coxal region in male.



Text-fig. 5

Figs. 24–29. *Nunciella kangarooensis,* n. sp. 24, Male pedipalp, prolateral view; 25, retrolateral view; 26, female pedipalp, retrolateral view; 27, second segment of male chelicera, dorsal view; 28, process in prodistal corner of coxa 1 in female; 29, same process in male.

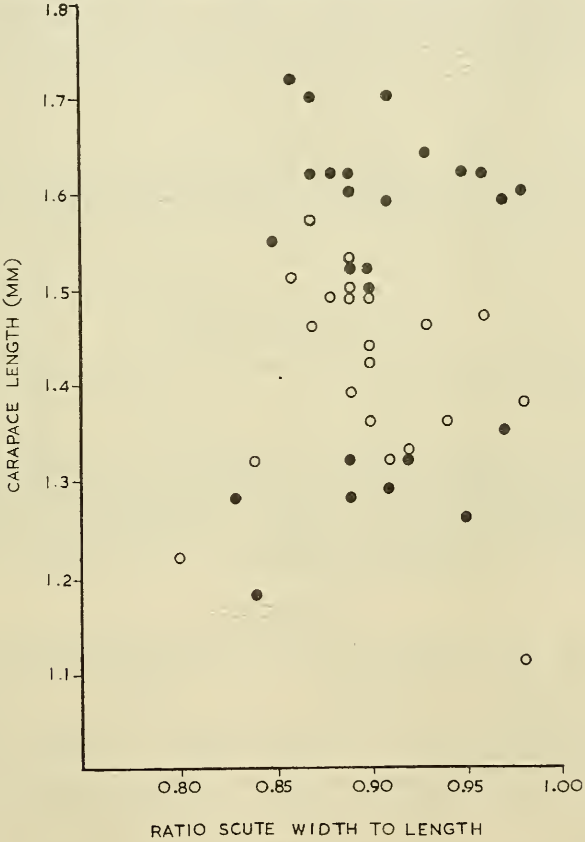
than astragalus, calcaneus of leg 1 without notch. Distitarsus of leg 1 two-segmented, that of leg 2 four-segmented. Tarsal formula : 4, 9–13, 4, 4.

Allotype female.

Measurements (mm.)*:* Length scute 3·89, width scute 3·45, length carapace 1·49, length genital operculum 0·51, width genital operculum 0·47.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tar.	Total
Leg 1 ..	1·18	0·57	1·82	0·81	1·35	1·78	1·08	8·59
Leg 2 ..	1·66	0·74	2·44	0·98	2·08	2·53	2·43	12·86
Leg 3 ..	1·37	0·59	1·76	0·78	1·35	1·99	1·22	9·06
Leg 4 ..	1·72	0·91	2·52	1·02	1·99	3·04	1·55	12·75
Pedipalp ..	1·01	0·54	1·62	0·88	1·15	—	1·08	6·28

Chelicera : First segment 1·04, second segment 1·66, total 2·70.



Text-fig. 6

Fig. 30. *Nunciella kangarooensis*, n. sp. Range of stoutness (ratio scute width to length) and size segregation of large and small males (dots) and females (circles).

Female Characteristics : As in other species in the genus, sexual dimorphism is strong. Female differs from male in the following respects. Dorsal pattern without median stripe, tergal areas more clearly defined, yellow patches around granules more prominent (Fig. 20). Retroproximal boss on dorsal surface of cheliceral first segment absent, but small tubercle occupies a near position ; corresponding process on anterior margin reduced. Spine in retrodistal corner of second segment absent. Pedipalps (Fig. 26) smaller. Proximoventral tooth on femur not extremely modified, coxa 1 without extreme cup-like modification to bifid process in prodistal corner (Fig. 28). Body less stout than male, though not in all the population (Fig. 30). Female type of similar length to male, though females in general shorter (Fig. 30). Degree of fusion of free tergites less. As with *N. tuberculata*, tarsus 1 in the female with three segments. Tarsal formula: 3, 8–11, 4, 4.

REMARKS

The males can be separated from those of other species in the genus, except some individuals of *N. aspera* and *N. karriensis*, by the presence of five mediodorsal teeth and two strong prolateral teeth on the pedipalp femur. A less granulate eyemound distinguishes them from the other two species.

N. kangarooensis, n. sp. is similar to *N. tuberculata* in having four segments in tarsus 1 of the male and three in the female. It resembles many other species in having a club-shaped median stripe on the dorsal surface of many males. It resembles *N. tasmaniensis* in the tendency for fusion of the free tergites in males. The structure of the genitalia suggests *N. kangarooensis* is more closely related to the eastern Australian species than those in Western Australia.

Types

Holotype male, allotype female and two paratype males in the Australian Museum, Sydney, Cat. No.'s K68773, K68774 and K68775. One male and one female paratype in the South Australian Museum, Adelaide.

Locality

Near Shackle Road crossing of Rocky River, Flinders Chase, Kangaroo Island, South Australia: in moist litter amongst the dead drooping blade-like leaves of tall monocots, one to two metres high (Type Locality). The habitat is shaded by thick vegetation beside the river. Altitude, under 60 metres. Coll. G. S. Hunt 7.i.69.

Variations

The collection contains 25 males, 23 females and one small nymph. As can be seen from Fig. 30, the males fall into two distinct groups based on size, for which carapace length is used as an index. The females show less tendency to fall into groups, the majority lying between the two groups of males in size. The size variations are summarized in Table 1.

TABLE 1

Size Variation in Nunciella kangarooensis, *n. sp.*

	Number of Specimens	Scute length (mm.)		Scute width (mm.)		Carapace length (mm.)	
		Range	Mean	Range	Mean	Range	Mean
Group of large males	17	3·69–4·42	3·93	3·24–3·82	3·56	1·50–1·72	1·67
Group of small males	8	2·86–3·21	3·03	2·40–3·11	2·73	1·18–1·35	1·29
Females ..	21	3·01–3·89	3·53	2·77–3·45	3·18	1·32–1·57	1·43

Two small females are not treated in the table as they do not fall into the main group. They have a scute length of 2·70 and 2·85 mm., scute width of 2·64 and 2·30 mm., and carapace length of 1·11 and 1·22 mm. The measurements of the nymph are 2·53, 2·09 and 1·04 mm. respectively.

Both males and females show roughly the same range in stoutness (ratio scute width to length, Fig. 30). Individuals vary in the tendency for fusion of the free tergites, the group of small males and the females generally showing less tendency. Both sexes vary slightly in body pattern. The density of granules on the scute varies, and the strength of teeth and shape of eyemound is subject to minor variation. The number of segments in tarsus 1, 3 and 4 is constant for each sex, except one male with five, not four, in right tarsus 1. The number of segments in tarsus 2 is subject to asymmetry and wide variation. The mean in females is 9·6 compared with 10·5 in males. The mode, however, is 10 in both sexes. The number of segments in distitarsus 2 is four in both sexes, except for one male with five in the right distitarsus.

Male Dimorphism

The two distinct groups of males (Fig. 30) are of interest. Individuals in both groups seem to have secondary sexual characteristics developed to the same degree. The two groups may indicate male dimorphism which has been recorded by Forster (1954) in some New Zealand triaenonychids and which also occurs in some Australian genera, notably *Equitius* Simon. The presence of two small females in the collection means that no definite conclusions can be made until the life history of the species is known and more specimens studied.

Habitat

Like most of the Laniatores, *N. kangarooensis*, n. sp. lives in humid situations which are provided by the shaded areas beside Rocky River. The species probably occurs beside other streams and around the edges of lagoons on the island. No specimens were found during limited searching on higher ground under the dead drooping leaves of the *Xanthorrhoea* (yakka) grass-tree, or under rocks in dolines on the limestone. Both situations, however, are potentially favourable habitats for harvestmen.

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LATE DEVONIAN CONODONTS FROM THE LUTON FORMATION, NORTHERN NEW SOUTH WALES

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(Plates v, vi)

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Synopsis

A small Upper Devonian conodont fauna is described from a limestone lens in the lower part of the Luton Formation, northern New South Wales. The fauna indicates a late Fammenian (*to* VI) age.

INTRODUCTION

In this article a small conodont fauna of late Fammenian age from the base of the Luton Formation, northern New South Wales, is described. The occurrence of conodonts in an impure limestone horizon in the Late Devonian rocks of this region promises to provide an accurate correlation of these strata, as well as locating more precisely the Devonian/Carboniferous boundary in northern New South Wales. To date correlation of the thick Late Devonian epiclastic sequences of the " Tamworth Trough " has been based on the few isolated occurrences of poorly preserved ammonoids (Pickett, 1960; Jenkins, 1966, 1968).

This work is an aspect of a project on eastern Australian Devonian biostratigraphy, supported by the Australian Research Grants Committee. We are grateful to Dr. Gilbert Klapper, University of Iowa, for useful discussions of this paper.

LOCALITY AND SIGNIFICANCE OF FAUNA

The conodonts were recovered from an impure limestone lens in the lower part of the Luton Formation, 7½ miles south-south-west of Horton (150° 24·3′ E., 30° 14·8′ S.). This falls on the Horton Map Sheet provided by McKelvey and White (1964), who also gave a summary of the stratigraphy. These writers provisionally placed the base of the Carboniferous at the base of the Luton Formation. To date no other horizons in the Luton Formation have yielded conodonts.

In all, approximately 50 kg. of sandy limestone was processed, and this yielded some 250 identifiable conodonts. The conodonts are dark brown in colour and have retained their " white matter ". Most of the conodonts are broken. The fauna is dominated by platform elements, in particular *Palmatolepis gracilis*, *Polygnathus vogesi*, *Polygnathus* cf. *pennatulus* and *Pseudopolygnathus dentilineatus*. Twenty-six different species of disjunct conodont were recognized.

Ziegler (1962) has provided the standard conodont zonation of the Upper Devonian, on the basis of sections mainly in the Rhenish Schiefergebirge. This was related by Ziegler to the well-established German ammonoid succession, and has been found to apply not only in Europe, but elsewhere in the world [e.g., in N. America (Klapper, 1966) and W. Australia (Glenister and Klapper, 1966)].

The highest Fammenian zone was named the *costatus* Zone by Ziegler (1962) and divided into three on the basis of the ranges of subspecies of *Spathognathus costatus sensu* Ziegler and *Palmatolepis gonioclymeniae*. The Lower *costatus*

Zone falls in the upper part of the *Clymenia* Stufe (*to* V), whereas the Middle and Upper *costatus* Zones are approximately coextensive with the *Wocklumeria* Stufe (*to* VI).

Although it is clear that the Luton conodont fauna is that of the *costatus* Zone, in the absence of *S. costatus sensu* Ziegler and *P. gonioclymeniae* it is difficult to arrive at a more precise estimate of its position.

Palmatolepis gracilis sigmoidalis ranges throughout the *costatus* Zone. *Polygnathus vogesi* is said by Ziegler (1962) to range from the Middle *costatus* Zone into the *Gattendorfia* Stufe. *Pseudopolygnathus trigonicus* was given by Ziegler (1962) as occurring in the Middle and Upper *costatus* Zones, although Freyer and Zakowa (1967) have extended the range down into the Lower *costatus* Zone. *Spathognathodus aculeatus sensu* Ziegler is usually considered to occur in the Lower and Middle *costatus* Zones, but there are problems in the identification of this form species. Another platformed element in the fauna suggestive of a *to* VI age is *Polygnathus* sp. cf. *symmetricus*. Other elements appear to be longer ranging.

The evidence therefore favours reference of the Luton conodont fauna to the Middle *costatus* Zone, equivalent to the early *Wocklumeria* Stufe (*to* VI). This indicates that the Devonian-Carboniferous boundary in New South Wales is to be found in the upper part of the Luton Formation. The *to* VI age for the lower part of the Luton Formation lends strong support to Pedder's (1968) conclusion that the Kiah Limestone Member (with *Cymaclymenia borahensis* Pickett) of the underlying Mandowa Mudstone is of *to* V age.

Systematics

Genus Bryantodus Bassler, 1925

Type species: *Bryantodus typicus* Bassler, 1925.

Bryantodus sp. (Pl. v, Fig. 1)

Figured hypotype: F10901/1.

Remarks: The most complete fragment of this form lacks the posterior bar. The anterior bar is arched and gently flexed, with fused, laterally compressed denticles. As far as can be ascertained, the species represented is similar to *Bryantodus typicus* Bassler (Huddle, 1968, p. 11, Pl. 3, figs. 1–15 ; Pl. 4, figs. 12–15).

Genus Diplopodella Bassler, 1925

Type species: *Diplopodella bilateralis* Bassler, 1925.

Diplopodella sp. (Pl. v, Fig. 16)

Figured hypotype: F10901/16.

Remarks: The more complete of the two available specimens lacks one lateral bar. The cusp is laterally compressed and projects posteriorly to form a short posterior bar bearing two compressed denticles. The lateral limbs are deep and bear closed spaced, fused denticles. There is no basal cavity.

Genus Hibbardella Bassler, 1927

Type species: *Prioniodus angulatus* Hinde, 1879.

Remarks: Recent discussions of the application of the genera *Hibbardella*, *Roundya* Hass, *Ellisonia* Müller and *Diplopodella* Bassler have been given by Philip (1966), Müller and Clark (1967) and Huddle (1968), who are all in substantial agreement. Here Huddle's interpretation of these genera has been followed. More recently Rhodes *et al.* (1969, p. 111) have proposed a new subgenus *Hassognathus*, based on *Trichognathus separatus* Branson and Mehl, for similar forms in which the basal cavity is located more beneath the posterior bar. They also maintain *Roundya* as a subgenus of *Hibbardella*.

Hibbardella sp. (Pl. v, Fig. 3)

Figured hypotype: F10901/3.

Remarks: The single available specimen of this form has a large subquadrate cusp and a deep basal cavity. It closely resembles *Hibbardella barnettana* (Hass, 1953, p. 89, Pl. 16, figs. 8–9), the type species of *Roundya* Hass, but as all three processes are broken, no positive identification is made.

Genus HINDEODELLA Bassler, 1925

Type species: *Hindeodella subtilis* Bassler, 1925.

Hindeodella sp. (Pl. v, Fig. 2)

Figured hypotype: F10901/2.

Remarks: Specimens of *Hindeodella* in the collection are all extremely fragmentary. It is likely that the specimen illustrated in Pl. v, Fig. 2 is referrable to *H. subtilis* Bassler as interpreted by Huddle (1968, pp. 17–18). The specimen illustrated as *Hindeodella* ? sp. in Pl. v, Fig. 11 (F10901/11) is apparently a different species, and, in the strong downward deflection of the anterior bar, resembles more closely *Hindeodella alternata* Ulrich and Bassler (Huddle, 1968, pp. 15–16, Pl. 5, figs. 1, 3). As the posterior bar is missing, however, the specimen cannot be positively assigned to *Hindeodella*.

Genus LIGONODINA Bassler, 1925

Type species: *Ligonodina pectinata* Ulrich and Bassler, 1926.

Ligonodina bicurvata Mound (Pl. v, Fig. 10)

Ligonodina delicata Branson and Mehl, 1934, p. 199, Pl. 14, figs. 22, 23.

Ligonodina bicurvata Mound, 1968, p. 489, Pl. 66, figs. 22, 30 (*q.v.* for full synonymy).

Ligonodina beata Rhodes, Austin and Druce, 1959, p. 135, Pl. 26, figs. 4–6*b*.

Not Phragmodus delicatula Branson and Mehl =*Ligonodina delicata* (Branson and Mehl).

Figured hypotype: F10901/10.

Description: This is a delicate species of *Ligonodina* with a long, gently recurved, somewhat flattened cusp continued downwards and inwards as a long anticusp. Up to about five isolated rounded denticles on anticusp; posterior bar with slender, backwardly directed, well separated, rounded denticles. Aboral surface of posterior bar marked with a longitudinal groove, which opens into the large basal cavity and is continued to the extremity of the anticusp.

Remarks: Mound's (*loc. cit.*) correction of the primary homonym which arose from Bergström's (1964, pp. 28–29) reference of *Phragmodus delicatus* Branson and Mehl to *Ligonodina* has priority over that of Rhodes *et al.* Ethington (1965) has noted that the *L. bicurvata* ranges from the Middle Devonian through into the Early Carboniferous.

Genus LONCHODINA Bassler, 1925

Type species: *Lonchodina typicalis* Bassler, 1925.

Lonchodina spp. (Pl. v, Figs. 9, 14–15)

Figured hypotypes: F10901/9, 14, 15.

Remarks: A number of asymmetrical, twisted and arched bar elements are present in the collection. Three different species of *Lonchodina* appear to be represented by the illustrated specimens. Of these, that shown in Pl. v, Fig. 15 resembles closely *Lonchodina clavata* (Hinde). However, more material is necessary before positive identification can be made.

Genus NEOPRIONIODUS Rhodes and Müller, 1956

Type species: Prioniodus conjunctus Gunnell, 1931.

Neoprioniodus oligus (Cooper) (Pl. VI, Fig. 14)

Prioniodus oligus Cooper, 1939, p. 405, Pl. 46, figs. 9–11, 63, 71 ; Pl. 47, figs. 20–21.

Prioniodina oliga (Cooper), Bischoff, 1957, pp. 47–48.

Neoprioniodus oligus (Cooper), Hass, 1959, p. 384, Pl. 47, fig. 3.

Figured hypotype: F10900/14.

Description: A form of *Neoprioniodus* in which the denticles of the posterior bar are strongly compressed and may be completely fused to form a deep ridge which merges with the cusp. Cusp flattened with anterior and posterior keels. Basal cavity large with a flaring inner margin.

Remarks: The single specimen recovered from the Luton Formation is identical with the material described by Hass (*loc. cit.*) from the Chappel Limestone of Texas. Hitherto the species appears to have been recorded only from Early Carboniferous strata.

Genus OZARKODINA Branson and Mehl, 1933

Type species: Ozarkodina typica Branson and Mehl.

Ozarkodina spp. (Pl. V, Figs. 4, 12, 13)

Figured hypotypes: F10901/4, 12, 13.

Remarks: Three separate species of *Ozarkodina* appear to be present in the collection, but all of the specimens are fragmentary. The form illustrated in Pl. V, Fig. 4 resembles closely *O. macra* Branson and Mehl, whereas that shown in Pl. V, Fig. 12 is a more delicate unit, and so may be compared with *O. elegans* (Stauffer). The specimen illustrated in Pl. V, Fig. 13 has a tiny basal cavity and a poorly differentiated cusp. These characters appear to distinguish it from previously described species.

Genus PALMATOLEPIS Ulrich and Bassler, 1926

Type species: Palmatolepis perlobata Ulrich and Bassler, 1926.

Remarks: Attempts to subdivide this widespread Devonian form genus (Müller, 1956 ; Helms, 1963) have not met with general acceptance. Although the genus is generally considered to be confined to the Late Devonian, Huddle (1968, p. 33) has suggested that his (1934) *P. minuta* (*non* Branson and Mehl) is an authentic Early Mississippian species.

Palmatolepis gracilis Branson and Mehl

Palmatolepis gracilis Branson and Mehl, 1934, p. 238, Pl. 18, figs. 2, 8 (not fig. 5) ; Mehl and Ziegler, 1963, pp. 200–205, Pl. 1, figs. 1–2.

Palmatolepis (*Deflectolepis*) *deflectens* Müller, 1956*a*, p. 32, Pl. 11, figs. 28–39.

Remarks: This species of *Palmatolepis* usually possesses a narrow platform running parallel with the carina. The platform is widest anteriorly and tapers to the posterior end. The outer margin of platform is regularly convex at the anterior end, and the inner margin forms an anterior subcircular lobe. Ziegler (1962) distinguished two subspecies, both of which occur in the Luton Formation.

Palmatolepis gracilis gracilis Branson and Mehl (Pl. VI, Figs. 8–10, 26–29)

Palmatolepis gracilis Branson and Mehl, 1934, p. 238, Pl. 18, figs. 2, 8 (not fig. 5) ; Wolska, 1967, p. 395, Pl. 11, figs. 1–3, 5 (not fig. 4 =*P. gracilis sigmoidalis*).

Palmatolepis deflectens deflectens Müller, Ziegler, 1962, p. 56, Pl. 3, figs. 17–22 ; Freyer *in* Freyer and Zakowa, 1967, pp. 114–115, Pl. 1, fig. 1 ; Pl. 2, figs. 3–4.

Palmatolepis gracilis gracilis Branson and Mehl, Klapper, 1966, p. 31, Pl. 6, fig. 3 ; Klapper and Glenister, 1966, pp. 814–815, Pl. 90, fig. 6 (*q.v.* for full synonymy) ; Druce, 1969, pp. 88–89, Pl. 17, figs. 3*a*–5*b*.

Figured hypotypes: F10900/8–10, 26–29.

Description: This subspecies of *P. gracilis* has a gently to strongly curved blade and carina. The keel is offset parallel to the margin of the inner platform lobe to form a semicircular ridge (Pl. VI, Fig. 27).

Remarks: Klapper (*loc. cit.*) has pointed out that in some specimens of *P. gracilis gracilis* the platform may become relatively large so that they resemble *P. gonioclymeniae.* In this latter species, however, the posterior end is arched upwards, the carina is more sharply deflected, and this deflection takes place closer to the anterior end. The larger specimens in the Luton fauna have been previously listed as *P. gonioclymeniae* in Pedder (1968, p. 141).

Palmatolepis gracilis sigmoidalis Ziegler (Pl. VI, Figs. 5–7)

Palmatolepis deflectens sigmoidalis Ziegler, 1962, pp. 56–57, Pl. 3, figs. 24–28.

Palmatolepis gracilis sigmoidalis Ziegler, Klapper, 1966, p. 31, Pl. 6, fig. 8 (*q.v.* for full synonymy); Druce, 1969, p. 89, Pl. 17, figs. 2*a*-*b*.

Palmatolepis gracilis Branson and Mehl, Wolska, 1967, p. 395, Pl. 11, fig. 4 (not figs. 1–3, 5 =*P. gracilis gracilis*).

Figured hypotypes: F10900/5–7.

Description: In this subspecies of *P. gracilis* the carina and platform are strongly sigmoidal.

Remarks: The specimens from the Luton Formation bear out Klapper's (*loc. cit.*) observation that this subspecies lacks the semicircular offset of the keel which is present in the nominate subspecies. *P. gracilis sigmoidalis* is confined to the *Spathognathodus costatus* Zone (*sensu* Ziegler, 1962) in both Europe and N. America.

Genus POLYGNATHUS Hinde, 1879

Type species: Polygnathus dubius Hinde, 1879.

Polygnathus cf. *pennatulus* Ulrich and Bassler (Pl. V, Figs. 23–27)

Cf. *Polygnathus pennatulus* Ulrich and Bassler, 1926, p. 45, Pl. 7, fig. 8, text-fig. 5 (7).

Polygnathus pennatula Ulrich and Bassler, Huddle, 1968, pp. 40–41, Pl. 15, figs. 11–12 (*q.v.* for full synonymy).

Figured hypotypes: F10901/23–27.

Description: The platform is thick and subtriangular with a high carina flanked by short, deep troughs. The unit is somewhat bowed and arched. The margins of the platform are crenulated by sharp transverse ridges. The basal cavity is relatively large, circular to ovate, usually with prominent lips.

Remarks: The Luton form is somewhat more laterally bowed than the specimens described by Huddle (*loc. cit.*). It is therefore only compared with *P. pennatulus. Polygnathus bischoffi* Rhodes *et al.* (1969, pp. 184–185, Pl. 13, figs. 8*a*–11*c*) is a species very close to, if not identical with *P. pennatulus.*

Polygnathus cf. *symmetricus* Branson (Pl. V, Figs. 17–18)

Cf. *Polygnathus symmetrica* Branson, 1934, p. 310, Pl. 25, fig. 11; Klapper, 1966, p. 21, Pl. 4, figs. 7, 9; Pl. 6, figs. 1, 5 (*q.v.* for full synonymy).

Figured hypotype: F10901/17.

Remarks: Although the illustrated specimen has a nearly bilaterally symmetrical platform with the anterolateral margins only slightly upturned, its posterior end is attenuated. It is therefore intermediate between *P. symmetricus* and *P. longiposticus* Branson and Mehl (Klapper, 1966, pp. 20–21). Klapper (*loc. cit.*) noted that many specimens in his material also were intermediate between these two species.

P. symmetricus ranges from *to* VI strata (Bischoff, 1956) to *cu* II strata (Bischoff and Ziegler, 1956).

Polygnathus vogesi Ziegler (Pl. v, Figs. 8, 19–22)

Polygnathus vogesi Ziegler, 1962, pp. 94–95, Pl. 11, figs. 5–7.

Polygnathus styriaca Ziegler *in* Flügel and Ziegler, 1957, pp. 47–48, Pl. 1, fig. 11 (not figs. 12–13 =*styriacus*).

Polygnathus cf. *styriaca* Ziegler, Voges, 1959, p. 294, Pl. 34, figs. 36–41.

Figured hypotypes : F10901/8, 19–22.

Description : This species of *Polygnathus* has a thin, upwardly arched, lanceolate platform. The platform is ornamented with two distinct denticulate ridges which run from the anterolateral corners to the central part of the platform. The anterior margin of the platform is deeply trough-shaped and grooves usually are present also posterior to the radiating ridges. Aboral surface has a tiny basal cavity mounted on the prominent keel. The lower surface may possess grooves complementary to the radiating ridges of the oral surface.

Remarks : This species closely resembles *P. communis carinus* Hass, 1959. Voges (*loc. cit.*) has already noted that in this latter form the basal cavity is distinctly larger, the radiating ridges are less regular, and the anterior end of the platform less sunken. The Australian specimens closely resemble those described by Voges. The specimens on which Ziegler (*loc. cit.*) based the species tend to have a somewhat broader platform and a suggestion of nodose ornament on the posterior part of the platform.

In Europe *P. vogesi* ranges from the Middle *costatus* Zone (*to* V ?–*to* VI) (Ziegler, 1962) into *cu* I strata.

Polygnathus sp. (Pl. v, Figs. 5–7)

Figured hypotypes : F10901/5, 7.

Remarks : This species resembles most closely *Polygnathus obliquicostatus* Ziegler (1962, pp. 92–93, Pl. 11, figs. 8–12 ; Klapper, 1966, p. 22, Pl. 6, figs. 2, 4). In its upper surface morphology it differs most notably in that the transverse ridges of the inner platform are not so oblique to the carina, and the carina extends to the posterior end of the platform. A keel is present throughout the length of the unit.

In the possession of a rostrum, this species, like *P. obliquicostatus*, resembles species of *Siphonodella*. However, Klapper (1966), in distinguishing *Siphonodella* and *Polygnathus*, has emphasized that the latter genus has a raised keel which runs the length of the platform and is interrupted only by the basal cavity. In contrast, the keel of *Siphonodella* is either absent or is represented by a thin groove which runs some distance posterior to the basal cavity.

This species, which is abundantly represented in material of Early Carboniferous age from Queensland, will be described in detail elsewhere.

Genus PSEUDOPOLYGNATHUS Branson and Mehl, 1934

Type species : *Pseudopolygnathus primus* Branson and Mehl.

Pseudopolygnathus dentilineatus Branson (Pl. vi, Figs. 23–25)

Pseudopolygnathus dentilineata Branson, 1934, p. 317, Pl. 26, fig. 22 ; Bishcoff, 1957, pp. 50–51, Pl. 4, figs. 29–32, 34 ; Voges, 1959, pp. 300–301, Pl. 34, figs. 49–50 ; Klapper, 1966, pp. 14–15, Pl. 5, figs. 10–11 (*q.v.* for full synonymy) ; van Adrichem Boogaert, 1966, p. 185, Pl. 3, fig. 8 ; Canis, 1968, p. 546, Pl. 73, figs. 10, 29–31.

Pseudopolygnathus dentilineatus Branson, Rhodes *et al.*, 1969, pp. 208–209, Pl. 5, figs. 9*a*–13*c* ; Pl. 6, figs. 8*a*-*c*.

Pseudopolygnathus vogesi Rhodes *et al.*, 1969, pp. 216–217, Pl. 5, figs. 1*a–c*, 3*a–c*, 5*a*–8 ; Druce, 1969, pp. 114–115, Pl. 36, figs. 1*a*–7*b*.

Figured hypotypes : F10900/23–25.

Description : The platform is usually narrow and pointed and ornamented with coarse nodes or irregular transverse ridges. The right side of the platform extends further toward the anterior end than does the left side. Basal cavity large, covering the entire width of the platform, and usually has flaring lips.

Remarks : Rhodes *et al.* (1969), on the basis of the Carboniferous conodont sequence of Britain, postulated three successive independent developments of *Pseudopolygnathus* from species of *Spathognathodus* with double rows of denticles. The first development included forms which they named as *P. vogesi* and considered as homeomorphs of *P. dentilineatus.* This latter name was restricted to a form postulated as originating from *Spathognathodus* as a later time. No morphological characters serve to distinguish these species. Until such time as a similar discontinuity in the occurrence of species of *Pseudopolygnathus* is established in N. America (e.g. in the Hannibal Formation in Missouri) it seems premature to follow this division.

Forms of the morphology of *P. dentilineatus* have a total range from the Upper *styriacus* Zone (*to* V) to the Z zone of the British Avonian (? *cu* II beta/gamma).

Pseudopolygnathus trigonicus Ziegler (Pl. VI, Figs. 16–19)

Pseudopolygnathus trigonica Ziegler, 1962, pp. 101–102, Pl. 12, figs. 8–13 ; Freyer and Zakowa, 1967, pp. 109–110.

Figured hypotypes : F10900/16–19.

Description : This species of *Pseudopolygnathus* has a thin, arched, triangular platform and a long high blade. The platform is ornamented with nodes, the largest of which form secondary carinae which run to the anterolateral margins of the platform. The inner platform usually has a secondary lobe. The aboral surface with a central pit and a well-defined posterior keel. Arising from the keel are two ridges, one of which runs to the lateral extremity of the outer platform and the other to the secondary lobe of the inner platform.

Remarks : The lateral ridges of the aboral surface delineate a shallow asymmetrical depression beneath the anterior part of the platform. This is interpreted as the basal cavity, and, as a consequence, the species was referred by Ziegler to *Pseudopolygnathus.* The species cannot be located here without some reservation as its upper surface morphology, however, is more akin to that of *Ancyrodella.*

Ziegler (1962) originally gave the range of *P. trigonicus* as Middle to Upper *costatus* Zone. Freyer and Zakowa (*loc. cit.*) have extended its range to the Lower *costatus* Zone in Poland.

Genus SPATHOGNATHODUS Branson and Mehl, 1941

Type species : Ctenognathus murchisoni Pander, 1856.

Spathognathus aculeatus (Branson and Mehl) (Pl. VI, Figs. 12, 20)

Spathodus aculeatus Branson and Mehl, 1934, pp. 186–187, Pl. 17, figs. 11, 14.

Spathognathodus aculeatus (Branson and Mehl, Ziegler, 1962, pp. 105–106, Pl. 13, figs. 27–36 ; Bouckaert and Ziegler, 1965, Pl. 5, figs. 1–4 ; Klapper, 1966, p. 24, Pl. 6, figs. 15–17 ; Glenister and Klapper, 1966, pp. 835–836, Pl. 95, fig. 11 (*q.v.* for complete synonymy) ; van Adrichem Boogaert, 1966, p. 186, Pl. 3, fig. 19 ; Freyer and Zakowa, 1967, p. 120, Pl. 1, fig. 12 ; Wolska, 1967, p. 425, Pl. 19, figs. 4–8.

Spathognathodus cf. *S. aculeatus* (Branson and Mehl), Druce, 1969, p. 124, Pl. 27, figs. 5*a–c*.

Figured hypotypes: F10900/12, 20.

Remarks: The Luton specimens are all broken but are certainly referrable to *S. aculeatus*, as generally interpreted. This form species usually has three to five lateral denticles joined to those of the blade by transverse ridges in the region of the basal cavity, which is mounted at midlength and is wide and circular.

Recently Rhodes *et al.* (1969, p. 236) stated that " forms described from Germany and identified by Ziegler (1961) and other authors may be distinct from *S. aculeatus* and are probably a new species ". As no basis for such a separation is apparent, here Ziegler's (1962) and Klapper's (1966) interpretation of the species is followed and the specimens from the Bonaparte Gulf Basin, compared by Druce with this species, are included in it.

Rhodes *et al.* (*op. cit.*) also describe a new species, *S. plumulus*, which differs from *S. aculeatus* in the possession of high, crested denticles at the anterior end of the unit.

As interpreted here, the species in Germany ranges from the middle Lower *costatus* Zone to the Middle *costatus* Zone (i.e. the boundary of *to* V and VI) to *to* VI alpha (Ziegler, 1962). It has a similar range in Spain (Higgins *et al.*, 1964 ; van Adrichem Bouckaert, 1966), Belgium (Bouckaert and Ziegler, 1965), Poland (Freyer and Zakowa, 1967 ; Wolska, 1967), the Mississippi Valley (Collinson, Scott and Rexroad, 1962, pp. 17, 18), the Canning Basin, Western Australia (Glenister and Klapper, 1966) and the Bonaparte Gulf Basin, Western Australia (Druce, 1969). Canis's (1968) record of this species from the Bachelor Formation of Missouri of *cu* II alpha age is based on *S. antiposicornis* Scott.

Spathognathus crassidentatus (Branson and Mehl) (Pl. VI, Fig. 1)

Spathodus crassidentatus Branson and Mehl, 1934, p. 276, Pl. 22, fig. 17.

Spathognathodus crassidentatus (Branson and Mehl), Klapper, 1966, p. 23, Pl. 5, figs. 15–17 (*q.v.* for full synonymy) ; Canis, 1968, pp. 552–553, Pl. 74, fig. 29 ; Rhodes *et al.*, 1969, pp. 226–227, Pl. 3, figs. 1*a*–4*b* ; Druce, 1969, pp. 127–128, Pl. 27, figs. 2*a*–3*b*.

Figured hypotype: F10900/1.

Description: This is a bladed unit, slightly arched in profile, sloping downwards to its posterior end. The anterior end has two enlarged denticles, markedly wider and higher than the remainder. The basal cavity extends from somewhat in front of midlength to near the posterior end ; its greatest width is at the rounded anterior margin, whence it tapers to the posterior end.

Remarks: The Luton specimens agree closely with the paucidenticulate forms described by Klapper (*loc. cit.*) rather than, for example, those illustrated by Rhodes *et al.* (*loc. cit.*). Most authors, however, have commented on the wide range of variation in this species.

Hitherto, *S. crassidentatus* has been recorded only from Early Carboniferous strata in N. America (Klapper, 1966 ; Canis, 1968), Europe (Rhodes *et al.*, 1969), and Australia (Druce, 1969).

Spathognathodus praelongus Cooper (Pl. VI, Fig. 21)

Spathognathodus praelongus Cooper *in* Cooper and Sloss, 1943, p. 175, Pl. 28, fig. 14 ; Klapper, 1966, p. 24, Pl. 6, fig. 23 (*q.v.* for full synonymy).

Figured hypotype: F10900/21.

Remarks: This is a bladed species of *Spathognathodus* with the posterior end of unit incurved. A slightly enlarged denticle present above the basal cavity, which is marked toward the posterior end of unit. Klapper (*loc. cit.*) gives the range of this species as Late Devonian in N. America.

Spathognathodus sp. A (Pl. vi, Figs. 11–12)

Figured hypotypes: F10900/11, 12.

Remarks: This is a bladed form of *Spathognathodus* in which the unit tends to be incurved. In profile the unit is arched. The basal cavity is symmetrical, widest at its anterior end and extending to near the posterior end of the unit. All specimens are badly broken, so that the species represented cannot be positively identified. It appears to be close to Late Devonian forms identified as *S. stabilis* (Branson and Mehl) (e.g. Klapper, 1966, Pl. 5, fig. 6).

Spathognathodus sp. B (Pl. vi, Figs. 2–4)

Figured hypotypes: F10900/2–4.

Remarks: This is a massive species of *Spathognathodus* with regular denticulation and a prominent asymmetric basal cavity mounted toward the posterior end of the unit. Nodes may be present on the upper surface of the lobes of the basal cavity. The form apparently bears little relationship to previously described Upper Devonian species.

Genus Synprioniodina Bassler, 1925

Type species: *Synprioniodina alternata* Bassler, 1925.

Synprioniodina sp. (Pl. vi, Figs. 13, 15)

Figured hypotypes: F10900/13, 15.

Remarks: In all of the available specimens the posterior bar is missing, so that positive identification is not possible. The cusp and the denticulated anticusp compare closely with those of *Synprioniodina alternata* Bassler (Huddle, 1968, pp. 45–46, Pl. 6, figs. 3–5, 12).

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EXPLANATION OF PLATES

All figures ×40 and specimens registered in the Palaeontological Collection of the University of New England.

Plate v

Fig. 1. *Bryantodus* sp. Lateral view of F10901/1.

Fig. 2. *Hindeodella* sp. Inner view of F10901/2.

Fig. 3. *Hibbardella* sp. Posterior view of F10901/3.

Fig. 4. *Ozarkodina* sp. Lateral view of F10901/4.

Figs. 5–7. *Polygnathus* sp. 5, Aboral view of F10901/5. 6, Oral view of same specimen. 7, Oral view of F10901/7.

Figs. 8, 19–22. *Polygnathus vogesi* Ziegler. 8, Lateral view of F10901/8. 19, Oral view of F10901/19. 20, Aboral view of F10901/20. 21, Oral view of F10901/21. 22, Oral view of F10901/22.

Fig. 9. *Lonchodina* sp. Inner view of F10901/9.

Fig. 10. *Ligonodina bicurvata* Mound. Inner view of F10901/10.

Fig. 11. *Hindeodella* ? sp. Inner view of F10901/11.

Fig. 12. *Ozarkodina* sp. Lateral view of F10901/12.

Fig. 13. *Ozarkodina* sp. Lateral view of F10901/13.
Fig. 14. *Lonchodina* sp. Inner view of F10901/14.
Fig. 15. *Lonchodina* sp. Inner view of F10901/15.
Fig. 16. *Diplopodella* sp. Posterior view of F10901/16.
Figs. 17–18. *Polygnathus* cf. *symmetricus* Branson. 17, Lateral view of F10901/17. 18, Oblique oral view of same specimen.
Figs. 23–27. *Polygnathus* cf. *pennatulus* Bassler. 23, Aboral view of F10901/23. 24, Aboral view of F10901/24. 25, Oblique oral view of F10901/25. 26, Aboral view of F10901/26. 27, Oblique oral view of F10901/27.

PLATE VI

Fig. 1. *Spathognathodus crassidentatus* (Branson and Mehl). Lateral view of F10900/1.
Figs. 2–4. *Spathognathodus* sp. B. 2, Lateral view of F10900/2. 3, Lateral view of F10900/3. 4, Oral view of F10900/4.
Figs. 5–7. *Palmatolepis gracilis sigmoidalis* Ziegler. 5, Oblique oral view of F10900/5. 6, Oblique oral view of F10900/6. 7, Oblique oral view of F10900/7.
Figs. 8–10, 26–29. *Palmatolepis gracilis gracilis* Branson and Mehl. 8, Oblique oral view of F10900/8. 9, Oral view of F10900/9. 10, Oral view of F10900/10. 26, Oral view of F10900/26. 27, Aboral view of F10900/27, a broken platform. 28, Oral view of F10900–28, a complete specimen with a fully developed platform. 29, Oral view of F10900/29.
Figs. 11, 22. *Spathognathodus* sp. A (Branson and Mehl). 11, Lateral view of F10900/11. 22, Lateral view of F10900/22.
Figs. 12, 20. *Spathognathodus aculeatus* (Branson and Mehl). 12, Aboral view of F10900/12. 20, Oral view of F10900/20.
Figs. 13, 15. *Synprioniodina* sp. 13, Inner view of F10900/13. 15, Inner view of F10900/15.
Fig. 14. *Neoprioniodus oligus* (Cooper). Inner view of F10900/14.
Figs. 16–19. *Pseudopolygnathus trigonicus* Ziegler. 16, Oral view of F10900/16. 17, Lateral view of F10900/17. 18, Oral view of F10900/18. 19, Aboral view of F10900/19.
Fig. 21 *Spathognathodus praelongus* Cooper Lateral view of F10900/21
Figs. 23–25. *Pseudopolygnathus dentilineatus* Branson. 23, Oral view of F10900/23. 24, Oral view of F10900/24. 25, Oral view of F10900/25.

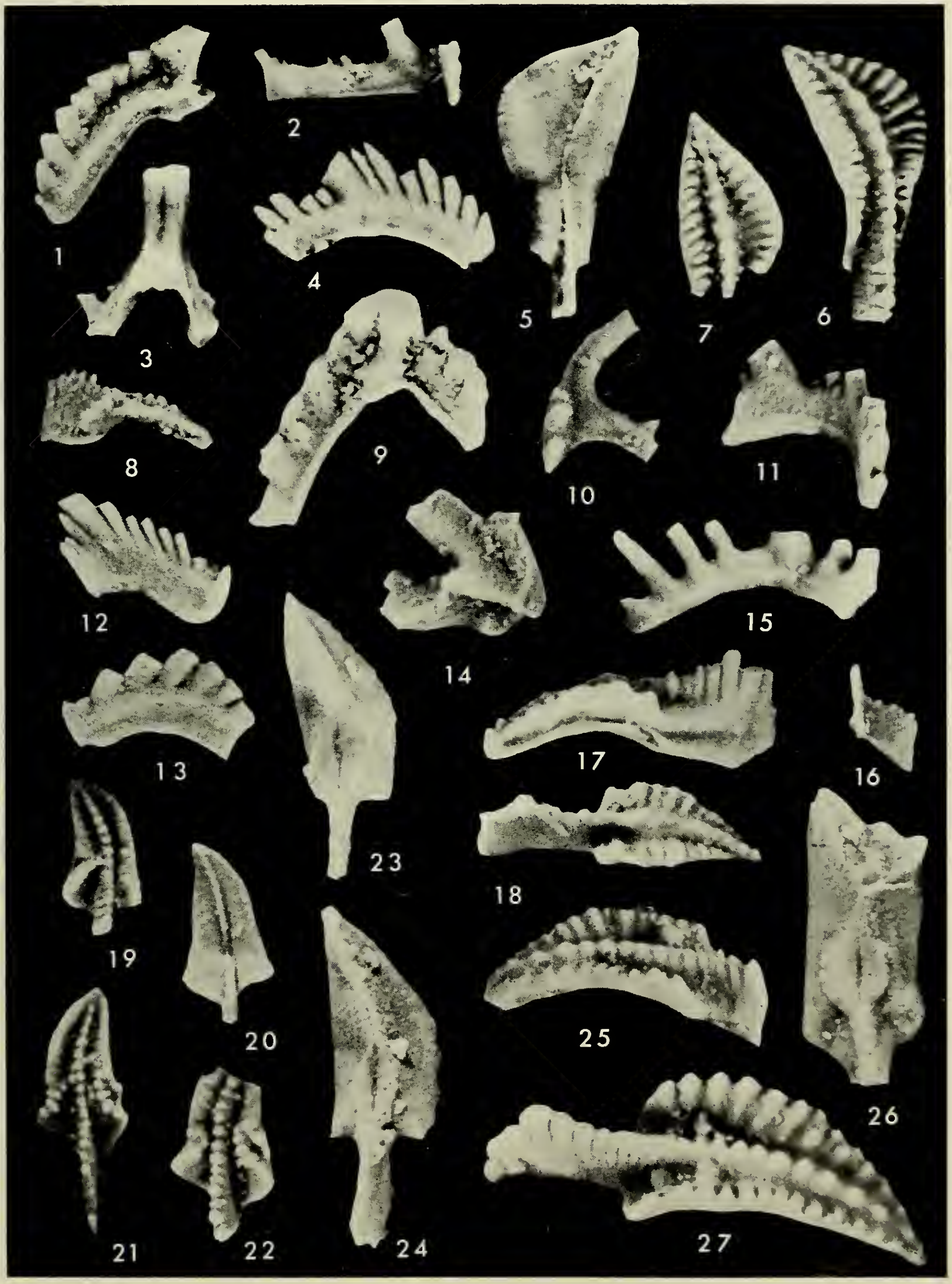
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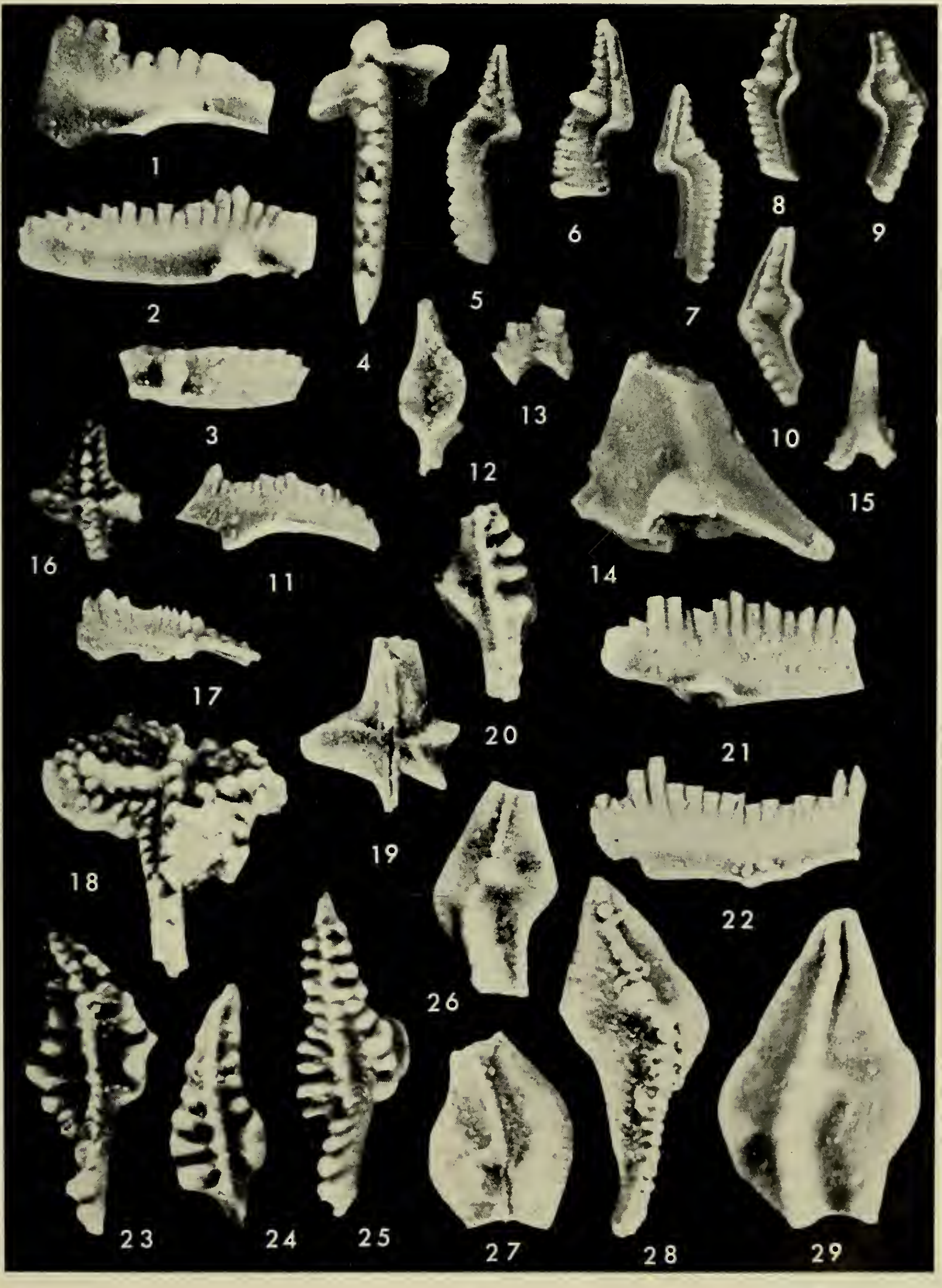
PLATE VI



A BACTERIAL LEAF SPOT OF ZINNIA IN NEW SOUTH WALES

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(Plates vii, viii)

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Synopsis

A bacterial disease of zinnia caused by *Xanthomonas nigromaculans* f. sp. *zinniae* is recorded for the first time in Australia. Two isolates from material collected at Armidale, N.S.W., were pathogenic on inoculation into the zinnia cultivar from which they were originally obtained and to eight other cultivars. These cultures were compared with two isolates of the species from Africa, including the original culture of Hopkins and Dowson (1949), and were shown to be indistinguishable except for some minor differences in carbohydrate utilization.

Introduction

In February 1969, leaves of zinnias growing in the grounds of Duval College, University of New England, Armidale, were observed to have irregular blackened spots from 1 mm. in diameter to large necrotic areas over 20 mm. across. The larger areas seemed to be formed by the coalescing of several small spots. The spots had a water-soaked appearance and all lesions were surrounded by yellow chlorotic margins (Plate vii, Fig. 1). A massive bacterial ooze was obtained from some of the spots on suspension in water. The plants were grown from commercial seed of the cultivar Giant Dahlia Flowered Mix.

The only earlier record of a bacterial leaf disease of zinnia in New South Wales is from Cremorne in December, 1948 (Anon., 1949). This specimen is filed in the Biology Branch Herbarium at Rydalmere (DAR 4007). The leaves show small black spots ; it is noted on the herbarium packet that abundant ooze was observed on the spots. The organism was not identified.

A survey of available plant disease check lists of other Australian States does not reveal any published record of a bacterial leaf disease of zinnia.

A bacterial leaf spot and flower disease of zinnia was reported by Hopkins and Dowson (1949) from Southern Rhodesia. The causal bacterium was described by them and named *Xanthomonas nigromaculans* f. sp. *zinniae*. The host symptoms described and illustrated closely resemble the symptoms observed at Armidale. This disease has also been recorded from Brazil (Robbs, 1954) and from Sierra Leone (Deighton, 1956).

In the following an account is given of the isolation and identification of the causative bacterium, which involved pathogenecity tests, cultural and physiological observations and electron microscopy. This detailed study was undertaken as the descriptions by Hopkins and Dowson (1949) and others are inadequate.

Materials and Methods

Isolation and cultural and physiological tests: Water-soaked spots were cut from leaves and suspended in 3 ml. of sterile distilled water; after standing for two hours at room temperature to allow egress of bacterial ooze, loopfuls of suspension were streaked out on 2% sucrose/peptone agar (Hayward, 1964).

Two isolates of *Xanthomonas nigromaculans* f. sp. *zinniae*, NCPPB 189 isolated from *Zinnia* sp. in Southern Rhodesia in 1946 and NCPPB 799 isolated from *Zinnia elegans* in Malawi in 1960, were obtained under licence from the National Collection of Plant Pathogenic Bacteria, Plant Pathology Laboratory, Hatching Green, Harpenden, Herts., England. This species is the only known bacterial pathogen affecting the leaves of *Zinnia*. The two cultures were compared with two isolates obtained from the Armidale collection, accessioned as 0365a and 0365b.

Cultural and physiological tests for identification were carried out as described by Allen, Hayward, Halliday and Fulcher (1970). All test media were incubated at 28° C. unless otherwise indicated. Yellow pigments from isolates of the bacterium were extracted and saponified using the techniques described by Starr and Stephens (1964). Solutions of the yellow pigments in petroleum ether were examined in a Perkin-Elmer 4000A, UV–VIS recording spectrophotometer.

Pathogenicity tests: Two isolates of the bacterium were grown on potato dextrose agar and a suspension in sterile distilled water was obtained by washing off the growth of six one-week-old slopes of each isolate in 50 ml. of water. The suspensions were atomized on 18-day-old seedlings from the same lot of seed from which the plants showing natural infection were grown. Controls were sprayed with sterile distilled water. Each group of plants was isolated in separated humid chambers. Plants of eight other cultivars grown from commercial seed were inoculated in the same way with one isolate of the bacterium.

Observations

Isolation and cultural characteristics: After 48 hours incubation at 28° C., the cultures originating from suspensions of ooze from leaf spots showed a glistening yellow growth accompanying a mixture of faster-growing bacterial colonies which were visible to the naked eye after 24 hours incubation. The slower growing yellow colonies were uniform in appearance. Colonies were picked off and purified by successive re-streaking. After three days incubation colonies of the yellow, slow-growing bacterium were 3·0–3·5 mm. in diameter, convex, circular with an entire edge, amorphous, glistening, viscid and readily emulsified in water. On a peptone/yeast extract medium lacking carbohydrate the colonies were 1·5–2·0 mm. in diameter after four days incubation at 28° C.; the colonies were low convex and markedly less mucoid than on the carbohydrate-containing medium. In cultural characteristics, therefore, the bacterium resembled the xanthomonads.

Cultural and physiological tests: The four cultures 0365a, 0365b, NCPPB 189 and NCPPB 799 were alike in being aerobic, Gram-negative, uniformly stained rods, actively motile with a single polar flagellum (Plate VIII), which produced yellow viscid growth on 2% sucrose/peptone agar. All cultures were oxidative in their metabolism of carbohydrates and produced acid under aerobic conditions from cellobiose, fructose, galactose, glucose, glycerol, lactose, maltose, sucrose and trehalose. NCPPB 189 produced acid from mannitol; the other three cultures were negative after 14 days incubation. Arabinose was oxidized promptly by NCPPB 189 and slowly by NCPPB 799 and 0365b; 0365a failed to oxidize arabinose. No acid was produced after 14 days incubation from the following carbohydrates: adonitol, dulcitol, inositol, salicin and sorbitol. The following tests were positive for all cultures: aesculin hydrolysis, phosphatase, malonate utilization in Leifson's medium, citrate utilization in Simmons' medium, growth in a peptone/yeast extract medium containing 2% sodium chloride, and in the same medium containing 3% sodium chloride. All cultures were strongly lipolytic on Tween 80 agar and gave wide zones of hydrolysis on starch agar and on gelatin agar. Twenty-four-hour peptone/yeast extract agar cultures were tested for catalase and for oxidase using Kovacs' method; all cultures were catalase-positive and gave a weak reaction in the Kovacs test, in which there was a colour change at 5–15 sec. after application of culture to the reagent-impregnated filter paper. Pectate gel medium was progressively softened at 7–28 days. Raw potato slices 10 mm. thick, heavily inoculated with each of the four cultures down a narrow median groove and incubated for 24 hours at 28° C. showed a golden to brownish band of growth and rot extending about 5 mm. on either side of the groove. The rot did not extend significantly after a further 24-hour incubation. This confirms the pectolytic activity of the species and perhaps indicates that this pathogen is potentially capable of producing a soft wet rot in plant tissues. The capacity to rot potato slices is fairly common in *Xanthomonas*. The following tests were uniformly negative: production of nitrite from nitrate, production of gas from nitrate, sulphatase, oxidation of gluconate, growth in peptone/yeast extract medium containing 6% sodium chloride, and in the same medium containing 10% sodium chloride, production of phenylpyruvic acid from phenylalanine, arginine dihydrolase, chitin hydrolysis, levan production on 5% sucrose/peptone agar, production of 3-ketolactoside from lactose. No diffusible pigments were produced on any medium. The extracted yellow pigments of cultures 0365a and 0365b were found to have the same absorption maxima claimed by Starr and Stephens (1964) to be characteristic of a carotenoid alcohol found only in xanthomonads.

Pathogenicity tests: All inoculated plants of Giant Dahlia Flowered Mix showed infection after 14 days. The controls sprayed with water remained healthy. The symptoms were similar to those found in natural infection (Plate VII, Fig. 2) and similar to published photographs (Hopkins and Dowson, 1949). There was no obvious difference between the reactions of the two isolates. The bacterium was readily re-isolated from infected plants.

All plants of the other eight cultivars of zinnia inoculated with one isolate of the bacterium became infected and the bacterium was re-isolated in each instance. The cultivars were Thumbelina Mixed, Persian Carpet, State Fair Tetraploid Mixed, Sprite Mixed, Semi-dwarf Coquette Mixed, Lilliput Mixed, Pink Buttons and Linearis.

Discussion and Conclusions

On symptoms the zinnia disease observed at Armidale appeared similar to that originally described by Hopkins and Dowson (1949) from Southern Rhodesia and subsequently found in Brazil (Robbs, 1954) and Sierra Leone (Deighton, 1956).

The cultural and physiological properties of the two isolates from zinnia leaves from Armidale are wholly consistent with the genus *Xanthomonas* as described by Dye (1962) and others. These cultures closely resemble the two cultures from Africa and differ only in the fact that alone of the four cultures NCPPB 189 oxidized both mannitol and arabinose promptly. The differences in carbohydrate utilization are trivial and within the range of variation which is encountered in other species of the genus *Xanthomonas*. There is no doubt that the two Armidale cultures are correctly identified as *Xanthomonas nigromaculans* (Takimoto) Dowson 1943 f. sp. *zinniae* Hopkins and Dowson 1949.

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EXPLANATION OF PLATES

PLATE VII

Fig. 1. Bacterial leaf spot of zinnia. Natural infection, Armidale, N.S.W. ×0·6.

Fig. 2. Bacterial leaf spot of zinnia. Artificial inoculation with isolate 0365b. ×1·2.

PLATE VIII

Fig. 1. *Xanthomonas nigromaculans* f. sp. *zinniae* NCPPB 189. ×24,540. Preparation negatively stained with 0·5% ammonium molybdate. A single polar flagellum is shown.

Fig. 2. *Xanthomonas nigromaculans* f. sp. *zinniae* 0365. ×8,180. Preparation negatively stained with 0·5% ammonium molybdate. Single polar flagella are shown.

[The technique of negative staining used was that described by Fuerst and Hayward (1969).]

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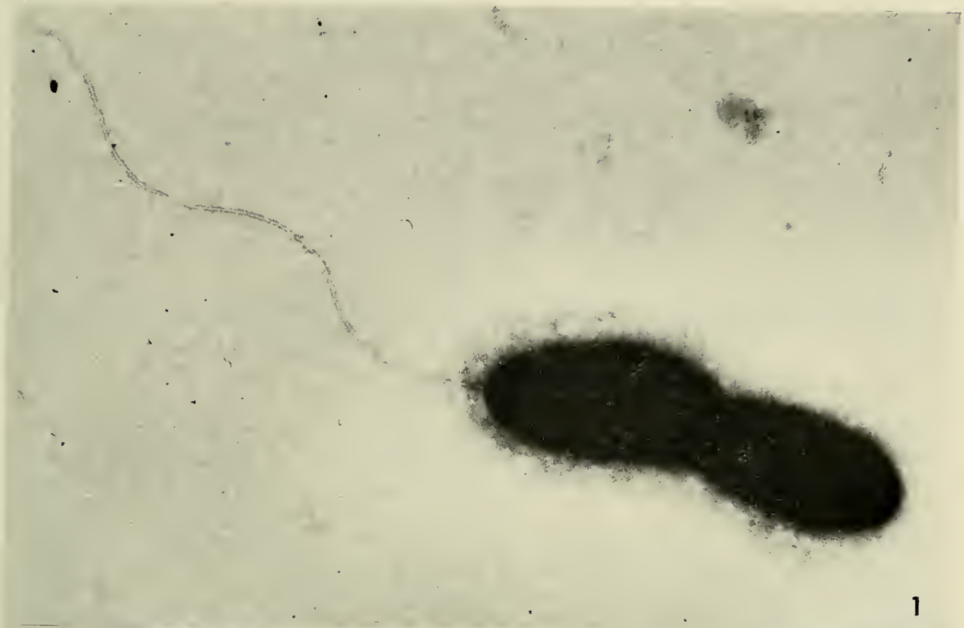

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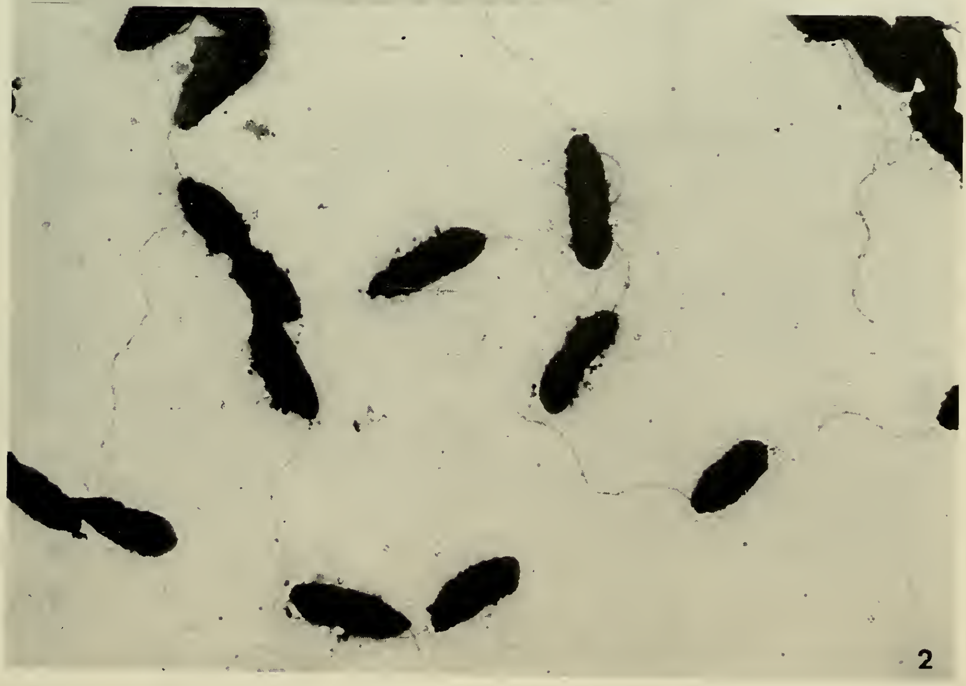

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A NEW SPECIES OF *LOPHOPETALUM* (CELASTRACEAE), A GENUS NEW FOR AUSTRALIA

N. Byrnes

Primary Industries Branch, Northern Territory Administration

(Plate IX)

[Accepted for publication 24th March 1971]

Synopsis

A new species of *Lophopetalum* is described: *Lophopetalum arnhemicum* N. Byrnes, from Katherine Gorge (14° 20′ S., 132° 27′ E.). Northern Territory, Australia.

The genus is new for Australia.

INTRODUCTION

The genus *Lophopetalum* is widely distributed throughout S.E. Asia and the islands to the north of Australia, where it is represented by about 18 species. Its discovery in Australia extends the range of the genus, but the species is distinct from those of Malaysia.

Through correspondence with Dr. C. G. G. J. van Steenis, Dr. Ding Hou commented that the species was " very distinct and interesting, very different from the New Guinea species ". Botanical surveys of the sandstone escarpment area of Arnhem Land, a previously poorly explored area, are revealing a number of new species and extending the range of many known species. This specimen was first collected in Katherine Gorge on a preliminary survey during December, 1966, but its identity as a new species was not realized until 1968. Complete material was collected during that year from a tree near the mouth of the gorge. The genus *Lophopetalum* is represented by evergreen trees with opposite or decussate leaves and is distinguished from other members of Celastraceae by having three-cornered dehiscent capsules with three loculi, each containing several seeds and each seed being completely surrounded by a wing.

Lophopetalum arnhemicum N. Byrnes, sp. nov.

Arbor 8 m. attingens cortice ramulorum laevi trunci versus basin tessellato saepe eroso. Folia opposita petiolo 0·5–1·0 cm. longo lamina lanceolata 6–12 cm. longa 1·5–2·5 cm. lata apice acuta basi anguste cuneata, venatione camptodroma. Inflorescentia glabra thyrsiformis usque ad 10 cm. longa pedunculis ad 1 cm. longis pedicellis 3–5 mm. longis. Flores circiter 1 cm. diametro calyce parvo discum vix superante. Petala late ovata usque ad 3 mm. longa sine appendiculis. Discus planus vel supre convexus. Stamina brevissima antheris ovatis. Pistillum triangulariter pyramidale discum 2 mm. superans. Ovarium triloculare ovulis in locula quoque 6–8 capsula triangularis fusiformis 6–8 cm. longa. Semina plana circiter 3·5 cm. longa 1·0 cm. lata ala inclusa.

Holotype: Katherine Gorge National Park, N. Byrnes 921; 7 Sep. 1968 (Darwin 2852).

Isotypes: K, L, A, CANB, NSW, BRI, PERTH, MEL, NT.

Paratype: Katherine Gorge National Park, N. Byrnes 1180; 25 Nov. 1968, Darwin, K, L, BRI, NSW, MEL.

A tree to 8 m. high. Bark smooth on the branchlets becoming tesselated and often eroded on the trunk. *Leaves* opposite on petioles 0·5–2·5 cm. long;

lamina lanceolate, 6–12 cm. long, 1·5–2·5 cm. wide with arched venation, acute, narrow cuneate at the base. *Inflorescence* a thryse, glabrous, up to 10 cm. long ; peduncles to 1 cm. long ; pedicels 3–5 mm. long. *Buds* shortly conical or globose to 3 mm. diam. *Flowers* about 1 cm. diam. *Calyx* 4 mm. diam. with depressed triangular lobes under 0·1 mm. long. *Petals* broadly ovate, 3 mm. long, without appendages. Disc obscurely five-angled, flat or slightly convex about 3 mm. diam. *Stamens* half as long as petals with ovate anthers. *Gynoecium* a triangular pyramid exerted about 2 mm. beyond the disc ; ovary trilocular, each loculus containing 6 to 8 ovules. *Fruit* a triangular spindle-shaped capsule 6–8 cm. long, dehiscing loculicidally. *Seeds* thin, flat, winged, 3·5 × 1·0 cm. including the wing.

The following description of the pollen was prepared by Mr. J. Muller of Rijksherbarium.

Pollen grains in tetrahedral tetrads. Total size 46 (52·3) 55μ, individual grains spherical, 29 (33·4) 36μ.

Pores circular, 4 (4·8) 6μ in diameter, not opposite in tetrad.

Total wall thickness 2 (3·1) 3·5μ.

Endexine ±1·5μ thick.

Columellae distinct, circular, 0·5μ in diameter, ±1·5μ high, arranged in a reticulate pattern in single rows.

Tectum reticulate ; lumina isodiametric, 0·5–0·75μ in diameter ; muri 0·5μ wide, 0·5μ high.

COMMENT

The pollen of this species belongs to the *Lophopetalum* B group as defined by Ding Hou (*Blumea*, XVII, I, 1969). It is very similar to that of *L. rigidum*, *L. floribundum*, *L. macranthum*, *L. javanicum*, *L. ledermanni*, *L. torricellense* and *L. subovatum*.

This species has been found along the Katherine, South Alligator and East Alligator River systems generally restricted to the banks of permanent or larger seasonal streams in the hilly sandstone areas. It flowers in August and September with the fruit maturing to release seeds during December and January.

Reference

DING HOU, 1963.—Celestraceae I. *Flora Malesiana*, 6 : 227–291 (Leyden).

————, 1969.—Pollen of Sarawakodendron (Celastraceae) and some related genera with notes on techniques. *Blumea*, 17 : 97.

NTA 66

HERBARIUM OF NORTHERN TERRITORY

AUSTRALIA

No

Name Lophopetalum arnhemicum sp. nov

Loc Katherine Gorge National Park

Coll N Byrnes 921 Date 7 Sep 1968

Notes Banks of river - sandy alluvium with rocks - Small tree to 8 m

Det. N Byrnes Dwn Mar 1970

The holotype of *Lophopetalum arnhemicum* N. Byrnes.

THE FOOD AND FEEDING OF WINTER WHITING (*SILLAGO MACULATA* QUOY AND GAIMARD) IN MORETON BAY

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[Accepted for publication 21st April 1971]

Synopsis

A description of the mouth structure and alimentary canal of *Sillago maculata* is given to indicate minor adaptations associated with a bottom feeding carnivore. Adult whiting, those longer than 10 cm., were found to consume polychaete worms mainly, but also a variety of crustaceans, echinoderms, and small fish, as well as pelecypod molluscs, and *Glossobalanus*.

The diet of juvenile whiting, which frequent shallower waters, was found to consist largely of mysidaceans and amphipods, and smaller quantities of other crustaceans, pycnogonids, polychaetes and gastropods.

In adults there is a change of diet with size. Only fish longer than 15 cm. were found to consume significant quantities of molluscs ; only fish longer than 16·5 cm. consumed *Glossobalanus* ; and only fish longer than 17 cm. ate brittle stars. No plant material was found in any whiting.

INTRODUCTION

Sillago maculata is a bottom feeder and forms part of the benthic nekton in Moreton Bay. It is a carnivorous fish, although fishermen sometimes assert that the fish feed on weed during the spawning season. For most of the year adult whiting inhabit parts of the bay which possess a muddy substrate. Some time is apparently spent in sandy areas (Roughley, 1916). However, no specimens were found in sandy parts of Moreton Bay in the course of this study.

The following description of the alimentary system of this species indicates the minor adaptations correlated with feeding behaviour.

(1) *Dentition.* Small villiform teeth are present on both jaws. Fine vomerine teeth are also present. Cardiform pharyngeal teeth occur as firm pads, a large median pad on the dorsal and two smaller pads on the medio-ventral surface of the pharynx, which leads to a short oesophagus.

(2) *Jaws.* The jaws are modified to enable the gape of the mouth to be directed obliquely downwards. This is accomplished by a membrane which allows protrusion of the upper jaw over the lower. A cartilaginous spine attached to the premaxilla provides rigidity for the membrane.

(3) *Alimentary canal.* The digestive tract is typically carnivorous in proportions (Al-Hussaini, 1949). An elongate caeciform stomach is present ; there are four pyloric caeca, and a short intestine follows. A nematode parasite frequently invades the intestine, and, less commonly, the stomach.

METHODS AND MATERIAL

Adult whiting examined for stomach contents were captured by trawl between Mud and St. Helena islands in Moreton Bay in March, May, June and September, 1966. The sampling area was typical of a large part of the bay, having a substrate of deep, soft, sandy mud. Depth ranged from two to six fathoms.

No juvenile whiting were obtained in this sampling area. Juvenile specimens were captured in water less than one fathom deep by bait net near the mouth of the Brisbane River in June and November, 1966, only.

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After capture, the fish were immediately placed in 10% formalin. Altogether, 433 whiting, including 42 juveniles, were examined for stomach contents. The size of juvenile fish ranged from 2·8 cm. to 9·6 cm., and the largest fish examined were 21 cm. Lengths of fish were caudal fork measurements (l.c.f.), that is the distance from the tip of the snout to the fork in the caudal fin.

In this study, only the presence or absence of each type of food organism was recorded. More sophisticated analyses, such as volumetric or gravimetric techniques (see review by Hynes, 1950), were precluded by the frequently disintegrated condition of the food in the stomachs. In many cases, food organisms were recognizable by their hardened portions only, such as skulls or other bones in fishes, parapodial chaetae in polychaetes, and various appendages or exoskeleton in the crustaceans. Stomachs in which no recognizable food organisms were found were either empty or contained small amounts of fluid mucus. Both these conditions were recorded as empty stomachs. By summation of the whole sample, results were converted to percentage occurrence of each item in the stomachs.

No significant variation with time was noted in the sampling period. Consequently, analysis of the data has been confined to variations in the diet with size of fish.

TABLE 1

Food Organisms Found in Stomachs of Winter Whiting in Moreton Bay

Classification	Genera or species
Phylum Annelida	
Class Polychaeta	Several species
Phylum Mollusca	
Class Pelecypoda	Several species
Class Gastropoda	One species
Pyhlum Arthropoda	
Class Pycnogonida	One species
Class Crustacea	
(*a*) Cirripedia	*Lepas* sp.
(*b*) Copepoda (Cyclopoida)	One species
(*c*) Ostracoda	One species
(*d*) Malocostraca (Amphipoda)	
Fam. Gammaridae	Several species
Fam. Caprellidae	Several species
Malocostraca (Stomatopoda)	*Squilla* spp.
,, (Mysidacea)	*Heteromysis* sp.
,, (Decapoda)	*Penaeus*, *Metapenaeus*, *Thenus*, several species
Phylum Echinodermata	
Class Ophiuroidea	One species
Class Holothuroidea	One species
Phylum Chordata	
Sub-phylum Hemichordata	*Glossobalanus* sp.
Sub-phylum Vertebrata	
Class Osteichthyes	Several species, including *Hyperlophus translucidus* McCulloch

RESULTS

A list of all identified genera or groups of food organisms found in the stomachs of *S. maculata* is recorded in Table 1. Of the 433 fish examined, 114 had empty stomachs.

Initially, the whiting were divided into two broad categories according to gonad condition, juvenile and adult, the latter class including all fish longer than 10 cm.

The diet of juvenile whiting was found to consist largely of small crustaceans, the largest being about 3 mm. long. The most prominent were found to be mysideans. Amphipods were second in order of abundance, and species of Gammaridae and Caprellidae were obtained. The mysids and amphipods were the most commonly occurring organisms in the stomachs and when present were usually in large quantity.

The remainder of organisms eaten by juveniles occurred infrequently and in small numbers. They include species of Polychaeta, Pycnogonida, Ostracoda, Copepoda, and Mollusca. Interestingly, only two of the juvenile whiting analysed had empty stomachs when examined. The frequency of occurrence of each food organism in the 42 fish examined is shown below in Table 2.

TABLE 2

Frequency of Occurrence of Food Organisms in the Stomachs of 42 Juvenile Whiting

Food organisms	Number of stomachs containing food organism	Frequency of occurrence in stomachs containing food (percentage)
Mysidacea	24	60
Amphipoda	12	30
Polychaeta	6	15
Pycnogonida	2	5
Ostracoda	2	5
Copepoda	1	2·5
Gastropoda	1	2·5
Empty stomachs ..	2	5

TABLE 3

Frequency of Occurrence of Food Organisms in the Stomachs of 391 Adult Whiting

Food organism	Number of stomachs containing food organism	Frequency of Occurrence in stomachs containing food (percentage)
Polychaeta	173	62
Pelecypoda	54	19·5
Ophiuroidea	29	10·5
Holothuroidea ..	3	1
Glossobalanus	17	6
Brachyura	41	15
Penaeidae	15	5·5
Squilla	8	3
Other Crustacea ..	48	17
Fish	15	5·5
Empty stomachs ..	112	—

Polychaete worms are by far the most commonly occurring food organism in the stomachs of adult whiting. Bivalve molluscs and crustaceans, especially crabs, comprise most of the remaining portion of the diet. Other crustaceans eaten in small numbers include prawns, mantis shrimps, barnacles, and the shovel nose lobster. Acorn worms (*Glossobalanus*), small fish, sea cucumbers, and brittle stars are also minor dietary items. One specimen only of Gastropoda was found. The frequency of occurrence of each food organism in adult whiting is shown in Table 3. " Other Crustacea " includes fragments of organisms not further recognizable.

Since there appeared to be some dietary differences between adult whiting of different sizes, they were divided into two arbitrary classes, small (10·1–15·5 cm.) and large (15·6–21·0 cm.), which were compared by " t " test for quantitative differences in dietary organisms. The tests revealed that at the 5% level of significance small adult whiting consumed relatively fewer molluscs, acorn worms and brittle stars, but more crustaceans other than those *identifiable* as crabs, prawns, or mantis shrimps.

TABLE 4

Frequency of Occurrence of Specified Food Organisms in Whiting of Various Size Groups

Size range (cm.)	Number of Fish	Empty stomachs (Percentage)	Brittle stars (Percentage)	Crabs (Percentage)	Molluscs (Percentage)	Polychaetes (Percentage)
10·1–10·5 ..	10	0	0	20	0	40
10·6–11·0 ..	6	0	0	17	17	50
11·1–11·5 ..	14	0	0	0	7	29
11·6–12·0 ..	12	0	0	0	8	42
12·1–12·5 ..	9	56	0	0	0	50
12·6–13·0 ..	7	29	0	20	0	60
13·1–13·5 ..	12	25	0	0	0	78
13·6–14·0 ..	19	16	0	13	0	50
14·1–14·5 ..	24	0	0	9	5	45
14·6–15·0 ..	30	20	0	4	4	46
15·1–15·5 ..	35	8	0	13	13	53
15·6–16·0 ..	17	23	0	8	22	54
16·1–16·5 ..	14	28	0	0	20	60
16·6–17·0 ..	16	69	0	20	0	40
17·1–17·5 ..	15	27	18	9	19	45
17·6–18·0 ..	25	24	5	0	21	58
18·1–18·5 ..	37	24	29	14	19	29
18·6–19·0 ..	37	27	19	14	19	33
19·1–19·5 ..	23	35	13	20	7	47
19·6–20·0 ..	16	69	0	0	0	80
20·1–20·5 ..	13	8	17	25	25	25
20·6–21·0 ..	6	17	20	20	0	40

A more detailed division of the adult whiting into 0·5 cm. size groups showed that acorn worms were found in fish longer than 16·5 cm. only, and brittle stars in fish longer than 17·0 cm. Molluscs became " regular " food items only in whiting longer than about 15 cm. The occurrence of " other Crustacea " became insignificant in fish longer than 16 cm. Table 4 shows the percentages of whiting in the various size groups whose stomachs contained one or more food items.

DISCUSSION

The dietary differences between juvenile and adult whiting are significant with regard to feeding behaviour. The minute crustaceans and pycnogonids which comprise the bulk of the diet of juvenile whiting are planktonic or cling to weeds. Bottom-living fauna, the small polychaete worms, are minor food items of juvenile fish. Thus, juvenile whiting are basically not bottom feeders. On the other hand, the adult whiting diet consists mainly of comparatively large benthic organisms, especially polychaetes and pelecypods. The change of diet apparently occurs during the movement of juvenile whiting from the shallows into deeper waters of the bay.

The selection by larger adult whiting of acorn worms, brittle stars and molluscs is difficult to explain. The species of brittle star consumed is one of the most commonly occurring invertebrate organisms in Moreton Bay, although apparently undescribed (Stephenson, personal communication). Pelecypoda possess hard shells which may deter smaller fish from eating them. The pharyngeal teeth, by which hard particles such as shells are broken up, probably strengthen with age.

The finding of less identifiable remains of crustaceans (" other Crustacea ") in large fish may also be correlated with a hardening or strengthening of teeth and jaws, such that less time is required to grind the food to a size which allows efficient digestion. If so, the frequency of occurrence of recognizable portions of the various crustacean food organisms may be correspondingly less. On the other hand, larger fish may simply tend to ignore most crustaceans, except crabs, as food.

TABLE 4—*Continued*

Size range (cm.)	Number of Fish	Acorn Worms (Percentage)	Prawns (Percentage)	Mantis Shrimps (Percentage)	Other Crustacea (Percentage)	Fish (Percentage)
10·1–10·5 ..	10	0	0	0	40	0
10·6–11·0 ..	6	0	0	0	16	0
11·1–11·5 ..	14	0	0	0	35	29
11·6–12·0 ..	12	0	17	8	17	8
12·1–12·5 ..	9	0	0	0	50	0
12·6–13·0 ..	7	0	0	0	20	0
13·1–13·5 ..	12	0	0	0	22	0
13·6–14·0 ..	19	0	18	0	19	0
14·1–14·5 ..	24	0	5	9	27	0
14·6–15·0 ..	30	0	4	8	26	8
15·1–15·5 ..	35	0	0	3	12	6
15·6–16·0 ..	17	0	8	0	8	0
16·1–16·5 ..	14	0	20	0	0	0
16·6–17·0 ..	16	20	0	0	20	0
17·1–17·5 ..	15	0	9	0	0	0
17·6–18·0 ..	25	5	5	0	6	0
18·1–18·5 ..	37	3	3	0	0	3
18·6–19·0 ..	37	3	4	4	0	4
19·1–19·5 ..	23	7	0	0	6	0
19·6–20·0 ..	16	0	20	0	0	0
20·1–20·5 ..	13	0	0	0	0	8
20·6–21·0 ..	6	0	0	0	20	0

The problem of relative importance of the various food organisms of *S. maculata* is pertinent to this study. Since volumetric and gravimetric methods were not applicable, the biomass of each item cannot be determined. In adult whiting the most frequently occurring food organisms, polychaetes, were also the largest, so that there is no question as to the main source of their metabolic requirements. The problem is significant in juvenile whiting, however. Food organisms of juveniles fall into two classes according to size : the minute planktonic forms and the somewhat larger polychaetes. The numbers of the former, when they occurred in the stomachs of the juvenile whiting, usually exceeded polychaetes at least sixfold, one worm fragment only being normally found in the stomach of a single juvenile fish. On the other hand, the polychaete pieces eaten were larger than the other food organisms, and thus polychaetes may approximate, or even exceed, the biomass of other foods eaten by the juvenile whiting.

Food preferences in fish are well known (Blegvad, 1930 ; Ivlev, 1961), and it is apparent that some form of food selection is exhibited by whiting.

Knowledge of the relative abundances of the benthic fauna in the whiting feeding grounds is required to ascertain the extent of this selection. It is hoped that the degree of preferences for different organisms by whiting in Moreton Bay can be established in the future, since Stephenson (personal communication) is currently investigating the abundance and distribution of benthic organisms there.

TAINTING

Fishermen frequently claim that adult whiting eat an iodine-rich weed during the spawning season. The basis of this claim is a characteristic odour, reminiscent of iodine, possessed by some mature specimens. Its origin was not discovered in the present study, and although some fish were found to possess this odour, none contained plant food of any type in their stomachs or intestines. The occurrence of the taint is of no commercial importance and it has not been sufficiently widespread to warrant investigation by fisheries authorities.

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THE EARLY HISTORY AND RELATIONSHIPS OF THE NEW GUINEA HIGHLAND DOG (*CANIS HALLSTROMI*)

Ellis Troughton*

[Accepted for publication 17th February 1971)

Synopsis

There are factual reports of a " barkless " dog from east coastal New Guinea from as early as 1606. Subsequent accounts indicate that this distinctive small dog was forced to the seclusion of a mountainous habitat by a combination of hostile circumstances : such as the eating of its progeny by natives, as reported from Mt. Giluwee, coupled with its lack of pig-hunting ability. This upland migration evidently occurred prior to hybridization with any introduced breed of domesticated canine, as indicated by the fact that the discovery of a small wild dog at about 7,000 ft. on Mount Scratchley in 1897 was considered a faunal novelty by the Administration, according to the Annual Report of the Lieut. Governor, Sir William Macgregor (1898). The term " feral " as applied to the New Guinea Dog by some authors is rejected as being irrelevant regarding the issue of its specific relationship.

In Diego de Prado's *Relacion* of Torres' voyage through the Strait in 1606, as translated from the Spanish in H. N. Stevens (1930) *New Light on the Discovery of Australia* (p. 141) Prado wrote from the Island of San Facundo [S.E. Papua] in 1606 : " We found small dumb dogs that neither bark nor howl, and do not cry out even if beaten with sticks." One is indebted to an old colleague, Gilbert Whitley, for this most significant reference, as well as several following made available from his bibliographical researches.

In an anonymous article on " Australasian Islands " in the *Colonial Magazine*, Vol. 7, 1842, p. 62, it is stated that " The bush-dog (*Canis Australiae familiaris*) is an inhabitant of the country Papua : . . . these dogs do not bark, but raise a howling whine, on being disturbed from their repose . . . Dogs form a portion of their native animal food." In 1886 in the *Voyage of the Bonito : an account of the Fly River Expedition to New Guinea*, in the Mitchell Library, William Bauerlen (pp. 28–29) refers to " Native dogs which cannot bark, on the Upper Fly or Strickland " rivers.

Alexander Morton, in " Notes on a trip to the islands of Torres Strait and the south-east coast of New Guinea in *Proc. Roy. Geograph. Soc. Austr., N.S.W. and Vict. Branches*, Vol. 1, 1883, p. 69, states that " Motu natives of the Port Moresby area in 1877 in their legends *attributed the gift of speech* to the Dogs ". However, Miklouho-Maclay (1881), comparing the " Circumvolutions of the Cerebrum " of the Dingo and Papuan Dog, concluded that the superior complexity of the Dingo brain indicated differences in modes of life of the respective canines. He wrote : " The dingo depends upon his skill to provide himself with sufficient food by hunting, which requires often the full use of his intellect." The New Guinea Dog " is very timid, and howls instead of barking . . . is used as food by the natives of the Maclay Coast ; his flesh however, when baked or boiled is dark and dry, and is generally regarded by the natives as inferior to that of pig. Although he is sometimes fed by his master and gets with the pigs, all the remnants of the meals, he is often to be seen on reefs at low water, feeding on crabs and small fishes, etc."

" During the night, the dog in company with the pig takes over the business of the ' Nightman ' and the ' scavenger ' of the Papuan villages. In only a very

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* Contributed to the Anthropology Section at the 42nd Congress of A.N.Z.A.A.S. at Port Moresby, Papua, on 20th August, 1970.

few instances have I seen the natives of the Maclay Coast using their dogs to assist them in their hunting the wild pig, the dorcopsis wallaby and the cassowary . . . I think it is not only too timid, but too lazy and stupid an animal for such an occupation."

In his book on " The Orokaiva Society ", F. E. Williams (1930) writes of " The food quest : Dogs are treated affectionately enough by their owners . . . However, the dog does not compare with the pig in the Orokaiva estimation. It is always less a pet than a servant, and is ultimately destined for the pot. In slaughtering it is seized by the hind legs and its body dashed against a tree, a method which seems brutal but is instantly effective ! Many specimens are mangy diseased. They are proverbially susceptible to the cold and are commonly seen crouching in the ashes of a hardly expired fire. Indeed the dog is said to have a special prerogative over the fire by virtue of the legendary fact that he first brought fire to the Orokaiva." A footnote adds : " The native dog of the Purari Delta is no doubt a degenerate of the same species. From the canine point of view the Delta must be a very unfortunate environment."

In his *Annual Report on British New Guinea* (1897–1898) Macgregor, referring to an extensive patrol of the Mount Scratchley region at 5,000–7,000 ft., wrote that where there is such an ample variety of food " Animals are rare. The wild dog, an occasional wallaby, a stray tree-kangaroo, and a long-snouted animal not yet obtained, form the bulk of the quadrupeds." Of the two dog specimens subsequently lodged in the Queensland Museum, it is recorded that they were obtained from natives, possibly through the interest of white prospectors in the area, resulting from the Administrative patrol.

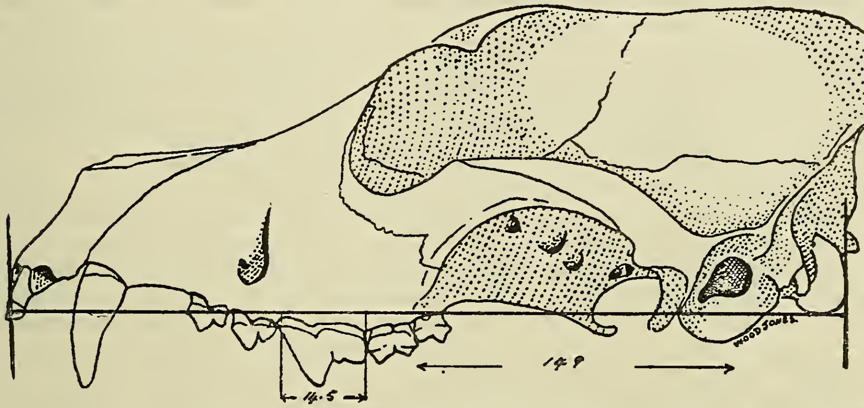
The first specimen, evidently received from Sir Wm. Macgregor, was described and figured by De Vis (1911) of the Queensland Museum. His generalized description accounts for the unduly dingo-like illustration in stating that the mounting was from a skin *long macerating in an entirely boneless state.* My examination of the two skins proved his colour description to be rather misleading in giving the overall colouring as " black and white, the black predominant ".

When reviewing the specific status of the dingo, Wood Jones (1925) stated that " examination of a series of Dingo skulls can leave no doubt as to the true affinities of the Australian animal . . . falls into line with all other races of domestic dogs in being of the true northern wolf type. Moreover, in the large size of its last upper premolar, or carnassial tooth, it approaches nearer to the ancestral type than do the other races of dogs of which I am able to obtain specimens or records."

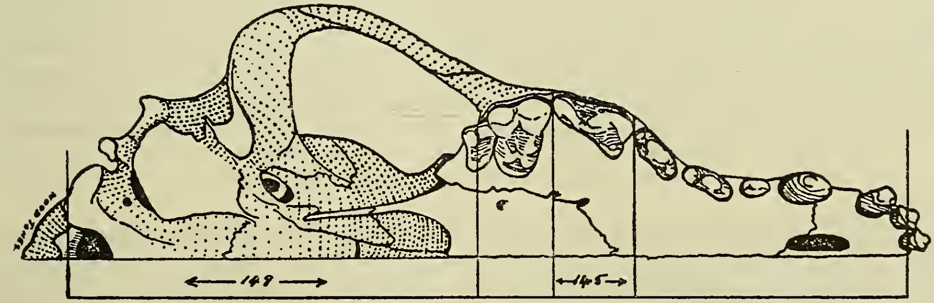
With special reference to the relative proportions of this carnassial tooth, Heber Longman (1928), in " Notes on the Dingo, the Indian Wild Dog, and a Papuan Dog ", speculated upon a common origin for the Dingo and Indian Wild Dog. He regarded the two specimens of Papuan Dog in the Queensland Museum as representing " a small breed of true dogs, possibly not truly feral or autochthonous . . . apparently very closely related to the Dingo ". However, Longman noted with interest that " this race agrees (in carnassial proportions) with the Indian Wild Dog (21·5 mm.), the Gray Wolf (25), and average of ten dingoes (20) in the relatively large proportion of the carnassial tooth, which is more than 10% of the basicondylor length of the skull ". The relative proportions of upper carnassial to basi-condylor length in the two Papuan Dogs is given respectively by Longman as 15·5 to 149 and 16 to 146 mm.

In his paper on " The cranial characters of the Papuan Dog ", Wood Jones (1929) refers to Longman's paper and to borrowing the two skulls of Papuan Dog for examination and description. On any doubts concerning their feral nature he stated " no opinion can be expressed . . . but it is abundantly evident that both skulls are of dogs of precisely the same type . . . and any suspicion of their being of impure breed is negatived by this remarkable identity. It is certain that these two skulls are of representatives of the same race and that this race is a primitive one."

" The skulls are of those of small dogs of the terrier type, with fairly elongated noses and well developed muscular crests and ridges. Their most outstanding characters are : (*a*) The form of the supraorbital processes, which are pointed, flat to concave on the upper surface, and singularly vulpine in character : (*b*) The sagittal crest, which is formed by a coalescence of the temporal ridges in the region of the coronary suture in both specimens, and which is extremely prominent in its caudal extremity where it joins the well marked nuchal crest : (*c*) The relatively large size of the upper carnassial tooth, the maximum length of which is nearly ten percent of the condylobasal length : (*d*) The backward prolongation of the palate behind the last molar tooth, a very well marked distinction of both skulls " (Text-figs. 1 and 2).



Text-fig. 1. *After* Wood Jones, *American Journal of Mammology*. Vol. 10. 1929. Illustrating some of the cranial features referred to in Wood Jones paper.



Text-fig 2. *After* Wood Jones, *American Journal of Mammology*, Vol. 10, 1929. Illustrating some of the cranial features referred to in Wood Jones paper.

Wood Jones concludes " Although these two skulls constitute the only material available for study of this dog, they probably afford definite evidence that the Papuan feral dog is a very definite race, possessing a relatively large upper carnassial tooth typical of primitive canine breeds, and differing widely in its characters from the dogs of certain other Pacific islands. It is much to be desired that more material should be secured before the crossing by the white man's dogs has rendered the breed too hybridized for the purposes of study."

In this regard a " Note on New Guinea Dogs " (1952) by the late Dr. G. H. H. Tate, then a Curator of Mammals at the American Museum of Natural History, becomes of special significance. Briefly reviewing the above contributions on the Papuan Dog, Tate records the Archbold collecting of five specimens along the Idenburg River, on the northern slopes of the central ranges in West Irian. Tate records that " In every instance the carnassial length is more than 10 per cent of the condylo-basal length in the Idenburg River specimens ". After some reference to range of colour, and absence of dew claws in both dingo and Papuan Dog, Tate refers to Wood Jones' conviction that the latter was a primitive race.

Thus we have a very considerable extension of the highland range of a small dog of the same type in major cranial characters, from the opposite coast and beyond the border of the Territory of New Guinea. While personally collecting for the Australian Museum around Mount Hagen in 1954, one had hoped to obtain specimens from the relatively intermediate locality of Mount Giluwee, where our host-mentor, Mr. N. E. P. Blood, had observed the dogs around villages at about 8,000 ft. on the 14,346 ft. mountain. Unfortunately, or possibly otherwise for myself, Mr. Blood of the Agricultural Station at Mt. Hagen found it unwise from an Administrative view to commit one to a 4–5 days' " walk " accompanied only by a native constable and " cook-boy ". A pair of the dogs was later obtained by an Assistant District Officer, which, because of their heavy toll on poultry around his Station, had to be sacrificed to the villagers.

Consequently, when Sir Edward Hallstrom arranged to receive a pair of the dogs at Taronga Park Zoo, one had no hesitation in naming them specifically for the President of the Trust, and benefactor of the Australian Museum. The living animals, *Canis hallstromi* (1957) were so named to offset the inevitable claims of " Zoo hybridization ". The male holotype No. M.8502 and female allotype No. M.8917 in the Australian Museum, came from the then uncontrolled country in the remote Lavani Valley in the Southern Highlands District of Papua. The relative carnassial to condylobasal lengths in the holotype are 15·1 to 151 mm., and 15·5 to 149 in the allotype; and are therefore within the characteristic 10% ratio according to Wood Jones.

Actually, E. P. Ramsay (1879) had named a dog from the south-east coast of Papua *Canis familiaris* var. *papuensis*, mainly on the reported inability to bark. The specimen was received from the collectors, Alexander Morton and Andrew Goldie, and " unfortunately arrived in a very bad state " and evidently was destroyed. Whether Ramsay's name be accepted, or rejected as a *nomen nudum*, it has since been overlooked by all authors with the exception of Miklouho-Maclay (December, 1881). Even Tate (1952), while listing Maclay's paper in his note on the " Papuan Dogs " did not refer to Ramsay's name *papuensis*, though quoting De Vis' statement that the Mount Scratchley dogs " might well be feral ".

Throughout this review the specific relationships of the New Guinea Dog have been obscured by the irrelevant use of the term " feral ", a taxonomic if not phylogenetic misnomer, without due allowance for the effect of prolonged restriction to a tropical environment. However, one may hope that specific naming of the New Guinea Dog will have served its purpose in bringing consideration of the actual status of the small canid, and its historical association with man, before world students of both Mammology and Anthropology, according with the expressed aims of Professor Wood Jones (1929).

As evidence of such interest, a Mrs. Il Ohman, of Hagford, has written of a Swedish research team's great interest in the New Guinea Dog and of their great anxiety that purity of the breed should be assured in captivity; referring also to a paper by a Dr. Von Rosen " attempting a definition as a species . . . as highly interesting and decidedly more primitive than the dingo, in general type ".

At the request of its author, Mrs. Ohman kindly mailed me a copy of the paper by Dr. Wolfhart Schultz (1969) on " Zur Kenntnis des Hallstromhundes (*Canis hallstromi* Troughton 1957) ".

The summary in English, after reviewing several domestic breeds of dog, refers to an examination of " descendants of the original two Papuan Dogs, bred in Kiel University Institut ". In his statement that a wide range in coat coloration in the two specimens does not prove them " to be members of a genetically uniform population ", Dr. Schultz apparently overlooks the fact that the litters of the original pair were entirely black at birth, as are those in San Diego Zoo and elsewhere, providing a natural basis for adult variation.

In view of the known fact that the New Guinea Dog was evidently well established in its present form prior to 1606, one finds it impossible to agree with Dr. Schultz' conclusion " that the Hallstrom-dogs are dogs returned to a wild state, which are in close relation to the Dingo ". A conclusion apparently overlooking the factors of time, isolation, and the extent of zoo-geographical barriers.

In a note on " The Dog of the Tengger ", Dr. F. A. Jentink (1896) writes of a peculiar kind of dogs living on Mount Tengger, the highest in East Java, which had been named *Canis familiaris* var. *tenggerana* by Dr. Kohlbrugge and which " could not live without mountains, they died not by ' Heimweh ', but by the heat of the lower regions, where they participated with different diseases, where they pined away and languished ". Two complete skeletons of the wild Tenggerese dog were presented to the Leyden Museum by Dr. Kohlbrugge. Photos of the skull show the relatively large proportions of the carnassial tooth. This account would seem to support my previous assumption regarding an early upland migration of the New Guinea Dog to its present highland habitat.

Actually, it is my assumption that the ancestral stock of the New Guinea Dog arrived by an Asian route and became established in their present form, prior to the deployment of the Pacific Island Dog of Hawaiian origin. A wider study of the relevant material may provide, according to Wood Jones, " a general factor in solving the problems of racial movements and racial origins of man and the mammals which may have accompanied or preceded him ". At Mount Hagen, in 1954, while Mr. N. E. P. Blood was assembling carriers for our several patrols, one was impressed by the yodelling calls used by the natives, simulating the vocal sounds of the " voiceless " New Guinea Dog, and reminding one of the Motu legend regarding the gift of speech. Suggestive also of an age-old association with man, though not of course the order of it.

Conclusion

A Papuan region covering the obvious biological unity of the mountainous region of Papua with the Atherton Tableland of N.E. Queensland, was proposed by Charles Hedley (1894). The types of vegetation, reptiles, birds, and marsupials were such, according to Hedley, that any traveller in the heart of the Atherton rainforest " could scarcely answer, from the surroundings, whether he were in New Guinea or Australia ".

Therefore, according with the recent discovery of skeletal remains of the Thylacine or " marsupial wolf " at 5,000 ft. (1,525 m.) in the Central Highlands of New Guinea, and doubtless its past occurrence on the Atherton Tableland, in view of persistent reports of a large striped marsupial having inhabited the Tableland, it is now postulated that the New Guinea Highland Dog had a similar prehistoric co-distribution, and became ancestral to the wild dog or Dingo of the Australian mainland, which provided an ample field for the development of the Dingo's hunting resources and physical growth.

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AN UNDESCRIBED SPECIES OF *USTILAGO* ON *CYPERUS LUCIDUS* R.Br. IN AUSTRALIA

With comments on Robert Brown's type collection of *C. lucidus*

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(Plates x, xi)

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Synopsis

An ovary smut of *Cyperus lucidus* R. Br. found in New South Wales is described as *Ustilago cyperi-lucidi* n. sp. It was also found in one collection of *C. lucidus* from Queensland and one from Victoria. Examination of two portions of Robert Brown's original gathering of *C. lucidus*, made in N.S.W. in 1802–1805, showed that the smut was present in the portion filed in the Herbarium, Royal Botanic Gardens, Kew, but not in the lectotype specimen in the British Museum (Natural History). The relationship of *U. cyperi-lucidi* to other species with pale spores, and especially to *Ustilago* spp. on Cyperaceae and Juncaceae, is discussed.

Introduction

During an examination of collections of *Cyperus* spp. at the National Herbarium of New South Wales, Mr. O. D. Evans found abnormal nuts in some collections of *Cyperus lucidus* R. Br. Detailed examination showed them to be filled with a yellowish powder composed of spores of an hitherto unrecognized

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Corrigenda

P. 100.—*For* Plate IX, *read* Plate X.
For Plate X, *read* Plate XI.
P. 102.—*For* Plate X, *read* Plate XI.
P. 103.—*For* Plate X, *read* Plate XI.
P. 104.—*For* Plate X, *read* Plate XI.
P. 107.—*For* Plate IX, *read* Plate X.
For Plate X, *read* Plate XI.

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primitus 10–15 in fasciculis laxe adherentes, demum singulatim, interdum cum frustillis affixis hypharum, (15) 16–22 (25) µm diam., spora gigantea rara ad 27 µm diam., vel sporae ovales 17–23 (25) × 12–17 µm (minus quam 10% sporarum), pallide viridi-flavae usque pallide flavobrunneae, pariete 1·5–2·0 µm lato, episporio subtiliter reticulato vel imperfecte reticulato, reticulum 1·5–2·0 µm altum, areolis 1·5–2·0 (2·5) µm diam. Sporae in solano glucoso agaro ad 15–21° C. in diem per promycelium 3-septatum 26–33 × 5–9 µm germinantes et sporidia ovalia 7–10 × 4–6 µm a omni cellula formata.

Habitat: In acheniis *Cyperi lucidi* in Nova Wallia Australi, Victoria et Terra Reginae, Australia.

Holotypus: In pasture, property of R. Skellern, Wyndham, west of Pambula, N.S.W., 11.vii.1969, J. Hindle, DAR 17587a.

U. cyperi-lucidi forms its sori within the nuts and in most collections all nuts in an infected inflorescence are smutted. Infected inflorescences are very difficult to detect except by a detailed examination of the florets, when the glumes are seen to be slightly more spread than in healthy florets. They are pushed open by the swollen diseased nuts between them (Plate IX, Fig. A). Sori are grey, elliptical to broadly obovate, and roughly the same length as normal nuts but somewhat wider (Plate IX, Fig. C). They measure 1·5–2·0 mm. long and 1–1·5 mm. wide ; nuts are roughly 2 mm. long and 0·5–0·8 mm. wide. In section, sori have a more rounded outline than the three-angled outline of normal nuts.

The sori are covered by the unaltered wall of the nut, with no sign of a fungal sheath. At maturity, they split open, often along one side (the central sorus in Plate IX, Fig. C) to expose the pale yellow (Munsell (1967) 7·5Y 9/4–6 ; Ridgeway (1912) Naphthalene Yellow) to pale yellow brown (Munsell 2·5Y 9/4–6 ; Ridgeway Warm Buff) spore mass. Some sori have a darker, pale reddish brown (Munsell 2·5YR 7/10 ; Ridgeway Ochraceous Salmon) spore mass and, in some sori with an otherwise pale spore mass, spores towards the base of the sorus are this darker colour. The spore mass is at first agglutinated but later powdery. There is a central columella of host vascular tissue.

Spores are mainly globose to subglobose, some oval, and a few slightly more angular in shape. Some tend to adhere in clumps of 10–15 or more, especially in the lighter coloured spore masses, and spores from such masses are usually more angular in outline than single spores. Spores from pale spore masses also have a paler golden yellow to greenish yellow (Munsell 10Y 9/6–8, 2·5GY 9/4 ; Ridgeway Pale Green-Yellow) wall than those from the darker spore masses, where the spore wall is darker yellow to light golden brown (Munsell 5Y 9/8, 7·5Y 9/10 ; Ridgeway Buff Yellow to Light Orange Yellow). Spores measure (15) 16–22 (25) μm in diameter, with an occasional giant spore up to 27 μm. Oval spores are 17–23 (25) × 12–17 μm, and make up less than 10% of the number of spores.

In some sori, fragments of hyaline hyphae 1·5–4 μm wide are seen amongst the spores. Often they are branched and twisted, and they vary in width along their length. Several spores with hyphal fragments up to 10–12 μm long attached to them occur and some spores have two fragments attached on opposite sides. The hyphae in the sori and attached to spores are seen mainly in paler, more agglutinated, less mature sori.

The spore wall is rough. In equatorial view (Plate X, Fig. A) the roughening is seen as conical blunt projections, 1·5–2·0 μm high and 1·5 μm wide at the base. In surface view (Plate X, Fig. B ; Text-fig. 1) these projections are seen to be the ridges of a reticulum, which is sometimes complete and produces angular areolae 1·5–2·0 (2·5) μm across. Often several ridges do not join up and an incomplete reticulum is formed. In a minority of spores, the surface pattern is seen as elongated, sometimes branched ridges, which seems to represent a very incomplete reticulum (Text-fig. 1). These do not seem to be developmental stages as all patterns have been seen on lighter and darker spores in both agglutinated and powdery sori.

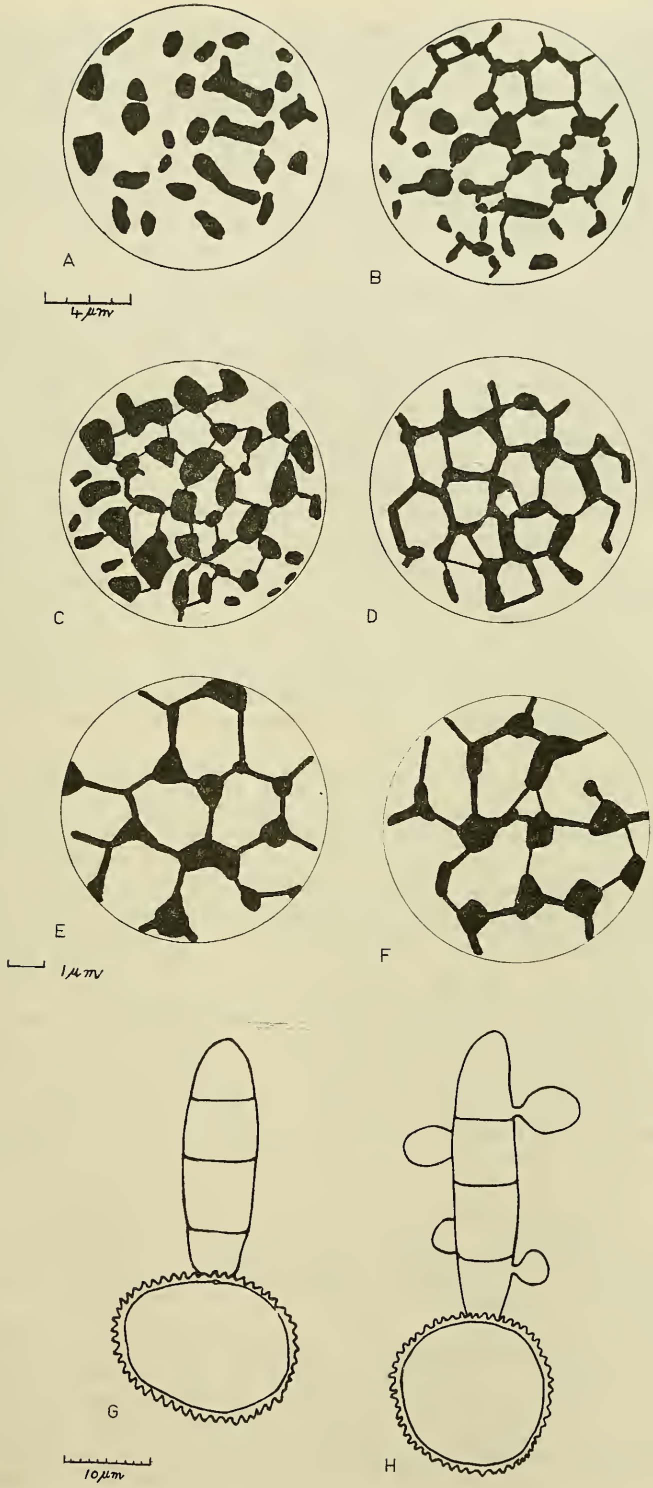
Explanation of Text-fig. 1.

Text-fig. 1.

Figs. A–D. Surface markings of *Ustilago cyperi-lucidi* spores, showing complete and incomplete reticulate patterns.

Figs. E–F. Details of reticulum.

Figs. G–H. Spores germinating by septate promycelium producing sporidia.


A
B
4 µm
C
D
E
F
1 µm
G
H
10 µm

Germination occurs within 24 hours when dry spores are sown on potato dextrose agar plates at room temperature (fluctuating 15°–21° C. during the test). A four-celled promycelium from 26–33 μm long and 5–9 μm wide is formed and each cell produces oval sporidia 7–10 × 4–6 μm (Plate x, Fig. E: Text-fig. 1, G–H).

Plants from the type collection have been grown on in the glasshouse. Basal shoots from infected parent plants gave rise to daughter plants with smutted florets, indicating that the smut systemically infects its host.

Relationship to Other Species

There are comparatively few species of *Ustilago* with a light coloured (yellowish brown to light reddish brown) spore powder. The seed smuts of Cruciferae (*Ustilago thlaspeos* (Beck) Lagerh. in Syd., and others) and of *Oxalis* spp. (*Ustilago oxalidis* Ell. and Tracy), and a few species on hosts in the families Juncaceae and Cyperaceae fall into this group. Nannfeldt (1959) suspects that the crucifer smuts and *U. oxalidis* show some relationship to those species of *Thecaphora* which have a pale spore powder. The pale reddish-brown colour of the spore powder in some sori of *U. cyperi-lucidi* is somewhat lighter than that seen in spore powders of *Thecaphora deformans* Dur. and Mont. in Tul. (DAR 11070: spore mass reddish-brown, Munsell 10R 4–6/10) and *T. seminis-convolvuli* (Desm.) Liro (DAR 13830: spore mass reddish-brown, Munsell 10R 4/8) but is very similar to that seen in a specimen of *U. oxalidis* (DAR 11080: pale reddish-brown, Munsell 2·5YR 6/12). In *U. cyperi-lucidi*, there is no sign of permanent spore balls or of spores ornamented only on one surface, or of other characteristics currently held for the genus *Thecaphora*. Spores of *U. cyperi-lucidi* are larger than those of *U. oxalidis* and *U. thlaspeos* and differ in ornamentation.

On the family Cyperaceae, Fischer and Holton (1957) list 111 species of smut fungi in 16 genera, and many other names occur in the literature. In Fischer and Holton's list there are only six species of *Ustilago* and one variety on hosts in this family and only one of these, *Ustilago subnitens* Schroter and P. Hennings, in Hennings (1896) resembles *U. cyperi-lucidi*. *U. subnitens* was described originally from Brazil on *Scleria* sp. near *S. pratensis* Lind., and has also been reported on *S. hispidula* Hochst. from Ethiopia by Zundel (1953). It was described as an ovary smut, and in his commentary Hennings (1896) states that only some florets in an inflorescence were infected. The sori remained long closed and were pale cinnamon in colour. The spores were described as subglobose to ellipsoidal, 12–18 × 10–15 μm, with a smooth yellowish-brown epispore. He stated that thin threads were sometimes present between the spores and attached to some of them. From the description, *U. subnitens* seems similar to *U. cyperi-lucidi*, differing in the smaller smooth spores. Unfortunately the type specimen is unavailable in Herb. B and was possibly lost during World War II (Dr. H. Scholz, personal communication). No specimens under the name *U. subnitens* were found in the National Fungus Collections at Beltsville, where Zundel's collections are kept (Dr. C. R. Benjamin, personal communication). Thus, no direct comparison of *U. subnitens* and *U. cyperi-lucidi* can be made. *U. cyperi-lucidi* does not resemble any other smut described on Cyperaceae.

On the family Juncaceae, there are three species of *Ustilago* with a yellowish-brown spore powder. These are *U. capensis* Rees on *Juncus* spp. in South Africa (Zundel, 1953), *U. vuyckii* Oudemans and Beijerinck in Oudemans (1895) on *Luzula* spp. in Europe and America (Fischer, 1953; Zundel, 1953) and *U. abstrusa* Malencon on *Juncus gerardii* Loisl. in France (Zundel, 1953). All have a yellowish to pale reddish brown spore powder, with reticulate spores in the range 14–24 μm in diameter. From the descriptions, they seem very similar to one another and to *U. cyperi-lucidi.*

Eight specimens of *U. vuyckii*, including the type collection, have been studied. The spore mass develops in the capsules of *Luzula* spp. and surrounds three small structures which may be ovule remnants. It is pale yellowish-brown to reddish-brown (Munsell 2·5YR 7/10 to Munsell 7·5YR 8/6) and is very similar to the darker shade seen in some sori of *U. cyperi-lucidi.* The spore mass in some sori is firmly agglutinated, but in others is granular to powdery. Spores are roughly spherical to globose, pale yellow in colour, (14) 16–20 (22) μm in diameter. They are strongly and regularly reticulate with roughly polygonal to hexagonal areolae 2–3 (3·5) μm across. In equatorial view, the reticulum is seen to project 2–3 μm above the spore surface (Plate x, Figs. C–D). Hyphal fragments are present in the sori, and many spores with one or two short hyaline hyphal fragments attached to them were seen. Some spores with a complete or partial, very thin (1 μm) hyaline sheath were seen, and this may be related to the method of spore development described for this species (Liro, 1924 ; Seyfert, 1927). Some immature spores inside hyphae were common in one specimen (Syd. Myc. germ. 2878). Spores were described by Oudemans (1895) as germinating by a simple or branched promycelium, 24 × 2–3 μm, which produced colourless elliptical to ovate sporidia 3·5 × 2·5 μm.

U. cyperi-lucidi is very similar to *U. vuyckii* in several respects. It differs mainly in its spore ornamentation, its smaller sporidia and its host family.

Specimens of *U. capensis* and *U. abstrusa* have not been seen. As described by Oudemans (1895) and Zundel (1938, as *Cintractia* ; 1953), *U. capensis* occurs on *Juncus* spp. in South Africa, and produces golden yellow powdery sori in the ovaries. Spores are globose, 15–16 μm diam., with a three-layered reticulate wall. Little else is known about it. *U. abstrusa* occurs on *Juncus gerardii* Lois. in France and produces powdery sori in the ovaries. Spores are yellowish, 16–22 × 15–20 μm, and reticulate, with areolae 2–2·5 μm across (Viennot-Bourgin, 1956, as *Cintractia*). Both seem to be closely related to *U. vuyckii*, which attacks plants in the same family.

The *Ustilago* spp. on Juncaceae discussed above were all transferred to the genus *Cintractia* by Ciferri (1931, pp. 56, 72) because of the presence in their sori of a columella. They do not fit into this genus as it is currently defined and are best left in *Ustilago.*

No smuts with light-coloured spores have been recorded previously in Australia on the families Cyperaceae or Juncaceae. Examination of the Australian collections of *Luzula* spp. and *Scleria* spp. in Herb. N.S.W. did not reveal the presence of any smuts. Brittlebank's (1937–1940) record of *Farysia olivacea* (DC.) H. and P. Syd. (as *Ustilago*) on *Cyperus lucidus* is based on a specimen of the smut on a species of *Carex* where the host was identified incorrectly (McAlpine, 1910, p. 158).

THE ORIGINAL COLLECTION OF *Cyperus lucidus*

The occurrence of a smut in several specimens identified as *Cyperus lucidus* prompted an examination of the original collection of this species. Some variation in the shape of the nut in *C. lucidus* has been suggested by some workers. In his monograph, Kükenthal (1935) describes the nut of the typical variety of *C. lucidus* as " obovata trigona obtusa " and lists only the original collection made by Robert Brown, No. 5884. The majority of collections listed from Queensland, New South Wales, Victoria and Tasmania he places as *C. lucidus* var. *sanguineo-fuscus* (Nees) Kükenth. and describes its nuts as "lineari-oblonga ". Willis (1962), in listing *C. lucidus* for Victoria, states " The most widely distributed variety, and only one represented in Victoria, has more remote glumes and comparatively narrower nuts than in the typical Port Jackson form; it is distinguished as var. *sanguineo-fuscus* (Nees, *ut* sp.) Kükenth.". Hooker (1858) describes the nut of *C. sanguineo-fuscus* Nees as " sharply trigonous, linear-obovate, acute, white, smooth " and lists two specimens. A duplicate of one of these, Gunn 956, in Herb. NSW has been examined and has healthy nuts as described by Hooker. At present, all specimens in Herb. NSW are filed under the name *C. lucidus*. The possibility that the wider nuts described for typical *C. lucidus* by some authors were in fact smutted was considered and an examination of Robert Brown's original collection was made.

Several florets from the type sheet in the British Museum (Natural History), and a duplicate sheet from the same collection in the Herbarium, Royal Botanic Gardens, Kew, were examined. On both sheets, two inflorescences were present. The British Museum specimen showed no nuts in one inflorescence and normal trigonous nuts in the other; the Kew specimen showed no nuts in one inflorescence, and smutted nuts in all florets of the other (Plate x, Figs. B, D). Robert Brown thus unknowingly collected this smut, and his original collection of *C. lucidus*, made in the Sydney-Newcastle area of N.S.W., consisted of a mixture of healthy and diseased inflorescences. The portion in the British Museum is healthy and can be used as lectotype in accordance with the recommendation made by Stearn (1960) for the selection of lectotypes of Brown's species. In nut shape, there is no difference between the BM specimen of *C. lucidus* and normal specimens of *C. lucidus* in Herb. NSW. Duplicates filed in other herbaria should be checked to see whether they are normal or smutted. The Kew specimen of *Ustilago cyperi-lucidi* in Robert Brown's gathering of *C. lucidus* is one of the earliest specimens of a plant-parasitic fungus from Australia.

SPECIMENS EXAMINED.

Ustilago cyperi-lucidi J. Walker—all on *Cyperus lucidus* R.Br.—QUEENSLAND: Buderim Mountain, C. T. White, April 1916, NSW 65047 (portion as DAR 19558).

NEW SOUTH WALES: Narrabri West, J. L. Boorman, June 1907, NSW 22730 (portion as DAR 16728); Walcha Road, Northern Tablelands, J. L. Boorman, Dec. 1912, NSW 65071 (portion as DAR 16731); in swamp, Brunswick Heads, B. G. Briggs 757, 25.v.1954, SYD without number (portion as DAR 17585); Upper Cudgegong River, E. of Olinda, 15 m. E of Rylstone, H. S. McKee, 10.i.1953, NSW 65074 (portion as DAR 16730); duplicate of same collection, SYD without number (portion as DAR 17584); Port Jackson, Robert Brown 5884, 1802–1805, Herb. K without number (sori and slides as DAR 17581); Five Crossings, Australian Capital Territory, N. T. Burbidge (Herb. Australiense 6579), 1.iv.1960, NSW 65079 (portion as DAR 16729); about 2500 ft. level, Clyde Mtn., R. Carolin B145, 21.iii.1957, SYD without number (portion as DAR 17586); property of R. Skellern, Wyndham, W. of Pambula, J. Hindle, 4.vi.1969, NSW 118232 (portion as DAR 17842); same locality, J. Hindle, 11.vii.1969, DAR 17587 (TYPE); China Wall, Tooma, E. J. McBarron, 4.i.1963, Herb. E. J. McBarron 7330 (portion as DAR 17731); same locality, E. J. McBarron, 4.i.1963, Herb. E. J. McBarron 7333 (portion as DAR 17730).

VICTORIA: Little River, Cathedral Range, near Taggerty, H. T. Clifford, 1950, MEL without number (portion as DAR 17583).

Ustilago vuyckii Oud. and Beijr. in Oud.—NETHERLANDS: near Voorschoten, L. Vuyck, 22.v.1894, on *Luzula campestris*, Herb. L, TYPE, (slide as DAR 19759); Keukenhof, L. Vuyck, 31.v.1894, on *L. campestris* Herb. L (slide as DAR 19760).

GERMANY : Sydow, Mycotheca germanica 2878, Brandenburg, near Kähnsdorf, E. Fahrendorff, June 1933, on *L. campestris*, Herb. L 937.56–90 (slide as DAR 19763) ; Sydow, Myc. germ. 3264, Brandenburg, Tiefensee near Werneuchen, H. Sydow, 10.v.1939, on *L. pilosa*, Herb. L 942.57–77 (slide as DAR 19761) ; Sydow, Myc. germ. 3265, Brandenburg, Hangelsberg, E. Fahrendorff, 18.v.1939, on *L. pilosa*, Herb L 942.57–30 (slide as DAR 19762) ; Sydow, Ustilagineen 311, Marienspring, P. Sydow, 6.vi.1904, on *L. pilosa*, Herb. L 910.253–449 (slide as DAR 19765).
SWEDEN : Fjellnäs in Herjedalia, G. V. Lagerheim, July 1897, on *L. pilosa*, Herb. L (slide as DAR 19766) ; duplicate of last collection, Sydow Ustilagineen 217, Herb. L 910.253–438 (slide as DAR 19764).

Ustilago oxalidis Ell. and Tracy—UNITED STATES OF AMERICA : on *Oxalis stricta*. Park Lane, Virginia, W. H. Long, 1911, DAR 11080 (duplicate of BPI 3863),

Thecaphora deformans Dur. and Mont. in Tul.—UNITED STATES OF AMERICA : on *Desmodium nudiflorum*, Virginia Polytechnic Institute, Montgomery Co., Virginia, A. B. Massey, 4.xi.1941, DAR 11070 (duplicate of BPI 71541).

Thecaphora seminis-convolvuli (Desm.) Liro—RUMANIA : on *Convolvulus arvensis* L., near Odorhei, Transylvania, K. Vanky Ust. 3, 8.ix.1956, DAR 13830.

Cyperus lucidus R. Br.—NEW SOUTH WALES : Port Jackson, Robert Brown 5884, 1802–1805, Herb. BM (lectotype). The collections of *Cyperus lucidus* in Herb. NSW were examined but the healthy collections are not listed in detail.

The Australian collections of *Scleria* spp. and *Luzula* spp. in Herb. NSW were also examined.

DISCUSSION

The genus *Ustilago* is the largest single genus of the Ustilaginales, with about one-quarter of the described species in it (Fischer and Holton, 1957). In proportion, the genus is poorly represented on the host family Cyperaceae. Few smuts have been recorded on Australian Cyperaceae, and *Ustilago cyperi-lucidi* is the first species of *Ustilago* recorded on the family in Australia. It occurs in eastern Australia from southern Queensland to Victoria, and may occur over a wider range. Its detection in the field would be difficult, and all collections of it made up to the present have been detected initially only by a detailed examination of inflorescences in botanical specimens.

Ustilago cyperi-lucidi causes a subtle distortion of infected plants. Nuts are altered in shape and this affects the appearance of the florets. It is possible that the alteration of the shape of the nuts by the smut in some collections of *C. lucidus* has been partly responsible in the past for varieties with narrow and wide nuts being distinguished. Systemic infection could result in the persistence of diseased plants in a locality and in these individuals retaining their characteristic appearance. A similar infection by a smut (DAR 6971 and others) has been found in N.S.W. on species in the *Restio gracilis* complex and on *R. dimorphus* R. Br. (Johnson and Evans, 1963). In this case, characters of the inflorescence were altered and, in the past, manuscript names, as varieties, had been given to some diseased specimens. The occurrence of *U. cyperi-lucidi* in portion of Robert Brown's original gathering of *C. lucidus* also points to the potential hazard of inconspicuous diseases in botanical taxonomy.

From the description, the smut of *Scleria* spp. described from Brazil as *Ustilago subnitens* is the species which most resembles *U. cyperi-lucidi*. No specimens of *U. subnitens* were available for study, and its exact relationship to the present species cannot be determined. The pale-spored smuts of Juncaceae are also very similar to *U. cyperi-lucidi*, differing in details of spore ornamentation and host family.

The method of spore development in *U. cyperi-lucidi* has not been studied, but the attachment of hyphal fragments to the spores and their presence in the sori is very similar to that seen in several specimens of *U. vuyckii*. Spore formation in chains in hyphae and the development of clamp connections have been reported for *U. vuyckii* (Liro, 1924 ; Seyfert, 1927) and a study of spore development in *U. cyperi-lucidi* would be of value in establishing its relationship to other species.

Note on the Spelling " Vuyckii "

Most authors who have mentioned *Ustilago vuyckii* have used the spelling " *vuijckii* " for the specific epithet. This spelling also occurs on the labels of some exsiccati of this species (Sydow, Mycotheca germanica 3264 and 3265). The spellings " *vuijckii* " and " *vuyckii* " both occur in Oudemans' (1895) original paper, but on the type packet it is spelt " *vuyckii* ". As the fungus was named after its collector, L. Vuyck, the correct spelling is " *vuyckii* ". I am grateful to Dr. R. A. Maas Geesteranus for confirming this opinion. The confusion in spelling may have arisen from the difficulty with some handwriting in distinguishing between " y " and " ij ".

Acknowledgements

I am indebted to Mr. O. D. Evans, National Herbarium of New South Wales, for bringing this smut to my notice and for comments on the taxonomy of *Cyperus* spp. ; to Mr. J. Hindle, District Agronomist, Bega, for collecting living infected plants ; to Mr. E. McBarron, Veterinary Research Station, Glenfield, for allowing me to examine specimens of *Cyperus lucidus* from his private herbarium ; to Mr. J. H. Willis, National Herbarium of Victoria, for lending specimens of *C. lucidus* ; to Mr. R. Ross, British Museum (Natural History), for florets from and a photograph of the lectotype of *C. lucidus* ; to the Director, the Herbarium, Royal Botanic Gardens, Kew, for lending a duplicate of Robert Brown's original collection of *C. lucidus* ; to Dr. R. A. Maas Geesteranus, Rijksherbarium, Leiden, for lending collections of *Ustilago vuyckii* ; to Dr. H. Scholz, Botanischer Garten und Museum, Berlin-Dahlem, and Dr. C. R. Benjamin, National Fungus Collections, Beltsville, for searching for specimens of *Ustilago subnitens* ; and to Mr. A. Searle, Biological and Chemical Research Institute, Rydalmere, for taking the photographs.

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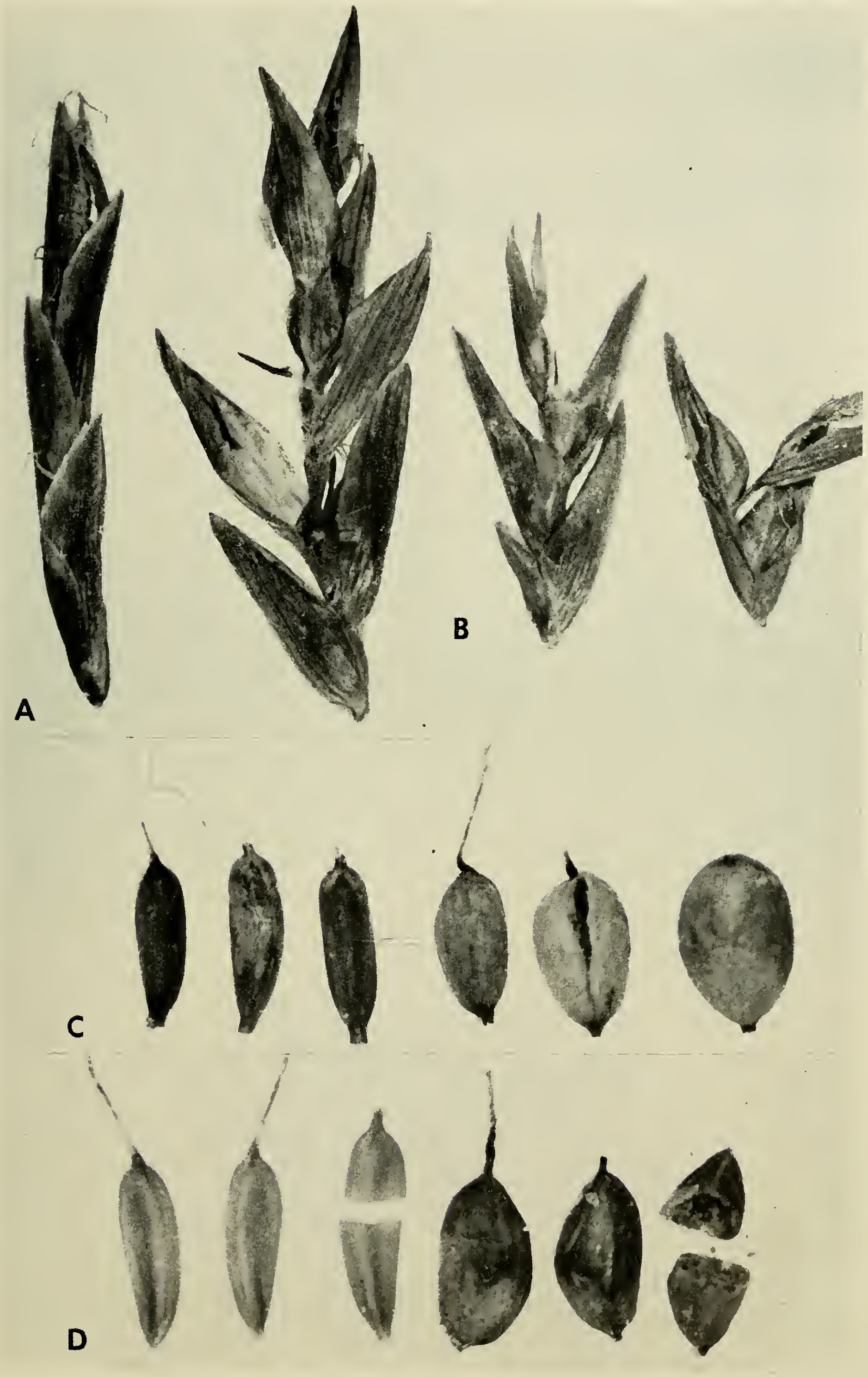
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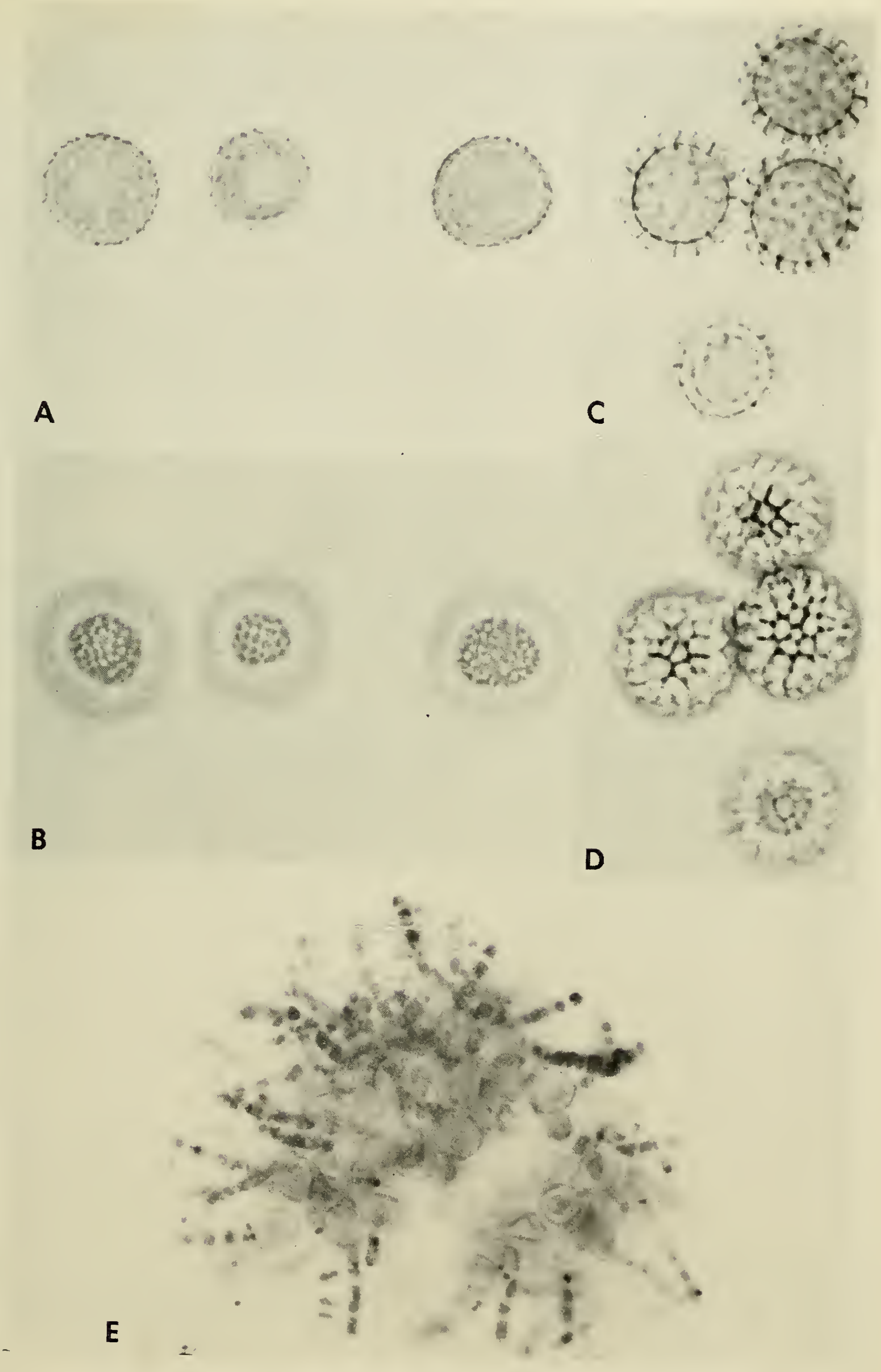
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EXPLANATION OF PLATES

PLATE IX

Ustilago cyperi-lucidi on *Cyperus lucidus*. A, left, healthy florets ex NSW 77363 ; right, smutted florets ex NSW 22730, ×8. B, smutted florets from Robert Brown 5884 ex K, ×8. C, left, three normal nuts ex NSW 77363 ; right, three smutted nuts ex NSW 22730, ×13. D, left, three normal nuts from Robert Brown 5884, ex BM : right, three smutted nuts from Robert Brown 5884 ex K, one cut to show spore mass, ×13.

PLATE X

A–B, *Ustilago cyperi-lucidi*, equatorial and surface views of spores showing fine reticulum and irregular markings ex DAR 17587a, ×1,000. C–D, *Ustilago vuyckii*, equatorial and surface views of spores, showing coarser regular reticulum, ex TYPE in Herb. L, ×1,000. E, *Ustilago cyperi-lucidi*, germinating spores with septate promycelium and sporidia, ex DAR 17587a, ×400.

SHOOT BLIGHT OF *EUCALYPTUS* SPP. CAUSED BY AN UNDESCRIBED SPECIES OF *RAMULARIA*

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(Plates XII, XIII)

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Synopsis

Ramularia pitereka n. sp. which causes a shoot blight and leaf spot of young plants of *Eucalyptus* spp. is described. It has been found only in eastern New South Wales on plants growing in nurseries and glasshouses. Inoculation tests and observations in nurseries indicate that only *Eucalyptus* spp. in the series Corymbosae-Peltatae of Blakely are susceptible. *Angophora costata* seedlings have been artificially infected. The possibility that this may have some taxonomic significance in the two host genera is mentioned. A possible relationship between *R. pitereka* and the canker fungus of *Eucalyptus ficifolia* in Western Australia is discussed.

Introduction

A shoot blight of *Eucalyptus* seedlings has been known in New South Wales for at least fifteen years. The only published information on it reports an outbreak in the N.S.W. Forestry Commission's nursery at West Pennant Hills in the autumn, winter and spring of 1960, and states : " An unidentified fungus was found causing severe blighting of the young shoot of seedlings of *E. maculata* and over 50% of some plantings of this species had been lost through the disease. The same fungus was found on a few seedlings of *E. eximia* " (N.S.W. Department of Agriculture, 1961). The disease was almost certainly described earlier than this by Mrs. J. de Bavay (personal communication) in notes she prepared in 1955. She observed a shoot blight on *Eucalyptus maculata* Hook. seedlings growing in a Sydney glasshouse and described it as follows : " Distortion was considerable in the young leaf and shoot tissue, in the infected zones. Scattered irregular necrotic areas appeared, over which a greyish white waxy bloom developed, due to the converging of masses of individual minute erumpent conidial pustules, each about ⅓ to ½ mm. in diameter." This is very similar to the disease described below.

Forestry officers have noticed the disease for several years on young plants in nurseries. It has been seen only on plants over three months old and, if not controlled by spraying, can kill or severely damage them. Although more common in spring and autumn, it has been collected throughout the year in nurseries, but has not been found on plants in the field.

Recent work has shown that the causal fungus is a previously undescribed species of *Ramularia*, which is described below. Standard abbreviations as given by Lanjouw and Stafleu (1964) are used in citing specimens in various herbaria.

Description

Ramularia pitereka sp. nov. (etym., *pitereka*, alba, in lingua aboriginum Australiae).

Pustulae in surculis juvenilibus tortis albae, confertae, usque ad 100 μm diametro, in caulibus erumpentes, in foliis praecipue hypophyllis et ex stomatibus orientes. Conidiophora in strato denso, cum stromate basali hyalino ex hyphis intertextis constata ; stromata 15–50 μm crassa. Conidiophora hyalina, usque ad 50 µm longa, 2–2·5 µm lata, plerumque cicatricibus numerosis parvis praedita, saepe geniculata, in regione cicatricum non septata. Conidia acrogena, levia, non septata, formae valde variabilis, plerumque clavata vel elongato-clavata, saepe cylindrica vel anguste pyriformia, conidia minoria saepe obclavata vel ovalia, (5) 6–17 (20) × 2·5–5 (6·5) µm, in catenis brevibus interdum portata, cicatrice vel basali vel in quoque extremo praedita, per hypham simplicem vel per

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cuticle and eventually rupturing it. The erumpent white pustules are up to 100 µm in diameter and closely packed on the diseased area (Plate XI, Fig. B). Some fusion between neighbouring pustules may occur during their development. On leaves, spots range from 1 mm. to 2 mm. in diameter up to large irregular areas which often develop along one edge and result in twisting and distortion of the leaf (Plate XI, Figs. C–E). Large infected areas often develop along the mid-vein (Plate XI, Fig. C). Spots are brown with a thin reddish-purple margin. Sunken brown lesions up to 1·5 cm. long have been seen on petioles and stems, especially on *Eucalyptus ficifolia* F. Muell. (Plate XI, Fig. F). Sporulation occurs abundantly on all diseased tissues; on leaf spots it is more prominent on the abaxial surface.

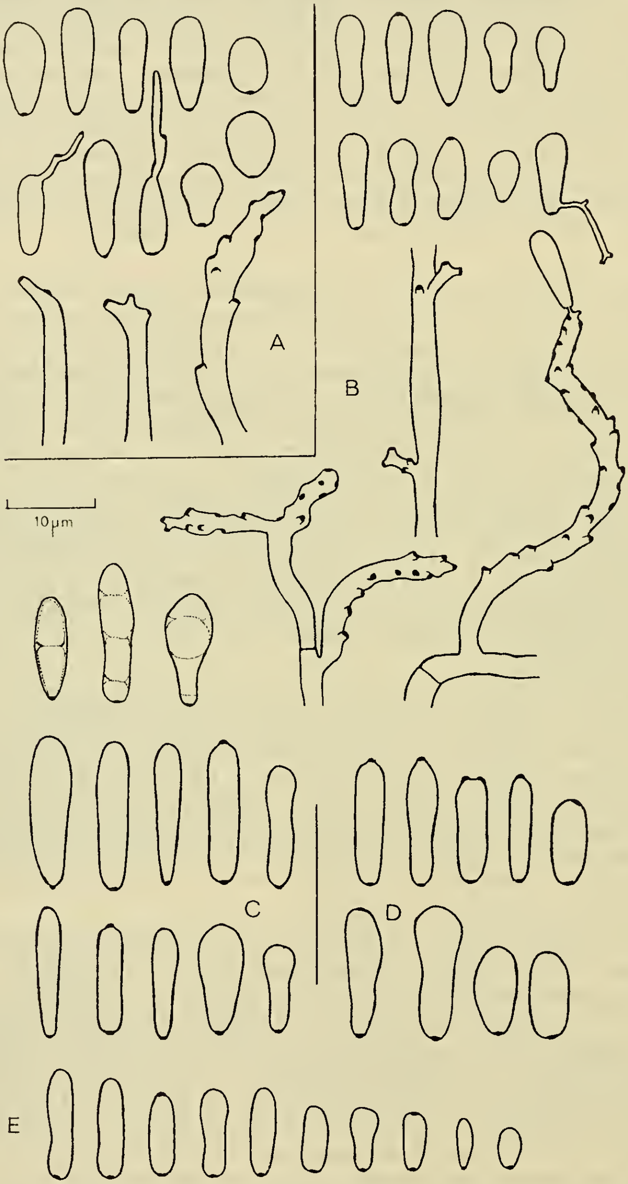
CORRIGENDA

P. 109.—*For* Plate XI, *read* Plate XII.
For Plate XII, *read* Plate XIII.
P. 110.—*For* Plate XII, *read* Plate XIII.
P. 111.—*For* Plate XII, *read* Plate XIII.
P. 115.—*For* Plate XI, *read* Plate XII.
For Plate XII, *read* Plate XIII.

Pustules are composed of a dense layer of conidiophores borne on a plectenchymatous stroma up to 50 µm thick, which develops in the host tissue (Plate XII, Fig. B). On shoots, the pustules rupture the epidermis and the thick cuticle, and are separated by their fragments; on leaves, they are mainly hypophyllous and the conidiophores emerge in clusters through the stomates from a sub-stomal stromata. Conidiophores are hyaline, up to 50 µm long and 2–2·5 µm wide, and non-septate. Older conidiophores have many spore scars (up to 14 or more), especially along the upper half, and are often prominently geniculate (Plate XII, Fig. E; Text-fig. 1, A and B).

Conidia are borne singly at the tip of the conidiophore which grows on around the scar. The distance between scars is often very short, so that several conidia may appear clustered on a short length of conidiophore. Conidia are hyaline, smooth, strongly vacuolate, very variable in size and shape, generally clavate to elongated-clavate, often cylindrical to narrowly pyriform, smaller ones obclavate to oval, and measure (5) 6–17 (20) × 2·5–5(6·5) µm (Plate XII, Figs. C–E; Text-fig. 1). Whilst conidia on all hosts are variable in size and shape, there is a tendency for slight variations between hosts to occur. For example, many conidia from *E. maculata* are slightly longer and more regularly clavate than the somewhat shorter and more variable spores from *E. eximia* Schau. They often form short chains and have either a basal spore scar or scars at each end. Conidia sometimes germinate in the pustule, and they often form short secondary conidiophores bearing small secondary conidia (Text-fig. 1, A). Germination usually occurs by one to two germ tubes anywhere on the spore, except that germination through the scar has not been seen.

On agar media, colonies are white, raised in the centre and when older, often wrinkled by fine radial folds (Plate XII, Fig. A). They are covered with an abundant dry growth of conidiophores and conidia. Conidiophores are of indeterminate length. Spore-bearing areas up to 120 μm long have been seen



Text-fig. 1. A–D, *Ramularia pitereka* conidia and conidiophores. A, from *Eucalyptus eximia* (DAR 19773), two conidia showing secondary conidiophores. B, from culture ex DAR 19773, showing types of conidiophore development, and three spores with vacuolate contents. C, from *E. maculata* (DAR 19769), natural infection. D, from *E. maculata* (DAR 19770), artificial inoculation. E, " *Sporotrichum destructor* " spores from IMI 7368.

and often several zones of scars occur along a conidiophore. Because of these zones of sporulation, conidia appear to be borne in clusters of varying size along the conidiophore. The arrangement of scars on the conidiophore is very similar to that described and illustrated by Hughes (1951, Fig. 2, E) for *Acrotheca acuta* Grove in culture. Often, conidiophores are branched and, apart from the spore scars, are very similar to vegetative hyphae. Conidia from all hosts are similar in culture and show a similar variability in shape to those from infected plants, but are generally slightly smaller, measuring (4) 5–13 (16) × (2·5) 3–5 (6) μm. Short chains are often formed (Plate xii, Fig. C ; Text-fig. 1).

ISOLATION AND GROWTH IN CULTURE

Ramularia pitereka is isolated easily from spores. It grows slowly on potato dextrose and malt agars and has an optimum temperature for radial growth between 20° and 25° C. After 24 days, colonies on malt agar are 12 mm. in diameter at 25° C. and 6 mm. in diameter at 30° C. No growth occurs at 35° C. and growth is very slight at 5° C., colonies being only 2 mm. in diameter after 45 days. Colonies are white above and pale cream below. In cultures three to four months old, colonies often develop a faint cream to pink tint, and the medium is slightly darkened.

INFECTION AND HOST RANGE

Artificial inoculations were carried out on a range of species of *Eucalyptus* and on *Angophora costata* (Gaertn.) Druce. Conidia from cultures were suspended in sterile water and applied with a fine brush to young shoots of seedlings in the glasshouse. Plants were kept in a humid atmosphere for 24 days after inoculation and then placed on the glasshouse bench. The characteristic symptoms of the disease and sporulation of the fungus were seen usually within three to four weeks of inoculation. The range of species tested and the results obtained are shown in Table 1.

TABLE 1

Reaction of Seedlings of Eucalyptus *and* Angophora *to Inoculation with* Ramularia pitereka

Section*	Series	Species	Number Inoculated	Number Infected
Macrantherae	Corymbosae-Peltatae	*E. eximia* Schau.	10	9
		E. ficifolia F. Muell.	10	10
		E. maculata Hook.	10	10
	Transversae	*E. longifolia* Link and Otto	10	0
		E. punctata DC.	10	0
	Exsertae	*E. camaldulensis* Dehn.	10	0
Macrantherae (Normales)	Globulares	*E. bridgesiana* R. T. Bak.	10	0
		E. pulverulenta Sims	10	0
Renantherae (Normales)	Pseudo-stringybarks	*E. pilularis* Sm.	10	0
	Pachyphloiae	*E. caliginosa* Blakely and McKie	10	0
Porantheroideae (Normales)	Buxeales	*E. albens* Benth.	10	0
Terminales	——	*E. sideroxylon* A. Cunn. ex Woolls	10	0
Platyantherae	Subulatae	*E. flocktoniae* Maiden	10	0
——	——	*Angophora costata* (Gaertn.) Druce	20	15

* The *Eucalyptus* spp. are arranged according to the sections and series given by Blakely (1965) and their nomenclature follows Johnston and Marryatt (1965).

In these tests the only *Eucalyptus* spp. attacked were in Blakely's (1965) series Corymbosae-Peltatae. Several plants of *Angophora costata* were also infected. The significance of these results is discussed below.

POSSIBLE RELATIONSHIP TO CANKER FUNGUS OF *EUCALYPTUS FICIFOLIA*

Possibly closely related to *R. pitereka* is the fungus that causes canker disease of adult trees of red-flowering gum (*E. ficifolia* F. Muell.) in Western Australia. Little has been published about this organism. In 1936 Mr. H. A. Pittman, then Government Plant Pathologist, reported on a canker disease of *E. ficifolia* in Western Australia (Anon., 1936). It had apparently been known for some years before this (Beard, 1963 ; Cass Smith, 1970), but Pittman was the first to isolate the causal fungus and suggest control measures. At the time he also sent a culture to the Commonwealth Mycological Institute. Subsequently, the fungus was referred to in various publications as " *Sporotrichum destructor* Pittman ". MacNish (1963) lists it as " *Sporotrichum destructor* Pittman n. sp." and in a footnote states " pathogen named 1936 ". Later authors dealing with canker have used this name (Beard, 1963 ; Cass Smith, 1970) or have referred to the disease as *Sporotrichum* canker (Pryor and Willing, 1963).

The name " *Sporotrichum destructor* " has never been validly published, and no description of the fungus has been found in the literature. Mr. Pittman (personal communication) wrote that, whilst he proved its pathogenicity and tentatively referred to it as *Sporotrichum*, he did not call it " *S. destructor* ". However, a description under this name has been obtained from Mr. H. L. Harvey, of the Department of Agriculture, Perth, Western Australia. This description, dated 20.x.1936, came from files of correspondence with the Commonwealth Mycological Institute, and was prepared there by Mr. E. W. Mason (F. C. Deighton, personal communication). It describes the fungus in culture. Colonies are described as " floccose, then powdery, finally showing radiating striations ", at first white and later pinkish-buff in colour. The fertile hyphae are described as " usually long (up to 150 μ), more rarely lateral and shorter, unbranched, cylindrical, typically straight and bearing in a stellate manner a single whorl, or occasionally a spiral of a few (up to 10) conidia, sometimes gently bent and provided with two or even more verticills or spirals. Conidia hyaline, cylindrical or oblong, rounded at both ends, 0-septate, sessile (that is—without sterigmata), 6–8 μ long, 2 to 2·5 μ broad."

The only specimen filed under the name " *Sporotrichum destructor* " at the Commonwealth Mycological Institute has been examined. It is a dried malt agar culture, light buff (Ridgeway, 1912) in colour, now showing as a fairly compact felted mat of hyphae on the dried agar. Abundant hyaline, unicellular conidia are present. They are variable in shape, cylindrical to clavate, with smaller conidia oval to obovate, measuring (2·5) 3–10 (12·5) × (2) 2·5–3·5 (4) μm, and have an indistinct spore scar at one end. Evidence of chain formation was present as some spores had a scar at each end. Conidiophores could not be clearly distinguished, but some fragments with probable indistinct spore scars were seen. In some cases, clusters of conidia were seen around probable conidiophores.

The spores from this specimen are smaller than those of *R. pitereka* in culture. From Mr. Mason's description, its cultural characters and some aspects of its conidiophore and conidium morphology are similar to those of *R. pitereka*, but until it can be studied from fresh specimens, its identity remains uncertain.

SPECIMENS EXAMINED

Ramularia pitereka J. Walker and A. L. Bertus—NEW SOUTH WALES : on *Eucalyptus eximia* Schau., in nursery, Forestry Commission of N.S.W., West Pennant Hills, A. L. Bertus and J. Walker, 3.vi.1970, DAR 19773 (type) (portion filed as IMI 151369); same locality, J. Walker, 18.xi.1960, DAR 6469; same locality, A. L. Bertus, 5.v.1970, DAR 20366; artificial inoculation, glasshouse, Department of Agriculture, Rydalmere, A. L. Bertus, 15.xi.1967, DAR 19771. On *Eucalyptus ficifolia* F. Muell., in nursery, Forestry Commission of N.S.W., West Pennant Hills, A. L. Bertus and J. Walker, 3.vi.1970, DAR 20361. On *Eucalyptus maculata* Hook., in nursery, Forestry Commission of N.S.W., West Pennant Hills, J. Walker, 30.vi.1960, DAR 5867a; in commercial nursery, Beverley Hills, J. Stronach, 24.ii.1967, DAR 19768; same locality, J. Stronach, 28.ii.1967, DAR 19769 (portion filed as IMI 151368); artificial inoculation, glasshouse, Department of Agriculture, Rydalmere, A. L. Bertus, 15.xi.1967, DAR 19770; in commercial nursery, Glenhaven, A. L. Bertus, 5.xi.1970, DAR 20468. On *Angophora costata* (Gaertn.) Druce, artificial inoculation, glasshouse. Department of Agriculture, Rydalmere, J. Walker, 16.xi.1970, DAR 20469.

" *Sporotrichum destructor* "—Western Australia: in dried malt agar culture, H. A. Pittman, 1936, IMI 7368 (slides filed as DAR 20410). On *Eucalyptus ficifolia* F. Muell., King's Park, Perth, L. Harvey, Sept., 1970, DAR 20409 (cankers only, no fungus seen).

Discussion

No previous description of a species of *Ramularia* on hosts in the family Myrtaceae has been found. Most species of *Ramularia* occur on herbaceous hosts and generally cause comparatively minor damage such as leaf spots and blotches. *R. pitereka* occurs on young growth of woody hosts and causes more severe damage than is usually seen with many other *Ramularia* spp. Whilst comparatively few species of *Ramularia* have been studied in culture, those that have generally shown sparse sporulation on artificial media; however, *R. pitereka* produces abundant spores in culture.

In the limited inoculation tests carried out so far only *Eucalyptus* spp. in the series Corymbosae-Peltatae of Blakely (1965) have been susceptible. The species used have also been arranged (Table 2) according to a new classification and coding of the genus (Pryor and Johnson, 1971) and in this system all the susceptible species fall into the subgenus C *Corymbia*. The one species of *Angophora* tested, *A. costata*, was experimentally infected. It is possible that this may have some taxonomic significance in the two host genera, and tests on a wider range of species will be carried out. The affinity in essential oil and certain morphological characters between species of *Eucalyptus* in the above and related series and the genus *Angophora* has been pointed out previously (Baker and Smith, 1920).

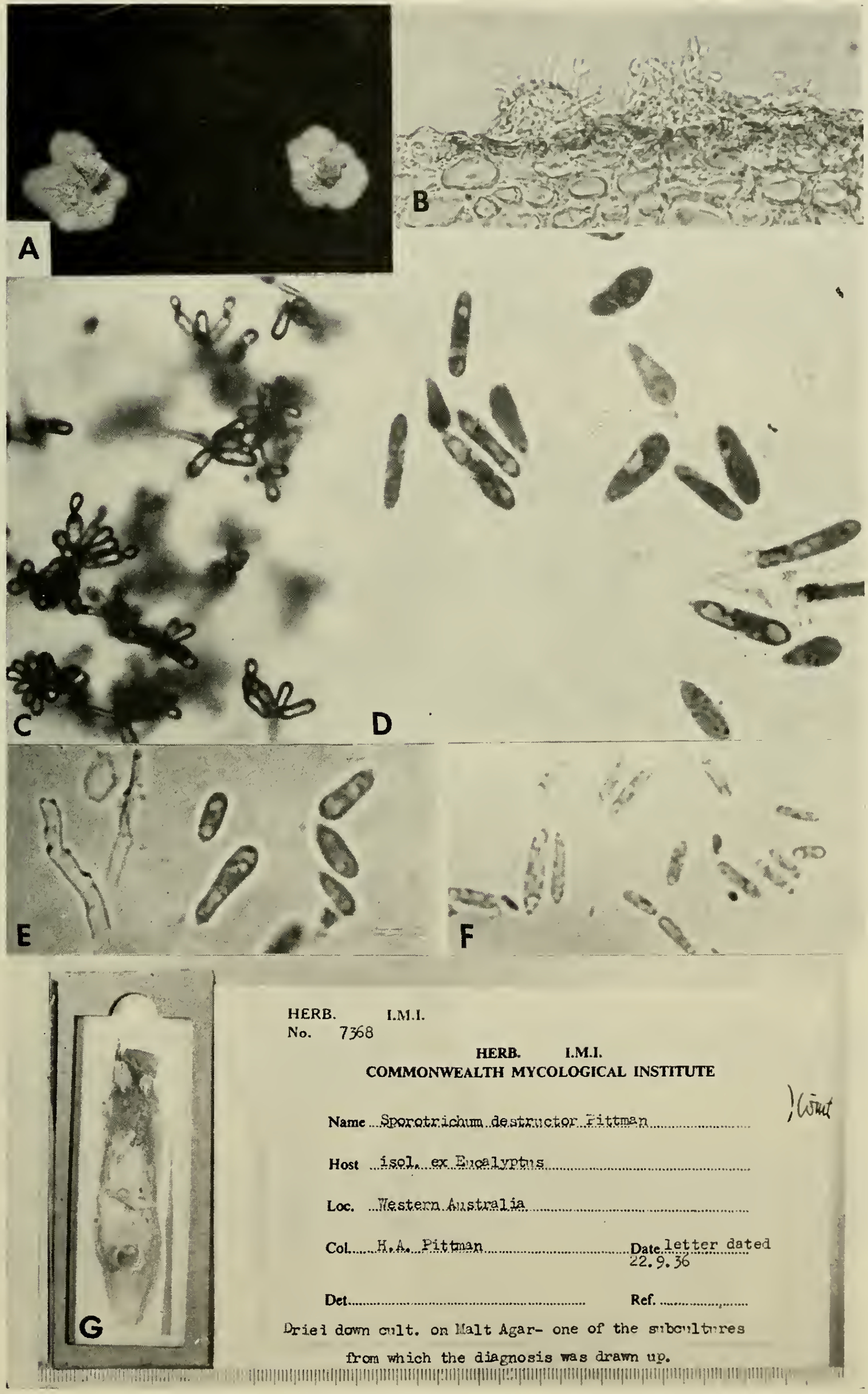
Finally, *R. pitereka* may be the same as the undescribed fungus causing canker of red-flowering gums in Western Australia, and referred to in the literature as " *Sporotrichum destructor* Pittman ". If so, it may have been introduced into eastern Australia from the west. Cass Smith (1970) indicates that in Western Australia the disease occurs naturally on *Eucalyptus calophylla* R. Br. ex Lindl., and that infections on cultivated *E. ficifolia* probably originated from naturally infected *E. calophylla*. So far, no plants infected with *R. pitereka* have been found in nature in N.S.W. Cass Smith (1970) also lists *E. haematoxylon* Maiden as another host of the canker fungus. All the known hosts of " *Sporotrichum destructor* " thus occur in Blakely's series Corymbosae-Peltatae (or subgenus C *Corymbia* in Pryor and Johnson's (1971) classification), and this provides a further indication of a possible relationship between the canker fungus and *R. pitereka*.

TABLE 2

Species of Eucalyptus *and* Angophora *Arranged According to the Classification and Coding of Pryor and Johnson (1971)*

Subgenus		Section		Series		Subseries		Species Code	Species
C	Corymbia	CA	Rufaria	CAF	Gummiferae	CAFO	Ficifolinae	CAFOA	*E. ficifolia* F. Muell.
		CA	Rufaria	CAF	Gummiferae	CAFU	Gummiferinae	CAFUA	*E. calophylla* R. Br. ex Lindl.
		CC	Ochraria	CCA	Eximiae		——	CCA:E	*E. eximia* Schau.
		CC	Ochraria	CCC	Maculatae		——	CCC:B	*E. maculata* Hook.
S	Symphyomyrtus	SE	Transversaria	SEC	Salignae	SECG	Longifolinae	SECGA	*E. longifolia* Link and Otto
						SECE	Punctatinae	SECED	*E. punctata* DC.
		SI	Bisectaria	SIT	Oleosae		——	SIT:T	*E. flocktoniae* Maiden
		SN	Exsertaria	SNE	Tereticornes	SNEE	Tereticorninae	SNEEP	*E. camaldulensis* Dehn.
		SP	Maidenaria	SPI	Viminales	SPID	Bridgesianinae	SPIDC	*E. bridgesiana* R. T. Bak.
						SPIN	Cordatinae	SPINQ	*E. pulverulenta* Sims
		SU	Adnataria	SUL	Moluccanae		——	SUL:G	*E. albens* Benth.
				SUX	Melliodorae		——	SUX:I	*E. sideroxylon* A. Cunn. ex Woolls
M	Monocalyptus	MA	Renantheria	MAI	Pilulares	MAIA	Pilularinae	MAIAA	*E. pilularis* Sm.
				MAH	Capitellatae	MAHE	Eugenioideinae	MAHED	*E. caliginosa* Blakely and McKie
A	*Angophora* (genus)	AA	Lemuria	AAA	Costatae	AAAD	Costatinae	AAADA	*Angophora costata* (Gaertn.) Druce


A
C
B
D
E
F



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COMMONWEALTH MYCOLOGICAL INSTITUTE

Name Sporotrichum destructor Pittman } Cont

Host isol. ex Eucalyptus

Loc. Western Australia

Col. H.A. Pittman Date letter dated 22.9.36

Det. Ref.

Dried down cult. on Malt Agar- one of the subcultures from which the diagnosis was drawn up.

ACKNOWLEDGEMENTS

We are indebted to Mr. D. J. Hartigan, Forestry Commission of N.S.W., and to the officers at the Forestry Nursery, West Pennant Hills, for providing information on the disease and specimens. Mrs. J. de Bavay, of Armidale, N.S.W., made available her early observations and Mr. H. A. Pittman, Upper Hawthorn, Victoria, provided valuable information on his work with " *Sporotrichum destructor* ". We thank Mr. F. C. Deighton and Dr. M. B. Ellis, of the Commonwealth Mycological Institute, for comments on these fungi and lending the specimen of " *S. destructor* ". Mr. L. Harvey, Officer-in-charge, Plant Pathology Branch, Department of Agriculture, Perth, sent us information on canker disease and provided a canker specimen, and Mr. L. A. S. Johnson, National Herbarium of N.S.W., sent seed of species of *Eucalyptus* and *Angophora* and information on their classification. Professor L. D. Pryor and Mr. Johnson allowed us to quote from their new classification and coding of the genus *Eucalyptus*. The photographs were taken by Mr. A. Searle, Department of Agriculture, Rydalmere.

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EXPLANATION OF PLATES

PLATE XI

Ramularia pitereka on *Eucalyptus* spp. A, B, on *E eximia* (DAR 19773) showing shoot symptoms and white pustules. C, D, E, on *E. maculata* (DAR 5867a) showing shoot blight and leaf spotting and distortion. F, on *E. ficifolia* (DAR 20361) showing stem lesion. A, C, D, E, slightly less than natural size. B, ×3·5. F, ×2.

PLATE XII

A–E, *Ramularia pitereka*. A, colonies 24 days old, on potato dextrose agar (natural size). B, young pustules on *E. eximia* shoots, ×288. C, spores in culture, some forming short chains, ×400. D, spores from *E. maculata* (DAR 19769), ×1,000. E, spores and fragment of conidiophore from *E. eximia* (DAR 19773), ×1,000. F, G, " *Sporotrichum destructor* " (IMI 7368), spores (×1,000) and specimen (scale in mm.).

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THE REACTION OF SEEDLINGS OF *CITRUS* SPP. AND RELATED GENERA TO *PHYTOPHTHORA CITROPHTHORA*

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[Accepted for publication 23rd June 1971]

Synopsis

Varieties and selections of *Citrus* and related genera were inoculated with *Phytophthora citrophthora* to determine their resistance to root and collar rots.

Poncirus trifoliata and its hybrids, *Microcitrus australis* and *Severinia buxifolia*, were highly resistant to stem inoculations of *P. citrophthora* ; mandarins were intermediate in susceptibility, while Rangpur lime, sweet orange varieties, Smooth Seville and rough lemon were highly susceptible. Smooth Seville is moderately resistant to root rot. Ruby Blood 3118 and Parramatta orange 3443 were more resistant to Phytophthora root rot than other sweet orange selections tested.

Of 150 clones of *Poncirus trifoliata*, all were uniformly and highly resistant to Phytophthora root rot.

INTRODUCTION

Phytophthora citrophthora (Sm. and Sm.) Leon, which causes root and collar rots, is one of the most destructive pathogens of citrus in New South Wales. The use of resistant rootstocks offers an excellent means of reducing the losses from root rot, and the resistant rootstock *Poncirus trifoliata* (L.) Raf. is widely used in New South Wales. However, it grows poorly in highly acid, highly alkaline or saline soils and is unsuitable for use as a rootstock for Eureka lemons (*Citrus limon* (L.) Burm. f.) because of its susceptibility to exocortis virus (scalybutt), which many old-line lemons carry. There is also an incompatibility factor which causes a bud-union weakness (Nauriyal *et al.*, 1958) with " Eureka " lemons. Therefore, an alternative Phytophthora-resistant stock without these disadvantages is needed and has been sought over a number of years.

Field behaviour of citrus stock-scion combinations in root rot-liable soils is difficult to assess on the basis of laboratory, glasshouse or small field plot testing. Factors other than the intrinsic susceptibility of the rootstock to rotting of roots are involved. The reaction to *Phytophthora* spp. of the scion, the regenerative ability of the stock, the level and type of nutrition, and possibly other factors may modify this and the final assessment must be made on long-term field behaviour. However, initial screening can only be made on the basis of the amount of disease resulting from inoculation, and several methods have been employed to arrive at a satisfactory rating.

Two species of *Phytophthora* are capable of causing root and collar rots of citrus, *P. citrophthora* and *P. nicotianae* (B. de Haan) var. *parasitica* (Dast.) Waterh. Their relative importance is dictated by temperature, *P. citrophthora* being the prevalent species at lower temperatures and *P. nicotianae* var. *parasitica* at higher temperatures. In New South Wales *P. citrophthora* is the predominant species. *P. nicotianae* var. *parasitica* is only rarely seen, and is restricted to the warmer parts of the central and north coast.

The resistance of citrus species and varieties as reported from California, where both species of *Phytophthora* occur, and Florida and Queensland, where

P. nicotianae var. *parasitica* is the predominant species, follows the same general pattern for both fungi, with only minor variation. No variation in pathogenicity of different isolates has been reported for *P. citrophthora*, but in Florida it has been found that considerable variation in pathogenicity occurs in *P. nicotianae* var. *parasitica* (Grimm and Whidden, 1962).

Methods of testing for Phytophthora resistance vary. Klotz and Fawcett (1930), Fraser (1942) and Rossetti (1947) studied the resistance of a large number of species and varieties of *Citrus* and related genera to bark inoculation with *P. citrophthora*, and Klotz *et al.* (1958*a*) examined the resistance to *P. nicotianae* var. *parasitica* using bark inoculations. To assess the percentage decay of fibrous roots by *P. citrophthora* and *P. nicotianae* var. *parasitica*, Klotz *et al.* (1958*b*) immersed the root systems in aerated water cultures containing the fungus. Carpenter and Furr (1962) inoculated roots with *P. nicotianae* var. *parasitica* and then transferred the seedlings to incubation beds to determine their reaction to infection. Incorporation of inoculum in soil in which the test plants are established has been fairly widely used. The results of all these different approaches indicate that resistance occurs in *Poncirus trifoliata* and its hybrids and to a lesser extent in *Citrus aurantium* L. (sour oranges), and a range of susceptibility is shown by orange, mandarin, grapefruit, lemon and other clones.

GENERAL METHODS

Three methods of assessing resistance were used in this study:

(*a*) Infestation of steam-air treated (140° F./30 min.) soil by adding corn-meal sand cultures of pathogenic isolates of *P. citrophthora.*

(*b*) Growth of plants in Hoagland's solution (Hoagland, 1919) to which cultures of *P. citrophthora* on lucerne (*Medicago sativa* L.) stems were added.

(*c*) Inoculation of wounded stems.

TABLE 1

Reaction of Citrus *spp. and Related Genera to* P. citrophthora *in Soil*

Common Name	Botanical Name	Number of Plants with Collar Rot				
		Above Ground	Soil Level	Below Ground	Mean Root Rot Rating	Number of Plants Killed
Trifoliate orange	*Poncirus trifoliata* (L.) Raf.	0	0	0	0·8	0
Rusk citrange	*P. trifoliata* × *C. sinensis*	0	0	0	0·8	0
Sampson tangelo	*C. paradisi* × *C. reticulata*	0	0	2	1·5	0
Thornton tangelo	*C. paradisi* × *C. reticulata*	1	0	1	1·5	0
Harvard sweet orange	*C. sinensis* (L.) Osbeck	1	1	3	1·9	2
Cleopatra mandarin	*C. lycopersicaeformis* Hort. ex Tan.	1	1	1	2·1	1
Sathgudi orange	*C. sinensis* (L.) Osbeck	0	2	2	2·1	1
Emperor mandarin	*C. reticulata* Blanco	1	0	1	2·2	0
Rough lemon (South Africa)	*C. jambhiri* Lush.	2	4	2	2·2	2
Kara mandarin	*C. reticulata* Blanco	1	2	1	2·3	0
Ellendale mandarin	*C. reticulata* Blanco	1	0	1	2·3	0
Rough lemon (N.S.W.)	*C. jambhiri* Lush.	3	5	3	2·5	1
Volkamer lemon	*C. volkameriana* Pasq.	4	5	8	2·5	1
Ruby blood sweet orange	*C. sinensis* (L.) Osbeck	1	1	2	2·7	1
Karna Khatta	*C. karna* Raf.	7	6	7	3·1	6

Citrus seeds were germinated in containers of steam-air treated soil (140° F./30 min.) When four to six inches tall, 10 seedlings of each variety were selected for uniformity and planted singly in one gallon containers, or in rows in large troughs of steam-air treated soil or transferred to aerated nutrient solution.

Experimental

(1) *Reaction of* Citrus *spp. and Related Genera to Root Inoculations with* P. citrophthora : *In Soil*

Experiment 1 : Citrus seedlings in one gallon containers were arranged randomly on the glasshouse bench. Ten replicates and 15 varieties were used. Ten gm. of inoculum was placed at a depth of 4 cm. in three holes around each plant. Inoculum consisted of a mixture of 12 isolates of *P. citrophthora* grown separately on corn-meal sand for six weeks. Eight of the 10 replicates were harvested after 11 weeks and the final two replicates 18 days later.

The root rot rating of each plant was assessed on a scale ranging from 0 (no observable injury) to 5 (most of root system rotted) and each rating represents the mean of 10 replicates. (Results are given in Table 1.)

The hypocotyl region of plants of Karna Khatta, rough lemon, sweet orange and Volkamer lemon was particularly susceptible to infection by *P. citrophthora* (Table 1). Often severe collar infection occurred with little root damage. Mandarins and tangelos were less severely infected by *P. citrophthora* than sweet orange or lemon. In the two replicates examined at 14 weeks, growth of roots had recommenced after a winter dormancy, and the pioneer roots which had been produced were not attacked by *P. citrophthora* even though a very high concentration of inoculum was present in the soil.

Experiment 2 : The reaction to *P. citrophthora* of 21 sweet orange and 14 sour orange clones and a number of other .varieties was assessed. Seedlings were grown in one gallon containers and inoculated at 16 months with corn-meal sand culture of four isolates of *P. citrophthora*. Plants were examined after six months and a visual assessment made of root rot injury on a scale similar to that used in Experiment 1. (The results are given in Table 2.)

In Aerated Nutrient Solution

Experiment 1 : Seedlings 6 in. high were suspended in aerated Hoagland's solution so that only the roots were immersed. A pathogenic isolate of *P. citrophthora* obtained from diseased citrus roots and grown on sterilized stems of lucerne, where it had produced sporangia, was enclosed in cheese-cloth and suspended in the culture solution for 24 hr. One month after inoculation the seedlings were removed from the Hoagland's solution and placed in a 1% solution of 2,3–5-triphenyl tetrazolium chloride (Klotz and De Wolfe, 1965) for 24 hr. in the absence of light and assessed on the basis of stained as compared with unstained roots.

Poncirus trifoliata, Troyer citrange, Ruby blood sweet orange, sweet orange (Symons clone), Smooth Seville (Warnock clone), Israel sour orange and rough lemon, in that order, showed increasing susceptibility to root rot as shown by stained living tissue. The method of testing susceptibility to *Phytophthora* root rot in aerated nutrient solution was a severe one, giving rapid results which were uniform for any given variety or species of citrus.

(2) *The Reaction of* Citrus *spp. and Related Genera to Stem Inoculations with* P. citrophthora

Seedlings, 18 months old, grown in one gallon cans, were arranged randomly on benches in the glasshouse in 10 replications. In Experiment 1, the resistance

TABLE 2

Reaction of Citrus *spp., Varieties and Related Genera to* P. citrophthora

Common Name	Botanical Name	Mean Root Rot Rating
Highly resistant :		
Trifoliate orange 22*	*Poncirus trifoliata* (L.) Raf.	1
Resistant :		
Stuart Smooth Seville (10)†	*C. aurantium* L. ?	1·5
Roberts Smooth Seville (10)	,, ,, ,, ?	1·6
Appleby Smooth Seville	,, ,, ,, ?	1·6
Haddon Smooth Seville	,, ,, ,, ?	1·7
Moderately susceptible :		
Parramatta orange 3443	*C. sinensis* (L) Osbeck	2
Ruby blood orange 3118	,, ,, ,, ,,	2·1
Rough lemon, Terrigal No. 3 selection (10)	*C. jambhiri* Lush.	2·1
Rough lemon, Terrigal No. 1 selection (10)	,, ,, ,,	2·2
Warnock Smooth Seville	*C. aurantium* L. ?	2·2
Rough lemon, Terrigal No. 4 selection (10)	*C. jambhiri* Lush.	2·4
Ellendale mandarin	*C. reticulata* Blanco ?	2·5
Citrus "*zigardia*" (a sweet orange type)	Origin unknown	2·5
Emperor mandarin (10)	*C. reticulata* Blanco	2·6
Marchant rough sour orange (10)	*C. aurantium* L.	2·6
Sweet orange 1259	*C. sinensis* (L.) Osbeck	2·7
Haddon rough sour orange A (10)	*C. aurantium* L.	2·7
Haddon rough sour orange C (10)	,, ,, ,,	2·7
Haddon rough sour orange B (10)	,, ,, ,,	2·7
Rough lemon, Terrigal No. 2 selection (10)	*C. jambhiri* Lush.	2·7
St. Michael orange 3109 (10)	*C. sinensis* (L.) Osbeck	2·9
Susceptible :		
Narara rough lemon	*C. jambhiri* Lush.	3
Cleopatra mandarin (N.S.W.) (10)	*C. lycopersicaeformis* Hort. ex Tan.	3
Brazilian sour orange	*C. aurantium* L.	3·1
Sweet lime (10)	*C. limettioides* Tan.	3·2
Wilson navel-type sour orange	*C. aurantium* L.	3·3
Chaffey sweet orange	*C. sinensis* (L.) Osbeck	3·4
Somersby rough sour orange A	*C. aurantium* L.	3·5
Somersby rough sour orange B	,, ,, ,,	3·4
Israel sour orange	,, ,, ,,	3·5
Pineapple orange 3199	*C. sinensis* (L.) Osbeck	3·6
Parramatta orange 3187 (10)	,, ,, ,, ,,	3·6
Bittersweet orange	*C. aurantium* L.	3·7
Parramatta orange 3188	*C. sinensis* (L.) Osbeck	3·8
Homosassa orange 3104	,, ,, ,, ,,	3·8
Waikerie sweet orange 3185	,, ,, ,, ,,	3·9
Highly susceptible :		
White Siletta orange	*C. sinensis* (L.) Osbeck	4
Yuzu (10)	*C. junos* Sub. ex Tan.	4
Jaffa orange 3610 (10)	*C. sinensis* (L.) Osbeck	4
Mediterranean sweet orange	,, ,, ,, ,,	4
Cleopatra mandarin (ex Florida)	*C. lycopersicaeformis* Hort. ex Tan.	4·1
Campuda sweet orange 3613 (10)	*C. sinensis* (L.) Osbeck	4·1
Parramatta orange 3146	,, ,, ,, ,,	4·2
Mayo orange	,, ,, ,, ,,	4·3
Paterson orange 3449	,, ,, ,, ,,	4·4
Calamondin (10)	*C. madurensis* Loureire	4·6
Maltese blood orange	*C. sinensis* (L.) Osbeck	4·8
Seedling sweet orange (Parramatta type)	,, ,, ,, ,,	4·8
Joppa orange	,, ,, ,, ,,	4·8

* Accession number referring to parent trees at the Department of Agriculture Horticultural Research Station, Narara.

† Number of plants tested was 20 unless otherwise stated.

of seven varieties of mandarin, Ruby blood sweet orange and rough lemon were tested. In Experiment 2 two trifoliate orange clones, five trifoliate hybrids, nine sweet orange clones and nine miscellaneous citrus species were tested. Discs of bark (5 mm. diameter) were removed with a cork borer from the collar region of the stem 40 mm. above soil level, inoculum inserted, and the area bound with plastic budding tape. Inoculum consisted of discs 5 mm. diameter cut from a six-day-old agar culture of *P. citrophthora* newly isolated from diseased citrus roots. The wrappings were removed after three weeks in Experiment 1, and after 10 days in Experiment 2 and the lesion measured. One plant of each variety was treated similarly, but no inoculum was added.

The reaction of mandarin varieties to collar rot is given in Table 3. *Poncirus trifoliata* and its hybrids, *Microcitrus australis* and *Severinia buxifolia*, were all highly resistant to stem inoculations of *P. citrophthora* (Table 4). The mandarins were intermediate in susceptibility, while Rangpur lime, sweet orange varieties, Smooth Seville and rough lemon were highly susceptible. There were no significant differences between sweet orange varieties (overall mean $=2 \cdot 03$, S.E. $(n^1=76)=\pm 0 \cdot 08$ on 67 degrees of freedom). Similarly, the two trifoliate selections did not differ significantly (overall mean $=0 \cdot 127$, S.E. $(n^1=11)=\pm 0 \cdot 043$ on nine degrees of freedom). One F_2 seedling of Yanco hybrid 3700 was highly susceptible to collar rot infection. There were highly significant differences between citranges, Yanco hybrid 3694 being more resistant and Yanco hybrid 3700 more susceptible to collar rot than the other citranges (S.E. mean $(n^1=10)=\pm 0 \cdot 027$ on 52 degrees of freedom). The reactions of Scarlet and Cleopatra mandarins did not differ significantly (overall mean $(n^1=14)=1 \cdot 66$ with S.E. $\pm 0 \cdot 122$ on 12 degrees of freedom).

TABLE 3

Reaction of Citrus *spp. and Related Genera to Stem Inoculation with* Phytophthora citrophthora

Common Name	Botanical Name	Length of Lesion in Cm. (Mean of 10 replicates)
Kara mandarin	*C. reticulata* Blanco	0·92
Scarlet mandarin	,, ,, ,,	1·18
Emperor mandarin	,, ,, ,,	1·28
Ellendale mandarin	*C. reticulata* ?	1·36
Dancy mandarin	*C. reticulata* Blanco	1·49
Rough lemon	*C. jambhiri* Lush.	1·55
Acid mandarin	*C. reticulata* Blanco	1·66
North Coast sour mandarin	,, ,, ,,	1·76
Ruby blood sweet orange	*C. sinensis* (L.) Osbeck	2·05

Standard deviation : 0·451 cm. or 30·9%.

Difference necessary for significance (5%) in comparison of means $=0 \cdot 451$ cm.

(3) *Reaction of* P. trifoliata *Selections and Trifoliate "Orange" Hybrids to* P. citrophthora : *Root Inoculation of* P. trifoliata

Seed was obtained from trees at the Horticultural Research Station, Somersby, where a collection of 148 clones of *P. trifoliata* collected in N.S.W. and two introduced from U.S.A. are maintained.

Experiment 1 : Ten seedlings 10 cm. tall of each of 48 clones of *P. trifoliata* and one clone of rough lemon were planted in troughs 3 ft. × 2 ft. × 6 in. containing steam-air treated (140° F./30 min.) soil. The soil had been inoculated with a mixed inoculum of five-week-old corn-meal sand cultures of 12 pathogenic isolates of *P. citrophthora*. Two months after planting, the plants were washed free of soil and the root damage assessed.

Despite the severity of the test, *P. trifoliata* seedlings showed little root injury. No infection of mature tissue occurred, but root tips were often infected or rotted away. Of the rough lemon seedlings, nine died within one month of transplanting into the infected soil and the one remaining plant was surviving with one lateral root, the taproot, having been rotted.

Experiment 2 : One clone of rough lemon and 129 clones of *P. trifoliata* were planted in one gallon containers of steam-air treated soil (140° F./30 min.), 10 seeds per container. Dormant seedlings were inoculated when 7 in. tall by adding to each tin 1 gm. of mixed corn-meal sand inoculum comprising 10 isolates of *P. citrophthora* which had grown for one month.

All *P. trifoliata* seedlings were highly resistant to *P. citrophthora* root rot. The rough lemon seedlings developed severe root rot.

TABLE 4

Reaction of Citrus *spp. and Related Genera to Stem Inoculation with* Phytophthora citrophthora

Common Name	Botanical Name	Length of Lesion in Cm. (Mean of 10)
Yanco hybrid 3694*	*Poncirus trifoliata* × *Citrus sinensis*. F_2 generation	0·05
Box orange 54–93–9	*Severinia buxifolia* (Poir.) Tenore	0·05
Trifoliate orange 111	*Poncirus trifoliata* (L.) Raf.	0·08
Australian wild lime	*Microcitrus australis* (Blanco) Swing.	0·09
Troyer citrange	*P. trifoliata* × *C. sinensis*	0·1
Box orange 54–91–11	*Severinia buxifolia* (Poir.) Tenore	0·11
Yanco hybrid 3698	*P. trifoliata* × *C. sinensis*. F_2 generation	0·14
Yanco hybrid 3693	,, ,, ,, ,, ,, ,,	0·18
Yanco hybrid 3697	,, ,, ,, ,, ,, ,,	0·18
Trifoliate orange 113	*Poncirus trifoliata* (L.) Raf.	0·2
Yanco hybrid 3700	*P. trifoliata* × *C. sinensis*. F_2 generation	0·42
Scarlet mandarin	*C. reticulata* Blanco	1·57
St. Michael sweet orange	*C. sinensis* (L.) Osbeck	1·59
Cleopatra mandarin (N.S.W.)	*C. lycopersicaeformis* Hort. ex Tan.	1·74
Rangpur lime 3234	*C. limonia* Osbeck	1·82
Cummins sweet orange	*C. sinensis* (L.) Osbeck	1·93
Ruby blood sweet orange 3699	,, ,, ,, ,,	1·96
Viticultural nursery sweet orange	,, ,, ,, ,,	1·99
Maltese blood sweet orange 3206	,, ,, ,, ,,	2·07
Moorland sweet orange	,, ,, ,, ,,	2·08
Ruby blood sweet orange 3696	,, ,, ,, ,,	2·1
Ruby blood sweet orange 3695	,, ,, ,, ,,	2·2
Harrison sweet orange	,, ,, ,, ,,	2·54
Rough lemon	*C. jambhiri* Lush.	2·68
Smooth Seville 3151	*C. aurantium* L. ?	2·75

* Refers to the accession number of the tree from which the seeds were obtained at the Horticultural Research Stations at Narara and Somersby.

Experiment 3 : Seeds of Troyer citrange, rough lemon and 13 clones of *P. trifoliata* were planted in rows (20 seeds per row) in troughs 3 ft. × 2 ft. × 6 in. deep containing steam-air treated (140° F./30 min.) soil. When the seedlings were 4 in. high corn-meal sand inoculum of 12 isolates of *P. citrophthora* grown for one month was incorporated into the soil. After five months plants were washed free of adhering soil and the root damage was assessed.

Only eight of 40 rough lemon seedlings survived. The remainder had callused lesions in the collar region or on the taproot. In the majority of plants at least 50% of the root system had been destroyed and plants were surviving on two or three lateral roots as the taproot had been rotted. Root regeneration was a major factor in the survival of these plants. The trifoliate clones and Troyer citrange plants were all highly resistant to *P. citrophthora*. Some root tips had been attacked, but the disease had not spread to mature tissue.

Stem and Root Inoculations of P. trifoliata *Hybrids*

One hundred and nineteen F1 hybrids of Smooth Seville *P. trifoliata*, 130 F1 hybrids of Ellendale mandarin × *P. trifoliata* and 10 rough lemon plants of nursery row size were subjected to root and stem inoculation as described in Sections (1) and (2).

Stem inoculations did not produce collar rot lesions in hybrid plants, although the rough lemon seedlings developed collar rot. Two hybrids of Smooth Seville × *P. trifoliata* were highly susceptible to root rot, while the remainder were moderately resistant. Ellendale mandarin hybrids varied in their reaction. In most plants only the tips of feeder roots were rotted away, but in seven plants the percentage of roots rotted varied from 10 to 40, compared with rough lemon, where 50–70% of roots were rotted.

Discussion

The resistance of *Poncirus trifoliata* and the citranges to root and collar inoculation with *P. citrophthora* confirmed field and nursery observations. All clones of *P. trifoliata* tested, one of which was a tetraploid, were extremely resistant to Phytophthora root rot. This was in contrast to the variation found by Klotz *et al.* (1958*a*) in percentage decay of fibrous roots of trifoliate orange selections caused by *P. citrophthora* and by *P. nicotianae* var. *parasitica*. Carpenter and Furr (1962) also found the percentage survival of trifoliate orange selections to be highly variable following inoculation with *P. nicotianae* var. *parasitica* and postulated that the reaction of *P. trifoliata* and its hybrids to *P. nicotianae* var. *parasitica* may be related to the degree of dormancy. No evidence to support this hypothesis was obtained with *P. citrophthora* in trials in New South Wales. Furr, Carpenter and Hewitt (1963) considered that differences in susceptibility of trifoliate oranges may be due to differences between young and old root systems, as well as to differences in pathogenicity of the species and isolates of *Phytophthora*. This explanation cannot be applied to the behaviour of *P. citrophthora* in New South Wales, where it has been found that the immature tissue in the region of elongation of trifoliate orange roots is rotted but mature cells are not attacked (Broadbent, 1969).

It is possible that the Australian clones of *P. trifoliata* have been derived from a small number of original introductions, which might explain the narrow range of variation.

The New South Wales selection of rough lemon, Volkamer lemon and the South African selection of rough lemon showed similar susceptibilities to root and collar infections by *P. citrophthora*. These stocks are vigorous and adaptable, and suitable for lemons, but lack the resistance to root rot necessary for citrus replant situations. The Terrigal selections of rough lemon were slightly less susceptible to Phytophthora root rot than the commonly grown rough lemon selection, and further search within the species for a more resistant clone may be desirable.

The tangelos and mandarins showed intermediate resistance to *P. citrophthora* and were more resistant than most of the sweet orange selections tested. The Ellendale mandarin, an Australian variety which is postulated to be a natural tangor (Swingle and Reece, 1967), is unsatisfactory as a stock as all its seedlings are gametic.

Cleopatra mandarin is in limited use as a rootstock in Australia and overseas, and for mandarins has an advantage over rough lemon stocks. The rating of Emperor mandarin as slightly more resistant than rough lemon confirms field observations that seedling trees of this variety persist better in root rot situations.

The resistance to root rot caused by *P. citrophthora* of four selections of Smooth Sevilles is in agreement with field observations and with the results obtained by Grimm and Garnsey (1969) using *P. nicotianae* var. *parasitica*. Under certain conditions Smooth Seville is highly susceptible to collar rot caused by *P. citrophthora*. The taxonomic status of the variety here called Smooth Seville is in doubt. It is not typical sour orange as described (Hodgson, 1967). A relatively high percentage of bifoliate and gametic seedlings is produced. Differences in susceptibility of unifoliate and bifoliate seedlings have been noted by Grimm and Garnsey (1969). Smooth Seville performs reasonably as a stock for lemons, but is unsatisfactory for oranges as this stock-scion combination declines due to tristeza virus (Stubbs, 1963).

A high degree of susceptibility was shown by most sweet oranges. Sweet orange is commonly used as a rootstock on the neutral to alkaline, free draining sandy loam soils of the inland districts of New South Wales. Ruby blood selection 3118 and Parramatta orange selection 3443 were somewhat more resistant to Phytophthora root rot than most of the other sweet orange selections. It may be significant that the parent tree of the Parramatta strain of sweet orange was a 100-year-old seedling tree from Northmead (New South Wales). It was in this area, once a prosperous citrus growing district, that *P. citrophthora* caused serious damage in 1860 (Fraser, 1949).

The reaction to Phytophthora root and collar rots of the range of species and varieties tested has provided a measure of the relative resistance of seedlings of many varieties of *Citrus* spp. and related genera. This can be used as a basis for further testing in the field as rootstocks and also provide information on resistance for future breeding purposes.

The genetic constitution of the citrus host rootstock and the suitability of the environment are of prime importance in determining the course of development of Phytophthora root or collar rots in the field. In genera such as *Poncirus*, *Microcitrus* and *Severinia*, resistance is conferred by some factor of genetic constitution. Where resistance is not complete, the degree of damage caused can be influenced by age, chemical composition, succulence and vigour of the infected tissue (Carpenter and Furr, 1962).

Under field conditions, environmental factors can influence both the course of the disease and the host. Soil characteristics, soil temperature, soil oxygen and moisture levels influence the development of citrus root rot (Klotz *et al.*, 1965; Stolzy *et al.*, 1965*a*). A low supply of oxygen in soils prevents root growth and regeneration, creating an unfavourable soil condition for infected plants to overcome the adverse effects of root decay (Stolzy *et al.*, 1965*b*). Soil fertility, with its effect on tree vigour and root development (Fraser, 1949), and the effect of the scion on rootstock (Klotz *et al.*, 1967) are also important.

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AUSTRALASIAN CERATOPOGONIDAE (DIPTERA, NEMATOCERA)

PART XV: THE GENUS *ALLUAUDOMYIA* KIEFFER IN AUSTRALIA AND NEW GUINEA

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Synopsis

The Australian and New Guinea species of the genus *Alluaudomyia* Kieffer are revised. Ten new species and one new subspecies are described, Skuse's *Ceratopogon latipennis* is transferred to this genus, and Tokunaga's *Alluaudomyia novaguineae* is placed in synonymy with *Alluaudomyia spinosipes* Tokunaga. New data are recorded for some previously described species, and a key is provided for identification of the 25 known species found in the area.

This study was prompted by the publication of Wirth and Delfinado's comprehensive revision of the Oriental species of *Alluaudomyia* (1964). In this paper the authors state that " only the Neotropical and Australian species are now poorly known, but undescribed material indicates that the genus is not well represented in the extreme south. Only 3 or 4 species collected in Australia . . . are known to us." The present study raises the number of species recorded from the Australian mainland to 14, but of these four are New Guinea or Oriental species which have penetrated to the far north of Australia and a further three have thus far only been recorded from the north of the continent, although they are not yet known from New Guinea. Of the remaining seven species, only two, *latipennis* and *alpina*, appear to have a purely southern distribution.

The first species of the genus to be recorded from the Australia-New Guinea area was described by Skuse in 1889 under the name *Ceratopogon latipennis*, but the correct generic status of this species has until now been unrecognized, and consequently it was omitted from Wirth and Delfinado's list of world species. No further record of the genus in this area appeared until 1955, when Lee and Reye reported its occurrence in Queensland and New South Wales. In 1959 a single species was described from New Guinea by Tokunaga, and a further 11 species were named from the same area in 1963, while one species previously described from Micronesia was also recorded. The present paper increases to 25 the number of species known from the Australia-New Guinea area. Of these 10 are new and one is a new subspecies of an Oriental species.

Wirth and Delfinado placed the Oriental species in five groups based on characters of wing pattern, spermathecae, hypopygium and leg banding. These groups have not been followed in the present paper as some of the Australian species combine the characteristics of more than one group, resulting in a partial breakdown of the classification. At present it appears that a group system based on the number and form of the spermathecae and certain male genitalic characters may be possible, but the resulting groups would be too large and contain too many widely differing forms to be of any practical value.

METHOD OF DESCRIPTION

All new descriptions are based on slide specimens cleared in a mixture of one part absolute alcohol to one part creosote and mounted in balsam on microscope slides, except for the few cases where alcoholic or pinned specimens have been available for detailed description of the thoracic pattern.

Table of Measurements

Measurements of newly described species are based on the holotype and, if available, the allotype, unless otherwise stated. Measurements of previously described species are taken directly from the original descriptions. Wing length is measured from the basal arculus to the wing tip, which gives a value approximately one-tenth less than the measurement employed by Tokunaga, and allowance should be made for this.

Morphological Terms

See Wirth (1952) and, for modifications, my previous paper in this series (Part XIII, Proc. Linn. Soc. N.S.W., 94 (2) : 145, 1970). For pupal characters, see Jones (1961). Length is measured from the vertex of the head to the tip of the abdomen.

Illustrations

Except for drawings of thoracic pattern, which are freehand, these were done with the aid of a graticule and squared paper. All are based on type specimens unless otherwise stated. In figures of femora and tibiae, the fore leg is uppermost.

Location of Types

Types of newly described species are lodged in the collection of the School of Public Health and Tropical Medicine, Sydney, unless otherwise stated. Paratypes, where available, are in the School of Public Health ; Australian National Insect Collection, Canberra, A.C.T. ; United States National Museum, Washington ; British Museum (Natural History) ; B. P. Bishop Museum, Honolulu.

Abbreviations

S.P.H. & T.M.	School of Public Health and Tropical Medicine, Sydney.
A.N.I.C.	Australian National Insect Collection, Canberra, A.C.T.
a.m.	anteromarginal (tubercle).
d.a.s.m.	dorsal anterosubmarginal (tubercle).
l.a.s.m.	lateral anterosubmarginal (tubercle).
d.p.m.	dorsal posteromarginal (tubercle).
l.p.m.	lateral posteromarginal (tubercle).
v.p.m.	ventral posteromarginal (tubercle)

Genus ALLUAUDOMYIA Kieffer

Alluaudomyia Kieffer, 1913, Voyage Ch. Alluaud et R. Jeannel en Afrique Orientale, Dipt., *1* : 12 ; de Meillon, 1939, *J. ent. Soc. S. Africa*, *2* : 7 : Okada, 1942, *Trans. Nat. Hist. Soc. Formosa*, *32* : 315 ; Wirth, 1952, *Ann. ent. Soc. Amer.*, *45* : 423 ; Tokunaga and Murachi, 1959, *Ins. Micronesia*, *12* : 352 ; Wirth and Delfinado, 1964, *Pacif. Insects*, *6* : 599. Type species, by monotypy, *Alluaudomyia imparunguis* Kieffer.

Neoceratopogon Malloch, 1915, *Bull. Ill. St. Lab. Nat. Hist.*, *11* : 310. Type species, by original designation, *Ceratopogon bellus* Coquillett.

Prionognathus Carter, Ingram and Macfie, 1921, *Ann. Trop. Med. Parasit.*, *14* : 309. Type species, by original designation, *Prionognathus marmoratus* Carter, Ingram and Macfie.

Thysanognathus Ingram and Macfie, 1922, *Ann. Trop. Med. Parasit.*, *16* : 244 (*nom. nov.* for *Prionognathus* Carter, Ingram and Macfie, *nec* La Ferté-Sénectère).

Isoecacta Garrett, 1925, Seventy New Diptera, p. 9. Type species, by monotypy, *Isoecacta poeyi* Garrett=*bella* (Coquillett).

Generic Diagnosis (from Wirth and Delfinado, 1964)

Body moderately slender, not strongly hairy, usually small to medium, but occasionally larger, up to 2·7 mm. Eyes bare or pubescent, contiguous to narrowly separated above. Palp 5-segmented, segment III usually with a small round pit on apical half bearing sensillae. Antenna 15-segmented, ♀ with distal 5 segments slightly elongated, ♂ with distal 3 segments elongated, plume present. Legs slender, without strong spines, occasionally with spine-like hairs; hind first tarsal segment bearded ventrally, fourth tarsal segment of all legs cordate, fifth slender, unarmed. Empodium vestigial; ♀ claws long and slender, simple, usually very unequal but sometimes subequal on one or more pairs of legs, ♂ claws all small and equal. Wing without microtrichia, macrotrichia usually present towards wing apex, sometimes extending over most of the membrane; first radial cell absent, R_{4+5} thickened just before its junction with costa, costa ending before to beyond middle of wing, median fork petiolate. Abdomen moderately stout; 1 or 2 sclerotized spermathecae present, sometimes an aberrant third one also present; ♂ genitalia with very diverse specific modifications, but ninth tergite usually elongate, ninth sternite usually short with caudomedian excavation, aedeagus usually with basal arch and distinct caudomedian stem, parameres usually separate, with a lateral, sometimes detached, basal arm, elongate stem, and distal armature of one or more spines, lobes or filaments.

Key to Australian and New Guinea Species of ALLUAUDOMYIA

1. Wing with more than 3 conspicuous dark spots 2
   Wing with 3 or fewer conspicuous dark spots, these situated at end of costa, just before r-m cross-vein and on R_1 7
2. Wing with 7 spots arranged on M_1, M_2, M_{3+4}, Cu_1 and anal vein, as well as mottling on radial veins 3
   Wing with spots situated in cells as well as on veins 5
3. ♂ wing with 3 dark punctures on Rs before r-m cross-vein; ♂ and ♀ wing without dark punctures on R_{4+5}[1] .... 1. *personata* n. sp.
   ♂ wing without dark punctures on Rs before r-m cross-vein; ♀ wing with 2 dark punctures on R_{4+5} 4
4. Aedeagus with a very elongate caudal stem; spermatheca large, elongate oval, approximately 0·12×0·08 mm.; some macrotrichia of ♀ wing with pale grey dots at bases .... 2. *annulipes australiensis* n. subsp.
   Aedeagus with a short caudal stem; spermatheca smaller, more rounded, 0·09×0·06 mm.; some macrotrichia of ♀ wing with conspicuous black dots at bases .... 3. *tokunagai* Wirth and Delfinado
5. Wing with spots in cells very close to wing margin; spot at end of costa scarcely extending on to membrane; mid and hind femora with basal half to two-thirds dark; spermathecae without diverticula .... 14. *varia* n. sp. (♀)
   Wing spots in cells not very close to wing margin; spot at end of costa extending considerably on to membrane; all femora broadly pale basally; spermathecae with diverticula .. 6
6. ♀ with wing margin broadly infuscated, spot in cell M_1 elongate rectangular; spot on vein R_1 absent in both sexes .... 4. *fumosipennis* n. sp.
   ♀ without conspicuous infuscation on wing margin, spot in cell M_1 small and round; both sexes with dark spot on vein R_1 .... 5. *unguistyla* n. sp.
7. Wing with a single, usually pale, spot at end of costa, without definite spot on membrane just before r-m cross-vein, although Rs and M may be slightly infuscated 8
   Wing with a distinct spot before r-m cross-vein, sometimes also with a spot on R_1 12
8. Eyes bare 9
   Eyes pubescent 11
9. Legs entirely yellow .... 6. *immaculata* Tokunaga
   Legs with pale but distinct brown bands 10
10. Abdomen largely yellow; aedeagus of male plate-like, deeply bifid apically, somewhat resembling a fish-tail.................................... 7. *insulana* Tokunaga and Murachi
    Abdomen dark brown dorsally, paler ventrally; aedeagus of male arched, with a single, short apical point.................................... 8. *verecunda* n. sp.

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[1] In this part of the key it is assumed that the unknown ♀ of *personata* resembles the female of the closely related *bifurcata* Wirth and Delfinado; this assumption may prove incorrect.

11. Wing of ♀ without macrotrichia, but with a row of spinule-like setae on anterior edge; ♂ aedeagus with a V-shaped apical notch, parameres hooked apically and with a long, slender apical process .... 9. *papuae* Tokunaga
Mid femur with a narrow pale base, rest of basal half dark 23
Wing of ♀ with a moderate number of macrotrichia, without spinule-like setae; ♂ aedeagus with a W-shaped apical notch, parameres rounded apically, apical process long, flattened and tapered .... 10. *bifasciata* Tokunaga

12. Spermathecae with diverticula; aedeagus bell-shaped, its apex produced into a short, ventrally bent process (Figs. 192, 205, 210, 216) 20
Spermathecae without diverticula; aedeagus various, but never as above 13

13. Very dark species, the legs dark brown with narrow paler bands preapically on all femora and sub-basally and preapically on all tibiae .... 11. *alpina* n. sp.
Legs more extensively pale 14

14. Spot at tip of R_{4+5} extending well on to wing membrane, at least in ♀; spermathecae elongate oval, the long axis parallel to the neck; ♂ with coxites long and narrow, parameres with detached basal arms 15
Spot at tip of R_{4+5} scarcely, if at all, extending on to wing membrane; spermathecae round or, if oval, long axis perpendicular to the neck; ♂ with coxites rather short and stout, parameres with basal arms attached 17

15. Mid tibia pale except for dark base and apex .... 12. *latipennis* (Skuse)
Mid tibia largely dark or at least with a distinct dark band on apical third 16

16. Humeral areas of scutum entirely pale; ♂ parameres with a long, broad, tapering preapical process arising well down the stem .... 13. *appendiculata* n. sp.
Humeral areas pale, but with distinct dark punctations at bases of setae; ♂ parameres with a pale, relatively short setose preapical process arising within the apical loop .... 14. *varia* n. sp. (♂)

17. Mid femur almost entirely brown, only narrowly pale basally and preapically .... 15. *platipyga* Tokunaga
Mid femur with a broad brown central band, a narrow brown preapical band and a brown apex, rest whitish 18

18. Aedeagus of ♂ a simple arch with a single hook-like apical process arising from its dorsal surface; parameres with stems slender, two long apical processes; ♀ genital sclerotization simple, V-shaped, inconspicuous (Fig. 151) .... 16. *reyei* n. sp.
Aedeagus with paired apical processes; parameres with stems broad basally, a single apical process; ♀ genital sclerotization larger, more conspicuous, U-shaped 19

19. Apical processes of aedeagus horn-like, not bent, broad basally and tapering to a rounded point; parameres with a long, tapering apical process; ♀ genital sclerotization distinctly U-shaped, without a heavily sclerotized process inside the loop of the "U" (Fig. 157) .... 17. *bicornis* n. sp.
Apical processes of aedeagus laterally bent before tip; parameres with a very short, parallel-sided process; ♀ genital sclerotization very conspicuous, U-shaped but very broad and rounded, a triangular, heavily sclerotized process within the loop of the "U" (Fig. 162) .... 18. *fragmentum* n. sp.

20. Mid femur with a distinct dark brown preapical band 21
Mid femur without a distinct dark preapical band; if band present it is very pale 24

21. Sub-basal dark band of mid tibia confluent with dark base forming a broad basal band .... 19. *petersi* Tokunaga
Sub-basal dark band of mid tibia separated from dark base by a distinct white or yellow band 22

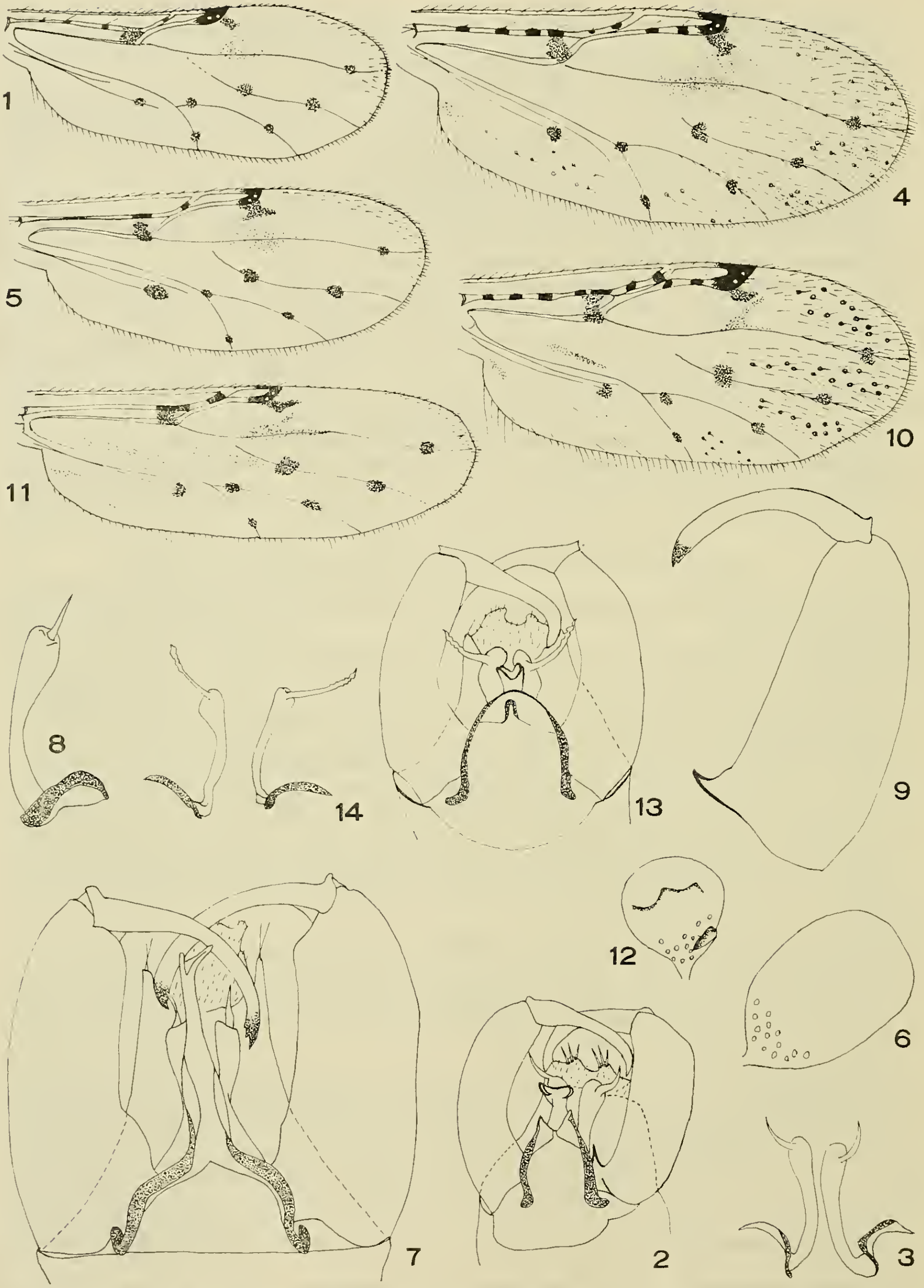
22. Basal half of mid femur entirely pale........ 20. *astera* Tokunaga

23. Two spermathecae, one with a short, straight diverticulum, the other with a long, undulate diverticulum; stems of parameres slender, apices flattened, slightly bent laterally, sub-triangular, sharply pointed .... 21. *jimmensis* Tokunaga
Both spermathecae with straight diverticula; male unknown...... 22. *smeei* Tokunaga

24. Claws of fore and mid legs subequal in ♀; diverticula of spermathecae slightly swollen apically; stems of parameres very narrow on basal half, broader on apical half, apices short, pointed, bent at right angles to stem .... 23. *spinosipes* Tokunaga
Claws of fore and mid legs very unequal in ♀; diverticula not swollen apically: parameres otherwise 25

25. Hind femur fuscous on basal two-thirds .... 24. N.G. No. 1
Hind femur with base broadly pale and a dark central or post-central band 26

26. Diverticula of spermathecae short, subequal, about 0·012 mm. long; basal half of stem of parameres strongly swollen, apices not undulate, somewhat rounded .. 25. *brandti* Tokunaga
Diverticula of spermathecae unequal, longer, about 0·051 and 0·042 mm. long; stems of parameres only slightly swollen basally, apices slender, undulate, sharply tapered .... 26. *tenuistylata* Tokunaga



Figs 1–3. *Alluaudomyia personata*. 1, ♂ wing, ×55 ; 2, ♂ hypopygium, ×200 ; 3, ♂ parameres, ×200. Figs. 4–9. *Alluaudomyia annulipes australiensis*. 4, ♀ wing, ×55 ; 5, ♂ wing (Townsville paratype), ×55 ; 6, ♀ spermatheca, ×200 ; 7, ♂ hypopygium (Townsville paratype), ×200 ; 8, ♂ paramere (Maprik paratype), ×200 ; 9, ♂ coxite and style (Maprik paratype), ×200. Figs. 10–14. *Alluaudomyia tokunagai*. 10, ♀ wing (Siutmeri specimen), ×55 ; 11, ♂ wing (Innisfail specimen), ×55 ; 12, ♀ spermatheca (Korogo specimen), ×200 ; 13, ♂ hypopygium (Innisfail specimen), ×200 ; 14, ♂ parameres (Korogo specimen), ×200.

1. ALLUAUDOMYIA PERSONATA n. sp. (Figs 1–3, 15–16)

Type: Holotype ♂.

Type Locality: Moran's Creek, Innisfail, Queensland (5.ix.1963, H. Standfast).

A small, brown and yellow mottled species, very similar to *A. bifurcata* Wirth and Delfinado. Female unknown.

Male: Length 1·28 mm., wing 0·96 × 0·37 mm.

Head brown, vertex yellow. Eyes bare, separate. Palp brown, segment III with a small apical pit bearing sensillae (Fig. 15). Antennal segment II brown, segments III–XI whitish, XII–XIII brown, rest missing ; plume brown.

Scutum yellow with brown mottling and punctures, scutellum yellowish but narrowly fuscous centrally, bearing 2 setae, postscutellum narrowly yellow on anterior edge, rest dark brown, pleuron yellow on upper half, brown on lower half. Coxae and trochanters light brown ; legs whitish, all femora with basal half dark, femora and tibiae with many brown bands (Fig. 16), hind tibial comb of 5–6 spines ; fore and hind first tarsal segment and basal half of mid first segment brown, rest of tarsi fuscous. Claws of fore and mid legs missing, of hind legs very small, less than one-third the length of the fifth tarsal segment, paired and equal, bifid at tip.

Wing (Fig. 1) with a dark spot before the r-m cross-vein, one at junction of costa and R_{4+5}, extending on to the wing membrane, and 7 posteriorly, one near apex of M_1, one near either end of M_2, one near apical end of M_{3+4}, Cu_1, and anal vein, and one on M_{3+4} just beyond $fMCu_1$, as well as 3 small punctures on Rs and 1 on R_1. Macrotrichia restricted to the wing margin between the ends of the costa and M_2. Haltere with stem white, knob fuscous but dark brown apically.

Abdomen very pale brown, pleural membranes grey. Hypopygium (Figs 2–3) brown, coxites narrow and curved, each with a strongly recurved ventral root, styles whitish, slightly swollen basally ; aedeagus deeply arched, with a v-shaped notch apically, caudal stem with a pair of slender apicolateral processes, parameres each with an attached basal arm, stem slightly curved, swollen apically, preapical process moderately long, approximately one-third the length of the stem.

Distribution: Known only from the type locality.

This species is very close, in both coloration and form of genitalia, to *Alluaudomyia bifurcata* Wirth and Delfinado from Malaya and Thailand. However, it can be distinguished by the dark bases on all femora, the recurved ventral root of the coxites, the pointed, not rounded, sides of the apical notch of the aedeagus, and the much longer preapical processes of the parameres. It can be distinguished from other similar species known from the area by the form of the male genitalia and the presence, in the male, of punctations on Rs ; assuming that the female closely resembles the female of *bifurcata*, it will be distinguishable from the females of *annulipes australiensis* and *tokunagai* by the absence of punctations on R_{4+5} and the absence of dots at the trichial bases.

2. ALLUAUDOMYIA ANNULIPES AUSTRALIENSIS n. subsp. (Figs 4–9, 17–22)

Types: Holotype ♂, allotype ♀ and 26 ♂♂ and 9 ♀♀ paratypes.

Type Locality: Townsville, Queensland (holotype 0001–0300 hours, allotype 2100–2359 hours, 18.xi.1955, light trap, Belgian Gardens, flying fox bait, A. K. O'Gower). Paratypes from Townsville (12 ♂♂, 1 ♀, 9.xi.1955, 1900–2100 hours, Belgian Gardens, A. K. O'Gower ; 2 ♂♂, 1 ♀, 13.xi.1955, 2100–2359 hours, light trap, Belgian Gardens, mangrove tree, A. K. O'Gower ; 1 ♀, 14.xi.1955, light trap, Belgian Gardens, A. K. O'Gower ; 1 ♂, 17.xi.1955, 1920–2100 hours, light trap, Belgian Gardens, flying fox bait, A. K. O'Gower ; 4 ♂♂, same data as holotype ; 2 ♂♂, same data as holotype but 0300–0530 hours ; 1 ♂, 1 ♀, same data as allotype ; 1 ♂, 20.xi.1955, 2200–0600 hours, light trap, Belgian Gardens, mango tree near polluted swamp, A. K. O'Gower), from Darwin, Northern Territory (1 ♀, 27–29.xi.1957, 2400–0630 hours, light trap, Maranga, E. J. Reye ; 1 ♂, 1 ♀, 13–14.vi.1958, light trap, Quarantine Stn., E. J. Reye ; 1 ♂, same data but 16–17.vi.1958 ; 1 ♀, same data but 4–5.vii.1958, N. J. light trap ; 1 ♀, same data but 12–13.vii.1958 ; 1 ♀, same data but 26–27.vii.1958, suction light trap), and from Maprik,[1] New Guinea (1 ♂, 1958).

These specimens are very close to *Alluaudomyia annulipes* Wirth and Delfinado, described from Malaya and Thailand, but the males differ markedly in the length of the apical process of the parameres. In the Asian specimens this is very short and spine-like, but in the Australian and New Guinea specimens it is considerably longer, being approximately one-fourth the length of the stem. As this feature is consistent throughout the present series, the Australian-New Guinea form is here regarded as a distinct subspecies, at least until such time as intermediate forms may be collected. The females of *annulipes australiensis* can be distinguished from females of the nominate race only by locality of collection.

Male: Length 1·59 mm., wing 1·01 × 0·38 mm.

Head brown, frons yellowish. Eyes bare, just contiguous. Palp brown, segment III with an apical pit bearing several sensillae (Fig. 18). Antennal segments II–III brown, IV–XI very pale, XII light brown, XIII brown on basal half, white on apical half, XIV brown with apical fourth white, XV brown (Fig. 20) ; plume yellowish-brown.

Scutum yellowish with brown mottling and punctures, scutellum yellow, with 4 setae, postscutellum brown centrally, ochreous laterally, pleuron ochreous. Fore coxae ochreous, mid and hind coxae brown, trochanters brown, fore pair paler ; femora and tibiae yellow with brown bands and punctures as figured (Fig. 21), number of narrow bands variable, hind tibial comb of 5 spines ; tarsi fuscous, fore segment I, base and apex of mid segment I, all of hind segment I and all fifth tarsal segments light brown. Claws of all legs small, under half the length of the fifth tarsal segment, paired and equal.

Wing (Fig. 5) with a spot before r-m cross-vein, one on R_1 (the holotype also has a second small spot on R_1), one at junction of R_{4+5} and costa, and 7 small spots posteriorly, one near apex of M_1, one near either end of M_2, one near apical end of M_{3+4} and Cu_1, one at $fMCu_1$, and one on anal vein. Macrotrichia restricted to the wing margin between the ends of the costa and M_2. Haltere whitish, apex of knob brown.

Abdomen light brown, pleural membranes brown. Hypopygium (Figs 7–9) brown, the coxites yellowish apically and on their inner faces, styles bidentate, apices brown ; aedeagus with a shallow, rounded basal arch and an elongate, apically forked caudal stem, parameres with a short, attached basal arm, stem slightly bent, apex expanded, blunt, bearing a flattened, tapering process about one-fourth the length of the stem.

Female: Length 1·67 mm., wing 1·35 × 0·53 mm.

Generally similar to male, differing as follows :

Approximately 17 mandibular teeth. Antennal segments IV–V white, VI–VIII brown centrally, base and apex broadly white, IX–X brown centrally, base and apex light brown, XI–XIV brown with apex white, XV brown (Fig. 19).

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[1] Specimens with the data " Maprik, New Guinea " are part of bulked light trap collections sent to S.P.H. and T.M. for study by Dr. W. Peters.

Claws of all legs unequal, ratio of length of claws to fifth tarsal segment 24 : 12 : 25 in fore, 23 : 12 : 24 in mid, 17 : 7 : 20 in hind (Fig. 22).

Wing (Fig. 4) also with several small brown punctures on Rs and R_{4+5}. Macrotrichia more extensive, on apical half of wing and in anal cell, with greyish dots at bases of many macrotrichia.

Cerci pale fuscous. Spermatheca large, elongate oval, with hyaline punctures anteriorly (Fig. 6).

Distribution: New Guinea, Northern Territory, north-eastern Queensland.

This subspecies can be distinguished from *tokunagai* by the form of the male genitalia, the larger, more elongate oval spermatheca, and the paler, less conspicuous dots at the trichial bases on the female wing.

3. ALLUAUDOMYIA TOKUNAGAI Wirth and Delfinado. (Figs 10–14, 23–27)

Alluaudomyia splendida Tokunaga, 1963 (*nec* Winnertz, 1852), *Pacif. Insects*, *5*: 216 (Type locality: Keravat, New Britain. Allotype from Goldie River, nr. Port Moresby, New Guinea; paratypes from Minj and Lae, New Guinea.)

Alluaudomyia tokunagai Wirth and Delfinado, 1964, *Pacif. Insects*, *6*: 633. *Nom. nov.* for *splendida* Tokunaga preocc. Winnertz, 1852.

Specimens examined: New Guinea: Korogo, Sepik River (2 ♂♂, 1 ♀, 8.iii.1964, D. H. Colless); Siutmeri, Sepik River (2 ♀♀, 17.iv.1964, D. H. Colless). Northern Territory: Darwin (1 ♂, 26–27.vii.1958, Quarantine Stn., suction light trap, E. J. Reye). Queensland: Innisfail (2 ♂♂, 13.vi.1963, Eubenangee Swamp, H. Standfast; 1 ♂, 5.ix.1963, Moran's Creek, H. Standfast).

Characteristics: Medium-sized mottled species. Head yellowish-brown, vertex with dark median spot, eyes bare. Scutum yellow, mottled with brown dots and stripes, scutellum entirely yellow or with a narrow central fuscous band, 4 setae in female, 2 in male, postscutellum yellow; legs yellow with many brown bands, basically as figured (Fig. 26) but number of narrow bands variable, female claws all very unequal, ratio of length of claws to fifth tarsal segment 28 : 15·5 : 27 in fore, 29 : 12·5 : 28·5 in mid, 23·5 : 9·5 : 25 in hind (Fig. 27), male claws all small and equal. Female wing with dark spots on Rs, R_1, R_{4+5}, M_1, M_2, M_{3+4}, Cu_1, and anal veins, and a spot proximal to r-m cross-vein, also with dark dots at some trichial bases (Fig. 10), male wing lacking spots on Rs and at trichial bases (Fig. 11), female with a moderate number of macrotrichia on apical half of wing and a few in anal cell, male with macrotrichia restricted to anterior edge and apex. Haltere with all or part of knob, and sometimes part of stem, fuscous. Abdomen pale ochreous to pale brown. Spermatheca (Fig. 12) large, single, oval, with hyaline dots before base of duct. Aedeagus with a deep basal arch and a small, four-pointed apical lobe, parameres separate, apical third expanded and flattened, with a slender preapical process (Figs 13–14).

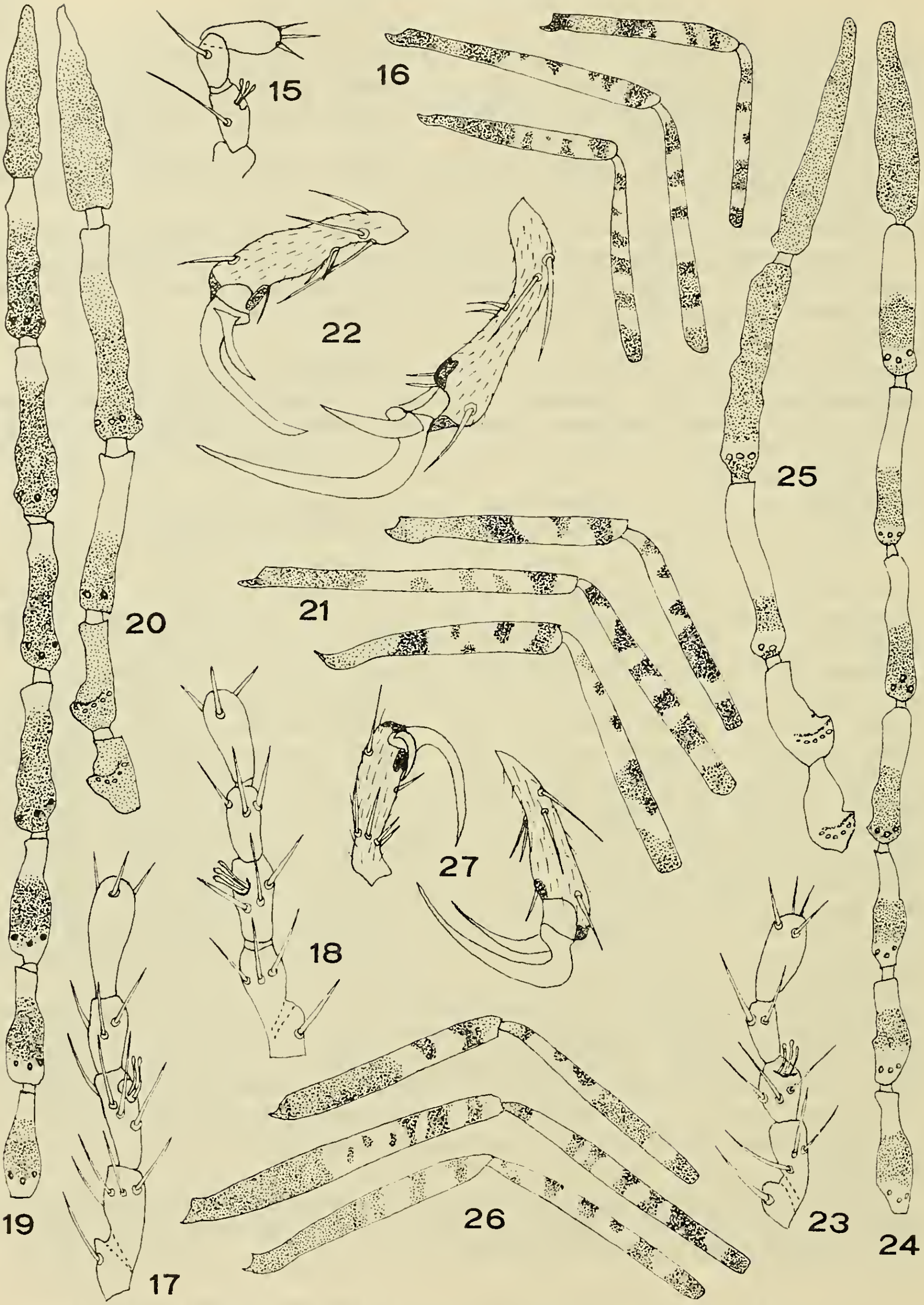
Distribution: New Britain, New Guinea, Northern Territory, north-eastern Queensland.

This species is readily distinguished from *annulipes australiensis* by the form of the male genitalia, the smaller, more rounded spermatheca and the very dark trichial bases on the female wing.

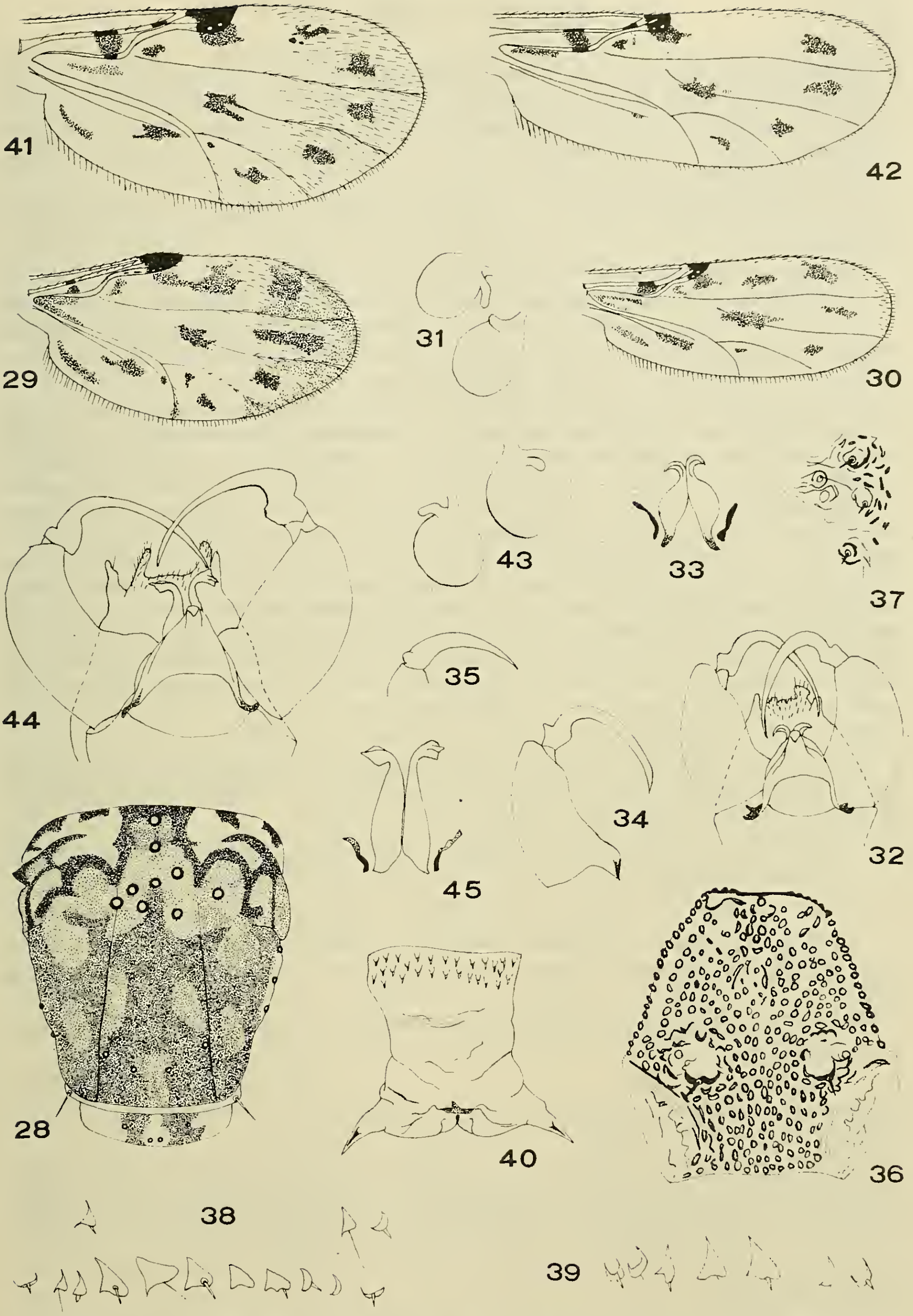
4. ALLUAUDOMYIA FUMOSIPENNIS n. sp. (Figs 28–40, 46–51)

Types: Holotype ♀, allotype ♂, 20 ♂♂ and 29 ♀♀ paratypes.

Type Locality: Darwin, Northern Territory (holotype 14–15.vi.1958, allotype 30–31.x.1957, Quarantine Stn., N.J. light trap, E. J. Reye). Paratypes from Darwin (2 ♂♂, 2 ♀♀, 27–28.vi.1956, 1 ♂, 22–23.xi.1957, 1 ♂, 10–11.vi.1958, 1 ♀, 11–12.vi.1958, 3 ♀♀, 13–14.vi.1958, 1 ♀, same data as holotype, 1♂, 2♀♀,



Figs 15–16. *Alluaudomyia personata*. 15, ♂ maxillary palp, segments III–V, ×350 ; 16, ♂ femora and tibiae, ×90. Figs 17–22. *Alluaudomyia annulipes australiensis*. 17, ♀ maxillary palp, ×350 ; 18, ♂ maxillary palp, ×350 ; 19, ♀ antennal segments VIII–XV, ×350 ; 20, ♂ antennal segments XI–XV, ×350 ; 21, ♂ femora and tibiae, ×90 ; 22, ♀ fore (*right*) and hind (*left*) tarsus V and claw, ×350. Figs 23–27. *Alluaudomyia tokunagai*. 23, ♀ maxillary palp (Siutmeri specimen), ×350 ; 24, ♀ antennal segments VIII–XV (Siutmeri specimen), ×350 ; 25, ♂ antennal segments XI–XV (Korogo specimen), ×350 ; 26, ♀ femora and tibiae (Siutmeri specimen), ×90 ; 27, ♀ fore (*right*—Siutmeri specimen) and hind (*left*—Korogo specimen) tarsus V and claw, ×350.



Figs 28–40. *Alluaudomyia fumosipennis.* 28, dorsum of thorax (Mt. Crosby specimen): 29, ♀ wing, ×55; 30, ♂ wing, ×55; 31, ♀ spermathecae, ×200; 32, ♂ hypopygium. ×200; 33, ♂ parameres, ×200: 34, ♂ coxite and style ×200; 35, ♂ style (paratype). ×200; 36–40, pupa. 36, operculum, ×200; 37, dorsal tubercles of cephalothorax, ×200: 38, tubercles of 7th abdominal segment, ×200: 39, tubercles of 8th abdominal segment. ×200; 40, anal segment, ×200. Figs 41–45. *Alluaudomyia unguistyla.* 41, ♀ wing, ×55; 42, ♂ wing (Noonameena specimen), ×55; 43, ♀ spermathecae, ×200: 44, ♂ hypopygium (Yeerongpilly specimen), ×200: 45, ♂ parameres (Yeerongpilly specimen), ×200.

18–19.vi.1958, 1 ♂, 22–23.vi.1958, 3 ♂♂, 1♀, 28–29.vi.1958, 1 ♀, 2–3.vii.1958, 1 ♂, 1 ♀, 5–6.vii.1958, 1 ♀, 10–11.vii.1958, 2 ♀♀, 12–13.vii.1958, 7 ♂♂, 12 ♀♀, 26–27.vii.1958, Quarantine Stn., light trap, E. J. Reye ; 1 ♂, 26–27.xi.1957, 1 ♂, 1–2.viii.1958, East Arm Convent, light trap, E. J. Reye ; 1 ♀, 21.iv.1958, 1 ♀, 5–6.v.1958, N.J. light trap, J. Dyer ; 1 ♂, 4–5.vii.1958, Winellie, suct. light trap, E. J. Reye).

A small, mottled species, the wing with many spots on the veins and membrane.

Female : Length 1·36 mm., wing 0·82×0·42 mm.

Head brown, vertex and frons ochreous. Eyes bare, contiguous. Mandible with 11 teeth. Palp pale brown, segment III with a shallow preapical pit bearing several long sensillae (Fig. 46). Antennal segment II ochreous, III–IX brown with bases whitish, X–XV brown (Fig. 47).

Scutum light brown, humeral areas yellow, the whole with a pattern of mid and dark brown (Fig. 28), scutellum yellow with a brown band each side of centre, with 4 setae, postscutellum dark brown centrally, paler laterally, pleuron yellowish with a brown transverse central band. Coxae and trochanters yellowish-fuscous ; femora and tibiae whitish, the fore femur with a broad central brown band and brown apex, mid femur with a broad brown sub-basal band, narrow brown preapical band and brown apex, hind femur similar to fore femur, fore tibia with brown base and apex and a broad brown central band, mid tibia with brown base and apex, a narrow brown sub-basal band and a broader preapical band, hind tibia similar to fore but central band narrower (Fig. 49), hind tibial comb of 6 spines ; tarsi whitish but hind first tarsal segment pale brown, segments IV and V of all legs pale fuscous. Claws of all legs unequal, ratio of length of claws to fifth tarsal segment 16 : 11 : 19 in fore, 18 : 11 : 18 in mid, ? : 8 : 16 in hind (13 : 7 : 16 in paratype) (Fig. 50).

Wing (Fig. 29) with extensive dark markings, wing margin from beyond end of costa to end of M_{3+4} shaded grey. Macrotrichia numerous on apical half of wing. Haltere white with apex of knob brown.

Abdomen pale brown, darker distally. Cerci white. Spermathecae (Fig. 31) two unequal, subspherical, each with a short diverticulum.

Male : Length 1·44 mm., wing 0·78×0·30 mm.

Generally similar to female, differing as follows :

Antennal segment II dark brown, flagellum light brown (Fig. 48) ; plume brown.

Claws of all legs small, equal, simple, just over half the length of the fifth tarsal segment.

Wing (Fig. 30) without dark margin, spotting less extensive. Macrotrichia restricted to the wing margin between the ends of the costa and M_2. Haltere white.

Abdominal segments brown with posterior edges broadly white, the anterior three segments largely white. Hypopygium (Figs 32–34) brown, coxites rather short, styles yellow-brown, long, strongly curved and sharply pointed : aedeagus with basal arch extending to about half total height, apex bent ventrally, parameres short, stems swollen centrally, contiguous on apical half, apices curved laterally.

Pupa (Gilruth Plains specimen) : Light yellowish-brown, slightly darker on dorsum of thorax. Respiratory trumpet short, about four times as long as broad, with about 9 pairs of spiracles on apical half (Fig. 51). Operculum short and broad, median tubercle not distinguishable, a.m. tubercles situated between lateral corners, each with a short, fine spine, remaining surface without spines, covered almost entirely with small tubercles (Fig. 36). Dorsal tubercles of cephalothorax as figured, 1, 2 and 3 with a short spine, 4 with a seta of medium length, 5 with pore only (Fig. 37). Tubercles of abdominal segments 3–7 as figured, d.a.s.m. 2 and l.a.s.m. with a short spine, d.a.s.m. 1 with a long, fine spine, all five d.p.m.'s present, 2, 3 and 5 with a short spine, 1 and 4 appear to be without spines ; l.p.m.'s 1 and 3 large, with a short spine, 2 similar but with a long fine spine, v.p.m.'s 1 and 3 with a short spine, 2 with a long spine (Fig. 38). Abdominal segment 8 lacking d.a.s.m.'s, l.a.s.m. and d.p.m.'s 3–5 (?), d.p.m. 2, l.p.m.'s 1 and 3 and v.p.m.'s 1 and 3 with a short spine, d.p.m. 1, l.p.m. 2 and v.p.m. 2 with a long, fine spine (Fig. 39). Anal segment with a basal band of 2–3 rows of small spines (Fig. 40).

Additional specimens : Queensland : Cloncurry River (1♀, pinned, 1.v.1955, 1715–1740 hours, Fort Constantine, net along damp edges of river bed, E. J. Reye) ; Longreach (1 ♀, 23.iv.1955, " Leander ", net on pond shore, E. J. Reye) ; Merivale Ck.-Maranoa R. junction (1 ♂, 1 ♀, 6.xi.1952, 6–9 p.m., suction light trap, A. L. Dyce) ; Mt. Crosby (1 ♂, 6 ♀♀, ♀'s in alcohol, 5.xii.1965, dusk-dawn, Lake Manchester Rd., 250 yds. from Brisbane Rd., in narrow, well-grassed, timbered gully, light trap, A. L. Dyce and M. D. Murray) ; Redbank Plains (1 ♀, 12.xii.1967, light trap, A. L. Dyce) ; Gilruth (1 ♂, 1 ♀, 26.vii.1963, light trap, A. L. Dyce and M. D. Murray ; 3 ♂♂, 5 ♀♀, 15.xii.1963, light trap, A. L. Dyce) ; Gilruth Plains (1 ♂, 2.ii.1963, light trap, 2 ♀♀, 1.iii.1963, bred, A. L. Dyce and M. D. Murray) ; Goodar Crossing, Weir R. (2 ♀♀, 28.iii.1953, 1730–2130 hours, suct. light trap, W. E. Poole) ; Yelarbon (1 ♂, 2 ♀♀, 27.iii.1953, 1800–2115 hours, 4 ♀♀, 27–28.iii.1953, 2115–0045 hours, suct. light trap, W. E. Poole) ; Noondoo (7 ♀♀, 29–30.iii.1952, 2145–0130 hours, bored spring, suct. light trap, W. E. Poole ; 1 ♀, 16.xii.1963, light trap, A. L. Dyce) ; Texas Stn. (1 ♂, 26.iii.1953, dusk–2130 hours, suction light trap, A. L. Dyce). New South Wales : Moree (1 ♂, 1 ♀, 1951, light trap, A. L. Dyce ; 1 ♂, no data except collector, A. L. Dyce, but probably from Moree ; 1 ♀, 30.i.1952–31.i.1952, 2030–dawn, mercury vapour light trap, A. L. Dyce ; 5 ♂♂, 23.ii.1963, to light, A. L. Dyce and M. D. Murray) ; Mungie Bundie, Meehi R., Moree (1 ♂, 16.ii.1952, 2000–2130 hours, suct. light trap, A. L. Dyce) ; Bundy Creek, via Moree (1 ♀, 1.xi.1951, light trap, 7 ♂♂, 6.xii.1951, 1700–2000 hours, 10 ♂♂, 6.xii.1951, 1800–2100 hours, 15 ♂♂, 5 ♀♀, 1 ⚥ gynandromorph, 7.xii.1951, 2400–0200 hours, 13 ♂♂, 6 ♀♀, 7.xii.1951, 0200–0500, 1 ♂, 7.xii.1951, 0500–0700 hours, mercury vapour light trap, A. L. Dyce ; 1 ♀, pinned, v.1952, 2 ♀♀, 20.v.1952, 1600 hours, net in creek bed, 1 ♀, 7.vi.1952, 1600 hours, net in creek bed, E. J. Reye) ; Hornsby (1 ♂, 5.i.1957, 1 ♂, 9.i.1957, light trap, D. J. Lee) ; Glenfield (29.iii.1957, light trap, Keast).

Distribution : Northern Territory, central and south-eastern Queensland, eastern New South Wales.

This widespread species can be distinguished from the similar *unguistyla* n. sp. by the absence of a spot on wing vein R_1, the presence of two well-developed distal spots in cell R_5, and the elongated spot in cell M_1. In addition, the grey wing margin in the female is very conspicuous, the costa in the female never reaches the midpoint of the wing, knee joints are never pale, and the parameres of the male tend to be shorter and very strongly swollen centrally.

The shape of the style in the male of this species varies, in some specimens being very strongly curved basally, as in the allotype, in others (as in the paratype figured, Fig. 35) being much more gently curved. In the type series the latter form predominates, but among the other specimens the former is most common.

5. Alluaudomyia unguistyla n. sp. (Figs 41–45, 52–57)

Types : Holotype ♀, allotype ♂ and 1 ♀ paratype.

Type Locality : Careel Bay, New South Wales (20.ii.1958, light trap, D. J.

Lee). Allotype from Newport, New South Wales (12.xii.1956, light trap, W. Wirth), paratype from Careel Bay (10.iv.1958, light trap, D. J. Lee).

A medium-sized, mottled species, very similar to *fumosipennis* n. sp.

Female: Length 1·70 mm., wing 1·01 × 0·50 mm.

Head brown, vertex light brown, frons ochreous. Eyes bare, contiguous. Mandible with 11–12 teeth. Palpal segments I–II white, III–V pale brown, segment III with a small, shallow preapical pit bearing sensillae (Fig. 52). Antennal segment II brown, segments III–IX light brown with bases broadly paler, X–XV brown (Fig. 53).

Scutum brown, paler laterally, humeral areas yellow with two small brown dots, dorsum with darker brown pattern and dark dots at setal bases, pattern similar to that of *fumosipennis*, scutellum pale yellow but very broadly dark centrally, with 4 setae, postscutellum brown, darker centrally, pleuron light brown to yellowish-brown with a dark central transverse band. Fore coxae and all trochanters yellowish-fuscous, mid and hind coxae brown; femora and tibiae whitish, the fore femur with a broad brown central band and brown apex, the mid femur with a broad precentral brown band, a narrow preapical brown band and a brown apex, hind femur as in fore but central band narrower, fore tibia with base very narrowly yellowish, narrow sub-basal brown band, broad central brown band and brown apex, mid tibia with base and apex as in fore, a narrow brown band at basal third and one at apical third, hind tibia as in fore but central band narrower (Fig. 55), hind tibial comb of 7–8 spines; tarsi whitish except hind first tarsal segment brown, distal two segments of all legs fuscous. Claws of all legs unequal, ratio of length of claws to fifth tarsal segment 16 : 7 : 17 in fore and mid, 13 : 4 : 16 in hind (Fig. 57).

Wing (Fig. 41) with extensive dark markings, pattern similar to *fumosipennis*, but a dark spot present on R_1, one spot in cell R_5 much reduced, spot in cell M_1 not elongated, wing margin not shaded grey. Macrotrichia numerous on apical half of wing. Haltere white.

Abdomen brown. Cerci white. Spermathecae (Fig. 43) two, subequal, subspherical, each with a short diverticulum.

Male: Length 1·71 mm., wing 1·10 × 0·36 mm.

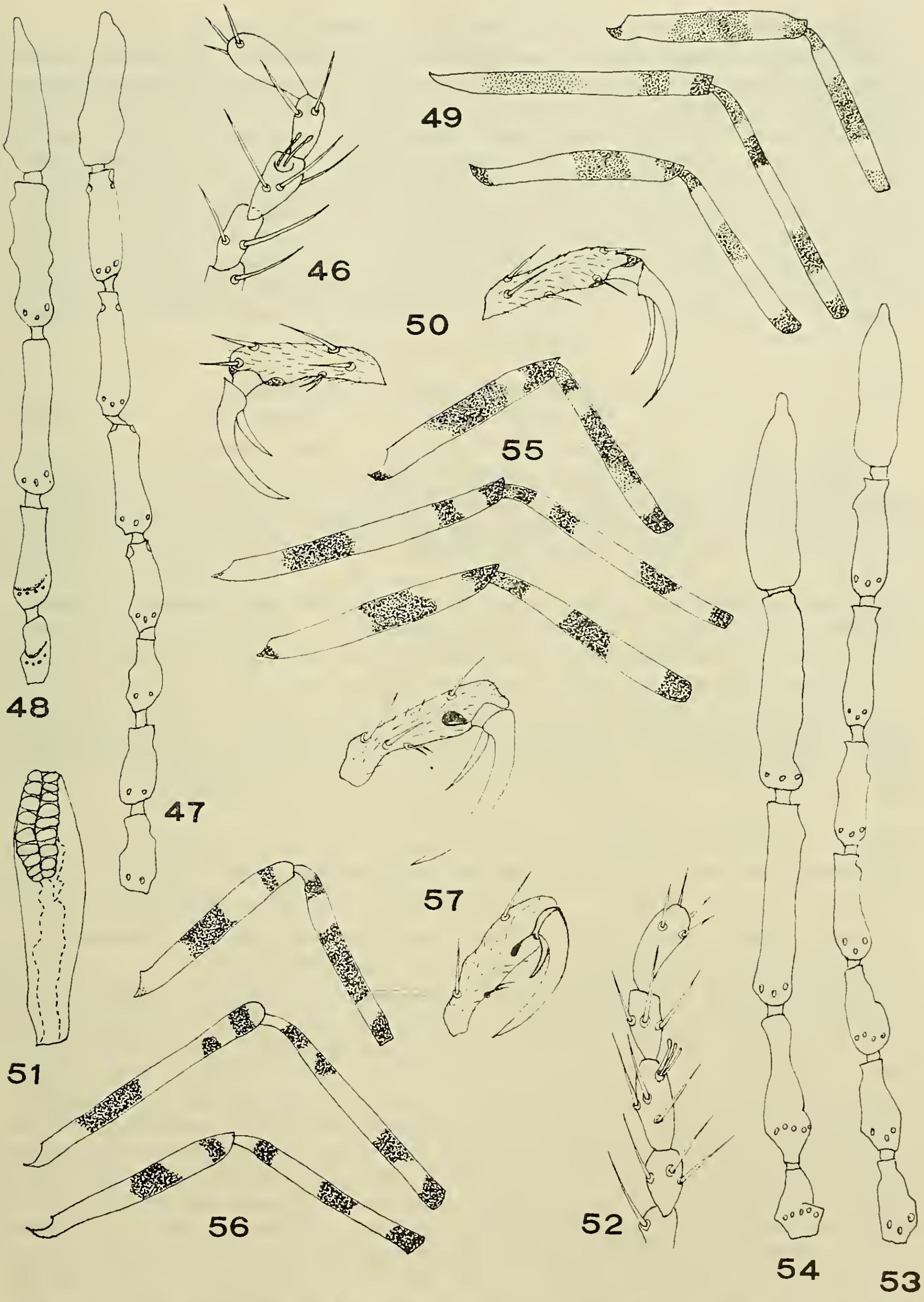
Generally similar to female, differing as follows: Antennal segments III–XI whitish, XII pale basally, brown apically, XIII–XV brown (Fig. 54); plume brown.

Pale bases of tibiae more distinct, femora also narrowly yellow apically, so knees conspicuously pale. Claws of all legs equal, simple, half the length of the fifth tarsal segment.

Wing (Fig. 42) with central spot in cell R_5 entirely absent. Macrotrichia restricted to wing margin between the ends of the costa and M_2.

Abdominal tergites brown with posterior edges white, sternites whitish. Hypopygium (Figs 44–45) brown, very similar in appearance to that of *fumosipennis*, but the parameres tend to be longer and not as conspicuously swollen centrally.

Additional specimens: Queensland: Yeerongpilly (1 ♂, 1950, light trap, R. Riek; 1 ♀, 4.viii.1951, light trap, E. J. Reye); Moggill (1 ♀, 4–5.xi.1965, G. L. Cannon); Dinmore (1 ♀, 5.xii.1965, light trap, A. L. Dyce and M. D. Murray); Coombabah Creek, nr. Pacific Highway (1 ♀, 13.v.1953, 1630 hours, net, E. J. Reye). New South Wales: "Noonameena" Stn. via Bingara (1 ♀, 24.ix.1952, swept in sunlight from above pool, A. L. Dyce; 1 ♂, 20–24.x.1952, A. L. Dyce); Hornsby (1 ♀, 24.ix.1956, 1 ♂, 24.x.1956, 1 ♀, 29.x.1957, light trap, D. J. Lee).



Figs 46–51. *Alluaudomyia fumosipennis.* 46, ♀ maxillary palp, ×350 ; 47, ♀ antennal segments VIII–XV, ×350 ; 48, ♂ antennal segments XI–XV, ×350 ; 49, ♀ femora and tibiae, ×90 ; 50, ♀ fore (*right*) and hind (*left*) tarsus V and claw, ×350 ; 51, pupal respiratory trumpet, ×350. Figs 52–57. *Alluaudomyia unguistyle.* 52, ♀ maxillary palp, ×350 ; 53, ♀ antennal segments VIII–XV, ×350 ; 54, ♂ antennal segments XI–XV, ×350 ; 55, ♀ femora and tibiae, ×90 ; 56, ♀ femora and tibiae (Moggill specimen), ×90 ; 57, ♀ fore (*upper*) and hind (*lower*) tarsus V and claw (Moggill specimen), ×350.

Distribution: South-eastern Queensland, eastern New South Wales.

This species is very close to *fumosipennis* n. sp., but it can be differentiated by the presence of a dark spot on wing vein R_1 in both sexes, the smaller, more rounded spot in cell M_1, and the reduction of one of the spots in cell R_5, in the female this consisting of at most a small, irregular, linear spot, the male having only a very pale, minute spot, or lacking it entirely. Other characters which may be useful, although less reliable than the preceding, are: much less conspicuous, sometimes absent, grey margin on wing than in *fumosipennis*; knee joints usually conspicuously pale, but sometimes only slightly so (never pale in *fumosipennis*); costa in female reaching to or beyond midpoint of wing (average costal ratio of male also greater than in male of *fumosipennis*, but there is a slight overlap at the extremes of the ranges); parameres of male tend to be longer and less strongly swollen centrally.

6. ALLUAUDOMYIA IMMACULATA Tokunaga

Alluaudomyia immaculata Tokunaga, 1963, *Pacif. Insects*, *5*: 219 (♂ only).

(Type locality: Kampong Landbouw, Biak, New Guinea.)

Characteristics: A small, pale ochreous species. Head ochreous, eyes bare. Scutum yellow on anterior half, with white humeral areas, ochreous on posterior half, scutellum yellow, with 2 setae, postscutellum ochreous; legs yellowish, only hind first tarsal segment slightly fuscous, claws all small and equal. Wing with a single pale ochreous spot at the junction of the costa and R_{4+5}, macrotrichia absent. Haltere white. Abdomen very pale brown, hypopygium brown. Aedeagus triangular, with a very shallow basal arch, parameres separate, each with a detached basal arm, apex extended into a long, flattened, tapering process.

Distribution: Known only from the type locality.

Distinguishable from *verecunda* n. sp. by the pale thorax and abdomen, entirely yellow femora and tibiae, and form of the genitalia. In coloration it is closest to *bifasciata* Tokunaga, but it is separated by the absence of fuscous areas on the femora and tibiae, the bare eyes, and the form of the genitalia.

7. ALLUAUDOMYIA INSULANA Tokunaga and Murachi

Alluaudomyia insulana Tokunaga and Murachi, 1959, *Ins. Micronesia*, *12*: 358.

(Type locality: Wena I., Truk, Caroline Is. Allotype from Mt. Unibot, Ton I., Truk; paratypes from Mwot and Mutunlik, Kusaie, Caroline Is.); Tokunaga, 1963, *Pacif. Insects*, *5*: 222 (New Britain).

Characteristics: A small species. Head brown, eyes bare. Scutum brown with yellow and fuscous markings, scutellum yellowish, brown centrally, with 2 setae; legs yellowish with variable pale brown markings; femora brown on basal two-thirds to three-fourths, or entirely pale brown except for yellow base, or with broad fuscous central bands, fore tibia pale brown on apical two-thirds to three-fourths, sometimes with a narrow yellow preapical band, or with a broad fuscous median band, mid tibia pale brown with apex dark and brownish clouds at basal and apical third, or pale brown with a broad basal and narrow preapical pale ring, or entirely yellow, hind tibia pale brown with brown cloud before middle and brown apex, or yellow with a broad brown central band and dark apex, or yellow with a small sub-basal fuscous spot and dark apex, female claws unequal, ratio of length of claws to fifth tarsal segment 18 : 17 : 9, male claws all small and equal. Wing with dark spots at junction of costa and R_{4+5} and on R_1, distal parts of Rs and M before r-m cross-veins fuscous, female with a moderate number of macrotrichia on anterior and apical areas of wing, male with macrotrichia sparsely arranged along anterior margin. Haltere pale yellow to white. Abdomen mainly yellow, female with three small brown clouds on tergite III, tergites IV and V with anterior margin brown, tergite VIII brown on anterior half, male with tergites II–V pale brown with a pair of yellowish spots. Spermathecae two, unequal, slightly pyriform. Aedeagus plate-like, deeply excavated apically giving it the appearance of a fish-tail, parameres with broad, expanded basal process, stems slightly tapering apically, apices bent at right angles, sharply pointed and with a small barb.

Distribution: Caroline Islands, New Britain.

The pale abdomen and distinctive genitalia identify this species.

8. ALLUAUDOMYIA VERECUNDA n. sp. (Figs 58–60, 68–70)

Types: Holotype ♂, 1 ♂ paratype.

Type Locality: Maprik, New Guinea (1958).

A small species with only a single conspicuous wing spot, but legs distinctly banded.

Male: Length 1·37 mm., wing 0·71×0·28 mm.

Head brown. Eyes bare, just contiguous. Palp very pale brown, segment III stout, with a shallow pit just above centre bearing several sensillae (Fig. 68). Antennal segment II dark brown, flagellar segments lighter brown (Fig. 69); plume dark brown.

Scutum brown, with yellowish areas anteriorly and laterally, scutellum yellow but brown centrally, with 2 setae, postscutellum brown, darker centrally, pleuron brown. Coxae brown, trochanters pale brown; legs pale fuscous yellow, apices of femora and tibiae, sub-basal two-thirds of femora, apical two-thirds of fore tibia and broad central area of hind tibia light brown (Fig. 70), hind tibial comb of 4–5 spines; tarsi whitish but hind segment I brown, base of fore segment I and all fourth and fifth segments fuscous. Claws of all legs small, equal, half the length of the fifth tarsal segment.

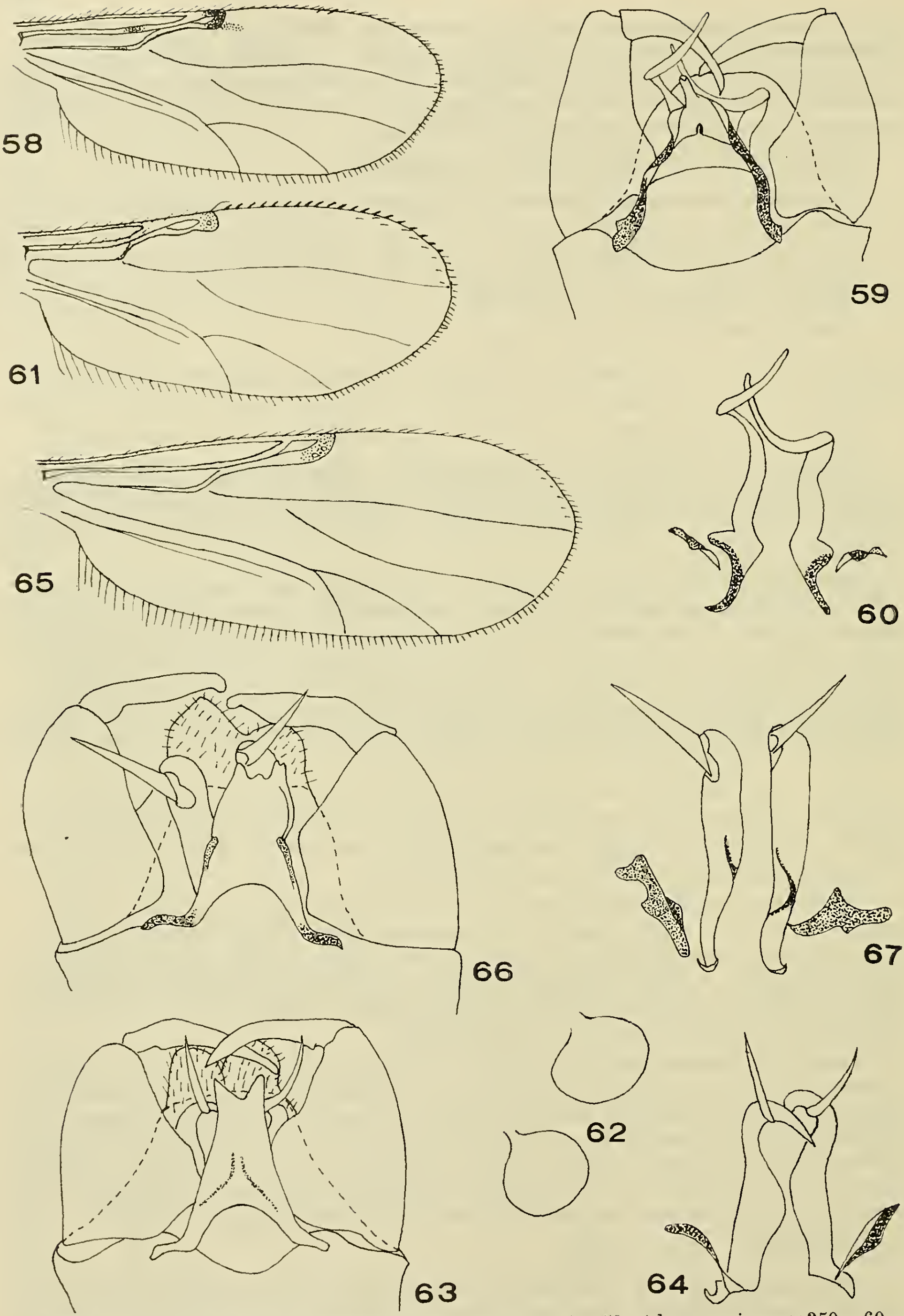
Wing (Fig. 58) with one light brown spot at junction of costa and R_{4+5}, extending slightly on to membrane, parts of Rs, M, M_1 and M_2 streaked with brown. A single row of macrotrichia on the wing margin between the ends of the costa and M_2. Haltere yellowish-white.

Abdominal tergites dark brown, sternites paler brown, pleuron greyish. Hypopygium (Figs 59–60) dark brown, coxites broad basally, narrow apically, styles pale, short, gently curved; aedeagus deeply arched, with a pair of preapical lateral folds and a short, ventrally bent caudal process, parameres separate, each with a short detached basal arm, base of stem expanded and curved, stem sinuous, apical process very long and tapered.

Female: A female specimen from the Bariji River Valley, New Guinea (2,000 ft., nr. Toma, S.S.W. of Popondetta, ix.1964, R. Pullen) resembles the type specimens but is darker, with the brown leg bands much more conspicuous, and the preapical pale bands of the femora narrower. The hind claw is single with a short basal tooth (other claws missing), and the spermathecae lack diverticula. However, as this specimen is badly damaged, it seems advisable to await the collection of further specimens before describing the female.

Distribution: New Guinea.

This species is readily distinguished from *immaculata* Tokunaga by its much darker coloration, banded legs, and the form of the male genitalia. The bare eyes, different pattern of leg banding and form of the genitalia separate it from the similarly dark-coloured *papuae* Tokunaga, and the genitalia and dark abdomen differentiate it from *insulana* Tokunaga and Murachi.



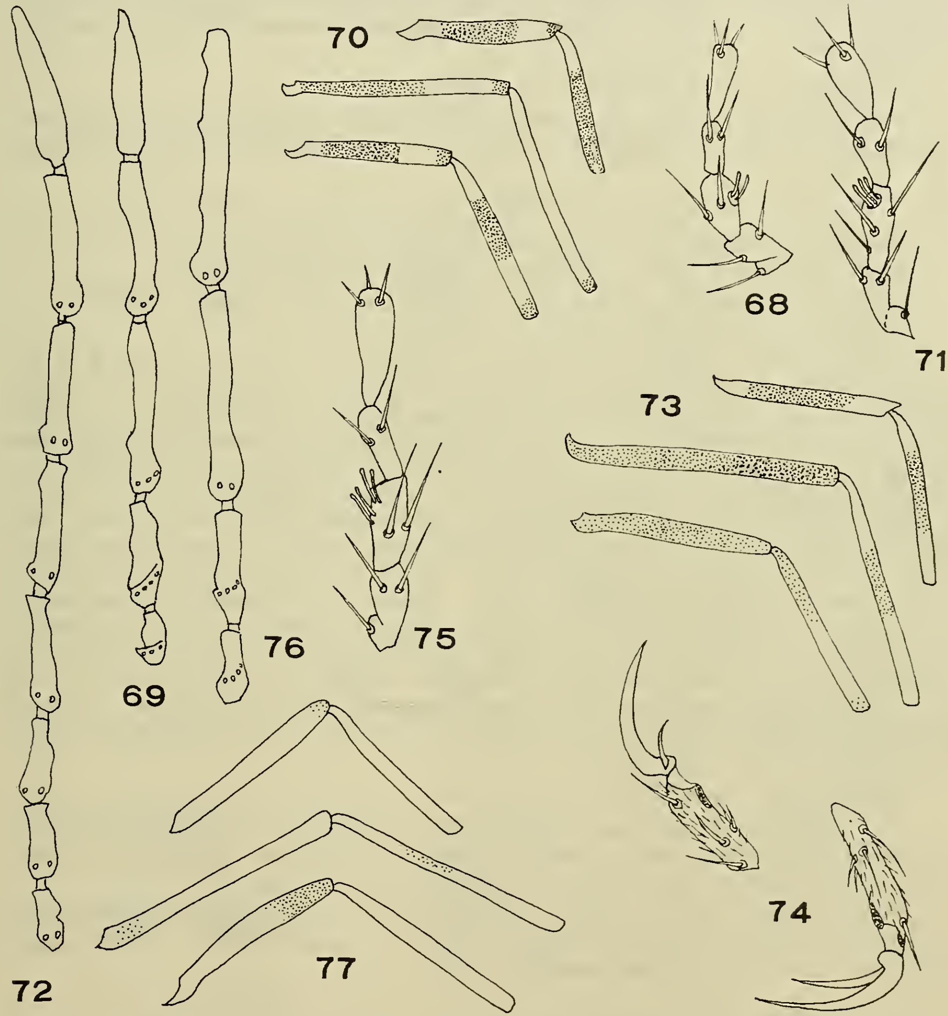
Figs 58–60. *Alluaudomyia verecunda*. 58, ♂ wing, × 90; 59, ♂ hypopygium, × 350; 60, ♂ parameres, × 350. Figs 61–64. *Alluaudomyia papuae*. 61, ♀ wing (Maprik specimen), × 90; 62, ♀ spermathecae (Maprik specimen), × 350; 63, ♂ hypopygium (Maprik specimen), × 350; 64, ♂ parameres (Maprik specimen), × 350. Figs 65–67. *Alluaudomyia bifasciata*. 65, ♂ wing (Musgrave R. specimen), × 90; 66, ♂ hypopygium (Musgrave R. specimen), × 350; 67, ♂ parameres (Musgrave R. specimen), × 350.

9. Alluaudomyia papuae Tokunaga (Figs 61–64, 71–74)

Alluaudomyia papuae Tokunaga, 1963, *Pacif. Insects*, *5*: 217. (Type locality: Keravat, New Britain. Allotype from Maprik, New Guinea; paratype from Bainyik, New Guinea.)

Specimens examined: New Guinea: Maprik (11 ♂♂, 7 ♀♀, 1958; 1 ♂, 2 ♀♀, iv.1958; 6 ♂♂, 2 ♀♀, 6.vii.1958); Nineia, Morobe District (2 ♀♀, 10.v.1960, aspirated from rock ledges, Sowat R., B. McMillan).

Characteristics: A small species with wings unmarked except for a pale yellowish spot at the end of the costa. Head dark brown, frons and proboscis paler, eyes pubescent. Thorax almost entirely dark brown but scutellum yellow



Figs 68–70. *Alluaudomyia verecunda*. 68, ♂ maxillary palp (paratype), ×350; 69, ♂ antennal segments XI–XV, ×350; 70, ♂ femora and tibiae, ×90. Figs 70–74. *Alluaudomyia papuae*. 71, ♀ maxillary palp (Maprik specimen), ×350; 72, ♀ antennal segments VIII–XV (Maprik specimen), ×350; 73, ♀ femora and tibiae (Maprik specimen), × 90; 74, ♀ fore (*right*) and hind (*left*) tarsus V and claw (Maprik specimen), ×350. Figs 75–77. *Alluaudomyia bifasciata*. 75, ♂ maxillary palp (Musgrave R. specimen), ×350; 76, ♂ antennal segments XI–XIV (Musgrave R. specimen), ×350; 77, ♂ femora and tibiae (Musgrave R. specimen), ×90.

with a dark median spot and 2 setae ; legs yellowish, with fuscous to brown clouds, markings more pronounced in female (Fig. 73), female claws (Fig. 74) unequal, ratio of length of claws to fifth tarsal segment 20·7 : 12·7 : 19·7 in fore, 24 : 15·7 : 20·7 in mid, 14·7 : 9·3 : 18·3 in hind, male claws all small and equal. Wings very pale, with a single very pale yellowish spot over the end of the costa, female without macrotrichia but with a row of spinulose setae on the anterior edge (Fig. 61), male with a few macrotrichia on the anterior edge. Haltere white. Abdominal tergites mainly dark brown, but II white, VI–VII fuscous, and in female posterior half of V and sometimes anterior half of VIII fuscous, sternites pale. Spermathecae (Fig. 62) two, brown, spherical or subspherical, subequal, sometimes also a third, vestigial, round. Aedeagus large, strongly sclerotized, with a V-shaped apical notch, parameres separate, expanded centrally, with a hook-like apex and a slender, tapering subapical process (Figs 63–64).

Distribution : New Britain, New Guinea.

This species is distinguished from the allied species *bifasciata* by its darker coloration, spinulose setae on the female wing, and form of the male genitalia.

10. Alluaudomyia bifasciata Tokunaga. (Figs 65–67, 75–77)

Alluaudomyia bifasciata Tokunaga, 1963, *Pacif. Insects, 5* : 220. (Type locality : Keravat, New Britain. Allotype from Waris, West Irian.)

Specimen examined : New Guinea : Musgrave R. nr. Port Moresby (1 ♂, 25.ii.1964, D. H. Colless). Allotype ♂ also examined.

Characteristics : Small, pale brown to ochreous species, wing with a single pale spot at the end of the costa. Head pale ochreous, eyes pubescent. Thorax pale brown or ochreous with humeral areas yellowish, scutellum pale yellow with a fuscous median spot and 2 setae ; legs yellow, mid femur slightly fuscous sub-basally and/or apically, hind femur fuscous apically (Fig. 77). Female claws unequal, ratio of length of claws to fifth tarsal segment 19·5 : 12·5 : 21·5 in fore, 20·5 : 12 : 20·5 in mid, 16·5 : 7·5 : 20 in hind, male claws all small and equal. Wing (Fig. 65) with a single pale ochreous spot at the end of the costa, female with a moderate number of macrotrichia at the wing apex, male with only a few macrotrichia. Haltere white. Abdomen of female with segments I–II and V–VI mainly white, III–IV and VII–IX mainly fuscous, but anterior part of V fuscous and anterior part of VII white, abdomen of male with I ochreous or pale brown, II white to yellow, III–IV or V and VIII–IX brown, V or VI–VII pale yellow. Spermathecae two, round, equal. Aedeagus large, with a W-shaped apical excavation, parameres separate, each with a flattened, tapering apicolateral process (Figs 66–67).

Distribution : New Britain, West Irian, New Guinea.

The Musgrave R. specimen lacks the strong spines on the coxite which are present in the allotype, but is otherwise similar. The costal ratio of the allotype is 0·53, not 0·43 as recorded in the original description.

This species is allied to *papuae* Tokunaga, but is distinguished by its paler coloration, absence of spinulose setae and presence of macrotrichia on the female wing, and form of the male genitalia.

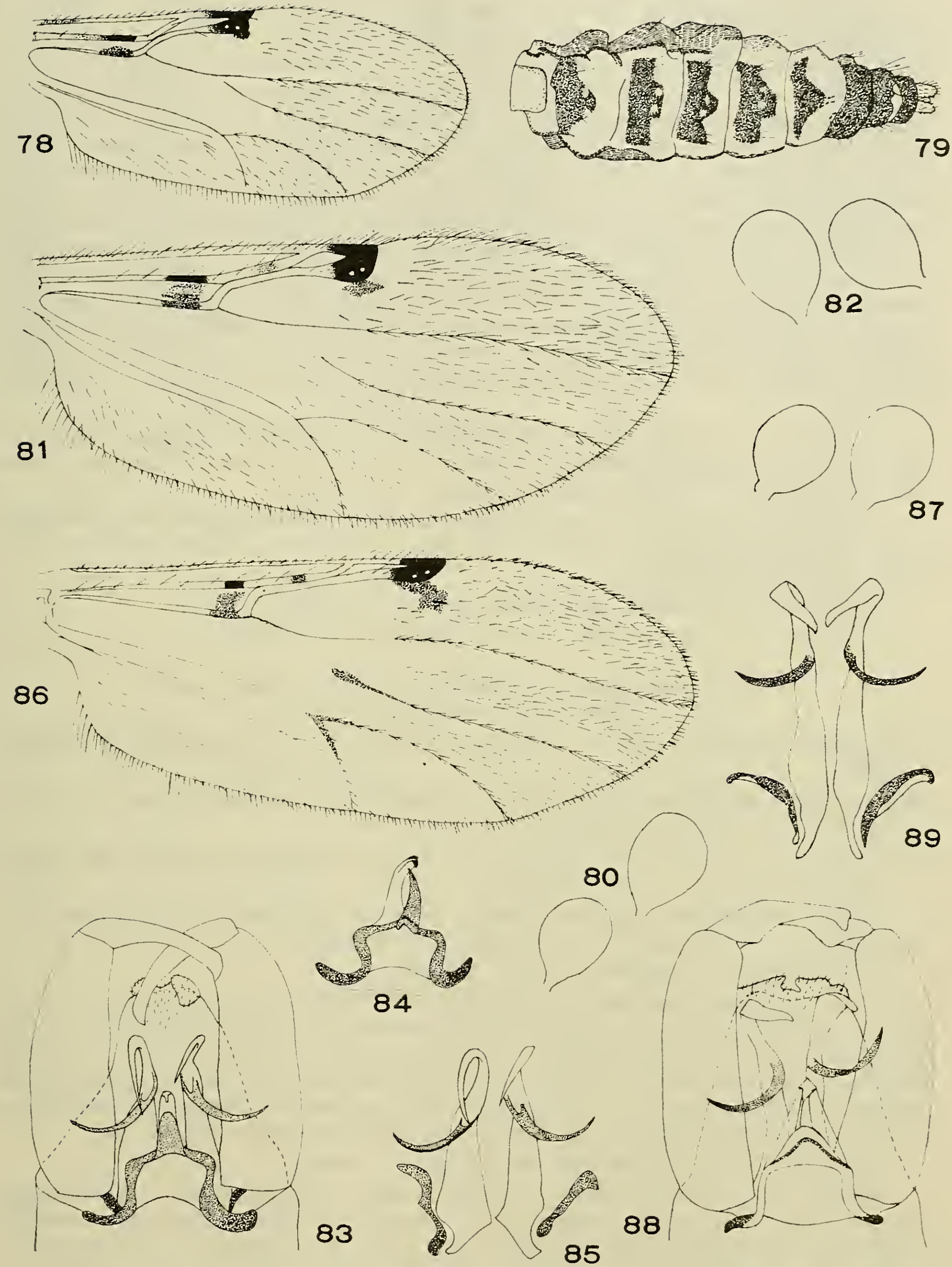
11. Alluaudomyia alpina n. sp. (Figs 78–80, 102–106)

Types : Holotype ♀ and 1♀ paratype.

Type Locality : Alpine Creek, Kiandra, N.S.W. (2.ii.1965, D. Colless).

A small, very dark species, the legs with narrow pale bands. Male unknown.

Female : Length 1·44 mm., wing 1·13 × 0·36 mm.



Figs 78–80. *Alluaudomyia alpina.* 78, ♀ wing, ×55 ; 79, ♀ abdomen (paratype), ×55 ; 80, ♀ spermathecae (paratype), ×200. Figs 81–85. *Alluaudomyia latipennis.* 81, ♀ wing (Hornsby specimen), ×55 ; 82, ♀ spermathecae (Hornsby specimen), ×200 ; 83, ♂ hypopygium (Nattai R. specimen), ×200 ; 84, ♂ aedeagus, with apical processes twisted laterally showing curvature (Hornsby specimen), ×200 ; 85, ♂ parameres (Nattai R. specimen), ×200. Figs 86–89. *Alluaudomyia appendiculata.* 86, ♀ wing, ×55 ; 87, ♀ spermathecae (paratype), ×200 ; 88, ♂ hypopygium (paratype), ×200 ; 89, ♂ parameres, ×200.

Head dark brown. Eyes bare, contiguous, mandibular teeth 9. Palp with proximal segments light brown, distal segments darker, segment III with a small subapical pit bearing a few long sensillae (Fig. 102). Antennal segment II dark brown, flagellar segments brown, IV–VII whitish basally (Fig. 103).

Scutum dark blackish-brown, humeral areas light brown, two large spots near each lateral margin also paler, scutellum broadly dark brown centrally, paler laterally, with 4 setae, postscutellum blackish-brown, pleuron dark brown. Fore coxa and fore and mid trochanters light brown, mid and hind coxae and hind trochanter dark brown ; femora and tibiae largely dark brown, the fore femur with base paler and a very narrow light brown preapical band, mid and hind femora with slightly broader pale preapical bands, fore and mid tibiae with light brown sub-basal and preapical bands, hind tibia with similar but broader bands (Fig. 104), hind tibial comb of 8 spines ; hind tarsal segment I brown, remaining tarsi pale fuscous, apices of segments I and II and all of III, IV and V darker. Claws of all legs very unequal, ratio of length of claws to fifth tarsal segment 16·5 : 8 : 19 in fore, 16 : 6 : 17 in mid, and 15 : 6 : 18 in hind (Fig. 105).

Wing (Fig. 78) with many macrotrichia on apical half and in anal area. Two wing spots, one at junction of costa and R_{4+5}, and one before r-m, veins slightly brownish. Haltere pale fuscous.

Abdominal segments, except last three, white with a large, broad, T-shaped spot, distal three segments brown (Fig. 79). Cerci white. Spermathecae two, oval, subequal (Fig. 80).

Distribution : Known only from the type locality.

The very dark legs of this species are quite distinctive.

12. ALLUAUDOMYIA LATIPENNIS (Skuse), comb. nov.
(Figs 81–85, 90–95, 107–113)

Ceratopogon latipennis Skuse, 1889, PROC. LINN. SOC. N.S.W., *4* (2nd series) : 308.

Didymorphleps latipennis (Skuse) Kieffer, 1906, *Genera Insectorum*, fasc. *42* : 56 ; 1917, *Ann. Mus. Nat. Hung.*, *15* : 193.

Bezzie latipennis (Skuse) Kieffer, 1906, *Genera Insectorum*, fasc. *42* : 193 ; Lee, 1948, PROC. LINN. SOC. N.S.W., *73* : 340.

Type : Holotype ♀, in the Macleay Museum, University of Sydney. All that remains of the type is a single mid leg (not hind leg, as stated by Lee).

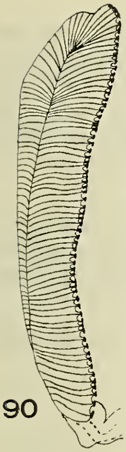
Type Locality : Berowra, N.S.W. (Masters).

It is apparent from Skuse's diagram and description that *latipennis* is a species of *Alluaudomyia.* A number of specimens in the collections of the S.P.H. and T.M. and the McMaster Laboratory, C.S.I.R.O. Division of Animal Health, agree very closely with the original description and are considered to be conspecific with *latipennis.* The species is here redescribed from a selected female and male collected at Hornsby, N.S.W., which is near the type locality.

Female : Length 2·02 mm., wing 1·53 × 0·69 mm.

Head light yellowish-brown. Eyes bare, just separated. Mandibular teeth 15–16. Palp slender, pale brown, segment III with a preapical sensory pit bearing several long sensillae (Fig. 107). Antennal segments II–III brownish-ochreous, segments IV–X whitish on basal half, light brown on apical half, XI–XIV light brown with base whitish, XV light brown (Fig. 108).

Scutum fuscous yellow, without pattern, scutellum fuscous yellow but brown centrally, with 4 strong setae, postscutellum brown, more yellowish laterally, pleuron fuscous yellow. All coxae fuscous yellow, trochanters fuscous ; all femora and tibiae pale yellowish-white, femora with apex brown, hind femur



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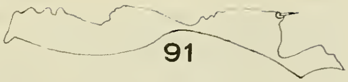

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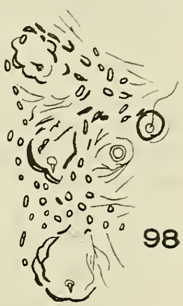

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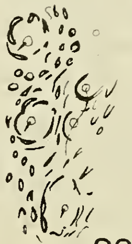

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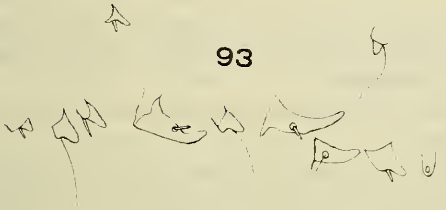

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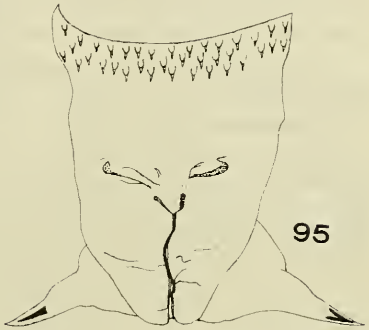

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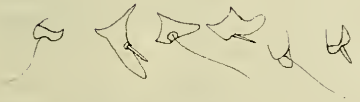

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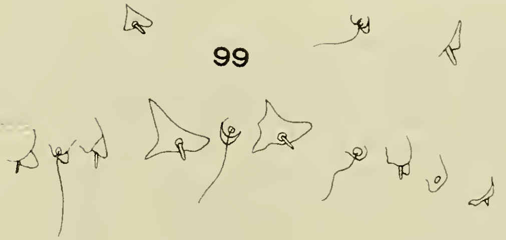

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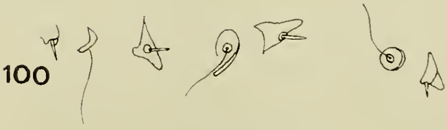

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Figs 90–95. *Alluaudomyia latipennis*, pupa. 90, ♂ respiratory trumpet (Nattai R. specimen). × 200; 91, profile of operculum, × 200; 92, dorsal tubercles of cephalothorax, × 200; 93, tubercles of 7th abdominal segment (Hornsby specimen), × 200; 94, tubercles of 8th abdominal segment (Hornsby specimen), × 200; 95, ♂ anal segment (Nattai R. specimen), × 200. Figs 96–101. *Alluaudomyia appendiculata*, pupa. 96, ♀ respiratory trumpet, × 200; 97, operculum (paratype), × 200; 98, dorsal tubercles of cephalothorax, × 200; 99, tubercles of 7th abdominal segment, × 200; 100, tubercles of 8th abdominal segment, × 200; 101, ♂ anal segment (paratype), × 200.

also with a broad, very pale fuscous sub-basal band, all tibiae with apex brown, fore tibia also with a narrow sub-basal brown band and broad, very faint fuscous central band, mid tibia with base brown, hind tibia with a pale fuscous central band (Fig. 110), hind tibial comb of 8–9 spines ; tarsi whitish except for distal two segments on all legs, which are pale fuscous, and hind segment I, which is light brown. Claws of fore and mid legs unequal, those of hind legs very unequal, ratio of length of claws to fifth tarsal segment 34 : 17 : 27 in fore, 33 : 16 : 27 in mid, and 25 : 9 : 24 in hind (Fig. 112).

Wing (Fig. 81) with numerous macrotrichia on apical half and in anal area. Three wing spots, one just before r-m, one on R_1, and one at the junction of the costa and R_{4+5}, the latter extending slightly on to cell R_5. Haltere with stalk white, knob fuscous.

Abdomen yellowish-brown. Cerci white. Spermathecae two, oval, subequal (Fig. 82).

Male : Length 1·87 mm., wing 1·27 × 0·48 mm.

Generally similar to female, differing as follows :

Antennal plume pale brown, flagearll segments III–XII pale yellow, XII–XVI brown (Fig. 109).

Legs lacking pale fuscous areas on fore tibia and hind femur, but central band on hind tibia darker. Claws all paired, equal and simple, slightly more than half the length of the fifth tarsal segment.

Wing with fewer macrotrichia, these restricted to the anterior edge and apical fourth of the wing. Haltere white.

Abdomen light brown. Hypopygium (Figs 83–85) light yellowish-brown, coxites long, narrow, styles short and scarcely curved, with rather blunt apices. Aedeagus with a low, squared basal arch and a pointed, dorsally curved apical process, caudal lobe long and narrow, ventrally curved ; parameres expanded and just touching basally, each with a detached basal arm, apex elongated into a narrow, tapering process, a similar process arising subapically.

Pupa : Light yellowish-brown, dorsum of thorax darker. Respiratory trumpet pale to dark brown, 0·25 mm. long in female, slightly longer in male, with about 45 pairs of spiracles in female and 65–75 pairs in male, arranged obliquely along most of its length (Fig. 90). Operculum similar to that of *appendiculata* n. sp. (see Fig. 97), median tubercle without spine, placed well back from distal margin, a.m. tubercles situated between lateral corners, each with a short, basally directed spine, rest of surface without spines, but with very small tubercles, these most prominent around the bases of the a.m.'s and on the distal margin (Fig. 91). Dorsal tubercles of cephalothorax situated as figured, 1, 2 and 3 with very short, stout spines, 4 with a long fine seta, 5 with pore only (Fig. 92). Tubercles of abdominal segments 3–7 as figured, d.a.s.m. 2 and l.a.s.m. small with a short, stout spine, d.a.s.m. 1 with a long, fine seta, of d.p.m.'s 5 absent, 4 and 3, when present, represented by pores only, 1 and 2 of intermediate size, 2 with a short spine and 1 with a long seta, l.p.m.'s 1 and 3 large, with a short spine, 2 small, with a long seta, v.p.m.'s of small to medium size, 1 and 3 with a short spine, 2 with a long seta (Fig. 93). Tubercles of 8th abdominal segment as figured, d.a.s.m.'s and l.a.s.m. absent, as are v.p.m.'s 1 and 3, otherwise similar to preceding segment (Fig. 94). Anal segment with spines in a basal band of 2–3 rows (Fig. 95).

Specimens examined : New South Wales : Mt. Dromedary (2 ♂♂, 9 ♀♀, 24.xi.1965, light trap, I. F. B. Common and M. Upton) ; Hornsby (2 ♀♀, pinned, 11.iv.1956, 1 ♀, pinned, 16.ix.1956, 1 ♂, 1 ♀, both pinned, 19.ix.1956, 1 ♂, 23.ix.1956, 1 ♂, 28.ix.1956, 1 ♀, 3.x.1956, 5 ♀♀, 8.x.1956, light trap, D. J. Lee ; 1 ♀, 9.x.1956, bred from pupa ex wet rock face, D. J. Lee and W. W. Wirth ;

2 ♂♂, 24.x.1956, 1 ♂, 25.x.1956, 1 ♂, 26.x.1956, 1 ♀, 10.xii.1956, 1 ♀, 30.x.1957, light trap, D. J. Lee) ; Stockyard Creek, Colo Vale (1 ♀, 26.x.1954, 1845–2000 hours, suction light trap, A. L. Dyce) ; Nattai River, Mittagong (1 ♀, 7.i.1964, light trap, D. J. Lee ; 1 ♂, 4.xi.1964, bred ex pupa, D. J. Lee and L. Smee ; 1 ♂, 15.xi.1968, bred ex pupa, D. J. Lee and M. L. Debenham).

Distribution : New South Wales.

The coloration and leg banding in this species is quite variable. In the Hornsby specimens the thorax ranges from fuscous yellow to ochreous brown, in the Colo Vale specimen it is ochreous yellow, in the Nattai River specimens yellow with fuscous clouds and a greenish tinge, and in the Mt. Dromedary specimens dark, slightly ochreous brown, sometimes with a greenish tinge. The legs are generally almost entirely pale, often with faint fuscous markings, but in the Mt. Dromedary specimens the markings are quite distinct (Fig. 111).

The paler forms of this species are readily recognizable by the almost entirely pale legs. The darker forms resemble *appendiculata* n. sp. but can be distinguished by the pale bases on all femora, the absence of a distinct preapical band on the mid tibia, and the different genitalia.

13. ALLUAUDOMYIA APPENDICULATA n. sp. (Figs 86–89, 96–101, 114–120)

Types : Holotype ♂, allotype ♀, 17 ♂♂ and 11 ♀♀ paratypes.

Type Locality : Hornsby, N.S.W. (holotype 28.ix.1956, light trap, D. J. Lee, allotype 9.x.1956, bred from pupa ex wet rock face, D. J. Lee and W. W. Wirth). Paratypes from Hornsby (1 ♀, pinned, 6.ix.1956, D. J. Lee and W. W. Wirth ; 1 ♂, 24.ix.1956, light trap, D. J. Lee ; 1 ♂, same data as holotype ; 1 ♂, 8.x.1956, light trap, D. J. Lee ; 2 ♂♂, 5 ♀♀ (3 ♀♀ pinned), same data as allotype ; 1 ♂, 10.x.1956, 1 ♂, 24.x.1956, 1 ♂, 1 ♀, 25.x.1956, 2 ♂♂, 26.x.1956, light trap, D. J. Lee ; 1 ♀, 22.x.1957, light trap, 300 ft., D. J. Lee ; 1 ♂, 28.x.1957, light trap, D. J. Lee ; 1 ♂, 29.x.1957, light trap, 300 ft., D. J. Lee) and Asquith, N.S.W. (2 ♂♂, 2 ♀♀, 19.xi.1965, 3 ♂♂, 1 ♀, 22.xii.1965, light trap, A. L. Dyce).

A large brown and yellow species, with legs distinctly banded, and the wing spot at the apex of the costa extending on to cell R_5.

Male : Length 2·62 mm., wing 1·42 × 0·49 mm.

Head brown. Eyes bare, contiguous. Palp light brown, segment III with a shallow preapical pit bearing several long sensillae (Fig. 115). Antennal segment II ochreous, III–XII very pale, XIII–XV brown (Fig. 117) ; plume brown.

Scutum yellowish-brown on anterior half with a large brown spot on posterior half, humeral areas whitish-yellow, scutellum yellow, dark fuscous centrally, with 4 setae, postscutellum and pleuron brown. Fore and mid coxae yellowish, hind coxa and all trochanters brown ; femora and tibiae yellow, the fore femur fuscous basally, broadly brown centrally, and with a brown preapical ring, mid femur brown on basal half and at apex, hind femur brown on basal half and with a brown preapical ring, fore tibia with a brown sub-basal ring, broadly brown centrally, apex brown, mid tibia with a brown sub-basal ring, a narrow brown preapical band and a brown apex, hind tibia with a brown sub-basal ring, a brown incomplete central band and a brown apex, hind tibial comb of 8 spines ; tarsi whitish but apices of segments I, II and III on fore and mid legs and segments II and III on hind leg fuscous, basal sixth of mid segment I and all of hind segment I brown, segments IV and V of all legs entirely fuscous. Claws of all legs small, equal, just over half the length of the fifth tarsal segment, each with a minute external basal tooth.

Wing with three brown spots, one just before r-m cross-vein, one on R_1, and one at junction of costa and R_{4+5}, the latter extending posteriorly for some


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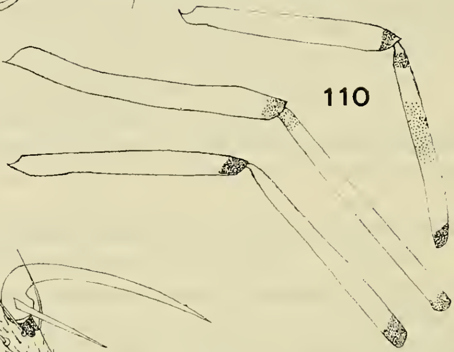
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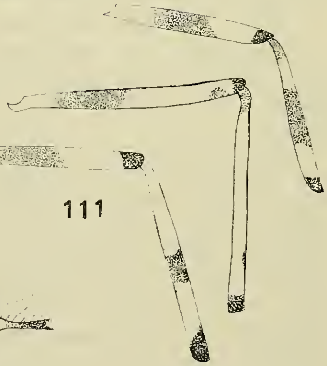
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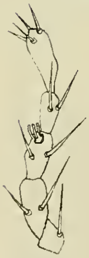
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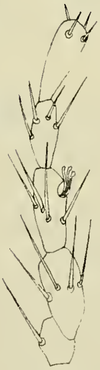
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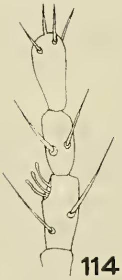
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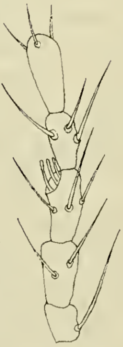
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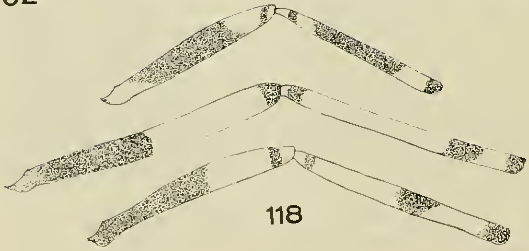
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distance into cell R_5, veins streaked with brown. Macrotrichia restricted to the anterior edge and apex between the ends of the costa and M_{3+4}. Haltere white.

Abdominal tergites brown except for the distal edge and posterolateral two-thirds, which are white, anterior sternites white, posterior sternites light brown on anterior half, pleural membranes white. Hypopygium (Figs 88–89) dark brown, coxites long and slender, styles whitish, short and rather stout; aedeagus deeply arched, with a long, pointed apical lobe, parameres separate, with a short, arcuate, detached basal arm, a long tapering subapical process and a broad, flattened, tapered apical extension.

Female: Length 2·25 mm., wing 1·62 × 0·64 mm.

Generally similar to male, differing as follows:

Colouring more yellowish. Eyes just contiguous. Mandibular teeth 12 large, 6 small. Segments I–III of palp (Fig. 114) whitish. Antennal segments brown, the basal ones paler, all except XV with base whitish (Fig. 116).

Scutum more yellowish, scutellum entirely yellow. Legs (Fig. 118) banded as in male. Claws of fore and mid legs unequal, those of hind leg very unequal, ratio of length of claws to fifth tarsal segment 20 : 10 : 25 in fore, 27 : 13 : 29 in mid, 25 : 8 : 25 in hind (Fig. 119).

Macrotrichia of wing (Fig. 86) much more extensive, covering apical half and part of the anal area. Brown streaking particularly prominent at base of M_2.

Abdomen more yellowish. Cerci white. Spermathecae (Fig. 87) two, subspherical, subequal, each with a short neck.

Pupa: Pale brown, thorax darker dorsally. Respiratory trumpet light to dark brown, approximately 0·26 mm. long, with 50–60 pairs of spiracles extending obliquely along most of its length (Fig. 96). Median tubercle of operculum without spine, situated well back from the distal edge, a.m. tubercles situated between lateral corners, each with a short, basally directed spine, rest of surface without spines but with very small tubercles as described for *latipennis* (Skuse) (Fig. 97). Dorsal tubercles of cephalothorax as figured, 1, 2 and 3 with very short, stout spines, 4 with a long, fine seta, 5 with pore only (Fig. 98). Tubercles of abdominal segments 3–7 as figured, d.a.s.m. 2 and l.a.s.m. small, with a blunt spine, d.a.s.m. 1 with a long seta, d.p.m. 5 absent, 4 with a very short spine, 3 with pore only, 2 with a blunt spine and 1 with a fine seta, l.p.m.'s 1 and 3 large, with a short, blunt spine, 2 smaller, with a long seta, b.p.m.'s also smaller, 1 and 3 with a short, blunt spine, 2 with a long seta (Fig. 99). Tubercles of 8th abdominal segment similar, but d.a.s.m.'s and l.a.s.m. absent, as are d.p.m.'s 3 and 4 and v.p.m. 1 (Fig. 100). Anal segment with basal band of spines in 2–3 rows (Fig. 101).

Additional specimens: Queensland: Ravenshoe, nr. Tully Falls (1 ♀, 4.viii.1967, light trap, R. Ellis and L. Hawkins); Mt. Crosby (1 ♀, in alcohol,

Explanation of Text figs. 102-120

Figs 102-106. *Alluaudomyia alpina.* 102, ♀ maxillary palp, × 200; 103, ♀ antennal segments VIII–XV, × 200; 104, ♀ femora and tibiae, × 55; 105, ♀ fore (*right*) and hind (*left*) tarsus V and claw, × 200; 106, ♀ genital sclerotization (paratype), × 200. Figs 107-113. *Alluaudomyia latipennis.* 107, ♀ maxillary palp (Hornsby specimen), × 200; 108, ♀ antennal segments VIII–XV (Hornsby specimen), × 200; 109, ♂ antennal segments X–XV (Nattai R. specimen), × 200; 110, ♀ femora and tibiae (Hornsby specimen), × 55; 111, ♀ femora and tibiae (Mt. Dromedary specimen), × 55; 112, ♀ fore (*left*) and hind (*right*) tarsus V and claw (Hornsby specimen), × 200; 113, ♀ genital sclerotization (Hornsby specimen), × 200. Figs 114–120. *Alluaudomyia appendiculata.* 114, ♀ maxillary palp, × 200; 115, ♂ maxillary palp, segments III–V, × 200; 116, ♀ antennal segments VIII–XV, × 200; 117, ♂ antennal segments XI–XV, × 200; 118, ♀ femora and tibiae, × 55; 119, ♀ fore (*left*) and hind (*right*) tarsus V and claw, × 200; 120, ♀ genital sclerotization, × 200.

4.xii.1965, dusk–1.30 a.m., below dam bank amongst lantana, light trap, A. L. Dyce; 4 ♂♂, 2 ♀♀, all except 1 ♂ in alcohol, 5.xii.1965, dusk-dawn, Lake Manchester Rd., 250 yds. from Brisbane Rd., in narrow, well-grassed, timbered gully, light trap, A. L. Dyce and M. D. Murray); Goodar Crossing, Weir River (1 ♂, 28.iii.1953, suction light trap, 1730–2130 hours, W. E. Poole); Noondoo (1 ♀, 16.xii.1963, light trap, A. L. Dyce and M. D. Murray); Yelarbon (3 ♂♂, 27.iii.1952, 1800–2115 hours, suction light trap, W. E. Poole). New South Wales: Yagobie Crossing (2 ♀♀, 3.xi.1951, suction light trap, 1920–2100 and 2315–0200 hours, A. L. Dyce); Bundy via Moree (1 ♀, 20.v.1952, 1600 hours, net in creek bed, E. J. Reye); "Noonameena" Station via Bingara (1 ♀, 24.ix.1952, swept in sunlight above pool, 1 ♀, 6.x.1952, swept from creek bank, A. L. Dyce); Bruxner Park, Coffs Harbour (3 ♀♀, 1.xi.1965, light trap, M. Upton); Otford (1 ♀, 5.iii.1969), bred ex pupa from mud, M. L. Debenham, R. Russell and J. Citowitsch); Colo Vale (1 ♀, 17.xi.1954, suction light trap, 1930–2030 hours, A. L. Dyce); Nattai River, Mittagong (2 ♂♂, 25.x.1968, D. J. Lee and M. L. Debenham); Minnamurra Falls (1 ♀, 16.xi.1960, M. Upton). Australian Capital Territory: Black Mountain (1 ♂, 17.x.1960, light trap, I. F. B. Common); Canberra (1 ♂, 29.iv.1963, light trap, I. F. B. Common).

Distribution: Queensland, New South Wales, A.C.T.

The thoracic coloration of this species is very variable, ranging from yellow with very pale fuscous markings to entirely dark brown. Sometimes a greenish tinge is present.

This species can be distinguished from the paler specimens of *latipennis* (Skuse) by the presence of distinct banding on the femora and tibiae, and from the darker specimens by the dark bases of the mid and hind femora and the presence of a distinct preapical brown band on the mid tibia, as well as by the different form of the aedeagus and the much broader apical lobe of the parameres. It is distinguished from the male of *varia* n. sp. by the absence of dark punctations in the humeral areas, the relatively narrow, well-defined preapical band of the mid tibia and the form of the genitalia.

14. ALLUAUDOMYIA VARIA n. sp. (Figs 121–131)

Types: Holotype ♂, allotype ♀ (both in A.N.I.C.), 7 ♂♂ and 1 ♀ paratypes.

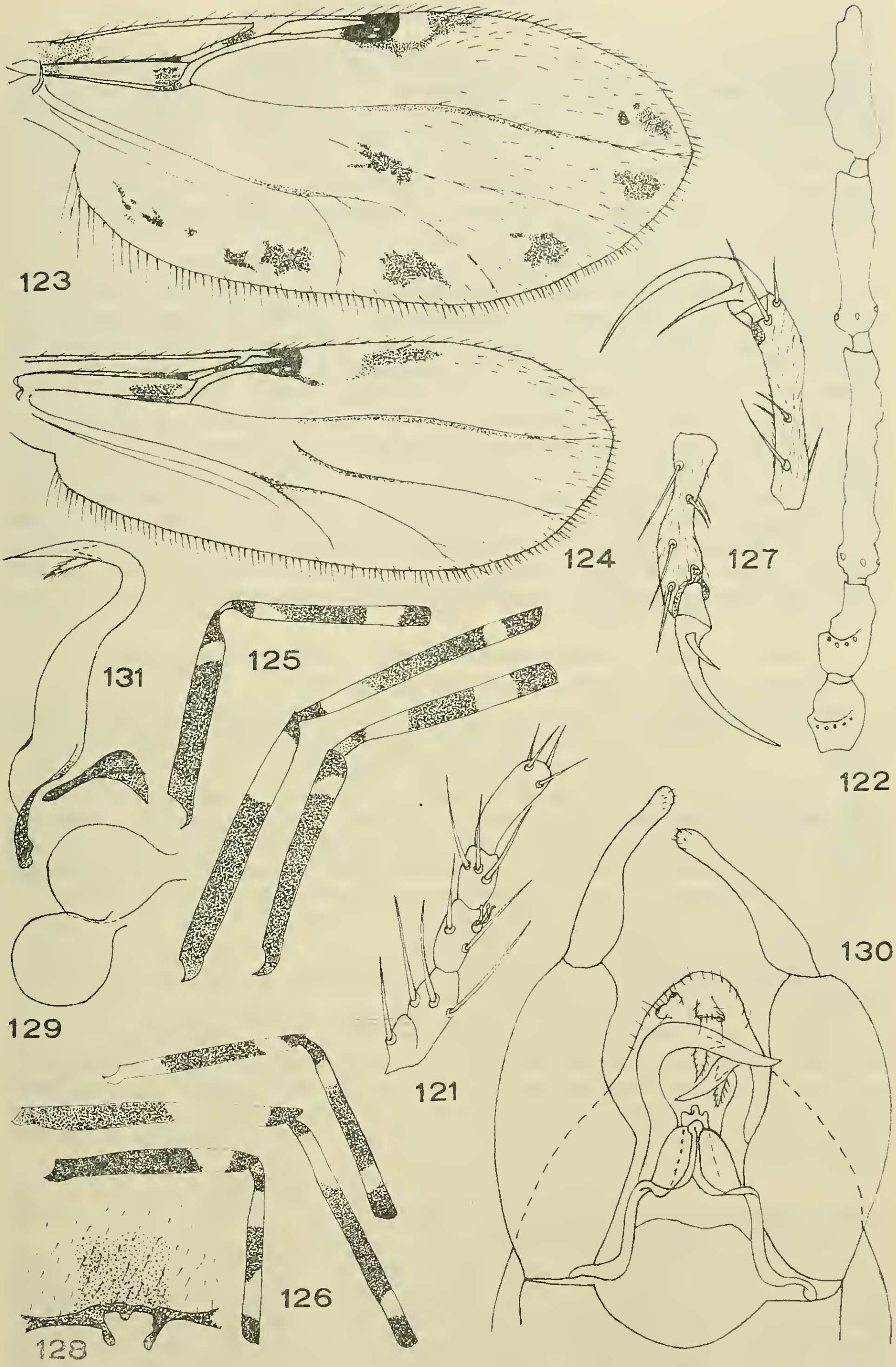
Type Locality: Yelarbon, Queensland (27.iii.1952, suction light trap, 1800–2115 hours, W. E. Poole). Allotype from Noondoo, Queensland (16.xii.1963, light trap, A. L. Dyce), paratypes from Yelarbon (5 ♂♂, same data as holotype), Noondoo (1 ♂, 29–30.iii.1952, suction light trap, 2145–0130 hours, bored spring, W. E. Poole), Moree, New South Wales (1 ♀, date unknown, A. L. Dyce) and Mungie Bundie, Meehi R., Moree, New South Wales (1 ♂, 16.ii.1952, suction light trap, 2000–2130 hours, A. L. Dyce).

A medium-sized species, the male resembling *appendiculata* n. sp. in coloration and form of genitalia, the female with a distinctive wing pattern which readily differentiates it from other known species. The head is missing in the allotype.

Male: Length 1·91 mm., wing 1·01 × 0·39 mm.

Head brown. Eyes bare, broadly contiguous. Palp whitish, segment III with a small preapical sensory pore bearing a few sensillae (Fig. 121). Antennal segment II dark brown, III–XII brown, XIII–XV dark brown (Fig. 122); plume dark brown.

Scutum brown, darker dorsally, humeral areas pale, dark punctations at setal bases, these especially conspicuous in the humeral areas, scutellum light brown with a broad dark band either side of centre, with 4 setae, postscutellum dark brown, pleuron brown. Coxae and trochanters brown, the hind pair darker; legs whitish, extensively banded with brown, the fore femur broadly



Figs 121–131. *Alluaudomyia varia*. 121, ♂ maxillary palp, × 350 ; 122, ♂ antennal segments XI–XV, × 350 ; 123, ♀ wing, × 90 ; 124, ♂ wing, × 90 ; 125, ♀ femora and tibiae, × 90 ; 126, ♂ femora and tibiae, × 90 ; 127, ♀ fore (*upper*) and hind (*lower*) tarsus V and claw, × 350 ; 128. ♀ genital sclerotization, × 350 ; 129 ♀ spermathecae, × 350 ; 130, ♂ hypopygium, × 350 ; 131. ♂ paramere, × 350.

pale basally, with a wide brown central band, a pale preapical band and a brown apex, mid femur brown on basal half and at apex, hind femur with basal two-thirds and apex brown, fore tibia largely brown with narrow, pale sub-basal and apical bands, mid tibia similar but sub-basal pale band broader, hind tibia with base and apex brown and a brown central band (Fig. 126), hind tibial comb of 6 spines ; tarsi pale fuscous, the distal segments slightly darker, apex of fore segment I, base and apex of mid segment I, and all of hind segment I, brown. Claws of all legs small, simple, equal, half the length of the fifth tarsal segment.

Wing (Fig. 124) with three brown spots, one proximal to r-m cross-vein, one on R_1, and one at junction of costa and R_{4+5}, as well as a pale brown cloud anteriorly in cell R_5 beyond the end of the costa, veins slightly brownish. A small number of macrotrichia present on the anterior edge and apex of the wing, with a single row extending along the wing margin from M_2 to Cu_1, and a few on the lower ends of M_1, M_2 and M_{3+4}. Haltere yellowish, apex of knob brown.

Abdominal tergites whitish, each with a large, pale brown, M-shaped spot, sternites pale, pleural membranes pale fuscous. Hypopygium (Figs 130–131) dark brown, coxites long and slightly tapered, styles whitish, short, apices rounded and finger-like ; aedeagus with a squared basal arch surmounted by a pair of membranous lobes, and with a trifid caudal stem arising dorsal to the lobes, parameres separate, with a detached basal arm, stems broad basally, tapering gradually, the apex produced into a long, curving, pointed process, on the inner surface of which is a small, triangular flap from which arises a pale, short, tapered, setose process.

Female : Length (without head) 1·75 mm., wing 1·14×0·53 mm.

Generally similar to male, but differing as follows :

Hind tibial comb of 8 spines. Claws of fore and mid legs unequal, those of hind legs very unequal, ratio of length of claws to fifth tarsal segment 20 : 9 : 24 in fore, 22 : 10 : 22 in mid, 18 : 4 : 21 in hind (Fig. 127).

Wing (Fig. 123) with three radial spots and pale cloud anteriorly in cell R_5 as in male, but also with large spots around the wing margin, one each at the apices of cells R_5, M_1, M_2 and M_4, and one large and several smaller along the margin of the anal cell, as well as a spot over the basal third of M_2. Macrotrichia more extensive than in male, covering most of apical half of wing.

Abdomen as in male, but distal tergites entirely brown. Cerci white. Spermathecae two, oval, equal (Fig. 129).

Additional specimen : Queensland : Cunnamulla, Warrego River (1 ♂, 28.ii.1963, A. L. Dyce and M. D. Murray).

Distribution : Southern Queensland, northern New South Wales.

The association of the sexes in this species is based on the close resemblances in coloration and leg banding, and the presence in both sexes of the pale brown cloud anteriorly in wing cell R_5 beyond the costa. However, a much larger series of specimens is needed before the association can be regarded as definite.

15. ALLUAUDOMYIA PLATIPYGA Tokunaga

Alluaudomyia platipyga Tokunaga, 1963, *Pacif. Insects*, *5* : 221 (♂ only). (Type locality : Maprik, Sepik District, New Guinea.)

Characteristics : A small, dark brown species. Head brown, mouth parts white, eyes bare. Thorax mainly brown, lateral margins of scutum yellow, scutellum yellow with a dark median spot, 2 setae ; femora largely brown with bases ochreous and a white preapical band (very narrow in mid femur), tibiae largely white, bases and apices dark, fore tibia with a median dark band, mid and hind tibiae with a narrow dark band just before centre. Wing with three spots, one before r-m cross-vein and one on R_1 pale, one at junction of costa and

R_{4+5} prominent, a few macrotrichia apically in cell R_5. Haltere white. Abdomen almost white, with very pale fuscous clouds on tergites I–IV. Hypopygium complex, aedeagus twice as broad as long, subsquare, with lateral caudal angles hooked, parameres broadly fused, each with apical part flattened, angulated and irregularly barbed.

Distribution: Known only from the type locality.

The structure of the hypopygium is unique.

16. ALLUAUDOMYIA REYEI n. sp. (Figs 132–133, 149–154, 165–169)

Types: Holotype ♂, allotype ♀, and 15 ♂♂ and 45 ♀♀ paratypes.

Type Locality: Darwin, Northern Territory (holotype and allotype 26–27.vii.1958, Quarantine Stn., suction light trap, E. J. Reye, paratypes 1♂, 4 ♀♀, 27–28.vi.1956, 1 ♀, 1–2.xi.1957, 1 ♀, 2–3.xi.1957, 3 ♀♀, 15–16.xi.1957, 4 ♂♂, 4 ♀♀, 22–23.xi.1957, 1 ♀, 22–23.v.1958, 1 ♂, 1 ♀, 28–29.v.1958, 1 ♀, 30–31.v.1958, 1 ♂, 4 ♀♀, 10–11.vi.1958, 2 ♀♀, 11–12.vi.1958, 2 ♀♀, 13–14.vi.1958, 1 ♀, 17–18.vi.1958, 1 ♂, 4 ♀♀, 18–19.vi.1958, 1 ♀, 28–29.vi.1958, 1 ♀, 6–7.vii.1958, 2 ♀♀, 9–10.vii.1958, 1 ♂, 2 ♀♀, 12–13.vii.1958, 4 ♂♂, 6 ♀♀, same date as holotype, all Quarantine Stn., light trap, E. J. Reye; 1 ♂, 1 ♀, 25–26.xi.1957, R.A.A.F. Marine Sect., E. J. Reye; 2 ♀♀, 26–27.xi.1957, East Arm Convent, N.J. light trap, E. J. Reye; 1 ♂, 28–29.xii.1957, N.J. light trap, J. Dyer; 1 ♀, 19–20.i.1958, R.A.A.F., N.J. light trap, J. Dyer).

A medium-sized brown and yellow species, the wing with spots on the anterior veins only.

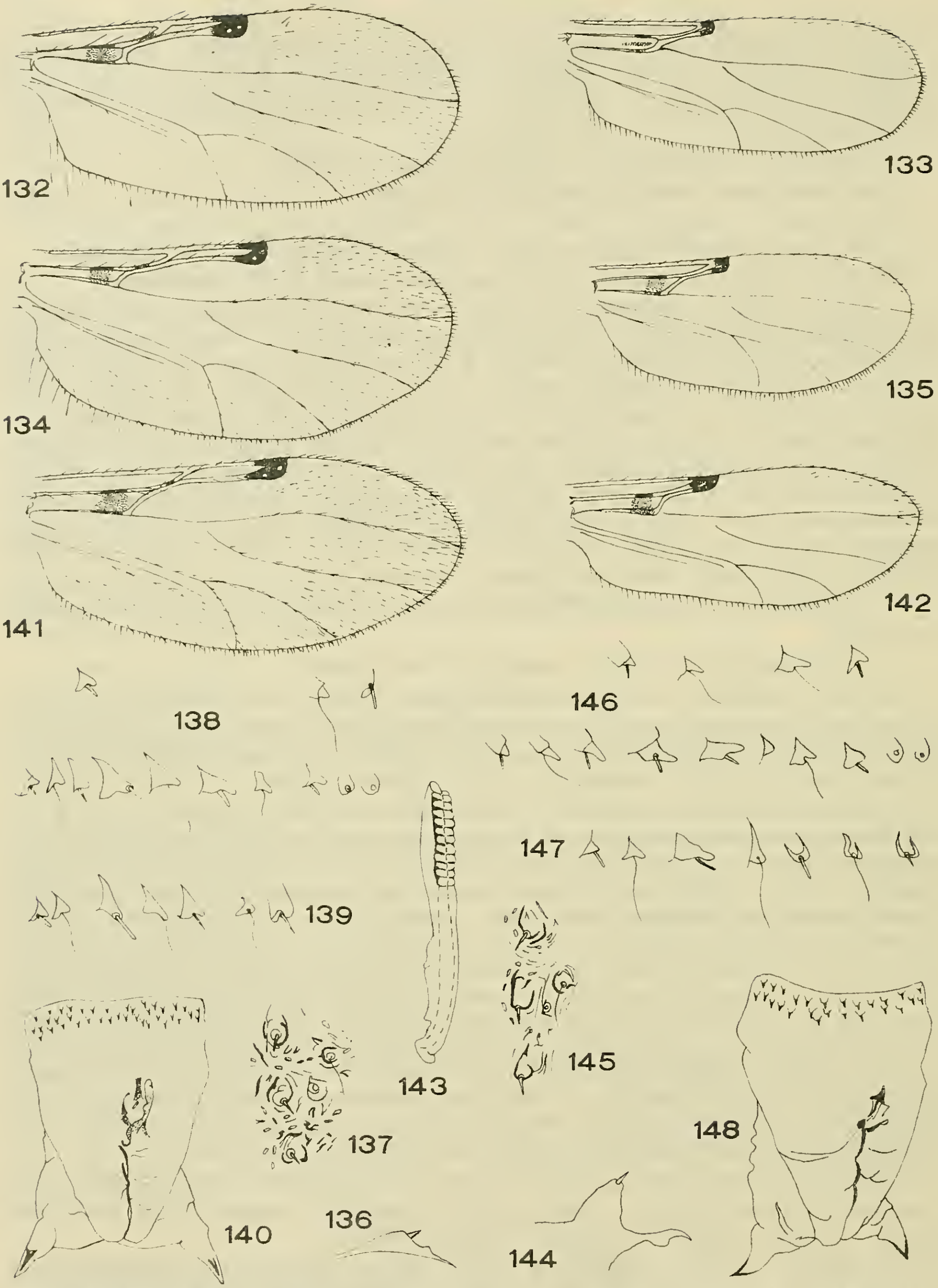
Male: Length 1·56 mm., wing 0·87 × 0·32 mm.

Head yellowish, vertex brown, clypeus light brown, proboscis yellow. Eyes bare, just contiguous. Palp whitish, segment V pale brown, segment III with a shallow preapical pit bearing a few sensillae. Antennal segment II dark brown, flagellum light brown (Fig. 167); plume brown.

Scutum ochreous with dark brown markings, the humeral areas white, scutellum fuscous on anterior half, whitish on posterior half, with 2 setae, postscutellum brown centrally, yellowish laterally, pleuron yellowish-ochreous, with fuscous clouds. Coxae and trochanters pale fuscous, hind pair more yellowish; femora and tibiae whitish, with brown markings, the fore femur with a broad brown central band and a brown apex, the mid femur with a broad, very pale brown sub-basal band, an equally pale brown preapical ring and a brown apex (Fig. 169), the hind femur with a broad brown postcentral band and a brown apex, the fore tibia with a brown base and apex and a broad central brown band, the mid tibia with a brown base and apex and very pale, narrow brown bands on the basal and apical thirds (Fig. 169), hind tibia very slightly fuscous basally, and with a brown central band and apex, hind tibial comb of 6 spines; tarsi whitish except hind segment I, which is brown. Claws of all legs small, equal and simple, just over half the length of the fifth tarsal segment.

Wing (Fig. 133) with two brown spots, one before r-m cross-vein and one at junction of costa and R_{4+5}. Only a few macrotrichia present, these restricted to the anterior edge of the wing. Haltere white.

Abdomen whitish, tergites I–V with a distinct, light brown M-shaped spot covering most of the tergite, VI with this spot indistinct, remaining tergites light brown. Hypopygium (Figs 152–154) brown, coxites short, styles almost straight, whitish, nearly as long as the coxites; aedeagus consisting of a simple arch, shallowly excavated basally, from which arises dorsally a ventrally bent, hook-like caudal process, parameres with long, attached basal apodemes, stems slender, with a pair of processes arising apically, one about twice the length of the other.



Figs 132–133. *Alluaudomyia reyei.* 132, ♀ wing, ×55 ; 133, ♂ wing, ×55. Figs 134–140. *Alluaudomyia bicornis.* 134, ♀ wing, ×55 ; 135, ♂ wing, ×55 ; 136–140. pupa. 136, anteromedian tubercle of operculum, lateral view, ×200 ; 137, dorsal tubercles of cephalothorax, ×200 ; 138, tubercles of 7th abdominal segment, ×200 ; 139, tubercles of 8th abdominal segment, ×200 ; 140, ♂ anal segment, ×200. Figs 141–148. *Alluaudomyia fragmentum.* 141, ♀ wing, ×55 ; 142, ♂ wing, ×55 ; 143–148, pupa. 143, ♂ respiratory trumpet (paratype), ×200 ; 144, anteromedian tubercle of operculum, lateral view (paratype), ×200 ; 145, dorsal tubercles of cephalothorax (paratype), ×200 ; 146, tubercles of 7th abdominal segment, ×200 ; 147, tubercles of 8th abdominal segment, ×200 ; 148, ♂ anal segment, ×200.

Female: Length 1·71 mm., wing 1·04 × 0·47 mm.

Generally similar to male, differing as follows:

Approximately 11 mandibular teeth. Eyes more broadly contiguous. Antennal segments III–IX with bases slightly whitish (Fig. 166).

Coloration of thorax and legs more intense than in male, leg bands quite distinct, dark area of mid femur more extensive (Fig. 168); distal two tarsal segments slightly fuscous. Claws of all legs very unequal, ratio of length of claws to fifth tarsal segment 21 : 12 : 21 in fore, 21 : 11 : 20 in mid, 16 : 6 : 18 in hind (Fig. 149).

Wing (Fig. 132) with an extra spot, on R_1. Macrotrichia extensive, covering the apical half of the wing and extending into the anal cell.

Cerci white. Spermathecae two, subspherical, subequal, each with a short chitinized neck (Fig. 150). Genital sclerotization as figured (Fig. 151).

Additional specimens: Queensland: Mossman Gorge (1 ♂, 23.iv.1967, D. H. Colless); Innisfail (1 ♀, Eubenangee Swamp, 13.vi.1963, H. Standfast); Magnetic Island (1 ♂, Horseshoe Bay, 9.vii.1952, 1100 hours, net, freshwater swamp, E. J. Reye); Belgian Gardens, Townsville (1 ♂, 11.xi.1955, 8 ♂♂, 12 ♀♀, of which 2 ♂♂ and 6 ♀♀ pinned, 13.xi.1955, 2100–2359 hours, mangrove tree, 3 ♂♂, 5 ♀♀, of which 2 ♂♂ and 3 ♀♀ pinned, 14.xi.1955, 1 ♂, 3 ♀♀, of which 1 ♀ pinned, 17.xi.1955, 1920–2100 hours, flying fox bait, 13 ♂♂, 4 ♀♀, 18.xi.1955, 0001–0300 hours, flying fox bait, 2 ♂♂, 1 ♀, same date, 0300–0500 hours, flying fox bait, 5 ♂♂, 3 ♀♀, same date, 2100–2359 hours, flying fox bait, 6 ♂♂, 5 ♀♀, 20.xi.1955, 2200–0600 hours, mango tree near polluted swamp, 2 ♀♀, 23.xi.1955, mango tree, all specimens light trap, A. K. O'Gower); Gilruth (2 ♂♂, 1 ♀, 11.xii.1963, dusk-dawn, light trap in fowl yard, A. L. Dyce); Yelarbon (1 ♀, 27.iii.1953, 1800–2115 hours, 1 ♂, 27–28.iii.1953, 2115–0045 hours, suction light trap, W. E. Poole). Western Australia: The Kimberleys (1 ♂, S.W. of Bedford Downs, 10 m. S. of Lansdowne H.S., vii.1964, light trap, R. Plumb).

Distribution: Northern Western Australia, Northern Territory, Queensland.

The male of this species is readily distinguishable from the males of *bicornis* and *fragmentum* by the form of the genitalia, but the females of these three species are very difficult to differentiate. However, the form of the female genital sclerotization is sufficiently distinctive in each of the three species to be of use in identification. The association of male and female in *reyei* is based on the evidence of a large series from Townsville, the males of which can all be classed as *reyei*, and the females of which all have the type of genital sclerotization here regarded as characteristic of the female of *reyei*. The sub-basal brown band of the mid femur also tends to be more extensive in *reyei* than in *fragmentum* and *bicornis*, but this character is difficult to use with certainty.

17. ALLUAUDOMYIA BICORNIS n. sp. (Figs 134–140, 155–159, 170–173)

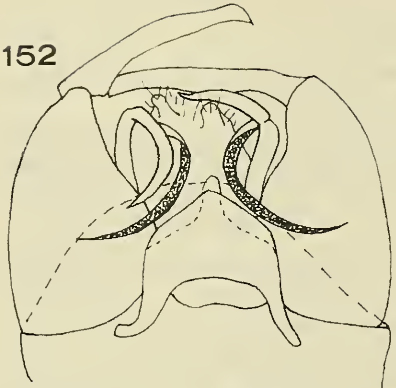
Types: Holotype ♂, allotype ♀, and 4 ♂♂ and 20 ♀♀ paratypes.

Type Locality: Darwin, Northern Territory ((holotype 17–18.vi.1958, N.J. light trap, allotype, 26–27.vii.1958, suction light trap, Quarantine Stn., E. J. Reye; paratypes, 1 ♀, 2–3.xi.1957, 1 ♀, 22–23.v.1958, 2 ♀♀, 27–28.v.1958, 1 ♀, 28–29.v.1958, 2 ♀♀, 10–11.vi.1958, 2 ♀♀, 13–14.vi.1958, 1 ♀, 14–15.vi.1958, 2 ♀♀, same date as holotype, 3 ♂♂, 4 ♀♀, 18–19.vi.1958, 1 ♂, 2 ♀♀, same date as allotype, Quarantine Stn., light trap, E. J. Reye; 1 ♀, 26–27.xi.1957, East Arm Convent, N.J. light trap, E. J. Reye; 1 ♀, 28.iv.1958, N.J. light trap, J. Dyer).

A small yellow and brown species with a two or three spotted wing.

Male: Length 1·27 mm., wing 0·81 × 0·30 mm.

Head brown. Eyes bare, just contiguous. Palp whitish, segment III with a preapical pit bearing sensillae (Fig. 170). Antennal segment II dark brown, segments III–XII whitish, segments XIII–XV brown (Fig. 172).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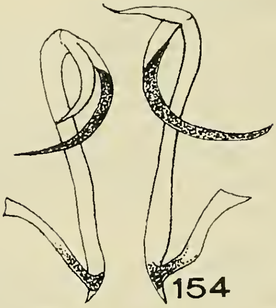
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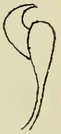
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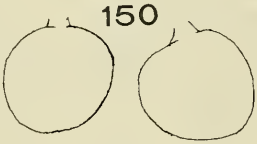
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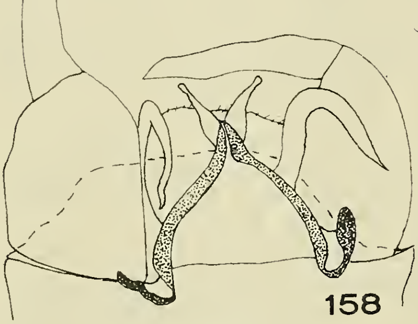
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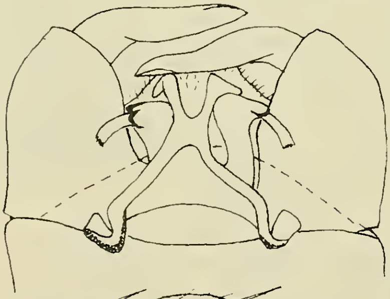
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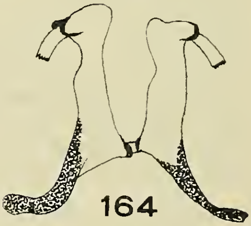
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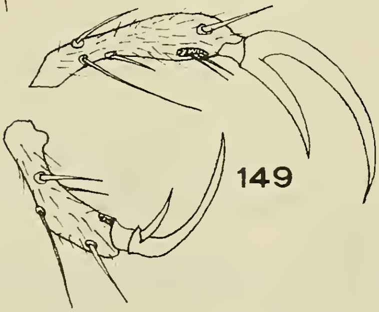
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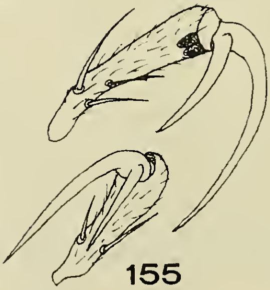
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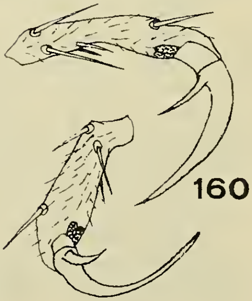
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Scutum brown with darker brown markings, particularly around setal bases, humeral areas and lateral margins yellowish, scutellum brown on anterior half, pale on posterior half, with 2 setae, postscutellum dark brown, lighter laterally, pleuron brown, but yellowish immediately below scutum. Coxae and trochanters pale yellowish-brown ; femora and tibiae whitish, fore femur with a broad brown band just beyond centre and brown apex, mid femur with a pale brown, moderately broad central band, a narrow, incomplete preapical ring and a brown apex, hind femur with a moderately broad brown band just beyond centre and a brown apex, fore tibia with base, broad central area and apex brown, mid tibia with base and apex brown and a very pale fuscous preapical band, hind tibia with base and apex brown and a narrow, incomplete central band, hind tibial comb of 6 spines ; tarsi whitish, hind first tarsal segment pale fuscous. Claws of all legs small, equal and simple, about half the length of the fifth tarsal segment.

Wing (Fig. 135) with two brown spots, one before r-m cross-vein and one at junction of costa and R_{4+5}. Macrotrichia very sparse, restricted to the anterior margin of the wing apex. Haltere white.

Abdomen pale brown, becoming slightly darker distally. Hypopygium (Figs 158–159) dark brown, styles white, slightly sinuous ; aedeagus with basal arch very shallow, scarcely excavated, apex bifid, forming a pair of horn-like processes, parameres with triangular bases, stems tapering, apices drawn out into long, tapered processes.

Female : Length 1·29 mm., wing 1·06 × 0·46 mm.

Generally similar to male, differing as follows :

Approximately 10 mandibular teeth. Antennal segments IV–VIII with bases whitish (Fig. 171).

Scutum more yellowish than in male, brown markings more distinct, humeral areas whitish. Leg banding more distinct, mid tibia with preapical band darker, also with a very pale fuscous sub-basal band, central band of hind tibia complete (Fig. 173), hind tibial comb of 7–8 spines. Claws of all legs very unequal, ratio of length of claws to fifth tarsal segment 23 : 12 : 22 in fore, 26 : 14 : 22 in mid, 20 : 10 : 18 in hind (Fig. 155).

Wing (Fig. 134) with three brown spots, one before r-m cross-vein, one on R_1 and one at junction of costa and R_{4+5}. Macrotrichia dense, covering apical half of wing and extending into anal cell.

Cerci white. Spermathecae (Fig. 156) two, subspherical, subequal, each with a short, stout, chitinized neck. Genital sclerotization as figured (Fig. 157).

Pupa (Manton R. specimen) : Light brown, dorsum of thorax darker. Respiratory trumpet shrivelled, but similar to that of *fragmentum* n. sp., with 12 pairs of spiracles. Operculum with small a.m. tubercles bearing short spines (Fig. 136) rest not visible. Dorsal tubercles of cephalothorax as figured, 1, 2 and 3 with a short, stout spine, 4 with a long, fine seta, 5 with pore only, 4 and 5 more widely separated than in *fumosipennis* n. sp. (Fig. 137). Tubercles of abdominal segments 3–7 as figured, d.a.s.m. 2 and l.a.s.m. with stout, blunt spines, d.a.s.m. 1 with a long seta, d.p.m.'s 4 and 5 with pore only, 3 with a stout spine,

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Explanation of Text figs. 149-164

Figs 149–154. *Alluaudomyia reyei.* 149, ♀ fore (*upper*) and hind (*lower*) tarsus V and claw, ×350 ; 150, ♀ spermathecae, ×350 ; 151, ♀ genital sclerotization, ×350 ; 152, ♂ hypopygium, ×350 ; 153, lateral view of aedeagal arch (Townsville specimen), ×350 ; 154, ♂ parameres, ×350. Figs 155–159. *Alluaudomyia bicornis.* 155, ♀ fore (*upper*) and hind (*lower*) tarsus V and claw, ×350 ; 156, ♀ spermathecae, ×350 ; 157, ♀ genital sclerotization, ×350 ; 158, ♂ hypopygium (Mossman Gorge specimen), ×350 ; 159, ♂ parameres (Mossman Gorge specimen), ×350. Figs 160–164. *Alluaudomyia fragmentum.* 160, ♀ fore (*upper*) and hind (*lower*) tarsus V and claw, ×350 ; 161, ♀ spermathecae, ×350 ; 162, ♀ genital sclerotization, ×350 ; 163, ♂ hypopygium, ×350 ; 164, ♂ parameres, ×350.

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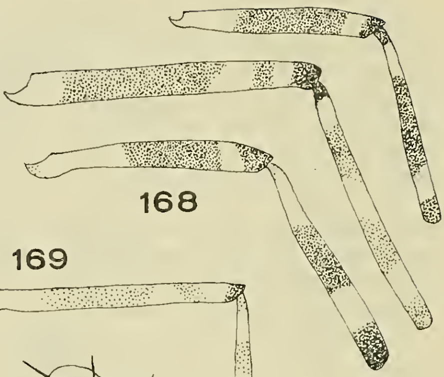

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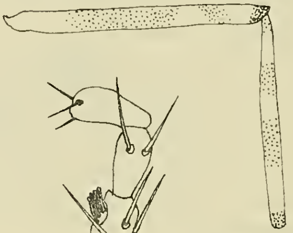

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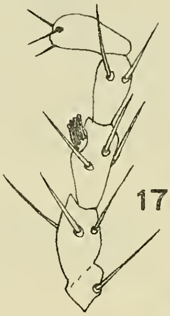

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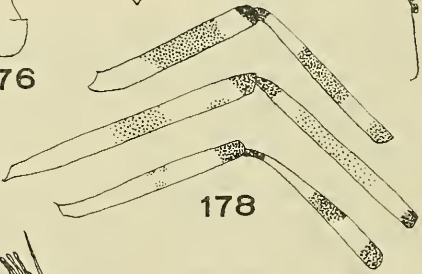

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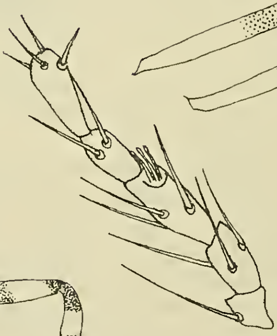

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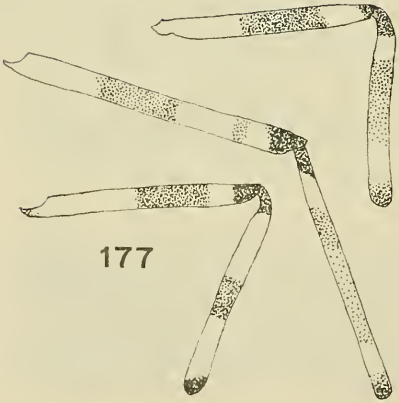

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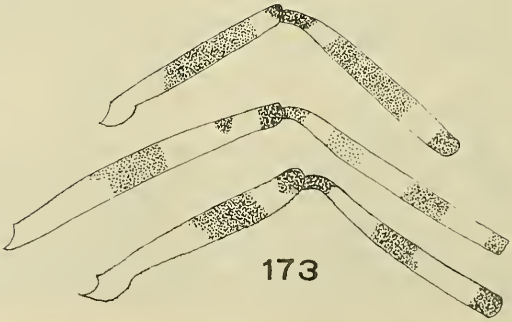

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2 with a long seta, 1 absent, l.p.m.'s 1 and 3 with a stout spine, 2 with a long seta, v.p.m.'s 1 and 3 with a spine, 2 with a seta (Fig. 138). Tubercles of abdominal segment 8 as figured, d.a.s.m.'s, l.a.s.m., d.p.m.'s 1 and 4–5, and v.p.m. 1 absent, remaining tubercles similar to those on preceding segment (Fig. 139). Anal segment with a narrow basal band of 2–3 rows of spines (Fig. 140).

Additional specimens: Northern Territory: Manton R. (1 ♂, 6.vi.1958, bred ex pupa from reservoir, E. J. Reye). Queensland: Mossman Gorge (1 ♂, 23.iv.1967, D. H. Colless); Gilruth (2 ♂♂, 15.xii.1963, light trap, A. L. Dyce); Yelarbon (2 ♀♀, 27.iii.1953, 1800–2115 hours, 7 ♀♀, 27–28.iii.1953, 2115–0045 hours, suction light trap, W. E. Poole); Noondoo (1 ♀, 29.iii.1953, 2145–0130 hours, suction light trap, W. E. Poole; 1 ♀, 26.ii.1963, light trap, A. L. Dyce and M. D. Murray; 1 ♀, 16.xii.1963, light trap, A. L. Dyce); Texas Station (2 ♀♀, 26.iii.1953, dusk–2110 hours and dusk–2130 hours, suction light trap, A. L. Dyce). New South Wales: Mungie Bundie, Meehi River, Moree (2 ♀♀, 16.ii.1952, 2000–2130 hours, suction light trap, A. L. Dyce); Yagobie (1 ♀, 3.xi.1951, 1920–2100 hours, suction light trap, A. L. Dyce).

Distribution: Northern Territory, Queensland, northern New South Wales.

The male genitalia of this species are quite distinctive, but females are apparently distinguishable from females of *reyei* n. sp. and *fragmentum* n. sp. only by the form of the genital sclerotization. The single pupa available can be distinguished from the pupa of *fragmentum* by the smaller anteromarginal tubercles on the operculum, the absence of the first dorsal posteromarginal tubercle on abdominal segments 3–7, and the lack of anterior displacement of the second lateral posteromarginal abdominal tubercle.

18. ALLUAUDOMYIA FRAGMENTUM n. sp. (Figs 141–148, 160–164, 174–178)

Types: Holotype ♂, allotype ♀, and 1 ♂ and 1 ♀ paratypes.

Type Locality: Manton River, Northern Territory (holotype, 6.vi.1958, bred from pupa, E. J. Reye; allotype 15.vi.1958, ex reservoir, E. J. Reye; paratype ♂ 1.vi.1958, bred from pupa ex reservoir, E. J. Reye; paratype ♀ same data as holotype, ex reservoir).

A medium-sized yellow and brown species with a pale abdomen and two or three spotted wing.

Male: Length 1·89 mm., wing 0·84 × 0·33 mm.

Head brown. Eyes bare, just contiguous. Palp whitish, segments IV and V pale brown, segment III with a preapical pit bearing sensillae (Fig. 174). Antennal segment II dark brown, flagellum brown (Fig. 176); plume dark brown.

Scutum brown with darker brown markings, particularly around setal bases, humeral areas and lateral margins yellowish, scutellum brown on anterior half, pale brown posteriorly, with 2 setae, postscutellum dark brown, paler laterally, pleuron brown except for a transverse yellow band just below the scutum. Coxae and trochanters pale brown; femora and tibiae whitish, fore femur with central third and apex brown, mid tibia with a broad central brown band, a pale brown preapical band and a brown apex, hind femur with an almost obsolete pale brown central band and a brown apex, fore tibia with base, apex and broad

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Explanation of Text figs. 165-178

Figs 165–169. *Alluaudomyia reyci.* 165, ♀ maxillary palp, × 350; 166, ♀ antennal segments VIII–XV, × 350; 167, ♂ antennal segments XI–XV (paratype), × 350; 168, ♀ femora and tibiae, × 90; 169, ♂ mid femur and tibia, × 90. Figs 170–173. *Alluaudomyia bicornis.* 170, ♂ maxillary palp, × 350; 171, ♀ antennal segments VIII–XV, × 350; 172, ♂ antennal segments XI–XV, × 350; 173, ♀ femora and tibiae, × 90. Figs 174–178. *Alluaudomyia fragmentum.* 174, ♂ maxillary palp, × 350; 175, ♀ antennal segments VIII–XV, × 350; 176, ♂ antennal segments XI–XV, × 350; 177, ♀ femora and tibiae, × 90; 178 ♂ femora and tibiae, × 90.

central area brown, mid tibia with base and apex brown, rest very pale fuscous except for a whitish sub-basal and preapical band, hind tibia with base, apex and narrow central band brown (Fig. 178), hind tibial comb of 6 spines ; tarsi whitish except hind tarsal segment I light brown. Claws of all legs small, equal and simple, half to two-thirds the length of the fifth tarsal segment.

Wing (Fig. 142) with two brown spots, one just before r-m cross-vein, the other covering R_1 and the apical ends of the costa and R_{4+5}. Macrotrichia very sparse, restricted to the anterior margin of the apical third of the wing. Haltere whitish.

Abdomen very pale, almost white, with light brown markings on tergites. Hypopygium (Figs 163–164) dark brown, but coxites paler on apical half, styles sinuous, rather stout ; aedeagus with a very shallow arch, the apex extended into two laterally bent processes, parameres with stout stems, each with a short, flat apical process which terminates abruptly in a serrated edge, as though broken.

Female : Length 1·78 mm., wing 1·06 × 0·45 mm.

Generally similar to male, differing as follows :

Approximately 12 mandibular teeth. Segments IV–VIII of antennae with bases whitish (Fig. 175).

Leg banding slightly more distinct, central band on hind femur not almost obsolete (Fig. 177), hind tibial comb of 6–7 spines. Claws of all legs very unequal, ratio of length of claws to fifth tarsal segment 18 : 7 : 21 in fore, 19 : 8 : 20 in mid, 16 : 6 : 19 in hind (Fig. 160).

Wing (Fig. 141) with three brown spots, one before r-m cross-vein, one on R_1 and one at junction of costa and R_{4+5}, radial cell considerably longer than in male. Macrotrichia dense, covering apical half of wing and extending into anal cell.

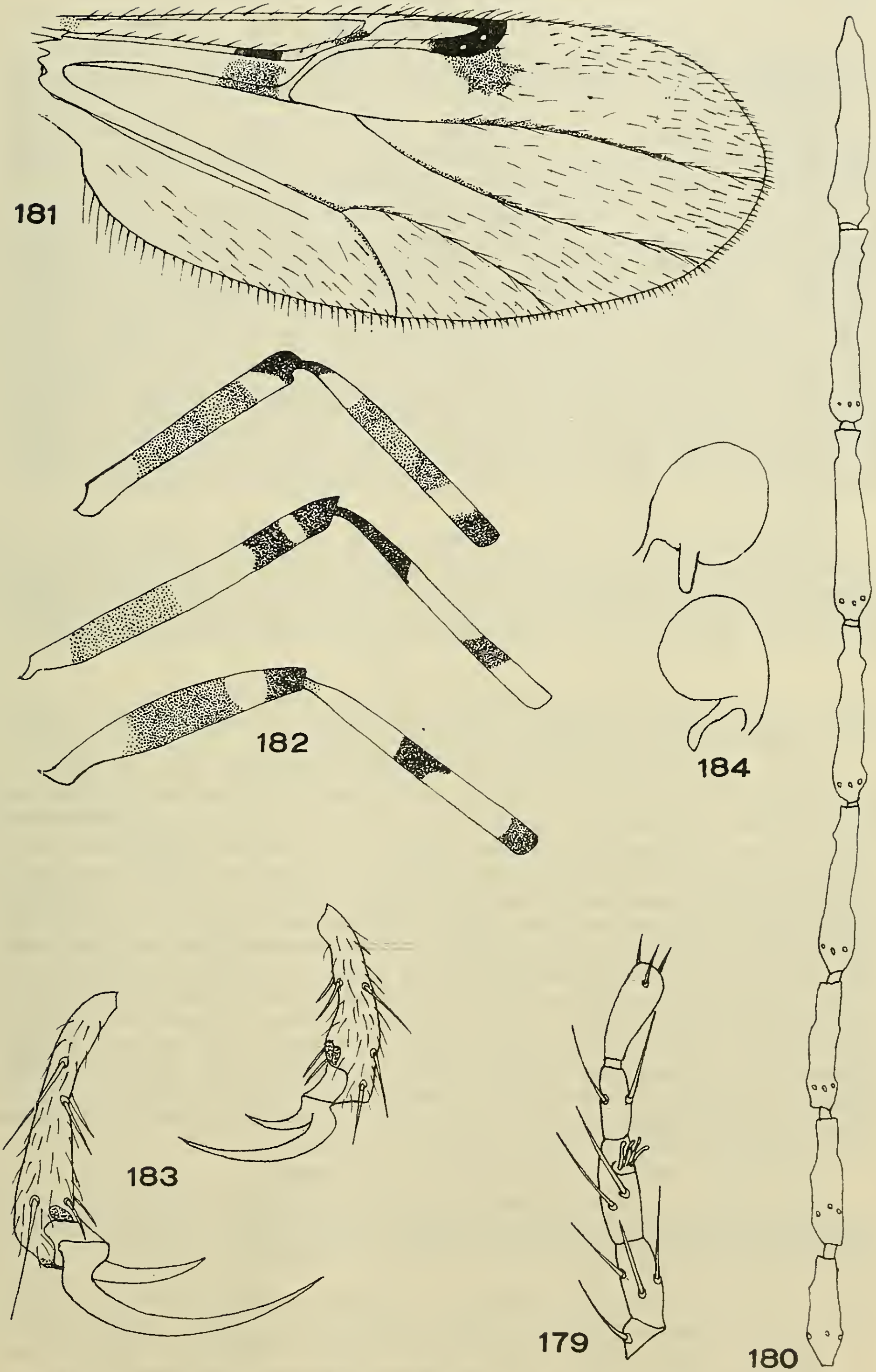
Cerci white. Spermathecae two, oval, subequal, each with a short, thick, chitinized neck (Fig. 161). Genital sclerotization extensive, as figured (Fig. 162).

Pupa : Light brown, dorsum of thorax darker. Respiratory trumpet dark brown, with 11–12 pairs of spiracles on apical third (Fig. 143). Median tubercle of operculum without spine, situated well back from distal edge, a.m. tubercles large, each with a short, stout spine (Fig. 144), rest of surface with small tubercles. Dorsal tubercles of cephalothorax as figured, 1, 2 and 3 with a short, stout spine, 4 with a long, fine seta, 5 with pore only (Fig. 145). Tubercles of abdominal segments 3–7 as figured, d.a.s.m. 2 and l.a.s.m. with a short, stout spine, d.a.s.m. 1 with a long seta, d.p.m.'s 1, 4 and 5 with pore only, 2 with a long seta and 3 with a stout spine, l.p.m.'s 1 and 3 with a stout spine, 2 displaced anteriorly so it is in line with the anterosubmarginal tubercles, with a long seta, v.p.m.'s 1 and 3 with a stout spine, 2 with a long seta (Fig. 146). Tubercles of abdominal segment 8 as figured, d.a.s.m.'s, l.a.s.m., d.p.m.'s 1, 4 and 5 and v.p.m. 1 absent, remaining tubercles similar to those on preceding segment (Fig. 147). Anal segment with a basal band of 2–3 rows of small spines (Fig. 148).

Additional specimen : Northern Territory : Darwin (1 ♀, 22–23.v.1958, Quarantine Stn., N.J. light trap, E. J. Reye).

Distribution : Northern Territory.

The male of this species can be readily identified by the form of the genitalia. The female is apparently only distinguishable from females of *reyei* n. sp. and *bicornis* n. sp. by the extensive genital sclerotization. The sexes are associated on the basis of pupal characters, particularly the anterior displacement of the second lateral posteromarginal tubercle on abdominal segments 3–7.



Figs 179–184. *Alluaudomyia petersi* (Lae specimen). 179, ♀ maxillary palp, × 350 ; 180, ♀ antennal segments XIII–XV × 350 ; 181, ♀ wing, × 90 ; 182, ♀ femora and tibiae, × 90 ; 183, ♀ fore (*left*) and hind (*right*) tarsus V and claw, × 350 ; 184, ♀ spermathecae, × 350.

19. ALLUAUDOMYIA PETERSI Tokunaga. (Figs 179–184)

Alluaudomyia petersi Tokunaga, 1963, *Pacif. Insects*, *5*: 228 (♀ only). (Type locality: Maprik, Sepik District, New Guinea; paratype from Bainyik, New Guinea.)

Specimens examined: New Guinea: Damanti Village, Finisterre Range, Madang Central Subdistrict (1 ♀, x.1964, 3,500 ft., R. Pullen); Lae (1 ♀, vii.1958, light trap, W. Peters). Holotype also examined.

Characteristics: A medium-sized brown and yellow species. Male unknown. Head ochreous, eyes bare. Thorax yellow, extensively mottled with brown, scutellum yellow with a median fuscous spot, 4 setae, postscutellum fuscous with two yellowish anterior spots; legs yellow, banding as figured (Fig. 182), female claws (Fig. 183) unequal, ratio of length of claws to fifth tarsal segment 28·8 : 14·8 : 28 in fore, 29·8 : 14·3 : 27·5 in mid, 19·3 : 8 : 22 in hind. Wing with three spots, one before r-m cross-vein, one on R_1 and one at junction of costa and R_{4+5}, the latter spot extending into cell R_5 (Fig. 181), macrotrichia numerous on apical half of wing and in anal cell. Haltere white. Abdominal tergites mainly brown, but I widely yellow, II–VIII yellow on distal margin, IX and caudal end white, cerci white. Spermathecae (Fig. 184) two, round, subequal, one with a short process, the other with a slightly longer process.

Distribution: New Guinea.

Tokunaga states that the macrotrichia on the wing of this species are "rather sparsely spread on apical part beyond level of costal end", and his diagram shows this arrangement, but a check of the holotype reveals that the macrotrichia are rather more extensive, agreeing with the present specimens. The broadly dark basal end of the mid tibia readily identifies this species.

20. ALLUAUDOMYIA ASTERA Tokunaga

Alluaudomyia astera Tokunaga, 1963, *Pacif. Insects*, *5*: 222 (♂ only). (Type locality: Inis Atoll, Bougainville I., Solomon Is.)

Characteristics: A small yellow and brown species. Female unknown. Head ochreous, eyes bare. Thorax with tergites mainly yellow, pleurites and sternites fuscous, scutum with a median star or crux-shaped dark spot and several fuscous clouds and spots, scutellum yellow with a dark median spot, 4 setae, postscutellum dark centrally, yellow laterally; legs yellow with brown bands, fore femur with narrow pale base, median part fuscous, a narrow, indistinctly paler preapical ring and dark apex, tibia with base, apex and broad median part dark, mid femur entirely pale except for a dark preapical ring and dark apex, tibia with base and apex dark and a dark sub-basal and preapical band, hind femur widely dark medially and with a dark apex, tibia with a narrow central dark band and dark apex. Wing with three spots, as in *petersi* Tokunaga, macrotrichia sparsely spread on wing margin between ends of costa and M_2. Haltere white. Abdomen yellowish ochreous, tergites I–VI with pale fuscous clouds, pleural membranes dark. Hypopygium yellow, coxites and tips of styles dark, aedeagus bell-shaped, short caudal stem bent ventrally, parameres broadened, flattened and oval on apical two-fifths.

Distribution: Known only from the type locality.

This species can be distinguished from *jimmensis* Tokunaga and *smeei* Tokunaga, which have similar leg banding, by the entirely pale basal two-thirds of the mid femur and by the more yellowish scutum.

21. ALLUAUDOMYIA JIMMENSIS Tokunaga. (Figs 185–195)

Alluaudomyia jimmensis Tokunaga, 1963, *Pacif. Insects*, *5*: 229. (Type locality: Tsenga, Jimmi Valley, N.E. New Guinea; allotype from Enarotadi, Wisselmeren, West Irian, paratype from Kainantu, N.E. New Guinea.)

Specimens examined: New Guinea: Lumi (1 ♂, v.1969, 2,000 ft., Dr. L. Wark); Maprik (2 ♂♂, 1 ♀, 1958).

Characteristics: A medium-sized brown and yellow species. Head brown, frons yellow, eyes bare. Thorax yellow with extensive light and dark brown markings (Fig. 195), scutellum yellow with two fuscous spots and 4 setae, postscutellum brown with two anterior yellow spots; legs yellow, with banding as figured (Fig. 189), female claws (Fig. 190) unequal, ratio of length of claws to fifth tarsal segment 28 : 15 : 30 in fore, 30 : 12 : 30 in mid, 20 : ? : 24·5 in hind (20 : 8·4 : 24 in Maprik specimen), male claws all small and equal. Wing with three spots, one before r-m cross-vein, one on R_1, and one at the junction of the costa and R_{4+5}, the latter spot extending on to the membrane (Fig. 188), female with a moderate number of macrotrichia on the apical third of the wing, male with only a few macrotrichia on the wing margin. Haltere white. Abdomen pale, in female tergite I with a small fuscous cloud, II–VI with M-shaped fuscous fuscous markings, VII–VIII fuscous, XI and cerci white, in male tergite I fuscous laterally, II–III with M-shaped spot, IV–V widely dark, VI–VII fuscous laterally, VIII entirely fuscous, hypopygium brown. Spermathecae (Fig. 191) two, equal, round, one with a short, straight diverticulum, the other with a long and undulate process. Aedeagus triangular, apex bent ventrally, parameres separate, each with a detached basal arm, stem slightly swollen medially, apex flattened and pointed, slightly bent laterally (Figs 192–194).

Distribution: New Guinea.

This species is very similar to *smeei* Tokunaga, but the females are readily distinguished by the spermathecal diverticula, the longer one in *jimmensis* being undulate and about 0·05 mm. long, while in *smeei* it is straight and under 0·04 mm. long. The male of *smeei* is unknown.

22. ALLUAUDOMYIA SMEEI Tokunaga. (Figs 196–197)

Alluaudomyia smeei Tokunaga, 1963, *Pacif. Insects*, *5*: 230 (♀ only). (Type locality: Lowlands Agr. Stat., Keravat, New Britain.)

Specimen examined: New Guinea: Maprik (1 ♀, iv.1958). Holotype also examined.

Characteristics: A small yellow and brown mottled species. Head brown, eyes bare. Thorax yellow and brown, scutum yellow with an extensive brown pattern very similar to that in *jimmensis*, scutellum brown centrally, yellow laterally, with 4 setae, postscutellum brown with two anterior yellow spots; legs yellow, banded brown as figured (Fig. 196), female claws (Fig. 197) all unequal, ratio of length of claws to fifth tarsal segment 20 : 12 : 19 in fore, 20 : 12* : 17 in mid, 14 : 6 : 16 in hind. Wing with two spots, one before r-m cross-vein and one at junction of costa and R_{4+5}, the latter spot extending very slightly into cell R_5, macrotrichia sparse, restricted almost entirely to wing margin between the ends of the costa and M_{3+4}. Haltere white. Abdominal tergites white with large M-shaped brown spots similar to *jimmensis*. Spermathecae round, slightly unequal, in the type diverticulum of larger spermatheca approximately twice the length of the diverticulum of the smaller.

Distribution: New Britain, northern New Guinea.

The specimen from Maprik differs in having the longer spermathecal diverticulum only one and a third times the length of the shorter diverticulum. However, it appears identical to *smeei* in other characters, and so at present is included in this species.

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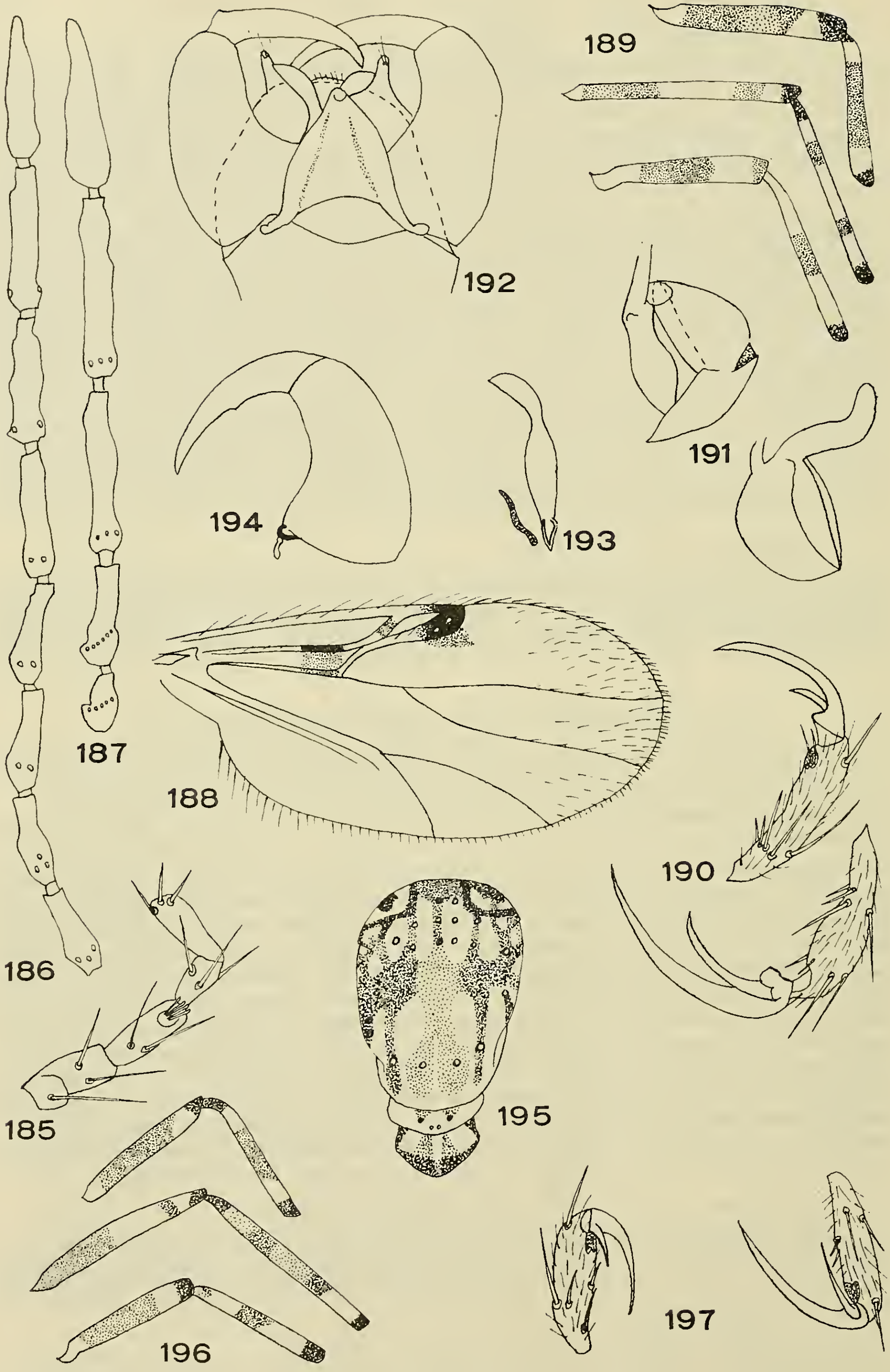
* Not 19 as in original description (remeasured on holotype).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23. ALLUAUDOMYIA SPINOSIPES Tokunaga. (Figs 198–207)

Alluaudomyia spinosipes Tokunaga, 1962, *Pacif. Insects*, *4*: 206. (Type locality: Chibana, Okinawa; paratypes from Sonabi and Yaka, Okinawa); Wirth and Delfinado, 1964, *Pacif. Insects*, *6*: 615 (Ceylon, Indonesia, Laos, Malaya, North Borneo, Philippines, Sarawak, Thailand, Viet Nam).

Alluaudomyia novaguineae (also as *novaguineana*) Tokunaga, 1963, *Pacif. Insects*, *5*: 227. (Type locality: Minj, W. Highlands, New Guinea; paratype from Maprik, New Guinea.) *New synonymy.*

Specimens examined: New Guinea: Maprik (3 ♂♂, 7 ♀♀, 1958; 1 ♀, iv.1958; 1 ♂, vii.1958). Holotype and allotype of *A. novaguineae* and 1 ♂, 11 ♀♀, from Wirth and Delfinado's specimens of *A. spinosipes* also examined.

Wirth and Delfinado state that *novaguineae* (*novaguineana*) differs from *spinosipes* in having the female claws all unequal. An examination of the allotype female of *novaguineae* shows that the claws are, in fact, as described for *spinosipes*, i.e. fore and mid claws subequal, hind unequal. Comparison of descriptions and specimens of *novaguineae* and *spinosipes* reveals no differences that could be regarded as of specific value, so *novaguineae* must be considered a synonym of *spinosipes*.

Characteristics: A medium-sized yellow and brown mottled species. Head brown, eyes bare. Scutum yellow, mottled extensively with dark brown, scutellum yellow with a central fuscous spot, 4 setae; legs yellow with brown bands as figured (Fig. 201), female with fore and mid claws subequal, hind claws very unequal (Fig. 202), ratio of length of claws to fifth tarsal segment 20 : 20 : 23 in fore and mid, 20 : 8 : 21 in hind, male claws all small and equal. Wing (Fig. 200) with two dark spots, one before r-m cross-vein and one at junction of costa and R_{4+5}, in female macrotrichia sparsely spread on anterior edge and apical fourth of wing, in male macrotrichia restricted to apical margin of cells R_5 and M_1. Haltere of male white, of female yellow with knob brown. Abdomen yellow and brown, tergite I yellow, sometimes with pale brown median spot, II–III yellow with brown T-shaped spot on proximal three-fourths, IV and V similar to III or entirely brown, VI similar to III, entirely brown, or yellow, VII yellow, VIII brown or yellow, IX brown or white (Fig. 203), female cerci white, male hypopygium brown. Spermathecae two, equal, subspherical, each with a short, clavate diverticulum (Fig. 204). Aedeagus bell-shaped, apex bent ventrally, parameres separate, stems very slender on basal half, broader on apical half, apices sharply bent laterally, triangular (Figs 205–207).

Distribution: Ceylon, Thailand, Laos, Viet Nam, Ryukyu Islands, Indonesia, Malaya, Sarawak, North Borneo, Philippines, New Guinea.

The subequal claws on the fore and mid legs of the female, the clavate diverticula of the spermathecae and the form of the male genitalia distinguish this species.

24. ALLUAUDOMYIA sp. N.G. No. 1

Alluaudomyia sp. N.G. No. 1 Tokunaga, 1963, *Pacif. Insects*, *5*: 226 (♀ only). (Locality: Aiyurop, 1,530 m., nr. Mendi, S. Highlands, New Guinea.)

The leg banding and structures of the spermathecae of the single specimen reported by Tokunaga suggest that it could belong to an as yet undescribed

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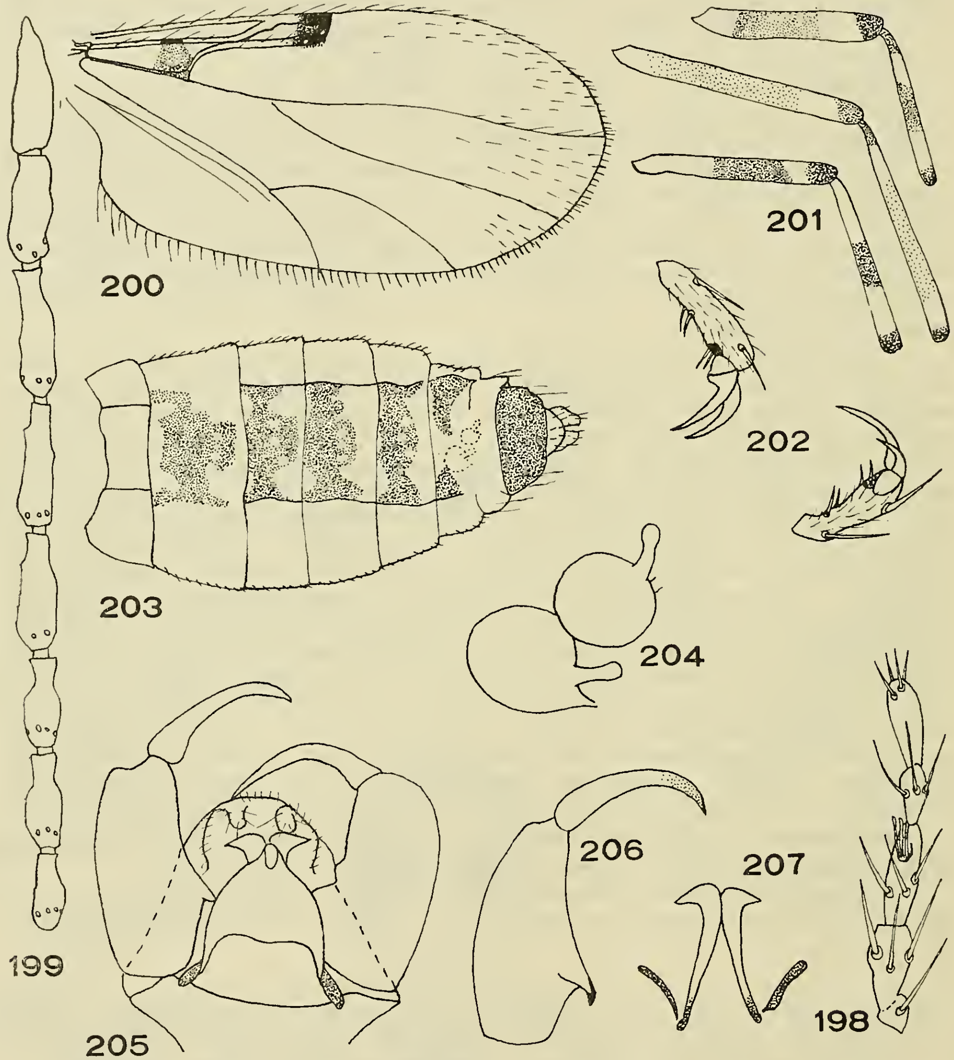
Explanation of Text-figs. 185-197.

Figs 185–195. *Alluaudomyia jimmensis* (Maprik specimen). 185, ♀ maxillary palp, ×350; 186, ♀ antennal segments VIII–XV, ×350; 187, ♂ antennal segments XI–XV, ×350; 188, ♀ wing, ×90; 189, ♂ femora and tibiae, ×90; 190, ♀ fore (*lower*) and hind (*upper*) tarsus V and claw, ×350; 191, ♀ spermathecae, ×350; 192, ♂ hypopygium, ×350; 193, ♂ paramere, ×350; 194, ♂ coxite and style, ×350; 195, dorsum of thorax (Lumi specimen). Figs 196–197. *Alluaudomyia smeei*. 196, ♀ femora and tibiae, ×90; 197, ♀ fore (*right*) and hind (*left*) tarsus V and claw, ×350.

species, but as both wings were broken off the specimen an adequate description cannot be made, and the species remains unnamed.

Characteristics: A medium-sized brown species. Head brown, eyes bare. Thorax largely brown, scutum with indistinct paler spots, scutellum yellow, 4 setae ; legs with all coxae, trochanters, knee parts and tibial apices dark, fore and hind femora fuscous on basal two-thirds, white preapically, mid femur fuscous on basal half, white on preapical half, tibiae largely white but fore femur with a fuscous median cloud, mid with a fuscous preapical cloud and hind with a prominent, oblique, fuscous sub-basal band, claws all unequal, ratio of lengths



Figs 198–207. *Alluaudomyia spinosipes* (Maprik specimen). 198, ♀ maxillary palp, × 350 ; 199, ♀ antennal segments VIII-XV, × 350 ; 200, ♀ wing, × 90 ; 201, ♀ femora and tibiae, × 90 ; 202, ♀ fore (*left*) and hind (*right*) tarsus V and claws, × 350 ; 203, ♀ abdomen, × 90 ; 204, ♀ spermathecae, × 350 ; 205, ♂ hypopygium, × 350 ; 206, ♂ coxite and style, × 350 ; 207, ♂ parameres, × 350.

of claws to fifth tarsal segment 31 : 22 : 26 in fore, 33 : 18 : 25 in mid, 21 : 11 : 20 in hind. Wing with a spot before r-m cross-vein, rest of wings broken off. Abdomen very pale ochreous, almost white, cerci white. Spermathecae round, subequal but with very unequal diverticula.

Distribution : Known only from the locality recorded by Tokunaga.

25. ALLUAUDOMYIA BRANDTI Tokunaga. (Figs 208–212)

Alluaudomyia brandti Tokunaga, 1963, *Pacif. Insects*, *5* : 223 (♀ only). (Type locality : Kulumadau Hill, Woodlark (Murua) I., New Guinea.)

Specimens examined : Northern Territory : Darwin (1 ♂, 1–2.vi.1957, 1 ♀, 27–28.v.1958, 1 ♀, 15–16.vi.1958, 1 ♀, 12–13.vii.1958, Quarantine Stn., N.J. light trap, E. J. Reye). Holotype also examined.

The Darwin specimens are very similar to the holotype except for the presence of dark dots at some of the thoracic setal bases (in the holotype only one or two extremely pale dots are present). However, because thoracic coloration is often variable within this genus, these specimens are at present regarded as *brandti.*

Female : Head dark brown, eyes bare. Scutum yellow, anterior margin fuscous, humeral pits dark, W-shaped dark stripe around posterior margins of humeral areas, fuscous rhombic median spot, small fuscous clouds posterior to scutal sutures and anterior to scutellum, which is yellow, with 4 setae, postscutellum brown centrally, yellow laterally ; legs yellow with brown bands as figured (Fig. 208), claws all very unequal (mid and hind claws missing in holotype) (Fig. 209). Wing with dark spots proximal to r-m and at junction of costa and R_{4+5} (also a faint spot on R_1 in the Darwin specimens), macrotrichia spread over apical half of wing. Haltere white. Abdomen yellow, tergites I–VI with pale brown T-shaped clouds on anterior part, VIII with a dark narrow median band. Spermathecae two, subequal, each with a small diverticulum.

Male : Length 1·59 mm., wing 0·84 × 0·30 mm.

Generally similar to female, differing as follows :

Antennal plume dark brown. Thorax light brown instead of yellow, but with similar dark markings except some setal bases with dark dots. Claws all small and equal, half the length of the fifth tarsal segment. Macrotrichia restricted to anterior edge of wing. Hypopygium (Figs 210–212) brown, styles with apical third brown, sharply bent. Aedeagus bell-shaped, apical point bent ventrally, parameres strongly swollen on basal half of stems, apices bent at right angles, scarcely tapered and rather blunt.

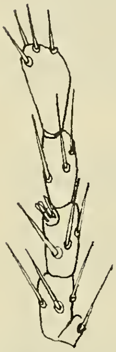
Distribution : Woodlark Island, Northern Territory.

Females of *brandti* are distinguished from those of *tenuistylata* by the shorter spermathecal diverticula. The males are distinguished most easily by the form of the parameres, in *brandti* the stems being swollen and the apices blunt and scarcely tapered, in *tenuistylata* the stems being slender and the apices more slender, tapering and undulate.

26. ALLUAUDOMYIA TENUISTYLATA Tokunaga. (Figs 213–218)

Alluaudomyia tenuistylata Tokunaga, 1959, *Pacif. Insects*, *1* : 296 (♂ only). (Type locality : Hollandia [Kotabaru], West Irian) ; Tokunaga, 1963, *Pacif. Insects*, *5* : 225 (♂, ♀, Kamo Valley, Itouda, Wisselmeren, West Irian and Maprik, Sepik District, New Guinea.)

Specimens examined : New Guinea : Maprik (1 ♂, iv.1958, 2 ♂♂, 1958). Queensland : Innisfail (1 ♂, Eubenangee Swamp, 14.ix.1963, H. Standfast). Holotype also examined.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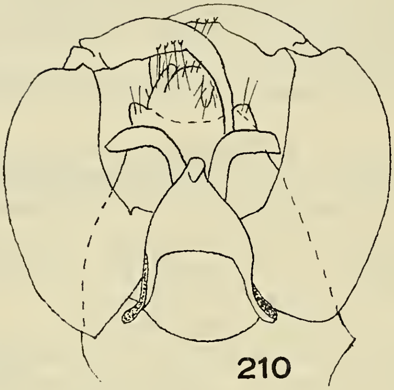
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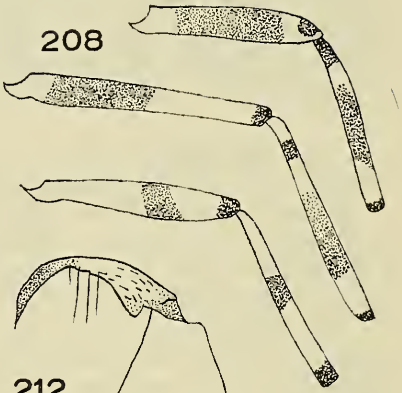
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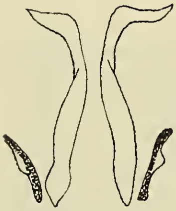
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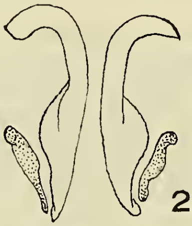
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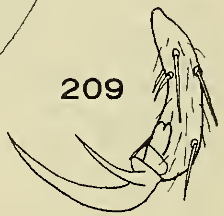
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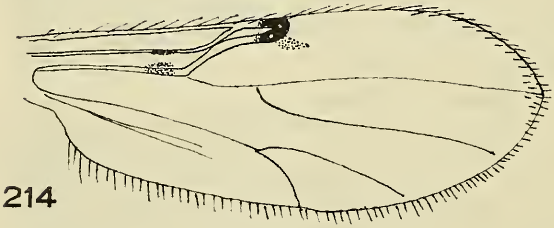
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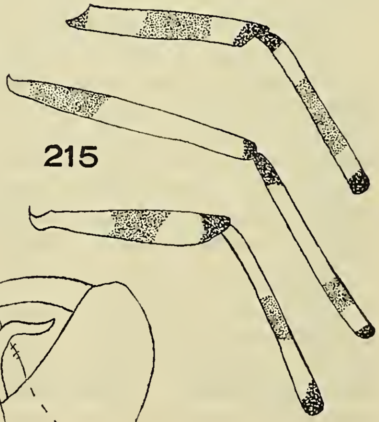
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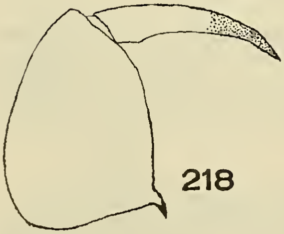
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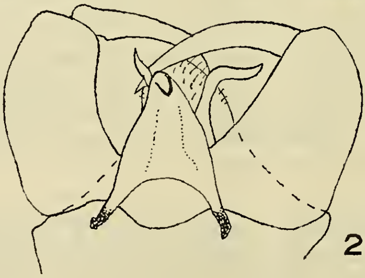
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Figs 208–212. *Alluaudomyia brandti*. 208, ♀ femora and tibiae, ×90; 209, ♀ fore tarsus V and claw, ×350; 210, ♂ hypopygium (Darwin specimen), ×350; 211, ♂ parameres (Darwin specimen). ×350; 212, ♂ coxite and style (Darwin specimen), ×350. Figs 213–218. *Alluaudomyia tenuistylata* (Maprik specimen). 213, ♂ maxillary palp, ×350; 214, ♂ wing, ×90; 215, ♂ femora and tibiae, ×90; 216, ♂ hypopygium, ×350; 217, ♂ parameres, ×350; 218, ♂ coxite and style, ×350.

Characteristics: A small to medium-sized, largely yellow species. Head brown, eyes contiguous to just separate. Thorax almost entirely yellow, scutum entirely yellow or with pale fuscous clouds, sometimes with fuscous dots at setal bases, scutellum yellow but fuscous centrally, 4 setae, postscutellum brown centrally, yellow laterally, legs white to yellow, with dark bands as figured (Fig. 215), female claws all unequal, ratio of length of claws to fifth tarsal segment 28 : 15 : 32 in fore, 29 : 15 : 29 in mid, 20 : 9 : 26 in hind, male claws all small and equal. Wing (Fig. 214) with two-three spots, one before r-m cross-vein, sometimes one on R_1, and one at junction of costa and R_{4+5} extending into cell R_5, macrotrichia spread on apical half of wing on female, restricted to wing margin between the ends of the costa and M_2 in the male. Haltere white or with knob pale fuscous. Abdomen widely white, in male anterior three tergites each with two lateral and one median brown spots, next two tergites with a very large subsquare brown spot, tergite VI with a T-shaped dark spot, VII with a pair of lateral spots, VIII with a narrow caudal dark band, female with tergites II–VI and VIII with pale fuscous bands anteriorly, cerci white. Spermathecae two, round and subequal, each with a long, slightly curved diverticulum. Aedeagus (Fig. 216) bell-shaped, short caudal stem bent ventrally, parameres (Fig. 218) with detached basal arms, stems not swollen, apices sharply bent laterally, narrow, strongly tapered, slightly undulate.

Distribution: New Guinea, northern Queensland.

This species can be separated from *brandti* Tokunaga, which has a similar pattern of leg banding, by the longer processes on the spermathecae and the more slender stems and narrower, tapering, undulate apices of the parameres.

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SYSTEMATIC POSITION OF THE GENERA *TRIODIA* R.BR. AND *PLECTRACHNE* HENR. (GRAMINEAE)

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Synopsis

The taxonomic position of *Triodia* and *Plectrachne* is investigated using essentially non-floral characters from 23 species of *Triodia* and two species of *Plectrachne*. The characters used are (i) morphology of the first seedling leaf, (ii) silica cells, (iii) bicellular microhairs, (iv) bundle sheath anatomy, (v) iodine staining, (vi) lodicules, (vii) chlorenchyma cells, (viii) starch grain morphology, and (ix) chromosome number and size. The usefulness and significance of these characters is discussed and the variation noted. From these characters it appears that the two genera are either Panicoid or Eragrostoid, but after consideration of floral morphology it is concluded that they are distinctly Eragrostoid and could perhaps be considered as primitive representatives of the tribe Eragrosteae.

The validity of the generic division between the two genera is discussed and accepted from present data.

INTRODUCTION

The position of *Triodia* and *Plectrachne* within the family Gramineae has been a source of some disagreement. Mueller (1858–1882) implies a close relationship with *Festuca*, if only by placing some *Triodia* species in that genus. Hubbard (1934) placed them in his tribe Eragrosteae and this system was retained for nearly 20 years. Vickery (1953) includes *Triodia* amongst members of the tribe Eragrosteae. Gardner (1952) distributed members of the tribe Eragrosteae, which he did not recognize, between his tribes Festuceae and Chlorideae. He placed *Triodia* and *Plectrachne* in the tribe Festuceae, along with other genera now included in the tribe Danthoneae, and this system has been retained by Vickery (1961).

These opinions have been largely based on comparative gross morphology. Although Burbidge (1946) presented an extensive study of the leaf anatomy of Western Australia *Triodia* species, little seems to have been done to incorporate these results into the classificatory system.

Since the work of Avdulov (1931) grass taxonomy has included more and more microscopic characters. The incorporation of these features has solved some seemingly intractable systematic problems, and the present investigation was undertaken to determine whether these characters could clarify the systematic position of *Triodia* and *Plectrachne*.

METHODS

The references accompanying each of the methods refers to publications in which the basis for the descriptive technique used here is set out.

The characters and methods used were :

(1) The morphology of the first seedling leaves (Bor, 1960) were observed after germinating seeds of *T. pungens*, *T. basedowii* and *T. irritans* in sand.

(2) Preparations for the study of silica cells (Metcalfe, 1960) were prepared by boiling portions of the leaf blade in a 1 : 1 : 1 mixture of 90 vols.

hydrogen peroxide : glacial acetic acid : water, until colourless, then transferring through a series of solutions to xylol and finally mounting whole in polystyrene.

(3) Bicellular microhairs (Tateoka, 1959) which were visible in the preparation for the silica cells.

(4) Bundle sheath anatomy (Brown, 1958) was determined by preparing transverse sections with a sledge microtome, using sections from near the centre of two leaves if possible ; double staining the sections with safranin and aniline blue, and subsequently mounting them in polystyrene.

(5) Iodine staining for location of areas of starch formation is a relatively new technique for which no records of any extensive investigations have been found to date. It was found that all sections had to be prepared from leaves collected immediately before staining if a consistent result was to be obtained. Sections were mounted in a weak iodine solution and no permanent mounts were prepared.

(6) Lodicules (Tateoka, 1960) were dissected from inflorescences, freshly preserved in 70% alcohol, mounted on slides, and drawn with the aid of a drawing apparatus.

(7) Separated chlorenchyma cells (Jacques-Felix, 1962 ; Freir, 1959) were prepared by macerating the leaf blade in a 1 : 1 mixture of 10% nitric acid and 10% chromic acid for approximately two to three days. After treatment, the material was transferred to absolute alcohol and, gently squashing the material, mounted in euparal.

(8) Starch grain morphology (Tateoka, 1962) was determined by scratching the surface of a seed of *T. pungens* and staining the starch obtained with a weak solution of iodine.

(9) Chromosome number and chromosome size (Avdulov, 1931) root tips were treated in 8-hydroxy quinoline for 3–4 hours, macerated in a 1 : 1 concentrated HCl and ethanol mixture, then stained in aceto-orcein.

The type species for the genus *Plectrachne* was designated by Henrard as *Plectrachne schinzii* in *Schinz. Vierteljahrs Naturf. Ges. Zürich* (74 : 132), whilst the type species for *Triodia* has been taken as *Triodia pungens* R.Br. (see Hitchcock, 1920). Both these species, as well as 22 other species of *Triodia* and one other species of *Plectrachne*, were examined for as many of the above characters as possible.

MATERIALS

All specimens for leaf characters were obtained from the National Herbarium of N.S.W., the majority of which were determined by Dr. N. T. Burbidge.

Seed material was obtained by collections made by the author for *T. basedowii* and *T. irritans* and from Dr. N. T. Burbidge for *T. pungens*.

Fresh sections for starch formation were obtained from specimens, collected by the author, growing in the Botany Department, University of Sydney.

Material for the lodicules was obtained from collections made by the author for *T. irritans* and from herbarium specimens from the N.S.W. National Herbarium for *T. longiceps* and *T. pungens*.

Material for chromosome counts was obtained from specimens growing in the Botany Department, University of Sydney.

RESULTS

(1) The morphology of the first seedling leaf has been classified into two main classes (Bor, 1960 ; Jacques-Felix, 1962) :

(i) Panicoid: characterized by an ovate to narrow-ovate first seedling leaf.

(ii) Poöid: characterized by a linear first seedling leaf.

Of these two classes, *Triodia basedowii* has a narrow-ovate first seedling leaf and is therefore Panicoid, and both *Triodia pungens* and *Triodia irritans* have linear first seedling leaves and are therefore Poöid.

(2) The characteristic silica cell shapes for various tribes have been described in detail by several authors (Duval-Jouve, 1875; Prat, 1932; Metcalfe, 1960; Bor, 1960; Jacques-Felix, 1962). In *Triodia* and *Plectrachne* several different forms were encountered which could be divided into two types (Fig. 1 (*a*)), viz. the basic Panicoid, or dumb-bell shape, and a series of similar types showing affinities with the Eragrostoid forms. Table 1 indicates an almost equal division of the species with Panicoid and Eragrostoid characteristics.

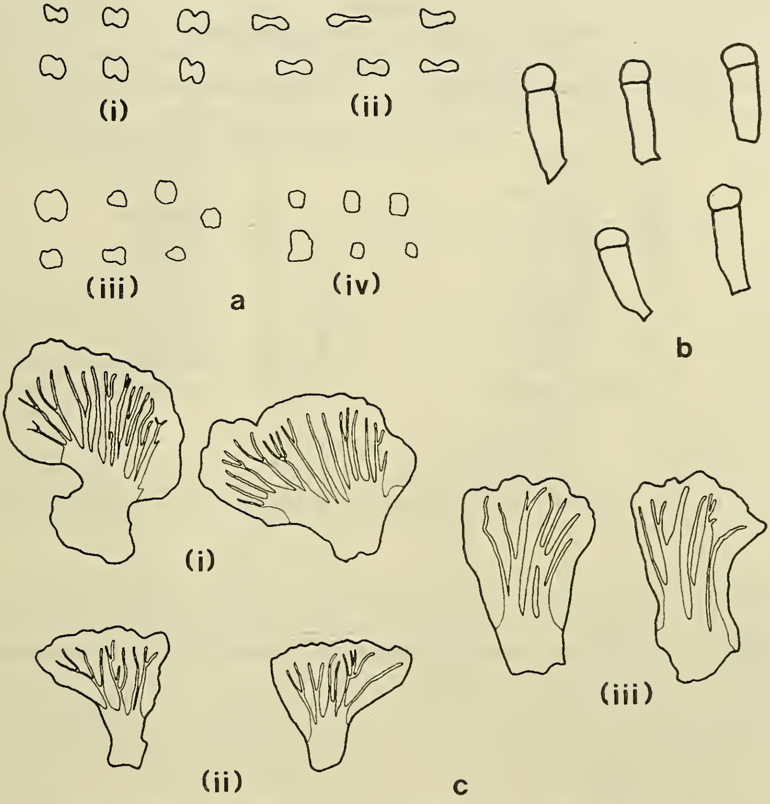

Fig. 1. (*a*) Silica cells or bodies of (i) *T. concinna*, (ii) *T. pungens*, (iii) *T. fitzgeraldii*, and (iv) *T. basedowii*. All × 250. (i) and (ii) are characteristic Panicoid forms and (iii) and (iv) are characteristic Eragrostoid form. (*b*) Bicellular microhairs from *T. irritans* (× 500). A typical Eragrostoid form. (*c*) Lodicules of (i) *T. longiceps* (× 60), (ii) *T. pungens* (× 36), (iii) *T. irritans* (× 42). Showing variations of the basic cuneate Eragrostoid form.

The silica cells of the *Plectrachne* spp. examined were observed to be well inside the range of variation exhibited by the *Triodia* spp.

Silica cell shapes are generally considered of importance as taxonomic characters, and presumably they are of use in the majority of cases for tribal classifications, but the presence of two very different forms in one genus makes their use difficult in this particular case. On the evidence available, sub-family classification has two alternatives (viz. Panicoideae or Eragrostoideae), but Panicoid silica cell forms have been reported in sub-family Eragrostoideae by Tateoka (1959).

(3) Bicellular microhairs were analysed using two ratios and a derived angle as an index of shape (Tateoka, 1959). The characteristics used were :

(i) $\dfrac{\text{Maximal width.}}{\text{Total length}}$

(ii) $\dfrac{\text{Length of upper cell.}}{\text{Length of lower cell}}$

(iii) $\theta = \tan^{-1}.\ \text{Maximal width} - \text{basal width} \times \dfrac{1}{\text{Length from base to rim of maximal width}}.$

TABLE 1

Grouping of Species on Silica-cell Shapes

Panicoid-type Silica Cells	Eragrostoid-type Silica Cells
Triodia pungens	*Triodia basedowii*
T. mitchelli	*T. secunda*
T. marginata	*T. fitzgeraldii*
T. irritans	*T. longiceps*
T. concinna	*T. clelandii*
T. hostilis	*T. wiseana*
T. stenostachya	*T. racemigera*
T. microstachya	*T. roscida*
T. hubbardii	*T. inutilis*
T. spicata	*T. inaequiloba*
T. lanata	*T. burkensis*
Plectrachne pungens	*T. intermedia*
P. schinzii	

TABLE 2

Class Limits used for the Presentation of Microhair Data (Table 3)

Characteristics	Class				
	0	1	2	3	4
$\dfrac{\text{Maximal width}}{\text{Total length}}$	0·125	0·126–0·250	0·251–0·375	0·376–0·500	0·501
$\dfrac{\text{Length of upper cell}}{\text{Length of lower cell}}$ . .	1·801	1·800–1·301	1·300–1·801	0·800–0·301	0·300
Angle between the axis of the hair and the line connecting the basal rim with the rim of maximal width . .	1°	2°–6°	7°–11°	12°–16°	17°

Each of these characteristics was subjectively divided into classes, class numbers or index values being assigned to each (Table 2), and presented in the form A (B, C, D), where B, C, D represent index values for characteristics (i), (ii) and (iii) respectively, and " A " represents the sum of the index values B, C and D (Table 3) (see Tateoka, 1959).

The calculations for Table 2 were based on a sample of five hairs and a mean value taken, the variation being small. Tateoka (1959) also accepts this sampling method as being accurate.

The microhairs (Fig. 1 (*b*)) are all very similar, and there is a continuous range of variation amongst the species, but a large section of the variation of index numbers could be ascribed to the establishment of arbitrary classes.

The range of values for these hairs occurs within the range of variation covered by the sub-family Eragrostoideae and would be classified under Tateoka's tribe Chlorideae, in which he includes the two tribes Eragrosteae and Chlorideae of other workers. For *Triodia* and *Plectrachne* bicellular microhairs appear advantageous as taxonomic characters because of their relative uniformity between the species. It should be noted that the two species of *Plectrachne* investigated occur within the range of variation observed within *Triodia*.

(4) Brown (1950) interpreted results published by Burbidge (1946) as being indicative of a Festucoid (Poöid) leaf anatomy. A Poöid leaf anatomy is characterized by a mestome or fibrous sheath surrounded by a parenchymatous sheath, although the latter is scarcely differentiated from the surrounding mesophyll, and contains chloroplasts approximately the same size as those of the mesophyll (Bor, 1960). The drawings and photographs presented by Burbidge are undoubtedly accurate, but their reproduction was not intended to show this scale of difference and, with a more critical study of the leaf, it can be seen to be very different from that typified as Poöid.

TABLE 3

Index Values from Microhair Data for the Species Examined

Species	Index	Species	Index
Triodia irritans	6 (2, 4, 0)	*Triodia concinna*	7 (2, 4, 1)
T. hostilis	6 (2, 3, 1)	*T. stenostachya*	7 (2, 4, 1)
T. fitzgeraldii	6 (2, 3, 1)	*T. clelandii*	7 (2, 4, 1)
T. basedowii	6 (2, 3, 1)	*T. racemigera*	7 (2, 4, 1)
T. pungens	7 (3, 3, 1)	*T. burkensis*	7 (2, 4, 1)
T. longiceps	7 (3, 3, 1)	*T. inaequiloba*	8 (3, 4, 1)
T. intermedia	7 (3, 3, 1)	*T. mitchelli*	8 (3, 4, 1)
T. microstachya	7 (3, 3, 1)	*T. secunda*	8 (4, 3, 1)
Plectrachne pungens	7 (3, 3, 1)	*T. marginata*	8 (3, 3, 2)
P. schinzii	7 (3, 3, 1)		

Triodia and *Plectrachne* are typified by relatively small areas of chlorenchyma enclosed by a well developed " bundle sheath " extended from around the vascular bundles (Fig. 2) and the relative size of the chloroplasts in the sheath appears to vary somewhat from being slightly larger to very much larger than those chloroplasts in the chlorenchyma. The range of differences between chloroplast sizes could be a result of drying the herbarium specimens, or of staining techniques. Sections of fresh material should produce more standardized results, but to date only fresh sections of *Triodia irritans*, from the Capertee Valley (which in fact has some characters in common with *T. scariosa*, but for the purpose of this paper it will be referred to as *T. irritans*) have been possible and these show a large size difference between the large sheath chloroplasts and the smaller ones in the chlorenchyma. This leaf anatomy could be characteristic of two sub-families, viz. Panicoideae and Eragrostoideae, the difference between the two being primarily the size difference between sheath chloroplasts and those of the chlorenchyma.

When comparing differences in leaf anatomy within the genera, using the division as suggested and illustrated by Burbidge (1953), which is based on the distribution of stomatal grooves on the abaxial surface of the lamina, then three arbitrary classes or divisions are obtained :

(i) Stomatal grooves present all over the abaxial surface of the lamineae.
(ii) Stomatal grooves present only below the midrib on the abaxial surface.
(iii) Stomatal grooves absent on the abaxial surface.

Class (i) (Table 4) can be further subdivided on the relative position of the vascular bundle as most of this group have bundles in the centre (T.S.) of the blade, but two, viz. *T. fitzgeraldii* and *T. molesta*, have bundles much nearer to the adaxial surface (Fig. 2 (*b*)). As well as these, there is one species, *T. racemigera*, whose bundles are slightly closer to the adaxial surface, i.e. it forms an intermediate form between *T. fitzgeraldii*, *T. molesta* and the remainder of the class. It is suggested that the bundles being closer to the adaxial surface could have been the first change leading to the loss of chlorenchyma (and stomata) on the lower surface, which would be an obvious ecological advantage for leaves capable of becoming terete under dry conditions. Using this hypothesis, a series of changes could be drawn up, culminating in the *T. hostilis* leaf form, perhaps representing an evolution of the leaf anatomy in response to the arid environment of the Australian interior. The *T. hostilis* leaf form is,

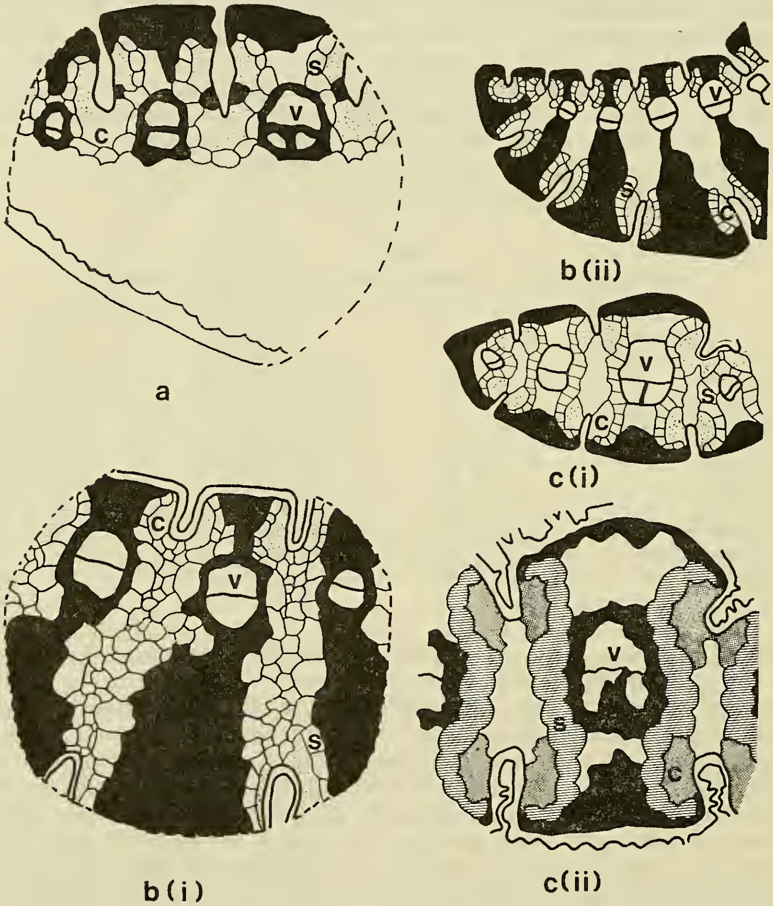

Fig. 2. (*a*) *T. hostilis* (×140), (*b*) (i) *T. fitzgeraldii* (×138), (ii) *T. fitzgeraldii* (×80), (*c*) (i) *T. irritans* (×111), (ii) *T. irritans* (×200). For all figures c=chlorenchyma, v=vascular bundle, s=parenchymatous "bundle" sheath. The completely inked-in areas are sclerenchyma.

in fact, very similar to the *T. pungens* leaf form and different specimens of *T. microstachya* have both types. In the *T. hostilis* leaf (Fig. 2 (*a*)) the " bundle sheath " seems to be highly developed and completely surrounding the chlorenchyma below the stomatal groove, with only a small portion of the sheath coming into actual contact with the bundle. The validity of even considering this sheath as a " bundle sheath " is discussed later.

Between the two genera *Triodia* and *Plectrachne* there is a range of anatomical forms with no particularly distinctive character separating the two genera.

(5) The utilization of starch formation detected by iodine staining as a taxonomic character has been mentioned in the literature (Brown, 1958 ; Bor, 1960) but has not assumed any importance. There are two main classes of reaction to the staining of fresh leaves with iodine :

(i) Members of the Poöideae stain throughout the chlorenchyma including the bundle sheath, whilst

(ii) members of the Panicoideae and Eragrostoideae only stain in the parenchymatous sheath.

TABLE 4

Division of Species on the Distribution of Stomatal Grooves. Class (i) Stomatal grooves present all over the abaxial surface of the laminae. Class (ii) Stomatal grooves present only below the midrib on the abaxial surface. Class (iii) Stomatal grooves absent on abaxial surface

Class (i)	Class (ii)	Class (iii)
T. concinna	*T. hubbardii*	*T. hostilis*
T. inaequiloba	*T. stenostachya*	*T. microstachya*
T. secunda	*T. marginata*	
T. clelandii	*T. pungens*	
T. longiceps	*T. mitchelli*	
T. wiseana	*P. schinzii*	
T. irritans	*P. pungens*	
T. burkensis		
T. lanata		
T. spicata		
T. roscida		
T. intermedia		
T. basedowii		
T. racemigera		
T. inutilis		
**T. molesta*		
**T. fitzgeraldii*		

* Bundles towards adaxial surface.

As well as these classes *Phragmites* sp. (Arundineae) stains only in the chlorenchyma with no staining in the sheath. The differential reactions to iodine staining appear to be related to the C_4 and C_3 photosynthetic pathways.

Triodia irritans (from Capertee Valley) was obtained, sectioned, and stained, revealing starch formation as being limited to the bundle sheath under high light intensities, indicating Panicoid or Eragrostoid affinities. For comparison, transverse sections of the leaf blade of a species of *Danthonia* were cut and stained. These showed Poöid affinities by staining throughout the chlorenchyma and parenchymatous sheath under high light intensities.

(6) Tateoka (1960) discusses the use of lodicules as a taxonomic character, but he only gives descriptions of a few tribes, a notable exception being tribes of the sub-family Panicoideae. From Tateoka's descriptions, the lodicules of *Triodia* (Fig. 1 (*c*)) would be characteristic of members of the tribe Eragrosteae, but only in comparison with other members of the sub-family Eragrostoideae and Poöideae. Prior to the use of lodicule morphology, number of lodicules

had been used to a limited extent, but only for a few tribes. *Triodia* has two cuneate, fleshy lodicules with fairly well developed vascularization.

(7) The value of the shape of the chlorenchyma cell as a taxonomic character has been elucidated by Freir (1959) and Jacques-Felix (1962). Four characteristic forms have been described by these authors :

(i) Poöid (Festucoid). Typical parenchymatous cells being approximately isodiametric with joining lobes.

(ii) Bambusoid-oryzoid. Lobed-tabular cells.

(iii) Panicoid. Ratchet cells with deep constrictions and large angular axes arranged radially.

(iv) Arundinoid. Ratchet cells arranged diffusely.

Of the forms described above, the chlorenchyma cells of *Triodia* would be classified as Poöid, although attention must be drawn to the fact that typical forms of the sub-family Eragrostoideae have hardly been investigated. One species of *Eragrostis* (aff. *brownii*) was examined and found to have Poöid chlorenchyma cells. Further elucidation of chlorenchyma cell morphology as a taxonomic character is essential prior to its widespread adoption.

(8) Tateoka (1962) re-evaluated the divisions of grass tribes based on starch grain morphology and concluded that simple, rounded, starch grains could be separated from compound, or simple, angular starch grains, resulting in two major divisions. The former grain type is characteristic of the sub-family Poöideae, whereas the remaining forms seem to occur throughout the non-Poöid tribes. The starch grains of *T. pungens*, *T. irritans* and *T. basedowii* are all simple and angular, i.e. they are non-Poöid starch grains.

(9) Accurate chromosome counts were difficult because of the unsuitable anther material collected and the thickness of the root tips to be examined. Associated with this was the relatively small number of cells actually dividing. The chromosome size was very small (i.e. non-Poöid—Bor, 1960) and this also complicated accurate counting especially with the rather large numbers found. The numbers quoted can only be given as approximate because of the difficulties mentioned ; *Triodia basedowii* had $2n=60$, *Triodia irritans* had $2n=30$. As can be seen with such numbers, arguments based on tribal characteristics of $n=5$, $n=6$, $n=7$, $n=9$ or $n=10$ tend to be relatively meaningless as by various hypotheses of chromosomal losses or gains it is possible to suggest any of these base numbers as being the original base number before polyploidy.

Discussion

Of the characters investigated, those generally considered to be of greater taxonomic significance are silica cells, bicellular microhairs, leaf anatomy and chromosome number. The results from the silica cells, leaf anatomy and chromosome size suggest Panicoid or Eragrostoid affinities, whereas the bicellular microhairs are more specific, indicating Eragrostoid affinities. The large variation of silica cell types within those genera increases the difficulty with which it can be applied satisfactorily, and it is suggested that silica cell shape can only satisfactorily be applied in conjunction with numerous other characters, and any attempt at identification purely by this character would be unsatisfactory.

Bicellular microhairs appear to be reasonably characteristic even to tribal level and, because of their uniformity, appear to be of value for application to this particular problem. The microhairs are obviously Eragrostoid and, by comparison with the sketches and data of Tateoka (1959), are more characteristic of the tribe Eragrosteae, as opposed to the tribe Chlorideae.

The anatomy of the leaf, with particular reference to bundle sheath anatomy, has been considered of importance since the data published by Avdulov (1931).

From this period the concept of a bundle sheath has never been questioned, but evidence from *Triodia* and *Plectrachne* (also *Festuca littoralis*) indicates that the parenchymatous sheath is more closely associated with the chlorenchyma and its function rather than the vascular bundle. In the majority of grasses the chlorenchyma and the vascular strands are separated by a parenchymatous sheath of some form and, since it surrounds the bundle, it was considered as a bundle sheath. Changing the concept from a bundle sheath to a chlorenchyma sheath has no effect on the anatomical characters used in taxonomy, but it will have important implications of physiological characters, e.g. that of starch formation and the associated biochemical pathways. The importance of size differences and functional differences between sheath chloroplasts and those of the chlorenchyma could perhaps be better appreciated by regarding the sheath as being more closely associated with the chlorenchyma.

The structure of the chlorenchyma, whether radially or diffusely arranged, has been utilized in conjunction with sheath type, but with *Triodia* the interpretation is difficult due to its remoteness from the vascular bundle.

Evidence from studies on the first seedling leaf has little reliability. The number of lodicules has been utilized in the delimitation of some groups (e.g. Bambuseae, Stipeae), but the variation is not sufficient for critical analysis to be applied. More critical studies are possible with lodicule morphology and the two lodicules in *Triodia* show distinct Eragrostoid affinities.

TABLE 5

Summary of Results of Characters Investigated

Character	*Danthonia*	Eragrosteae	Paniceae	Poaeae	Triodia-Plectrachne
Silica cells	Panicoid	Eragrostoid	Panicoid	Poöid	Eragrostoid +Panicoid
Bicellular microhairs . .	Panicoid	Eragrostoid	Panicoid	Poöid	Eragrostoid
Bundle sheath anatomy . .	Poöid	Eragrostoid	Panicoid	Poöid	Eragrostoid/ Panicoid
Lodicule shape	Oblong Danthoneae	Cuneate Eragrostoid	—	Two-lobed Poöid	Cuneate Eragrostoid
Chlorenchyma cell shape . .	Poöid	Poöid	Panicoid	Poöid	Poöid
Iodine staining	Poöid	Panicoid	Panicoid	Poöid	Panicoid
Starch grain morphology . .	Poöid	Panicoid	Panicoid	Poöid	Panicoid
Morphology of first seedling leaf	Poöid	Poöid	Panicoid	Poöid	Poöid

The use of chlorenchyma cell shape is a relatively new technique, but suffers the disadvantage of having an almost continual gradation between forms, rendering them of limited value in many cases. Starch grain type was considered of prime importance prior to the work of Tateoka (1962), who has since cast doubt on their assumed importance.

Staining fresh leaves with iodine is one of the simpler physiological characters which can be readily tested, and could become increasingly important in grass systematics once sufficient information has been obtained on the subject.

Considering all the characters (Table 5) investigated, the most satisfactory course appears to be to include *Triodia* in sub-family Eragrostoideae or Panicoideae. To this point only leaf characteristics have been mentioned (except for lodicules and chromosomes), but spikelet characteristics surely deserve consideration. On casual observation spikelet morphology indicates no apparent relationship to the Panicoideae at all, but, in some species, notably *T. irritans* (Capertee Valley), there is an apparently classical Eragrostoid type spikelet structure with numerous fertile florets with the lemma three-nerved. The lemmas of *Triodia* are often apparently three-nerved, but this nervation consists of three groups of three traces with the laterals (of each group) being lost in some cases (Burbidge, 1953), as in the *Triodia* from the Capertee Valley. It is suggested that this could represent a primitive condition in the sub-family Eragrostoideae (in lemma characters only) supporting Hartley's (1960) estimation of the centre of origin of the sub-family Eragrostoideae as being the arid regions of either Australia or South Africa.

CONCLUSIONS

Sub-family classification would place *Triodia* and *Plectrachne* in the sub-family Eragrostoideae, but tribal classification is more difficult. It is suggested that rather than attempting to establish new tribes, these genera should be placed in the tribe Eragrosteae, perhaps representing a " primitive " condition within that tribe.

Burbidge (1953) expresses the view that *Triodia* should be placed in the tribe Danthoneae which, in Australia at least, appears somewhat heterogeneous but microhair characteristics, as well as silica cell shape, iodine-staining results, leaf anatomy, etc., prevent it (Danthoneae) from being included in the sub-family Eragrostoideae. Arguments based on glume lengths and form of lobing appears rather arbitrary due to the large variation of these characters within the genus *Triodia*. Furthermore, the chromosome numbers reported are sufficiently large to accommodate any decisions based on base number (Eragrosteae : n=10 (5 ?) 12 ; Danthoneae : n=6, 9, 12—Bor, 1960).

Another problem worthy of consideration is the validity of the generic division between *Triodia* and *Plectrachne*. The establishment of a genus is based on a set of correlated characters which, initially, were concerned mainly with the inflorescence, and, using only these characters, a generic division is justifiable. However, it can be seen that there are no apparent discontinuities for the sets of characters investigated and, indeed, the characteristics of *Plectrachne* spp. are usually well within the range of variation exhibited by *Triodia*. Taxonomically, the two genera are very close, but it is suggested that the generic division be maintained even if only in consideration of the large number of species. This division could only be maintained if no intermediate lemma form is discovered, but, if a lemma is found with long lobes tapering into small awns with a comparatively small, slightly indurated base, then the generic division would be invalidated since this is the sole feature which distinguishes the two genera.

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APHIDS OF PAPUA AND NEW GUINEA: AN ANNOTATED CHECK LIST

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Synopsis

Fifty-seven species of aphids are listed from New Guinea. Most of these have been part of a collection of 6,000 alates from Moericke traps located in four different areas. Some host information is given, together with an index of host plants. The British Museum (Natural History) collection has been examined.

Introduction

During the past three years, more than 6,000 specimens of alate aphids have been collected at four main sites in the Territory of Papua and New Guinea. Since no previous lists of aphids have been published for this country, the systematic results of trapping are summarized here, together with limited host information, mainly based on materials in the collection of the British Museum (Natural History). Some records from earlier literature are included, but species not seen by the author are marked with an asterisk (*). Fifty-five species are listed. Sixteen of these species were mentioned by Eastop (1966) as occurring in Papua or New Guinea.

Trapping was carried out using yellow Moericke trays at Waigani (near Port Moresby), Central District; at Bulolo (altitude 2,400 ft.), Morobe District; at Goroka (altitude 5,300 ft.), Eastern Highlands District; and at Keravat (altitude 50 ft.), East New Britain District. Trapped species are marked " T " and specimens examined in the British Museum Collection are marked " BM ".

Family Aphididae

Subfamily *Aphidinae*

1. *Aphis* (*Pergandeida*) *craccivora* Koch, 1854.
   BM; T—Waigani, Bulolo, Goroka, Keravat, also specimens from Morobe and Aiyura. Hosts: *Vigna sinensis sesquipedalis* (yard-long bean), *Vigna sinensis sinensis*, *Phaseolus* sp., *Centrosema pubescens*, *Gliricidia sepium*, peanut. Eastop (1966).
2. *Aphis* (*Cerosipha*) *glycines* Matsumura, 1917.
   BM; T—Waigani, Bulolo, Keravat. Host: Soya bean.
3. *Aphis* (*Cerosipha*) *gossypii* Glover, 1877.
   BM; T—Waigani, Goroka, Bulolo, also specimens from Morobe and Chimbu. Hosts: *Carica papaya*, *Cassia* sp., *Albizia chinensis*, *Cucurbita moschata*, *Hibiscus abelmoschus*, *Hibiscus rosa-sinensis*, *Cyphomandra* (tree tomato), potato, taro, *Tephrosia* sp. Heie (1967), Valoka, New Britain; Szent-Ivany (1956) on *Malva parviflora*. One of the most abundant and widespread aphid species.
4. *Aphis ? hardyi* Eastop, 1966.
   T—Bulolo.

5. *Aphis nerii* Boyer de Fonscolombe, 1841.
BM; T—Waigani, Bulolo, Heie (1967)—*Asclepias curassavica* L. Lorengau, Manus, Admiralty Is. 24.vi.1962.

6. *Aphis* (*Medoralis*) *spiraecola* Patch, 1914.
BM; T—Waigani, Bulolo, Keravat. Eastop (1966).

7. *Brachycaudus helichrysi* (Kaltenbach, 1843).
BM; T—Waigani, Goroka, Keravat; also recorded from Aiyura. Host: *Crotalaria anagyroides*. Szent-Ivany (1956).

8. *Brachysiphoniella montana* (van der Goot, 1917).
BM; Aiyura, on *Leersia hexandra*.

9. *Capitophorus hippophaes mitegoni* Eastop, 1956.
BM; T—Waigani.

10. *Hyalopterus pruni* (Geoffrey, 1762).
BM; T—Waigani, Bulolo. Host: *Celosia argentea* (banana). Eastop (1966).

11. *Hyperomyzus carduellinus* (Theobald, 1915).
BM; T—Bulolo.

12. *Hysteroneura setariae* (Thomas, 1877).
BM; T—Waigani, Bulolo; also specimens from Gaimazung.

13. **Indomegoura indica* (van der Goot, 1916).
Calilung (1967) refers to this species as occurring in "Dutch New Guinea".

14. *Lipaphis erysimi* (Kaltenbach, 1843).
BM; T—Waigani, Bulolo, Keravat.

15. *Longiunguis sacchari* (Zehntner, 1897).
BM; T—Waigani, Keravat; also specimens from Bulia on sugar-cane. Eastop (1966).

16. *Macromyzus polypodicola* (Takahashi, 1921).
BM; T—Waigani, Goroka, Bulolo, Keravat.

17. *Macrosiphoniella* (*Pyrethromyzus*) *sanborni* (Gillette, 1908).
BM; Aiyura, on *Chrysanthemum* sp. Eastop (1966).

18. *Macrosiphum* (*Sitobion*) *graminis* Takahashi, 1950.
BM; T—Goroka; Mt. Kaindi, on grass (B. C. Peters).

19. **Macrosiphum* (*Sitobion*) *leelamaniae* Kan. David, 1958.
Bulolo, on grass (B. C. Peters).

20. *Macrosiphum* (*Sitobion*) *? rosaeformis* Das, 1918.
T—Goroka.

21. **Macrosiphum* (*Sitoion*) *? smilacifoliae* Takahashi, 1921.
Recorded by Heie (1967) from Yalom, New Britain.

22. *Macrosiphum rosae* (L., 1758).
BM; Kainantu and Aiyura, on rose.

23. *Micromyzus dispersum* (van der Goot, 1917).
(Syn. *M. eastopi* Carver, 1965).
BM; T—Goroka.

24. *Micromyzus ? katoi* (Takahashi, 1925).
On *Platycerium wandae* (syn. *P. wilhelminae-reginae*), Bulolo (B. C. Peters).

25. *Myzus ornatus* Laing, 1932.
BM; Aiyura, on *Crotalaria anagyroides*.

26. *Myzus* (*Nectarosiphon*) *persicae* (Sulzer, 1776).
BM ; T—Bulolo, Goroka, Keravat ; also recorded from Aiyura. Hosts : *Crotalaria anagyroides*, *Cyphomandra*, *Gladiolus*, *Ipomoea batatas*, *Passiflora foetida*, *Vitis arborea* (pepper vine). Eastop (1966).

27. *Neomyzus circumflexus* (Buckton, 1876).
BM ; Aiyura, Wau, Bulolo. Hosts : *Physalis peruviana*, *Smilax* sp. Eastop (1966).

28. *Pentalonia gavarri* Eastop, 1967.
BM ; T—Keravat.

29. *Pentalonia nigronervosa* Coquerel, 1859.
BM ; T—Waigani, Bulolo, Goroka, Keravat. Hosts : Banana, *Colocasia*, *Caladium*.

30. *Rhopalosiphum maidis* (Fitch, 1856).
BM ; T—Waigani, Bulolo, Keravat ; also recorded from Asaro Valley, Aiyura, Tapini. Hosts : *Sorghum vulgare*, *Zea mays*. Szent-Ivany (1958).

31. *Rhopalosiphum rufiabdominalis* (Sasaki, 1899).
T—Bulolo.

32. *Schizaphis cyperi* (van der Goot, 1917).
BM ; T—Bulolo.

33. *Schizaphis graminum* (Rondani, 1852).
T—Keravat.

34. *Schizaphis minuta* (van der Goot, 1917).
BM ; T—Waigani.

35. *Shinjia pteridifoliae* (Shinji, 1929).
BM ; T—Goroka.

36. *Sinomegoura citricola* (van der Goot, 1917).
BM ; Kainantu, on Avocado. Eastop (1966).

37. *Toxoptera aurantii* (Boyer de Fonscolombe, 1841).
BM ; T—Waigani, Bulolo, Keravat ; also recorded from Aiyura, Bubia, Goroka, Madang, Morobe, Popondetta. Hosts : *Amaranthus*, Cacao, *Coffea arabica*, pepper vine, tea. Dun (1954).

38. *Toxoptera citricidus* (Kirkaldy, 1907).
BM ; T—Waigani ; also recorded from Aiyura, Asaro, Bubia, Rigo and Wau on *Citrus*. Eastop (1966).

Subfamily *Lachninae*

39. *Lachnus tropicalis* (van der Goot, 1916).
BM ; Goroka on *Casuarina equisetifolia*.

40. *Greenidia ficicola* Takahashi, 1921.
BM ; Eastern Highlands, on *Ficus*. Eastop (1966).

41. *Greenidia* (*Trichosiphum*) *formosana* (Maki, 1917).
BM ; T—Bulolo, Wau.

42. **Paratrichosiphum ? javanicum* Ray Chaudhuri, 1956.
T—Goroka, Wau.

Subfamily *Greenideinae*

43. *Anomalosiphum pithecolobii* Takahashi, 1934.
BM ; T—Waigani.

44. *Cervaphis rappardi* H. R. Lambers, 1956.
BM ; Keravat, on cacao flowers.

45. *Schoutedenia lutea* (van der Goot, 1917).
BM ; Port Moresby, on *Breynia cernua*.

Subfamily *Drepanosiphinae*

46. *Neophyllaphis araucariae* Takahashi, 1937.
BM; T—Bulolo, Goroka; Bulolo, on *Araucaria cunninghamii* (B. C. Peters); Wau.

47. **Neophyllaphis rappardi* Hille Ris Lambers, 1967.
On *Agathis labillardieri*, Bosniak, Biak, Western New Guinea (Hille Ris Lambers, 1967).

48. **Sensoriaphis* sp. nov.
On *Nothofagus* sp., Mt. Kaindi (T. Tigner).

Subfamily *Thelaxinae*

49. *Kurisakia onigurumi* (Shinji, 1923).
T—Wan (Y. Lubin).

Subfamily *Hormaphidinae*

50. *Astegopteryx nipae* (van der Goot, 1917).
T—Goroka.

51. *Astegopteryx rappardi* H. R. Lambers, 1953.
BM; Morobe, on coconut. Szent-Ivany (1961).

52. *Ceratovacuna lanigera* Zehntner, 1897.
BM; T—Waigani, Keravat; also recorded from Aiyura, Manum, Samarai, on *Saccharum robustum* (sugar-cane). Szent-Ivany and Cattley (1966).

53. *Cerataphis variabilis* H. R. Lambers, 1953.
BM; T—Keravat; Kokopo, Popondetta, Wewak. Hosts: Coconut, cacao. Szent-Ivany (1961).

54. *Pseudoregma bambusicola* (Takahashi, 1921).
BM; Southern Highlands, on bamboo.

Subfamily *Pemphiginae*

55. *Tetraneura radicicola* Strand, 1929.
BM; Kainantu, on roots of *Imperata*. Szent-Ivany (1956).

56. *Tetraneura nigriabdominalis* (Sasaki, 1899).
BM; T—Waigani, Bulolo, Goroka, Keravat; also recorded from Galmazug and Kainantu. Hosts: grass (roots), *Ipomoea batatas*, Pangola grass roots, *Passiflora foetida*, rice stool, *Leersia hexandra*. This widespread and abundant root aphid often causes reddish-purple leaf discoloration. Heie (1967)—Kwalalessi, New Britain. Eastop (1966).

57. *Geoica lucifuga* (Zehntner, 1897).
BM; T—Goroka; Wau.

Host Plant Index

Albizia chinensis (Osb.) (Leguminosae-Mimosoideae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Amaranthus sp. (Amaranthaceae)—*Toxoptera aurantii* (B.d.F.).

Arachis hypogaea L. (Leguminosae-Lotoideae)—*Aphis* (*Pergandeida*) *craccivora* Koch.

Araucaria cunninghamii Ait. (Araucariaceae)—*Neophyllaphis araucariae* Tak.

Avocado—see *Persea americana*.

Bamboo—see *Bambusa* sp.

Bambusa sp. (Gramineae)—*Pseudoregma bambusicola* (Tak.).

Banana—see *Musa* sp.

Bean—see *Phaseolus*, *Vigna*.

Breynia cernua Muell. Arg. (Euphorbiaceae)—*Schoutedenia lutea* (v. d. G.).

Cacao—see *Theobroma*.

Caladium sp. (Araceae)—*Pentalonia nigronervosa* Coq.

Camellia sinensis (L.) Kuntze (Theaceae)—*Toxoptera aurantii* (B.d.F.).

Carica papaya L. (Caricaceae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Cassia sp. (Leguminosae-Caesalpinioideae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Casuarina equisetifolia Forst. (Casuarinaceae)—*Lachnus tropicalis* (v.d.G.).

Celosia argentea (L.) Lautb. and K. Schum. (Amaranthaceae)—*Hyalopterus pruni* (Geoff.).

Centrosema pubescens Benth. (Leguminosae-Lotoideae)—*Aphis* (*Pergandeida*) *craccivora* Koch.

Chrysanthemum sp. (Compositae)—*Macrosiphoniella* (*Pyrethromyzus*) *sanborni* (Gillette).

Citrus sp. (Rutaceae)—*Toxoptera citricidus* (Kirkaldy).

Cocoa—see *Theobroma cacao*.

Cocos nucifera L. (Palmae)—*Astegopteryx rappardi* H.R.L., *Cerataphis variabilis* H.R.L.

Coconut—see *Cocos nucifera*.

Coffea arabica L. (Rubiaceae)—*Toxoptera aurantii* (B.d.F.).

Coffee—see *Coffea arabica*.

Colocasia sp. (Araceae)—*Aphis* (*Cerosipha*) *gossypii* Glover, *Pentalonia nigronervosa* Coq.

Cowpea—see *Vigna sinensis sinensis*.

Crotalaria anagyroides H.B. and K. (Leguminosae-Lotoideae)—*Brachycaudus helichrysi* (Kltb.), *Myzus ornatus* Laing, *Myzus* (*Nectarosiphon*) *persicae* (Sulz.).

Cucurbita moschata Duchesne (Cucurbitaceae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Cyphomandra sp. (Solanaceae)—*Aphis* (*Cerosipha*) *gossypii* Glover, *Myzus* (*Nectarosiphon*) *persicae* (Sulz.).

Ficus sp. (Moraceae)—*Greenidia ficicola* Tak., 1921.

Fig—see *Ficus*.

Gladiolus sp. (Iridaceae)—*Myzus* (*Nectarosiphon*) *persicae* (Sulz.).

Gliricidia sepium (Jacq.) Steud. (Leguminosae-Lotoideae)—*Aphis* (*Pergandeida*) *craccivora* Koch.

Glycine max (L.) Merr. (Leguminosae-Lotoideae)—*Aphis* (*Cerosipha*) *glycines* Mats.

Gramineae—*Brachysiphoniella montana* (v.d.G.), *Ceratovacuna lanigera* Zehnt., *Longiunguis sacchari* (Zehnt.), *Macrosiphum* (*Sitobion*) *leelamaniae* Kan. David, *Pseudoregma bambusicola* (Tak.), *Rhopalosiphum maidis* (Fitch), *Tetraneura radicicola* Strand, *Tetraneura nigriabdominalis* (Sas.).

Grasses—see *Gramineae*.

Hibiscus abelmoschus L. (Malvaceae)—*Aphis* (*Cerosipha*) *gossypii* Glov.

Hibiscus rosa-sinensis L. (Malvaceae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Imperata cylindrica (L.) Beauv. (Gramineae)—*Tetraneura radicicola* Strand.

Ipomoea batatas (L.) Lam. (Convolvulaceae)—*Myzus* (*Nectarosiphon*) *persicae* (Sulz.), *Tetraneura nigriabdominalis* (Sas.).

Kunai grass—see *Imperata cylindrica*.

Leersia hexandra Sw. (Gramineae)—*Brachysiphoniella montana* (v.d.G.), *Tetraneura nigriabdominalis* (Sas.).

Maize—see *Zea mays.*

Malva parviflora L. (Malvaceae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Musa spp. (Musaceae)—*Pentalonia nigronervosa* Coq.

Oryza sativa L. (Gramineae)—*Tetraneura nigriabdominalis* (Sas.).

Passiflora foetida L. (Passifloraceae)—*Myzus* (*Nectarosiphon*) *persicae* (Sulz.), *Tetraneura nigriabdominalis* (Sas.).

Paw-paw—see *Carica papaya.*

Peanut—see *Arachis hypogaea.*

Pepper—see *Piper* sp.

Pepper vine—see *Vitis arborea.*

**Persea americana* Mill. (Lauraceae)—*Sinomegoura citricola* (v.d.G.).

Phaseolus sp. (Leguminosae-Lotoideae)—*Aphis* (*Pergandeida*) *craccivora* Koch.

Physalis peruviana L. (Solanaceae)—*Neomyzus circumflexus* (Buckt.).

Piper sp. (Piperaceae)—*Toxoptera aurantii* (B.d.F.).

" Pit-pit "—see *Saccharum robustum.*

Platycerium wandae Raciborski (Polypodiaceae)—*Micromyzus ? katoi* (Tak.).

Potato—see *Solanum tuberosum.*

Potato, sweet—see *Ipomoea batatas.*

Pumpkin, native—see *Cucurbita moschata.*

Rice—see *Oryza sativa.*

Rosa sp. (Rosaceae)—*Macrosiphum rosae* (L.).

Saccharum robustum Brandes and Jesweit ex Grassl. (Gramineae)—*Ceratovacuna lanigera* Zehnt.

Saccharum officinarum L. (Gramineae)—*Longiunguis sacchari* (Zehnt.).

Smilax sp. (Liliaceae)—*Neomyzus circumflexus* (Buckt.).

Solanum tuberosum L. (Solanaceae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Sorghum bicolor (L.) Moench (Gramineae)—*Rhopalosiphum maidis* (Fitch).

Soya bean—see *Glycine max.*

Staghorn fern—see *Platycerium.*

Sugar-cane—see *Saccharum officinarum.*

Sweet potato—see *Ipomoea batatas.*

Taro—see *Colocasia* sp.

Tea—see *Camellia sinensis.*

Tephrosia sp. (Leguminosae-Lotoideae)—*Aphis* (*Cerosipha*) *gossypii* Glover.

Theobroma cacao L. (Sterculiaceae)—*Toxoptera aurantii* (B.d.F.), *Cervaphis rappardi* H.R.L., *Cerataphis variabilis* H.R.L.

Tree tomato—see *Cyphomandra.*

Vigna sinensis sesquipedalis (L.) Fruw. (Leguminosae-Lotoideae)—*Aphis* (*Pergandeida*) *craccivora* Koch.

Vigna sinensis sinensis Stickm. (Leguminosae-Lotoideae)—*Aphis* (*Pergandeida*) *craccivora* Koch.

Vitis arborea (Vitaceae)—*Myzus* (*Nectarosiphon*) *persicae* (Sulz.), *Toxoptera aurantii* (B.de.F.).

Yard-long bean—see *Vigna sinensis sesquipedalis.*

Zea mays L. (Gramineae)—*Rhopalosiphum maidis* (Fitch).

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PHENOLOGY OF SPECIES COMMON TO THREE SEMI-ARID GRASSLANDS

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Synopsis

Australian phenological studies are reviewed briefly before presenting data on the leafing phenology of seven species and the flowering phenology of 25 species common to (i) a *Danthonia caespitosa* grassland on Riverina clay, (ii) a *Stipa variabilis-D. caespitosa* grassland on Billabong clay, and (iii) a *Stipa aristiglumis-D. caespitosa* grassland on Deniboota loam. Data were collected for 1952 (annual rainfall 18·4 in.) and 1953 (annual rainfall 12·9 in.). The disclimax grasslands adjoin on a level depositional plain situated in the south-west of New South Wales.

The differences in leafing phenology of a species common to the three grasslands appear to be related to soil differences such as permanent wilting percentage (15-bar value) and water-holding capacity. This is more evident for warm-season species than for cool-season species.

The growth-rhythms of the short-lived annual plants, which include many exotics, and the autumn- to spring-growing perennials indicate that the three disclimax grasslands are in equilibrium with the present annual climatic cycle. The remaining few perennial plants which respond to summer rainfall are related to, or are the indigenes of, the original communities from which the grasslands have developed.

In those species which bloom once in the spring-early summer period, the onset of flowering appears to be related in part to day-length change. For most species the difference in the date of the onset of flowering between years in the one grassland appears to be greater than the differences between grasslands. Those species which have more than one flowering period do not exhibit a fixed relationship between day-length in spring-early summer, and day-length at the commencement of any other bloom period.

It is concluded that the difference between the grasslands is found more in differences in the number of individual plants of each species and in the leafing phenology of the warm-season species common to the three grasslands, than in differences in species composition and in the flowering phenology of those species with only one bloom period.

INTRODUCTION

Moore (1880), in his Anniversary Address to the Royal Society of New South Wales, asked pastoralists to collect information on the habitat, vegetative and flowering performance of plant species on their sheep and cattle runs. No useful data appear to have been collected. Haviland (1886) compiled eight lists of indigenous species found about Sydney, N.S.W., and recorded the months in which they were in bloom. Maiden (1909) published a short bibliography of Australian phenological literature.

Heyward (1931) constructed a phenological record for all 554 indigenous Victorian genera using herbarium records supplemented by personal observations. She noted that most species did not vary their flowering dates by more than a few weeks even though temperature, rainfall, or elevation varied substantially. After discussing the importance of environmental factors in natural selection, and in particular the influence of the dry, hot summer, Heyward concluded that no single factor could be the sole determinant of time and duration of flowering. In this study the flowering periods of all species in a genus were combined to give a generalized picture.

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Patton (1933) recorded the number of species flowering in each month on a heath at Cheltenham, Vic. He noted the large spring peak of bloom, that several indigenes performed exceptionally by flowering in summer, and that summer rainfall seldom elicited a plant response because of high evaporation. Patton (1936) recorded a similar late spring peak of bloom in an indigenous tussock grassland near Melbourne, Vic.

Biddiscombe *et al.* (1954) reported leafing and flowering phenology of the major perennial grasses and winter-growing herbs in a disclimax grassland at Trangie, N.S.W. The first detailed list of flowering dates for individual species in an Australian community was reported by Specht and Rayson (1957) for the heath near Keith, S.A. Derrick (1962) presented charts for all Australian States (excluding the Northern Territory) which show the approximate flowering season of many common indigenes and exotics. Groves and Specht (1965) have presented flowering times for two areas of heath vegetation at Wilson's Promontory, Vic., and Groves (1965*b*) for indigenous and naturalized species in a *Themeda* tussock grassland at St. Albans, Vic.

The first report on both flowering and leafing phenology for more than one year was presented by Williams (1961) for a number of species in a *Danthonia caespitosa* grassland on Riverina clay at Deniliquin, N.S.W. In the present paper the 1952 and 1953 data on leafing and flowering phenology of selected species in this grassland are compared with the same species in two adjoining semi-arid grasslands, *Stipa variabilis-D. caespitosa* on Billabong clay, and *S. aristiglumis-D. caespitosa* on Deniboota loam. The data are considered in relation to estimates of the periods during which soil water is available for plant growth. Differences and similarities in phenology are discussed. Climate is common to all three communities because they adjoin, trees are absent, short-grasses and herbs predominate, and the general topography is featureless.

Environment

Climate

Detailed characteristics of the Deniliquin climate have been presented previously (Williams, 1956). The seasons are taken as summer (December to February), autumn (March to May), winter (June to August), and spring (September to November). The mean annual rainfall is 15·8 in., and cool-season rains are more reliable than summer rains.

Rainfall recorded in 1952 and 1953 at the meteorological station proximate to the three sites is set out in the lower part of Fig. 1 as in./15 days. In 1952 the annual rainfall was 18·4 in., or 10% above average, while in 1953 it was 12·9 in., 23% below average.

Summers are hot, with occasional thunderstorms. January is the hottest month, with a mean maximum temperature of 89·5° F. and a mean minimum of 61° F. From January to March, 1952, there were 34 days, and from October to December eight days with maximum temperatures in excess of 90° F. The corresponding values in 1953 were 33 and 14 days.

Winters are cool. In both 1952 and 1953 there were approximately 30 light frosts (screen temperature $>32°$ $<36°$ F.) and 16 severe frosts (screen temperature $<32°$ F.).

Day length (civil twilight) at the experimental site ranges from a maximum of 15 hours in December to a minimum of 10 hours in June.

In summary, incidence and quantity of rainfall and the period of heavy frost were the factors which differed most markedly between the two years.

Soils

(i) Topography and general distribution

The topography and soils of the general area have been described by Churchward (1958). The three experimental sites are located at the C.S.I.R.O.

Falkiner Memorial Field Station, the *D. caespitosa* and *Stipa variabilis-D. caespitosa* grasslands on the lower and upper levels of the clay plains, and the *S. aristiglumis-D. caespitosa* grassland on the loam of the Stud Park River Ridge.

(ii) Soil-types

The soils at each site are similar to those described and named by Smith (1945), Butler and Johnston (1946), and Johnston (1953) as Riverina clay, Billabong clay, and Deniboota loam.

Riverina clay is a grey clay (Stace *et al.*, 1968, p. 79) with a 0–0·5 in. A horizon of slightly structured light clay which is hard when dry and sticky when wet. The B_1 horizon of 0·5–10 in. is a moderately structured heavy clay overlying grey poorly-structured heavy clay. The permanent to semi-permanent cleavage planes extend to the surface. All three components of the gilgai micro-relief, the puff, shelf and depression are represented (Williams, 1955).

Billabong clay is a brown clay (Stace *et al.*, 1968, pp. 79, 103) with a 0–0·5 in. A horizon of grey-brown compacted clay loam which is hard when dry and sticky when wet. The B_1 horizon of 0·5–12 in. is a dark grey-brown massive heavy clay with blocky structure. It is hard when dry and intractable when wet. Below 12 in. the soil is a poorly-structured heavy clay. Cleavage planes are few and rarely extend to the surface. There are few areas of puff, and a small amount of depression.

Deniboota loam is a red-brown earth (Stace *et al.*, 1968, pp. 211, 214) with a 0–3 in. A_1 horizon of brown loam which is hard when dry and friable when wet. The A_2 horizon is 3–6 in. of grey-brown sandy clay loam which is slightly compact and hard when dry but friable when wet. The B_1 and B_2 horizons from 6–24 in. are medium clays with well developed medium prismatic structure grading into grey-brown clay.

The main chemical differences between the three soils in the top 24 in. are (1) the acid reaction of the Billabong clay and Deniboota loam surfaces compared with the alkaline reaction of the Riverina clay (pH 6·1, 6·5 *v.* 7·5) and the pronounced alkaline reaction (pH 8·8) of the loam below 9 in., (2) the small amount of chloride in the Deniboota loam profile compared with the amounts in the Riverina and Billabong clays (0·034 *v.* 0·237 and 0·206 at the 9–18 in. depth, expressed as NaCl per cent. oven dry weight).

The differences in nitrogen and phosphorus status between the various surface soils are small, with a range of 0·052 to 0·100% and 0·017 to 0·020% respectively.

Both calcium and magnesium on the exchange complex of Riverina clay greatly exceed the values obtained from Deniboota loam (13·98 *v.* 2·27 and 14·05 *v.* 1·92 m-equiv./100 g. oven dry weight).

(iii) Soil moisture relationships

The periods over which water in the 0–3 and 3–9 in. depth is available for plant growth are set out in the lower part of Fig. 1, together with a record of the sampling dates and the incidence of rain sufficient to raise the moisture content of the 0–3 in. depth to the 15-bar level and above for short periods between sampling dates. These periods were calculated for the various depths by gravimetric determinations of soil moisture for two sites in each gilgai component on the clay soils, and at two sites in the loam, 15-bar values for each depth, and bulk densities for the soil horizons. Slivers of wet soil were taken from the sides of cracks after rain and the soil water content determined.

The amount of water which raised the moisture content of the surface 0–3 in. from the minimum field value to the 15-bar value ranged from 0.08 in. for Deniboota loam, 0·28 and 0·40 in. for the shelf of Riverina clay and Billabong clay, to 0·50 and 0·56 in. for the depression of the Riverina clay and Billabong clay. Small amounts of rain are sufficient to provide available water in the surface of Deniboota loam.

The available water within the maximum wetted profile over the 1952–53 period ranged from 4·3 in. in the Deniboota loam, 1·7 and 1·0 in. in the depression and shelf of the Riverina clay, to 0·8 and 0·4 in. in the depression and shelf of Billabong clay.

In 1952 the Deniboota loam had available water in the 0–3 in. depth for 270 days, the Riverina clay for 260 days (depression) and 240 days (shelf), the Billabong clay for 220 days (depression) and 140 days (shelf). In 1953 these periods were shortened by from 70 to 110 days.

Depressions tend to be wetter than 15-bar values, *per se*, indicate because depressions are recipients of run-off from the massive surface of the neighbouring shelf. Further, run-off into cleavage planes modifies the generalized available water situation because it produces localized pockets of wet soil at depth. Water penetration is more uniform in Deniboota loam.

Vegetation

The three grasslands appear to differ markedly from the original communities of 100 years ago.

(i) *Danthonia caespitosa* grassland.

This grassland has been the subject of several papers (Williams, 1955, 1956, 1961). It has developed from an *Atriplex nummularia* Lindl. shrub-steppe community, possibly by way of an *A. vesicaria* Hew. ex Benth. community.

The last *A. vesicaria* plants were eliminated from the experimental area by sheep grazing in 1948.

(ii) *Stipa variabilis-Danthonia caespitosa* grassland.

This grassland appears to have developed from the *Acacia pendula-Atriplex nummularia* association (Moore, 1953*a*, pp. 514–5). Few areas of unmodified shrub woodland now exist.

The present grassland has been described by Moore (1953*b*, p. 561) as a disclimax community, and Williams (1956) has measured its botanical composition. Of the original dominants, only scattered plants of *Kochia aphylla* R.Br. remain.

(iii) *Stipa aristiglumis-Danthonia caespitosa* grassland

This grassland is a disclimax community at the western margin of the *Eucalyptus woollsiana-Callitris columellaris* association within the *E. woollsiana* alliance (Moore, 1953*a*, p. 508). Small areas of the original savanna woodland still exist to the east of the Field Station.

The present grassland developed under intensive sheep grazing and the felling of trees for drought-fodder, structural timber or firewood.

PROCEDURE

The procedure followed the pattern of the previous study (Williams, 1961), with the frequent recording of species behaviour within a fixed area in each of the three grasslands. These observations were made monthly, or more frequently, e.g. every two or three days, when plants were flowering.

The commencement of leafing, onset and duration of flowering and leaf senescence were recorded for each species. The periods when plants were vigorously vegetative, or were making limited leaf growth were estimated using plant height, plant diameter, or leaf length, appropriate to the growth habit of the particular species. Recording commenced in mid-1951 and continued until the end of 1954. Confirmatory checks of bloom periods were made between 1956 and 1961.

Soil sampling was started in mid-1951 and continued until the end of 1953. The two years 1952 and 1953 with coincidental vegetation and soil moisture data are used in this paper.

Results

The phenological data are presented in two sections: (*a*) the leafing phenology of seven species common to all three grasslands in 1952 and 1953, and (*b*) the flowering phenology for 25 common species during the same period.

(*a*) *Leafing Phenology*

Figure 1 illustrates the leafing phenology of seven species chosen because there were complete records for both soils and years and because they illustrate the behaviour of many species in the grasslands. Rainfall, frost periods and periods of available water in the 0–3 and 3–9 in. depths for each site are shown for 1952 and 1953.

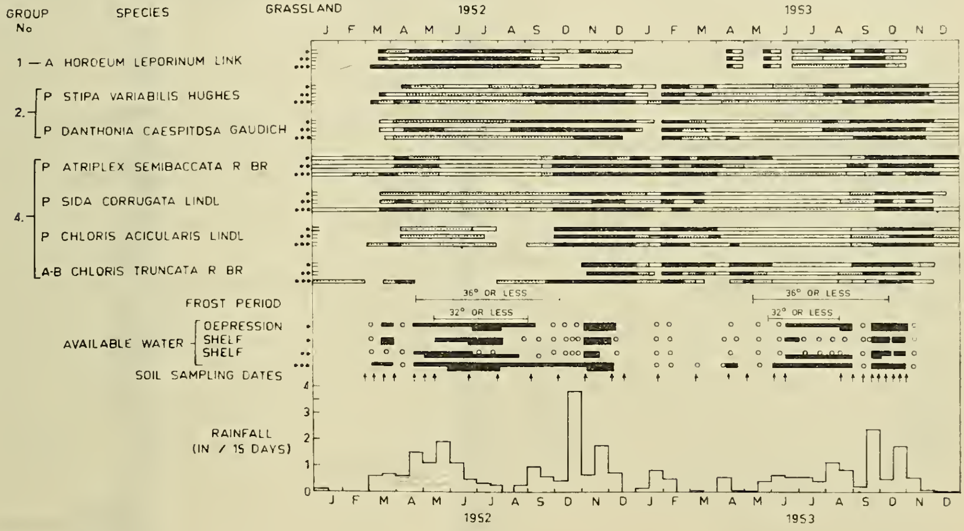

Fig. 1.

The three groups are numbered 1, 2, and 4, and are arranged as previously described (Williams, 1961) in the order of predominantly cool-season growth, through growth in all seasons, to predominantly warm-season growth. Groups 3 and 5 are omitted because they contained no species which grew continuously on all three soils in each year.

The difference between the sites is illustrated by the performance of species as follows: Deniboota loam and the depressions in Riverina clay tend to maintain green leaf longer, as with *Hordeum leporinum* in spring and early summer, than do the other soils. In Group 2–1952 *Stipa variabilis* tends to start growth first in Deniboota loam, then Billabong clay, and Riverina clay. In Group 4 there were differences in species behaviour on the three soils, e.g. *Atriplex semibaccata* (May, 1953), *Sida corrugata* (January-February, 1952), *Chloris acicularis* (March,

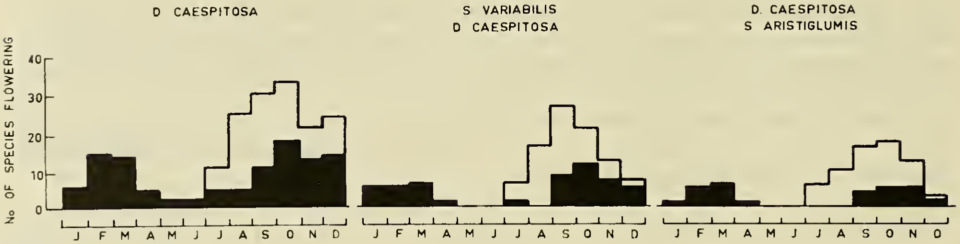
D CAESPITOSA
S VARIABILIS
D CAESPITOSA
D. CAESPITOSA
S ARISTIGLUMIS
No OF SPECIES FLOWERING
40
30
20
10
0
J F M A M J J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D

Fig. 2.

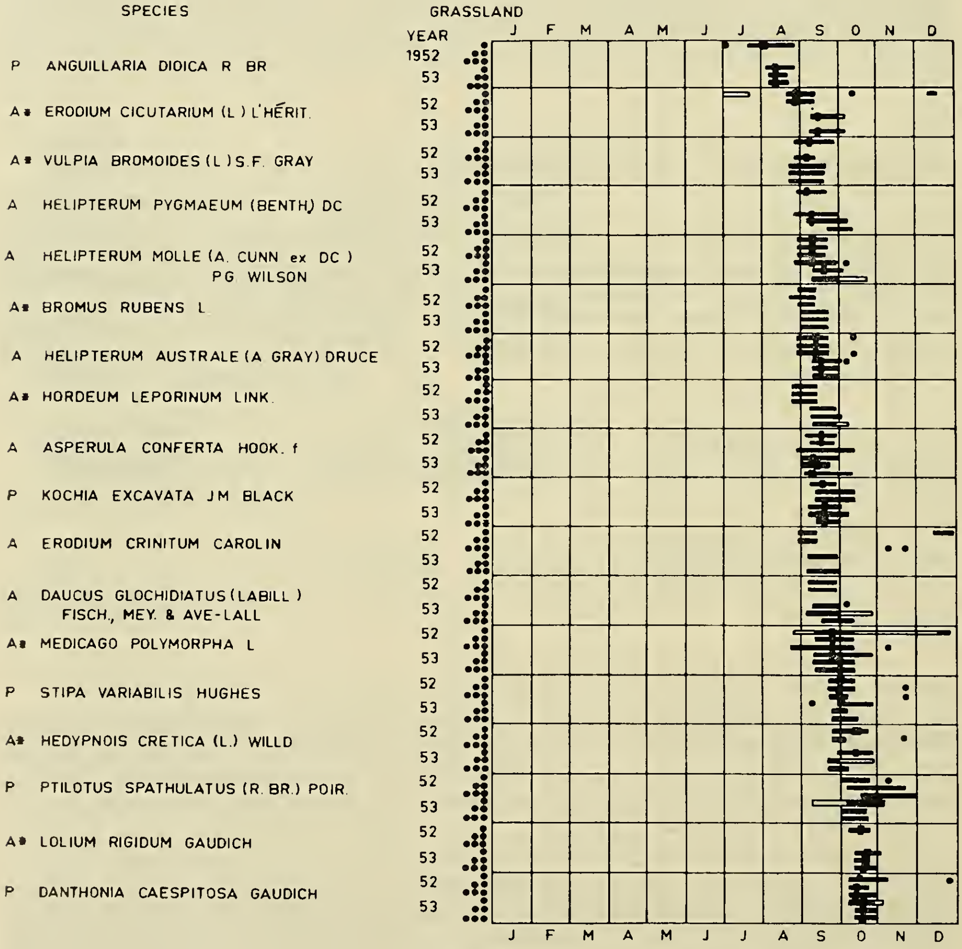
SPECIES
GRASSLAND
YEAR
J F M A M J J A S O N D
P ANGUILLARIA DIOICA R BR
1952
53
A* ERODIUM CICUTARIUM (L) L'HÉRIT.
52
53
A* VULPIA BROMOIDES (L) S.F. GRAY
52
53
A HELIPTERUM PYGMAEUM (BENTH) DC
52
53
A HELIPTERUM MOLLE (A. CUNN ex DC) P.G. WILSON
52
53
A* BROMUS RUBENS L
52
53
A HELIPTERUM AUSTRALE (A GRAY) DRUCE
52
53
A* HORDEUM LEPORINUM LINK.
52
53
A ASPERULA CONFERTA HOOK. f
52
53
P KOCHIA EXCAVATA J M BLACK
52
53
A ERODIUM CRINITUM CAROLIN
52
53
A DAUCUS GLOCHIDIATUS (LABILL) FISCH., MEY. & AVE-LALL
52
53
A* MEDICAGO POLYMORPHA L
52
53
P STIPA VARIABILIS HUGHES
52
53
A* HEDYPNOIS CRETICA (L.) WILLD
52
53
P PTILOTUS SPATHULATUS (R. BR.) POIR.
52
53
A* LOLIUM RIGIDUM GAUDICH
52
53
P DANTHONIA CAESPITOSA GAUDICH
52
53
J F M A M J J A S O N D

Fig. 3.

1952), but more particularly *C. truncata* (January to April, 1952; August to October, 1952; and September to November, 1953).

The growth differences between 1952 and 1953 were substantial. In 1952 active growth commenced in mid-March, but in 1953 there were two false starts, and the species in Group 1 did not commence active growth until the end of June. The heavy rainfall in October, 1952, with the vigorous leaf-growth of Group 4 species, which continued until the end of December, contrasts strongly with the tapering off in the growth of these species at the conclusion of the 1953 spring. Low winter temperatures and frosts do not prohibit leaf growth in Groups 1 and 2.

Years in which the soil moisture is low in autumn and winter, as in 1953, are not unusual.

(*b*) *Flowering Phenology*

(i) Flowering rhythms

In Fig. 2 the flowering rhythms of the three grasslands are set out. The maximum number of species observed flowering in each particular month of the two-years experimental period has been used to construct this figure.

A feature of these flowering rhythms is the contribution made by species that have more than one bloom period.

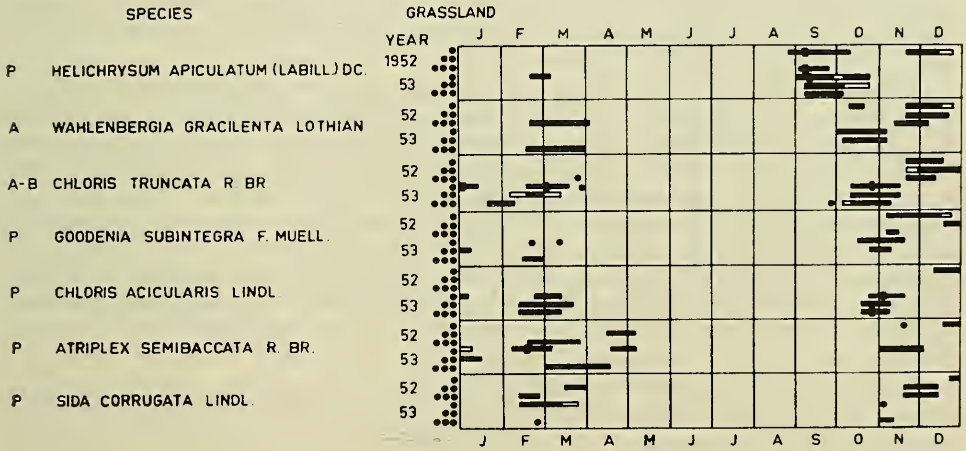

Fig. 4.

(ii) Flowering dates

The flowering dates for species common to the three grasslands are set out in Figs 3 and 4.

Figure 3 summarizes the records for 18 species which have consistently exhibited one main bloom period between July and December, but at no other time. They are arranged in order of flowering. Most plants in these disclimax grasslands belong to this category.

The onset of the main bloom period differed between soils for *Ptilotus spathulatus* in 1952, *Helipterum pygmaeum* in 1953, and to a lesser degree for *Helipterum molle* and *Daucus glochidiatus* in 1953. It differed between years for *Helipterum australe* and *Hordeum leporinum*. Though the bloom periods of some species, e.g. *Hordeum leporinum* started earlier in 1952 than in 1953, other species, e.g. *Vulpia bromoides*, behaved in the opposite manner. Peak bloom in 1952 was generally a few days to a week earlier than in 1953.

Species which may exhibit one bloom period between July and December, and another in summer and autumn, cause the February to April peak in Figure 2. The flowering periods of seven species in this group, arranged in order of spring flower appearance, are shown in Fig. 4.

The onset of the spring bloom period differed between years for *Wahlenbergia gracilenta* and *Chloris truncata*. Differences between the soils in either 1952 or 1953 were seldom greater than one week for these species, but up to six weeks for species such as *Goodenia subintegra*.

Summer and autumn flowering varies markedly between years, and, with the exception of *Chloris acicularis*, between soils in the one year.

Discussion

Leafing Phenology

Differences in leafing phenology of common species in the three grasslands are apparent in early 1952 in the *S. aristiglumis-D. caespitosa* grassland, where there was a tendency for Group 1 species to start growth first and for the Group 4 species to maintain vigorous growth over a longer period than in the other two grasslands. This performance was repeated in late 1952, but not in late 1953.

The summer-growing species of Group 4 are rather irregular in their performance, because they depend on the erratic summer rains. Even so, there are several important differences between the grasslands for species such as *Sida corrugata* and *Chloris truncata*.

These differences are attributed to differences in soil water between Deniboota loam, Billabong clay and Riverina clay, and in particular, to the low 15-bar value, high permeability, and large water-holding capacity of Deniboota loam relative to the other soils. The crude nature of the relationship between the overall leafing phenology and available water in Fig. 1 reflects the inadequacy of the gravimetric method for determining moisture in soils which rains penetrate unevenly and roots do not exploit uniformly. The relationship between the drying cycles and the leafing phenology is particularly unsatisfactory. It is noteworthy that the more successful studies of this type have been recorded on permeable soils in regions of pronounced seasonal rainfall (Specht, 1957).

The pattern of vegetative growth in 1952 and 1953 illustrates the performance in a long and a short season ; performances which occur frequently over large tracts of southern Australia. There is nothing atypical in the two false starts of the 1953 season and the associated contrast in leafing phenology between annuals and perennials. Heavy rain makes moisture available for germination or growth on all three soils, whereas a light rain elicits a response only from the loam soil.

Specht and Rayson (1957), in their studies of the vegetative performance of heath species at Dark Island, South Australia, reported that, as expected in southern Australia, the geophytes made maximum growth in spring. However, some perennial components of the heath grew during hot, dry summers on soil water stored from the preceding winter-spring rains. Occasional ineffective rain, or rare effective storms between December and March, do not appear to upset the notion that this lack of a relationship between the vegetative growth cycle of the dominant perennial (*Banksia ornata*), and the present rainfall regime is due to a long-term shift in climate (Specht and Rayson, 1957 ; Specht, 1958). These summer-growing species maintain vegetative growth patterns which are possibly characteristic of this previous climate. Burbidge (1960) has commented upon this out-of-phase characteristic for *Eucalyptus* and *Banksia* spp. in Western Australia, and Johnston and Briggs (1963) for Proteaceae. It is likely that these rare effective storms, together with impoverished soils, frequent burning, and the low intensity of grazing by introduced herbivores have been important in maintaining the dominants at Dark Island.

Groves (1965*a*) has recorded the maximum growth-rate of Victorian heaths in summer, from December to March, and of *Themeda* tussock grassland (Groves, 1965*b*) from October to early December. He contrasted these performances with the performance of a sown pasture of *Lolium perenne* and *Trifolium subterraneum*, which exhibited a maximum growth-rate from August to September (Twentyman, 1938). Groves commented further that the productivity of the *Danthonia* spp. in the *Themeda* grassland suggests that a *Danthonia* grassland may reach its maximum growth-rate some months before the *Themeda* community. Within most communities studied so far there are species groups which do not conform to the general community pattern. For example, Holland (1968), in seasonal growth studies in mallee communities in central New South Wales and western Victoria, has shown that tall shrubs and mallee eucalypts *do* make summer growth, but field layer plants do not. The three grasslands in the present study contain a wide range of phenological performances which similarly preclude a statement as to the particular community growth-rhythm.

In the Riverine plain the original communities appear to have been dominated by species with potential growth-rhythms of the warm-season type. From 1845 onwards these communities have been shaped by the process of species elimination, species invasion under the influence of sheep, rabbits, various other herbivores, and intermittent droughts (Williams, 1968). These processes have favoured the plants that can complete their life-cycle within the more reliable rainfall period from May to October, resulting in either the dominance of indigenes which can cope with the new conditions or the dominance of annual and perennial species of the Mediterranean type, or a mixture of the two groups. The remaining species are wholly, or partly, opportunist and rely on the erratic summer rains. Amongst the wholly opportunist species is *Chloris truncata*. Perennial species such as *Chloris acicularis* represent the vegetative pattern of the type of indigene which dominated the original communities. In spite of the wide-ranging root systems of these perennial indigenes, the growth pattern is not as regular as that of the heath dominants described by Specht and Rayson (*loc. cit.*), doubtless because soil moisture storage and rooting depth, even in Deniboota loam, are limiting on more occasions than they appear to be under heath vegetation. Thus each of the three communities expresses a wide range of species phenology. The exact form of this vegetative phenology is influenced by micro-topography, soil water differences between the grasslands, and different rainfall between years.

Flowering Rhythms

The flowering rhythms of the two species groups in each of the three grasslands are similar (Fig. 2). They appear to have counterparts in *Themeda* grassland (Groves, 1965*b*) and in southern heaths (Specht and Rayson, 1957; Groves and Specht, 1965), but not in montane communities in New Zealand (Scott, 1960; Clarke, 1968).

In the Riverine plain this two-population situation probably reflects the partial species elimination and concurrent invasion of species discussed previously.

Flowering Phenology

It has already been suggested (Williams, 1961) that the regular onset of bloom for spring flowering species of the *Danthonia caespitosa* grassland may be attributed in part to changes in day-length. This suggestion appears to be valid for these species in the other two grasslands.

Plasticity in vegetative characteristics does not appear to extend to flowering phenology. At best, a large vegetative response may promote a small flowering response in bloom period, but no shift in date of first bloom has been noted so far. Extended, or additional bloom periods in such annual species as *Medicago polymorpha* and the two *Erodium* spp. appear to be due to progressive flowering in favoured sites and the presence of more than one age group in the population.

The processes of species elimination and invasion, coupled with the reliable rainfall period in winter and spring, have favoured annual or perennial species of the Mediterranean type. By seeding profusely before the end of October, with or without hard-seed production, these species maintain themselves in the community.

The species which can flower in spring-summer and at other times are ephemerals of the *Wahlenbergia gracilenta* type or long-lived perennials of the *Chloris acicularis* type. An examination of the dates of first bloom has shown that the spring and autumn photoperiodic range for individual species is wide under natural conditions, and critical investigations using clones, transplants and field irrigation are needed.

The frequent-flowering perennials at Deniliquin are important from the ecological viewpoint because they are either remnants of the indigenes which dominated the original communities or are similar to them in leafing and flowering phenology. Their population density is low, as might be anticipated in a pastoral zone. This also appears to be the case at Trangie (Biddiscombe, 1953).

In principle, the maintenance of a plant in a community depends upon the longevity of the plants, the opportunity during that life-span to produce viable seed, the viability of the seed in the soil, and the opportunity to germinate and establish. Flowering, *per se*, may not mean much for trees and long-lived shrubs, but will mean a great deal for annuals (Holland, 1968). It will be critical in the early stage of colonization by a new species, becoming less important as the seed supply in the soil builds up and the area colonized increases.

Until the advent of domestic stock, there seems to have been scant advantage for the indigenes to produce seed or to possess superlative seedling vigour, because the parent plants were long-lived. In contrast, today there is a survival advantage in heavy spring seeding, in leaf-growth during the reliable rainfall period, and possibly in a limited vegetative response to out-of-season rainfall. Although the grazing pressures applied to the communities should favour earlier flowering through changes in botanical composition, the erratic summer storms support a counter movement. Herein lies one more reason for the difficulty in manipulating grasslands of this type by grazing, *per se* (Williams, 1969).

It is concluded that differences between species common to the three grasslands are found to some degree in leafing phenology, particularly the leafing of the warm-season species, and to a more limited degree in the flowering phenology. The substantial difference between grasslands is not found so much in representation by different species or in the flowering phenology of those species common to the grasslands, as in the number of individuals of each species, and the leafing phenology of the warm-season species common to the three grasslands. Apparently the general soil differences, though substantial, have not been sufficient to provide a stimulus for ecotypic differentiation *in the presence of the grazing animal* over the past 100 years.

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CHECK LIST OF NORTHERN TERRITORY PLANTS

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Synopsis

The need for a check list of Northern Territory plant species is discussed with a brief outline of the vegetation. New combinations are made for *Borreria involucrata* (O. Schwarz) Chippendale and *Canthium schultzii* (O. Schwarz) Chippendale. Tables show the geographic distribution of species, families, and of naturalized and adventive species. The check list contains the names of 2,695 native species and 113 introduced species. A bibliography provides references to support the check list.

INTRODUCTION

The Northern Territory of Australia was little known when Ewart and Davies (1917) compiled " The Flora of the Northern Territory ", a work which had many faults mentioned in a critical review (Anon., 1919). Not surprisingly, Specht (1958) for the northern area, and Chippendale (1959) for the central area listed many new records. As remarked by Cochrane (1967), the Northern Territory is " . . . still vegetatively relatively unexplored . . . ". Thus, a check list of the known species should be a useful basis for the present and future taxonomy and ecology in the area.

This enumeration of the plant species occurring in the Northern Territory was compiled mainly while the author was working in the Herbarium of the Northern Territory at Alice Springs. However, in addition to using specimens in that herbarium, much relevant literature has been searched and is mentioned in the bibliography. Each species included is supported by a specimen seen by the author in an Australian herbarium or by the citation of a specimen in published work. Actual references to specimens are not given.

Of the literature searched, some of the older references were inaccurate or vague. For instance, Bentham (1863–78) gave many records from Northern Territory localities and a few specifically from Central Australian localities, but his records from " Northern Australia " and " Islands of the Gulf of Carpentaria " were often wider, geographically, than the Northern Territory. Likewise, Ewart and Davies (1917) gave records from " North Australia ". Such records have not necessarily been accepted as occurring in the Northern Territory ; usually these species are included in the check list only if they have since been reliably collected.

VEGETATION

The four major pastoral districts of the Northern Territory (Fig. 1) are used to give an indication of the geographic occurrence of species. These districts are primarily administrative in origin, but broadly each represents different ecological conditions.

The Darwin and Gulf District is dominated by tall open forest, predominantly of *Eucalyptus tetrodonta* and *E. miniata* in the more northern parts, with an understorey of tall perennial grasses. Some shrubland has dense stands of the palm *Livistona humilis* which merges with communities including *Calytrix*, *Grevillea*, *Persoonia*, *Acacia* and *Bossiaea*. There are minor areas of monsoon forest, and the seasonally flooded sub-coastal plains support grassland, sometimes surrounded by a narrow stand of tall *Melaleuca leucadendron.* Mangroves and beach dune species occur on the coastal strand.

Open forests and woodland cover much of the Victoria River District, and include many species of *Eucalyptus*, with associated coarse perennial grasses. *Erythrophloeum chlorostachys* is prominent in some of these woodlands, and *Acacia shirleyi* forms a dense low forest in the eastern part of the district. Lesser areas are dominated by shrublands of *Macropteranthes kekwickii* and *Excaecaria parvifolia.* Grasslands composed mainly of species of *Dichanthium*, *Iseilema* and *Astrebla* occupy comparatively smaller areas between the woodlands, and the southern area is dominated by *Triodia* grassland and open *Acacia* shrubland.

The poorly-drained black soils of the Barkly Tableland carry extensive grassland mainly of species of *Astrebla*, but including *Iseilema*, *Dichanthium*, *Sorghum* and *Dactyloctenium* with associated forbs. Relatively small areas are dominated by small trees and open shrubland, including *Eucalyptus pruinosa*, *Ventilago viminalis*, *Atalaya hemiglauca* and *Carissa lanceolata.* Areas of *Triodia pungens* are features of the southern part of the Tableland, while *Acacia cambagei* shrubland occurs in the south-eastern part.

In the Central Australia District, various *Acacia* shrublands cover desert sandplains, desert loams and desert sandhills. *Acacia aneura* and *A. georginae* are the most common shrub or small tree species, and there are many associated grasses and forbs. *Triodia* and *Plectrachne* species dominate the deep sandy areas. Open low shrubland and sparse grassland occur in the southern area, including many species in the family *Chenopodiaceae.* The mountain ranges contain relic areas with micro-habitats in which *Macrozamia macdonnellii*, *Livistona mariae*, several fern species, and some other unique species occur.

FLORA

Two new nomenclatural combinations necessary for this check list are :

Borreria involucrata (O. Schwarz) Chippendale comb. nov. Basionym *Spermacoce involucrata* O. Schwarz in Fedde Repertorium XXIV (1927), 102.

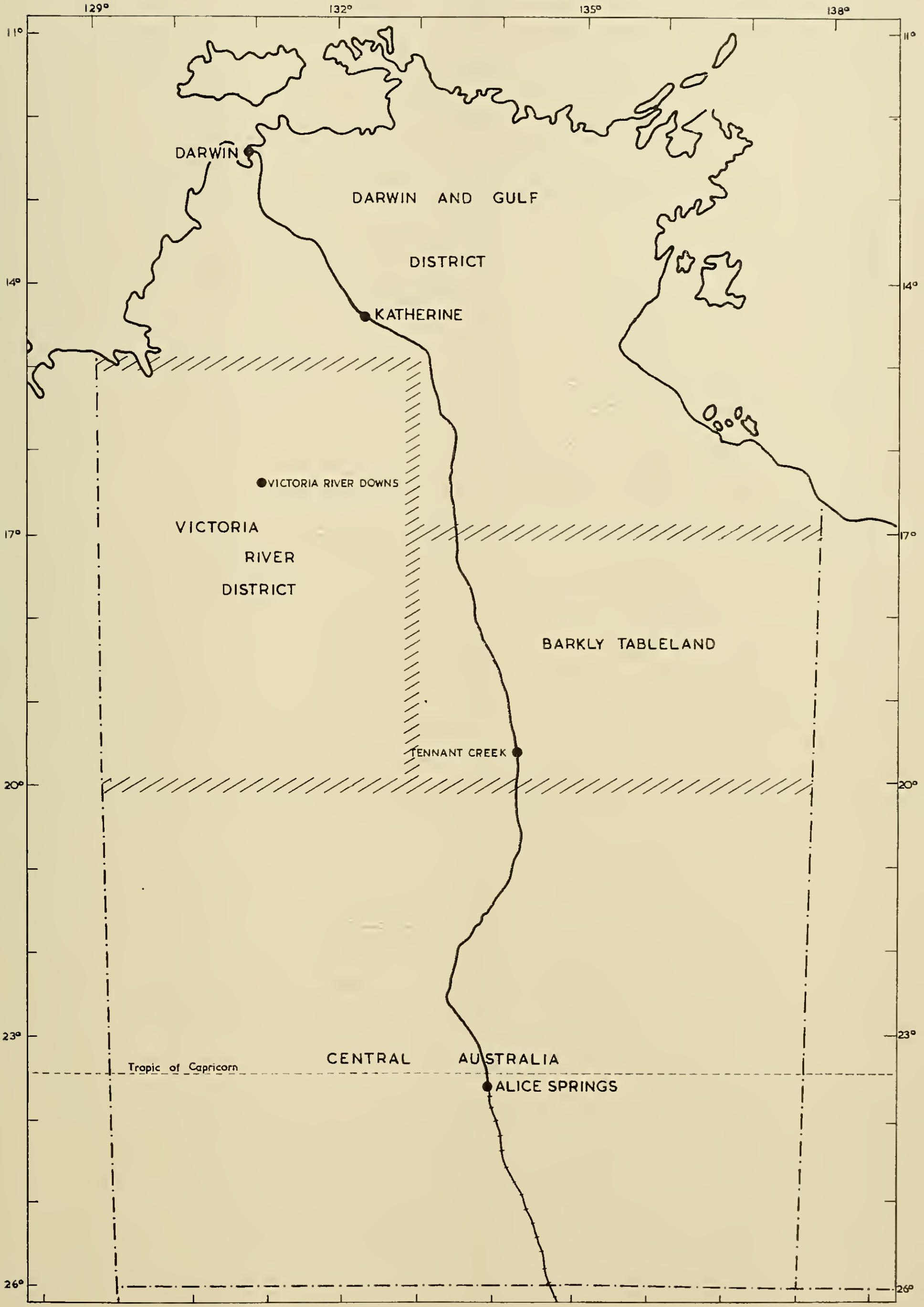
Canthium schultzii (O. Schwarz) Chippendale comb. nov. Basionym *Plectronia schultzii* O. Schwarz in Fedde Repertorium XXIV (1927), 101.

TABLE 1

Summary of Numbers of Plant Species in the Northern Territory

District	Total Species			Percentage Endemism Native Species Only
	Native	Naturalized or Adventive	Restricted Native Species	
C.A. (Central Australia) ..	1,182	54	701	59
B.T. (Barkly Tableland) ..	494	8	42	8
V.R.D. (Victoria River District)	918	9	144	16
D.G. (Darwin and Gulf District)	1,566	64	895	57
C.A.-B.T.	1,357	59	794	58
C.A.-V.R.D.	1,732	61	916	53
B.T.-V.R.D.	1,059	15	210	20
D.G.-B.T.	1,779	66	963	54
D.G.-V.R.D.	1,902	65	1,338	70

Table 1 shows a summary of the species distribution in the Northern Territory. The Darwin and Gulf District is the richest in number of species, and this is also the area where many more species should yet be recorded. Collecting of specimens during the " wet " season, when the forbs are available,



NORTHERN TERRITORY OF AUSTRALIA

TABLE 2

Geographic Distribution of Plant Families in the Northern Territory

(Where two numbers are shown, the lower one is for naturalized or adventive species.)

Family	C.A.	C.A. B.T.	C.A. B.T. V.R.D.	C.A. V.R.D.	C.A. D.G.	C.A. B.T. D.G.	C.A. V.R.D. D.G.	B.T. V.R.D.	B.T. D.G.	B.T. V.R.D. D.G.	V.R.D. D.G.	B.T.	V.R.D.	D.G.	C.A. B.T. V.R.D. D.G.	Total
Lycopodiaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Selaginellaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Isoetaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Psilotaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Ophioglossaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	2	—	3
Schizaeaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	5
Gleicheniaceae	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	3
Dennstaedtiaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Hymenophyllaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Lindsaeaceae	—	—	—	—	1	—	—	—	—	—	—	—	—	2	—	3
Adiantaceae	4	—	—	—	—	—	2	—	—	—	—	—	1	9	—	16
Pteridaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2
Parkeriaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Polypodiaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Davalliaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2
Aspleniaceae	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Thelypteridaceae	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	2
Blechnaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3
Aspidiaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Marsileaceae	—	—	1	1	2	—	1	—	—	—	1	—	—	—	—	6
Azollaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Cycadaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Zamiaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Cupressaceae	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2
Typhaceae	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
Pandanaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	9	—	10
Potamogetonaceae	2	—	—	—	—	—	—	—	—	—	—	—	—	1	—	3
Naiadaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Aponogetonaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Scheuzeriaceae	3	—	—	—	—	—	—	—	—	—	1	—	—	1	—	5
Alismataceae	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	2
Hydrocharitaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	6	—	7
Gramineae	56 4	7	12	8	11 3	6	7	2	2 1	15	29	8	16	95 7	35 1	309 16
Cyperaceae	16	—	4	2	5	2	5	2	2	3	20	1	16	74 1	3	155 1
Palmae	1	—	—	—	—	—	—	—	—	—	—	—	—	9	—	10
Araceae	1	—	—	—	—	—	—	—	—	—	—	—	1	6	—	8
Flagellariaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Restionaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Centrolepidaceae	1	—	—	—	—	—	—	—	—	—	1	—	—	2	—	4
Xyridaceae	—	—	—	—	—	—	—	—	—	—	2	—	—	2	—	4
Eriocaulaceae	1	—	—	—	—	—	—	—	—	—	3	—	—	5	—	9
Commelinaceae	1	—	—	—	—	—	—	—	1	1	1	—	1	4	1	10
Pontederiaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Philydraceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Juncaceae	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Roxburghiaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Liliaceae	7	—	—	—	1	—	—	—	—	—	1	—	—	9	—	18
Haemodoraceae	—	—	—	—	—	—	—	—	—	—	1	—	1	4	—	6
Amaryllidaceae	1	—	—	—	—	—	—	—	—	—	1	—	—	3	—	5
Taccaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Dioscoreaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	4
Zingiberaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Burmanniaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Orchidaceae	—	—	—	—	—	—	—	—	—	—	—	—	3	12	—	15
Casuarinaceae	1	—	—	—	—	—	—	—	—	—	1	—	—	1	—	3
Piperaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3
Ulmaceae	—	—	1	—	—	—	—	—	—	—	1	—	—	1	—	3
Moraceae	1	—	—	—	—	—	1	—	—	—	3	1	1	13	—	20
Urticaceae	1 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1 1
Proteaceae	8	1	2	2	—	—	—	—	—	2	9	—	2	5	2	33
Loranthaceae	8	—	—	2	2	1	—	—	1	—	5	—	—	17	2	38
Santalaceae	4	—	—	—	—	—	—	—	—	—	1	—	—	2	1	8
Opiliaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	2
Olacaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Aristolochiaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Polygonaceae	4 3	—	1	—	—	—	—	—	—	—	—	—	—	1	1	7 3
Chenopodiaceae	71 1	3	5	2	2	2	—	—	—	—	—	—	1	—	2	91 1
Amaranthaceae	16	4	4	3	1 1	—	2 1	1	1	3	5	3	3	11	6	63 2
Nyctaginaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	1	1	3
Gyrostemonaceae	4	—	—	1	—	—	—	—	—	—	—	—	—	—	—	5
Sphenocleaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Aizoaceae	4	1	1	2	1	—	1	—	—	—	—	—	—	4	2	16
Portulacaceae	10	—	—	—	—	—	—	2	—	—	4	—	—	1	2	19
Caryophyllaceae	2 2	—	—	—	—	—	3	—	—	1	2	—	—	3	1	12 2
Nymphaeaceae	—	—	—	—	—	1	—	—	—	—	1	—	—	1	—	3
Ceratophyllaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Ranunculaceae	— 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	— 1
Menispermaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	3	1	4
Annonaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	5 1	—	5 1
Myristicaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Lauraceae	—	—	—	—	—	—	—	—	—	—	—	—	—	4	1	5
Hernandiaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Papaveraceae	— 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	— 2
Cruciferae	14 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14 6
Capparidaceae	2	1	—	—	—	—	—	—	—	—	4	—	—	1	3	11
Droseraceae	—	—	—	—	—	—	1	—	—	—	1	—	—	—	1	3
Byblidaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Crassulaceae	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Pittosporaceae	—	—	—	1	—	—	—	—	—	—	1	—	—	1	—	3
Rosaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	2	—	3
Mimosaceae	29	7	11	4	—	2	3	4	2	9	14	2 1	9	27 4	7	130 5
Caesalpiniaceae	10	1	5	2	—	—	—	—	—	1	2 2	—	3	7 5	6	37 7
Papilionaceae	48 4	5	10	5	1	2	3	2	3	5 1	21 1	5	14	63 6	20	207 12
Geraniaceae	4 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4 2
Oxalidaceae	1 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1 2
Erythroxylaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Zygophyllaceae	15	—	—	—	—	—	—	—	—	1	—	—	3	1	2	22
Rutaceae	—	—	—	—	—	—	—	—	—	—	—	—	1	7	—	8
Simarubaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	3
Burseraceae	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Meliaceae	2	—	—	—	—	—	—	—	—	—	1	—	—	6	—	9
Polygalaceae	2	—	—	—	1	—	—	—	—	1	3	—	2	5	—	14
Euphorbiaceae	12 2	1	2	1	—	—	1	—	— 1	6	9	2	1	43 3	6	84 6
Anacardiaceae	—	—	—	—	—	—	—	—	—	—	2	—	—	4	—	6
Aquifoliaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Celastraceae	—	—	—	—	—	—	—	1	—	—	1	—	—	2	—	4
Stackhousiaceae	2	—	—	1	—	—	1	—	—	—	1	—	—	—	—	5
Sapindaceae	7	—	1	—	—	—	—	—	2	1	2	—	1	7	2	23
Rhamnaceae	1	—	1	—	—	—	—	—	—	1	1	—	—	6	—	10
Vitaceae	—	—	—	—	—	—	—	—	—	1	1	—	—	4	—	6
Elaeocarpaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Tiliaceae	2	—	1	1	—	—	—	—	—	2	6	1	5	10	1	29
Malvaceae	20 1	5	11	4	—	—	1	2	2	4	5 2	2	1	16 3	5	78 6
Bombacaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Sterculiaceae	7	—	1	2	—	—	—	—	—	2	3	1	3	5 1	2	26 1
Dilleniaceae	1	—	—	—	—	—	—	—	—	—	3	—	1	11	—	16
Guttiferae	1	—	—	1	—	—	—	—	—	—	—	—	—	4	—	6
Elatinaceae	3	—	—	—	—	—	—	—	—	—	—	—	1	1	—	5
Frankeniaceae	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
Cochlospermaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	3
Violaceae	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	2
Passifloraceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1 2	—	1 2
Cactaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	— 1	—	— 1
Thymelaeaceae	2	—	1	—	—	—	—	—	—	1	—	—	—	1	—	5
Lythraceae	2	—	—	—	—	—	2	—	1	1	2	—	1	5	—	14
Sonneratiaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Barringtoniaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	2
Rhizophoraceae	—	—	—	—	—	—	—	—	—	—	2	—	—	6	—	8
Combretaceae	—	—	—	—	—	—	—	2	1	3	5	—	1	6	—	18
Myrtaceae	18	1	3	2	1	1	1	1	1	7	18	—	5	31	11	101
Melastomataceae	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	3
Onagraceae	—	—	—	—	—	—	—	—	1	2	—	—	—	2	—	5
Haloragaceae	3	—	—	1	—	—	1	—	—	—	1	1	1	1	—	9
Araliaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Umbelliferae	6	—	—	—	—	—	1	—	—	—	1	—	1	3	—	12
Epacridaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Myrsinaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Primulaceae	1 1	—	—	—	—	—	—	—	—	—	—	—	—	— 1	—	1 2
Plumbaginaceae	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	2
Sapotaceae	—	—	—	—	—	—	—	—	—	—	1	—	—	4	—	5
Ebenaceae	—	—	—	—	—	—	—	—	—	—	2	—	—	3	—	5
Oleaceae	1	—	—	1	—	—	—	—	—	—	1	—	—	4	—	7
Loganiaceae	—	—	—	—	—	—	—	—	—	—	5	—	8	8	—	21
Gentianaceae	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	2
Menyanthaceae	—	—	—	—	1	—	—	—	1	—	—	—	—	3	—	5
Apocynaceae	—	—	—	—	—	—	—	—	—	—	3	—	—	5	1	9
Asclepiadaceae	2	—	—	1	—	—	1	—	—	—	6	—	4	8 1	—	22 1
Convolvulaceae	3	2	—	1	1	—	1	—	—	4	4	5	5	21 1	5	52 1
Boraginaceae	15 2	—	1	1	—	—	—	1	—	—	2	2	2	8	5	37 2
Ehretiaceae	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Verbenaceae	12	—	2	—	—	—	—	—	—	1	4	1	—	13 3	1	34 3
Labiatae	10	—	1	—	—	—	—	—	—	—	5	—	—	4 2	—	20 2
Solanaceae	19 2	2	—	3	1	1	1	—	—	—	1	—	3	4	1	36 2
Scrophulariaceae	6	—	1	2	1	—	3	—	1	—	6	—	3	19	1	43
Bignoniaceae	1	—	—	—	—	—	—	1	—	—	1	—	—	—	—	3
Pedaliaceae	—	—	—	1	—	—	—	—	—	—	—	—	—	— 1	—	1 1
Martyniaceae	—	—	—	—	—	—	—	—	—	—	—	—	—	— 1	—	— 1
Lentibulariaceae	—	—	—	—	—	—	—	—	—	—	4	—	—	23	—	27
Acanthaceae	4	—	—	—	—	—	—	—	—	—	5	—	— 1	4 1	1	14 2
Myoporaceae	30	1	2	—	—	1	—	—	—	—	—	1	—	—	1	36
Plantaginaceae	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Rubiaceae	8	—	1	2	1	—	—	2	—	2	10	—	2	35	2	65
Cucurbitaceae	1 1	— 1	—	—	—	— 1	1	—	—	—	—	—	2	4	1	9 3
Campanulaceae	6	—	—	1	—	—	—	—	—	—	1	—	2	3	—	13
Goodeniaceae	26	4	5	1	—	2	—	—	2	—	7	2	5	15	1	73
Brunoniaceae	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Stylidiaceae	1	—	—	—	—	—	2	—	—	—	5	—	2	10	—	20
Compositae	81 9	5	4	5	1	1	3	1	2 1	2	7	4	2	21 3	2	141 13
Total	701 46	51 1	96	71	40 4	22 1	51 1	21	26 3	83 1	299 5	42 1	144 1	895 48	160 1	2,695 113

still presents difficulties owing to the lack of all-weather roads to some areas. The trees and shrubs have been reasonably, though not exhaustively, collected. Many species in the area need investigation to ascertain not only their taxonomic position within the Australian flora, but also their relationship with species in neighbouring islands and Asia.

The Victoria River district has a comparatively low total number of species, and it seems likely that more records are yet to be made. The number of species in the Barkly Tableland is low, and from experience it seems unlikely that there will be any vast increase in this number. Further thorough collecting in both of these districts seems necessary.

Since Chippendale's (1959) check list for Central Australian plants, the number of recorded species has increased from 1,101 to 1,236. Some of this increase has been on account of new collections, particularly in the area adjacent to Western Australia, but recent revisions of genera have also contributed by distinguishing species not previously described. J. H. Willis (personal communications), from the Melbourne Herbarium, advised of previous misidentifications and of some undescribed species :

Styphelia mitchellii F. Muell., recorded from Mt. Sonder, is actually an undescribed species of *Leucopogon*.

Prostanthera schultzii F. Muell. ex Tate, recorded from Mt. Sonder, is actually an undescribed species of *Wrixonia*.

Eriostemon argyreus F. Muell. ex Tate, in Central Australia, was a misidentified fragment of a species of *Pityrodia* from the " Mt. Saunders " area near Coolgardie, Western Australia.

Goodenia sp. nov. (Palm Valley).

Goodenia sp. nov. (Mt. Liebig).

Ricinocarpos sp. nov. (Simpson's Gap).

Euphorbia sp. nov. (King's Canyon).

Portulaca sp. nov. (King's Canyon).

Revisions of many genera in recent years have been most valuable, including *Pandanus*, *Cassia*, *Triodia*, *Bassia*, *Enneapogon*, *Ptilotus*, *Ficus*, *Capparis*, *Sesbania*, *Swainsona*, *Zornia*, *Neptunia*, *Erodium*, *Drosera*, *Frankenia*, some *Hibiscus*, *Gossypium*, some *Eucalyptus*, some *Melaleuca*, *Velleia*, *Stylidium*, *Nicotiana*, *Utricularia*, *Brachycome*, *Calotis*, some *Acacia* and parts of the families *Loranthaceae*, *Sapotaceae*, *Cruciferae* and *Acanthaceae*.

Much needed are revisions of the important and extensive *Cyperus*, *Fimbristylis*, *Sida*, *Eragrostis*, *Indigofera*, *Tephrosia*, *Desmodium*, *Crotalaria*, *Phyllanthus*, *Euphorbia*, *Terminalia*, *Mitrasacme*, *Heliotropium*, *Dicrastylis*, *Newcastlia*, *Solanum*, *Eremophila*, *Borreria*, *Goodenia*, *Scaevola*, and the family *Scrophulariaceae*.

Table 1 shows the degree of endemism to be greatest in the Darwin and Gulf and the Victoria River Districts, if these adjoining zones are considered as one. Central Australia District, and the Darwin and Gulf District show only a slight difference in percentage endemism, but considering the probability of unrecorded species in the more northern seasonally-wet areas, it seems likely that the Darwin Gulf District will ultimately show the greatest percentage of endemism. There appears to be little endemism in the Barkly Tableland and Victoria River District.

In Table 2 it can be seen that ferns are notably more prevalent in the Darwin and Gulf District, with a much smaller number in Central Australia, and only a few species elsewhere. This same pattern is evident in *Cyperaceae*, *Loranthaceae*, *Euphorbiaceae*, *Myrtaceae*, *Scrophulariaceae*, and *Rubiaceae*. A similar pattern, but with an increased number of species in Central Australia, is shown for

Gramineae, *Papilionaceae* and *Caesalpiniaceae*. There are approximately equal numbers of species in central and northern regions in *Liliaceae*, *Proteaceae*, *Amaranthaceae*, *Aizoaceae*, *Mimosaceae*, *Malvaceae*, *Sapindaceae*, *Sterculiaceae* and *Boraginaceae*. The number of species in the Central Australia District is significantly greater in *Portulacaceae*, *Cruciferae*, *Zygophyllaceae*, *Frankeniaceae*, *Solanaceae*, *Myoporaceae*, *Goodeniaceae* and *Compositae*. The northern areas have a greater number of species in *Palmae*, *Araceae*, *Eriocaulaceae*, *Haemodoraceae*, *Orchidaceae*, *Moraceae*, *Rutaceae*, *Tiliaceae*, *Combretaceae*, *Loganiaceae*, *Lentibulariaceae* and *Stylidiaceae*.

Table 2 also shows the distribution geographically and botanically, of naturalized or adventive species. Few of these are widespread. The majority are within the influences of the larger population centres, particularly Darwin and Alice Springs. In the check list, *Verbena officinalis* is recorded by Ewart and Davies (1917) and *V. macrostachya* is recorded by Tate (1896), and supporting specimens are in the National Herbarium of Victoria, Melbourne. These two taxa have been regarded as native Australian species by Bentham (l.c.). However, there has been no further record of these species in the Northern Territory.

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CHECK LIST

* Naturalized.
† Adventive.

	C.A.	B.T.	V.R.D.	D. & G.
LYCOPODIACEAE				
Lycopodium cernuum L.	..	..	×	×
SELAGINELLACEAE				
Selaginella ciliaris (Retz.) Spring	..	..	..	×
Selaginella uliginosa (Labill.) Spring	..	..	..	×
ISOETACEAE				
Isoetes humilior F. Muell. ex A.Br.	×	..	..	..
PSILOTACEAE				
Psilotum nudum (L.) Griseb.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Ophioglossaceae				
Helminthostachys zeylanica (L.) Hook.	..	..	..	×
Ophioglossum lusitanicum L. ssp. *coriaceum* (A. Cunn.) Clausen	×	..	..	..
Ophioglossum vulgatum L.	..	..	..	×
Schizaeaceae				
Lygodium flexuosum (L.) Swartz	..	..	..	×
Lygodium japonicum Swartz	..	..	..	×
Lygodium microphyllum (Cav.) R.Br.	..	..	..	×
Schizaea bifida Willd.	..	..	..	×
Schizaea dichotoma (L.) Sm.	..	..	..	×
Gleicheniaceae				
Dicranopteris linearis (Burm. f.) Underwood	..	..	..	×
Dicranopteris sp.	..	..	×	×
Gleichenia sp.	..	..	×	..
Dennstaedtiaceae				
Histiopteris incisa (Thunb.) J.Sm.	×	..	..	..
Hymenophyllaceae				
Selenodesmium sp.	..	..	..	×
Lindsaeaceae				
Lindsaea ensifolia Swartz	×	..	..	×
Lindsaea fraseri Hook.	..	..	..	×
Lindsaea orbiculata Mett.	..	..	..	×
Adiantaceae				
Adiantum hispidulum Swartz	×	..	..	..
Adiantum philippense L.	..	..	..	×
Cheilanthes distans (R.Br.) Mett.	..	..	..	×
Cheilanthes fragillima F. Muell.	..	..	..	×
Cheilanthes javensis Moore	..	..	..	×
Cheilanthes lasiophylla Pic.-Ser.	×	..	..	..
Cheilanthes paucijuga Benth.	..	..	..	×
Cheilanthes ? sciadioides Domin	..	..	×	..
Cheilanthes sieberi Kuntze	×	..	..	..
Cheilanthes tenuifolia (Burm. f.) Swartz var. *tenuifolia*	×	..	×	×
Cheilanthes tenuifolia (Burm. f.) Swartz var. *nudiuscula* (R.Br.) F. M. Bail.	..	..	..	×
Cheilanthes vellea (R.Br.) F. Muell.	×	..	×	×
Gymnogramma reynoldsii (F. Muell.) J. M. Black	×	..	..	..
Neurosoria pteroides (R.Br.) Mett.	..	..	..	×
Platyzoma microphyllum R.Br.	..	..	..	×
Taenitis blechnoides (Willd.) Swartz	..	..	..	×
Pteridaceae				
Acrostichum speciosum Willd.	..	..	..	×
Pteris tremula R.Br.	×	..	..	..
Polypodiaceae				
Drynaria quercifolia (L.) J.Sm.	..	..	..	×
Microsorium scolopendria (Burm. f.) Copel.	..	..	..	×
Parkeriaceae				
Ceratopteris thalictroides (L.) Brongn.	..	..	..	×
Davalliaceae				
Nephrolepis cordifolia (L.) Presl	×	..	..	..
Nephrolepis obliterata (R.Br.) Carr.	..	..	..	×
Aspleniaceae				
Pleurosorus rutifolius (R.Br.) Fée	×	..	..	..
Pleurosorus subglandulosus (Hook. et Grev.) M. Tindale	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Thelypteridaceae				
Cyclosorus gongylodes (Schkuhr) Link	×	..	..	×
Cyclosorus sp.	×	..	..	..
Blechnaceae				
Blechnum indicum Burm. f.	..	..	..	×
Blechnum orientale L.	..	..	..	×
Stenochlaena palustris (Burm. f.) Bedd.	..	..	..	×
Aspidiaceae				
Polystichum proliferum (R.Br.) Presl	×	..	..	..
Marsileaceae				
Marsilea angustifolia R.Br.	..	..	×	×
Marsilea crenata Presl	×	..	..	×
Marsilea drummondii A.Br.	×	..	..	×
Marsilea exarata A.Br.	×	×	×	..
Marsilea hirsuta R.Br.	×	..	×	..
Marsilea mutica Mett.	×	..	×	×
Azollaceae				
Azolla pinnata R.Br.	..	..	..	×
Cycadaceae				
Cycas media R.Br.	..	..	..	×
Cycas sp.	..	..	..	×
Zamiaceae				
Macrozamia macdonnellii (F. Muell. ex Miq.) A.DC.	×	..	..	..
Cupressaceae				
Callitris glauca R.Br. ex R.T.Bak. et H.G.Sm.	×	..	..	..
Callitris intratropica R. T. Bak. et H.G.Sm.	..	..	×	×
Typhaceae				
Typha domingensis Pers.	×	..	..	×
Pandanaceae				
Pandanus arnhemicus St. John	..	..	..	×
Pandanus basedowii C. H. Wright	..	..	..	×
Pandanus convexus St. John	..	..	..	×
Pandanus darwinensis St. John	..	..	..	×
Pandanus integer St. John	..	..	×	×
Pandanus latifructus St. John	..	..	..	×
Pandanus semiarmatus St. John	..	..	..	×
Pandanus spechtii St. John	..	..	..	×
Pandanus thermalis St. John	..	..	..	×
Pandanus yirrkalaensis St. John	..	..	..	×
Potamogetonaceae				
Potamogeton tenuicaulis F. Muell.	..	..	..	×
Potamogeton tricarinatus A. Bennett	×	..	..	..
Ruppia maritima L.	×	..	..	..
Naiadaceae				
Naias marina L.	×	..	..	..
Aponogetonaceae				
Aponogeton elongatus (F. Muell.) Benth.	..	..	..	×
Scheuchzeriaceae				
Triglochin calcitrapa Hook.	×	..	..	..
Triglochin centrocarpa Hook.	×	..	..	..
Triglochin hexagona J. M. Black	×	..	..	..
Triglochin procera R.Br. var. *dubia* (R.Br.) Benth.	..	..	×	×
Triglochin procera R.Br. var. *procera*	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
ALISMATACEAE				
Alisma acanthocarpum F. Muell.	..	..	×	..
Alisma oligococcum F. Muell.	..	..	×	×
HYDROCHARITACEAE				
Blyxa octandra (Roxb.) Planch. ex Thw.	..	..	..	×
Blyxa sp.	..	..	..	×
Halophila ovalis (R.Br.) Hook. f.	..	..	..	×
Hydrilla verticillata (L.f.) Royle	..	..	..	×
Ottelia alismoides Pers.	..	..	..	×
Ottelia ovalifolia (R.Br.) L. C. Rich	×	..	..	..
Vallisneria spiralis L.	..	..	..	×
GRAMINEAE				
Acrachne racemosa (Heyne ex R. et S.) Ohwi	..	..	×	..
Alloteropsis semialata (R.Br.) Hitchc.	..	..	×	×
Amphipogon caricinus F. Muell. var. *caricinus*	×	×	×	..
Amphipogon caricinus F. Muell. var. *sericeus* J. Vickery	×	×	×	..
Aristida anthoxanthoides (Domin) Henr.	×	×	×	..
Aristida biglandulosa J. M. Black	×	..	..	..
Aristida browniana Henr.	×	×	×	×
Aristida capillifolia Henr.	×	..	×	×
Aristida contorta F. Muell.	×	..	..	..
Aristida echinata Henr.	×	..	..	..
Aristida exserta S. T. Blake	..	×	×	×
Aristida hygrometrica R.Br.	..	×	×	×
Aristida inaequiglumis Domin	×	..	×	..
Aristida ingrata Domin	..	..	..	×
Aristida jerichoensis Domin	..	×	..	..
Aristida latifolia Domin	×	×	×	×
Aristida macroclada Henr.	..	..	..	×
Aristida nitidula (Henr.) S. T. Blake ex J. M. Black	×	..	..	..
Aristida obscura Henr.	×	..	..	..
Aristida pruinosa Domin	×	×	×	×
Aristida queenslandica Henr.	..	..	..	×
Aristida schultzii Mez	..	..	..	×
Aristida strigosa (Henr.) S. T. Blake	×	..	..	..
Arundinella nepalensis Trin.	..	×	×	×
Arundinella setosa Trin.	..	×	..	..
Astrebla elymoides F. Muell. ex F. M. Bail.	×	×	..	..
Astrebla lappacea (Lindl.) Domin	×	×	..	×
Astrebla pectinata (Lindl.) F. Muell. ex Benth.	×	×	×	..
Astrebla squarrosa C. E. Hubbard	..	×	×	..
†*Avena fatua* L.	×	..	..	..
Bambusa arnhemica F. Muell.	..	..	..	×
Bothriochloa decipiens (Hack.) C. E. Hubbard var. *cloncurrensis* (Domin) C. E. Hubbard	..	×	..	..
Bothriochloa ewartiana (Domin) C. E. Hubbard	×	..	..	..
Bothriochloa bladhi (Retz.) S. T. Blake	×	×	×	×
Brachiaria argentea (R.Br.) Hughes	..	..	..	×
**Brachiaria distachya* (L.) Stapf	..	..	..	×
Brachiaria gilesii (Benth.) Chase	×	..	..	..
Brachiaria holosericea (R.Br.) Hughes	×	..	×	×
Brachiaria miliiformis (C. B. Presl) Chase	×	..	..	×
Brachiaria mutica (Forsk.) Stapf	..	..	..	×
Brachiaria notochthona (Domin) Stapf	×	..	..	..
Brachiaria piligera (F. Muell. ex Benth.) Hughes	×	×	×	×
Brachiaria polyphylla (R.Br.) Hughes	..	..	..	×
Brachiaria praetervisa (Domin) C. E. Hubbard	×	..	..	..
Brachiaria ramosa (L.) Stapf var. *grandiflora* Hughes	..	..	×	×
Brachiaria reptans (L.) C. A. Gardn. et C. E. Hubbard	..	..	×	×
Brachyachne ciliaris (Benth.) C. E. Hubbard	×	..	..	..
Brachyachne convergens (F. Muell.) Stapf	..	×	×	×
Brachyachne tenella (R.Br.) C. E. Hubbard	..	×	×	×
Capillipedium parviflorum (R.Br.) Stapf	..	..	..	×
Capillipedium spicigerum S. T. Blake	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
**Cenchrus brownii* R. et S.	..	..	..	×
**Cenchrus ciliaris* L.	×	×	×	×
**Cenchrus echinatus* L.	×	..	..	×
Cenchrus elymoides F. Muell.	..	..	×	×
**Cenchrus setigerus* Vahl	..	..	..	×
**Cenchrus tribuloides* L.	..	..	..	×
Chamaeraphis hordacea R.Br.	..	..	..	×
Chionachne cyathopoda (F. Muell.) F. Muell. ex Benth.	..	..	×	..
Chionachne hubbardiana Henr.	..	×	..	×
Chloris acicularis Lindl.	×	..	..	..
**Chloris barbata* (L.) Swartz	..	..	..	×
Chloris pectinata Benth.	×	×	..	..
Chloris pumilio R.Br.	..	..	..	×
Chloris scariosa F. Muell.	×	×	×	×
Chloris virgata Swartz	×	..	..	..
Chrysopogon fallax S. T. Blake	×	×	×	×
Chrysopogon latifolius S. T. Blake	..	..	..	×
Chrysopogon pallidus (R.Br.) Trin. ex Steud.	×	×	..	×
Chrysopogon setifolius Stapf	..	..	..	×
Coelorhachis rottboellioides (R.Br.) A. Camus	..	..	×	×
Cymbopogon ambiguus A. Camus	×	×	×	×
Cymbopogon bombycinus (R.Br.) Domin	×	×	×	×
Cymbopogon obtectus S. T. Blake	×	×	×	×
Cymbopogon procerus (R.Br.) Domin	..	..	×	×
Cymbopogon refractus (R.Br.) A. Camus	..	..	..	×
**Cynodon arcuatus* J. S. Presl ex C. B. Presl	..	..	..	×
**Cynodon dactylon* (L.) Pers.	×	..	..	×
**Dactyloctenium aegyptium* (L.) Beauv.	..	×	..	×
Dactyloctenium radulans (R.Br.) Beauv.	×	×	×	×
Danthonia bipartita F. Muell.	×	..	..	..
Dichanthium affine (R.Br.) A. Camus	×	..	..	..
Dichanthium annulatum (Forsk.) Stapf	..	..	×	×
Dichanthium fecundum S. T. Blake	..	×	×	×
Dichanthium sericeum (R.Br.) A. Camus	×	×	×	×
Dichanthium tenuiculum (Steud.) S. T. Blake	..	×	×	×
Digitaria adscendens (H.B.K.) Henr.	..	..	..	×
Digitaria ammophila (F. Muell.) Hughes	×	..	..	..
Digitaria brownii (R. et S.) Hughes	×	×	×	×
Digitaria coenicola (F. Muell.) Hughes	×	..	..	..
Digitaria ctenantha (F. Muell.) Hughes	×	×	×	×
Digitaria eriolepis Henr.	×	..	..	..
Digitaria gibbosa (R.Br.) Beauv.	..	..	×	×
Digitaria leucostachya (Domin) Henr.	..	..	..	×
Digitaria longiflora (Retz.) Pers.	..	..	..	×
Digitaria papposa (R.Br.) Beauv.	..	..	..	×
Digitaria robusta Hughes	..	..	..	×
Digitaria sanguinalis (L.) Scop.	..	..	..	×
Digitaria stenostachya (Benth.) Hughes	..	..	×	..
Dimeria ornithopoda Trin.	..	..	..	×
Diplachne fusca (L.) P. Beauv.	×	..	×	×
Diplachne muelleri Benth.	×	..	..	..
Diplachne parviflora (R.Br.) Benth.	×	..	..	×
Echinochloa colonum (L.) Link	×	..	×	×
Echinochloa crus-galli (L.) Beauv.	..	..	×	×
Echinochloa turneriana Domin	..	×	..	..
Echinochloa stagnina (Retz.) Beauv.	..	..	..	×
Ectrosia agrostoides Benth.	..	..	..	×
Ectrosia laxa S. T. Blake	..	..	..	×
Ectrosia leporina R.Br. var. *leporina*	×	×	×	×
Ectrosia leporina R.Br. var. *micrantha* Benth.	..	..	..	×
Ectrosia scabrida C. E. Hubbard	..	×	..	..
Ectrosia schultzii Benth.	..	..	×	×
Eleusine indica (L.) Gaertn.	..	..	..	×
Elyonurys citreus (R.Br.) Munro ex Benth.	..	..	..	×
Elytrophorus spicatus (Willd.) A. Camus	×	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Enneapogon avenaceus (Lindl.) C. E. Hubbard	×	×	..	×
Enneapogon clelandii N. T. Burbidge	×	..	..	..
Enneapogon cylindricus N. T. Burbidge	×	..	..	..
Enneapogon glaber N. T. Burbidge	×	..	×	×
Enneapogon lindleyanus (Domin) C. E. Hubbard	×	..	×	..
Enneapogon oblongus N. T. Burbidge	×	..	..	..
Enneapogon pallidus (R.Br.) Beauv.	×	×	..	×
Enneapogon planifolius N. T. Burbidge	..	..	×	×
Enneapogon polyphyllus (Domin) N. T. Burbidge	×	×	×	×
Enneapogon purpurascens (R.Br.) Beauv.	..	..	×	×
Eragrostis barrelieri Daveau	×	..	..	..
Eragrostis bleeseri Pilger	..	..	..	×
Eragrostis brownii (Kunth.) Nees	×	..	×	×
†*Eragrostis cilianensis* (All.) Link ex Lutati	×	..	..	..
Eragrostis concinna (R.Br.) Steud.	..	..	..	×
Eragrostis confertiflora (J. M. Black) J. M. Black	×	..	..	..
Eragrostis cumingii Steud.	×	..	..	×
Eragrostis desertorum Domin	×	×	×	..
Eragrostis dielsii Pilger	×	..	..	..
Eragrostis elongata (Willd.) J. F. Jacq.	×	×	×	×
Eragrostis eriopoda Benth.	×	×	×	..
Eragrostis falcata Gaud.	×	..	×	..
Eragrostis interrupta Beauv.	..	..	..	×
Eragrostis japonica (Thunb.) Trin.	×	×	×	×
Eragrostis kennedyae F. Turner	×	..	..	×
Eragrostis lacunaria F. Muell. ex Benth.	×	..	..	..
Eragrostis laniflora Benth.	×	..	..	..
Eragrostis leptocarpa Benth.	×	..	..	..
Eragrostis parviflora (R.Br.) Trin.	×	..	..	×
Eragrostis schultzii Benth.	..	..	..	×
Eragrostis setifolia Nees	×	×	..	..
Eragrostis speciosa (R. et S.) Steud.	×	×	×	×
Eragrostis stenostachya Steud. var. *floribunda* Benth.	..	..	..	×
Eragrostis tenax Jedw.	..	×	×	×
Eragrostis xerophila Domin	×	..	..	..
Eriachne agrostidea F. Muell.	..	..	..	×
Eriachne aristidea F. Muell.	×	..	×	..
Eriachne armitii F. Muell. ex Benth.	×	..	..	×
Eriachne avenacea R.Br.	..	..	×	×
Eriachne basedowii W. Hartley	..	..	×	..
Eriachne benthamii W. Hartley	×	..	..	..
Eriachne burkittii Jansen	..	..	..	×
Eriachne ciliata R.Br.	..	×	×	×
Eriachne festucacea F. Muell.	..	..	×	..
Eriachne filiformis W. Hartley	..	..	..	×
Eriachne glauca R.Br.	..	..	×	×
Eriachne helmsii (Domin) W. Hartley	×	..	..	..
Eriachne isingiana J. M. Black	×	..	..	..
Eriachne laidlawii Jansen	..	..	..	×
Eriachne melicacea F. Muell.	..	×	×	×
Eriachne mucronata R.Br. var. *mucronata*	×	..	..	..
Eriachne mucronata R.Br. var. *desertorum* C. A. Gardn.	×	..	..	..
Eriachne nervosa Ewart et Cookson	×	×	×	×
Eriachne obtusa R.Br. var. *obtusa*	×	×	×	×
Eriachne obtusa R.Br. var. *major* Ewart et Davies	..	..	..	×
Eriachne pulchella Domin	×	..	..	..
Eriachne rara R.Br.	..	..	..	×
Eriachne schultziana F. Muell.	..	..	..	×
Eriachne scleranthoides F. Muell.	×	..	..	..
Eriachne setacea Benth.	..	..	..	×
Eriachne squarrosa R.Br.	..	..	×	×
Eriachne stipacea F. Muell. var. *hirsuta* W. Hartley	..	..	..	×
Eriachne sulcata W. Hartley	..	..	×	..
Eriachne triodioides Domin	..	..	..	×
Eriachne triseta Nees et Steud.	..	..	..	×
Eriochloa australiensis Stapf ex Thell.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Eriochloa crebra S. T. Blake	..	..	..	×
Eriochloa procera (Retz.) C. E. Hubbard	..	..	..	×
Eriochloa pseudoacrotricha (Stapf ex Thell.) C. E. Hubbard ex S. T. Blake	×	..	..	..
Eulalia fulva (R.Br.) Kuntze	×	×	×	×
Eulalia mackinlayi (F. Muell. ex Benth.) S. T. Blake	..	..	..	×
aff. *Eulalia* (undescribed sp.)	..	..	..	×
Heterachne abortiva (R.Br.) Druce	..	..	..	×
Heteropogon contortus (L.) Beauv. ex R. et S.	..	×	×	×
Heteropogon triticeus (R.Br.) Stapf	..	..	..	×
†*Hordeum leporinum* Link	×	..	..	..
Hymenachne acutigluma (Steud.) Gillil.	..	..	..	×
Imperata cylindrica (L.) Beauv. var. *major* (Nees) C. E. Hubbard	..	..	×	×
Isachne confusa Ohwi	..	..	..	×
Isachne firmula Buse	..	..	..	×
Ischaemum arundinaceum F. Muell. ex Benth.	..	..	..	×
Ischaemum australe R.Br. var. *villosum* Benth.	..	..	..	×
Ischaemum decumbens Benth.	..	..	..	×
Ischaemum rugosum Salisb. var. *segetum* (Trin.) Hack.	..	..	..	×
Iseilema dolichotrichum C. E. Hubbard	×	..	..	..
Iseilema fragile S. T. Blake	..	×	×	×
Iseilema macratherum Domin	×	..	×	×
Iseilema membranaceum (Lindl.) Domin	×	×	×	×
Iseilema vaginiflorum Domin	×	×	×	×
Iseilema windersii C. E. Hubbard	..	..	×	..
Iseilema sp.	..	..	..	×
Leptochloa brownii C. E. Hubbard	..	..	×	×
Leptochloa digitata (R.Br.) Domin	×	..	..	..
Lepturus repens (Forst. f.) R.Br.	..	..	..	×
Lepturus xerophilus Domin	..	..	..	×
†*Lolium rigidum* Gaud.	×	..	..	..
Micraira subulifolia F. Muell.	..	..	..	×
Neurachne alopecuroides R.Br.	×	..	..	..
Neurachne mitchelliana Nees	×	..	..	..
Neurachne muelleri Hack.	×	×	..	..
Neurachne munroi (F. Muell.) F. Muell.	×	..	..	..
Ophiuros exaltatus (L.) Kuntze	..	..	×	×
Oplismenus burmannii (Retz.) Beauv.	..	..	..	×
Oryza australiensis Domin	..	..	×	×
Oryza rufipogon Griff.	..	..	..	×
Panicum airoides R.Br.	..	..	..	×
Panicum australiense Domin	×	×	×	..
Panicum capillipes Benth.	..	..	..	×
Panicum cymbiforme Hughes	×	×	×	×
Panicum decompositum R.Br.	×	×	×	×
Panicum delicatum Hughes	..	..	..	×
Panicum effusum R.Br.	×	..	..	..
Panicum majusculum F. Muell. ex Benth.	..	..	×	×
Panicum pauciflorum R.Br.	..	..	..	×
Panicum seminudum Domin	..	..	..	×
Panicum trachyrhachis Benth.	..	..	×	×
Panicum trichoides Swartz	..	..	..	×
Panicum whitei J. M. Black	×	×	×	..
Paractaenum novae-hollandiae Beauv.	×	..	..	..
Paspalidium clementii (Domin) C. E. Hubbard	×	..	..	..
Paspalidium constrictum (Domin) C. E. Hubbard	×	..	..	..
Paspalidium distans (Trin.) Hughes	..	..	..	×
Paspalidium gracile (R.Br.) Hughes	..	×	..	..
Paspalidium jubiflorum (Trin.) Hughes	..	..	×	×
Paspalidium rarum (R.Br.) Hughes	×	×	×	×
Paspalidium retiglume (Domin) Hughes	..	×	..	..
Paspalum orbiculare Forst. f.	..	..	..	×
Pennisetum arnhemicum F. Muell.	..	..	×	..
**Pennisetum polystachyon* (Thell.) Schultz	..	..	..	×
Perotis rara R.Br.	×	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Pheidochloa gracilis S. T. Blake	..	..	..	×
Phragmites karka (Retz.) Trin. ex Steud.	×	..	..	×
Plagiosetum refractum (F. Muell.) Benth.	×	..	..	..
Plectrachne bynoei C. E. Hubbard	..	..	×	..
Plectrachne melvillei C. E. Hubbard	..	..	×	..
Plectrachne pungens (R.Br.) C. E. Hubbard var. *pungens*	×	×	×	×
Plectrachne pungens (R.Br.) C. E. Hubbard var. *callosum* C. E. Hubbard	..	..	×	..
Plectrachne schinzii Henr.	×	×	×	..
Pseudopogonatherum contortum (Brongn.) A. Camus	..	..	..	×
Pseudopogonatherum irritans (R.Br.) A. Camus	..	..	..	×
Pseudoraphis spinescens (R.Br.) J. Vickery	×	..	..	×
**Rhynchelytrum repens* (Willd.) C. E. Hubbard	×	..	..	×
Rottboellia formosa R.Br.	..	..	×	×
Sacciolepis indica (L.) Chase	..	..	..	×
Sacciolepis myosuroides (R.Br.) A. Camus	..	..	×	×
Schizachyrium fragile (R.Br.) A. Camus	×	×	×	×
Schizachyrium pseudeulalia (Hosokawa) S. T. Blake	..	..	..	×
Sclerandrium grandiflorum S. T. Blake	..	..	..	×
Sclerandrium trancatiglume (F. Muell. ex Benth) Stapf et C. E. Hubbard	..	..	..	×
Sehima nervosum (Rottl.) Stapf	..	×	×	×
Setaria adhaerens (Forsk.) Chiov.	..	..	×	..
Setaria apiculata (Scribn. et Merr.) K. Schum.	..	..	×	×
Setaria brownii Herrm.	×	×	×	×
Setaria dielsii Herrm.	×	..	..	×
Setaria glauca (L.) Beauv.	..	..	..	×
Setaria oplismenoides Herrm.	..	..	..	×
Setaria viridis (L.) Beauv.	×	..	..	×
Sorghum australiense Garber et Snyder	..	×	×	×
Sorghum intrans F. Muell. ex Benth.	..	..	..	×
Sorghum laxiflorum F. M. Bail.	..	..	..	×
Sorghum macrospermum Garber	..	..	..	×
Sorghum matarankensis Garber et Snyder	..	..	×	..
Sorghum plumosum (R.Br.) P. Beauv.	×	×	×	×
Sorghum stipoideum (Ewart et White) C. A. Gardn. et C. E. Hubbard	..	..	..	×
Sorghum sp. aff. *angustum*	..	..	..	×
Sorghum sp.	..	..	..	×
Spathia neurosa Ewart et Archer	×	×	..	..
Spinifex longifolius R.Br.	..	..	..	×
Sporobolus actinocladus (F. Muell.) F. Muell.	×	×	..	×
Sporobolus australasicus Domin	×	×	×	×
Sporobolus caroli Mez	×	..	×	..
Sporobolus mitchellii (Trin.) C. E. Hubbard ex S. T. Blake	×	×	..	..
Sporobolus pulchellus R.Br.	..	×	×	×
Sporobolus virginicus (L.) Kunth.	..	×	..	×
Sporobolus sp.	×	..	..	..
Stipa scabra Lindl.	×	..	..	..
Thaumastochloa major S. T. Blake	..	..	..	×
Thaumastochloa pubescens (Domin) C. E. Hubbard	..	..	..	×
Themeda arguens (L.) Hack.	..	..	..	×
Themeda australis (R.Br.) Stapf	×	..	..	×
Themeda avenacea (F. Muell.) Maid. et Betche	×	×	×	..
Thuarea involuta (Forst. f.) R. et S.	..	..	..	×
Tragus australianus S. T. Blake	×	×	×	..
Triodia basedowii E. Pritz.	×	..	..	..
Triodia clelandii N. T. Burbidge	×	..	..	..
Triodia hubbardii N. T. Burbidge	×	..	..	..
Triodia intermedia Cheel	..	..	×	..
Triodia inutilis N. T. Burbidge	..	×	×	..
Triodia irritans R.Br. var. *irritans*	×	..	..	..
Triodia longiceps J. M. Black	×	×	..	..
Triodia microstachya R.Br.	..	..	×	×
Triodia procera R.Br.	..	..	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Triodia pungens R.Br. var. *linearis* N. T. Burbidge	..	×	..	..
Triodia pungens R.Br. var. *pungens*	×	×	×	..
Triodia racemigera C. A. Gardn.	..	..	×	..
Triodia roscida N. T. Burbidge	..	..	×	..
Triodia spicata N. T. Burbidge	×	..	×	..
Triodia stenostachya Domin	..	..	×	×
Triodia wiseana C. A. Gardn. var. *wiseana*	×	..	×	..
Tripogon loliiformis (F. Muell.) C. E. Hubbard	×	×	×	×
Triraphis mollis R.Br.	×	×	..	×
Uranthoecium truncatum (Maid. et Betche) Stapf	×	..	..	..
Vetiveria elongata (R.Br.) Stapf ex C. E. Hubbard	..	..	..	×
Vetiveria pauciflora S. T. Blake	..	..	..	×
Whiteochloa semitonsa (F. Muell. ex Benth.) C. E. Hubbard	..	..	..	×
Xerochloa barbata R.Br.	..	..	..	×
Xerochloa imberbis R.Br.	..	..	×	×
Xerochloa laniflora Benth.	×	..	×	..
Zygochloa paradoxa (R.Br.) S. T. Blake	×	..	..	..
Cyperaceae				
Arthrostylis aphylla R.Br.	..	..	..	×
Bulbostylis barbata (Rottb.) C. B. Clarke	×	×	×	×
Bulbostylis turbinata S. T. Blake	×	..	..	..
Caustis flexuosa R.Br.	..	..	..	×
Cladium glomeratum R.Br.	..	..	..	×
Cladium procerum S. T. Blake	..	..	..	×
Crosslandia setifolia W. V. Fitzg.	..	..	..	×
Cyperus albomarginatus Mart. et Schrad. ex Nees	..	..	..	×
Cyperus angustatus R.Br.	..	..	..	×
Cyperus aquatilis R.Br.	..	..	..	×
Cyperus armstrongii Benth.	..	..	..	×
Cyperus articulatus L.	..	..	..	×
Cyperus bifax C. B. Clarke	×	×	×	×
Cyperus bulbosus Vahl	×	..	..	..
Cyperus castaneus Willd. var. *brevimucronatus* Kukenth.	..	..	..	×
Cyperus compressus L.	..	..	..	×
Cyperus conicus (R.Br.) Boeck.	×	..	..	×
Cyperus cristulatus S. T. Blake	..	..	..	×
Cyperus cunninghamii (C. B. Clarke) C. A. Gardn.	×	..	..	×
Cyperus cuspidatus H.B.K.	..	..	..	×
Cyperus dactylotes Benth.	×	×	×	..
Cyperus decompositus (R.Br.) F. Muell.	..	..	..	×
Cyperus difformis L.	×	×	×	×
Cyperus diffusus Vahl	..	..	..	×
Cyperus diphyllus Retz.	..	..	..	×
Cyperus fasciculigerus (F. Muell.) Domin	×	..	..	..
Cyperus gilesii Benth.	..	×	..	..
Cyperus gunnii Hook.	×	..	..	..
Cyperus haspan L.	..	..	×	×
Cyperus holoschoenus R.Br.	..	×	×	×
Cyperus iria L.	×	×	..	×
Cyperus ixiocarpus F. Muell.	×	..	..	×
Cyperus microcephalus R.Br.	..	×	×	..
Cyperus pennatus Lam.	..	..	×	×
Cyperus platystylis R.Br.	..	..	..	×
Cyperus polystachyos Rottb.	..	..	..	×
Cyperus pulchellus R.Br.	..	..	×	×
Cyperus pygmaeus Rottb.	×	..	×	..
Cyperus ramosii Kukenth.	..	..	..	×
**Cyperus rotundus* L.	..	..	..	×
Cyperus rutilans (C. B. Clarke) Maid. et Betche	×	..	..	..
Cyperus scariosus R.Br.	..	..	..	×
Cyperus sporobolus R.Br.	..	..	×	×
Cyperus squarrosus L.	×	..	..	..
Cyperus stoloniferus Retz.	..	..	..	×
Cyperus subpinnatus Kukenth. var. *subpinnatus*	×	..	..	..
Cyperus subpinnatus Kukenth. var. *subrigidellus* Kukenth.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Cyperus tegetiformis Roxb.	..	..	×	..
Cyperus tenuispica Steud.	..	..	×	×
Cyperus trinervis R.Br.	..	..	..	×
Cyperus tuberosus Rottb.	..	..	..	×
Cyperus vaginatus R.Br.	×	..	×	..
Cyperus victoriensis C. B. Clarke	×	..	..	..
Cyperus xerophilus Domin	×	..	..	..
Cyperus sp.	×	..	..	..
Cyperus sp.	×	..	..	..
Diplacrum pygmaeum (R.Br.) Nees ex Boeck.	..	..	..	×
Eleocharis atropurpurea (Retz.) Kunth.	..	..	×	..
Eleocharis brassii S. T. Blake	..	..	..	×
Eleocharis caribaea (Rottb.) S. T. Blake	×	..	×	×
Eleocharis dulcis (Burm. f.) Trin. ex Hensch.	..	..	..	×
Eleocharis nigrescens (Nees) Steud.	..	..	..	×
Eleocharis pallens S. T. Blake	×	×	×	..
Eleocharis sphacelata R.Br.	..	..	..	×
Eleocharis spiralis (Rottb.) R. et S.	..	..	..	×
Fimbristylis acicularis R.Br.	..	..	..	×
Fimbristylis acuminata Vahl	..	..	..	×
Fimbristylis allenii Turrill	..	..	..	×
Fimbristylis argentea Vahl	..	..	..	×
Fimbristylis arthrostyloides W. V. Fitzg.	..	..	..	×
Fimbristylis bisumbellata (Forsk.) Bubani	..	..	..	×
Fimbristylis caespitosa R.Br.	..	..	×	×
Fimbristylis cardiocarpa F. Muell.	..	×	×	×
Fimbristylis cephalophora F. Muell.	..	..	×	..
Fimbristylis compacta Turrill	..	..	..	×
Fimbristylis corynocarya F. Muell.	..	..	×	..
Fimbristylis cymosa R.Br.	..	..	..	×
Fimbristylis cyperoides R.Br.	..	..	..	×
Fimbristylis debilis F. Muell.	..	..	×	..
Fimbristylis densa S. T. Blake	..	..	..	×
Fimbristylis denudata R.Br.	..	..	×	×
Fimbristylis depauperata R.Br.	..	..	×	×
Fimbristylis diphylla (Retz.) Vahl	×	..	×	×
Fimbristylis dipsacea (Rottb.) Benth. ex C. B. Clarke	..	..	..	×
Fimbristylis ferruginea Vahl	×	..	..	×
Fimbristylis furva R.Br.	..	..	..	×
Fimbristylis humilis S. T. Blake	×	..	..	..
Fimbristylis leucocolea Benth.	..	..	×	..
Fimbristylis littoralis Gaud.	..	×	..	×
Fimbristylis macrantha Boeck.	..	..	×	×
Fimbristylis macrostachya Boeck.	..	..	..	×
Fimbristylis microcarya F. Muell.	..	..	×	..
Fimbristylis miliacea Vahl	..	..	×	×
Fimbristylis monandra F. Muell	..	..	×	..
Fimbristylis multifolia Boeck.	..	..	..	×
Fimbristylis nuda Boeck.	..	..	×	..
Fimbristylis nutans (Retz.) Vahl	..	..	..	×
Fimbristylis obtusangula F. Muell.	..	..	×	..
Fimbristylis oligocephala W. V. Fitzg.	..	..	..	×
Fimbristylis oxystachya F. Muell.	×	..	×	×
Fimbristylis pallida S. T. Blake	..	..	..	×
Fimbristylis pauciflora R.Br.	..	..	..	×
Fimbristylis phaeoleuca S. T. Blake	..	..	×	..
Fimbristylis pterygosperma R.Br.	..	..	×	×
Fimbristylis punctata R.Br.	..	..	..	×
Fimbristylis quinquangularis Kunth.	..	..	×	..
Fimbristylis rara R.Br.	..	..	×	×
Fimbristylis recta F. M. Bail.	..	..	..	×
Fimbristylis rhyticarya F. Muell.	..	..	×	×
Fimbristylis schoenoides (Retz.) Vahl	..	×	..	×
Fimbristylis schultzii Boeck.	..	..	..	×
Fimbristylis sericea R.Br.	..	..	×	×
Fimbristylis setacea Benth.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Fimbristylis solidifolia F. Muell.	..	..	×	..
Fimbristylis sphaerocephala Benth.	..	..	×	..
Fimbristylis spiralis R.Br.	..	..	..	×
Fimbristylis squarrosa Vahl. var. *squarrosa*	×	..	..	..
Fimbristylis squarrosa Vahl var. *esquarrosa* Makino	×	..	..	..
Fimbristylis squarrulosa F. Muell.	..	..	×	×
Fimbristylis stellata S. T. Blake	..	..	..	×
Fimbristylis tetragona R.Br.	..	×	×	×
Fimbristylis trachycarya F. Muell.	..	..	×	×
Fimbristylis trigastrocarya F. Muell.	..	..	×	×
Fimbristylis xyridis R.Br.	..	..	..	×
Fimbristylis sp. aff. *dichotoma*	×	×	×	..
Fuirena ciliaris (L.) Roxb.	×	..	×	×
Fuirena incrassata S. T. Blake	×	×	×	..
Fuirena umbellata Rottb.	..	..	..	×
Lepironia articulata (Retz.) Domin	..	..	..	×
Lipocarpha microcephala (R.Br.) Kunth.	×	×	..	×
Rhynchospora affinis W. V. Fitzg.	..	..	..	×
Rhynchospora heterochaeta S. T. Blake	..	..	..	×
Rhynchospora longisetus R.Br.	..	..	×	×
Rhynchospora pterochaeta F. Muell.	..	..	..	×
Rhynchospora rubra (Lour.) Makino	..	..	..	×
Rhynchospora tenuifolia Benth.	..	..	×	..
Schoenus falcatus R.Br.	..	..	..	×
Schoenus sparteus R.Br.	..	..	..	×
Scirpus articulatus L.	..	..	×	×
Scirpus debilis Pursh.	..	..	×	..
Scirpus dissachanthus S. T. Blake	..	×	×	..
Scirpus grossus L.f.	..	..	..	×
Scirpus laevis S. T. Blake	×	..	..	×
Scirpus lateriflorus Gmel.	..	..	..	×
Scirpus litoralis Schrad.	×	..	×	×
Scirpus maritimus L.	×	..	..	..
Scleria brownii Kunth.	..	..	..	×
Scleria ciliaris Nees	..	..	..	×
Scleria hebecarpa Nees	..	..	..	×
Scleria lithosperma Willd.	..	..	..	×
Scleria margaritifera Willd.	..	..	..	×
Scleria novae-hollandiae Boeck.	..	..	..	×
Scleria pygmaea R.Br.	..	..	..	×
Scleria rugosa R.Br.	..	..	×	×
Scleria tricuspidata S. T. Blake	..	..	..	×
Tricostularia fimbristyloides (F. Muell.) Benth.	..	..	..	×
PALMAE				
Carpentaria acuminata (Wendl. et Drude) Becc.	..	..	..	×
Corypha elata Roxb.	..	..	..	×
Hydriastele wendlandiana Wendl. et Drude	..	..	..	×
Kentia ramsayi (Becc.) Becc.	..	..	..	×
Livistona benthamii F. M. Bail.	..	..	..	×
Livistona humilis R.Br.	..	..	..	×
Livistona loriphylla Becc.	..	..	..	×
Livistona mariae F. Muell.	×	..	..	..
Nypa fruticans Wurmb.	..	..	..	×
Ptychosperma elegans (R.Br.) Bl.	..	..	..	×
ARACEAE				
Amorphophallus galbra F. M. Bail.	..	..	..	×
Amorphophallus variabilis Bl.	..	..	..	×
Pistia stratiotes L.	..	..	..	×
Raphidophora australasica F. M. Bail.	..	..	..	×
Typhonium angustilobum F. Muell.	..	..	..	×
Typhonium brownii Schott.	×	..	..	..
Typhonium liliifolium Schott.	..	..	×	..
Typhonium oblongifolium Engl.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Flagellariaceae				
Flagellaria indica L.	..	..	×	×
Restionaceae				
Leptocarpus elatior R.Br.	..	..	..	×
Leptocarpus spathaceus R.Br.	..	..	..	×
Centrolepidaceae				
Centrolepis banksii (R.Br.) R. et S.	..	..	×	×
Centrolepis exserta (R.Br.) R. et S.	..	..	..	×
Centrolepis polygyna (R.Br.) Hieron	×	..	..	..
Centrolepis pusilla (R.Br.) R. et S.	..	..	..	×
Xyridaceae				
Xyris complanata R.Br.	..	..	×	×
Xyris juncea R.Br.	..	..	..	×
Xyris paludosa R.Br.	..	..	..	×
Xyris pauciflora Willd.	..	..	×	×
Eriocaulaceae				
Eriocaulon australe R.Br.	..	..	..	×
Eriocaulon bifistulosum van Heurck et J. Muell.	..	..	..	×
Eriocaulon cinereum R.Br.	..	..	×	×
Eriocaulon graphitinum F. Muell. et Tate ex Ewart et Cookson	×	..	..	..
Eriocaulon heterogynum F. Muell.	..	..	×	×
Eriocaulon scariosum R.Br.	..	..	..	×
Eriocaulon schultzii Benth.	..	..	..	×
Eriocaulon tortuosum F. Muell.	..	..	×	×
Eriocaulon sp.	..	..	..	×
Commelinaceae				
Cartonema parviflorum Hassk.	..	..	×	×
Cartonema spicatum R.Br.	..	..	..	×
Commelina cyanea R.Br.	..	..	×	..
Commelina ensifolia R.Br.	×	×	×	×
Commelina lanceolata R.Br.	..	×	..	×
Commelina undulata R.Br.	×	..	..	..
Cyanotis axillaris (L.) D. Don	..	..	..	×
Murdannia gigantea (R.Br.) Bruckn.	..	..	..	×
Murdannia graminea (R.Br.) Bruckn.	..	×	×	×
Murdannia vaginata (L.) R.Br.	..	..	..	×
Pontederiaceae				
Monochoria cyanea F. Muell.	..	..	×	×
Philydraceae				
Philydrum lanuginosum Banks et Soland. ex Gaertn.	..	..	..	×
Juncaceae				
Juncus sp.	×	..	..	..
Juncus sp.	×	..	..	..
Roxburghiaceae				
Roxburghia javanica Kunth.	..	..	..	×
Liliaceae				
Anguillaria dioica R.Br.	×	..	..	..
Asparagus racemosus Willd.	..	..	×	×
Caesia setifera Baker	..	..	..	×
Corynotheca lateriflora (R.Br.) Benth.	×	..	..	×
Dianella caerulea Sims	..	..	..	×
Dianella ensifolia Red.	..	..	..	×
Dracaena angustifolia Roxb.	..	..	..	×
Lomandra leucocephala (R.Br.) Ewart ssp. *robusta* A. Lee	×	..	..	..
Lomandra multiflora (R.Br.) J. Britt.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Lomandra patens A. Lee	×	..	..	..
Smilax australis R.Br.	..	..	..	×
Smilax latifolia R.Br.	..	..	..	×
Sowerbaea alliacea F. Muell.	..	..	..	×
Thysanotus chinensis Benth.	..	..	..	×
Thysanotus exiliflorus F. Muell.	×	..	..	..
Thysanotus tuberosus R.Br.	×	..	..	..
Tricoryne elatior R.Br.	×	..	..	..
Xanthorrhoea thorntonii Tate	×	..	..	..
HAEMODORACEAE				
Haemodorum brevicaule F. Muell.	..	..	..	×
Haemodorum coccineum R.Br.	..	..	×	×
Haemodorum ensifolium F. Muell.	..	..	..	×
Haemodorum leptostachyum Benth.	..	..	..	×
Haemodorum parviflorum Benth.	..	..	..	×
Haemodorum subvirens F. Muell.	..	..	×	..
AMARYLLIDACEAE				
Crinum asiaticum L. var. *asiaticum*	..	..	×	×
Crinum asiaticum L. var. *angustifolium* Benth.	..	..	..	×
Crinum flaccidum Herbert	×	..	..	..
Crinum uniflorum F. Muell.	..	..	..	×
Curculigo ensifolia R.Br.	..	..	..	×
TACCACEAE				
Tacca leontopetaloides (L.) Kuntze	..	..	×	×
DIOSCOREACEAE				
Dioscorea bulbifera L.	..	..	..	×
Dioscorea sativa L. var. *sativa*	..	..	..	×
Dioscorea sativa L. var. *rotunda* F. M. Bail.	..	..	..	×
Dioscorea transversa R.Br.	..	..	..	×
ZINGIBERACEAE				
Curcuma australasica Hook. f.	..	..	..	×
BURMANNIACEAE				
Burmannia juncea Sol.	..	..	..	×
ORCHIDACEAE				
Cymbidium canaliculatum R.Br. var. *barrettii* W. H. Nicholls	..	..	..	×
Dendrobium dicuphum F. Muell.	..	..	..	×
Dendrobium johannis Reichb. f.	..	..	..	×
Dipodium stenocheilum O. Schwarz	..	..	..	×
Eulophia holtzei F. Muell.	..	..	..	×
Eulophia venosa Reichb. f.	..	..	..	×
Geodorum pictum (R.Br.) Lindl.	..	..	..	×
Habenaria elongata R.Br.	..	..	..	×
Habenaria ferdinandi Schlechter	..	..	..	×
Habenaria holtzei F. Muell.	..	..	..	×
Habenaria hymenophylla Schlechter	..	..	..	×
Habenaria ochroleuca R.Br.	..	..	×	..
Luisia teretifolia Gaud.	..	..	..	×
Nervilia sp.	..	..	×	..
Spiculaea sp.	..	..	×	..
CASUARINACEAE				
Casuarina cunninghamiana Miq.	..	..	×	×
Casuarina decaisneana F. Muell.	×	..	..	..
Casuarina equisetifolia Forst. et Forst. f.	..	..	..	×
PIPERACEAE				
Peperomia pellucida (L.) H.B.K.	..	..	..	×
Piper holtzei F. Muell.	..	..	..	×
Piper novae-hollandiae Miq.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Ulmaceae				
Celtis philippensis Blanco	..	..	×	×
Trema amboinensis (Willd.) Bl.	..	..	..	×
Trema aspera (Brongn.) Bl.	×	×	×	..
Moraceae				
Antiaris toxicaria Lesch. var. *macrophylla* (R.Br.) Corner	..	..	..	×
Fatoua pilosa Gaud.	..	..	..	×
Ficus benjamina L. var. *benjamina*	..	..	..	×
Ficus coronulata F. Muell.	..	..	×	..
Ficus hispida L.f. var. *hispida*	..	..	..	×
Ficus lacor Buch. Ham.	..	..	..	×
Ficus leucotricha Miq. var. *leucotricha*	..	..	..	×
Ficus leucotricha Miq. var. *megacarpa* F. Muell. ex Corner	..	×	..	..
Ficus obliqua Forst. f. var. *obliqua*	..	..	..	×
Ficus opposita Miq. var. *indecora* (A. Cunn. ex Miq.) Corner	..	..	..	×
Ficus opposita Miq. var. *micracantha* (Miq.) Corner	..	..	×	×
Ficus platypoda (Miq.) A. Cunn. ex Miq. var. *angustata* (Miq.) Corner	..	..	..	×
Ficus platypoda (Miq.) A. Cunn. ex Miq. var. *cordata* Specht	..	..	×	×
Ficus platypoda (Miq.) A. Cunn. ex Miq. var. *minor* Benth.	×	..	×	×
Ficus platypoda (Miq.) A. Cunn. ex Miq. var. *platypoda*	×	..	..	..
Ficus racemosa L. var. *racemosa*	..	..	×	×
Ficus scobina Benth.	..	..	..	×
Ficus superba Miq. var. *henneana* (Miq.) Corner	..	..	..	×
Ficus virens Ait.	..	..	..	×
Malaisia scandens (Lour.) Planch.	..	..	..	×
Urticaceae				
Parietaria debilis Forst. f.	×	..	..	..
†*Urtica urens* L.	×	..	..	..
Proteaceae				
Banksia dentata L.f.	..	..	×	×
Grevillea agrifolia A. Cunn. ex R.Br.	..	..	×	..
Grevillea angulata R.Br.	..	..	×	×
Grevillea dimidiata F. Muell.	..	..	×	×
Grevillea dryandri R.Br.	..	×	×	×
Grevillea eriostachya Lindl.	×	..	..	..
Grevillea goodii R.Br.	..	..	..	×
Grevillea heliosperma R.Br.	..	..	×	×
Grevillea juncifolia Hook.	×	×	..	..
Grevillea leucadendron A. Cunn. ex R.Br.	..	..	×	×
Grevillea mimosoides R.Br.	..	..	×	×
Grevillea nematophylla F. Muell.	×	..	..	..
Grevillea pachypoda O. Schwarz	..	..	..	×
Grevillea parallela Knight	..	×	×	×
Grevillea pteridiifolia Knight	..	..	×	×
Grevillea pungens R.Br.	..	..	..	×
Grevillea refracta R.Br.	×	×	×	×
Grevillea stenobotrya F. Muell.	×	..	..	..
Grevillea striata R.Br.	×	..	×	..
Grevillea wickhamii Meissn.	×	×	×	..
Hakea arborescens R.Br.	×	×	×	×
Hakea chordophylla F. Muell.	×	×	×	..
Hakea cunninghamii R.Br.	..	..	×	×
Hakea divaricata L. Johnson	×	..	..	..
Hakea leucoptera R.Br.	×	..	..	..
Hakea macrocarpa A. Cunn. ex R.Br.	×	..	×	..
Hakea morrisoniana W. V. Fitzg.	..	..	×	..
Hakea multilineata Meissn. var. *grammatophylla* F. Muell.	×	..	..	..
Hakea suberea S. Moore	×	..	..	..
Hakea sp.	×	..	..	..
Helicea australasica F. Muell.	..	..	..	×
Persoonia falcata R.Br.	..	..	×	×
Stenocarpus cunninghamii R.Br.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
LORANTHACEAE				
Amyema benthamii (Blakely) Dans.	..	..	..	×
Amyema bifurcatum (Benth.) Tiegh.	×	×	×	×
Amyema brevicaule Barlow	..	..	..	×
Amyema conspicuum (F. M. Bail.) Dans. ssp. *obscurinerve* Barlow	..	..	..	×
Amyema fulviflorum Barlow	..	..	..	×
Amyema gibberulum (Tate) Dans. var. *gibberulum*	×	..	..	..
Amyema haematodes (O. Schwarz) Dans.	..	..	..	×
Amyema herbertianum Barlow	..	..	..	×
Amyema hillianum (Blakely) Dans.	×	..	..	..
Amyema mackayense (Blakely) Dans. ssp. *cycnei-sinus* (Blakely) Barlow	..	..	..	×
Amyema maidenii (Blakely) Barlow ssp. *maidenii*	×	..	..	..
Amyema miquelii (Lehm. ex Miq.) Tiegh.	×	..	..	×
Amyema miraculosum (Miq.) Tiegh. ssp. *boormanii* (Blakely) Barlow	×	..	..	..
Amyema pendulum (Sieb. ex Spreng.) Tiegh.	..	..	×	×
Amyema preissii (Miq.) Tiegh.	×	..	..	..
Amyema quandang (Lindl.) Tiegh. var. *quandang*	×	..	×	..
Amyema sanguineum (F. Muell.) Dans. var. *pulcher* (Ewart) Barlow	..	..	..	×
Amyema sanguineum (F. Muell.) Dans. var. *sanguineum*	×	×	..	×
Amyema thalassium Barlow	..	..	..	×
Amyema villiflorum (Domin) Barlow ssp. *tomentellum* (Blakely) Barlow	..	..	..	×
Amyema villiflorum (Domin) Barlow ssp. *villiflorum*	..	..	..	×
Decaisnina brittenii (Blakely) Barlow	..	..	..	×
Decaisnina petiolata (Barlow) Barlow	..	..	..	×
Decaisnina signata (F. Muell. ex Benth.) Barlow ssp. *cardiophylla* (Domin) Barlow	..	..	..	×
Decaisnina signata (F. Muell. ex Benth.) Barlow ssp. *signata*	..	..	×	×
Dendrophthoe acacioides (A. Cunn. ex Benth.) Tiegh. var. *acacioides*	..	..	×	×
Dendrophthoe acacioides (A. Cunn. ex Benth.) Tiegh. var. *longifolia* (Specht) Barlow	..	..	×	×
Dendrophthoe falcata (L.f.) Ettingsh.	..	..	×	×
Dendrophthoe glabrescens (Blakely) Barlow	..	..	..	×
Dendrophthoe odontocalyx (F. Muell. ex Benth.) Tiegh.	..	..	..	×
Diplatia furcata Barlow	..	..	..	×
Diplatia grandibractea (F. Muell.) Tiegh.	×	×	..	×
Lysiana exocarpi (Behr) Tiegh. ssp. *diamantinensis* (J. M. Black) Barlow	×	..	..	..
Lysiana murrayi (F. Muell. et Tate) Tiegh.	×	..	..	..
Lysiana spathulata (Blakely) Barlow ssp. *parvifolia* Barlow	×	..	..	..
Lysiana spathulata (Blakely) Barlow ssp. *spathulata*	×	×	×	×
Lysiana subfalcata (Hook.) Barlow ssp. *subfalcata*	×	..	×	..
Viscum flexicaule Barlow	..	..	..	×
SANTALACEAE				
Anthobolus leptomerioides F. Muell.	×	..	..	..
Anthobolus filifolius R.Br.	..	..	..	×
Exocarpos latifolius R.Br.	..	..	×	×
Exocarpos sparteus R.Br.	×	..	..	..
Santalum acuminatum (R.Br.) A.DC.	×	..	..	..
Santalum lanceolatum R.Br. var. *angustifolium* Benth.	×	..	..	..
Santalum lanceolatum R.Br. var. *lanceolatum*	×	×	×	×
Santalum ovatum R.Br.	..	..	..	×
OPILIACEAE				
Cansjera leptostachya Benth.	..	..	..	×
Opilia amentacea Roxb.	..	..	×	×
OLACACEAE				
Olax aphylla R.Br.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
ARISTOLOCHIACEAE				
Aristolochia thozetii F. Muell.	..	..	..	×
POLYGONACEAE				
†*Emex australis* Steinh.	×	..	..	..
Muehlenbeckia cunninghamii (Meissn.) F. Muell.	×	×	×	..
Polygonum attenuatum R.Br.	×	×	×	×
†*Polygonum aviculare* L.	×	..	..	..
Polygonum lapathifolium L.	×	..	..	..
Polygonum orientale L.	..	..	..	×
Polygonum plebeium R.Br.	×	..	..	..
Polygonum serrulatum Lag.	×	..	..	..
Rumex crystallinus Lange	×	..	..	..
**Rumex vesicarius* L.	×	..	..	..
CHENOPODIACEAE				
Arthrocnemum halocnemoides Nees var. *halocnemoides*	×	..	×	..
Arthrocnemum halocnemoides Nees var. *pergranulatum* J. M. Black	..	..	×	..
Arthrocnemum leiostachyum (Benth.) Paulsen	×	..	..	×
Atriplex angulata Benth.	×	..	..	..
Atriplex conduplicata F. Muell.	×	..	..	..
Atriplex elachophylla F. Muell.	×	..	..	..
Atriplex holocarpa F. Muell.	×	..	..	..
Atriplex incrassata F. Muell.	×	..	..	..
Atriplex limbata Benth.	×	..	..	..
Atriplex lindleyi Moq.	×	..	..	..
Atriplex muelleri Benth.	×	..	..	..
Atriplex nummularia Lindl.	×	..	..	..
Atriplex pseudocampanulata Aellen	×	..	..	..
Atriplex semibaccata R.Br.	×	..	..	..
Atriplex spongiosa F. Muell.	×	..	..	..
Atriplex turbinata (R. H. Anderson) Aellen	×	..	..	..
Atriplex velutinella F. Muell.	×	..	..	..
Atriplex vesicaria Heward ex Benth.	×	..	..	..
Babbagia acroptera F. Muell. et Tate	×	..	..	..
Babbagia dipterocarpa F. Muell.	×	..	..	..
Bassia andersonii Ising	×	×	..	×
Bassia bicornis (Lindl.) F. Muell. var. *bicornis*	×	×	..	×
Bassia bicornis (Lindl.) F. Muell. var. *horrida* (Domin) C. T. White	×	×	..	..
Bassia biflora (R.Br.) F. Muell. var. *biflora*	×	..	..	..
Bassia birchii (F. Muell.) F. Muell.	×	..	..	..
Bassia calcarata Ising	×	..	..	..
Bassia chippendalei Ising	×	..	..	..
Bassia clelandii Ising	×	..	..	..
Bassia convexula R. H. Anderson	×	..	..	..
Bassia cornishiana F. Muell.	×	×	×	..
Bassia costata R. H. Anderson	×	..	..	..
Bassia decurrens J. M. Black	×	..	..	..
Bassia diacantha (Nees) F. Muell.	×	..	..	..
Bassia divaricata (R.Br.) F. Muell.	×	..	..	..
Bassia eremaea Ising	×	..	..	..
Bassia eriacantha (F. Muell.) R. H. Anderson	×	..	..	..
Bassia glabra (F. Muell.) F. Muell.	×	..	×	..
Bassia intricata R. H. Anderson	×	..	..	..
Bassia johnsonii Ising	×	..	..	..
Bassia lanicuspis (F. Muell.) F. Muell.	×	×	..	..
Bassia limbata J. M. Black	×	..	..	..
Bassia longicuspis F. Muell.	×	..	..	..
Bassia luehmannii F. Muell.	×	..	..	..
Bassia obconica Ising	×	..	..	..
Bassia obliquicuspis R. H. Anderson	×	..	..	..
Bassia paradoxa (R.Br.) F. Muell.	×	..	..	..
Bassia parallelicuspis R. H. Anderson	×	..	..	..
Bassia patenticuspis R. H. Anderson	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Bassia quinquecuspis (F. Muell.) F. Muell. var. *lanata* Ising	×	..	..	..
Bassia quinquecuspis (F. Muell.) F. Muell. var. *villosa* (Benth.) J. M. Black	×	..	..	..
Bassia sclerolaenoides (F. Muell.) F. Muell.	×	..	..	..
Bassia urceolata Ising	×	..	..	..
Chenopodium anidiophyllum Aellen	×	..	..	..
Chenopodium auricomum Lindl.	×	×	×	..
Chenopodium cristatum (F. Muell.) F. Muell.	×	..	..	..
Chenopodium desertorum (J. M. Black) J. M. Black	×	..	..	..
Chenopodium melanocarpum (J. M. Black) J. M. Black	×	..	..	..
†*Chenopodium murale* L.	×	..	..	..
Chenopodium nitrariaceum (F. Muell.) F. Muell. ex Benth.	×	..	..	..
Chenopodium pumilio R.Br.	×	..	..	..
Chenopodium rhadinostachyum F. Muell.	×	..	..	..
Dysphania littoralis R.Br.	×	..	..	..
Dysphania plantaginella F. Muell.	×	..	..	..
Dysphania simulans F. Muell. et Tate ex Tate	×	..	..	..
Enchylaena tomentosa R.Br.	×	×	×	..
Kochia aphylla R.Br.	×	..	..	..
Kochia appressa Benth.	×	..	..	..
Kochia astrotricha L. Johnson	×	..	..	..
Kochia brevifolia R.Br.	×	..	..	..
Kochia coronata J. M. Black	×	..	..	..
Kochia enchylaenoides (J. M. Black) J. M. Black	×	..	..	..
Kochia georgei Diels	×	×	..	..
Kochia lanosa Lindl.	×	..	..	..
Kochia lobiflora F. Muell.	×	..	..	..
Kochia planifolia F. Muell.	×	..	..	..
Kochia scleroptera J. M. Black	×	..	..	..
Kochia spongiocarpa F. Muell.	×	..	..	..
Kochia tomentosa F. Muell.	×	×	×	..
Kochia triptera Benth.	×	..	..	..
Kochia villosa Lindl.	×	..	..	..
Kochia sp.	×	..	..	..
Kochia sp.	×	..	..	..
Pachycornia tenuis (Benth.) J. M. Black	×	..	..	..
Pachycornia triandra (F. Muell.) J. M. Black	×	..	..	..
Rhagodia nutans R.Br.	×	×	×	..
Rhagodia parabolica R.Br.	×	..	..	..
Rhagodia spinescens R.Br.	×	..	..	..
Salsola kali L. var. *kali*	×	×	×	×
Salsola kali L. var. *strobilifera* Benth.	×	×	×	×
Tecticornia cinerea (F. Muell.) Hook. f. et Jackson	×	..	..	×
Threlkeldia inchoata (J. M. Black) J. M. Black	×	..	..	..
Threlkeldia proceriflora F. Muell.	×	..	..	..
AMARANTHACEAE				
Achyranthes aspera L.	×	×	×	×
Alternanthera angustifolia R.Br.	×	×	×	×
Alternanthera denticulata R.Br.	×	..	×	×
Alternanthera micrantha (Benth.) Domin	..	..	..	×
Alternanthera nana R.Br.	×	×	×	..
Alternanthera nodiflora R.Br.	×	×	×	×
**Alternanthera pungens* H.B.K.	×	..	×	×
Amaranthus cochleitepalus Domin	..	×	..	..
Amaranthus grandiflorus (J. M. Black) J. M. Black	×	..	..	..
Amaranthus interruptus R.Br.	×	..	×	×
Amaranthus leptostachyus Benth.	..	..	..	×
Amaranthus mitchellii Benth.	×	×	..	..
Amaranthus pallidiflorus F. Muell.	..	..	×	..
†*Amaranthus viridis* L.	×	..	..	×
**Celosia argentea* L.	..	..	..	×
Gomphrena affinis F. Muell.	..	..	×	×
Gomphrena alba Farmar	..	..	..	×
Gomphrena brachystylis F. Muell.	..	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Gomphrena canescens (Poir.) R.Br.	..	×	×	×
Gomphrena conferta Benth.	..	..	×	..
Gomphrena conica Spreng.	..	×	×	..
Gomphrena cunninghamii (Moq.) Druce	..	..	×	..
Gomphrena flaccida R.Br.	..	..	×	×
Gomphrena humilis R.Br.	..	..	..	×
Gomphrena lanata R.Br.	×	×	×	..
Gomphrena parviflora Benth.	..	..	..	×
Ptilotus aervoides (F. Muell.) F. Muell.	×	..	..	..
Ptilotus aristatus Benl	×	..	..	..
Ptilotus arthrolasius F. Muell.	×	..	×	..
Ptilotus atriplicifolius (A. Cunn. ex Moq.) Benl var. *atriplicifolius*	×	..	..	..
Ptilotus atriplicifolius (A. Cunn. ex Moq.) Benl. var. *elderi* (Farmar) Benl.	×	..	..	..
Ptilotus calostachyus (F. Muell.) F. Muell. var. *calostachyus*	×	×	×	..
Ptilotus calostachyus (F. Muell.) F. Muell. var. *procerus* (Diels) Benl	×	..	..	..
Ptilotus clementii (Farmar) Benl	×	..	×	..
Ptilotus conicus R.Br.	..	..	..	×
Ptilotus corymbosus R.Br. var. *acutiflorus* Benth.	..	..	..	×
Ptilotus corymbosus R.Br. var. *corymbosus*	..	..	×	×
Ptilotus decipiens (Benth.) C. A. Gardn.	×	..	..	..
Ptilotus dissitiflorus F. Muell.	..	..	×	×
Ptilotus distans (R.Br.) Poir.	..	..	×	×
Ptilotus exaltatus Nees ex Lehm.	×	×	×	×
Ptilotus fusiformis (R.Br.) Poir. var. *fusiformis*	×	×	×	×
Ptilotus fusiformis (R.Br.) Poir. var. *gracilis* (R.Br.) Benl	..	×	×	×
Ptilotus gaudichaudii (Steud.) J. M. Black var. *gaudichaudii*	×	..	..	..
Ptilotus helipteroides (F. Muell.) F. Muell.	×	..	..	..
Ptilotus incanus (R.Br.) Poir. var. *elongatus* Benl	..	×	..	..
Ptilotus incanus (R.Br.) Poir. var. *incanus*	×	..	..	..
Ptilotus latifolius R.Br. var. *latifolius*	×	..	..	..
Ptilotus latifolius R.Br. var. *maior* (C. A. Gardn.) Benl	×	..	..	..
Ptilotus leucocoma (Moq.) F. Muell.	×	..	..	..
Ptilotus lophotrichus Benl	..	..	..	×
Ptilotus macrocephalus (R.Br.) Poir.	×	×	×	..
Ptilotus murrayi F. Muell.	×	..	..	×
Ptilotus nobilis (Lindl.) F. Muell. var. *nobilis*	×	×	..	..
Ptilotus obovatus (Gaud.) F. Muell. var. *griseus* Benl	×	..	..	..
Ptilotus obovatus (Gaud.) F. Muell. var. *obovatus*	×	×	..	..
Ptilotus obovatus (Gaud.) F. Muell. var. *parviflorus* (Lindl.) Benl	..	×	..	..
Ptilotus parvifolius (F. Muell.) F. Muell.	×	..	..	..
Ptilotus polystachyus (Gaud.) F. Muell. emend Benl forma *polystachyus*	×	×	..	..
Ptilotus polystachyus (Gaud.) F. Muell. emend Benl forma *rubriflorus* (Black) Benl	×	..	×	..
Ptilotus schwartzii F. Muell. ex Tate	×	..	..	..
Ptilotus spicatus F. Muell. ex Benth. ssp. *leianthus* (Benth.) Benl var. *leianthus*	..	×	..	×
Ptilotus spicatus F. Muell. ex Benth. ssp. *leianthus* (Benth.) Benl var. *longiceps* Benl	..	..	..	×
Ptilotus spicatus F. Muell. ex Benth. ssp. *spicatus*	×	×	×	×
Pupalia lappacea (L.) Juss.	..	..	..	×
NYCTAGINACEAE				
Boerhavia diffusa L.	×	×	×	×
Boerhavia repanda Willd.	×	..	..	..
Pisonia aculeata L.	..	..	..	×
GYROSTEMONACEAE				
Codonocarpus cotinifolius (Desf.) F. Muell.	×	..	..	..
Gyrostemon australasicus (Moq.) Heimerl.	×	..	..	..
Gyrostemon ramulosus Desf.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Gyrostemon sp.	×	..	..	..
Gyrostemon sp.	×	..	×	..
Sphenocleaceae				
Sphenoclea zeylanica Gaertn.	..	..	..	×
Aizoaceae				
Aizoon quadrifidum (F. Muell.) F. Muell.	×	..	..	..
Aizoon zygophylloides (F. Muell.) F. Muell.	×	..	..	×
Glinus lotoides L.	×	×	×	×
Glinus oppositifolius (L.) A.DC.	×	..	×	×
Glinus orygioides F. Muell.	×	..	..	..
Macarthuria apetala Harv.	..	..	..	×
Mollugo cerviana (L.) Ser.	×	..	..	..
Mollugo molluginea (F. Muell.) Druce	×	×	×	..
Mollugo pentaphylla L.	..	..	..	×
Sesuvium portulacastrum L.	..	..	..	×
Trianthema oxycalyptra F. Muell.	×	..	..	..
Trianthema pilosa F. Muell.	×	×	×	×
Trianthema portulacastrum L.	..	..	..	×
Trianthema triquetra Willd. var. *clavata* (J. M. Black) Eichler	×	..	×	..
Trianthema triquetra Willd. var. *triquetra*	×	..	×	..
Zaleya galericulata (Melville) Eichler	×	×	..	..
Portulacaceae				
Calandrinia balonensis Lindl.	×	..	..	..
Calandrinia eremaea Ewart	×	..	..	..
Calandrinia gracilis Benth.	..	..	..	×
Calandrinia polyandra Benth.	×	..	..	..
Calandrinia ptychosperma F. Muell.	×	..	..	..
Calandrinia pumila (F. Muell. ex Benth.) F. Muell.	×	..	..	..
Calandrinia quadrivalvis F. Muell.	..	..	×	×
Calandrinia remota J. M. Black	×	..	..	..
Calandrinia spergularina F. Muell.	×	..	..	..
Calandrinia stagnensis J. M. Black	×	..	..	..
Calandrinia uniflora F. Muell.	..	..	×	×
Portulaca bicolor F. Muell.	..	..	×	×
Portulaca digyna F. Muell.	..	×	×	..
Portulaca filifolia F. Muell.	×	×	×	×
Portulaca intraterranea J. M. Black	×	..	..	..
Portulaca oleracea L.	×	×	×	×
Portulaca oligosperma F. Muell.	..	×	×	..
Portulaca napiformis F. Muell. ex Benth.	..	..	×	×
Portulaca sp.	×	..	..	..
Caryophyllaceae				
†*Cerastium* aff. *glomeratum* Thuill	×	..	..	..
Polycarpaea breviflora F. Muell.	×	..	×	×
Polycarpaea burtonii F. M. Bail.	..	..	..	×
Polycarpaea corymbosa (L.) Lam.	×	×	×	×
Polycarpaea holtzii Maid. et Betche	..	..	..	×
Polycarpaea involucrata F. Muell.	×	..	×	×
Polycarpaea longiflora F. Muell. var. *longiflora*	..	×	×	×
Polycarpaea longiflora F. Muell. var. *leucantha* Benth.	..	..	×	×
Polycarpaea staminodina F. Muell.	..	..	×	×
Polycarpaea synandra F. Muell.	×	..	×	×
Polycarpaea triloba Ewart et Cookson	×	..	..	..
Polycarpaea violacea (Mart.) Benth.	..	..	..	×
Polycarpon tetraphyllum (L.) L.	×	..	..	..
†*Spergularia* sp.	×	..	..	..
Nymphaeaceae				
Nelumbo nucifera Gaertn.	..	..	..	×
Nymphaea gigantea Hook. var. *gigantea*	..	..	×	×
Nymphaea violacea Lehm.	×	×	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Ceratophyllaceae				
Ceratophyllum demersum L.	..	..	..	×
Ranunculaceae				
†*Adonis aestivalis* L.	×	..	..	..
Menispermaceae				
Hypserpa decumbens (Benth.) Diels	..	..	..	×
Pachygone ovata Miers ex Hook. f. et Thomas	..	..	..	×
Stephania japonica (Thunb.) Miers var. *timoriensis* (DC.) Forman	..	..	..	×
Tinospora smilacina Benth.	×	×	×	×
Annonaceae				
**Annona reticulata* L.	..	..	..	×
Polyalthia holtzeana F. Muell.	..	..	..	×
Polyalthia nitidissima (Dcne.) Benth.	..	..	..	×
Popowia australis Benth.	..	..	..	×
Uvaria holtzei F. Muell.	..	..	..	×
Uvaria membranacea Benth.	..	..	..	×
Myristicaceae				
Myrtistica insipida R.Br.	..	..	..	×
Horsfieldia australiana S. T. Blake	..	..	..	×
Lauraceae				
Cassytha filiformis L.	×	×	×	×
Cassytha glabella R.Br.	..	..	..	×
Cryptocarya cunninghamii Meissn.	..	..	..	×
Litsea chinensis Lam.	..	..	..	×
Litsea glutinosa (Lour.) C. B. Robinson	..	..	..	×
Hernandiaceae				
Gyrocarpus americanus Jacq.	..	..	×	×
Papaveraceae				
†*Glaucium corniculatum* (L.) Rudolph	×	..	..	..
†*Papaver hybridum* L.	×	..	..	..
Cruciferae				
Arabidella trisecta (F. Muell.) Schulz	×	..	..	..
Blennodia canescens R.Br.	×	..	..	..
Blennodia pterosperma (J. M. Black) J. M. Black	×	..	..	..
**Brassica tournefortii* Gouan.	×	..	..	..
†*Capsella bursa-pastoris* (L.) Medik.	×	..	..	..
†*Carrichtera annua* (L.) Prantl	×	..	..	..
Harmsiodoxa blennodioides (F. Muell.) Schulz	×	..	..	..
Lepidium muelleri-ferdinandi Thell.	×	..	..	..
Lepidium oxytrichum Sprague	×	..	..	..
Lepidium papillosum F. Muell.	×	..	..	..
Lepidium rotundum (Desv.) DC.	×	..	..	..
Menkea sphaerocarpa F. Muell.	×	..	..	..
Menkea villosula (F. Muell. et Tate) J. M. Black	×	..	..	..
Phlegmatospermum cochlearinum (F. Muell.) Schulz	×	..	..	..
†*Sisymbrium erysimoides* Desf.	×	..	..	..
†*Sisymbrium irio* L.	×	..	..	..
†*Sisymbrium orientale* L.	×	..	..	..
Stenopetalum lineare R.Br. ex DC.	×	..	..	..
Stenopetalum nutans F. Muell.	×	..	..	..
Stenopetalum velutinum F. Muell.	×	..	..	..
Capparidaceae				
Capparis lasiantha R.Br. ex DC.	×	×	×	×
Capparis loranthifolia Lindl. var. *loranthifolia*	×	×	..	..
Capparis mitchellii (Lindl. ex F. Muell.) Benth.	×	..	..	..
Capparis quiniflora DC.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Capparis sepiaria L. ssp. *umbellata* (R.Br. ex DC.) Jacobs	..	..	×	×
Capparis spinosa L. var. *nummularia* (DC.) F. M. Bail.	×	..	..	..
Capparis umbonata Lindl.	×	×	×	×
Cleome oxalidea F. Muell.	..	..	×	×
Cleome tetrandra Banks ex DC.	..	..	×	×
Cleome viscosa L.	×	×	×	×
Justago cleomoides (F. Muell.) Kuntze	..	..	×	×
DROSERACEAE				
Drosera burmannii Vahl	×	..	×	×
Drosera indica L.	×	×	×	×
Drosera petiolaris R.Br. ex DC.	..	..	×	×
BYBLIDACEAE				
Byblis liniflora Salisb.	..	..	×	×
CRASSULACEAE				
Crassula colorata (Nees) Ostenf.	×	..	..	..
Crassula purpurata (Hook. f.) Domin	×	..	..	..
PITTOSPORACEAE				
Pittosporum ferrugineum Ait.	..	..	..	×
Pittosporum melanospermum F. Muell.	..	..	×	×
Pittosporum phylliraeoides DC.	×	..	×	..
ROSACEAE				
Parinari corymbosum (Bl.) Miq.	..	..	..	×
Rubus hillii F. Muell.	..	..	..	×
Stylobasium spathulatum Desf.	×	..	..	..
MIMOSACEAE				
Acacia acradenia F. Muell.	..	×	×	..
Acacia adsurgens Maid. et Blakely	×	×	×	..
Acacia alleniana Maid.	..	..	..	×
Acacia amentifera F. Muell.	..	..	×	..
Acacia ancistrocarpa Maid. et Blakely	×	×	×	..
Acacia aneura F. Muell. ex Benth. var. *aneura*	×	×	..	..
Acacia aneura F. Muell. ex Benth. var. *latifolia* J. M. Black	×	..	..	..
Acacia argyraea Tindale	..	..	..	×
Acacia arida Benth.	..	..	..	×
Acacia asperulacea F. Muell.	..	..	×	×
Acacia aulacocarpa A. Cunn. ex Benth. var. *aulacocarpa*	..	×	×	×
Acacia aulacocarpa A. Cunn. ex Benth. var. *macrocarpa* Benth.	..	..	..	×
Acacia auriculiformis A. Cunn. ex Benth.	..	..	..	×
Acacia basedowii Maid.	×	..	..	..
Acacia aff. *bidwillii* Benth.	..	..	×	×
Acacia brachystachya Benth.	×	..	..	..
Acacia calcicola Forde et Ising	×	..	..	..
Acacia cambagei R. T. Bak.	×	×	..	..
Acacia chisholmii F. M. Bail.	..	×	..	..
Acacia colletioides Benth.	×	..	..	..
Acacia conspersa F. Muell.	..	..	..	×
Acacia coriacea DC.	×	×	×	..
Acacia cowleana Tate	×	×	×	×
Acacia cunninghamii Hook.	..	×	×	×
Acacia cuthbertsonii Luehm.	×	×	×	..
Acacia cyperophylla F. Muell. ex Benth.	×	..	..	..
Acacia dictyophleba F. Muell.	×	×	..	..
Acacia difficilis Maid.	..	..	..	×
Acacia dimidiata Benth.	..	..	×	×
Acacia dineura F. Muell.	..	..	..	×
Acacia aff. *doratoxylon* A. Cunn.	×	..	..	..
Acacia drepanocarpa F. Muell.	..	..	×	..

	C.A.	B.T.	V.R.D.	D. & G.
Acacia dunnii (Maid.) Turrill	..	..	×	..
Acacia estrophiolata F. Muell.	×	..	×	..
Acacia farnesiana (L.) Willd.	×	..	×	×
Acacia froggattii Maid.	..	..	×	..
Acacia galioides Benth.	×	..	×	..
Acacia aff. *genistoides* A. Cunn. ex Benth.	×	..	..	..
Acacia georginae F. M. Bail.	×	..	..	..
Acacia gonocarpa F. Muell.	..	..	..	×
Acacia gonoclada F. Muell. ex Benth.	×	×	×	..
Acacia hammondii Maid.	..	×	×	..
Acacia hemignosta F. Muell.	×	×	×	×
Acacia hemsleyi Maid.	..	×	..	×
Acacia hilliana Maid.	×	×	×	..
Acacia aff. *hippuroides* Heward ex Benth.	..	×	..	×
Acacia holosericea A. Cunn. ex G. Don.	×	×	×	×
Acacia humifusa A. Cunn. ex Benth.	..	..	×	×
Acacia impressa F. Muell.	..	..	×	..
Acacia jennerae Maid.	×	..	..	..
Acacia kempeana F. Muell.	×	..	..	..
Acacia aff. *kempeana* F. Muell.	×	..	..	..
Acacia lamprocarpa O. Schwarz	..	..	..	×
Acacia latescens Benth.	..	..	..	×
Acacia latifolia Benth.	..	..	..	×
Acacia leptocarpa A. Cunn. ex Benth.	..	..	×	×
Acacia aff. *leptocarpa* A. Cunn. ex Benth.	..	..	..	×
Acacia leptophleba F. Muell.	..	..	×	..
Acacia ligulata A. Cunn. ex Benth.	×	×	..	..
Acacia linarioides Benth.	..	..	..	×
Acacia linophylla W. V. Fitzg.	×	..	..	..
Acacia luehmannii F. Muell.	..	..	..	×
Acacia lycopodiifolia A. Cunn. ex Hook.	..	..	×	×
Acacia aff. *lycopodiifolia* A. Cunn. ex Hook.	..	..	×	..
Acacia aff. *lycopodiifolia* A. Cunn. ex Hook.	×	..	×	..
Acacia aff. *lycopodiifolia* A. Cunn. ex Hook.	×	×	..	..
Acacia lysiphloia F. Muell. ex Benth.	×	×	×	×
Acacia maitlandii F. Muell.	×	..	×	..
Acacia malloclada Maid. et Blakely	..	..	..	×
Acacia microbotrya Benth.	×	..	..	..
Acacia minutifolia F. Muell.	×	..	..	..
Acacia monticola J. M. Black	×	×	×	..
Acacia mountfordiae Specht	..	..	..	×
Acacia murrayana F. Muell. ex Benth.	×	..	..	..
Acacia nuperrima Bak. f.	..	..	..	×
Acacia oligoneura F. Muell.	..	..	×	×
Acacia oncinocarpa Benth.	..	..	×	×
Acacia oswaldii F. Muell.	×	..	..	..
Acacia aff. *oswaldii* F. Muell.	×	..	..	..
Acacia pachyphloia W. V. Fitzg. ex Maid.	..	..	×	×
Acacia pallida F. Muell.	..	..	..	×
Acacia pellita O. Schwarz	..	..	×	×
Acacia peuce F. Muell.	×	..	..	..
Acacia phlebocarpa F. Muell.	..	..	..	×
Acacia plectocarpa A. Cunn. ex Benth.	..	..	..	×
Acacia polystachya A. Cunn. ex Benth.	..	..	..	×
Acacia praelongata F. Muell.	..	..	..	×
Acacia proxima Maid.	..	×	..	..
Acacia pruinocarpa Tindale	×	..	..	..
Acacia ptychophylla F. Muell.	..	×	×	..
Acacia pyrifolia DC.	×	..	..	..
Acacia ramulosa W. V. Fitzg.	×	×	..	..
Acacia retivenia F. Muell.	×	×	×	×
Acacia salicina Lindl.	×	..	..	..
Acacia sericata A. Cunn. ex Benth.	..	..	×	×
Acacia sessiliceps F. Muell.	×	..	..	..
Acacia shirleyi Maid.	..	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Acacia aff. *sibirica* S. Moore	×	..	..	..
Acacia aff. *signata* F. Muell.	×	..	..	..
Acacia simsii A. Cunn. ex Benth.	..	×	×	×
Acacia spondylophylla F. Muell.	×	×	..	..
Acacia stenophylla A. Cunn. ex Benth.	×	×	×	..
Acacia stigmatophylla A. Cunn. ex Benth.	..	..	×	..
Acacia stipuligera F. Muell.	×	×	×	×
Acacia stipulosa F. Muell.	..	..	×	..
Acacia strongylophylla F. Muell.	×	..	..	..
Acacia subternata F. Muell.	..	×	×	×
Acacia sutherlandii F. Muell.	..	×	×	..
Acacia tanumbirinensis Maid.	..	×	×	×
Acacia tenuissima F. Muell.	×	×	×	..
Acacia tetragonophylla F. Muell.	×	..	..	..
Acacia torulosa Benth.	×	×	..	×
Acacia translucens A. Cunn. ex Hook.	×	..	×	×
Acacia tumida F. Muell.	..	×	×	×
Acacia umbellata A. Cunn. ex Benth.	×	..	×	×
Acacia validinervia Maid. et Blakely	×	..	..	..
Acacia victoriae Benth.	×	×	×	..
Acacia wickhamii Benth.	..	..	×	×
Acacia wilhelmiana F. Muell.	×	..	..	..
Acacia xylocarpa A. Cunn. ex Benth.	×	×	..	×
Acacia yirkallensis Specht	..	..	..	×
Albizia canescens Benth.	..	..	..	×
†*Albizia lebbek* Benth.	..	×	..	..
Cathormion umbellatum (Vahl) Kostermans	..	..	×	×
Dichrostachys cinerea (L.) Wight et Arn. subsp. *malesiana* Brenan et Brummitt	.	..	..	×
Dichrostachys spicata (F. Muell.) Domin	..	×	×	×
**Leucaena leucocephala* (Lam.) de Wit	..	..	..	×
**Mimosa acanthocarpa* Poir.	..	..	..	×
**Mimosa pigra* L.	..	..	..	×
**Mimosa pudica* L.	..	..	..	×
Neptunia dimorphantha Domin	×	×	×	..
Neptunia gracilis Benth. forma *glandulosa* Windler	..	×	×	×
Neptunia gracilis Benth. forma *gracilis*	..	..	×	×
Neptunia major (Benth.) Windler	..	..	..	×
Neptunia monosperma F. Muell.	×	×	×	×
CAESALPINIACEAE				
Bauhinia cunninghamii (Benth.) Benth.	×	×	×	×
Bauhinia hookeri F. Muell.	..	..	..	×
Cassia absus L.	..	..	×	×
**Cassia alata* L.	..	..	..	×
Cassia artemisioides Gaud. ex DC.	×	..	..	..
Cassia costata J. F. Bail. et C. T. White	×	×	×	×
Cassia desolata F. Muell.	×	..	×	..
Cassia glutinosa DC.	×	×	×	..
Cassia harneyi Specht	..	..	..	×
Cassia helmsii Symon	×	..	×	..
Cassia leptoclada Benth.	..	..	..	×
Cassia luerssenii Domin	×	..	..	..
Cassia magnifolia F. Muell.	..	..	×	..
Cassia mimosoides L.	..	..	×	×
Cassia eremophila A. Cunn. ex Vogel var. *coriacea* (Benth.) Symon	×	..	..	..
Cassia eremophila A. Cunn. ex Vogel var. *eremophila*	×	..	..	..
Cassia eremophila A. Cunn. ex Vogel var. *platypoda* (R.Br.) Benth.	×	..	..	..
Cassia eremophila A. Cunn. ex Vogel var. *zygophylla* (Benth.) Benth.	×	..	..	..
Cassia notabilis F. Muell.	×	×	×	..
**Cassia obtusifolia* L.	..	..	..	×
**Cassia occidentalis* L.	..	..	..	×
Cassia oligoclada F. Muell.	×	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Cassia oligophylla F. Muell. var. *oligophylla*	×	×	×	. .
Cassia oligophylla F. Muell. var. *sericea* Symon	×	. .	. .	. .
Cassia phyllodinea R.Br.	×	. .	. .	. .
Cassia planitiicola Domin	×	×	×	. .
Cassia pleurocarpa F. Muell. var. *pleurocarpa*	×	×	. .	. .
Cassia pruinosa F. Muell.	×	×	×	. .
Cassia pumila Lam.	×	×	×	×
Cassia sturtii R.Br.	×	. .	. .	. .
**Cassia surattensis* Burm. f.	. .	. .	. .	×
Cassia timoriensis DC.	. .	. .	. .	×
**Cassia tora* L.	. .	. .	. .	×
Cassia venusta F. Muell.	×	×	×	×
Erythrophleum chlorostachyum (F. Muell.) Hennings ex Taub.	. .	×	×	×
Guilandina bonduc L.	. .	. .	. .	×
Labichea lanceolata Benth.	. .	. .	×	. .
Labichea nitida Benth.	. .	. .	×	. .
**Parkinsonia aculeata* L.	. .	. .	×	×
Peltophorum pterocarpum (DC.) Backer ex K. Heyne	. .	. .	. .	×
Petalostylis labicheoides R.Br. var. *cassioides* Benth.	×	×	×	×
Petalostylis spinescens E. Pritz.	×	. .	. .	. .
Piliostigma malabaricum (Roxb.) Benth. var. *acidum* (Korth.) de Wit	. .	. .	. .	×
**Tamarindus indicus* L.	. .	. .	×	×
PAPILIONACEAE				
Abrus precatorius L.	. .	. .	. .	×
**Aeschynomene americana* L.	. .	. .	. .	×
Aeschynomene indica L.	×	×	×	×
Alysicarpus longifolius Wight et Arn.	. .	. .	. .	×
Alysicarpus rugosus (Willd.) DC.	. .	×	×	×
Alysicarpus vaginalis (L.) DC.	. .	. .	. .	×
Atylosia cinerea F. Muell. ex Benth.	. .	×	×	×
Atylosia grandifolia F. Muell. ex Benth.	. .	. .	×	×
Atylosia marmorata Benth.	. .	. .	×	×
Atylosia reticulata (Ait.) Benth.	. .	. .	. .	×
Bossiaea phylloclada F. Muell.	. .	. .	. .	×
Brachysema bossiaeoides Benth.	. .	. .	. .	×
Brachysema chambersii (F. Muell.) F. Muell. ex Benth.	×	. .	. .	. .
Burtonia polyzyga (F. Muell.) Benth.	×	. .	. .	. .
Burtonia simplicifolia F. Muell. et Tate	×	. .	. .	. .
Burtonia subulata Benth.	. .	. .	. .	×
Canavalia cathartica Thouars	. .	. .	. .	×
Canavalia maritima (Aubl.) Thouars	. .	. .	×	×
Clianthus formosus (G. Don) Ford et Vickery	×	. .	. .	. .
**Clitoria ternatea* L.	. .	. .	. .	×
**Crotalaria acuminata* DC.	. .	. .	. .	×
Crotalaria calycina Schrank	. .	. .	. .	×
Crotalaria crispata F. Muell. ex Benth.	×	×	×	×
Crotalaria aff. *crispata* F. Muell. ex Benth.	. .	. .	. .	×
Crotalaria cunninghamii R.Br.	×	×	×	×
Crotalaria dissitiflora Benth. var. *dissitiflora*	×	×	. .	×
Crotalaria dissitiflora Benth. var. *rugosa* Benth.	×	×	×	. .
Crotalaria incana L.	×	. .	. .	. .
Crotalaria juncea L.	. .	. .	×	×
Crotalaria linifolia L.f.	×	×	×	×
Crotalaria mitchellii Benth. var. *tomentosa* Ewart	×	. .	. .	. .
Crotalaria nana Burm. f.	. .	. .	. .	×
Crotalaria novae-hollandiae DC. var. *lasiophylla* Benth.	. .	. .	. .	×
Crotalaria novae-hollandiae DC. var. *novae-hollandiae*	×	×	×	×
**Crotalaria pallida* Ait.	. .	. .	. .	×
Crotalaria retusa L.	. .	×	×	×
Crotalaria strehlowii E. Pritz.	×	×	×	. .
Crotalaria trifoliastrum Willd.	×	×	×	×
Crotalaria verrucosa L.	. .	. .	×	×
**Cyamopsis tetragonoloba* (L.) Taub.	. .	. .	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Cyclocarpa stellaris Afz. ex J. G. Bak.	..	..	..	×
Daviesia arthropoda F. Muell.	×	..	..	..
Daviesia reclinata A. Cunn. ex Benth.	..	..	..	×
Daviesia sp.	×	..	..	..
Dendrolobium stipatum S. T. Blake	..	..	..	×
Derris trifoliata Lour.	..	..	..	×
Desmodium campylocaulon F. Muell. ex Benth.	..	×	..	..
Desmodium filiforme Zoll. et Morr.	..	..	..	×
Desmodium gangeticum DC.	..	..	×	..
Desmodium muelleri Benth.	×	×	×	×
Desmodium aff. *muelleri* Benth.	..	..	..	×
Desmodium neurocarpum Benth.	×	..	×	×
Desmodium aff. *neurocarpum* Benth.	..	..	..	×
Desmodium polyneurum S. T. Blake	..	..	..	×
Desmodium aff. *polyneurum* S. T. Blake	..	..	..	×
Desmodium tortuosum (Sw.) DC.	..	..	..	×
Desmodium trichostachyum Benth.	..	..	×	×
Desmodium aff. *trichostachyum* Benth.	..	..	..	×
Desmodium umbellatum DC.	..	..	..	×
Dicerma biarticulatum (L.) DC.	..	×	..	×
Dunbaria singuliflora F. Muell.	..	..	..	×
Eriosema chinense Vog.	..	..	..	×
Erythrina variegata L. var. *orientalis* (L.) Merr.	..	..	..	×
Erythrina vespertilio Benth.	×	×	×	×
Galactia megalophylla (F. Muell.) J. H. Willis	..	..	..	×
Galactia muelleri Benth.	..	..	..	×
Galactia tenuiflora (Klein ex Willd.) Wight et Arn.	..	×	×	×
Gastrolobium grandiflorum F. Muell.	×	×	..	..
Glycine canescens F. J. Herm.	×	..	..	..
Glycine clandestina Wendl.	×	..	..	..
Glycine falcata Benth.	×	..	..	..
Glycine tabacina (Lab.) Benth.	..	..	..	×
Glycine tomentosa Benth.	..	..	×	×
Hovea longifolia R.Br. ex Ait. var. *longifolia*	..	..	..	×
Hovea longifolia R.Br. ex Ait. var. *pannosa* (A. Cunn.) Benth.	..	..	..	×
Indigofera basedowii E. Pritz.	×	..	..	..
Indigofera brevidens Benth. var. *brevidens*	×	..	..	..
Indigofera brevidens Benth. var. *uncinata* Benth.	×	..	..	..
Indigofera colutea (Burm. f.) Merr.	×	..	×	×
Indigofera cordifolia Heyne	..	..	..	×
Indigofera dominii Eichler	×	×	×	×
Indigofera georgei E. Pritz.	×	..	×	..
Indigofera glandulosa Willd.	..	..	..	×
Indigofera haplophylla F. Muell.	..	..	×	×
Indigofera hirsuta L.	×	×	×	×
Indigofera aff. *hirsuta* L.	×	..	..	..
Indigofera leucotricha E. Pritz.	×	..	..	..
Indigofera linifolia (L.f.) Retz.	×	×	×	×
Indigofera monophylla DC.	×	..	..	..
Indigofera parviflora Heyne ex Wight et Arn.	×	×	×	×
Indigofera saxicola F. Muell. ex Benth.	..	..	..	×
Indigofera subulata Heyne	..	×	..	..
Indigofera tinctoria L.	..	..	..	×
Indigofera trita L.f.	×	×	×	×
Isotropis atropurpurea F. Muell.	×	×	..	..
Isotropis parviflora Benth.	..	×	..	×
Isotropis wheeleri F. Muell. ex Benth.	×	..	..	..
Isotropis winneckeana F. Muell.	×	..	..	..
Jacksonia anomala Ewart et Morr.	×	×	×	..
Jacksonia dilatata Benth.	..	..	×	×
Jacksonia odontoclada F. Muell.	×	×	×	×
Jacksonia ramosissima Benth.	..	..	×	×
Jacksonia thesioides A. Cunn.	..	..	×	..
Jacksonia vernicosa F. Muell. ex Benth.	..	×	..	×
Kennedya prorepens (F. Muell.) F. Muell.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Lotus australis Andr. var. *australis*	..	..	×	..
Lotus australis Andr. var. *exstipulatus* J. M. Black	×	..	..	..
Lotus cruentus Court	×	..	..	..
Lourea obcordata Desv.	..	..	×	..
†*Medicago polymorpha* L. var. *brevispina* (Benth.) Heyn	×	..	..	..
†*Medicago polymorpha* L. var. *vulgaris* (Benth.) Shinners	×	..	..	..
†*Medicago truncatula* Gaertn. var. *truncatula*	×	..	..	..
Mirbelia viminalis (A. Cunn.) C. A. Gardn.	×	×	×	..
Moghania involucrata (Benth.) Kuntze	..	..	..	×
Moghania lineata (Roxb.) Kuntze	..	..	×	×
Moghania parviflora (Benth.) Kuntze	..	..	..	×
Moghania pauciflora (Benth.) Kuntze	..	..	×	×
Mucuna gigantea (Willd.) DC.	..	..	..	×
Mucuna urens (L.) DC. var. *papuana* F. M. Bail.	..	..	..	×
Paratephrosia lanata (Benth.) Domin	×	..	..	..
Phaseolus lathyroides L.	..	..	..	×
†*Phaseolus mungo* L.	..	..	..	×
†*Phaseolus radiatus* L.	..	×	×	×
Pongamia glabra Vent.	..	..	..	×
Pongamia pinnata (L.) Pierre	..	..	..	×
Psoralea archeri F. Muell.	..	..	×	..
Psoralea badacana (Blanco) Benth. var. *badacana*	..	..	..	×
Psoralea badacana (Blanco) Benth. var. *grandiflora* Benth.	..	..	×	×
Psoralea balsamica F. Muell.	×	×	×	..
Psoralea cinerea Lindl.	×	×	×	..
Psoralea eriantha Benth.	×	..	..	..
Psoralea leucantha F. Muell.	×	×	×	..
Psoralea martinii F. Muell.	×	..	×	..
Psoralea patens Lindl.	×	×	×	×
Psoralea plumosa F. Muell.	..	×	×	..
Psoralea pustulata F. Muell.	×	×	×	×
Psoralea schultzii F. Muell.	..	..	..	×
Psoralea walkingtonii F. Muell.	×	..	..	..
Ptychosema anomalum F. Muell.	×	..	..	..
Ptychosema stipulare J. M. Black	×	..	..	..
Ptychosema trifoliolatum F. Muell.	×	..	×	..
Pycnospora lutescens (Poir.) Schindl.	..	..	..	×
Rhynchosia acutifolia F. Muell. ex Benth.	..	..	×	×
Rhynchosia australis Benth.	×	..	..	×
Rhynchosia minima (L.) DC.	×	×	×	×
Rhynchosia rhomboidea F. Muell. ex Benth.	..	..	×	..
Rothia trifoliata Pers.	..	..	×	..
Sesbania benthamiana Domin	..	..	×	×
Sesbania brachycarpa F. Muell.	..	×	..	..
Sesbania cannabina (Retz.) Poir. var. *cannabina*	×	..	×	×
Sesbania cannabina (Retz.) Poir. var. *sericea* (Benth.) N. T. Burbidge	..	..	×	×
Sesbania chippendalei N. T. Burbidge	×	×	..	..
Sesbania erubescens (Benth.) N. T. Burbidge	..	..	×	×
Sesbania formosa (F. Muell.) N. T. Burbidge	..	..	×	×
Sesbania javanica Miq.	..	..	..	×
Sesbania sesban (L.) Merr.	..	..	..	×
Sesbania simpliciuscula F. Muell. ex Benth. var. *simpliciuscula*	..	..	×	..
Smithia conferta Sm.	..	..	..	×
**Stylosanthes humilis* H.B.K.	..	..	..	×
Swainsona beasleyana (F. Muell.) A. Lee subsp. *beasleyana*	×	..	..	..
Swainsona burkei F. Muell. ex Benth. subsp. *acuticarinata* A. Lee	×	..	..	..
Swainsona burkei F. Muell. ex Benth. subsp. *burkei*	×	×	..	..
Swainsona campylantha F. Muell.	×	..	..	..
Swainsona canescens (Benth.) F. Muell. var. *canescens*	×	..	..	..
Swainsona canescens (Benth.) F. Muell. var. *horniana* J. M. Black	×	..	..	..
Swainsona cyclocarpa F. Muell. var. *cyclocarpa*	×	..	..	..
Swainsona flavicarinata J. M. Black	×	×	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Swainsona microcalyx J. M. Black subsp. *microcalyx*	×	..	..	..
Swainsona microphylla A. Gray subsp. *affinis* A. Lee	×	..	..	..
Swainsona microphylla A. Gray subsp. *glabrescens* A. Lee	×	..	..	..
Swainsona microphylla A. Gray subsp. *pallescens* A. Lee	×	..	..	..
Swainsona oligophylla F. Muell. ex Benth.	×	..	..	..
Swainsona oroboides F. Muell. ex Benth. subsp. *oroboides*	×	..	..	..
Swainsona phacoides Benth. subsp. *phacoides*	×	..	..	..
Swainsona rigida (Benth.) J. M. Black	×	..	..	..
Swainsona unifoliata F. Muell.	×	..	..	..
Swainsona villosa J. M. Black	×	..	..	..
Templetonia egena (F. Muell.) Benth.	×	..	×	..
Templetonia hookeri (F. Muell.) Benth.	×	×	×	..
Tephrosia brachycarpa F. Muell. ex Benth.	×	..	×	..
Tephrosia coriacea Benth.	..	..	×	×
Tephrosia eriocarpa Benth.	×	×	×	..
Tephrosia filipes Benth.	×	..	..	..
Tephrosia flammea F. Muell. ex Benth.	..	..	×	..
Tephrosia juncea Benth.	..	..	..	×
Tephrosia leptoclada Benth.	..	..	×	..
Tephrosia macrocarpa Benth.	..	×	×	..
Tephrosia oligophylla Benth.	..	..	..	×
Tephrosia phaeosperma F. Muell. ex Benth.	×	×	×	×
Tephrosia polyzyga F. Muell. ex Benth.	..	..	×	..
Tephrosia porrecta R.Br. ex Benth.	..	..	..	×
Tephrosia purpurea (L.) Pers. var. *axillaris* Bak. f.	..	..	..	×
Tephrosia purpurea (L.) Pers. var. *brevidens* Benth.	..	..	..	×
Tephrosia purpurea (L.) Pers. var. *longifolia* Benth.	×	×	×	×
Tephrosia purpurea (L.) Pers. var. *purpurea*	×	×	..	×
Tephrosia remotiflora F. Muell. ex Benth.	×	×	×	×
Tephrosia rosea F. Muell. ex Benth.	..	..	×	..
Tephrosia sphaerospora F. Muell.	×	..	..	..
Tephrosia simplicifolia F. Muell. ex Benth.	..	..	..	×
Tephrosia stuartii Benth.	..	×	..	..
Tephrosia aff. *stuartii* Benth.	..	×	..	..
Tephrosia uniovulata F. Muell.	×	×	×	..
Trigonella suavissima Lindl.	×	..	..	..
Uraria cylindracea Benth.	..	..	×	×
Uraria lagopodoides (L.) Desv. ex DC.	..	..	..	×
†*Vicia calcarata* Desf.	×	..	..	..
Vigna canescens C. T. White	..	..	..	×
Vigna lanceolata Benth. var. *filiformis* Benth.	..	..	×	×
Vigna lanceolata Benth. var. *latifolia* C. T. White	×	..	..	..
Vigna lanceolata Benth. var. *lanceolata*	..	×	×	×
Vigna luteola (Jacq.) Benth.	..	..	..	×
Vigna marina (Burm. f.) Merr.	..	..	×	..
Vigna vexillata (L.) Benth. var. *youngiana* F. M. Bail.	..	..	..	×
Zornia albiflora Mohlenbrock	×	..	..	..
Zornia areolata Mohlenbrock	..	..	..	×
Zornia chaetophora F. Muell.	..	..	×	..
Zornia gibbosa Span	..	..	..	×
Zornia muriculata Mohlenbrock	..	..	..	×
Zornia nervata Mohlenbrock	..	..	..	×
GERANIACEAE				
Erodium aureum Carolin	×	..	..	..
†*Erodium botrys* (Cav.) Bertol.	×	..	..	..
†*Erodium cicutarium* (L.) L'Her.	×	..	..	..
Erodium crinitum Carolin	×	..	..	..
Erodium cygnorum Nees ssp. *cygnorum*	×	..	..	..
Erodium cygnorum Nees ssp. *glandulosum* Carolin	×	..	..	..
OXALIDACEAE				
Oxalis corniculata L.	×	..	..	..
†*Oxalis corymbosa* DC.	×	..	..	..
†*Oxalis pes-caprae* L.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Erythroxylaceae				
Erythroxylum ellipticum R.Br.	..	..	..	×
Zygophyllaceae				
Nitraria schoberi L.	×	..	..	..
Tribulus angustifolius (R.Br.) Benth.	×	×	×	×
Tribulus astrocarpus F. Muell.	×	..	..	..
Tribulus bicolor F. Muell.	..	..	×	..
Tribulus cistoides L.	..	..	..	×
Tribulus hystrix R.Br.	×	..	..	..
Tribulus macrocarpus F. Muell. ex Benth.	×	..	..	..
Tribulus occidentalis R.Br.	×	..	..	..
Tribulus pentandrus Benth.	..	×	×	×
Tribulus renunculiflorus F. Muell.	..	..	×	..
Tribulus solandri F. Muell.	..	..	×	..
Tribulus terrestris L.	×	×	×	×
Zygophyllum ammophilum F. Muell.	×	..	..	..
Zygophyllum apiculatum F. Muell.	×	..	..	..
Zygophyllum aurantiacum Lindl.	×	..	..	..
Zygophyllum compressum J. M. Black	×	..	..	..
Zygophyllum eremaeum (Diels) Ostenf.	×	..	..	..
Zygophyllum glaucescens F. Muell.	×	..	..	..
Zygophyllum howittii F. Muell.	×	..	..	..
Zygophyllum iodocarpum F. Muell.	×	..	..	..
Zygophyllum prismatothecum F. Muell.	×	..	..	..
Zygophyllum tesquorum J. M. Black	×	..	..	..
Rutaceae				
Atalantia recurva Benth.	..	..	..	×
Boronia affinis R.Br. ex Benth.	..	..	..	×
Boronia artemisiaefolia F. Muell. var. *artemisiaefolia*	..	..	..	×
Boronia artemisiaefolia F. Muell. var. *wilsonii* F. Muell.	..	..	×	..
Boronia lanceolata F. Muell.	..	..	..	×
Glycosmis trifoliata Spreng.	..	..	..	×
Micromelum minutum (Forst. f.) Wight et Arn.	..	..	..	×
Zanthoxylum parviflorum Benth.	..	..	..	×
Simarubaceae				
Brucea javanica (L.) Merr.	..	..	×	×
Harrisonia brownii A. Juss.	..	..	..	×
Suriana maritima L.	..	..	..	×
Burseraceae				
Canarium australianum F. Muell. var. *australianum*	..	..	..	×
Canarium australianum F. Muell. var. *glabrum* Leenh.	..	..	..	×
Meliaceae				
Aglaia elaeagnoides (A. Juss.) Benth.	..	..	..	×
Dysoxylum oppositifolium F. Muell. ex DC.	..	..	..	×
Melia composita Willd.	..	..	..	×
Owenia acidula F. Muell.	×	..	..	..
Owenia reticulata F. Muell.	×	..	..	..
Owenia vernicosa F. Muell.	..	..	×	×
Vavaea australiana S. T. Blake	..	..	..	×
Xylocarpus australasicus Ridl.	..	..	..	×
Xylocarpus granatum Koenig	..	..	..	×
Polygalaceae				
Comesperma aphyllum R.Br. ex Benth.	..	..	..	×
Comesperma secundum Banks ex DC.	..	..	..	×
Comesperma sylvestre Lindl.	×	..	..	..
Comesperma viscidulum F. Muell.	×	..	..	..
Polygala elongata Klein.	..	..	..	×
Polygala eriocephala F. Muell. ex Benth.	..	..	×	×
Polygala exsquarrosa Adema	×	..	..	×
Polygala linariifolia Willd.	..	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Polygala longifolia Poir.	..	..	×	×
Polygala orbicularis Benth.	..	..	..	×
Polygala rhinanthoides Sol. ex Benth.	..	..	×	×
Polygala stenoclada Benth.	..	..	×	..
Polygala tepperi F. Muell.	..	..	×	..
Salomonia oblongifolia DC.	..	..	..	×
EUPHORBIACEAE				
Adriana acerifolia Hook.	..	..	×	×
Adriana hookeri (F. Muell.) J. Muell.	×	..	..	..
Andrachne decaisnei Benth.	..	×	×	×
Antidesma dallachyanum Baill.	..	..	..	×
Antidesma ghaesembilla Gaertn.	..	..	×	×
Antidesma parvifolium F. Muell.	..	..	..	×
Antidesma schultzii Benth.	..	..	..	×
Beyeria bickertonensis Specht	..	..	..	×
Breynia oblongifolia J. Muell.	..	..	..	×
Breynia stipitata J. Muell.	..	..	..	×
Bridelia monoica (Lour.) Merr.	..	..	×	×
Bridelia ovata Dcne.	..	..	..	×
Calycopeplus sp.	..	..	..	×
Croton arnhemicus J. Muell.	..	..	×	×
Croton schultzii Benth.	..	..	..	×
Croton tomentellus F. Muell.	..	..	×	..
Croton verreauxii Baill.	..	..	..	×
Dissiliaria tricornis Benth.	..	..	..	×
Drypetes australasica (J. Muell.) Pax et Hoffm.	..	..	..	×
Euphorbia alsinaeflora Baill.	..	..	..	×
Euphorbia armstrongiana Boiss.	..	..	..	×
Euphorbia atoto Forst. f.	..	..	..	×
Euphorbia australis Boiss.	×	..	×	..
Euphorbia boophthona C. A. Gardn.	×	..	..	..
Euphorbia coghlanii F. M. Bail.	×	×	×	×
Euphorbia comans W. V. Fitzg.	..	×	..	..
*_Euphorbia dentata_ Michx.	..	..	..	×
Euphorbia drummondii Boiss.	×	×	×	×
Euphorbia eremophila A. Cunn.	×	×	×	..
Euphorbia filipes Benth.	..	..	..	×
Euphorbia finlaysonii J. M. Black	×	..	..	..
*_Euphorbia heterophylla_ L.	..	..	..	×
Euphorbia hirta L.	..	..	..	×
Euphorbia micradenia Boiss.	..	×	×	×
Euphorbia mitchelliana Boiss. var. *mitchelliana*	..	×	×	×
Euphorbia mitchelliana Boiss. var. *stenophylla* Benth.	..	..	..	×
Euphorbia muelleri Boiss.	..	..	..	×
†*Euphorbia peplus* L.	×	..	..	..
Euphorbia petala Ewart et Kerr	×	..	..	..
Euphorbia schizolepis F. Muell. ex Boiss.	..	..	×	×
Euphorbia schultzii Benth.	..	×	×	×
Euphorbia stevenii F. M. Bail.	×	×	..	..
Euphorbia tannensis Spreng.	..	..	..	×
Euphorbia vachelii Hook. et Arn.	..	..	..	×
Euphorbia wheeleri F. M. Bail.	×	..	..	..
Euphorbia sp.	×	..	..	..
Excaecaria agallocha L.	..	..	×	×
Excaecaria parvifolia J. Muell.	..	×	..	..
Glochidion ferdinandi (J. Muell.) F. M. Bail. var. *ferdinandi*	..	..	..	×
Glochidion ferdinandi (J. Muell.) F. M. Bail. var. *supra-axillaris* (Benth.) F. M. Bail.	..	..	..	×
Hemicyclia lasiogyna F. Muell.	..	..	..	×
Hemicyclia sepiaria Wight et Arn.	..	..	..	×
*_Jatropha gossypifolia_ L.	..	×	..	×
Macaranga involucrata (Roxb.) Baill.	..	..	..	×
Macaranga tanarius (L.) J. Muell.	..	..	..	×
Mallotus nesophilus F. Muell. ex J. Muell.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
**Micrococca mercurialis* (L.) Benth.	..	..	..	×
Petalostigma banksii Britten et S. Moore	..	..	..	×
Petalostigma haplocladum Pax et K. Hoffm.	..	..	..	×
Petalostigma quadriloculare F. Muell. var. *glabrescens* Benth.	..	..	..	×
Petalostigma quadriloculare F. Muell. var. *nigrum* Ewart et Davies	×	×	×	×
Petalostigma quadriloculare F. Muell. var. *quadriloculare*	..	×	×	×
Petalostigma quadriloculare F. Muell. var. *sericeum* J. Muell.	..	..	..	×
Phyllanthus adamii J. Muell.	..	..	..	×
Phyllanthus baccatus F. Muell. ex Benth.	..	..	×	×
Phyllanthus carpentariae J. Muell.	..	..	..	×
Phyllanthus ditassoides J. Muell.	..	..	..	×
Phyllanthus fuernrohrii F. Muell.	×	..	..	..
Phyllanthus huntii Ewart et Davies	×	×	×	..
Phyllanthus lacunarius F. Muell.	×	..	..	..
Phyllanthus maderaspatanus L. var. *angustifolius* Benth.	×	×	×	×
Phyllanthus maderaspatanus L. var. *maderaspatanus*	×	×	×	×
Phyllanthus aff. *maderaspatanus* L.	..	..	..	×
Phyllanthus ochrophyllus Benth.	..	..	..	×
Phyllanthus ramosissimus (F. Muell.) J. Muell.	×	..	..	..
Phyllanthus rhytidospermus F. Muell. ex J. Muell.	×	..	×	×
Phyllanthus simplex Retz. var. *minutiflorus* (F. Muell.) Domin	..	..	×	×
Phyllanthus simplex Retz. var. *simplex*	..	×	×	×
Phyllanthus aff. *simplex* Retz.	..	..	..	×
Phyllanthus thesioides Benth.	×	..	..	..
Phyllanthus trachygyne Benth.	..	..	..	×
Phyllanthus trachyspermus F. Muell.	×	..	..	..
Phyllanthus urinaria L.	..	..	..	×
Phyllanthus xerocarpus O. Schwarz	..	..	..	×
Poranthera coerulea O. Schwarz	..	..	..	×
Poranthera microphylla Brongn.	..	..	..	×
Ricinocarpos sp.	×	..	..	..
**Ricinus communis* L.	×	..	..	..
Sebastiania chamelaea (L.) J. Muell.	×	×	×	×
Securinega virosa (Roxb. ex Willd.) Pax et Hoffm.	..	..	×	×
ANACARDIACEAE				
Blepharocarya depauperata Specht	..	..	..	×
Blepharocarya involucrigera F. Muell.	..	..	..	×
Buchanania angustifolia Roxb.	..	..	..	×
Buchanania arborescens (Bl.) Bl.	..	..	×	×
Buchanania obovata Engl.	..	..	×	×
Semecarpus australiensis Engl.	..	..	..	×
AQUIFOLIACEAE				
Ilex arnhemensis (F. Muell.) Loes.	..	..	..	×
CELASTRACEAE				
Denhamia obscura (A. Rich.) Meissn.	..	..	×	×
Elaeodendron melanocarpum F. Muell.	..	..	..	×
Lophopetalum arnhemicum N. Byrnes	..	..	..	×
Maytenus cunninghamii (Hook.) Loes.	..	×	×	..
STACKHOUSIACEAE				
Macgregoria racemigera F. Muell.	×	..	×	..
Stackhousia intermedia F. M. Bail.	×	..	..	..
Stackhousia megaloptera F. Muell.	×	..	..	..
Stackhousia muricata Lindl.	..	..	×	×
Stackhousia viminea Sm.	×	..	×	×
SAPINDACEAE				
Allophylus serratus (Roxb.) Kurz.	..	..	..	×
Atalaya hemiglauca (F. Muell.) F. Muell. ex Benth.	×	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Atalaya salicifolia Bl.	..	..	..	×
Atalaya variifolia F. Muell. ex Benth.	..	..	..	×
Cardiospermum halicacabum L.	..	..	×	×
Cupaniopsis anacardioides (A. Rich.) Radlk.	..	..	..	×
Diplopeltis stuartii F. Muell.	×	..	..	..
Distichostemon filamentosus S. Moore	..	×	..	×
Distichostemon hispidulus (Endl.) Baill.	..	×	×	×
Dodonaea attenuata A. Cunn.	×	..	..	..
Dodonaea lanceolata F. Muell.	×	×	×	×
Dodonaea microzyga F. Muell.	×	..	..	..
Dodonaea oxyptera F. Muell.	..	×	..	×
Dodonaea peduncularis Lindl. var. *coriacea* Ewart et Davies	×	×	×	..
Dodonaea petiolaris F. Muell.	×	..	..	..
Dodonaea physocarpa F. Muell.	..	..	×	×
Dodonaea platyptera F. Muell.	..	..	..	×
Dodonaea polyzyga F. Muell.	..	..	×	..
Dodonaea viscosa Jacq. var. *spatulata* (Sm.) Benth.	×	..	..	..
Ganophyllum falcatum Bl.	..	..	..	×
Harpullia leichhardtii F. Muell. ex Benth.	..	..	..	×
Heterodendrum floribundum E. Pritz.	×	..	..	..
Heterodendrum oleifolium Desf.	×	..	..	..
RHAMNACEAE				
Alphitonia excelsa (Fenzl.) Benth.	..	×	×	×
Alphitonia incana (Roxb.) Teijsm. et Binn. ex Kurz.	..	..	..	×
Alphitonia aff. *moluccana* Tiejsm. et Binn.	..	..	..	×
Alphitonia petrei Braid. et White	..	..	..	×
Colubrina asiatica (L.) Brongn.	..	..	..	×
Spyridium spathulatum (F. Muell.) F. Muell. ex Benth.	×	..	..	..
Ventilago viminalis Hook.	×	×	×	..
Ziziphus mauritiana Lam.	..	..	..	×
Ziziphus oenoplia Mill.	..	..	..	×
Ziziphus quadrilocularis F. Muell.	..	..	×	×
VITACEAE				
Ampelocissus acetosa (F. Muell.) Planch.	..	..	×	×
Ampelocissus sp.	..	..	..	×
Cayratia trifolia (L.) Domin	..	×	×	×
Cissus reniformis Domin	..	..	..	×
Cissus repens Lam.	..	..	..	×
Leea brunoniana C. B. Clarke	..	..	..	×
ELAEOCARPACEAE				
Elaeocarpus arnhemicus F. Muell.	..	..	..	×
TILIACEAE				
Corchorus acutangulus Lam.	..	..	×	×
Corchorus capsularis L.	..	..	..	×
Corchorus echinatus Benth.	..	..	×	..
Corchorus elderi F. Muell.	×	..	..	..
Corchorus fascicularis Lam.	..	..	×	×
Corchorus macropetalus Domin	..	..	×	..
Corchorus olitorius L.	..	..	×	×
Corchorus pascuorum Domin	..	×	..	..
Corchorus pumilio R.Br. ex Benth.	..	..	×	×
Corchorus rostrisepalus Domin	..	..	..	×
Corchorus sericeus Ewart et Davies	..	..	..	×
Corchorus sidioides F. Muell.	×	×	×	×
Corchorus tridens L.	..	..	×	..
Corchorus vermicularis F. Muell.	×	..	×	..
Grewia breviflora Benth.	..	..	..	×
Grewia latifolia F. Muell. ex Benth.	..	..	..	×
Grewia multiflora Juss.	..	..	..	×
Grewia orbifolia F. Muell. ex Benth.	..	..	×	..
Grewia orientalis Benth.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Grewia retusifolia Kurz.	..	..	×	×
Grewia scabrella Benth.	..	..	×	..
Grewia xanthopetala F. Muell. ex Benth.	..	..	×	×
Triumfetta appendiculata F. Muell.	..	..	..	×
Triumfetta denticulata R.Br. ex Benth.	..	..	..	×
Triumfetta glaucescens R.Br. ex Benth.	..	×	×	×
Triumfetta micracantha F. Muell.	×	×	×	..
Triumfetta plumigera F. Muell.	..	×	×	×
Triumfetta rhomboidea Jacq.	..	..	..	×
Triumfetta winneckeana F. Muell.	×	..	..	..
MALVACEAE				
Abelmoschus ficulneus (L.) Wight et Arn.	..	×	×	×
Abelmoschus moschatus Medic. ssp. *tuberosus* (Span.) Borss.	..	..	..	×
Abutilon andrewsianum W. V. Fitzg.	..	..	×	×
Abutilon crispum G. Don	..	..	×	×
Abutilon cryptopetalum (F. Muell.) F. Muell. ex Benth.	×	..	..	..
Abutilon cunninghamii Benth.	..	..	..	×
Abutilon fraseri (Hook.) Hook. ex Walt.	×	..	..	..
Abutilon indicum (L.) Sweet var. *australiense* Hockr. ex J. Britt.	..	..	..	×
Abutilon aff. *indicum* (L.) Sweet	..	×	..	×
Abutilon leucopetalum (F. Muell.) F. Muell. ex Benth.	×	×	×	..
Abutilon macrum F. Muell.	×	..	..	..
Abutilon malvifolium (Benth.) J. M. Black	×	..	..	..
Abutilon otocarpum F. Muell.	×	×	×	×
Alyogyne pinonianus (Gaud.) Fryxell var. *pinonianus*	×	..	..	..
Camptostemon schultzii Mast.	..	..	..	×
Gossypium australe F. Muell.	×	×	×	×
Gossypium bickii Prokh.	×	×	×	..
Gossypium cunninghamii Todaro	..	..	..	×
**Gossypium hirsutum* L. var. *punctatum* (Schum.) J. B. Hutch.	..	..	..	×
Gossypium sturtianum J. H. Willis var. *sturtianum*	×	..	..	..
Hibiscus brachychlaenus F. Muell.	×	×	×	×
Hibiscus brachysiphonius F. Muell.	..	×	..	..
Hibiscus caesius Garcke	..	×	×	×
Hibiscus crassicalyx J. M. Black	×	..	..	..
Hibiscus divaricatus Grah.	..	..	..	×
Hibiscus drummondii Turcz.	×	..	..	..
Hibiscus farragei F. Muell.	×	..	..	..
Hibiscus heterophyllus Vent.	..	..	..	×
Hibiscus krichauffianus F. Muell. var. *chippendalei* Fryxell	×	..	×	..
Hibiscus krichauffianus F. Muell. var. *krichauffianus*	×	..	..	..
Hibiscus leptocladus Benth.	..	..	×	×
Hibiscus menzelii F. D. Wilson and N. Byrnes	..	..	..	×
Hibiscus meraukensis Hochr.	×	×	×	×
Hibiscus panduriformis Burm. f.	..	..	×	×
Hibiscus pentaphyllus F. Muell.	..	..	×	×
**Hibiscus sabdariffa* L.	..	..	×	×
Hibiscus setulosus F. Muell.	..	..	..	×
Hibiscus sturtii Hook. var. *campylochlamys* Benth.	..	×	×	×
Hibiscus sturtii Hook. var. *grandiflorus* Benth.	×	×	..	..
Hibiscus sturtii Hook. var. *muelleri* Benth.	×	..	×	..
Hibiscus sturtii Hook. var. *platychlamys* Benth.	×	×	×	..
Hibiscus sturtii Hook. var. *sturtii*	×	..	×	..
Hibiscus sturtii Hook. var. *truncatus* Fryxell	×	..	..	..
Hibiscus symonii F. D. Wilson and N. Byrnes	..	..	..	×
Hibiscus tiliaceus L. ssp. *tiliaceus*	..	×	..	×
Hibiscus trionum L.	×	×	×	..
Hibiscus zonatus F. Muell.	..	..	..	×
Lavatera plebeia Sims	×	..	..	..
**Malachra fasciata* Jacq.	..	..	..	×
**Malva parviflora* L.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Malvastrum americanum (L.) Torr.	×	×	×	..
Plagianthus glomeratus (Hook.) Benth.	×	..	..	..
*_Sida acuta_ Burm. f.	..	..	×	×
Sida ammophila F. Muell. ex J. H. Willis	×	..	..	..
Sida calyxhymenia J. Gay ex DC.	×	×	×	..
Sida cardiophylla F. Muell.	×	×	..	..
Sida cleisocalyx F. Muell.	×	×	×	..
*_Sida cordifolia_ L.	..	..	..	×
Sida corrugata Lindl. var. _angustifolia_ Benth.	×	..	..	..
Sida corrugata Lindl. var. _corrugata_	×	×	×	×
Sida cryphiopetala F. Muell.	×	..	..	..
Sida cunninghamii White	×	..	..	..
Sida fibulifera Lindl.	×	×	×	..
Sida aff. _fibulifera_ Lindl.	..	×	×	..
Sida filiformis A. Cunn.	×	×	×	..
Sida goniocarpa (F. Muell. ex Benth.) Domin	×	×	..	..
Sida intricata F. Muell.	×	..	×	..
Sida lepida F. Muell.	×	..	..	..
Sida macropoda F. Muell. ex Benth.	×	×	×	..
Sida petrophila F. Muell.	..	×	×	..
Sida platycalyx F. Muell. ex Benth.	×	×	×	..
Sida rhombifolia L. var. _incana_ Benth.	×	..	..	..
Sida rhombifolia L. var. _rhombifolia_	..	..	..	×
Sida rohlenae Domin	×	×	..	..
Sida spinosa L.	..	×	×	×
Sida subspicata F. Muell. ex Benth.	..	..	×	..
Sida trichopoda F. Muell.	×	×	..	..
Sida virgata Hook. var. _phaeotricha_ (F. Muell.) Benth.	×	..	..	..
Sida virgata Hook. var. _virgata_	×	..	×	×
Sida sp.	..	×	..	..
Thespesia lampas (Cav.) Dalz. ex Dalz. et Gibbs var. _thespidioides_ (R.Br. ex Benth.) Fryxell	..	..	..	×
Thespesia populnea (L.) Sol. ex Corr.	..	..	..	×
Urena lobata L.	..	..	..	×
Urena spenceri (Ewart) Fryxell	..	..	..	×
BOMBACACEAE				
Bombax ceiba L. var. _leiocarpum_ Robyns	..	..	..	×
STERCULIACEAE				
Brachychiton diversifolium R.Br.	..	×	×	×
Brachychiton gregorii F. Muell.	×	..	..	..
Brachychiton paradoxum Schott.	..	×	×	×
Brachychiton tuberculata W. V. Fitzg.	..	..	×	..
Commersonia crispa Turcz.	×	..	..	..
Commersonia melanopetala F. Muell.	×	..	..	..
Dicarpidium monoicum F. Muell.	..	..	..	×
Gilesia biniflora F. Muell.	×	..	..	..
Hannafordia bissellii F. Muell.	×	..	..	..
Helicteres cana (Schott.) Benth.	..	..	×	×
Helicteres dentata F. Muell. ex Benth. var. _dentata_	..	..	×	..
Helicteres dentata F. Muell. ex Benth. var. _flagellaris_ Benth.	..	..	..	×
Helicteres dentata F. Muell. ex Benth. var. _procumbens_ Benth.	..	..	..	×
Helicteres isora L.	..	..	..	×
Keraudrenia integrifolia Steud.	×	×	×	..
Keraudrenia nephrosperma (F. Muell.) F. Muell. ex J. M. Black	×	..	×	..
Melhania oblongifolia F. Muell.	×	×	×	×
Melhania ovata (Cav.) Spreng.	..	×	..	..
Melochia corchorifolia L.	..	..	×	×
Melochia pyramidata L.	..	..	×	×
*_Pentapetes phoenicea_ L.	..	..	..	×
Rulingia kempeana (F. Muell.) F. Muell. ex J. M. Black	×	..	..	..
Rulingia loxophylla F. Muell.	×	..	×	..

	C.A.	B.T.	V.R.D.	D. & G.
Rulingia magniflora F. Muell.	×	..	..	..
Sterculia quadrifida R.Br.	..	..	..	×
Waltheria indica L.	×	×	×	×
Waltheria virgata Ewart et Cookson	..	..	×	..
DILLENIACEAE				
Dillenia alata (R.Br. ex DC.) Martelli	..	..	..	×
Hibbertia brownii Benth.	..	..	..	×
Hibbertia cistifolia R.Br.	..	..	..	×
Hibbertia dealbata Benth.	..	..	..	×
Hibbertia glaberrima F. Muell.	×	..	..	..
Hibbertia holtzei F. Muell.	..	..	..	×
Hibbertia lepidota R.Br.	..	..	×	×
Hibbertia muelleri Benth.	..	..	×	×
Hibbertia oblongata R.Br. var. *brevifolia* Benth.	..	..	×	..
Hibbertia oblongata R.Br. var. *oblongata*	..	..	..	×
Hibbertia scabra R.Br. ex Benth.	..	..	..	×
Hibbertia tomentosa R.Br.	..	..	..	×
Pachynema complanatum R.Br.	..	..	..	×
Pachynema dilatatum Benth.	..	..	..	×
Pachynema junceum Benth.	..	..	×	×
Pachynema sphenandrum F. Muell. et Tate	..	..	..	×
GUTTIFERAE				
Calophyllum australianum F. Muell.	..	..	..	×
Calophyllum inophyllum L.	..	..	..	×
Calophyllum lonchophyllum O. Schwarz	..	..	..	×
Calophyllum ramiflorum O. Schwarz	..	..	..	×
Hypericum gramineum Forst. f.	×	..	..	..
Hypericum japonicum Thunb.	×	..	×	..
ELATINACEAE				
Bergia ammannioides Roth.	..	..	×	..
Bergia pedicellaris F. Muell. ex Benth.	..	..	×	×
Bergia perennis (F. Muell.) F. Muell. ex Benth.	×	..	..	..
Bergia pusilla Benth.	..	..	..	×
Bergia trimera Fisch. et Mey.	×	..	..	..
Elatine gratioloides A. Cunn.	×	..	..	..
FRANKENIACEAE				
Frankenia connata Sprague	×	..	..	..
Frankenia cordata J. M. Black	×	..	..	..
Frankenia gracilis Summerh.	×	..	..	..
Frankenia muscosa J. M. Black	×	..	..	..
Frankenia planifolia Sprague et Summerh.	×	..	..	..
Frankenia serpyllifolia Lindl.	×	..	..	..
Frankenia speciosa Summerh.	×	..	..	..
Frankenia stuartii Summerh.	×	..	..	..
COCHLOSPERMACEAE				
Cochlospermum fraseri Planch.	..	..	×	×
Cochlospermum gillivrayi Benth.	..	..	..	×
Cochlospermum gregorii F. Muell.	..	..	..	×
VIOLACEAE				
Hybanthus enneaspermus (L.) F. Muell. var. *banksianus* Domin	..	×	×	×
Hybanthus enneaspermus (L.) F. Muell. var. *enneaspermus*	×	×	×	×
PASSIFLORACEAE				
Adenia australis (R.Br. ex DC.) Engl.	..	..	..	×
**Passiflora foetida* L.	..	..	..	×
**Passiflora suberosa* L.	..	..	..	×
CACTACEAE				
**Opuntia stricta* Haw.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
THYMELAEACEAE				
Phaleria blumei Benth. var. *latifolia* Benth.	..	..	..	×
Pimelea ammocharis F. Muell.	×	×	×	..
Pimelea microcephala R.Br.	×	..	..	..
Pimelea punicea R.Br.	..	×	×	×
Pimelea trichostachya Lindl.	×	..	..	..
LYTHRACEAE				
Ammannia auriculata Willd.	×	..	..	..
Ammannia crinipes F. Muell.	..	..	×	×
Ammannia indica Lam.	..	..	×	..
Ammannia multiflora Roxb.	×	..	×	×
Ammannia occultiflora Koehne var. *leichhardtii* Koehne	..	..	..	×
Ammannia triflora R.Br. ex Benth.	..	..	..	×
Lawsonia alba Lam.	..	..	..	×
Lythrum arnhemicum F. Muell.	..	..	×	×
Pemphis acidula Forst. et f.	..	..	..	×
Rotala diandra (F. Muell.) Koehne	×	..	×	×
Rotala mexicana Cham. et Schlecht.	..	×	..	×
Rotala roxburghiana Wight	..	×	×	×
Rotala verticillaris L.	×	..	..	..
Rotala sp.	..	..	..	×
SONNERATIACEAE				
Sonneratia caseolaris (L.) Engl.	..	..	..	×
BARRINGTONIACEAE				
Barringtonia acutangula (L.) Gaertn. ssp. *acutangula*	..	..	×	×
Planchonia careya (F. Muell.) R. Knuth	..	..	..	×
RHIZOPHORACEAE				
Bruguiera gymnorrhiza Lam.	..	..	..	×
Bruguiera parviflora (Roxb.) Wight et Arn.	..	..	..	×
Bruguiera rheedii Bl.	..	..	..	×
Bruguiera sexangula (Lour.) Poir.	..	..	..	×
Carallia brachiata (Lour.) Merr.	..	..	×	×
Ceriops tagal (Perr.) C. B. Robinson	..	..	×	×
Rhizophora mucronata Lam.	..	..	..	×
Rhizophora stylosa Griff.	..	..	..	×
COMBRETACEAE				
Lumnitzera littorea (Jack) Voigt	..	..	..	×
Lumnitzera racemosa Willd.	..	..	..	×
Macropteranthes kekwickii F. Muell.	..	×	×	..
Terminalia aridicola Domin	..	×	..	×
Terminalia arostrata Ewart et Davies	..	..	..	×
Terminalia bursarina F. Muell.	..	×	×	×
Terminalia canescens (DC.) Radlk.	..	×	×	..
Terminalia carpentariae White	..	..	..	×
Terminalia erythrocarpa F. Muell.	..	..	×	×
Terminalia ferdinandiana Exell	..	..	×	×
Terminalia grandiflora Benth.	..	×	×	×
Terminalia latipes Benth.	..	..	×	..
Terminalia melanocarpa F. Muell.	..	..	..	×
Terminalia platyphylla F. Muell.	..	..	×	×
Terminalia platyptera F. Muell.	..	..	×	×
Terminalia pterocarya F. Muell.	..	..	×	×
Terminalia sericocarpa F. Muell.	..	..	..	×
Terminalia volucris R.Br. ex Benth.	..	×	×	×
MYRTACEAE				
Acmena smithii (Poir.) Merr. et Perry	..	..	..	×
Baeckea intratropica (F. Muell.) Niedenzu	..	..	..	×
Baeckea polystemona F. Muell.	×	..	..	..
Baeckea virgata Andr.	..	..	×	..

	C.A.	B.T.	V.R.D.	D. & G.
Callistemon aff. *viminalis* (Sol. ex Gaertn.) G. Don ex Loud.	×	..	..	..
Calytrix achaeta F. Muell.	..	..	×	×
Calytrix arborescens F. Muell.	..	..	..	×
Calytrix brachychaeta F. Muell.	..	×	×	..
Calytrix laricina R.Br. ex Benth.	..	..	..	×
Calytrix longiflora F. Muell.	×	×	×	..
Calytrix microphylla A. Cunn.	..	×	×	×
Cleistocalyx operculata (Roxb.) Merr. et Perry	..	..	..	×
Eucalyptus abbreviata Blakely et Jacobs	..	..	×	×
Eucalyptus alba Reinw. ex Bl.	..	..	..	×
Eucalyptus apodophylla Blakely et Jacobs	..	..	..	×
Eucalyptus argillacea W. V. Fitzg.	×	×	×	×
Eucalyptus aspera F. Muell.	×	×	×	×
Eucalyptus bigalerita F. Muell.	..	..	×	×
Eucalyptus bleeseri Blakely	..	..	×	×
Eucalyptus brachyandra F. Muell.	..	..	×	..
Eucalyptus brevifolia F. Muell.	×	×	×	×
Eucalyptus camaldulensis Dehnh.	×	×	×	×
Eucalyptus clavigera A. Cunn. ex Schau.	..	..	..	×
Eucalyptus cliftoniana W. V. Fitzg.	..	..	×	..
Eucalyptus confertiflora F. Muell.	..	..	×	×
Eucalyptus cyanoclada Blakely	..	×	..	×
Eucalyptus dichromophloia F. Muell.	×	×	×	×
Eucalyptus ferruginea Schau.	..	×	×	×
Eucalyptus foelscheana F. Muell.	..	..	×	×
Eucalyptus gamophylla F. Muell.	×	..	..	..
Eucalyptus gongylocarpa Blakely	×	..	..	..
Eucalyptus grandifolia R.Br. ex Benth.	..	..	×	×
Eucalyptus herbertiana Maid.	..	..	..	×
Eucalyptus intertexta R. T. Bak.	×	..	..	..
Eucalyptus jacobsiana Blakely	..	..	..	×
Eucalyptus jensenii Maid.	..	..	×	×
Eucalyptus latifolia F. Muell.	..	..	×	×
Eucalyptus mannensis Boomsma	×	..	..	..
Eucalyptus microtheca F. Muell.	×	×	×	×
Eucalyptus miniata A. Cunn. ex Schau.	..	×	×	×
Eucalyptus morrisii R. T. Bak.	×	..	×	..
Eucalyptus nesophila Blakely	..	..	..	×
Eucalyptus normantonensis Maid. et Cambage	×	×	..	..
Eucalyptus odontocarpa F. Muell.	×	×	×	..
Eucalyptus oligantha Schau.	..	..	..	×
Eucalyptus oxymitra Blakely	×	..	..	..
Eucalyptus pachyphylla F. Muell.	×	×	×	..
Eucalyptus papuana F. Muell.	×	×	×	×
Eucalyptus patellaris F. Muell.	..	..	×	×
Eucalyptus phoenicea F. Muell.	..	..	×	×
Eucalyptus polycarpa F. Muell.	..	×	×	×
Eucalyptus porrecta S. T. Blake	..	..	..	×
Eucalyptus pruinosa Schau.	×	×	×	×
Eucalyptus ptychocarpa F. Muell.	..	..	..	×
Eucalyptus sessilis (Maid.) Blakely	×	..	..	..
Eucalyptus setosa Schau.	×	×	..	×
Eucalyptus tectifica F. Muell.	..	×	×	×
Eucalyptus terminalis F. Muell.	×	×	×	×
Eucalyptus tetrodonta F. Muell.	..	..	×	×
Eucalyptus thozetiana F. Muell.	×	..	..	..
Eucalyptus aff. *transcontinentalis* Maid.	×	..	..	..
Eucalyptus trivalvis Blakely	×	..	..	..
Eucalyptus umbrawarrensis Maid.	..	..	..	×
Eucalyptus websterana Maid.	×	..	..	..
Eugenia armstrongii Benth.	..	..	..	×
Eugenia bleeseri O. Schwarz	..	..	..	×
Eugenia eucalyptoides F. Muell.	..	..	×	×
Eugenia suborbicularis Benth.	..	..	..	×
Fenzlia retusa Endl.	..	..	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Homalocalyx ericaeus F. Muell.	..	..	..	×
Leptospermum abnorme F. Muell. ex Benth.	..	..	..	×
Melaleuca acacioides F. Muell.	×	..	..	×
Melaleuca alsophila A. Cunn. ex Benth.	..	..	×	..
Melaleuca argentea W. V. Fitzg.	..	..	×	×
Melaleuca bracteata F. Muell.	×	..	×	×
Melaleuca cajuputi Powell	..	..	..	×
Melaleuca dealbata S. T. Blake	..	..	..	×
Melaleuca dissitiflora F. Muell.	×	..	..	..
Melaleuca glomerata F. Muell.	×	..	×	..
Melaleuca lasiandra F. Muell.	×	×	×	×
Melaleuca leucadendron (L.) L.	..	..	..	×
Melaleuca linariifolia Sm.	×	..	..	..
Melaleuca linophylla F. Muell.	..	..	..	×
Melaleuca magnifica Specht	..	..	..	×
Melaleuca minutifolia F. Muell.	..	..	×	..
Melaleuca nervosa (Lindl.) Cheel	..	×	×	×
Melaleuca symphyocarpa F. Muell.	..	..	..	×
Melaleuca viridiflora Sol. ex Gaertn.	×	×	×	×
Melaleuca sp.	×	..	..	..
Metrosideros eucalyptoides (F. Muell.) F. Muell.	..	..	..	×
Micromyrtus flaviflora (F. Muell.) F. Muell. ex J. M. Black	×	..	..	..
Osbornia octodonta F. Muell.	..	..	..	×
Thryptomene maisonneuvii F. Muell.	×	..	..	..
Thryptomene parviflora (F. Muell.) Domin	×	..	..	..
Tristania grandiflora Cheel	..	×	×	×
Tristania lactiflua F. Muell.	..	..	..	×
Tristania suaveolens Sm. var. *glabrescens* F. M. Bail.	..	..	..	×
Tristania suaveolens Sm. var. *suaveolens*	..	..	×	×
Verticordia cunninghamii Schau.	..	..	×	×
Verticordia sp.	..	..	..	×
Xanthostemon paradoxus F. Muell.	..	..	×	×
MELASTOMATACEAE				
Melastoma denticulatum Labill.	..	..	..	×
Memecylon pauciflorum Bl.	..	..	..	×
Osbeckia australiana Naud.	..	..	×	×
ONAGRACEAE				
Ludwigia adscendens (L.) Hara	..	..	..	×
Ludwigia hyssopifolia (G. Don) Exell	..	..	..	×
Ludwigia octovalvis (Jacq.) Raven ssp. *octovalvis*	..	×	×	×
Ludwigia octovalvis (Jacq.) Raven ssp. *sessiliflora* (Mich.) Raven	..	×	..	×
Ludwigia perennis L.	..	×	×	×
HALORAGACEAE				
Haloragis acanthocarpa Brongn.	..	..	×	×
Haloragis glabrescens C. T. White	..	×	..	..
Haloragis gossei F. Muell.	×	..	..	..
Haloragis heterophylla Brongn. var. *glaucifolia* Schindler	..	..	×	..
Halorogis heterophylla Brongn. var. *heterophylla*	×	..	×	..
Haloragis odontocarpa F. Muell.	×	..	..	..
Loudonia roei (Endl.) Schldl.	×	..	..	..
Myriophyllum diococcum F. Muell.	..	..	..	×
Myriophyllum verrucosum Lindl.	×	..	×	×
ARALIACEAE				
Mackinlaya macrosciadea (F. Muell.) F. Muell.	..	..	..	×
Schefflera actinophylla (Endl.) Harms	..	..	..	×
UMBELLIFERAE				
Actinotus schwarzii F. Muell.	×	..	..	..
†*Apium leptophyllum* (DC.) F. Muell.	×	..	..	..
Daucus glochidiatus (Labill.) Fisch., Mey. et Ave-Lav.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Hydrocotyle trachycarpa F. Muell.	×	..	..	..
Platysace arnhemica Specht	..	..	..	×
Trachymene didiscoides (F. Muell.) B. L. Burtt	×	..	×	×
Trachymene dusenii (Domin) B. L. Burtt	..	..	×	..
Trachymene gilleniae (Tate ex Domin) B. L. Burtt	×	..	..	..
Trachymene glaucifolia (F. Muell.) Benth.	×	..	..	..
Trachymene microcephala (Vent.) B. L. Burtt	..	..	..	×
Trachymene setosa (O. Schwarz) B. L. Burtt	..	..	..	×
Trachymene villosa (F. Muell.) Benth.	..	..	×	×
EPACRIDACEAE				
Leucopogon sp.	×	..	..	..
MYRSINACEAE				
Aegiceras corniculatum (L.) Blanco	..	..	..	×
PRIMULACEAE				
†*Anagallis foemina* Mill.	×	..	..	..
**Anagallis pumila* Swartz	..	..	..	×
Samolus valerandi L.	×	..	..	..
PLUMBAGINACEAE				
Aegialitis annulata R.Br.	..	..	..	×
Plumbago zeylanica L.	×	..	×	×
SAPOTACEAE				
Mimusops elengi L.	..	..	..	×
Planchonella arnhemica (F. Muell. ex Benth.) van Royen	..	..	..	×
Planchonella crocodiliensis van Royen	..	..	..	×
Planchonella laurifolia (Richard) Pierre	..	..	..	×
Planchonella sericea (Ait.) Baehni	..	..	×	×
EBENACEAE				
Diospyros calycantha O. Schwarz	..	..	..	×
Diospyros ferrea (Willd.) Bakh. var. *humilis* (R.Br.) Bakh.	..	..	×	×
Diospyros maritima Bl.	..	..	..	×
Diospyros montana Roxb. var. *timorensis* Bakh.	..	..	×	×
Diospyros sp.	..	..	..	×
OLEACEAE				
Jasminum aemulum R.Br.	..	..	..	×
Jasminum calcarium F. Muell.	×	..	×	..
Jasminum didymum Forst. f.	..	..	×	×
Jasminum lineare R.Br.	×	..	..	..
Jasminum molle R.Br.	..	..	..	×
Jasminum simplicifolium Forst. f.	..	..	..	×
Jasminum volubile Jacq.	..	..	..	×
LOGANIACEAE				
Fagraea racemosa Jack	..	..	..	×
Mitrasacme alsinoides R.Br.	..	..	..	×
Mitrasacme arnhemica Specht var. *arnhemica*	..	..	..	×
Mitrasacme arnhemica Specht var. *pygmaea* Specht	..	..	..	×
Mitrasacme connata R.Br.	..	..	×	×
Mitrasacme elata R.Br.	..	..	..	×
Mitrasacme exserta F. Muell.	..	..	×	×
Mitrasacme gentianea F. Muell.	..	..	×	..
Mitrasacme indica Wight	..	..	×	..
Mitrasacme laevis Benth.	..	..	×	..
Mitrasacme laricifolia R.Br.	..	..	×	..
Mitrasacme longiflora F. Muell. ex Benth.	..	..	×	×
Mitrasacme lutea F. Muell.	..	..	..	×
Mitrasacme multicaulis R.Br.	..	..	×	..
Mitrasacme nummularia S. Moore	..	..	×	..
Mitrasacme polymorpha R.Br.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Mitrasacme prolifera R.Br.	..	..	×	..
Mitrasacme stellata R.Br. var. *latifolia* Benth.	..	..	×	×
Mitrasacme tenuiflora Benth.	..	..	×	..
Mitrasacme volubilis O. Schwarz	..	..	..	×
Strychnos lucida R.Br.	..	..	×	×
Gentianaceae				
Centaurium spicatum (L.) Fritsch	×	..	×	×
Canscora diffusa R.Br.	..	..	×	..
Menyanthaceae				
Nymphoides crenatum (F. Muell.) Kuntze	..	×	..	×
Nymphoides geminatum (R.Br.) Kuntze	×	..	..	×
Nymphoides furculaefolia Specht	..	..	..	×
Nymphoides indica (L.) Kuntze	..	..	..	×
Nymphoides minimum (F. Muell.) Kuntze	..	..	..	×
Apocynaceae				
Alstonia actinophylla (A. Cunn.) K. Schum.	..	..	..	×
Alstonia ophioxyloides F. Muell.	..	..	×	×
Alyxia spicata R.Br.	..	..	..	×
Carissa lanceolata R.Br.	×	×	×	×
Ervatamia orientalis (R.Br.) Domin	..	..	..	×
Ervatamia pubescens (R.Br.) Domin	..	..	..	×
Parsonsia velutina R.Br.	..	..	×	×
Wrightia pubescens R.Br. ssp. *pubescens*	..	..	..	×
Wrightia saligna (R.Br.) F. Muell. ex Benth.	..	..	×	×
Asclepiadaceae				
**Calotropis procera* (Willd.) R.Br. ex Ait.	..	..	..	×
Cynanchum carnosum (R.Br.) Domin	..	..	×	×
Cynanchum floribundum R.Br.	×	..	..	..
Cynanchum pedunculatum R.Br.	..	..	×	×
Cynanchum puberulum F. Muell. ex Benth.	..	..	×	..
Gymnanthera nitida R.Br.	..	..	×	×
Gymnema geminatum R.Br.	..	..	..	×
Gymnema muelleri Benth.	..	..	×	..
Gymnema stenophyllum A. Gray	..	..	×	×
Gymnema trinerve R.Br.	..	..	..	×
Hoya sp.	..	..	..	×
Leichhardtia australis R.Br.	×	..	×	..
Marsdenia cinerascens R.Br.	..	..	..	×
Marsdenia velutina R.Br.	..	..	..	×
Marsdenia viridiflora R.Br.	..	..	×	×
Microstemma glabriflorum F. Muell.	..	..	×	..
Pentatropis linearis Dcne.	×	..	..	..
Pentatropis quinquepartita Benth.	..	..	×	..
Sarcostemma australe R.Br.	×	..	×	×
Tylophora erecta F. Muell. ex Benth.	..	..	..	×
Tylophora flexuosa R.Br.	..	..	×	×
Tylophora macrophylla Benth.	..	..	..	×
Vincetoxicum ovatum Benth.	..	..	..	×
Convolvulaceae				
Bonamia linearis (R.Br.) Hall. f.	×	×	×	×
Bonamia pannosa (R.Br.) Hall. f.	..	×	×	×
Bonamia rosea (F. Muell.) Hall. f.	×	..	..	..
Convolvulus erubescens Sims	×	..	..	..
Cressa australis R.Br.	..	..	×	..
Cressa cretica L.	..	..	×	×
Cuscuta australis R.Br.	×	..	..	×
Dichondra repens Forst. et f.	..	..	..	×
Evolvulus alsinoides L. var. *alsinoides*	..	..	..	×
Evolvulus alsinoides L. var. *decumbens* (R.Br.) v. Ooststr.	×	×	×	×
Evolvulus alsinoides L. var. *sericeus* Benth.	..	..	..	×
Evolvulus alsinoides L. var. *villosicalyx* v. Ooststr.	×	×	×	×

	C.A.	B.T.	V.R.D.	D. & G.
Ipomoea abrupta R.Br.	..	..	..	×
Ipomoea alata R.Br.	..	×	..	..
Ipomoea aquatica Forsk.	×	..	×	×
Ipomoea aff. *aquatica* Forsk.	..	×	..	..
Ipomoea aff. *aquatica* Forsk.	..	..	..	×
Ipomoea aff. *biloba* Forsk.	..	×	..	..
Ipomoea coptica (L.) Roth. ex R. et S.	..	×	×	×
Ipomoea costata F. Muell. ex Benth.	×	×	..	..
Ipomoea aff. *costata* F. Muell. ex Benth.	..	..	..	×
Ipomoea davenportii F. Muell.	×	×	..	..
Ipomoea eriocarpa R.Br.	..	..	×	..
Ipomoea flava F. Muell. ex Benth.	..	..	..	×
Ipomoea gracilis R.Br.	..	..	..	×
Ipomoea graminea R.Br.	..	..	..	×
Ipomoea hederacea Jacq.	..	..	×	..
Ipomoea incisa R.Br.	..	..	×	..
Ipomoea lonchophylla J. M. Black	×	×	×	×
Ipomoea longiflora R.Br.	..	..	×	..
Ipomoea muelleri Benth.	×	..	×	..
Ipomoea nil (L.) Roth.	..	..	×	×
Ipomoea brasiliensis (L.) G. F. W. Mey.	..	..	..	×
Ipomoea plebeia R.Br.	..	..	..	×
Ipomoea polymorpha R. et S.	×	×	×	×
Ipomoea racemigera F. Muell. et Tate	×	..	..	..
Ipomoea triloba L.	..	..	..	×
Ipomoea velutina R.Br.	..	..	..	×
Jacquemontia browniana v. Ooststr.	..	×	×	×
Jacquemontia aff. *browniana* v. Ooststr.	..	..	..	×
Jacquemontia paniculata (Burm. f.) Hall. f. var. *paniculata*	..	..	×	×
Jacquemontia paniculata (Burm. f.) Hall. f. var. *tomentosa* (Warb.) v. Ooststr.	..	..	..	×
Merremia aegyptia (L.) Urban	..	..	..	×
**Merremia dissecta* (Jacq.) Hall. f.	..	..	..	×
Merremia gemella (Burm. f.) Hall. f.	..	..	..	×
Merremia quinata (R.Br.) v. Ooststr.	..	..	..	×
Merremia tridentata (L.) Hall. f. ssp. *angustifolia* (Jacq.) v. Ooststr.	..	..	×	×
Merremia tridentata (L.) Hall. f. ssp. *hastata* (Desf.) v. Ooststr.	..	..	..	×
Merremia tridentata (L.) Hall. f. ssp. *tridentata*	..	..	..	×
Operculina aff. *brownii* v. Ooststr.	..	×	..	..
Polymeria ambigua R.Br.	..	×	×	×
Polymeria longifolia Lindl.	..	×	..	..
Polymeria pusilla R.Br.	..	..	..	×
BORAGINACEAE				
†*Buglossoides arvense* (L.) I. M. Johnston	×	..	..	..
Coldenia procumbens L.	..	..	×	×
Cordia subcordata Lam.	..	..	..	×
Cynoglossum australe R.Br. var. *drummondii* (Benth.) Brand.	×	..	..	..
**Echium lycopsis* L.	×	..	..	..
Halgania cyanea Lindl. var. *cyanea*	×	..	..	..
Halgania cyanea Lindl. var. *preissiana* (Lehm.) Maid. et Betche	×	..	..	..
Halgania erecta Ewart et Rees	×	..	..	..
Halgania glabra J. M. Black	×	..	..	..
Halgania solanacea F. Muell.	×	×	×	..
Halgania aff. *solanacea* F. Muell.	..	..	×	..
Heliotropium asperrimum R.Br.	×	..	..	..
Heliotropium ballii Domin	..	×	..	..
Heliotropium bacciferum Forsk.	×	..	..	..
Heliotropium bracteatum R.Br. var. *bracteatum*	..	..	..	×
Heliotropium bracteatum R.Br. var. *leptostachyum* Benth.	..	..	..	×
Heliotropium carpentariae Specht	..	..	..	×
Heliotropium conocarpum F. Muell. ex Benth.	..	..	×	..

	C.A.	B.T.	V.R.D.	D. & G.
Heliotropium curassavicum L.	×	..	..	..
Heliotropium diversifolium F. Muell. ex Benth.	×	..	..	..
Heliotropium ethelium Ewart et McLennan	..	..	..	×
Heliotropium fasciculatum R.Br.	×	×	×	×
Heliotropium filaginoides Benth.	×	..	..	..
Heliotropium flaviflorum W. V. Fitzg.	..	×	..	..
Heliotropium heteranthum (F. Muell.) Ewart et Davies	×	..	..	..
Heliotropium indicum L.	..	..	..	×
Heliotropium ovalifolium Forsk.	×	×	×	×
Heliotropium paniculatum R.Br.	×	×	×	×
Heliotropium pleiopterum F. Muell.	×	..	..	..
Heliotropium strigosum Willd. ex DC.	×	..	×	..
Heliotropium tenuifolium R.Br. var. *parviflorum* J. M. Black	×	..	..	..
Heliotropium tenuifolium R.Br. var. *tenuifolium*	×	×	×	×
Heliotropium undulatum Vahl	..	..	..	×
Heliotropium ventricosum R.Br.	..	..	×	×
Heliotropium sp.	×	..	..	..
Messersmidia argentea (L.f.) I. M. Johnston	..	..	..	×
Omphalolappula concava (F. Muell.) Brand.	×	..	..	..
Trichodesma zeylanicum (Burm. f.) R.Br. var. *latisepalum* F. Muell.	..	×	×	..
Trichodesma zeylanicum (Burm. f.) R.Br. var. *zeylanicum*	×	×	×	×
Ehretiaceae				
Ehretia saligna R.Br.	×	×	×	..
Verbenaceae				
Avicennia marina (Forsk.) Vierh. var. *resinifera* (Forst. f.) Bakh.	..	..	..	×
Callicarpa cana L.	..	..	×	×
Clerodendrum cunninghamii Benth.	..	..	..	×
Clerodendrum floribundum R.Br.	×	×	×	×
Clerodendrum holtzei F. Muell.	..	..	..	×
Clerodendrum inerme (L.) Gaertn.	..	..	..	×
Clerodendrum tomentosum R.Br.	..	×	..	..
Denisonia tenuifolia F. Muell.	..	..	..	×
Dicrastylis beveridgei F. Muell.	×	..	..	..
Dicrastylis costelloi F. M. Bail.	×	..	..	..
Dicrastylis doranii F. Muell. var. *doranii*	×	..	..	..
Dicrastylis doranii F. Muell. var. *eriantha* F. Muell. ex J. M. Black	×	..	..	..
Dicrastylis exsuccosa (F. Muell.) Druce	×	×	×	..
Dicrastylis gilesii F. Muell.	×	..	..	..
Dicrastylis lewellinii (F. Muell.) F. Muell.	×	..	..	..
Gmelina dalrympleana (F. Muell.) H. J. Lam.	..	..	..	×
Huxleya linifolia Ewart et Rees	..	..	..	×
**Lantana camara* L.	..	..	..	×
Newcastlia bracteosa F. Muell.	×	..	..	..
Newcastlia cephalantha F. Muell.	×	..	..	..
Newcastlia spodiotricha F. Muell.	×	×	×	..
Phyla nodiflora (L.) Greene	..	..	×	×
Pityrodia hemigenioides (F. Muell.) F. Muell. ex Benth.	..	..	..	×
Pityrodia jamesii Specht	..	..	..	×
Premna acuminata R.Br.	..	×	×	×
Premna integrifolia L.	..	..	..	×
Premna obtusifolia R.Br.	..	..	..	×
Spartothamnella puberulus (F. Muell.) Maid. et Betche	×	..	..	..
Spartothamnella teucriiflora (F. Muell.) Moldenke	×	..	..	..
**Stachytarpheta dichotoma* (Ruiz. et Pav.) Vahl	..	..	..	×
**Stachytarpheta jamaicensis* (L.) Vahl	..	..	..	×
Verbena macrostachya F. Muell.	×	..	..	..
Verbena officinalis L.	×	..	..	..
Vitex glabrata R.Br.	..	..	×	×
Vitex ovata Thunb.	..	..	..	×
Vitex rotundifolia L.f.	..	..	..	×
Vitex trifolia L.	..	..	×	×

	C.A.	B.T.	V.R.D.	D. & G.
LABIATAE				
Anisomeles salviifolia R.Br.	..	..	×	×
Basilicum polystachyon (L.) Moench	..	..	×	×
Coleus scutellarioides (L.) Benth. var. *angustifolia* Benth.	..	..	×	×
Coleus scutellarioides (L.) Benth. var. *laxa* Benth.	..	..	..	×
Coleus scutellarioides (L.) Benth. var. *limnophila* F. Muell. ex Benth.	..	..	..	×
Coleus scutellarioides (L.) Benth. var. *scutellarioides*	..	..	..	×
**Hyptis suaveolens* (L.) Poit	..	..	..	×
**Leonotis nepetaefolia* R.Br.	..	..	..	×
Mentha australis R.Br.	×	..	..	..
Microcorys macredieana F. Muell.	×	..	..	..
Moschosma australe Benth.	..	..	×	×
Ocimum sanctum L. var. *angustifolium* Benth.	..	..	×	×
Plectranthus intraterraneus S. T. Blake	×	..	..	..
Plectranthus sp.	..	..	..	×
Prostanthera baxteri A. Cunn. ex Benth. var. *crassifolia* Benth.	×	..		..
Prostanthera baxteri A. Cunn. ex Benth. var. *sericea* J. M. Black	×	..	..	..
Prostanthera striatiflora F. Muell.	×	..	..	..
Prostanthera wilkieana F. Muell.	×	..	..	..
Teucrium grandiusculum F. Muell. et Tate	×	..	..	..
Teucrium integrifolium F. Muell. ex Benth.	×	×	×	..
Teucrium racemosum R.Br.	×	..	..	..
Wrixonia sp.	×	..	..	..
SOLANACEAE				
Anthotroche blackii F. Muell.	×	..	..	..
Datura leichhardtii F. Muell. ex Benth.	×	×	..	..
Duboisia hopwoodii (F. Muell.) F. Muell.	×	..	..	..
†*Lycium ferocissimum* Miers	×	..	..	..
Nicotiana benthamiana Domin	×	..	×	..
Nicotiana excelsior J. M. Black	×	..	..	..
**Nicotiana glauca* Grah.	×	..	..	..
Nicotiana gossei Domin	×	..	..	..
Nicotiana ingulba J. M. Black	×	..	..	..
Nicotiana megalosiphon Heurck et J. Muell.	×	..	..	..
Nicotiana occidentalis Wheeler ssp. *obliqua* Burbidge	×	..	..	..
Nicotiana simulans Burbidge	×	..	..	..
Nicotiana velutina Wheeler	×	..	..	..
Physalis minima L.	..	..	×	×
Solanum asymmetriphyllum Specht	..	..	..	×
Solanum centrale J. M. Black	×	..	..	..
Solanum chenopodinum F. Muell.	×	..	..	..
Solanum coactiliferum J. M. Black	×	..	..	..
Solanum cunninghamii Benth.	..	..	×	..
Solanum diversiflorum F. Muell.	×	..	×	×
Solanum echinatum R.Br.	..	..	×	..
Solanum ellipticum R.Br.	×	..	..	×
Solanum eremophilum F. Muell.	×	..	..	..
Solanum esuriale Lindl.	×	×	..	..
Solanum aff. *esuriale* Lindl.	×	..	..	..
Solanum ferocissimum Lindl.	×	..	..	..
Solanum lasiophyllum Dun.	×	..	..	..
Solanum lucanii F. Muell.	..	..	×	..
Solanum melanospermum F. Muell.	×	×	..	×
Solanum nigrum L.	×	..	..	..
Solanum aff. *orbiculatum* Dun.	×	..	..	..
Solanum petrophilum F. Muell. var.	×	..	×	..
Solanum phlomoides A. Cunn. ex Benth.	×	..	..	..
Solanum pugiunculiferum C. T. White	..	..	..	×
Solanum quadriloculatum F. Muell.	×	×	×	×
Solanum sturtianum F. Muell.	×	..	×	..
Solanum tetrandrum R.Br.	..	..	..	×
Solanum wilkinsii S. Moore	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Scrophulariaceae				
Adenosma muelleri Benth.	..	..	..	×
Bacopa floribunda (R.Br.) Wettst.	..	..	×	×
Buchnera filicaulis O. Schwarz	..	..	..	×
Buchnera linearis R.Br.	×	..	×	×
Buchnera tenella R.Br.	..	..	×	×
Buchnera tetragona R.Br.	..	..	..	×
Buchnera urticifolia R.Br.	..	..	×	×
Centranthera cochinchinensis (Lour.) Merr.	..	..	×	×
Elacholoma hornii F. Muell. et Tate	×	..	..	..
Hemiarrhena plantaginea Benth.	..	..	..	×
Ilysanthes clausa (F. Muell.) With.	..	..	×	..
Ilysanthes mitrasacmoides O. Schwarz	..	..	..	×
Limosella australis R.Br.	×	..	..	..
Limnophila chinensis (Osbeck) Merr.	..	..	..	×
Limnophila fragrans (Forst. f.) Seem.	..	..	×	×
Lindernia alsinoides R.Br.	..	..	..	×
Lindernia crustacea (L.) F. Muell.	..	..	..	×
Lindernia grossidentata O. Schwarz	..	..	..	×
Lindernia lobelioides (F. Muell.) F. Muell.	×	..	×	×
Lindernia pubescens (Benth.) F. Muell.	..	..	..	×
Lindernia scapigera R.Br.	..	..	..	×
Lindernia subulata R.Br. var. *glanduligera* Specht	..	..	..	×
Lindernia subulata R.Br. var. *subulata*	..	×	..	×
Microcarpaea muscosa R.Br.	..	..	..	×
Mimulus gracilis R.Br.	×	×	×	..
Mimulus linearis (R.Br.) Wettst.	..	..	..	×
Morgania floribunda Benth.	×	..	..	..
Morgania glabra R.Br.	×	×	×	×
Morgania gracilis R.Br.	×	..	..	..
Morgania parviflora Benth.	..	..	..	×
Morgania pubescens R.Br.	×	..	..	×
Peplidium humifusum Delile	..	..	×	..
Peplidium maritimum (L.f.) Wettst.	×	..	..	..
Peplidium muelleri Benth.	×	..	×	..
Scoparia dulcis L.	..	..	..	×
Stemodia coerulea Benth.	×	..	×	×
Stemodia debilis Benth.	..	..	..	×
Stemodia grossa Benth.	..	..	×	..
Stemodia micrantha O. Schwarz	..	..	..	×
Stemodia viscosa Roxb.	×	..	×	..
Stemodia viscosa Roxb. var.	×	..	..	..
Striga curviflora (R.Br.) Benth.	..	..	..	×
Striga multiflora Benth.	..	..	×	×
Bignoniaceae				
Dolichandrone filiformis (DC.) Seem.	..	..	×	×
Dolichandrone heterophylla F. Muell.	..	×	×	..
Pandorea doratoxylon (J. M. Black) J. M. Black	×	..	..	..
Pedaliaceae				
Josephinia eugeniae F. Muell.	×	..	×	..
**Sesamum indicum* L.	..	..	..	×
Martyniaceae				
**Martynia annua* L.	..	..	..	×
Lentibulariaceae				
Utricularia albiflora R.Br.	..	..	..	×
Utricularia bifida L. ex D. Oliver	..	..	..	×
Utricularia biloba R.Br.	..	..	..	×
Utricularia caerulea L.	..	..	..	×
Utricularia capilliflora F. Muell.	..	..	..	×
Utricularia ceratophylloides O. Schwarz	..	..	..	×
Utricularia chrysantha R.Br.	..	..	×	×
Utricularia dunstanii Lloyd	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Utricularia exoleta R.Br.	..	..	×	×
Utricularia flava R.Br.	..	..	..	×
Utricularia flexuosa Vahl	..	..	..	×
Utricularia fulva F. Muell.	..	..	×	×
Utricularia hamiltonii Lloyd	..	..	..	×
Utricularia holtzei F. Muell.	..	..	..	×
Utricularia inflexa Forsk. var. *stellaris* (L.f.) P. Taylor	..	..	..	×
Utricularia kamienski F. Muell.	..	..	..	×
Utricularia kimberleyensis C. A. Gardn.	..	..	..	×
Utricularia lasiocaulis F. Muell.	..	..	..	×
Utricularia leptoplectra F. Muell.	..	..	..	×
Utricularia leptorhyncha O. Schwarz	..	..	..	×
Utricularia limosa R.Br.	..	..	..	×
Utricularia minutissima Vahl	..	..	..	×
Utricularia pachyceras O. Schwarz	..	..	..	×
Utricularia scandens Benj.	..	..	..	×
Utricularia singerana F. Muell.	..	..	..	×
Utricularia tubulata F. Muell.	..	..	..	×
Utricularia uliginosa Vahl	..	..	×	×
ACANTHACEAE				
Acanthus ilicifolius L.	..	..	..	×
**Andrographis paniculata* (Burm.) Wall. ex Nees	..	..	..	×
**Barleria prionitis* L.	..	..	×	..
Dicliptera glabra Dcne.	..	..	×	×
Dipteracanthus corynothecus (F. Muell. ex Benth.) Brem. var. *corynothecus*	×	..	..	..
Dipteracanthus corynothecus (F. Muell. ex Benth.) Brem. var. *grandiflorus* Brem.	×	..	..	..
Dipteracanthus sessiliflorus Brem.	×	..	..	..
Ebermaiera glauca Nees	..	..	×	×
Hygrophila salicifolia Nees	..	..	×	×
Hypoestes floribunda R.Br. var. *angustifolia* Benth.	..	..	×	×
Hypoestes floribunda R.Br. var. *floribunda*	..	..	..	×
Hypoestes floribunda R.Br. var. *paniculata* Benth.	..	..	..	×
Nelsonia campestris R.Br.	..	..	×	×
Rostellularia pogonanthera F. Muell.	×	×	×	×
Sarojusticia kempeana (F. Muell.) Brem.	×	..	..	..
Thunbergia arnhemica F. Muell.	..	..	..	×
MYOPORACEAE				
Eremophila alternifolia R.Br.	×	..	..	..
Eremophila battii F. Muell. var. *battii*	×	..	..	..
Eremophila battii F. Muell. var. *major* J. M. Black	×	..	..	..
Eremophila bignoniiflora F. Muell.	..	×	..	..
Eremophila calycina S. Moore	×	..	..	..
Eremophila castelli arminii E. Pritz.	×	..	..	..
Eremophila christopheri F. Muell.	×	..	..	..
Eremophila cordatisepalea L. Smith	×	..	..	..
Eremophila dalyana F. Muell.	×	..	..	..
Eremophila duttonii F. Muell.	×	×	..	×
Eremophila elderi F. Muell.	×	..	..	..
Eremophila exotrachys Kraenzl.	×	..	..	..
Eremophila freelingii F. Muell.	×	..	..	..
Eremophila gibsonii F. Muell.	×	..	..	..
Eremophila gilesii F. Muell. var. *argentea* Ewart	×	..	..	..
Eremophila gilesii F. Muell. *filiforme* Ewart et Davies	×	..	..	..
Eremophila gilesii F. Muell. var. *gilesii*	×	..	..	..
Eremophila glabra (R.Br.) Ostenf.	×	..	..	..
Eremophila goodwinii F. Muell.	×	×	..	..
Eremophila latrobei F. Muell.	×	×	×	×
Eremophila leonhardiana E. Pritz.	×	..	..	..
Eremophila longifolia (R.Br.) F. Muell.	×	×	×	..
Eremophila macdonnellii F. Muell. var. *glabriuscula* J. M. Black	×	..	..	..
Eremophila macdonnellii F. Muell. var. *macdonnellii*	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Eremophila macdonnellii F. Muell. var. *macrocarpa* Ewart et Davies	×	. .	. .	. .
Eremophila maculata (Ker-Gawl.) F. Muell.	×	×	×	. .
Eremophila obovata L. Smith var. *obovata*	×	. .	. .	. .
Eremophila paisleyi F. Muell.	×	. .	. .	. .
Eremophila rotundifolia F. Muell.	×	. .	. .	. .
Eremophila serrulata (A. Cunn. ex A.DC.) Druce	×	. .	. .	. .
Eremophila strehlowii E. Pritz.	×	. .	. .	. .
Eremophila strongylophylla F. Muell.	×	. .	. .	. .
Eremophila sturtii R.Br.	×	. .	. .	. .
Eremophila willsii F. Muell. var. *integrifolia* Ewart	×	. .	. .	. .
Eremophila willsii F. Muell. var. *willsii*	×	. .	. .	. .
Myoporum montanum R.Br.	×	. .	. .	. .
PLANTAGINACEAE				
Plantago varia R.Br. sens. lat.	×	. .	. .	. .
RUBIACEAE				
Borreria australiana Specht	×	×	×	×
Borreria brachystema (R.Br. ex Benth.) Valet.	×	×	×	×
Borreria breviflora (F. Muell. ex Benth.) Specht	. .	×	×	×
Borreria breviflora (F. Muell. ex Benth.) Specht var.	. .	. .	. .	×
Borreria carpentariae Specht	. .	. .	. .	×
Borreria exserta (Benth.) K. Schum.	. .	. .	. .	×
Borreria geeingwa Specht var. *dilatata* (Benth.) Specht	. .	. .	. .	×
Borreria geeingwa Specht var. *hispida* (Benth.) Specht	. .	. .	. .	×
Borreria gilliesae Specht	. .	. .	. .	×
Borreria hillii Chippendale	×	. .	. .	. .
Borreria inaperta (F. Muell.) K. Schum.	. .	. .	×	. .
Borreria involucrata (O. Schwarz) Chippendale	. .	. .	. .	×
Borreria leptoloba (Benth.) Specht	. .	. .	. .	×
Borreria pogostoma (Benth.) K. Schum.	. .	. .	×	×
Borreria suffruticosa Specht	. .	. .	. .	×
Borreria sp.	. .	×	×	×
Canthium attenuatum R.Br. ex Benth.	×	×	×	. .
Canthium latifolium F. Muell. ex Benth.	×	. .	. .	. .
Canthium lineare E. Pritz.	×	. .	. .	. .
Canthium aff. *lucidum* Hook. et Arn.	. .	. .	. .	×
Canthium schultzii (O. Schwarz) Chippendale	. .	. .	. .	×
Canthium sp.	×	. .	. .	. .
Coelospermum reticulatum (F. Muell.) Benth.	. .	. .	×	×
Dentella asperata Airy-Shaw	×	. .	. .	. .
Dentella browniana Domin	. .	. .	. .	×
Dentella dioeca Airy-Shaw	. .	. .	. .	×
Dentella pulvinata Airy-Shaw var. *repanda* Airy-Shaw	×	. .	. .	. .
Dentella repens (L.) Forst. et f.	. .	. .	×	×
Gardenia edulis F. Muell.	. .	. .	×	×
Gardenia fucata R.Br. ex Benth.	. .	. .	. .	×
Gardenia megasperma F. Muell. var. *arborea* Ewart et Cookson	. .	×	×	. .
Gardenia megasperma F. Muell. var. *megasperma*	. .	. .	×	×
Gardenia aff. *megasperma* F. Muell.	. .	. .	. .	×
Gardenia petiolata O. Schwarz	. .	. .	. .	×
Gardenia pyriformis A. Cunn. ex Benth.	. .	. .	×	×
Gardenia resinosa F. Muell.	. .	. .	×	. .
Gardenia suffruticosa R.Br. ex Benth.	. .	. .	. .	×
Guettarda speciosa L.	. .	. .	. .	×
Hedyotis mitrasacmoides F. Muell.	. .	. .	×	×
Hedyotis pterospora F. Muell.	×	. .	×	. .
Hedyotis scleranthoides F. Muell.	×	. .	×	. .
Ixora coccinea L.	. .	. .	. .	×
Ixora klanderana F. Muell.	. .	. .	. .	×
Ixora pentamera Benth.	. .	. .	. .	×
Ixora timorensis Dcne.	. .	. .	. .	×
Ixora tomentosa Roxb.	. .	. .	×	×
Knoxia stricta Gaertn.	. .	. .	. .	×

	C.A.	B.T.	V.R.D.	D. & G.
Morinda citrifolia L.	..	..	..	×
Nauclea orientalis L.	..	..	×	×
Oldenlandia corymbosa L.	..	..	..	×
Oldenlandia galioides (F. Muell.) F. Muell.	×	..	..	×
Oldenlandia mollugoides O. Schwarz	..	..	..	×
Oldenlandia tenuissima O. Schwarz	..	..	..	×
Pavetta brownii Brem. var. *brownii*	..	..	..	×
Pavetta brownii Brem. var. *glabra* Brem.	..	..	..	×
Pavetta granitica F. Muell. ex Brem.	..	×	×	..
Pavetta muelleri Brem.	..	..	..	×
Pomax umbellata (Gaertn.) Soland. ex A. Rich.	×	..	..	..
Psychotria nesophila F. Muell.	..	..	..	×
Randia cochinchinensis (Lour.) Merr.	..	..	..	×
Randia lamprophylla O. Schwarz	..	..	..	×
Scyphiphora hydrophyllacea Gaertn. f.	..	..	..	×
Synaptantha tillaeacea (F. Muell.) Hook. f.	×	..	..	..
Tarenna dallachiana (F. Muell. ex Benth.) S. Moore	..	..	..	×
Timonius timon (Spreng.) Merr.	..	..	×	×
CUCURBITACEAE				
Bryonopsis laciniosa (L.) Naud.	..	..	..	×
**Citrullis colocynthus* (L.) Schrad.	×	×	..	..
**Citrullis lanatus* (Thunb.) Mansf.	×	×	..	×
Coccinea cordifolia (L.) Cogn.	..	..	..	×
Coldenia procumbens L.	..	..	..	×
Cucumis melo L. ssp. *agrestis* (Naud.) Greb.	×	..	×	×
**Cucumis myriocarpus* Naud.	×	..	..	..
Luffa aegyptiaca Mill.	..	..	..	×
Luffa graveolens Roxb.	..	..	×	..
Melothria maderaspatana (L.) Cogn.	×	×	×	×
Melothria micrantha (F. Muell.) F. Muell. ex Cogn.	×	..	..	..
Trichosanthes cucumerina L.	..	..	×	..
CAMPANULACEAE				
Isotoma petraea F. Muell.	×	..	..	..
Lobelia arnhemiaca Wimmer	..	..	×	..
Lobelia dioica R.Br.	..	..	..	×
Lobelia heterophylla Labill.	×	..	..	..
Lobelia stenophylla Benth.	..	..	..	×
Lobelia quadrangularis R.Br.	..	..	×	×
Lobelia aff. *rhombifolia* de Vr.	×	..	..	..
Wahlenbergia sp.	×	..	..	..
Wahlenbergia sp.	×	..	..	..
Wahlenbergia sp.	×	..	..	..
Wahlenbergia sp.	×	..	×	..
Wahlenbergia sp.	..	..	×	..
Wahlenbergia sp.	..	..	..	×
GOODENIACEAE				
Calogyne berardiana (Gaud.) F. Muell.	×	..	..	..
Calogyne heteroptera F. Muell.	..	..	..	×
Calogyne hians O. Schwarz	..	..	..	×
Calogyne holtzeana Specht	..	..	..	×
Calogyne pilosa R.Br.	..	×	..	×
Calogyne purpurea F. Muell.	..	..	..	×
Calogyne raphanoides O. Schwarz	..	..	..	×
Catosperma goodeniaceum (F. Muell.) Krause	×	×	×	..
Dampiera candicans F. Muell.	×	..	×	..
Dampiera cinerea Ewart et Davies	×	..	..	..
Goodenia armitiana F. Muell. var. *armitiana*	×	×	×	×
Goodenia armitiana F. Muell. var. *multicaulis* Blakely	×	..	..	..
Goodenia armstrongiana de Vr.	..	..	×	×
Goodenia aff. *armstrongiana* de Vr.	..	..	..	×
Goodenia auriculata Benth.	..	..	×	×
Goodenia aff. *auriculata* Benth.	..	..	..	×
Goodenia azurea F. Muell.	×	×	×	..

	C.A.	B.T.	V.R.D.	D. & G.
Goodenia basedowii Krause	×	..	..	..
Goodenia cirrifera F. Muell.	..	..	..	×
Goodenia aff. *coronopifolia* R.Br.	..	..	×	..
Goodenia cycloptera R.Br.	×	..	..	..
Goodenia erecta Ewart	×	..	..	..
Goodenia glabra R.Br.	×	..	..	..
Goodenia glauca F. Muell.	×	..	×	..
Goodenia gracilis R.Br.	..	×	..	..
Goodenia grandiflora Sims	×	..	..	..
Goodenia heterochila F. Muell. var. *foliosa* Benth.	..	..	×	..
Goodenia heterochila F. Muell. var. *heterochila*	×	×	..	×
Goodenia heterochila F. Muell. var. *runcinata* Benth.	..	..	..	×
Goodenia hirsuta F. Muell.	×	..	..	..
Goodenia hispida R.Br.	..	..	..	×
Goodenia aff. *hispida* R.Br.	..	..	..	×
Goodenia horniana Tate	×	..	..	..
Goodenia lamprosperma F. Muell.	..	..	×	×
Goodenia larapinta Tate	×	..	..	..
Goodenia linifolia W. V. Fitzg. ex Krause	×	..	×	..
Goodenia lunata J. M. Black	×	×	..	..
Goodenia microptera F. Muell.	×	..	..	..
Goodenia mitchelliana Benth.	×	..	..	..
Goodenia mueckeana F. Muell.	×	..	..	..
Goodenia pumilio R.Br.	..	..	..	×
Goodenia purpurascens R.Br. var. *minima* F. Muell. ex Benth.	..	..	×	×
Goodenia purpurascens R.Br. var. *purpurascens*	..	..	×	×
Goodenia ramelii F. Muell.	×	×	..	..
Goodenia scaevolina F. Muell.	..	..	×	..
Goodenia sepalosa F. Muell. ex Benth. var. *brachypoda* F. Muell. ex Benth.	..	..	×	..
Goodenia sepalosa F. Muell. ex Benth. var. *sepalosa*	..	..	..	×
Goodenia strangfordii F. Muell.	×	×	×	..
Goodenia subintegra F. Muell. ex Tate	×	×	..	..
Goodenia vilmorinae F. Muell.	×	..	×	..
Goodenia sp.	×	..	..	..
Goodenia sp.	×	..	..	..
Leschenaultia agrostophylla F. Muell.	..	..	×	×
Leschenaultia divaricata F. Muell.	×	..	..	..
Leschenaultia filiformis R.Br.	..	..	..	×
Leschenaultia striata F. Muell.	×	..	..	..
Scaevola aemula F. Muell.	×	×	..	×
Scaevola aff. *aemula* F. Muell.	×	..	..	..
Scaevola angulata R.Br.	..	..	..	×
Scaevola collaris F. Muell.	×	..	..	..
Scaevola daleana Blakely	×	..	..	..
Scaevola densevestita Domin	..	×	..	..
Scaevola depauperata R.Br.	×	..	..	..
Scaevola frutescens (Mill.) Krause	..	..	×	×
Scaevola ovalifolia R.Br. var. *glabra* R.Br.	×	..	..	..
Scaevola ovalifolia R.Br. var. *ovalifolia*	×	×	×	..
Scaevola paniculata Ewart et Davies	..	×	..	×
Scaevola parvifolia F. Muell. ex Benth.	×	×	×	..
Scaevola revoluta R.Br.	..	..	×	..
Scaevola spinescens R.Br.	×	..	..	..
Velleia connata F. Muell.	×	..	..	..
Velleia glabrata Carolin	×	..	..	..
Velleia macrocalyx de Vr.	×	×	..	..
BRUNONIACEAE				
Brunonia australis Sm.	×	..	×	..
STYLIDIACEAE				
Levenhookia chippendalei Erickson et Willis	..	..	×	..
Stylidium alsinoides R.Br.	..	..	×	×
Stylidium ceratophorum O. Schwarz	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Stylidium cordifolium W. V. Fitzg.	..	..	..	×
Stylidium ericksonae J. H. Willis	..	..	..	×
Stylidium fissilobium F. Muell.	..	..	×	×
Stylidium floodii F. Muell.	×	..	×	×
Stylidium floribundum R.Br.	×	..	×	×
Stylidium inaequipetalum J. M. Black	×	..	..	..
Stylidium irriguum W. V. Fitzg.	..	..	..	×
Stylidium leptorrhizum F. Muell.	..	..	×	×
Stylidium lobuliflorum F. Muell.	..	..	×	..
Stylidium multiscapum O. Schwarz	..	..	..	×
Stylidium muscicola F. Muell.	..	..	×	×
Stylidium pachyrrhizum F. Muell.	..	..	..	×
Stylidium pedunculatum R.Br.	..	..	..	×
Stylidium quadrifurcatum Erickson et Willis	..	..	..	×
Stylidium schizanthum F. Muell.	..	..	×	×
Stylidium tenerrimum F. Muell.	..	..	..	×
Stylidium uliginosum Sw.	..	..	..	×
COMPOSITAE				
**Acanthospermum hispidum* DC.	..	×	..	×
Actinobole uliginosum (A. Gray) Eichler	×	..	..	..
Adenostemma lavenia (L.) Kuntze	..	..	..	×
Ageratum conyzoides L.	..	..	..	×
Angianthus pusillus (Benth.) Benth.	×	..	..	..
Angianthus tenellus (F. Muell.) Benth.	×	..	..	..
Bidens bipinnata L.	×	..	×	×
**Bidens pilosa* L.	..	..	..	×
Blainvillea dubia Specht	..	..	..	×
Blumea diffusa R.Br. ex Benth.	..	..	..	×
Blumea hieracifolia (D. Don) DC.	..	..	..	×
Blumea integrifolia DC.	..	×	×	×
Blumea lacera (Burm. f.) DC.	..	..	×	×
Blumea mollis (D. Don) Merr.	..	..	×	×
Blumea pannosa O. Schwarz	..	..	..	×
Blumea saxatilis Zoll. et Mor.	..	..	..	×
Brachycome blackii Davis	×	..	..	..
Brachycome ciliaris (Labill.) Less. var. *ciliaris*	×	..	..	..
Brachycome ciliaris (Labill.) Less. var. *lanuginosa* (Steetz) Benth.	×	..	..	..
Brachycome iberidifolia Benth.	×	..	..	..
Brachycome lineariloba (DC.) Druce	×	..	..	..
Brachycome tesquorum J. M. Black	×	..	..	..
Calocephalus knappii Ewart et Davies	×	..	..	..
Calocephalus platycephalus (F. Muell.) Benth.	×	..	..	..
Calotis breviseta Benth.	..	×	×	×
Calotis cuneifolia R.Br.	×	..	..	..
Calotis cymbacantha F. Muell.	×	..	..	..
Calotis erinacea Steetz	×	..	..	..
Calotis hispidula (F. Muell.) F. Muell.	×	×	..	×
Calotis kempei F. Muell.	×	..	..	..
Calotis latiuscula F. Muell. et Tate	×	..	..	..
Calotis multicaulis (Turcz.) Druce	×	..	..	..
Calotis porphyroglossa F. Muell. ex Benth.	×	..	..	..
**Carthamus lanatus* L.	×	..	..	..
Centipeda cunninghamii (DC.) A.Br. et Aschers	×	..	..	×
Centipeda minima (L.) A.Br. et Aschers var. *lanuginosa* (DC.) Domin	×	..	..	..
Centipeda minima (L.) A.Br. et Aschers var. *minima*	×	..	×	..
Centipeda thespidioides F. Muell.	×	..	..	..
Chthonocephalus pseudevax Steetz	×	..	..	..
Coleocoma centaurea F. Muell.	×	..	×	..
**Conyza bonariensis* (L.) Cronquist	×	..	..	..
Craspedia chrysantha (Schlechtd.) Benth.	..	×	..	..
†*Cryptostemma calendula* (L.) Druce	×	..	..	..
Eclipta alatocarpa Melville	..	×	..	..
Eclipta platyglossa F. Muell.	..	..	..	×

	C.A.	B.T.	V.R.D.	D. & G.
Eclipta prostrata (L.) L.	. .	. .	. .	×
Elephantopus scaber L.	. .	. .	. .	×
**Emilia sonchifolia* (L.) DC.	. .	. .	. .	×
Epaltes australis Less.	×	. .	×	×
Erigeron ambiguus F. Muell.	. .	×	. .	×
**Erigeron floribundus* (H.B.K.) Sch.Bip.	×	. .	. .	. .
Flaveria australasica Hook.	×	×	×	×
Glossogyne filifolia F. Muell. ex Benth.	. .	. .	×	. .
Glossogyne tenuifolia (Labill.) Cass.	×	. .	. .	. .
Gnaphalium involucratum Forst. f.	×	. .	. .	. .
Gnaphalium luteoalbum L.	×	×	. .	. .
Gnephosis eriocarpa (F. Muell.) Benth.	×	. .	. .	. .
Gnephosis foliata (Sond.) Eichler	×	. .	. .	. .
Helichrysum ambiguum Turcz. var. *ambiguum*	×	. .	. .	. .
Helichrysum ambiguum Turcz. var. *paucisetum* J. M. Black	×	. .	. .	. .
Helichrysum aff. *ambiguum* Turcz.	×	. .	. .	. .
Helichrysum apiculatum (Labill.) D. Don	×	. .	. .	. .
Helichrysum ayersii F. Muell.	×	. .	. .	. .
Helichrysum bracteatum (Vent.) Andr.	×	. .	. .	×
Helichrysum cassinianum Gaud.	×	. .	. .	. .
Helichrysum davenportii F. Muell.	×	. .	. .	. .
Helichrysum kempei F. Muell.	×	. .	. .	. .
Helichrysum ramossisimum Hook.	×	. .	. .	. .
Helichrysum semifertile F. Muell.	×	. .	. .	. .
Helichrysum thomsonii F. Muell.	×	. .	. .	. .
Helipterum charsleyae F. Muell.	×	. .	. .	. .
Helipterum corymbiflorum Schlechtd.	×	. .	. .	. .
Helipterum fitzgibbonii F. Muell.	×	. .	. .	. .
Helipterum floribundum DC.	×	. .	. .	. .
Helipterum moschatum (A. Cunn. ex DC.) Benth.	×	. .	. .	. .
Helipterum pterochaetum (F. Muell.) Benth.	×	. .	. .	. .
Helipterum saxatile Wilson	×	. .	. .	. .
Helipterum stipitatum (F. Muell.) F. Muell. ex Benth.	×	. .	. .	. .
Helipterum strictum (Lindl.) Benth.	×	. .	. .	. .
Helipterum tietkensii F. Muell.	×	. .	. .	. .
†*Hypochoeris glabra* L.	×	. .	. .	. .
Ixiolaena leptolepis (DC.) Benth.	×	. .	×	. .
†*Lactuca serriola* L. var. *integrifolia* Gren. et Godr.	×	. .	. .	. .
†*Lactuca serriola* L. var. *serriola*	×	. .	. .	. .
Millotia greevesii F. Muell. ssp. *kempei* (F. Muell.) Schodde var. *helmsii* (F. Muell. et Tate) Schodde	×	. .	. .	. .
Millotia greevesii F. Muell. ssp. *kempei* (F. Muell.) Schodde var. *kempei*	×	. .	. .	. .
Minuria cunninghamii Benth.	×	. .	. .	. .
Minuria denticulata (DC.) Benth.	×	. .	. .	. .
Minuria integerrima (DC.) Benth.	×	×	×	. .
Minuria leptophylla DC.	×	. .	. .	. .
Moonia ecliptoides (F. Muell.) Benth.	. .	. .	×	×
Moonia procumbens (DC.) Benth.	. .	. .	. .	×
Myriocephalus rudallii (F. Muell.) Benth.	×	. .	. .	. .
Myriocephalus stuartii (F. Muell. et Sond. ex Sond.) Benth.	×	. .	. .	. .
Olearia ferresii (F. Muell.) F. Muell. ex Benth.	×	. .	. .	. .
Olearia aff. *muelleri* (Sond.) Benth.	×	. .	. .	. .
Olearia stuartii (F. Muell.) F. Muell. ex Benth.	×	. .	. .	. .
Olearia subspicata (Hook.) Benth.	×	. .	. .	. .
Phacellothrix cladochaeta F. Muell.	. .	. .	. .	×
Pluchea dentex R.Br. ex Benth.	×	×	. .	. .
Pluchea indica Less.	. .	. .	. .	×
Pluchea rubelliflora (F. Muell.) B. L. Robinson	×	. .	×	. .
Pluchea squarrosa Benth.	×	. .	. .	. .
Pluchea tetranthera F. Muell. var. *tetranthera*	. .	. .	×	. .
Pluchea tetranthera F. Muell. var. *tomentosa* Benth.	×	. .	. .	×
Pleurocarpaea denticulata Benth.	. .	. .	. .	×
Podocoma cuneifolia R.Br.	×	. .	. .	. .
Podocoma sp.	×	. .	. .	. .

	C.A.	B.T.	V.R.D.	D. & G.
Podolepis canescens A. Cunn. ex DC.	×	..	..	..
Podolepis capillaris (Steetz) Diels	×	..	..	..
Podolepis georgei Diels	×	..	..	..
Pterigeron adscendens Benth.	×	..	..	..
Pterigeron cylindriceps J. M. Black	×	..	..	..
Pterigeron decurrens (DC.) Benth.	×	..	×	..
Pterigeron dentatifolius F. Muell.	×	..	..	..
Pterigeron liatroides (Turcz.) Benth.	×	×	..	..
Pterigeron odorus (F. Muell.) Benth. var. *major* Benth.	..	..	..	×
Pterigeron odorus (F. Muell.) Benth. var. *odorus*	×	×	×	..
Pterocaulon glandulosum (F. Muell. ex Benth.) Benth. et Hook. f. var. *glandulosum*	×	×	..	..
Pterocaulon glandulosum (F. Muell. ex Benth.) Benth. et Hook. f. var. *velutinum* Ewart et Davies	×	..	×	×
Pterocaulon serratum O. Schwarz	..	..	..	×
Pterocaulon sphacelatum (Labill.) Benth. et Hook. f.	×	×	×	×
Pterocaulon verbascifolium F. Muell.	..	..	×	×
Rutidosis helichrysoides DC.	×	×	×	..
Senecio aff. *cunninghamii* DC.	×	..	..	..
Senecio gregorii F. Muell.	×	..	..	..
Senecio laceratus (F. Muell.) Belcher	×	..	..	..
Senecio lautus Forst. f. ex Willd. aff. ssp. *dissectifolius* Ali	×	×	..	..
Senecio magnificus F. Muell.	×	..	..	..
Senecio odoratus Hornemann	×	..	..	..
Senecio sp.	..	×	..	..
Sigesbeckia microcephala DC.	×	..	..	..
**Sonchus oleraceus* L.	×	..	..	..
Sphaeranthus africanus L.	..	..	..	×
Sphaeranthus hirtus Willd.	..	..	×	×
Sphaeranthus indicus L.	..	×	×	..
Spilanthes grandiflora Turcz.	..	×	..	..
Synedrella nodiflora (L.) Gaertn.	..	..	..	×
Thespidium basiflorum (F. Muell.) F. Muell.	..	..	..	×
**Tridax procumbens* L.	..	..	..	×
Vernonia cinerea (L.) Less. var. *cinerea*	..	..	×	×
Vernonia cinerea (L.) Less. var. *lanata* Kost.	×	..	..	×
Vittadinia brachycomoides F. Muell.	..	..	×	×
Vittadinia macrorhiza (DC.) A. Gray	..	×	..	×
Vittadinia pterochaeta (F. Muell. ex Benth.) J. M. Black	×	..	..	..
Vittadinia scabra DC.	×	..	..	..
Vittadinia aff. *scabra* sensu J. M. Black	×	..	..	..
Vittadinia triloba (Gaud.) DC. sens. lat.	×	..	..	..
Vittadinia sp.	×	..	..	..
Vittadinia sp.	×	..	..	..
Waitzia acuminata Steetz	×	..	..	..
Waitzia citrina (Benth.) Steetz	×	..	..	..
Wedelia asperrima (Dcne.) Benth.	×	×	×	..
Wedelia biflora (L.) DC.	..	..	..	×
Wedelia stirlingii Tate	×	..	..	..
Wedelia verbesinoides F. Muell. ex Benth.	..	..	..	×
**Xanthium spinosum* L.	×	..	..	..

ADDENDUM

Since this paper was submitted to the Society, several papers concerning Northern Territory plants have been published. These are:

COURT, A. B., 1971.—A new combination in the genus *Bossiaea* Vent. (*Papilionaceae*). *Muelleria*, 2 (2): 139–42.

FRYXELL, P. A., and HASHMI, SHARIFUL H., 1971.—The segregation of *Radyera* from *Hibiscus* (Malvaceae). *Bot. Gaz.*, 132 (1): 57–62.

MACONOCHIE, J. R., and BYRNES, N., 1971.—Additions to the Flora of the Northern Territory. *Muelleria*, 2 (2): 133–37.

MACONOCHIE, J. R., and PARKER, S. A., 1971.—Further collections of two little known *Stylidiaceae* from the Northern Territory. *Muelleria*, 2 (2): 145.

The information and records in these papers will mean small corrections to Tables 1 and 2, but do not significantly affect the comments on these tables. The records in the papers bring the total numbers of plant species now known to the following :

Northern Territory :	2736 native spp.,	114 introduced spp.
Central Australia :	1208 ,, ,,	55 ,, ,,
Barkly Tableland :	495 ,, ,,	8 ,, ,,
Victoria River District :	919 ,, ,,	9 ,, ,,
Darwin and Gulf :	1581 ,, ,,	64 ,, ,,

Additions to the Check List are :

	C.A.	B.T.	V.R.D.	D. & G.
TYPHACEAE				
Typha orientalis Presl	..	..	..	×
HYDROCHARITACEAE				
Blyxa aubertii Rich.	..	..	..	×
Maidenia rubra (W. V. Fitzg.) Rendle	..	..	..	×
GRAMINEAE				
Eragrostis australasica (Steud.) C. E. Hubbard	×	..	..	..
Eragrostis clelandii S. T. Blake	×	..	..	..
Sporobolus elongatus R.Br.	×	..	..	..
PONTEDERIACEAE				
Monochoria hastata (L.) Solms.	..	..	..	×
ORCHIDACEAE				
Nervilia discolor (Bl.) Schltr.	..	..	..	×
Nervilia holochila (F. Muell.) Schltr.	..	..	..	×
PROTEACEAE				
Grevillea erythroclada W. V. Fitzg.	..	..	..	×
Grevillea pterosperma F. Muell.	×	..	..	..
Hakea rhombales F. Muell.	×	..	..	..
SANTALACEAE				
Santalum album L.	..	..	..	×
CHENOPODIACEAE				
Atriplex suberecta I. C. Verdoorn	×	..	..	..
Bassia astrocarpa F. Muell.	×	..	..	..
Bassia articulata J. M. Black	×	..	..	..
Bassia brachyptera (F. Muell.) R. H. Anderson	×	..	..	..
Bassia georgei E. H. Ising	×	..	..	..
Bassia minuta E. H. Ising	×	..	..	..
Kochia radiata P. G. Wilson	..	×	..	..
Malacocera tricornis (Benth.) R. H. Anderson	×	..	..	..
Suaeda australis (R.Br.) Moq.	..	..	..	×
AMARANTHACEAE				
Ptilotus royceanus Benl	×	..	..	..
PORTULACACEAE				
Anacampseros australiana J. M. Black	×	..	..	..
Calandrinia disperma J. M. Black	×	..	..	..
MIMOSACEAE				
Acacia pachyacra Maiden et Blakely	×	..	..	..
PAPILIONACEAE				
Bossiaea bossiaeoides (A. Cunn. ex Benth.) A. B. Court (syn. *Bossiaea phylloclada* F. Muell.)	..	..	..	×
Crotalaria alata Buch.-Ham. ex D. Don	..	..	..	×
Crotalaria quinquifolia L.	..	..	..	×
ZYGOPHYLLACEAE				
Tribulus hirsutus Benth.	×	..	..	..

	C.A.	B.T.	V.R.D.	D. & G.
Rutaceae				
Geijera linearifolia (DC.) J. M. Black	×	..	..	..
Euphorbiaceae				
Omalanthus populifolius Grah.	..	..	..	×
Rhamnaceae				
Emmenosperma cunninghamii Benth.	..	..	..	×
Malvaceae				
Radyera farragei (F. Muell.) Fryxell et Hashmi (syn. *Hibiscus farragei* F. Muell.)	×	..	..	..
Combretaceae				
Terminalia crassifolia Exell	..	..	..	×
Terminalia fitzgeraldii C. A. Gardner	..	..	..	×
Boraginaceae				
**Amsinckia hispida* (Ruiz. et Pav.) I. M. Johnston	×	..	..	..
Verbenaceae				
Newcastlia cladotricha F. Muell.	×	..	..	..
Scrophulariaceae				
Mimulus prostratus Benth.	×	..	..	..
Mimulus repens R.Br.	×	..	..	..
Myoporaceae				
Eremophila polyclada (F. Muell.) F. Muell.	×	..	..	..
Eremophila turtonii F. Muell.	×	..	..	..
Goodeniaceae				
Leschenaultia helmsii Krause	×	..	..	..
Stylidiaceae				
Levenhookia chippendalei Erickson et Willis	×	..	×	..

A BRACHYOPID LABYRINTHODONT FROM THE LOWER TRIAS OF QUEENSLAND

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(Plates XIV, XV)

Synopsis

The skull of a new species of brachyopid labyrinthodont from the Lower Triassic Rewan Formation of Queensland is described and compared with other brachyopids using the method of Welles and Estes (1969). It is the most complete and the best ossified brachyopid yet found and is closely related to a form from the Mangali Beds of Central India.

Introduction

Following an initial productive field trip to the Lower Triassic Rewan Formation in 1969 (Bartholomai and Howie, 1970 ; Howie, in press), a second trip was organized in June, 1970. The purpose of this was first to collect from known vertebrate-bearing localities, and second to explore likely areas of the Bowen Basin for further Rewan exposures. The trip was a success on both counts, yielding an excellent capitosaur skull (an account of which is almost ready for publication), several small reptile skulls similar to those reported by Bartholomai and Howie (1970), a tiny (2 cm.) temnospondylous labyrinthodont skull, and many fragmentary fish, amphibian and reptilian remains from the chief known locality (Queensland Museum field locality L78), and providing us with a new productive locality some 79 miles north-north-east from L78.

Field Locality

The new locality (A. A. Howie Field Locality Q6) is at the headwaters of Duckworth Creek, south-west of the settlement of Bluff, and lies on the north-west edge of the Mimosa Syncline. Here faces of the rarely exposed Rewan Formation are found beneath the more massive escarpments of the Middle Triassic Clematis Sandstone and the overlying Lower Jurassic Precipice Sandstone which form the northern edges of the Blackdown Tableland. Malone, Olgers and Kirkegaard (1969) note that in this area the Rewan sediments are so similar lithologically and in stratigraphic position to the Rewan Formation of the type area (which is near locality L78) that direct correlation is justified and add that they are almost certainly continuous below the surface.

This Duckworth Creek exposure consists of several small linked erosion gullies, and specimens are found in these and in the alluvium at their bases. Rewan mudstone was exposed to a maximum depth of about 20 feet and included a single broad pale green band of very fine-grained sandstone.

Associated Material

Associated with the brachyopid labyrinthodont described below were several other amphibian species but no fish or reptiles, a strong contrast with locality L78, where reptiles were a common component of the fauna. Laby-

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rinthodont remains include a femur which probably belonged to a very large capitosaur, left and right femora and other postcranial remains of a more terrestrial type of labyrinthodont, nodules containing rhachitomous vertebrae, bone scraps bearing ornament of the type described by Cosgriff (1965) in *Deltasaurus kimberleyensis*, numerous coprolites, and fragments of an unprepared skull which I think can be assigned to *Rewana* sp. (Howie, in press). Although the brachyopid skull was found in the red mudstone, all the other more complete remains came preserved in nodules from the pale green band.

The Family Brachyopidae

In 1956 Watson published a review of the brachyopid labyrinthodonts and was followed by Cosgriff (1969), who largely used Watson's criteria for inclusion of a species within the Family Brachyopidae, and Welles and Estes (1969), who built on studies of Watson, Shishkin (1964, 1966) and Bystrow (1935) to establish a revised and extended set of brachyopid characters.

Within the " brachyopids proper " Watson recognized *Bothriceps australis* and *B. major* (which he renamed *Trucheosaurus*), *Brachyops laticeps*, *Batrachosuchus watsoni* and *B. browni*, *Pelorocephalus*, and "*Platyceps*" *wilkinsoni*, but he included forms such as *Eobrachyops*, *Dvinosaurus* and the plagiosaurs within a larger brachyopid grouping. Panchen showed in 1959 that the plagiosaurs were not closely allied to the brachyopids. Cosgriff made "*Platyceps*" *wilkinsoni* the type of a new genus, *Blinasaurus* which had two known species, *B. wilkinsoni* and *B. henwoodi*, and recognized *Bothriceps*, *Trucheosaurus*, *Brachyops laticeps*, *Batrachosuchus watsoni*, *B. browni*, *Hadrokkosaurus* and *Boreosaurus* as being true members of the Family Brachyopidae. Welles and Estes took a more conservative viewpoint, eliminated genera which they thought were doubtful (*Boreosaurus*, for example) and ended with *Blinasaurus henwoodi*, *Bothriceps* (which included *B. australis*, Watson's *Trucheosaurus major* and "*Platyceps*" *wilkinsoni*, Cosgriff's type for *Blinasaurus*), *Batrachosuchus watsoni*, *B. browni* and *B. lacer* (from Sushkin's *Batrachosuchoides lacer*), *Brachyops* and *Hadrokkosaurus*, thus reducing the number of brachyopid genera to five.

I intend to follow Welles and Estes' grouping of the brachyopids and their set of brachyopid skull characters, while adding to these Cosgriff's characters for brachyopid lower jaws. I do not agree with Cosgriff's brachyopid skull character of palatal teeth being present only on the vomer bones; irregular palatine teeth can be seen in *Hadrokkosaurus* (on the ectopterygoid and palatine bones) and in *Brachyops allos* n. sp. (on the ectopterygoid bone).

SYSTEMATIC DESCRIPTION

Class Amphibia
Subclass Labyrinthodontia
Order Temnospondyli
Superfamily Brachyopoidea
Family Brachyopidae

Characters of the family. Skull short, broad; no zones of intensive growth (other than in the cheek region—see below). Orbits anterior and usually relatively large. Otic notch absent, or at most a shallow embayment. Tabulars short and broad; tabular horns absent or weak. Parasphenoid flat, becoming elevated anteriorly above vomers. Usually a single tusk pit pair on vomer, palatine, and ectopterygoid; interstitial smaller teeth little developed or absent; tusks usually much elongated and massive; dentary tooth row relatively short. Vomerine plate short. Occiput with strong slope posteroventrally to occipital condyles, the latter usually quite large. Quadrate condyles large, ventrally produced, anteroventral in position relative to occipital condyles. Squamosal and quadratojugal with strong occipital flanges forming a vertical transversely concave trough lateral to the pterygoid. Pterygoid forming a steeply arched, flat-roofed palate. Quadrate somewhat compressed laterally, wedged anterolaterally between flange of pterygoid and squamosal-quadratojugal trough. Retroarticular process elongate. Posterior meckelian foramen and angular-prearticular suture on ventral surface or very low on lingual surface.

Brachyops Owen 1855

Type species: *Brachyops laticeps* Owen. *Brachyops* is the first described and thus the typical brachyopid. Other brachyopids differ from *Brachyops* mainly in their skull proportions—the most obvious differences are as follows:

Blinasaurus Cosgriff (1969) differs in that its snout is more rounded, its orbits are larger and therefore closer together, its external nostrils are closer together, its parietal foramen is relatively much closer to its orbits, its tabulars and postparietals are reduced, its interpterygoid vacuities are much longer relative to their width, so that the anterior part of the palate is shortened and the posterior part lengthened.

Bothriceps Huxley (1859) has a much narrower skull so that its orbits and nares are closer together, and its interpterygoid vacuities are longer relative to their width.

Hadrokkosaurus Welles (1957) is larger than *Brachyops*, its skull is much broader relative to its length and is shorter postorbitally.

Batrachosuchus Broom (1903) has a broader, less pointed skull, the preorbital skull is shorter, the interpterygoid vacuities are longer relative to their width, and the anterior part of the palate is shortened.

Brachyops allos n.sp.

Holotype. A skull complete but for the left cheek region, part of the right quadratojugal and pterygoid, and a few scraps from the dermal skull roof. Queensland Museum No. F6572.

Type locality. A. A. Howie field locality Q6, near the headwaters of the Duckworth Creek, south-west of the settlement of Bluff, South Central Queensland.

Horizon. Lower Upper Rewan Formation of the Mimosa Group, Lower Trias.

Characters of the species. Brachyops allos differs from *Brachyops laticeps*, especially in that its exoccipital condyles are much nearer the level of the quadrate condyles, so that the backwardly sloping portion of the occiput in *B. allos* is greatly reduced. Although this character is one which Watson (1956) considered showed the stage of evolutionary advancement of a brachyopid, the two species are otherwise so alike that generic separation at this stage would be foolish. The cultriform process of the parasphenoid in *B. allos* is clasped laterally by posteriorly directed processes of the vomers rather than overlying these as it does in *B. laticeps*. Posteromedially the process bears an area of dermal denticles in *B. allos*. On the dorsal surface of the skull the tabulars are exposed a little less in *B. allos* than they are in *B. laticeps*. Anteriorly the interpterygoid vacuities are broader in *B. allos*, but this difference is less between *B. allos* and *B. laticeps* than between *B. allos* and all other brachyopids. The rather long tripartite anterior palatal foramen in *B. allos* is also distinctive.

THE SKULL OF *BRACHYOPS ALLOS*

When found, the skull was lying upside down with the anterior part of the palate exposed. Although a large area was excavated when the skull was being encased in a plaster cast, no postcranial material which could positively be associated with the skull was recovered. In the laboratory exposed bones were glued together with Butvar B76 and impregnated with Butvar B98. Preparing the skull was difficult as the bone was softer in places than the matrix and the latter tended to remove a layer of bone as it was chipped away with an automatic mallet. Much of the matrix on the ventral surface of the skull roof has been left as a reinforcing agent as the bone is extremely thin.

Slight dorsoventral crushing has forced the anterolateral margins of the skull outwards (Plate XIV) and has caused a little warping in the occipital region, but on the whole the skull is well preserved.

Typical labyrinthodont ornament is present on all the skull roofing bones and the sensory canals where present are well impressed into this. The ornament is more reticular than that found in *B. laticeps* but is linear towards the edges of the bones, especially the squamosal and quadratojugal. So the suggestion by Bystrow (1935) that brachyopids have no regions of elongation in the skull does not apply to this deep cheek region where the pattern of ornament shows that the skull bones have grown rapidly ventrally. Watson (1956) notes this transverse elongation in the cheek region of *Batrachosuchus*, as did Säve-Söderbergh (1937) in brachyopids in general.

Dorsal Surface. In dorsal view the skull is very similar in shape to that of *Brachyops laticeps* except that less of the occiput is exposed. The orbits and choanae are rounded and the parietal foramen is small and set well back in the skull. A cross-section of the midline of the skull roof shows a strongly developed ventrally produced ridge which runs along the midline from the anterior part of the frontal bones posteriorly to end behind the parietal foramen (Fig. 1, x–y). Nine millimetres in front of this foramen the ridge divides into two, bypasses the foramen, and comes together again at the level of the ventral surface of the skull roof 6 mm. behind the foramen. The result is an elongate pineal cavity which is loaf-shaped at the level of the external opening.

The premaxillae, nasals, frontals, parietals, postparietals, postfrontals, postorbitals, supratemporals and squamosals are very like those of *Brachyops laticeps* except that the suture between the frontals and parietals is more towards the front of the skull in *B. allos.* A flange of the nasal bone which extends lateral to the external naris on each side could be a septomaxilla as shown by Shishkin (1966) in *Batrachosuchus lacer*, but no nasal-septomaxillary suture is visible. More probably the circle of bone which floors the nostril is the septomaxilla, as could have been the case in *Hadrokkosaurus* (Welles and Estes, 1969). No suture can be found between the maxillary and prefrontal bones ; the suture shown in this position in Fig. 1 is hypothetical and has been placed in its most likely position in relation to the ornament and the sensory canals. If it is correctly placed it excludes the maxilla from the orbit. A thin process of the jugal extends around the anterior border of the orbit to a greater extent than it does in other brachyopids. Much of the right quadratojugal remains and forms the posterolateral corner of the skull, sending sheets of bone medially to cover parts of the posterior and anterior faces of the quadrate.

Ventral Surface. A ventral view of the skull shows unusually wide interpterygoid vacuities and an enlarged anterior palatal vacuity. The latter is tripartite (Fig. 2), as is the one found by Shishkin (1966) in *Batrachosuchus.*

Large tusks and tusk replacement pits are found in the vomers palatines and right ectopterygoid, which also bears a palatal tooth. While no palatal teeth can be found on the vomer, an additional small tusk is present right of the midline just posterior to the anterior palatal vacuity. A raised median area on the cultriform process of the parasphenoid bears a shagreen of minute denticles which are not present elsewhere on the palate.

Premaxillary, maxillary, vomer and palatine bones vary little from the characteristic brachyopid pattern as seen in *B. laticeps.* The parasphenoid body

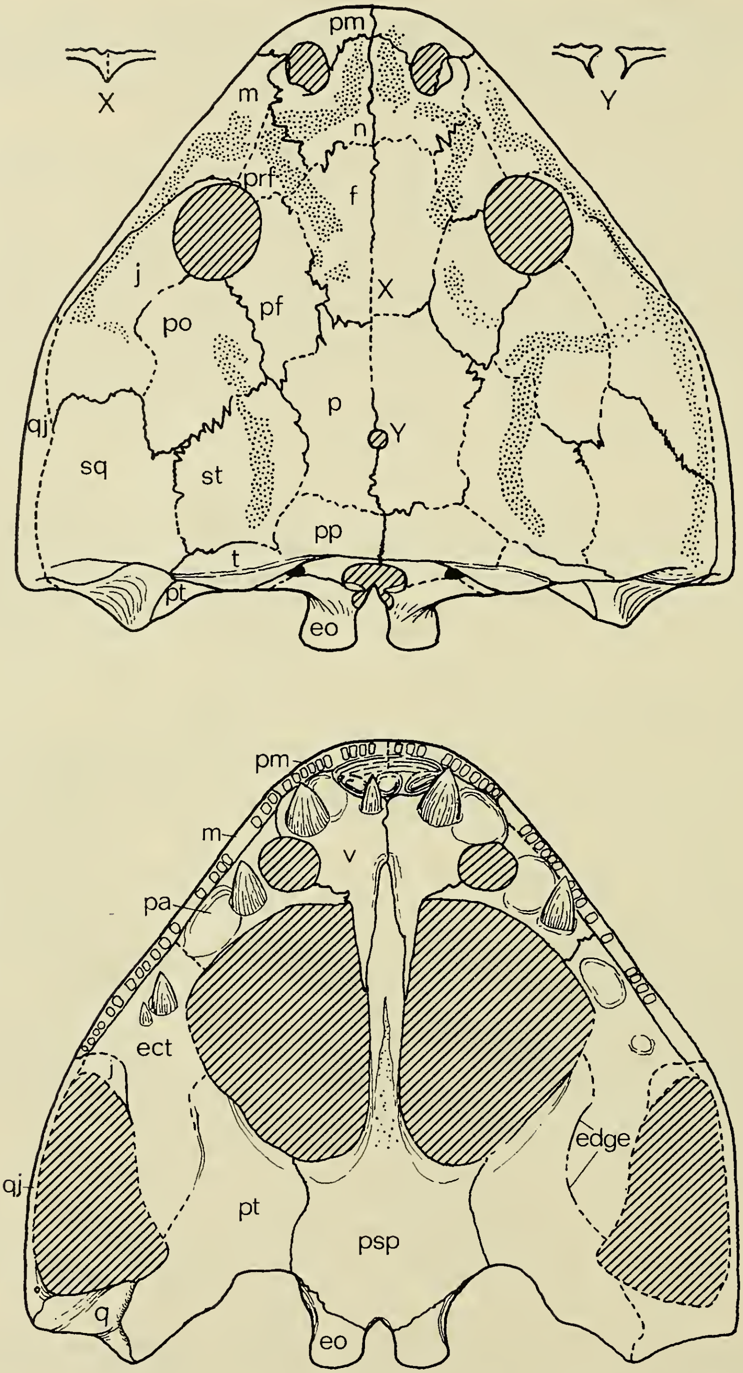

Fig. 1. *Brachyops allos* n.sp. a : Dorsal view of the skull drawn normal to the skull roof. b : Ventral view of the skull drawn normal to the parasphenoid. x, y : Sections of the skull midline at x and y. $\times \frac{2}{3}$. Sensory grooves are stippled.

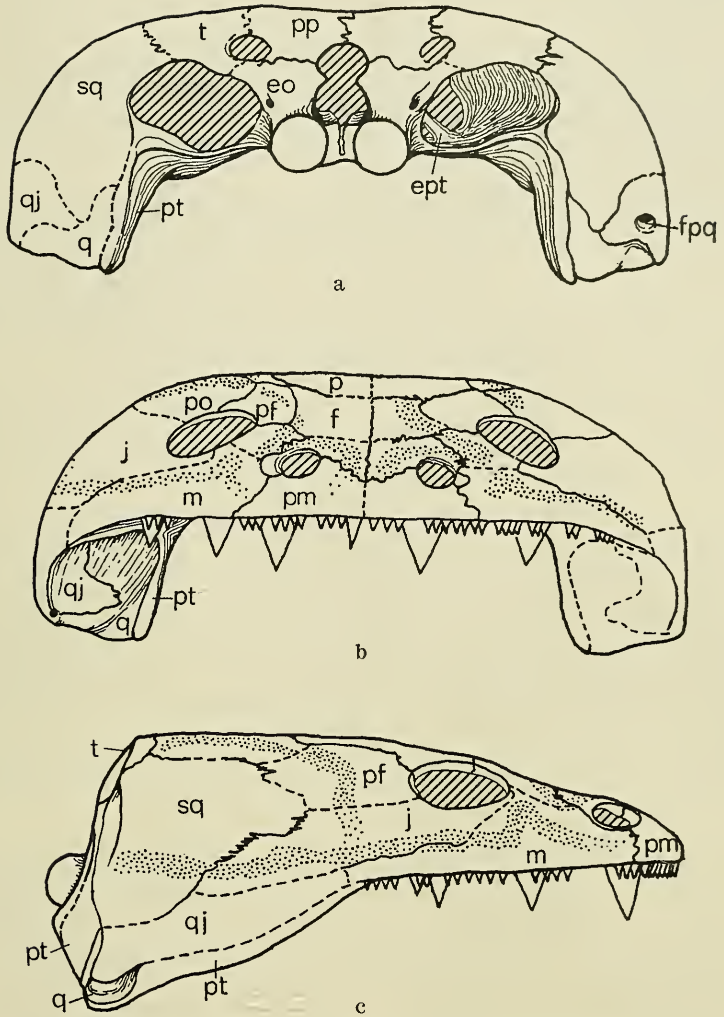

Fig. 2. *Brachyops allos* n.sp. a : Occipital view of the skull. b : Anterior view of the skull. c : Lateral view of the skull drawn normal to the saggital plane of the skull. × ⅔.

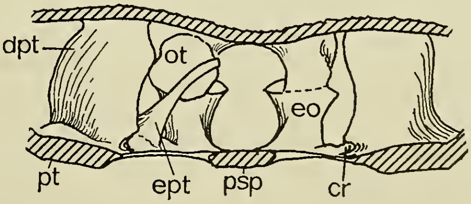

Fig. 3. *Brachyops allos* n.sp. Sketch of a section of the skull in the braincase area to show the (?) epipterygoid. Looking posteriorly from the proximal end of the cultiform process. × ⅔

is arched a little dorsally and extends further posteriorly than it does in *B. laticeps*, so that the exoccipitals are separated in the midline. No crista muscularis as noted by Welles and Estes in *Hadrokkosaurus* is present, but a well-developed ridge runs from the cultriform process behind the interpterygoid vacuity and is continued on the palatal ramus of the pterygoid. The cultriform process dips dorsally above the vomers at its anterior end but is narrower here than it is in *B. laticeps*, being clasped laterally by posterior extensions of the vomers rather than bearing these on its ventral surface.

The pterygoids are typically brachyopid except in their lateral margins. On the left side the anterolateral border of the palatal ramus of the pterygoid is a true edge (edge, Fig. 2), so that on this side the ramus is less than half the width of the right ramus. However, a ridge on the right ramus follows a similar line to that taken by the true edge of the left ramus. I interpret this edge as being the suture line between the pterygoid and ectopterygoid, so that the ectopterygoid extends posterolaterally along the pterygoid.

The right quadrate is preserved and shows an advanced level of ossification when compared with other brachyopids. The condyle has a lateral area and a larger and more ventral median area, the two being linked by a groove to form a screw-shaped condyle similar to that found in other well ossified rhachitomes.

Because of the greater degree of ossification in this specimen, an occipital view differs from the same view in other brachyopids in that the gap between the squamosal-quadratojugal complex and the pterygoid is filled with a dorsal extension of the quadrate. The supraoccipital and basioccipital areas are unossified, but a well-developed processus lamellosus divides the supraoccipital space from the foramen magnum. The processus basalis of the exoccipital is even more fully ossified than it is in *Hadrokkosaurus*. A paraquadrate foramen is present in the right quadratojugal. The posterior face of each tabular has a large rugosity above the paroccipital process.

The lamina ascendens or dorsal process of the pterygoid is much the same as the one present in *Hadrokkosaurus* except that it reaches the skull roof, touching the tabular medially and the squamosal more laterally.

Epipterygoid. On the right side, 4 mm. medial to and a little behind the leading edge of the dorsal process of the pterygoid, is a further ossification (Figs 2 (*a*), 3) which may be an epipterygoid. This originates from an 8 mm. base on the pterygoid near its suture with the parasphenoid and ascends dorsomedially, becoming narrower and rounder to end just anterior to the postparietals and 7 mm. lateral to the midline. A small excavation beneath the anteromedial edge of the ascending process of the pterygoid is probably the conical recess for the basipterygoid process of the basisphenoid. Between the head of the (?) epipterygoid and the anterior face of the paroccipital process and attached to the latter is an irregular ossification which may be part of the otic capsule.

From *Eusthenopteron* through early amphibia like *Eryops* and *Edops* and later Triassic Amphibia like *Parotosaurus* the epipterygoid whether more or less well ossified bears a contant relationship to the pterygoid ; it is found adpressed to the lateral (morphologically internal) surface of the dorsal process of the pterygoid. In *Eusthenopteron* and early Amphibia the palatoquadrate cartilage is present as a continuous element which runs forward from the quadrate along the dorsolateral margin of the pterygoid, but is usually not preserved anterior of the epipterygoid region. In the more " advanced " labyrinthodonts ossification in the palatoquadrate is gradually reduced to a quadrate element and an epipterygoid element, the latter consisting of an expanded basal portion which usually forms the dorsal roof of the conical recess for the basipterygoid process of the basisphenoid, an anterodorsal process which eventually becomes the columella cranii of reptiles, and a posterodorsal or otic process. In Triassic amphibians such as *Lyrocephalus*, *Parotosaurus* and *Metoposaurus* the otic process is lost. In life, no doubt a cartilaginous connection was maintained between the quadrate and the epipterygoid.

Previously described brachyopids have been poorly ossified, a condition reflected in their fragmentary or missing quadrates and the lack of any ossification in the braincase area. In *Brachyops allos* the quadrate is better ossified than it is in many earlier labyrinthodonts, and it would not be unreasonable to expect some part of the epipterygoid to be preserved. However, the column of bone preserved in *B. allos* differs from other known epipterygoids in that its foot lies just medial to the pterygoid rather than being adpressed to its lateral edge, so that any cartilaginous connection between the epipterygoids and the quadrate would be extremely awkward.

One possibility is that the element is a displaced stapes, but Watson described a very different stapes in *Batrachosuchus*, as did Bystrow (1937) in *Dvinosaurus*. Also, the bone is apparently in place within the skull and slopes dorsomedially ; a stapes would be more likely to have its distal end at least outside the skull, and would slope dorsolaterally.

RELATIONSHIPS OF *BRACHYOPS ALLOS*

In their review of the brachyopids Welles and Estes (1969) used the method developed by Welles and Cosgriff (1965) for their review of the capitosaurus. A series of arbitrary measurements is made on the skulls, and indices are derived from these measurements. The sum of the differences between indices for any two species is then assumed to be a useful indication of the relationship between these species. Welles and Estes acknowledge the various shortcomings of this method of analysis, one of which is the small number of specimens from which all measurements can be obtained. Data from additional specimens can only improve this situaton so the relevant figures for *B. allos* are tabled below.

The figures given are for the reconstructed skull ; they differ slightly from those obtained from the actual specimen.

	cm.
Interorbital breadth, A	4·5
Breadth of skull roof across quadratojugals, B	14·2
Midline postorbital length, D	5·6
Length of vomers, E	2·1
Midline distance between nostrils and orbits, F	1·6
Breadth across vomers, G	2·7
Height of parasphenoid, H	2·4
Internarial breadth, J	1·6
Length of skull roof, L	11·0
Midline preorbital length, O	3·3
Distance behind orbits of parietal foramen, P	3·0
Length of body of pterygoid, Q	2·3
Breadth across pterygoids at concavity, R	8·5
Distance of parietal foramen in front of end skull table, T	2·2
Midline orbital length, U	2·0
Length of interpterygoid vacuity, Y	5·25
Breadth of interpterygoid vacuity, Z	3·7

Indices :

B : L	130	U : L	19	G : E	129
J : L	15	D : L	51	Q : R	27
A : L	41	P : A	66	Y : L	48
O : L	30	T : A	49	Z : Y	70

Sums of Differences (using Welles and Estes data as plotted in figs 2–13):

Brachyops allos *Hadrokkosaurus bradyi*	149
Brachyops allos *Batrachosuchus watsoni*	73
Brachyops allos *Batrachosuchus browni*	61
Brachyops allos *Brachyops laticeps*	62
Brachyops laticeps *Blinasaurus henwoodi*	146
Brachyops allos *Bothriceps major*	101
Brachyops allos *Bothriceps australis*	113
Brachyops allos *Dvinosaurus primus*	155

Assuming that the smaller totals of index differences are real measures of relationship, this table shows that *Brachyops* is most closely related to *Batrachosuchus* and next to *Bothriceps*—the same finding as Welles and Estes' original analysis showed. The fact that *Brachyops allos* is closer by one point to *Batrachosuchus browni* than to *Brachyops laticeps* only emphasizes the fact that until more brachyopid specimens are known a few points difference between two skulls cannot be taken as a significant measure of a relationship or a non-relationship; the equivalent figures for the *Brachyops allos* skull before reconstruction indicate that *B. allos* is closer by five points to *B. laticeps* than it is to *Batrachosuchus watsoni*.

Welles and Estes suggest that a sum of differences of 57 might reasonably be considered as representing a specific level. If this is so, then *Brachyops allos* should be placed in a genus separate from *Brachyops laticeps* and *Batrachosuchus*. This would be "splitting" in the extreme and it could be more valid to unite *Brachyops laticens*, *Brachyops allos* and *Batrachosuchus* into a single genus.

Whether it is *Brachyops* or *Batrachosuchus*, *Brachyops allos* will link Welles and Estes' two Palaeogeographic units, their Australian brachyopid line, and their second brachyopid line which includes African and Indian-North American forms.

Brachyops allos is thus a particularly well-preserved and well-ossified member of its family and hence shows several features not previously found in the Brachyopidae. These include the presence of a paraquadrate foramen, an area of denticles on the parasphenoid, an ossified quadrate and a probable epipterygoid.

Being the first brachyopid to be described since Welles and Estes' analysis of the family, it can be used to test their methods. These proved to be accurate in indicating relationships at a level a little above the generic one, but, at least until the discovery of more specimens allows a statistically valid index to be calculated, the methods cannot be used to establish generic or specific relationships.

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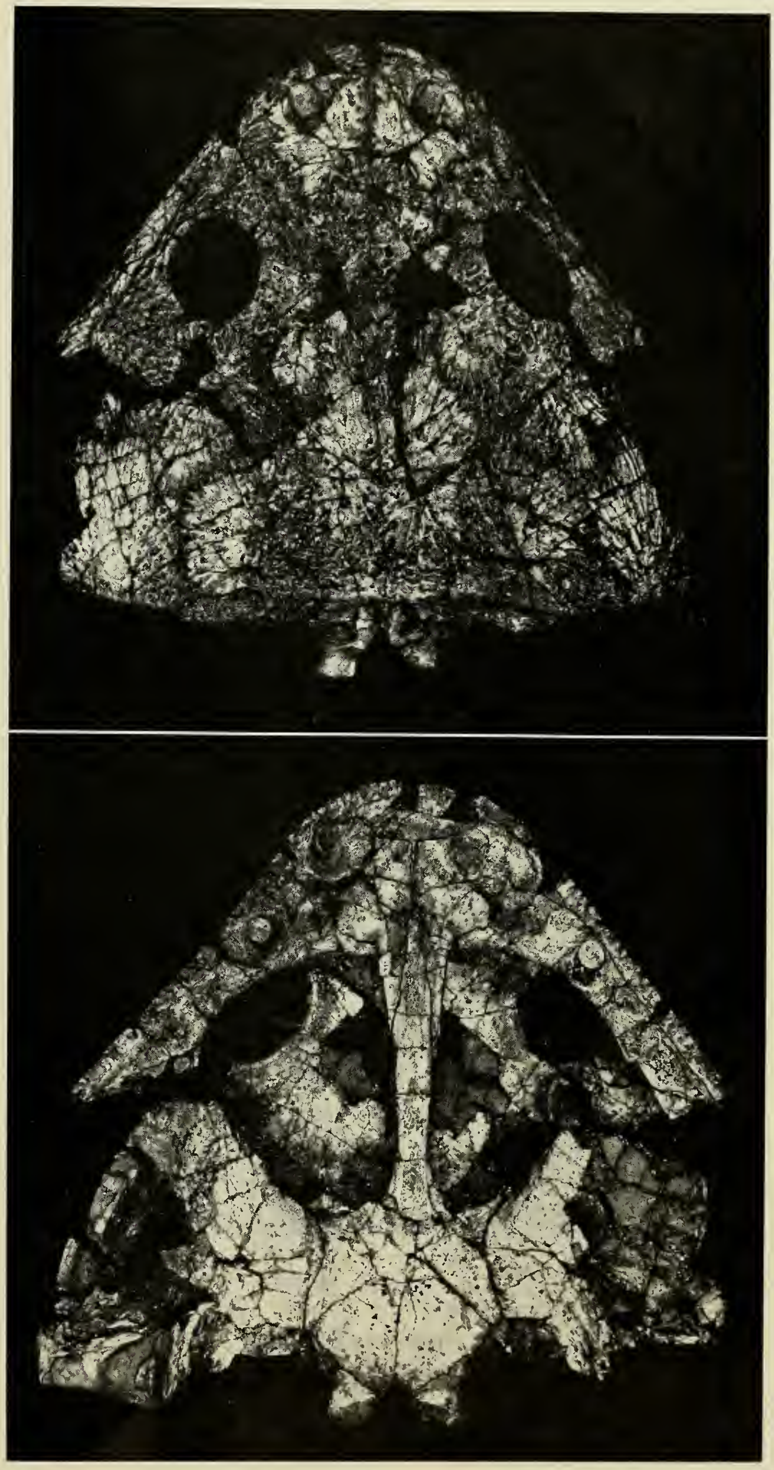
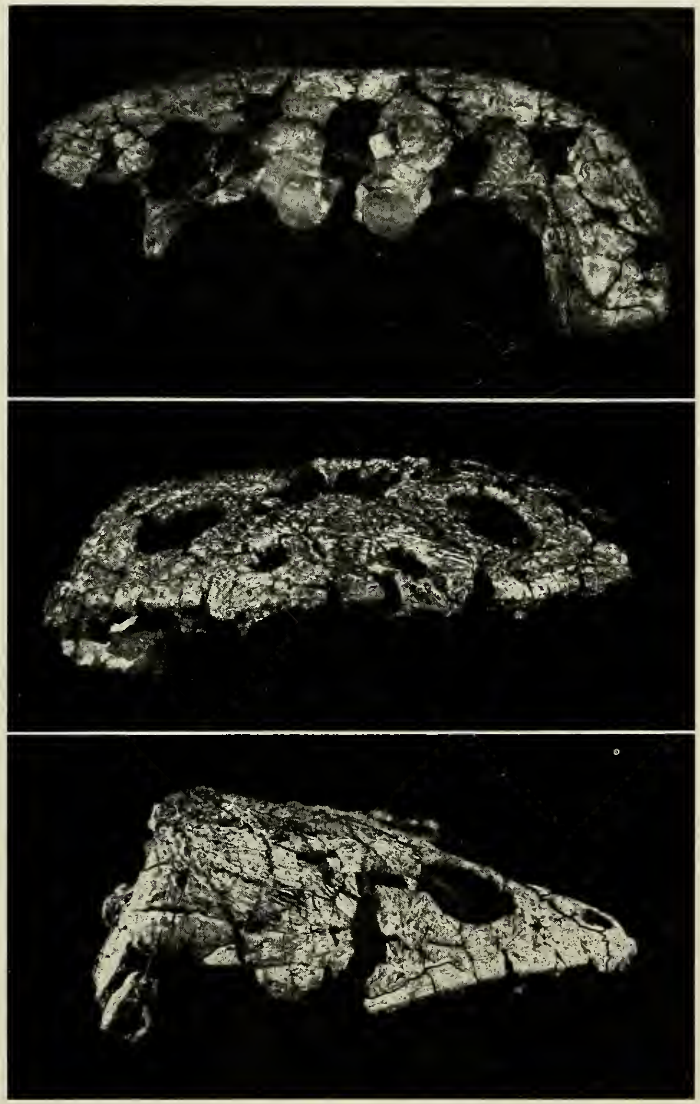


Brachyops allos n.sp. a : Dorsal view of the skull. b : Ventral view of the skull. $\times \frac{2}{3}$.



Brachyops allos n.sp. a : Occipital view of the skull. b : Anterior view of the skull. c : Lateral view of the skull. $\times \frac{2}{3}$.

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Abbreviations

cr	conical recess for the basipterygoid process of the basisphenoid
dpt	dorsal process of the pterygoid
ect	ectopterygoid
edge	true edge on the palatal ramus of the pterygoid
eo	exoccipital
ept	epipterygoid
f	frontal
j	jugal
m	maxilla
n	nasal
ot	otic ossification
p	parietal
pa	palatine
pf	postfrontal
pm	premaxilla
po	postorbital
pp	postparietal
prf	prefrontal
psp	parasphenoid
pt	pterygoid
q	quadrate
qj	quadratojugal
sq	squamosal
t	tabular

THE DEPOSITIONAL ENVIRONMENT OF THE ORGANIC DEPOSITS ON THE FORESHORE AT NORTH DEEWHY, NEW SOUTH WALES

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Synopsis

Pollen analysis of the coastal site at North Deewhy necessitates qualification of a previously published statement that could be taken to imply that the peat at this site is of brackish or marine origin, and that it is *ipso facto* evidence of a higher-than-present sea level stand less than 4,000 years ago.

The so-called " peat ", exposed on the foreshore at North Deewhy (southern side of Long Reef, lat. 33° 44′ S., long. 151° 19·7′ E.), has attracted attention for many years and was the subject of a radiocarbon dating (Hubbs, Bien and Suess, 1963).

I was asked in 1962 to pollen-analyse a sample from this deposit to find whether marine influence was indicated. The position of this sample in the sequence was apparently at the same level as the C_{14}-dated sample, i.e. the base of the organic deposits, just above heavy blue clay. The analysis showed high *Casuarina* values (*Casuarina* is only dominant at the base of the sequence), rather high Chenopodiaceae values and the presence of Hystrichosphaeridae, which were then generally regarded as brackish and marine indicator organisms. On this basis, it was concluded that the sample did show some evidence of proximity to the sea.

The C_{14} sample was subsequently published (*loc. cit.*, p. 259, sample LJ451), the date being 3980 ± 150 yrs. (2030 B.C.), and bore the comment " The peat is possibly indicative of a higher-than-present sea-stand ; pollen analysis indicates that it is probably of brackish or saltwater origin ". This comment goes further than the data available warranted at the time, since peat of saltwater origin in this latitude would almost necessarily be a mangrove peat, and none of the palynological evidence indicated mangrove presence. Except for the Hystrichosphaeridae, the aquatic plants and algae identified were freshwater forms, though some were euryhaline. The determination of the depositional environment of this peat is crucial to its use as evidence of sea-level change, since, if the peat is of salt or brackish water origin, its position must indicate a sea-level higher than to-day's, whereas if it is essentially a freshwater environment (even if influenced by proximity to the sea) it can offer evidence only of a negative kind.

A pollen analysis of the entire short vertical sequence is now available. Fig. 1 (*a*) represents the pollen of woody plants and herbaceous plants of apparently non-local origin. Fig. 1 (*b*) represents aquatic and swamp plants and other locally produced herbs. By " local " is meant those plants most likely to have been floristic components of the actual area of deposition at the time. These latter are expressed as a percentage of the pollen sum formed by the elements of Fig. 1 (*a*). The stratigraphic sequence at the point of sampling is depicted on the right-hand side of Fig. 1 (*a*) and is as follows :

0 cm. upwards (arbitrary datum) ..	Dune sand with plant roots
17 cm.– 0 cm.	Sandy limnic humus, more peaty at base
43 cm.–17 cm.	Humified and compressed coarse detritus mud
63 cm.–43 cm.	Compressed grey-brown fine detritus mud
Below 63 cm.	Stiff blue-grey clay.

At an undetermined depth the blue clay appears to be resting on eroded brick earth (laterite), which outcrops seawards and can also be seen dipping under the deposits farther east along the shore.

The pollen diagrams, from bottom to top, show:

(i) Shallow lacustrine conditions with *Chara* and *Pediastrum*, *Triglochin* (or *Potamogeton*), Cyperaceae and probably *Casuarina* fringing woodland.

(ii) *Casuarina* being replaced by Eucalyptoideae: declining *Chara*, but desmids (*Pleurotaenium* and *Cosmarium*) abundant; Dinoflagellates and Hystrichosphaeres becoming commoner.

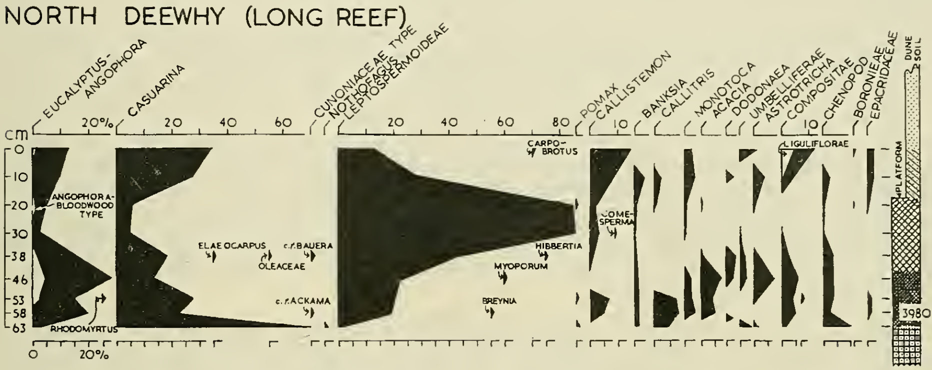

Fig. 1*a*. Pollen diagram of deposits at North Deewhy: Arboreal and herbaceous pollen other than local and swamp plants.
The *Angophora* — bloodwood eucalypt type is shown (white) as a component of the total *Eucalyptus-Angophora* pollen percentage.

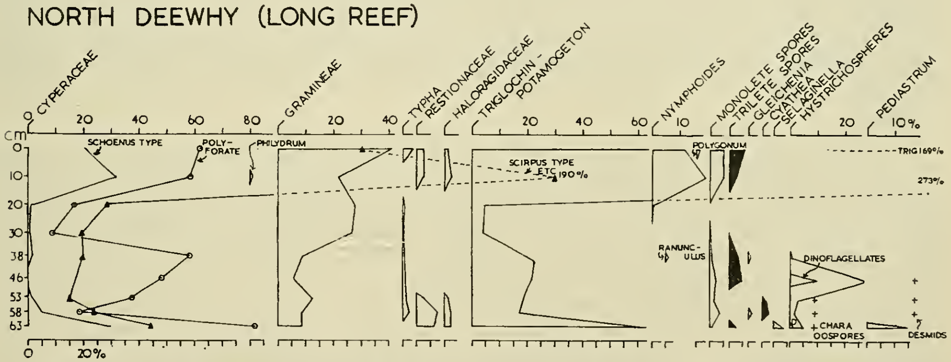

Fig. 1*b*. Pollen diagram of deposits at North Deewhy: Local (i.e. presumed components of the peat) flora, expressed as a percentage of pollen sum of Fig. 1*a*. *Cyathea* and trilete spores other than *Gleichenia* are percentaged with the non-local flora, but are included with other Pteridophytes for convenience.

(iii) The fine detritus mud changing quite sharply to a coarse detritus mud; much higher values for Leptospermoideae (*Leptospermum*, *Melaleuca* and *Kunzea* not being easily separable) probably indicating nearby ti-tree swamp, but wood fragments occurring neither at the point of sampling or elsewhere along the exposure. The influx of Leptospermoideae is probably responsible for an artificial lowering of the background pollen of *Eucalyptus*, etc.

(iv) Peat development, with occasional very compressed Cyperaceae rhizomes, at about the point at which Cyperaceae pollen becomes abundant in the profile. This level also corresponds to a step cut in the deposit which is apparently due to a difference in erodability of the two sediment types.

(v) The peat grading into the more limnic sandy-humic layer upwards, itself not sharply demarcated from the overlying sand, but apparently waterlogged conditions prevailed to the time of obliteration of the swamp, as indicated by the vast quantities of *Triglochin* and Cyperaceae pollen and the entry of *Philydrum* and *Nymphoides* into the profile. Leptospermoideae, apart from *Callistemon*, which actually increases slightly, decline towards the top of the profile, resulting in a recovery of the non-local *Casuarina*, Eucalyptoideae and *Callitris*.

It is now clear that the lower third of the sequence represents a lake or freshwater lagoon with a desmid and *Pediastrum* phytoplankton. There is no warrant for the belief that the deposit was in a marine or brackish (as that word is usually understood) environment, and the presence of ferrous sulphide (FeS_2) crystals, which occur in the basal lake mud, is quite compatible with formation in a freshwater lagoon under slight marine influence (e.g. Degens, 1965). The freshwater tolerance of hystrichosphaeres (in this context, microplanktonic fossils with spherical bodies and radiating processes that are not obvious Dinoflagellates) appears to be higher than formerly supposed (Churchill and Sarjeant, 1962), and in the general context of this deposit they can hardly be said to provide clear evidence of high salinity.

The central part of the sequence, which lacks even equivocal indicators of salinity, must have been produced under waterlogged or near-waterlogged conditions if not open water, because of the dominance of swamp-living angiosperms. A slight rise in water level may be implied by the replacement of a Leptospermoideae swamp by a Cyperaceae-*Nymphoides*-*Triglochin* swamp in the upper part of the sequence, but the absence of any wood fragments makes the precise meaning of the high Leptospermoideae values uncertain. The changes in flora indicated by the pollen analysis do not reflect a straightforward plant succession and could have been brought about by minor changes in water level, which itself would be influenced by factors such as the movements of nearby dunes, shoreline recession and migration of the mouth of the nearby Deewhy Lagoon.

An opportunity to obtain the true level of the deposit did not occur until this year. Consequently, the precise position from which the samples were taken could no longer be located, though the general position was located within a few metres. The outcrop along the beach is stratigraphically uniform and fairly flat except for a slight rise at the eastern edge. Thus, the level obtained is believed to be representative of the outcrop as a whole. At the new point of measurement the surface of the deposit is 3·0 m. above standard datum (N.S.W. standard datum is 2·93 ft. or 0·89 m. above Indian Springs Low Water at Fort Denison, Sydney). The tidal range at Narrabeen is approximately the same as at Fort Denison, i.e. 0 to +2·0 m., and the clay/mud transition is 2·2 m. above standard datum, the deposit being 80 cm. thick. A second measurement a few metres from the first gave a thickness of 75 cm., compared with 64 cm. at the point of sampling in 1965 when the pollen samples were collected.

Allowing for the compression which has taken place during the burial of the sediments under dune sand, the deposit appears to have formed within about 2·3 m. of local HHWS. The water level in the existing nearby Deewhy Lagoon was 0·9 m. below the peat base at the time of survey and peat forming at the present day round the margin of the lagoon is approximately 0·6 m. below the base of the peat on the foreshore. One can point to a number of still existing freshwater peat swamps, at levels ranging from several metres higher to about 0·5 m. lower than the North Deewhy deposits, in similar areas along the central coast of New South Wales (e.g. Kurnell Peninsula). In each case local water-table conditions determine the level at which peat formation occurs. Needless to say, such deposits cast very limited light on existing sea level.

An interesting sidelight of the work is the finding of a few pollen grains of several unexpected plants, e.g. *Nothofagus*, *Rhodomyrtus* and cf. *Ackama*. The two latter seem to represent a coastal rainforest or wet sclerophyll element in the flora. Rainforest remnants still grow on the Narrabeen shales of the Palm Beach Peninsula, e.g. at Bilgola, a few miles to the north of Deewhy, though neither of these genera are now present locally. *Nothofagus*, on the other hand, appears to represent a long-range component. The grain is of the *N. moorei* type, the nearest source of which, today, would be the Barrington Tops forests, *ca.* 200 km. distant. The single grain is unlikely to be a contaminant, as it contains small ferrous sulphide crystals, as do other pollen grains at this level.

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PETROLOGY AND STRATIGRAPHY OF THE BRAYTON DISTRICT, NEW SOUTH WALES

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(Communicated by Dr. R. E. Wass)
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(Plate XVI)

Synopsis

An angular unconformity separating Upper Ordovician beds from (?) Silurian sediments and basic and acid volcanics has been mapped in the Brayton area. It is shown that the fine-grained silicic igneous rocks constitute a series of contemporaneous volcanic flows within the (?) Silurian succession, a conclusion at variance with earlier opinion. These volcanic rocks and the Marulan batholithic rocks are therefore distinct and separate entities. The hybrid zones of previous workers are re-interpreted as zones of increasing metamorphic grade where intrusion of granitic rocks into the silicic volcanics produced a contact aureole. A Tertiary dolerite body and two Tertiary basaltic flows exhibit closely correlative mineralogy, while the dolerite shows limited upward differentiation.

INTRODUCTION

The Brayton area lies approximately 130 miles south-west of Sydney, 10 miles north of Marulan. About 12 square miles were mapped in detail as shown in Fig. 1.

Upper Ordovician slates, quartzites and phyllites have undergone much regional deformation, culminating in an isoclinally folded sequence with a macroscopic meridional trend and approximately vertical dips. The (?) Silurian succession, which includes three distinct units, overlies the Ordovician rocks with angular unconformity. At the base, a series of shales, sandstones and calcareous siltstones with a general north-south strike and steep westward dip outcrop. Succeeding these sediments are basic volcanic flows with rare sedimentary lenses and a small limestone pod. Extensive silicic volcanic flows ranging from toscanites to dacites with some tuff bands comprise the youngest unit.

Field and petrological evidence indicates that the (?) Silurian sediments, basic volcanics and silicic volcanics constitute a conformable sequence and have shown synchronous response to low-grade metamorphism and regional deformation superimposed on the already deformed Ordovician sequence.

Granitic rocks forming part of the Marulan batholithic complex have intruded these Palaeozoic strata, producing contact metamorphic effects within an aureole at least one mile wide. An intermediate dyke of unknown age intrudes one of the granitic bodies.

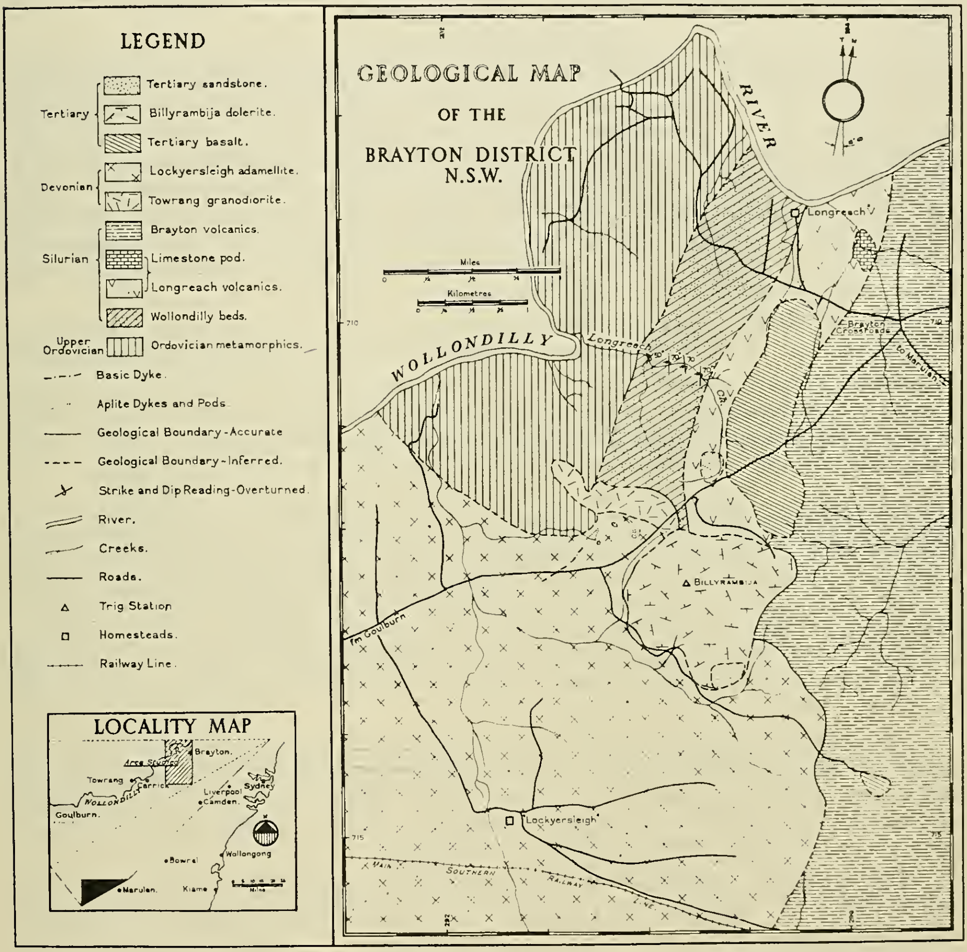
The remaining rocks are Tertiary in age. These include the Billyrambija dolerite, two basalt flows, and the associated Tertiary sediments, which are rich in a fossil flora.

PREVIOUS WORKERS

First geological observations made in the area were those of Clarke (1845). He stated that the Wollondilly River from its source to the junction with Paddy's River cut through igneous and metamorphic rocks which were laid bare over a considerable area between the Cookbundoon and the Uringalla.

Craft (1928) recorded that the Lower Palaeozoic rocks of the Wollondilly area are mostly Silurian and Devonian and " . . . consist of quartzites, slates and claystones together with some shales and intrusive granites. The general strike is about 10° east of north . . .".

Woolnough (1909) investigated the general geology of the Marulan-Tallong district, to the south of Brayton. More detailed petrological studies on the Marulan batholithic rocks at South Marulan were carried out by Osborne (1948). Lovering (1950), Svenson (1950) and Osborne and Lovering (1952) studied in detail the " quartz porphyrites " and " quartz porphyrite hybrids " at South Marulan. These rocks are similar to the silicic volcanics at Brayton.



In a series of papers, Naylor (1935*a*, 1935*b*, 1938, 1939 and 1949) outlined the general geology of the Goulburn district. Of these, the first and last papers are particularly pertinent as rocks of the Brayton area are mentioned. Ordovician and Silurian boundaries, the extent of the Marulan Batholith and Tertiary basic igneous rocks were mapped on a scale of four miles to an inch. No differentiation into formations was effected, while the silicic volcanics were included as an integral part of the Marulan Batholith.

Browne (1933) first mentioned the dolerite outcropping at Billyrambija Trig., near Brayton. This he considered to represent a denuded Tertiary sill.

ORDOVICIAN ROCKS

The Ordovician strata are typically highly deformed, have a regional meridional trend, are steeply dipping westward, and contain an Upper Ordovician graptolite fauna.

Primary bedding is defined by alternating layers of dark blue-grey carbonaceous slates and quartzites, both ranging typically from five to 12 feet in thickness. Within the quartzite layers are occasional fine bands of phyllitic siltstones six inches to 12 inches in width.

Structure: These beds probably lie on the overturned limb of a macroscopic fold or fold system which also involves the (?) Silurian sequence. Beds are almost vertical and all foliations measured are steeply dipping. Two fold types are evident on a mesoscopic scale. The first comprises similar folds with attenuated limbs and wider hinge areas. Wavelength is about 10 feet, with a comparable amplitude, the strike of the axial plane being approximately east-west. The axis is vertical; the fold surface is primary bedding. The second comprises small isoclinal folds with average wavelength approximately one foot and amplitude of two to four inches. The axial plane is vertical and strikes east-west, while axes plunge steeply westward.

Slates exhibit greater deformation than the more competent quartzites. The degree and style of deformation are not constant throughout the sequence.

Two further penetrative structural elements occur. One is a mineral streaking, approximately axial plane for the small isoclinal folds. The other is a layering defined by lenticular pods and isolated small closures. These show somewhat random orientation, but an overall east-west trend is evident.

Age and fauna: The dark grey carbonaceous slates yield two graptolite forms, *Climacograptus bicornis* and *Dicellograptus* sp. An age of Upper Gisbornian to Bolindian may thus be deduced (Thomas, 1960). Naylor (1949) previously recognized *Climacograptus bicornis*, *Diplograptus quadrimucronatus* and *Dicellograptus complanatus* in the vicinity of Brayton, but no precise locality was given.

Petrography: The quartzites consist of detrital quartz grains with rare felspar laths in a matrix of sericite and chlorite. Characteristic heavy minerals are smoky blue to blue-green pleochroic tourmaline, brownish-yellow to olive-brown pleochroic hornblende and opaque grains.

The matrix, forming up to 40% of the rock, has an incipient microscopic layering. Quartz shows evidence of deformation, including undulose extinction, Böhm lamellae and growth of small strain-free grains at sub-grain boundaries. Strings of tiny inclusions as well as apatite and zircon needles indicate a possible igneous origin for at least some of the quartz.

The phyllitic siltstones are compositionally equivalent to the quartzites. Macroscopically, the sheen and crenulations on penetrative surfaces are those of true phyllites.

The slates contain quartz (50%), sericite (20%), carbonaceous matter (18%) and opaque granules with rare zircon and tourmaline.

Contact metamorphism: The metamorphic grade attained by the pelitic rocks close to the granitic contact appears to be consistent with that of the hornblende hornfels facies. Quartz-muscovite-biotite-cordierite is the characteristic assemblage. The carbonaceous slates show development of andalusite needles up to 4 mm. long. Retrogression of the andalusite to sericite aggregates is ubiquitous.

(?) SILURIAN SEQUENCE

As the age of this sequence cannot be strictly defined, it is referred to as (?) Silurian thus. The (?) Silurian beds are separated from the Ordovician rocks by a distinct angular unconformity which is discussed in detail below. Three units may be distinguished by lithological differences. These are the Wollondilly beds, Longreach volcanics and Brayton volcanics in ascending stratigraphic order. Their conformity is indicated by structural features including close correspondence of dips, strikes and orientation of the two ubiquitous joint sets. All (?) Silurian rocks show comparable mineralogical adjustments to a low-grade metamorphic environment. Thus synchronous deformation may be inferred.

WOLLONDILLY BEDS

A measured section extending from the unconformity against Ordovician rocks (29387150)* to the top of the Longreach volcanics (29497150) indicates the thickness of this unit is approximately 2,800 feet.

Four hundred feet of calcareous siltstones containing a brachiopod fauna succeed a thin conglomerate band (about five feet thick) which defines the base of the sequence. The remainder consists of interbedded sandstones and shales. Two prominent joint sets of consistent orientation dominate these rocks and bedding is often discernible only as a gross lithological layering. A penetrative cleavage is developed in the fine shale bands.

The Wollondilly beds and Ordovician rocks are unconformable. Because of overturning, the Ordovician overlies the (?) Silurian in the field. Angular unconformity is based on the following criteria:

(1) The two distinctive faunas indicate an hiatus at least from Upper Ordovician to possibly Upper Llandovery.
(2) The lithologies and structural complexity of the Ordovician rocks which must have suffered regional deformation before (?) Silurian sedimentation are distinctive.
(3) The trend of the boundary is in places transgressive to the strike of the (?) Silurian strata and suggests a gently undulating depositional surface.
(4) A conglomerate bed at the base of the (?) Silurian sequence contains pebbles from the Ordovician succession.

Sedimentary structures including current bedding, small-scale minor graded bedding, load casts and trace fossils indicate the sequence has been overturned. That bedding dips more steeply than the dominant cleavage, if this is axial plane cleavage, also supports overturning.

Age and fauna: The calcareous siltstones contain a profuse brachiopod fauna: fossils are abundant parallel to original bedding planes. Preservation is extremely poor but three forms were identified.

The first is characterized by ornamentation typical of *Atrypa*. Absence of further distinctive features precludes determination. The second is a delthyrid brachiopod, internal moulds of pedicle valves being preserved. Thus a maximum time span from Lower Silurian to Middle Devonian is indicated. This brachiopod could be *Howellella* sp., which would refine the time interval to from Upper Llandovery to Gedinnian. However, identification is not unequivocal due to the absence of definitive brachial valves. The remaining brachiopod occurs as internal moulds of brachial valves and has features consistent with those of *Schuchertella* sp., which is a Lower Devonian form (N. M. Savage, pers. comm.).

The unconformity between Ordovician and (?) Silurian beds is thus firmly established on faunal grounds. Because generic attribution cannot be positively made, the sediments containing the brachiopod fauna are tentatively called (?) Silurian.

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* Grid references refer to the Goulburn 1 : 250,000 sheet SI 55–12.

Naylor (1949) considered these beds to be Lower Silurian, based on the lithological similarity with the Jerrara Beds near Bungonia, which yields a Lower Silurian graptolite fauna. He assigned an Upper Silurian age to the limestone pod in the Longreach volcanics because of the profusion of Upper Silurian limestones in the Goulburn district.

Petrography: The calcareous siltstones consist of approximately 30% carbonate, 30% quartz, 20% plagioclase and 20% interstitial chloride. Subangular quartz granules are generally less than 0·1 mm. across, and show serrated edges. Plagioclase laths up to 0·3 mm. long are An_{0-5} where unaltered to chlorite and zeolitic minerals. Carbonate occurs as granular aggregates possibly detrital in origin and as patches up to 0·5 mm. across, apparently replacing original matrix. Authigenic chlorite occurs as a cement. Where developed, massive or spherulitic aggregates of chlorite randomly replace plagioclase and original matrix. The chlorite is pale green, non-pleochroic and isotropic.

Detritus and matrix of the sandstones and shales are identical, only grain-size being distinct. Quartz, felspar, zircon and hornblende, tourmaline and opaque grains comprise the detritus. Grains are subangular and sorting is fair.

Quartz (60% to 70%) is of two types: angular grains with sharp extinction and subangular grains with undulose extinction and sometimes showing sub-grain development. These grains also contain strings of tiny particles and acicular zircon crystals. Marginal serration of all quartz is typical.

Felspar ranges from 5% to 20% in mode and is extensively altered to sericite and chlorite. Some show vestiges of multiple twinning but composition cannot be determined due to alteration. Interstitial material includes abundant sericite as fibrous aggregates which often encroach on detrital plagioclase margins. A colourless or pale green isotropic chlorite is subordinate. This cement constitutes up to 20% of the rock.

Contact metamorphism: The metamorphic rocks may be divided broadly into lower and higher grade assemblages dependent on distance from the granitic contact. Only original sandstones and shales outcrop within the aureole and observed assemblages are as follows:

(1) Lower grade:
    Quartz-albite-muscovite-biotite
    Quartz-muscovite-chlorite-opaque minerals

(2) Higher grade:
    Quartz-muscovite-cordierite-biotite
    K-felspar-biotite-plagioclase-corundum.

Different assemblages probably reflect the original composition of the sediment, although no silica-poor rocks were found outside the aureole. Lower grade rocks are consistent with parageneses of the albite-epidote hornfels facies, those of higher grade rocks generally lie in the hornblende hornfels facies. However, where potassium felspar is associated with corundum, pyroxene hornfels facies may be indicated.

LONGREACH VOLCANICS

The Longreach volcanics comprise a series of basaltic flows best exposed at 29567088. Outcrops extend over about half a mile between the Wollondilly beds and the Brayton volcanics. As flows are now vertical, this represents the thickness of the sequence. Small bands of sediment occur rarely between these flows and a small limestone pod outcrops at 29637092. Trend of flows is meridional, while two sets of prominent vertical joints are developed with orientations consistently 290° and 245°, as in the Wollondilly beds.

At 29557057 basaltic dykes transect the Wollondilly beds. These intrusions may represent feeder dykes for the flows of the Longreach volcanics as they show analogous low-grade alteration. Dykes show no preferred orientation and thus were not controlled by any pre-existing structural elements.

Petrography: The basalts are extensively altered and similar to spilitic basalts in fabric, mineralogy, chemistry and geological occurrence—the four criteria discussed by Vallance (1960). Three distinct types of alteration are evident, based on the dominant phases: (*a*) chlorite-epidote-tremolite, (*b*) chlorite, and (*c*) prehnite-calcite. Mutual gradations exist with no systematic distribution of alteration types.

The basalts generally show an intersertal texture with glomeroporphyritic aggregates of augite, plagioclase or augite and plagioclase. Flow foliation is evident but often obscured by alteration; amygdales abound. A subvariolitic texture is common (e.g. 33692*). Quartz xenocrysts are abundant; these generally show no mantling by pyroxene or evidence of reaction.

Plagioclase occurs as microlites, laths and glomeroporphyritic aggregates of laths up to 1 mm. long, with composition about An_5. Swallow-tail terminations indicate rapid chilling. Relict *augite* crystals have $2V_x = 60°$, $Z \wedge c = 40°$ and are colourless. Subhedral grains range from 0·5 mm. to 2·0 mm. across; glomeroporphyritic aggregates are common. The original mesostasis has been almost completely obliterated. It was probably glassy to cryptocrystalline; 33692 shows glass shards pseudomorphed by chlorite. Felspar microlites, tremolite needles, turbid sphene granules, chlorite and a felted layer silicate now constitute the groundmass.

A typical chlorite-tremolite-epidote assemblage is present in 33694. *Epidote* occurs as granular aggregates, prismatic crystals or sheaves of bladed crystals. Colourless granules replace plagioclase, but most epidote lines or fills amygdales. Optical properties are highly variable, often within the one crystal, some being pleochroic from bright to pale yellow with $2V_x = 70°$, some being colourless with $2V_z = 15°$. Two types of *chlorite* are present. One is colourless and isotropic, the other pleochroic from pale blue-green to pale yellow-green and shows brilliant anomalous blue interference colours. The chlorite generally replaces augite but may also infill or line amygdales. *Tremolite* occurs as felted aggregates of acicular needles (*ca.* 0·2 mm. long) in amygdales, as tiny needles (less than 0·1 mm. long) in the groundmass and as large rods associated with altered augite. It is generally colourless, but larger laths may be faintly pleochroic from colourless to pale blue-green. $2V_x$ is about 80°, $Z \wedge c$ is about 20°. Rare prehnite occurs as spherulites replacing augite and groundmass or infilling amygdales.

Dominant chloritic alteration is shown in 33687 and 33692. Relict augite and original glass shards (e.g. 33692–3) are altered to pale green chlorite showing brilliant purple anomalous interference colours. Amygdales are typically infilled with calcite or quartz, with or without chlorite. Felspar laths are extensively sericitized.

Prehnite-calcite alteration is typified by 33690–1. Here felspar shows no clouding. Augite is much altered to radiating sheaves of prehnite closely associated with patches of chlorite. *Prehnite* is optically positive with 2V ranging from 40° to 60° within a crystal. A pinkish hue in plane polarized light may be due to included haematite. Prehnite occurs as spherulites about 0·3 mm. in diameter, replacing augite and groundmass non-selectively. It also occurs as massive or sheaf prehnite where it pseudomorphs phenocrysts, appears not to replace the groundmass and is invariably rimmed by opaque grains. Abundant *calcite* is intimately associated with sheaves of prehnite and also occurs as ragged anhedra up to 3 mm. across and as amygdale infillings. Tremolite, sphene and epidote are present in the groundmass. Small orange spherulites are dotted

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* Five-figure numbers used throughout the text refer to rocks in the Sydney University Geology Department collection.

sparsely throughout the prehnite. Amygdale assemblages include laumontite (?)-prehnite-calcite and quartz-calcite-chlorite-opaque minerals.

Contact metamorphics: In the lower grade rocks (e.g. 33701, 33709, 33711) the characteristic assemblage includes tremolite-actinolite, plagioclase, calcite, quartz, minor sphene and opaque grains. Plagioclase-actinolite-calcite assemblages appear to be analogous to patches of prehnite-epidote-chlorite in rocks outside the aureole. Plagioclase (*ca.* An_{44}) occurs as granoblastic aggregates of anhedral grains and as tiny laths in the groundmass. Tremolite-actinolite pseudomorphs original glomeroporphyritic pyroxene and occurs as a felt of tiny laths and needles replacing the original mesostasis. It is pleochroic with X=pale yellow-green, Y=colourless, Z=pale blue-green. $2V_x$ is 80°: $Z \wedge c$ ranges from 15° to 20°. Refractive index β is 1·620.

The higher grade rocks develop two distinctive types of assemblages, one abundant in pyroxene, the other dominated by hornblende and plagioclase. Both types still retain features of the original basaltic fabric. The texture is invariably blastoporphyritic; original amygdales and quartz xenocrysts are recognizable, although both are recrystallized and the former have mineralogically adjusted. The patchy, variolitic aspect of the flows is also preserved.

Hornblende-plagioclase rocks are the more abundant. The mineral assemblage comprises hornblende, plagioclase, quartz, sphene, epidote, opaques, potassium felspar and sphene. Hornblende pseudomorphs original augite glomeroporphs, occurs as discrete rods up to 2 mm. long and forms a groundmass network. Pleochroism with X=yellow, Y=bright yellow-green, Z=blue-green is distinctive. $2V_x$ is high, *ca.* 85°, $Z \wedge c$ is *ca.* 20° to 24°. Retrogression to a yellow uralitic product ranges from incipient to extensive. Plagioclase, An_{52} to An_{56} occurs as euhedral laths up to 0·5 mm. long. Pyroxene-rich assemblages occur as veins or patches in the normal hornblende-plagioclase rocks. Minerals present are diopside, rare hedenbergite, plagioclase (An_{58}), calcite, scapolite, hornblende, sphene, garnet, epidote and rare opaque granules.

Brayton Volcanics

The youngest unit within the (?) Silurian succession represents a period of silicic volcanic activity. Toscanites, dacites and tuffs, which extend beyond the area mapped, outcrop over about one mile normal to strike. As the sequence is now vertical, this represents a thickness of 5,000 feet. Evidence for vertical tilting is based on (*a*) marked variation in rocks types on a foot scale stratigraphically, while a few distinctive flow types may be traced for over a mile in a north-south direction and (*b*) the apparent conformity of all the (?) Silurian rocks.

Age and geological relationships: The silicic volcanics were extruded prior to emplacement of the Marulan batholithic rocks. Contact of the Brayton volcanics with the granitic rocks is sharply delineated and intrusion by the Lockyersleigh adamellite is undoubted, as evidenced by the metamorphic effects discussed below. Four factors are most significant:

(1) These rocks are extrusive as is first indicated by their conformity with the Wollondilly beds and the Longreach volcanics. The Brayton volcanics form an integral part of the stratigraphy.

(2) Recognition of flow units, presence of tuff bands, flow lineation (Plate xvi, fig. 1) and relict glass shards (Plate xvi, fig. 2) indicate a volcanic origin. Evidence for extrusion is observed in several exposures whose brecciated nature indicates explosive activity. Angular toscanite fragments (1 in. to 6 in. across) are separated by a network of essentially epidote-hornblende domains up to 1 in. in width. This network probably represents original glass which formed a groundmass for the breccia.

Subsequent low grade alteration effected chemical redistribution involving both glass and breccia fragments.

(3) The intrusive nature of the granitic rocks demonstrates the older age of the Brayton volcanics. That considerable time intervenes is a logical result of the conformity of the whole (?) Silurian sequence. A period of structural deformation and low grade rock alteration must have occurred before introduction of the granitic rocks. As discussed above, the Brayton volcanics are tentatively assigned to the Upper Silurian although a Lower Devonian age is not precluded. The age of the Marulan Batholith on present data may be pre-Upper Devonian to Carboniferous (see below).

(4) Chemical evidence is inconclusive as the two chemical analyses available (Osborne and Lovering, 1952) demand no genetic relationship between the silicic volcanics and granitic rocks.

In summary, the extrusive nature and approximate time of extrusion indicate that the Brayton volcanics and the Marulan batholithic rocks are discrete entities.

This departs from the concepts of previous workers, notably Woolnough (1909), Naylor (1935*a*) and Osborne and Lovering (1952), who considered the silicic volcanics to be shallow intrusions intimately associated in time and possibly comagmatic with rocks of the Marulan Batholith.

Petrography: Mesoscopically the silicic volcanics are fine to medium grained and range from dark grey green to greenish blue; flow foliation is sometimes visible. Phenocrysts of euhedral quartz, zoned plagioclase, alkali felspar, hornblende and biotite averaging 1 mm. to 4 mm. in length are set in an aphanitic groundmass.

Microscopically, many of these silicic volcanics are tuffaceous with fragmented phenocrysts in a once glassy mesostasis. Primary phenocrysts are quartz, plagioclase, alkali felspar, biotite, hornblende and rare pyroxene. Accessories include opaque oxides, sulphides, zircon and apatite.

Quartz phenocrysts up to 4 mm. across constitute 10% to 30% of the rock and typically show embayments. Euhedral outlines suggest an original phase. Strings of tiny particles and inclusions of felspar, zircon and apatite are common. Fracturing of phenocrysts and undulatory extinction are characteristic.

Plagioclase (10% to 30% of the rock) occurs as subhedral laths and angular fragments, both compositionally identical. Extensive alteration to carbonate, sericite, epidote, prehnite and zeolites often obscures original compositions. Where determinations are possible cores are andesine and rims albite. Small laths are albitic (An_{3-6}) while larger grains show patchy albitization. *Potassic felspar* phenocrysts are not abundant but locally may reach 20% in some flows. Usually the potassic felspar is surrounded by a rim about 0·2 mm. wide of albite as indicated by staining. Alteration to sericite and carbonate is widespread.

Biotite (0–10%) occurs as phenocrysts and replacing hornblende. Laths may reach 2 mm. long. Most show kinked cleavages and shredding parallel to the basal cleavage. *Hornblende* phenocrysts are rare and often represented by small relict patches in areas of alteration. Pleochroism from olive green to mid brown is sometimes evident. Rare *hypersthene* may have been present more abundantly before alteration. The *groundmass* is typically cryptocrystalline and exhibits excellent flow structures. Staining shows, where grain size is resolvable, a granophyric (or granoblastic, if devitrified) intergrowth of quartz, potassic felspar and albite. Devitrified glass shards, following flow lineations, may constitute 50% of the mesostasis. Arcuate lenses of minutely crystalline quartz and more rarely alkali felspar appear to result from devitrification (e.g. 33729). Here, lenticular areas consist of parallel rows of tiny zeolite needles. Replacement of shards by chlorite has also taken place.

The classification of these silicic volcanics as toscanites and dacites with tuffaceous equivalents is based on observed modes now evident in the rocks.

Contact metamorphism—Petrography: The Brayton volcanics exhibit the effects of contact metamorphism in four main ways:

(1) Grain growth of the mesostasis obliterates all evidence of primary structures. A granoblastic intergrowth of quartz and alkali felspar with minor biotite replaces the original groundmass.

(2) Original mafic phenocrysts show progressive changes. Low grade alteration of pre-existing hornblende, pyroxene and biotite produced prehnite, sphene, chlorite, opaque grains and epidote prior to contact metamorphism. Approach to the granitic contact shows development of green " biotite " (interlayered chlorite and mica ?), then hornblende, or brown biotite.

(3) Contact metamorphism of minerals in veins previously formed by low grade alteration, produced assemblages such as epidote-diopside-garnet-amphibole-quartz-albite.

(4) Annealing recrystallization of large strained embayed quartz grains is evident (see Plate XIV, fig. 3).

Three broad zones which represent an increase in metamorphic response are observable progressing towards the adamellite contact. Their recognition is based on the degree of recrystallization of the groundmass and mineralogical changes.

33635 is typical of silicic volcanics on the outer edge of the aureole. The groundmass shows moderate recrystallization with no remaining flow structures. No zeolite phases persist and tiny flakes of pale green amphibole are scattered throughout. Quartz phenocrysts are unaffected, alkali felspars are extensively altered to sericitic patches, while plagioclase is mostly albitic and clouded with epidote, carbonate, chlorite and sericite. Original mafic phenocrysts are completely pseudomorphed by epidote associated with cloudy aggregates of sphene and leucoxene, or interlocking felts or pale green mica with flakes of blue green amphibole and minor epidote.

33648 shows a successive metamorphic response. The groundmass grain size has increased but quartz is still unaffected. Potassic felspar is completely altered to sericite and tiny quartz blebs. Original phenocrysts are all rimmed by a narrow zone, 0·1 mm. wide, of clear albite granules. Green-brown biotite and subordinate green chlorite occur. Outlines of original euhedral phenocrysts are no longer sharply defined.

The highest metamorphic grade attained is shown in 33740 and 33755, which exhibit hornblende-rich and biotite-rich assemblages respectively. The groundmass is granoblastic and the assemblages indicate probable attainment of upper hornblende hornfels facies conditions. Potassic felspar grains are not extensively altered and both felspars show incipient recrystallization. Quartz grains (see Plate XVI, fig. 3) show annealing crystallization where grains were originally strained. 33740 contains clots and strings of hornblende laths up to 0·1 mm. long. These are pleochroic with X=deep blue green, Y=dark olive green and Z=pale yellow green. $2V_x$ is *ca.* 70°, $Z \wedge c$ is *ca.* 20°. Associated sphene granules abound. 33755 exhibits decussate aggregates of biotite (Plate XVI, fig. 4) with each lath up to 0·5 mm. long. Rare amphibole laths and opaque grains may be associated with biotite, while sphene is absent. Opaque grains, zircon and apatite are constant accessories.

Thin sections 33645 to 33652 are representative of the explosive breccia discussed above. This outcrops at 29587139, close to the adamellite contact. Silicic volcanic fragments show zonation with an inner core of normal dacite or toscanite surrounded by a quartzofelspathic outer rim up to 15 mm. wide comprising a zone leached of mafic constituents. These are set in a "groundmass" of granular intergrowths of diopside, hedenbergite and epidote which may be penetrated by laths of amphibole. Irregular, clear quartz blebs, carbonate patches and garnet grains are evident. Rare porphyroblasts of albite occur, while tiny opaque and sphene granules may be locally abundant. These contrasted compositions arise from an original chemically homogeneous rock as indicated by the migration of mafic components from fragment peripheries. While the inner core of fragments is compositionally equivalent to the normal silicic volcanics, their leached rims are higher in alkali and silica content, and the inter-fragment area is enriched in iron, calcium and magnesium.

It has been suggested above that this breccia formed by explosive volcanic activity. Devitrification at low temperatures and pressures prior to granitic intrusions initiated chemical reorganization mainly involving the "groundmass" but also affecting fragment rims. The granite subsequently produced the observed assemblages (*cf.* Vallance, 1967).

Metamorphism and previous concepts : The relationship of the granitic rocks to the silicic volcanics closely parallels that of the granodiorite and "porphyrites" south of Marulan. They were studied in detail by Osborne and Lovering (1952) and Svenson (1950), following Woolnough's (1909) general observations.

Osborne and Lovering (1952) considered the "porphyrites" were intruded as a high-level sill into Lower Palaeozoic country rocks. With the "porphyrites" still at elevated temperatures, intrusion of the granodiorite took place. Through slow cooling hybridization by interaction of magma and porphyrite ensued. Three "hybrid zones" were developed exhibiting mutual gradations representing successive degrees of hybridization. This process involved migration of soda from the magma to be deposited as albite rims in the hybrids. Extensive hydrothermal activity supplied "vigorous solutions" which effected formation of epidote, sericite and chlorite in hybrid "porphyrites". Diffusion into hybrids of TiO_2 and alkalis as well as concentration of CaO and MgO to produce hornblende and biotite was also invoked. Analyses of one porphyrite, two hybrids and the granodiorite were recorded.

No evidence of such chemical interaction was detected between rocks of the Brayton volcanics and the Lockyersleigh adamellite. A similar relationship was noted by Gould (1966) and Wass and Gould (1968) between the Tangerang volcanics and Glenrock granodiorite at South Marulan.

The silicic volcanics show both extensive alteration and response to contact metamorphism. Observed characters may be attributed to a metamorphic progression towards the granite contact in rocks already altered rather than to development of "hybrid zones". These zones are probably correlative with the three stages of metamorphism discussed above. Compositional variations may be due to redistribution of components during previous low grade alteration and intrinsic chemical differences in individual flows.

The sodic rims on alkali felspars do not necessitate addition of sodium. This phenomenon occurs even in rocks removed from the influence of the granitic rocks and may represent complete subsolvus unmixing of sodic and potassic phases. Formation of hornblende and biotite clots near the granitic contact does not require concentration of CaO and MgO as the chlorite and epidote of outer zones could contribute required components.

Thus the present study of the Brayton volcanics indicates that a metamorphic progression rather than development of hybrid zones accounts for textures and mineral assemblages observed.

IGNEOUS INTRUSIONS

Two components of the Marulan batholithic complex are represented. These are the Lockyersleigh adamellite and Towrang granodiorite. A contact metamorphic aureole up to one mile in width is developed. Metamorphic assemblages produced in the intruded rocks have been discussed within each rock unit.

Lockyersleigh Adamellite

The Lockyersleigh adamellite was mapped over approximately three square miles (Fig. 1), but extends considerably southwards. Where exposed, contacts with country rock are sharp. Silicic volcanics of the Brayton volcanics were intruded by this adamellite and are cut by leucocratic veins derived from the intrusion. In places, exposures must be close to the roof of the intrusion as fine-grained phases are evident. Aplitic dykes, representing late-stage crystallization of the adamellite, contain miarolitic cavities lined with alkali felspar, smoky quartz and tourmaline crystals. Veins of epidote up to 2 mm. wide occur throughout the adamellite.

Petrography: The adamellite is holocrystalline, hypidiomorphic granular and shows a porphyritic texture with phenocrysts of alkali felspar, plagioclase, quartz and, rarely, biotite or hornblende. These minerals are duplicated in the groundmass. Abundant sphene, opaque grains, epidote, zircon, apatite and alteration products including chlorite, carbonate, and sheaves of muscovite and prehnite are present. *Quartz* generally constitutes 30% to 40% of the rock. Phenocrysts are up to 4 mm. across, anhedral and often embayed. Undulose extinction, Böhm striae and development of strain-free grains are common. *Potassium felspar* constitutes about 30% of the rock. Subhedral phenocrysts range from 4 mm. to 10 mm. long. The optic axial plane is perpendicular to (010); $2V_x$ is approximately 50°; extinction on (001) is parallel to (010) cleavage, and on (010) ranges from 7° to 9°. Thus the felspar is monoclinic or has very low triclinicity. The latter is doubtful as "tartan" twinning is absent (Laves, 1950). The composition lies in the range $Or_{85-70}Ab+An_{15-30}$ (Tuttle, 1952), and thus the felspar is an orthoclase low-albite perthite. Film and vein perthites are well developed: myrmekitic intergrowths are common. *Plagioclase* forms about 30% of the rock. Phenocrysts (2 mm. to 4 mm. long) show consistent core/rim compositional ranges of about An_{55} to about An_{22} respectively. *Hornblende* (absent in the Towrang granodiorite) occurs sporadically as euhedra or ragged subhedra; a reaction relationship giving biotite is often observed. It is pleochroic X = pale yellow, Y = grass green, Z = olive green. $2V_x$ is approximately 70°. *Biotite* comprises up to 5% of the rock. Pleochroism is X = orange brown, Y = pale straw yellow, Z = deep speckled chocolate brown. $2V_x$ is approximately 10°. Alteration to chlorite, muscovite, prehnite, carbonate and granular epidote is common. Modal *sphene* may reach 5%. It occurs as granular aggregates, but commonly as euhedra 0·5 mm. to 2 mm. long. Sphene is more abundant where hornblende is locally in excess of biotite. The intergranular groundmass forms 20% to 40% of the rock and comprises all mineral phases present in the rock.

Towrang Granodiorite

This granodiorite forms a small stock exposed at 294712. In outcrop it is approximately elliptical with east-west elongation. About one mile west of the area and one mile north of Towrang, a similar granodiorite is evident. These two masses may represent a single intrusion.

The relationship with the Lockyersleigh adamellite is obscure because of poor outcrop on the boundary. The grey and white rock is quite uniform in hand specimen although occasional pegmatite patches are noted. These occur as veneer-like pods up to one foot in diameter, but never exceeding one inch in thickness. Distinct from the Lockyersleigh adamellite, no tourmaline occurs in the granodiorite but pyrite is common in the pegmatite phases.

Petrography : In thin section the rock is holocrystalline, allotriomorphic granular. Minerals present are quartz, plagioclase, potassium felspar, biotite, opaque grains and accessory epidote, sphene, apatite, zircon, carbonate and muscovite. *Quartz* constitutes 30% to 40% of the mode and is typically anhedral and interstitial, although grains may obtain a maximum diameter of 3 mm. Well-developed Böhm lamellae and mosaic textures are evident. *Plagioclase* occurs as poorly terminated subhedra from 1 mm. to 4 mm. long and constitutes up to 40% of the mode. Compositions range from an average of An_{50} for the most calcic cores to An_{20} for outermost rims. Broad antiperthitic veins show rare development. Some large plagioclase grains have highly resorbed cores which appear to be accumulophyric. Vance (1962) attributes such textures to " patchy zoning ", arising from an intense phase of uneven resorption and subsequent re-precipitation and infilling by more sodic plagioclase. In rare grains with resorbed cores mosaic domains in optical continuity produce a patchiness on a 0·1 mm. scale and appear to control or be controlled by twin lamellae.

Potassium felspar constitutes 20% to 30% of the rock and occurs as anhedra up to 4 mm. across. The optic axial plane is perpendicular to (010) and straight extinction of (001) indicates a monoclinic structure. Extinction on (010) of 10° to 12° indicates a composition $Or_{65}Ab+An_{35}$ to $Or_{50}Ab+An_{50}$. Perthitic textures are variably developed : albitic rims and large segregations are rare while no myrmekite was detected.

Biotite tends to occur in aggregates and represents no more than 5% of the mode. Laths (0·2 to 1·0 mm. long) are pleochroic with X=straw yellow, Y=red-brown, Z=chocolate brown. Inclusions of zircon and apatite euhedra are common.

Emplacement and Age

Employing the genetic classification of Tuttle and Bowen (1958), the Lockyersleigh adamellite and the Towrang granodiorite both represent subsolvus or group II granites. All features observed are characteristic of plutons emplaced in epizonal regions (Buddington, 1959).

The age of these intrusions can only be determined broadly as post-Brayton volcanics (Upper Silurian to Lower Devonian) and pre-Tertiary. Regarding the Marulan batholithic complex as a whole, Naylor (1939) records Upper Devonian sediments with a typical Lambian fauna, resting unconformably on granitic rocks near Taralga and Bungonia. At South Marulan quarry, Upper Silurian limestone is metamorphosed by granite. Thus an age of Lower to Middle Devonian may be inferred on stratigraphic evidence. However, Evernden and Richards (1962), using the K/Ar ratio of constituent biotite of a granodiorite from Bungonia, determined an age of 307×10^6 years (Carboniferous). This apparent anomaly may be due to non-contemporaneity of all phases comprising the Marulan batholithic complex or to loss of original argon.

TERTIARY ROCKS

Two basaltic flows (see Fig. 1), the Billyrambija dolerite mass and scattered sediments represent Tertiary rocks present. Age of the igneous rocks is inferred from their intimate association with sediments containing Tertiary flora and from their petrological affinity to basaltic rocks in the Moss Vale region which have a Tertiary age as shown by potassium-argon dating (P. Wellman, pers. comm.).

Tertiary Sediments

Isolated small outcrops of Tertiary sediment are associated with the Billyrambija dolerite where they occur mainly at the base and the 100 feet contour level, and with the two flows. Lamination of relatively fine and coarse fractions on a centimetre scale is marked, each layer often exhibiting graded bedding. Detritus comprises dominant volcanic, plutonic and reworked quartz grains, together with altered felspar grains and aggregates, while hornblende, epidote and muscovite are accessories. This detritus appears to be derived directly from nearby sources such as the Brayton volcanics, the silicic intrusions and the Ordovician or (?) Silurian sediments. Extreme angularity of grains suggests little transportation. The interstitial material may be partly matrix and partly cement and constitutes from 20% to 30% of the rock. It consists of very fine-grained, heavily iron-stained siliceous material.

The flora is poorly preserved, but most specimens are dicotyledonous leaves belonging to the *Cinnamomum* flora. One well-preserved fragment is similar to *Cinnamomum polymorphoides*, McCoy, 1874. That the leaves may be placed in the family *Lauraceae* and compared with species of *Cinnamomum* is indicated by comparison with similar but well-preserved fossil leaves from Wingello, which are considered to belong to the *Cinnamomum* flora (D. Selkirk, pers. comm.). This flora is Tertiary or, less probably, late Cretaceous in age. However, such leaves are termed Tertiary as geologists, on topographic and physiographic evidence, have considered closely associated basalts to be Tertiary. The gradual accumulation of potassium-argon dating of such basalts (e.g. McDougall and Wilkinson, 1967) supports this in general and thus, with available data, it seems reasonable to consider these sediments Tertiary.

Billyrambija Dolerite

The Billyrambija dolerite has a maximum exposed height of 340 ± 10 feet and outcrops in an approximately circular pattern with a diameter of one mile. Field relations do not provide conclusive evidence on the mode of emplacement. However, it is suggested that it may represent a very high level intrusion, possibly disrupting unconsolidated sediment and reaching the surface in places. This is supported by the presence of chilled phases which form randomly placed knolls and shoulders, and the presence of blocks of Tertiary sediment at the 100 feet contour line which show random bedding orientations.

Three components of the dolerite are recognized : chilled phases, dykes and the main dolerite body. The *chilled phases* occur associated with Tertiary sediment and are mineralogically comparable to the dolerite. Phenocrysts of titanaugite rarely exceed 2 mm. in diameter ; olivines are typically skeletal and clouded with inclusions, are unzoned and have a composition about Fo_{85} ($\beta = 1 \cdot 680 \pm 0 \cdot 003$). Plagioclase ($An_{60}$ core to An_{45} margin) is abundant and laths often show swallow-tail terminations. The groundmass is extremely fine-grained but tiny pyroxene and opaque granules are evident. *Dyke rocks* are distinctive in mineralogy and field occurrence. Dykes apparently intruding the dolerite can usually be traced over a vertical height of 20 feet and vary from five feet to one foot in width. Wider dykes exhibit chilled margins. Euhedral titanaugite, olivine and plagioclase (core An_{50}, margin An_{40}) are set in a fine-grained groundmass dominantly composed of aegirine-augite and magnetite. Pyroxene phenocrysts may be mantled by aegirine-augite and are often densely clouded with magnetite granules. Olivine phenocrysts are zoned from Fo_{80} to Fo_{60} (core and margin respectively). Amygdales abound in dyke rocks and are filled with thomsonite, chabazite, natrolite, analcite, prehnite or clay minerals.

The Billyrambija dolerite comprises pyroxene (35–40%), olivine (13–28%), plagioclase (14–25%) and opaque grains (3%) set in a mesostasis (14–25%) of zeolites, tiny opaque granules, laths of K-felspar, flakes of aegirine and (?) kaersutite, analcite and secondary chlorite. Apatite needles up to 0·5 mm. long abound.

Titanaugite euhedra occur in two generations. Those of the first generation reach 5 mm. across, may occur singly or in glomeroporphyritic aggregates, and are commonly sub-ophitically indented by plagioclase. Inclusions of a cubic iron-titanium oxide, olivine and a colourless (?) pyroxene are common. Pleochroism with X=pinkish yellow, Y=pink, Z=mauve-pink is variable in intensity. Well-developed hour-glass structures are present. Zoning is striking and generally limited to the outer few millimetres of the large euhedra. Second generation pyroxenes are prismatic and reach a length of 0·5 mm., lack significant zoning, and are optically identical to the outer margins of large pyroxenes.

Olivine also occurs in two distinct generations, as subhedral to anhedral grains up to 0·5 mm. across and as euhedra up to 2 mm. long. The latter have compositions from about Fo_{70} to Fo_{85} as determined by refractive index and X-ray methods.

Plagioclase occurs as euhedral, zoned laths 0·5–2·0 mm. long. Cores exhibit compositional variation with upward progression from An_{85} to An_{63}, rims being up to 15 mol. per cent. richer in Ab.

Opaque minerals identified were ilmenite and titanomagnetite. *Ilmenite* occurs as laths which may be sub-dendritic in habit and represent 10% of opaque minerals present. *Titanomagnetite* occurs as octahedra up to 0·2 mm. wide. Compositions were estimated by measuring cell edges and using the curve of Basta (1957). Titanomagnetite from the lowest level was approximately 96% Fe_2TiO_4, that from the highest level 70% Fe_2TiO_4.

Modal analyses indicate that mild differentiation may have taken place within the dolerite body : there is an upward decrease in mode of olivine and plagioclase and increase in volume percentage of mesostasis. This is supported by the limited and preliminary compositional data on the plagioclases and titanomagnetites.

Tertiary Basaltic Flows

Two tertiary basaltic flows are evident (Fig. 1). The southerly flow is petrographically identical with the chilled phase of the Billyrambija dolerite. Perhaps the original extent of this latter body was greater than now observed, this flow representing a southerly projection of the Billyrambija dolerite.

The northerly flow is petrographically distinct, although still a typical alkali basalt. Extensive alteration, mainly due to weathering, has taken place. Pyroxene is rare ; olivine euhedra up to 1·0 mm. long comprise 10% of the rock and are extensively altered. Plagioclase laths (30% of the rock) are zoned from An_{58} (core) to An_{45} (margin) and define a flow lineation. The groundmass may have been glassy ; felspar microlites abound as well as fine opaque particles.

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EXPLANATION OF PLATE XVI

1. Flow foliation in an altered dacite outside the contact aureole, 33729. ×45.
2. Devitrified glass shards in a dacitic tuff outside the contact aureole, 33734. ×45.
3. Embayed quartz phenocryst showing incipient recrystallization in a dacite within the contact aureole, 33728. ×45.
4. Biotite clot and hornfelsic texture in a metamorphosed acid volcanic rock adjacent to the adamellite contact, 33655. ×45.

SEDIMENTATION IN JERVIS BAY

G. Taylor
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(Communicated by Dr. K. A. W. Crook)

[Accepted for publication 23rd June 1971]

Synopsis

Jervis Bay is underlain by a lenticular sand body occupying a river valley cut in Permian sandstones and siltstones. The sediment covers an area of 84 km.^{2} with an average thickness of 20 m.

Two zones are evident, a low energy central zone consisting of a sublitharenite containing less than 85% quartz and a marginal high energy zone containing quartz arenites and sublitharenites containing greater than 85% quartz.

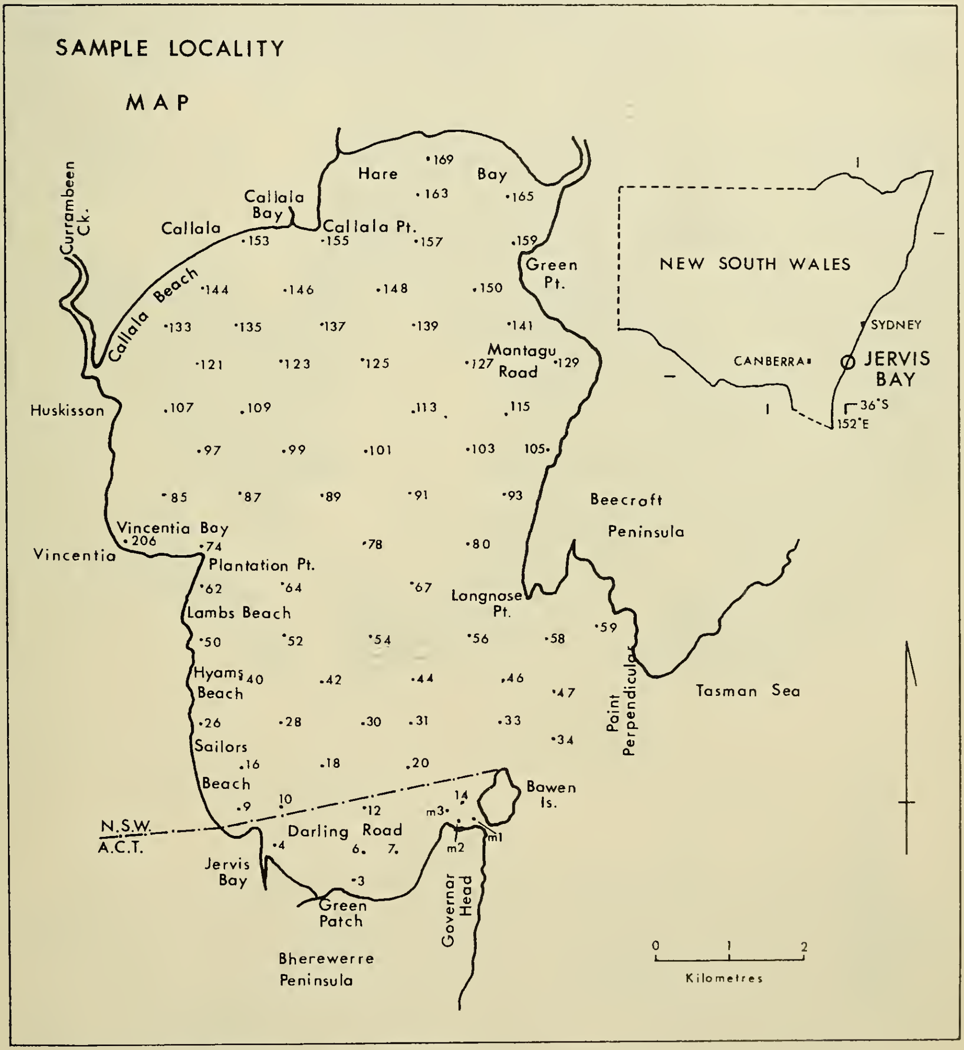

Fig. 1. Map showing local names referred to in the text and sample localities.

Introduction

The recent marine sediments in Jervis Bay have been investigated (Taylor, 1970) and an attempt made to delineate the character of the sediments, the processes involved in sedimentation, and the history of the embayment. This was carried out by surface sampling (Fig. 1), continuous seismic profiling and a detailed examination of the hydrology, bathymetry and Quarternary geology of the bay.

Regional Geology

Jervis Bay is an embayment in the coastline of New South Wales approximately 84 km.^{2} in area with its entrance 6 km. east of the general line of the coast. It is situated in a gently folded sequence of Lower Permian sublitharenites and siltstones (Rose, 1966) (Fig. 2). Permian rocks crop out over half of the coastline of the bay; the remainder is bordered by beaches and beach ridges dating back to the Pleistocene (Walker, 1967).

Only one stream of any significance, Currambeen Creek, drains into the bay, and most of its sediment load is deposited before reaching the bay. Other streams deposit their load in back-swamps and lagoons around the bay.

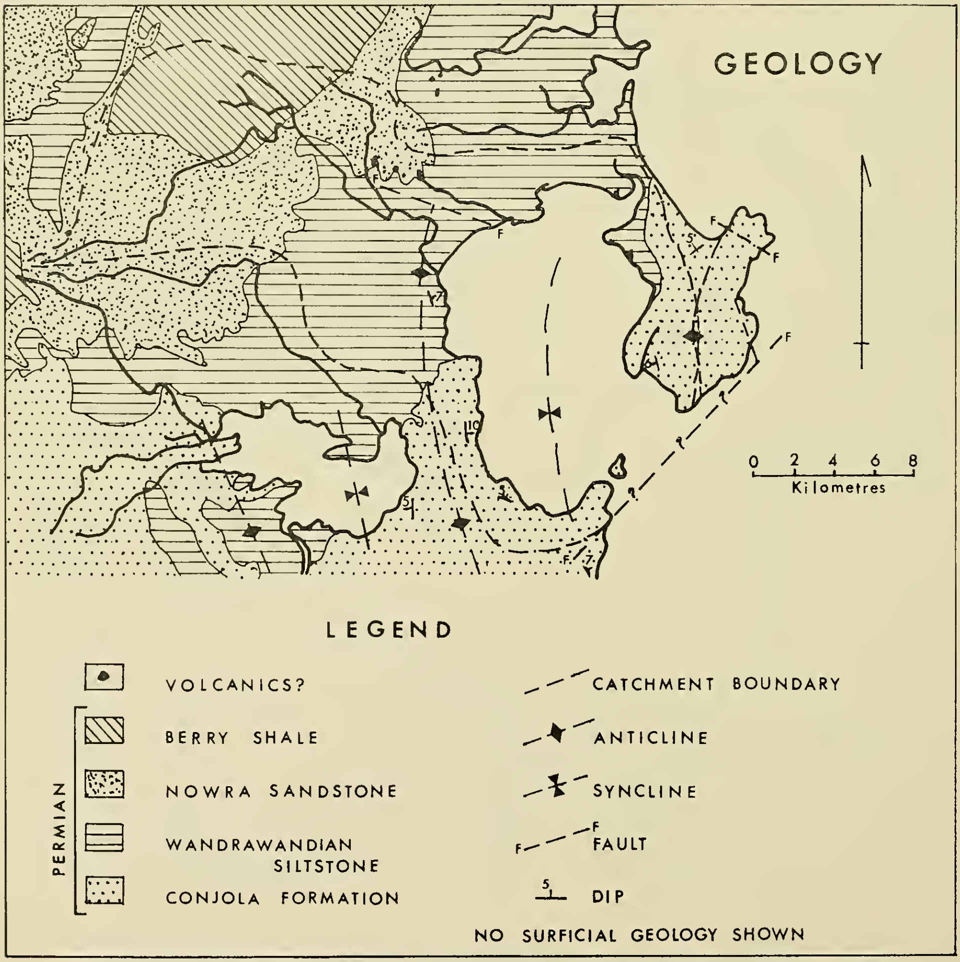

Fig. 2. Catchment Geology of Jervis Bay and of streams entering the bay.

BATHYMETRY

R.A.N. Chart AUS. 80 shows that the bottom slopes gently to 26 m. from the north, west and south, the eastern shoreline sloping more steeply (Fig. 3). The entrance to the bay reaches a maximum depth of 41 m.

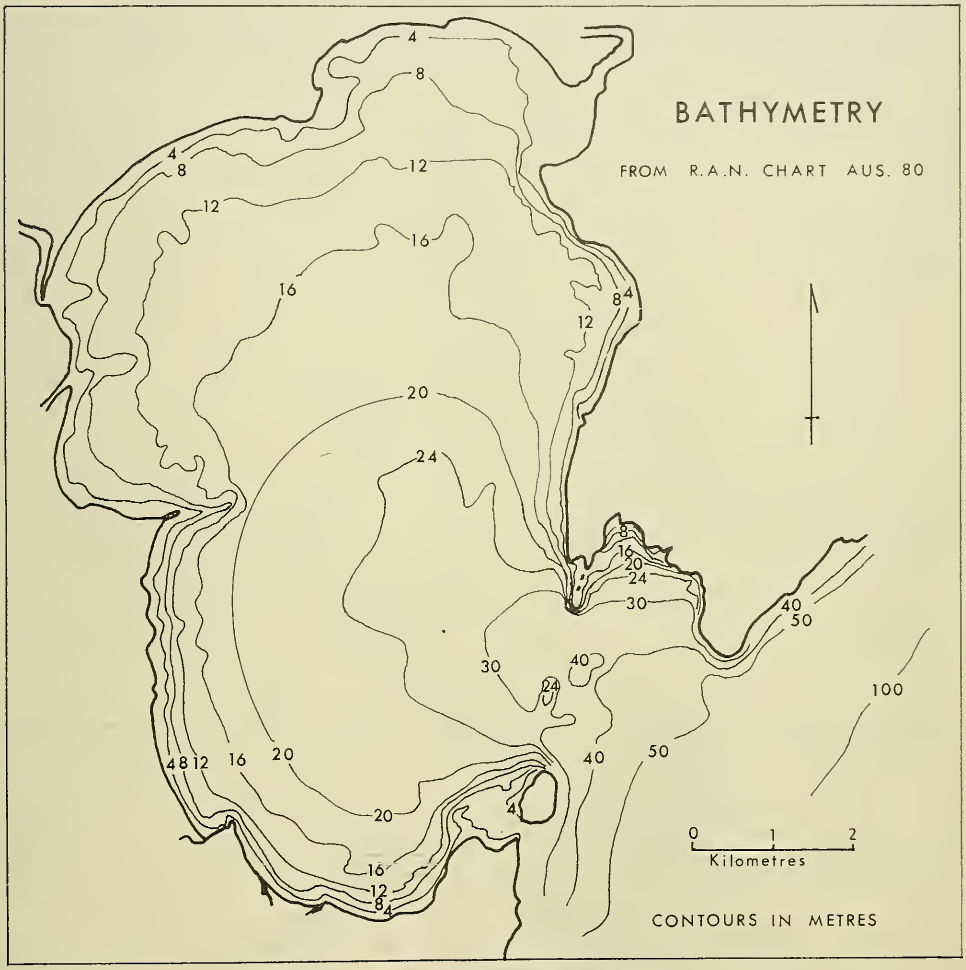

Fig. 3. Bathymetry of Jervis Bay.

HYDROLOGY

No full-scale hydrological survey has been conducted in Jervis Bay. A limited survey was conducted in the southern half of the bay by the author in the summer of 1968. Three water layers were present: an upper layer up to 17 m. thick, with an intermediate layer up to 4·5 m. thick, and a lower layer up to 20 m. thick in the deeper parts of the bay. The mean summer surface and bottom temperatures are 23·1° C. and 19·8° C. respectively and average chlorinites are 19·65‰. The bay has a similar hydrographic environment to other open estuaries in eastern New South Wales (Rochford, 1951).

The predominant swell entering the bay is from the south-east, causing turbulence on exposed shores all year to a depth of 19 m. Predominant winds are north-easterly and north-westerly, with southerly storm winds. Hence all shorelines within the bay are subject to continual wave activity, except south-facing shores at the north end of the bay, which are only affected during southerly storms.

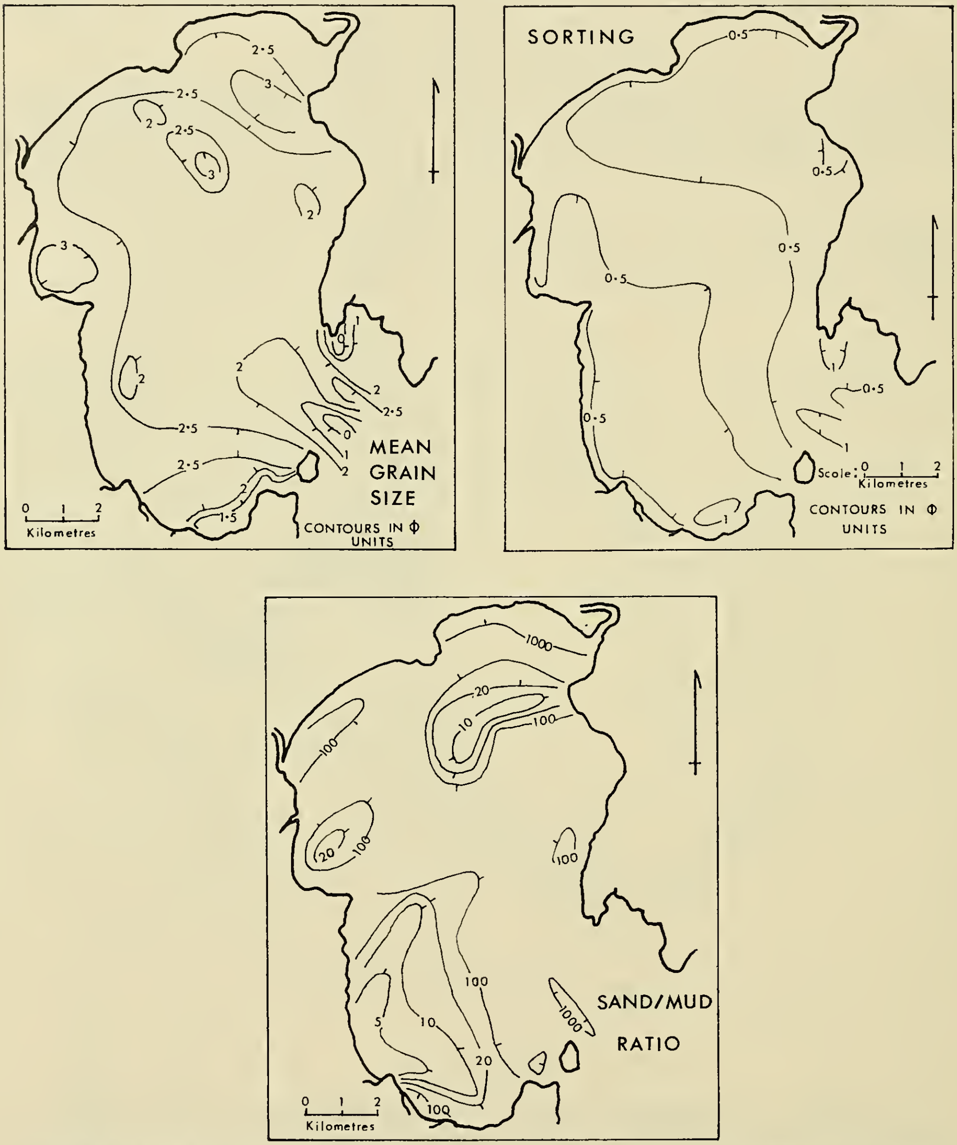

Fig. 4. Maps showing the surface distribution of grain size, sorting and sand/mud ratios in Jervis Bay.

FIELD AND LABORATORY PROCEDURES

Grab samples of the top 15 cm. of sediment were taken at 1·6 km. intervals on an E.-W. grid and at 0·8 km. on a N.-S. grid. The samples were split, desalinated, and dried in preparation for mechanical and mineralogical analysis.

MECHANICAL ANALYSIS

Measurements of grainsize, sorting and sand/mud ratios were made using techniques described by Folk (1968). The mean size and sorting coefficients were calculated from frequency data using formulae derived by Folk and Ward (1957).

The mean size of sediments, excluding the mud fraction, varies from 0·64φ to 3·37φ. The areas of coarse sediment are confined to regions of high energy in the entrance to the bay. The general trend in the bay is a fining marginwards (Fig. 4); off Callala Beach and Darling Road this trend is masked by growth of

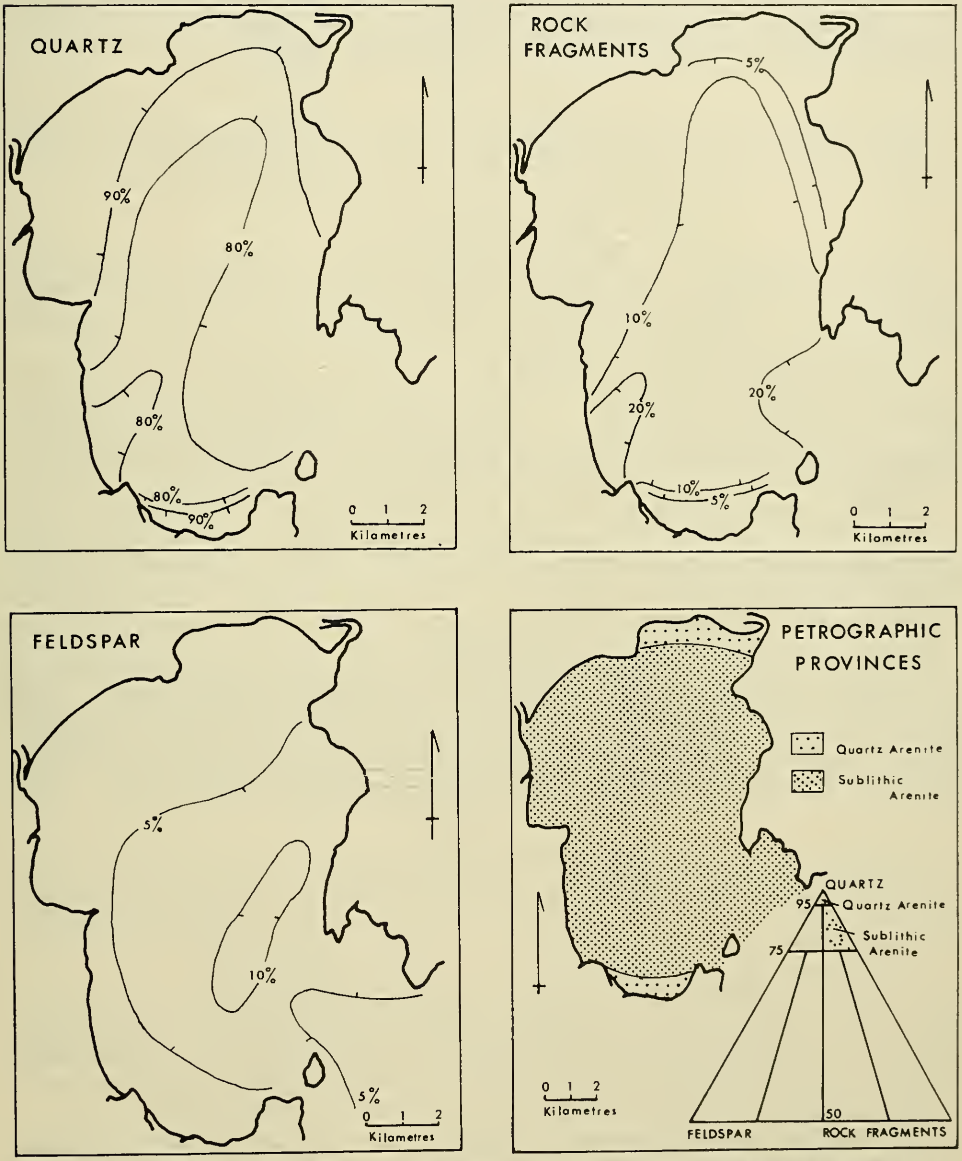

Fig. 5. Maps showing the surface distribution of quartz, rock fragments, feldspar and petrographic provinces in Jervis Bay.

molluscan fauna. The mud fraction has a mean size in the coarse silt range (4·76φ to 5·01φ) with less than 5% being finer than 7φ.

The marginal sediments are slightly better sorted than those towards the centre (Fig. 4). The coarse sediments in the entrance and in areas of molluscan growth are poorly sorted. The sorting values vary from 1·90φ units to 0·33φ units, and the areal distribution pattern follows that for mean size, i.e. the better sorted sediments occur in marginal regions and more poorly sorted areas are central.

No sediment contains more than 20% mud, and most contain less than 1%. The sand/mud ratio (Fig. 4) varies from infinity to 1·75. The regions of high mud concentration occur in areas protected from the south-easterly swell, e.g. Vincentia Bay, Green Point and off South Sailors Beach.

Mineralogy

The composition of the terrigenous sediments was determined by point counting, and the amount of carbonates by solution in hydrochloric acid.

Light Minerals

The abundance of quartz varies between 73% and 96% of the total terrigenous constituents. The higher concentrations are restricted to the marginal regions (Fig. 5). The majority of quartz is well rounded and monocrystalline, indicating a high degree of maturity.

Rock fragments make up between 3% and 21%, the highest concentrations being in the central region (Fig. 5). The majority of rock fragments are sandstone from the seacliffs surrounding the bay. Minor basic igneous and siltstone fragments are also found. These rock fragments are all unstable and reworking destroys them, hence their paucity in the marginal zones.

Feldspar occurs in minor amounts in the central region (Fig. 5) and in areas of active erosion of the Nowra Sandstone (Rose, 1966). It is mostly highly altered and contains included mica. It is mostly a sodium-calcium variety with little potassium feldspar.

Carbonates

The carbonates locally contribute up to 80% of the sediment in the areas of strong tidal currents near the entrance, and of abundant faunal growth. The greater part of the sediments however contain between 5% and 20% carbonate (Fig. 6). The carbonates are made up of complete and fragmented remains of bivalves, gastropods, echinoids, forams, polyzoans and ostracods, the last four being more common in the southern region of the bay.

Petrographic Provinces

The petrographic sand types have been classified according to Folk (1968). Sublitharenites cover most of the bay with small areas of quartzarenite at the north and south end (Fig. 5).

The abundance of quartz in marginal zones of high energy and fine grain size and the comparative lack of rock fragments in these zones is presumably due in part to the break-up of rock fragments. Since the rock fragments are mainly of a sublitharenite, the contribution to the sediments from their breakdown is essentially quartz. This process is effected less rapidly in areas of lower energy (i.e. central region) and hence rock fragments survive longer.

The erosion of Nowra Sandstone (Rose, 1966) around the eastern margin of the bay continuously supplies rock fragments in that region, hence although it is a high energy coast, rock fragments are relatively abundant.

Feldspars are more abundant in the deeper lower energy zones of the bay, presumably because of their instability in areas of continual wave activity.

These provinces are masked to some extent by abundant carbonate detritus present in some localities.

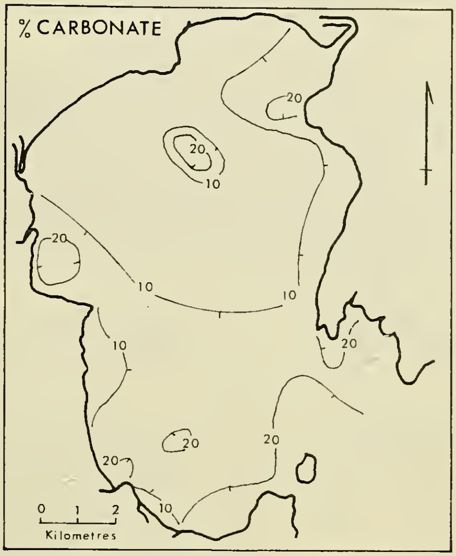

Fig. 6. Map showing the surface distribution of the carbonate components of the sediment.

HEAVY MINERALS

The heavy minerals from 10 g. splits of sediment were separated by use of tetrabromethane. The sizes of the grains separated varied from 0·08 to 0·12 mm. and from less than 0·01% to 0·9% of the marine samples by weight and up to 63% in one beach concentrate. The separates were then examined and " species " counts made on at least 200 grains. Eighteen different " species " were noted, of which 50% (mean percentage) were opaques, including magnetite, hematite, leucoxene, pyrite, cassiterite and ilmenite. Minor constituents (monazite, rutile, hornblende, andalusite, corundum, garnet, spinels and biotite) make up 14%. The remaning minerals, zircon (2·5%), tourmaline (18%) and epidote (16%), are of environmental significance.

The provenance of these minerals is the Permian sediments in the catchment and seacliffs and from reworking of older unconsolidated sediments, themselves originating essentially from the Permian.

From the heavy mineral provinces (Fig. 7)

(zircon province ..	8%	zircon
Tourmaline province	20%	tourmaline
epidote province ..	15%	,,)

it is clear that zircon predominantly occurs around the margins of the bay and that tourmaline and epidote are restricted to the deeper central areas.

These distributions reflect the energy conditions in the bay and the specific gravity of zircon and tourmaline/epidote. The heavier mineral, zircon, is concentrated in the high energy zones and the lighter minerals, tourmaline and epidote, are concentrated in the deeper low energy zones (Fig. 7).

MUD FRACTION MINERALOGY

Between 40% and 60% of the muds are composed of biogenic carbonate debris. A variety of terrigenous components are present in the muds, the most abundant being quartz (>90% of the total terrigenous fraction in all samples analysed). Other minerals found in minor percentages only include feldspar, kaolinite, chlorite, heavy minerals and muscovite.

SEDIMENTARY HISTORY

A continuous seismic reflection survey of 10 traverses (Fig. 8) using a low output " sparker " system with a visual display recorder, showed that Jervis Bay is an infilled river valley formed during a Pleistocene low stand of sea level (Fig. 8). The sediments deposited in these valleys have since been reworked and redistributed by at least one marine transgression. Examination of the records shows some patches of relict sediment which have been interpreted as lag-deposits of either the original fluvial sediments or sediments redistributed from an earlier marine transgression.

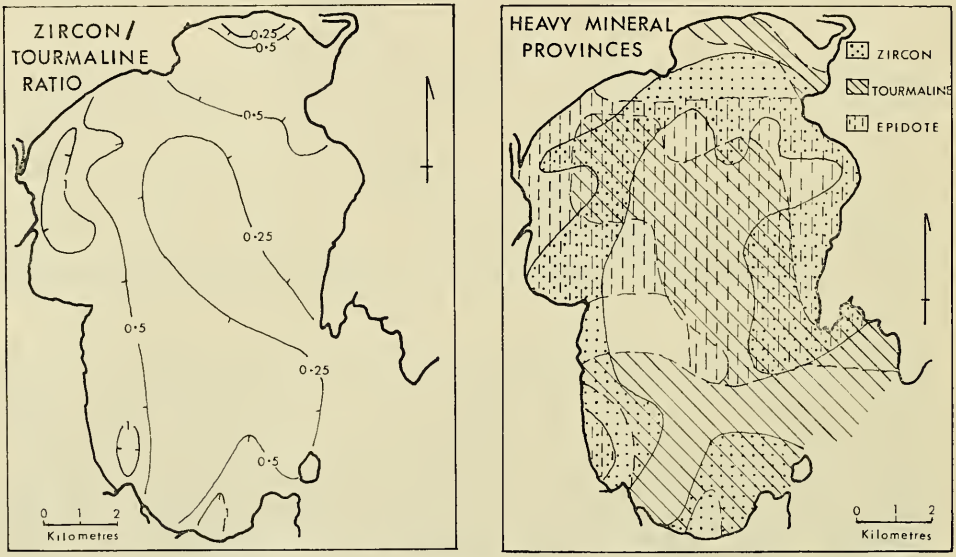

Fig. 7. **Heavy mineral provinces and zircon/tourmaline ratios of the surface sediments in Jervis Bay.**

Another source of sediment is the erosion of the seacliffs during the various interglacial high sea levels. No sediment is entering the bay from the shelf under present conditions ; however, this may not have been so during Pleistocene regressions and transgressions. The contribution of sediment from outside the bay while the bay was open at Hare Bay is unknown. A. D. Albani (pers. comm.), from seismic profiles in the Hare Bay region, confirms that the bay was at one time open to the sea at the north end also. Sediment in the bay is up to 30 m. thick in the deeper central areas, thinning to zero at the margins and over a basement high in the entrance region (Fig. 8). The thickness under the areas of beach-ridge development (e.g. Callala Beach) is unknown.

Evidence of sedimentary structures is absent from both the seismic records and from grab samples. This is probably due in part to disturbance of the materials during sampling ; however, in the few undisturbed samples taken few structures were apparent, owing to destruction by bioturbation.

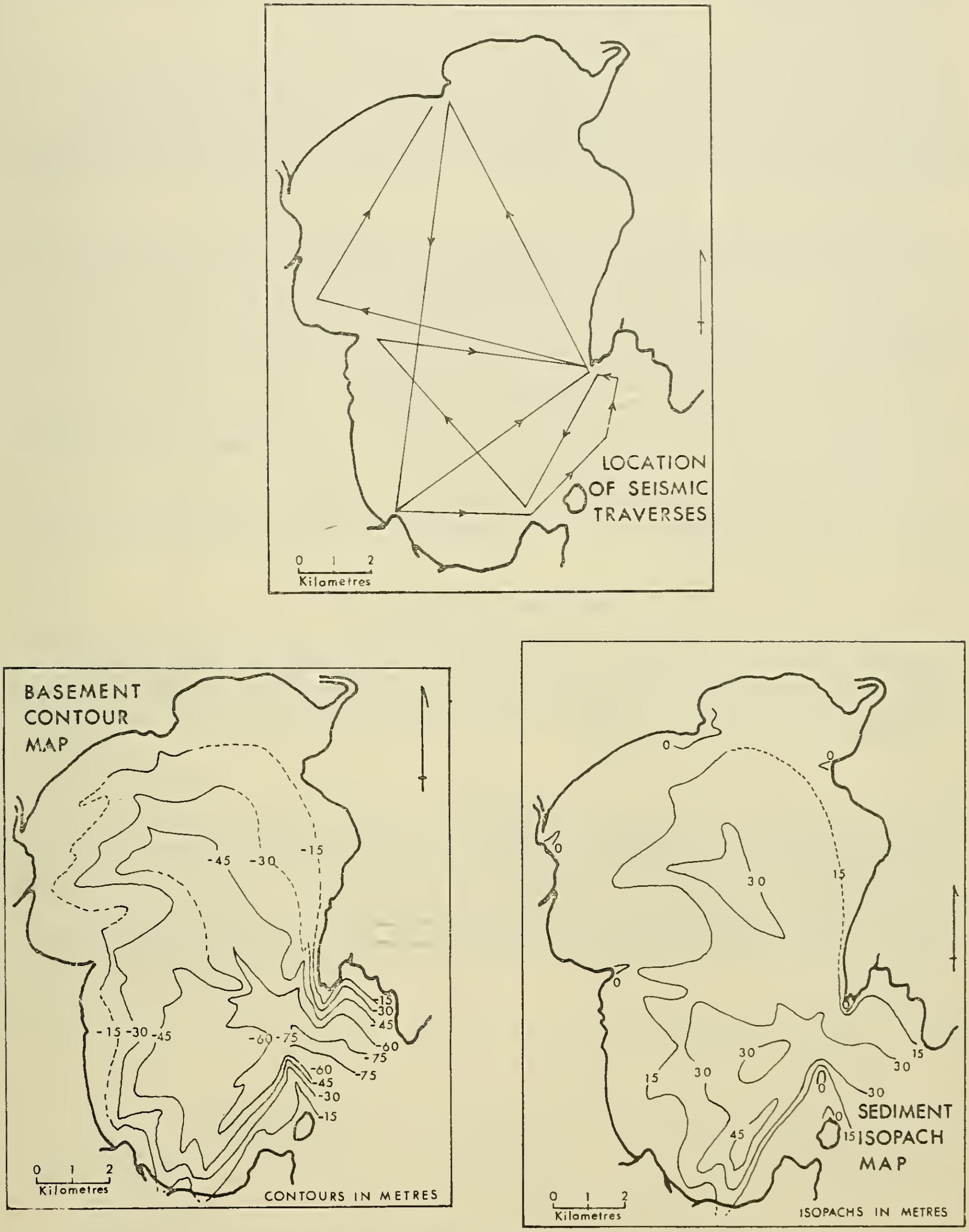

Fig. 8. Maps showing the location of seismic traverses, the configuration of the solid substratum and an isopach map of the unconsolidated sediments.

DISCUSSION

Sedimentation in Jervis Bay forms two distinct zones, the centre and the margin. These zones of deposition are based on differences between sediments forming in them.

The grain size in the marginal zone is finer than that in the centre (2·44φ and 2·11φ respectively). This results from the more intense reworking by wave activity in the marginal zones and the removal of silt, clay and carbonates to the central zone. The carbonate grains are significantly different in shape from the bulk of the sediment in the marginal zone and are hence unstable in this area. Thus it follows that the central zone is enriched in silt, clay and carbonates with respect to the marginal zone.

As a result of the continual reworking in the marginal zone and the rejection of unstable particles, marginal sediments are better sorted (0·49φ units compared to 0·69φ units) than those in the central zone. The energy difference between the central and marginal zones also controls the mineralogy. Sedimentary rock fragments are broken down into their constituents, the major one being quartz. Hence quartz is more abundant in the marginal zone than in the central zone and rock fragments are more abundant in the central zone.

The heavy minerals also reflect the differences in energy distributions; the heaviest (i.e. zircon) concentrates in the high energy zones, and tourmaline and epidote in the low energy zones.

In summary, the sediment distribution is controlled almost entirely by energy regimes in the bay. The only effective variable with respect to this in the bay is wave activity.

ACKNOWLEDGEMENTS

This study was carried out for a Master's degree at the University of New South Wales in part under a Commonwealth Postgraduate Scholarship. The author wishes to acknowledge help, during all stages of the work, from Dr. A. N. Carter of the University of New South Wales and Dr. K. A. W. Crook of the Australian National University.

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ABSTRACT OF PROCEEDINGS

Ordinary General Meeting

31st March 1971

Mr. L. A. S. Johnson, President, in the chair.

Minutes of the last Ordinary General Meeting (25th November 1970) and of the Special General Meeting (25th November 1970) were taken as read and confirmed.

Suggestions for 1971 Programme:

The Chairman invited comments and suggestions from members for meetings during 1971. After discussion, it was resolved that these would be passed on to the incoming Programme Committee for consideration.

It was also resolved to recommend that Council consider abolishing the printed abstract of Proceedings, and that Council investigate the possibility of circulating brief quarterly summaries of Council activities.

Council subsequently resolved to abolish printing the Abstract and substitute a roneoed circular instead.

Paper read (by title only, with an opportunity for discussion at the next Ordinary General Meeting):

The Trichomes of the Goodeniaceae. By R. C. Carolin.

Ordinary General Meeting

28th April 1971

Held in the Committee Room, Institution of Engineers, Science House.

Mr. L. A. S. Johnson, President, in the chair.

Minutes of the last Ordinary Meeting (31st March 1971) were read and confirmed.

Announcements:

The Secretary announced that the First International Congress of Systematic and Evolutionary Biology would be held at the University of Colorado, Boulder, U.S.A., in August 1973. Details could be obtained from the Secretary on request.

The President announced with great regret the death of Professor H. N. Barker on 16th April 1971. Professor Barber had been a Life Member of the Society since 1950.

Papers read (by title only):

Australian sea stars of the genus *Patiriella* (Asteroidea, Astirinidae). By A. J. Dartnall.

A sea star of genus *Ctenodiscus* from Tasmania. By A. J. Dartnall.

Late Devonian conodonts from the Luton Formation, northern New South Wales. By G. M. Philip and J. H. Jackson.

Paper taken as read at the March Ordinary General Meeting (with an opportunity for discussion at the April Ordinary General Meeting):

The Trichomes of the Goodeniaceae. By R. C. Carolin.

Papers read:

1. The genus *Nunciella* Roewer (Opiliones, Laniatores) with description of a new species from Kangaroo Island, South Australia. By G. S. Hunt.
2. The reptiles of Lord Howe Island. By H. G. Cogger.

ORDINARY GENERAL MEETING

30th June 1971

Held in the Committee Rooms, Institution of Engineers, Science House, at 7.30 p.m.

Dr. L. A. S. Johnson, President, in the chair.

Announcements :

The President announced the conditions adopted by the Council of the Royal Society of N.S.W. for the award of the Walter Burfitt Prize.

The President read a statement by the Minister for the Department of the Vice-President of the Executive Council regarding the formation of the Scientific and Technological Information Services Enquiry Committee.

The following meetings of the Royal Society of N.S.W. were announced :

7th July, at 7.45. (An address on 150 years of scientific associations. The Royal Society is celebrating its 150th anniversary.)

4th August, at 7.45. An address by Colonel Magee, Sydney Cove Redevelopment Authority.

Papers read :

A bacterial leaf spot of zinnia in New South Wales. By A. L. Bertus and A. C. Hayward.

An undescribed species of *Ustilago* on *Cyperus lucidus* R.Br. in Australia with comments on Robert Brown's type collection of *C. lucidus*. By J. Walker.

Shoot blight of *Eucalyptus* spp. caused by an undescribed species of *Ramularia*. By J. Walker and A. L. Bertus.

Address :

An address was given by Dr. J. S. Beard, Director, Royal Botanic Gardens, on " New light on some aspects of geomorphology in Western Australia afforded by vegetation mapping ".

ORDINARY GENERAL MEETING

28th July 1971

Held in the Committee Rooms, Institution of Engineers, Science House, at 7.30 p.m.

Dr. L. A. S. Johnson, President, in the chair.

Announcements :

The President announced that there would be a Field Day on 19th September 1971. Members would be notified later of further details. This would replace the ordinary monthly meeting for September.

Papers read :

The following papers were read by title only :

New Species of *Lophopetalum* (Celastraceae), a genus new for Australia. By N. Byrnes.

The food and feeding of winter whiting (*Sillago maculata* Quoy and Gaimard) in Moreton Bay. By John L. Maclean.

Paper read :

The early history and relationship of the New Guinea highland dog (*Canis hallstromi*). By E. LeG. Troughton.

Address :

An address was given by Mr. S. Jacobs, Royal Botanic Gardens, Sydney, entitled " New Approaches to Grass Systematics ".

ORDINARY GENERAL MEETING

19th September 1971

A Field Day Excursion to Dharug National Park replaced the Ordinary General Meeting in September.

ORDINARY GENERAL MEETING

27th October 1971

Held in the Committee Room of the Institution of Engineers, Science House, Sydney, on Wednesday, 27th October 1971, at 7.30 p.m.

Dr. L. A. S. Johnson, President, in the chair.

Announcements :

The President announced the establishment of the Keith Hindwood Memorial Fund.

Although the form of a memorial would depend on the amount of money donated, it was hoped that a Bird Studies Centre might be established. This, if it developed along lines of similar institutes abroad, would be available to the amateur student, a place where he could have access to a scientific library, record material, and which would be a nerve centre to concentrate and stimulate work by amateurs.

Should enough money be raised, it might be possible to buy headquarters and pay for modest staffing, with options for future growth, although voluntary staff could be used at the beginning.

The Trustees of the Australian Museum had generously consented to set up this Memorial Fund, and this meant all donations would be tax-deductible, cheques to be made payable to the Australian Museum Keith Hindwood Memorial Fund.

Papers read :

Australasian Ceratopogonidae. Part XV. The genus *Alluaudomyia* Kieffer in Australia and New Guinea. By M. L. Debenham.

Papers read by title only :

The reaction of seedlings of *Citrus* spp. and related genera to *Phytophthora citrophthora*. By P. Broadbent, L. R. Fraser and Y. Waterworth.

Systematic position of the genera *Triodia* R.Br. and *Plectrachne* Henr. (Gramineae). By S. Jacobs.

Aphids of Papua and New Guinea : An annotated check list. By K. P. Lamb.

The phenology of species common to three semi-arid grasslands. By O. B. Williams.

Symposium :

A symposium was given by Mr. G. P. Whitley, Mr. G. N. Baur and Dr. F. J. McDonald on " The Effect of Man on Australian Fauna and Flora ". The President thanked the participating speakers and called for a short discussion period.

SPECIAL GENERAL MEETING

24th November 1971

Held at the Australian Museum, Sydney, at 7.30 p.m.

Professor N. G. Stephenson, Vice-President, in the chair.

Business :

Professor Stephenson outlined the developments of the past year and gave reasons for calling a special General Meeting to discuss the need to widen the Society's Act of Incorporation. He then called on Dr. Vickery, the Honorary Treasurer, to explain the proposed changes in detail.

After discussion, the meeting resolved unanimously to endorse the action taken by Council to widen the Society's powers.

The meeting closed at 8.25 p.m.

ORDINARY GENERAL MEETING

24th November 1971

Held at the Australian Museum, Sydney, on Wednesday, 24th November 1971, at 8.30 p.m.

Professor N. G. Stephenson, Vice-President, in the chair.

Announcements :

The Chairman welcomed Mr. H. J. de S. Disney and Dr. C. N. Smithers, both new members, to their first General Meeting.

Myall Lakes Committee. The Chairman drew the attention of members to a request for help from the Committee to support the report of the State Planning Authority regarding leases in the Myall Lakes area ; details were available from the Secretary.

A letter from the "Stop Duffy's Forest Airport" Committee asking for support in opposing the airport scheme was read to the meeting.

Papers read (by title only) :

1. Petrology and Stratigraphy of the Brayton District, New South Wales. By S. Y. O'Reilly.
2. Check List of Northern Territory Plants. By G. M. Chippendale.
3. Organic Deposits on Foreshore at North Deewhy. By A. R. H. Martin.
4. A Brachyopid Labyrinthodont from the Lower Trias of Queensland. By A. Howie.
5. Sedimentation in Jervis Bay. By G. Taylor.

NOTES AND EXHIBITS

Mr. D. J. McGillivray spoke on *Grevillea rosmarinifolia* re-discovered in Scotland.

This species was discovered by Allan Cunningham on the banks of the Cox's River in 1822. Since that time it has not been recorded from its native habitat, nor known from cultivation in Australia. Several closely related species are known from New South Wales and Victoria.

Within a few years of its discovery *Grevillea rosmarinifolia* was in cultivation and flowering in England. It was illustrated in Robert Sweet's "Flora Australasica" in 1828, and also in Curtis's Botanical Magazine in 1872.

In 1969 a plant of this species was observed by the speaker growing in the open beside a building in the Edinburgh Botanic Garden. Although it was not in flower and was labelled *Grevillea lanata* (an error for *G. lanigera*), it showed a close resemblance to my recollection of the type specimen seen at the Herbarium, Royal Botanic

Gardens, Kew. Cuttings were sent from Edinburgh to the Royal Botanic Gardens, Sydney, and now a number of thriving plants are in cultivation in Sydney.

Dr. A. Ritchie and Dr. Joan Beattie exhibited a fossil vertebrate collected from the rock platform on the northern side of Long Reef immediately to the east of the area known as " The Basin " in August this year. The horizon in which the specimen occurred was near the top of the Collaroy Claystone, Narrabeen Group (Triassic).

The bones included a femur (about 10 inches long), scapula, rib and other fragments and have been provisionally identified as amphibian (labyrinthodont) ; their size indicates that the individual was some 12 to 14 feet in length. Dr. Anne Howie, who has been working on faunas from the Rewan Formation (of equivalent age) of the Bowen Basin, has recently examined this specimen and it is hoped that she will, on further examination, find the material sufficient for identification.

Mr. H. J. de S. Disney, Curator of Birds at the Australian Museum, showed a map and aerial photograph of Lord Howe Island and also study skins of the Flightless Lord Howe Island Woodhen, *Tricholimnas sylvestris*, with a skin of a New Zealand Weka, *Gallirallus australis*. Also exhibited was the skeleton of a Woodhen to show the tiny sternum, not much bigger than that of the now extinct Doctor Bird or Vinous-tinted Blackbird, *Turdus vinitinctus* (also on display).

Mr. Disney said he first visited the island and Mt. Gower in November 1969 with Dr. Smithers, and found that the Woodhens appeared to be present only in very small numbers on top of the mountain. As part of a general survey of the flora and fauna of the island a more intense investigation was started in February of this year. Birds were caught and colour-banded ; on subsequent visits their movements were recorded. From these records, as shown on a map of the plateau, there are apparently only 20 birds occupying 10 territories.

The birds originally were found everywhere on the island. In 1914 they were still common in Erskine Valley Little Slope and on Mt. Lidgbird. In 1936 some were still present in Erskine Valley, but they are now confined to the top of Mt. Gower.

In January 1972 it is hoped that data on breeding success will be obtained ; however, there is some indication that the summit does not provide an optimum habitat.

The decline in the species may be the result of habitat disturbance by goats and pigs, or by predation by rats (which were introduced in 1918) or cats.

The habits of these birds are similar in many respects to those of the Weka of New Zealand. Little is known of their breeding habits, but some have been recorded nesting in petrel burrows.

From the archives of the Australian Museum Mr. G. P. Whitley exhibited a photographic portrait of Dr. Haynes Gibbes Alleyne (1815 ?–1882), one of the founders of the Linnean Society of New South Wales.

Dr. Cogger exhibited a living pair of Fijian Iguanas (*Brachylophus fasciatus*) from the island of Kadavu. These lizards are now uncommon in Fiji and are regarded as an endangered species. A closely-allied form occurs in Tonga.

The family Iguanidae, to which these lizards belong, is otherwise confined to the Americas and Madagascar ; its representation in the south-west Pacific area is a unique situation in vertebrate zoogeography, and the Fijian and Tongan lizards clearly represent an example of " rafting " from continental America.

Dr. C. N. Smithers exhibited specimens of the seven commonest species of butterflies from Norfolk Island. Eleven species are known, of which nine occur in Australia. Two of these have recognizable island forms ; the eleventh species is known also from New Caledonia.

A map of Norfolk Island, showing the proposed National Park, was exhibited. Action to establish the park is being taken following a report from the Australian Conservation Foundation based on a survey carried out in 1967.

This meeting concluded the session. The Ninety-seventh Annual General Meeting, together with the next Ordinary General Meeting, will be held on Wednesday, the 29th March 1972.

LIST OF MEMBERS

(*31st December, 1971*)

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(An asterisk (*) denotes Life Member)

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1968 Blaxell, Donald Frederick, D.D.A., B.Sc., Royal Botanic Gardens, Sydney, 2000.
1960 Bourke, Terrence Victor, B.Sc.Agr., c/- Department of Agriculture, Stock and Fisheries, Popondetta, Papua.
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1955 *Fairey, Kenneth David, Box 1176, G.P.O., Sydney, 2001.
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1948 Millerd, Miss Alison Adèle, Ph.D., C.S.I.R.O., Division of Plant Industry, P.O. Box 109, City, Canberra, A.C.T., 2601.

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