

Memoirs of the  
**NATIONAL MUSEUM**  
of Victoria

Melbourne Australia 7 July 1978



Number 39

Front Cover—Squirrel Glider.  
Back Cover—Plains-wanderer.

**MEMOIRS**  
of the  
**NATIONAL MUSEUM OF VICTORIA**  
MELBOURNE AUSTRALIA

No. 39

*Director*

JOHN McNALLY

*Deputy Director*

THOMAS A. DARRAGH

*Editor*

DOUGLAS M. STONE

PUBLISHED BY ORDER OF THE COUNCIL  
7 JULY 1978

© National Museum of Victoria Council 1978

Printed by Brown Prior Anderson Pty Ltd Burwood Victoria

# NATIONAL MUSEUM OF VICTORIA

## MEMBERS OF COUNCIL

SIR ROBERT BLACKWOOD, MCE BEE FIE Aust (President)  
PROFESSOR J. W. WARREN, MA PhD (Calif) (Deputy President)  
JAMES C. F. WHARTON, BSc (Treasurer)  
PROFESSOR E. S. HILLS, CBE PhD (Lond) Hon DSc (Dunelm) DSc (Melb) FIC FAA FRS  
PROFESSOR SIR SYDNEY SUNDERLAND, CMG MD BS DSc FRACP FRACS FAA  
DR H. K. WORNER, CBE DSc (Melb) Hon DSc (Newcastle) ABSM FAA FTS FRACI FIM  
FIMM MAIMM MAIME  
DR H. N. B. WETTENHALL, MD BS FRCP FRACP  
BRIGADIER P. P. JACKSON, CMG BE FIE Aust FIMechE FAIM  
HENRY G. A. OSBORNE, BAgSc  
JOHN McNALLY, ED MSc Chief Executive Officer  
I. J. CURRY, AASA Secretary to Council

## STAFF (as at 1/5/1978)

*Director:* JOHN McNALLY, ED MSc AMAA  
*Deputy Director:* THOMAS A. DARRAGH, MSc DipEd AMAA  
*Administration:* A. G. PARSONS (in charge)  
DEBBIE VALENTINE  
E. ROWLEY  
R. DOMICAN  
PATRICIA BATCHELOR  
JUDITH FREEMAN  
KAYELENE TRAYNOR  
LYNETTE ANDERSON  
URSULA GAWRONSKI

## SCIENTIFIC STAFF

### *Geology and Palaeontology:*

Curator of Fossils: T. H. RICH, BA PhD  
Curator of Minerals: W. D. BIRCH, BSc (Hons) PhD  
Assistant Curator of Fossils: JULIET O'CONNOR, BSc  
Assistants: KERRY GENT, SUSAN GIBSON, H. VEITCH

### *Zoology:*

Senior Curator (Zoology): B. J. SMITH, BSc PhD AMAA  
Curator of Vertebrates: JOAN M. DIXON, BSc (Hons)  
Curator of Birds: A. R. McEVEY, B.A.  
OIC Herpetology: A. J. COVENTRY  
Curator of Insects: A. NEBOISS, MSc PhD FRES  
Assistant Curator of Insects: A. A. CALDER, BSc (Hons)  
Curator of Invertebrates: Vacant  
Assistant Curator of Invertebrates: SUZANNE BOYD, BSc  
Assistants: ELIZABETH MATHESON, RHYLLIS PLANT, JOAN PHILLIPS, LINDA HUXLEY, BSc,  
LORENE REID

### *Anthropology:*

Curator of Anthropology: A. L. WEST, BA DipSocStud  
Assistant Curator of Anthropology: ALISON M. OATES, BA  
Research Assistant: JUDITH WISEMAN, BA  
Assistant: CHRISTINE HOGARTH, BA

### *Survey:*

Survey Officer: J. D. BLYTH, BSc  
Assistants: H. G. BAWDEN, ALENA GLAISTER, BSc

### *Conservation:*

Conservation Officer: D. S. WOOD, BA

## SERVICE STAFF

### *Library:*

Librarian in Charge: CLARA MYERS, BA DipLib  
Librarian: CHRISTINE MCKENZIE, BA DipLib  
Assistant: SUSAN ALEXANDER

### *Display and Preparation:*

Display Officer: A. G. SOLIMAN, BA (Cairo)  
Assistants: DIANE STEPHENS, DipAd, JOHN CHALLIS, DipArt, SANDRA BROWN, DipArt  
Senior Preparator: L. CHAPMAN  
Preparators: M. G. TRAYNOR, B. HALL, K. KELLY

### *Photography:*

Photographer: F. COFFA, DipArt (Photo Illust.)

### *Education Service:*

R. N. MILLER, DipArt (in charge)  
A. PERRY TPTC  
JULIE CARTER, BA (Hons) DipEd  
ROSEMARY TAYLOR, BA TPTC  
WENDY PROUDLOCK, TPTC  
ANNETTE SEEMAN, DipTeaching  
VALERIE MCCORMACK (Typist)

## HONORARY ASSOCIATES

with year of appointment

### *Geology:*

A. A. BAKER, 1951  
A. W. BEASLEY, MSc PhD DIC, 1973  
A. C. COLLINS: FRAIA ARIBA AMTPI MACE, 1953  
E. D. GILL, ISM BA BD FGS FRGS, 1973  
PROFESSOR J. F. LOVERING, MSc PhD, 1974  
D. J. TAYLOR, MSc, 1966  
J. A. TALENT, MSc PhD, 1966  
H. E. WILKINSON, BSc, 1970

### *Vertebrate Zoology:*

C. N. AUSTIN, 1955  
C. W. BRAZENOR, 1962  
A. G. BROWN, MRCS (Eng) LRCP (London), 1968  
N. J. FAVALORO, 1945  
A. K. LEE, BSc (WA) MA PhD (Calif), 1972  
M. J. LITTLEJOHN, PhD (WA) MSc, 1972  
P. A. RAWLINSON, BSc, 1968  
C. TANNER, 1953  
R. M. WARNEKE, MSc BAgSc, 1966

### *Invertebrate Zoology:*

K. N. BELL, BSc DipEd, 1973  
J. HOPE BLACK, MSc, 1966  
R. F. BURN, 1962  
A. N. BURNS, MSc FRES, 1966  
D. F. CROSBY, FRES AASA AFAIM, 1968  
R. L. JENSZ, BSc DipEd, 1968  
C. McCUBBIN, 1974  
A. E. MONGER, LS MIS (Aust), 1974  
E. T. SMITH, 1960  
JEANETTE E. WATSON, ASMB AMTC, 1970  
L. WINSOR, DipMedTech FAIMT AAIST, 1974

### *Anthropology:*

J. H. MCNAMARA, MB BS FRCPA, 1969  
N. M. WALLACE, 1970  
SIR WILLIAM DARGIE, CBE FRSA, 1977

## CONTENTS

### GEOLOGY

1. Geology and Structural Development of the Cerberean Cauldron, Central Victoria. By W. D. Birch, A. J. W. Gleadow, B. W. Nottle, J. A. Ross and Whately. 1

### INVERTEBRATE PALAEOLOGY

2. Gastropods from the Early Devonian Bell Point Limestone, Cape Liptrap Peninsula, Victoria. By C. B. Tassell. (Plate 1) 19
3. The Omphalocirridae: A new family of Palaeozoic Gastropoda which exhibits sexual dimorphism. By R. M. Linsley. (Plates 2-10) 33

### VERTEBRATE PALAEOLOGY

4. *Propleopus chillagoensis*, a new North Queensland species of extinct giant rat-kangaroo (Macropodidae: Potorinae). By M. Archer, A. Bartholomei and L. G. Marshall. (Plate 11) 55
5. Detailed comparisons of the dentitions of extant Hexanchid Sharks and Tertiary Hexanchid Teeth from South Australia and Victoria, Australia. (Selachii:Hexanchidae). By N. R. Kemp. (Plates 12-15) 61
6. *Raemeotherium yatkolai* gen et. sp. nov., a primitive diprotodontid from the medial Miocene of South Australia. By T. H. Rich, M. Archer and R. H. Tedford. (Plate 16) 85
7. Synonymy of the fossil wombat *Vombatus pliocenus* (McCoy) with the living species *Vombatus hirsutus* (Perry). By H. E. Wilkinson. (Plates 17-18) 93

### INVERTEBRATE ZOOLOGY

8. Comments on the species concept in some Australian *Anisops* Spinola (Hemiptera:Notonectidae). By I. Lansbury. 101
9. Revision of the Australian Euasthetinae (Coleoptera: Staphylinidae). By V. Puthz. 117
10. *Leptanthura* and new related genera (Crustacea, Isopoda, Anthuridea) from Eastern Australia. By G. C. B. Poore 135
11. The Spionidae (Polychaeta) from Southeastern Australia with a revision of the genera of the family. By J. A. Blake and J. D. Kudenov. 171

### VERTEBRATE ZOOLOGY

12. Survey of the Vertebrate Fauna in the Grampians-Edenhope area of Southwestern Victoria. By W. B. Emison, J. W. Porter, K. C. Norris and G. J. Apps. (Plates 19-21) 281

Contributions towards the cost of printing this Memoir have been made by—

Dr R. M. Linsley (Paper 3); The Tasmanian Museum and Art Gallery (Paper 5); Dr J. A. Blake (Paper 11); Marine Studies Group, Ministry for Conservation (Paper 11); and Fisheries and Wildlife Division, Ministry for Conservation (Paper 12).

## INSTRUCTIONS TO AUTHORS

Two copies of the manuscript, with any accompanying Plates and Figures, should be submitted initially to the Deputy Director, National Museum of Victoria.

Authors should consult a recent number of the *Memoirs* to acquaint themselves with the format.

**Manuscripts** must be typed on quarto paper, double-spaced, on one side of paper only, and with ample margins. Captions to Text Figures and Explanations of Plates must be attached to the MS as final pages. Underlining should be restricted to generic and specific names of biological taxa. Measurements must be expressed in the metric system (SI units).

**References** should be listed alphabetically at the end of the paper. Abbreviations of titles of periodicals must conform with those in *A World List of Scientific Periodicals* (1963-4, 4th ed., London, Butterworth). References to books should give the year of publication, number of edition, city of publication, name of publisher. Titles of books and (abbreviated) names of periodicals should be underlined in the typed list of references.

**Acknowledgements** are placed at the end of the paper before References.

Maximum size for **Plates** is 15.5 cm x 21 cm. Photographs must have clear definition and

may be submitted as either glossy or flat prints, at **actual size for reproduction**. Each plate (photograph) must be mounted on white card to furnish a white surround of at least 5 cm, and the Plate number clearly labelled on the back of card.

Line drawings for **Text Figures** should be made in black ink on white card or drawing linen. Maximum size (full page) is 15.5 cm x 21.0 cm: single column width 7.5 cm. Figures are preferably submitted at **actual size**: they may well be drawn larger and photographed by the author to be submitted as glossy prints of required size. Graphic scales must be included with the drawings, and on maps and geographic plan views, compass directions should be indicated. Lettering on Figures must be inserted by the author, and special care is needed to ensure that all letters and numerals are still readable when the Figure is reduced.

Oversized illustrations, tables or maps are accepted for publication as **Foldouts** only with the understanding that the author meet any additional costs involved in their production. Maximum size for foldouts is 21 cm x 31.5 cm. Short Tables will be type-set within the text. Extensive Tables which are likely to cover one page of print should be typed, on an electric typewriter to ensure clarity and evenness, within the dimensions 27.9 cm x 22.5 cm. They should then be photographed to reduce them to full page size, 15.5 cm x 21 cm, and submitted as glossy prints. They will be reproduced on metal, not type-set, and hence must be finally correct when submitted, since they cannot be corrected at the proof stage.



# GEOLOGY AND STRUCTURAL DEVELOPMENT OF THE CERBEREAN CAULDRON, CENTRAL VICTORIA

By W. D. BIRCH,\* A. J. W. GLEADOW,† B. W. NOTTLE,†  
J. A. ROSS† and R. WHATELY†

\* Mineralogy Department, National Museum of Victoria

† Geology Department, Melbourne University

## Abstract

The Cerberean Cauldron, in Central Victoria, is a classic example of the cauldron subsidence phenomenon. The ring and radial fracture patterns and the interbedded volcanic and sedimentary units preserved enable the history of the cauldron's development to be traced in detail. Three cycles of acid magma represented by rhyolite-rhyodacite ash flows with associated tuffaceous sediments were interspersed with periods of sedimentation or eruptions of basic lavas. The earliest formations, constituting the pre-collapse phase, show variable thickness and distribution within the cauldron, whereas the thick Cerberean Volcanics, representing the major subsidence event overlap all other formations. The rhyolites and rhyodacites respectively from the three acid volcanic formations show similar petrographic features.

Igneous activity in the region may have commenced with basining and ash-flow eruptions from along early formed faults or isolated vents. The ring and radial fractures were probably initiated by a point explosion at depth in the chamber providing magma for the Cerberean Volcanics. Eventual collapse of the central block was one of foundering under gravity, following removal of magmatic support due to substantial ash-flow eruptions. Activity culminated in high level intrusions of granodioritic magma.

## Introduction

Upper Devonian vulcanism in Central Victoria is represented by a number of well-exposed subsidence complexes, occupied by part or all of a remarkably similar rhyolite-dacite sequence. The total volume of acid-intermediate magma preserved is of the order of several thousand cubic kilometres. (A general outline of the geology of the Central Victorian province is given by Marsden, 1976.)

The Cerberean Cauldron is the most spectacular complex, being a classical example of cauldron subsidence (in the sense of Smith and Bailey, 1948). Its importance lies in that its three cycles of acid volcanism may reflect rhythmic crustal movements and magmatism in the prevailing tectonic regime.

The geometric centre of the Cerberean Cauldron complex lies 96 km northeast of Melbourne. The volcanic rocks within the structure now comprise the Cerberean Ranges, the high-level, roughly elliptical plateau forming part of Victoria's Eastern Highlands.

The area was mapped in detail by Birch *et al.* (1970) and covers an area of about 1 150 square kilometres (Fig. 1). Earlier mapping work on parts of the cauldron had been carried out by Bell (1959), Thomas

(1947), Hills (1929, 1932) and Whitelaw (1913). Additional mapping of the Acheron Cauldron, which adjoins the Cerberean along the latter's southern edge, was carried out by Dudley *et al.* (1971) and Howard (1972). Mapping of the basement sediments, in particular the Cathedral and Koala Creek Sandstone, was carried out by Vandenberg (1977).

This paper outlines the general geology of the Cerberean cauldron and its structural development, and provides a brief petrography of the main rock types. The chemistry and petrogenesis will be discussed in more detail in further papers, although these have been alluded to by Birch and Gleadow (1974).

## Tectonic Setting

The Central Victorian Trough was apparently a localized basin of sedimentation, possibly representing a marginal sea within the Lachlan Geosyncline, at the southern end of the Palaeozoic Tasman Mobile Belt. The Trough is geologically bounded on east and west by complex up-faulted axial structures consisting of Cambrian sediments and greenstones with tholeiitic affinities—the Mt Wellington and Heathcote axes respectively. Within this trough, marine geosynclinal conditions

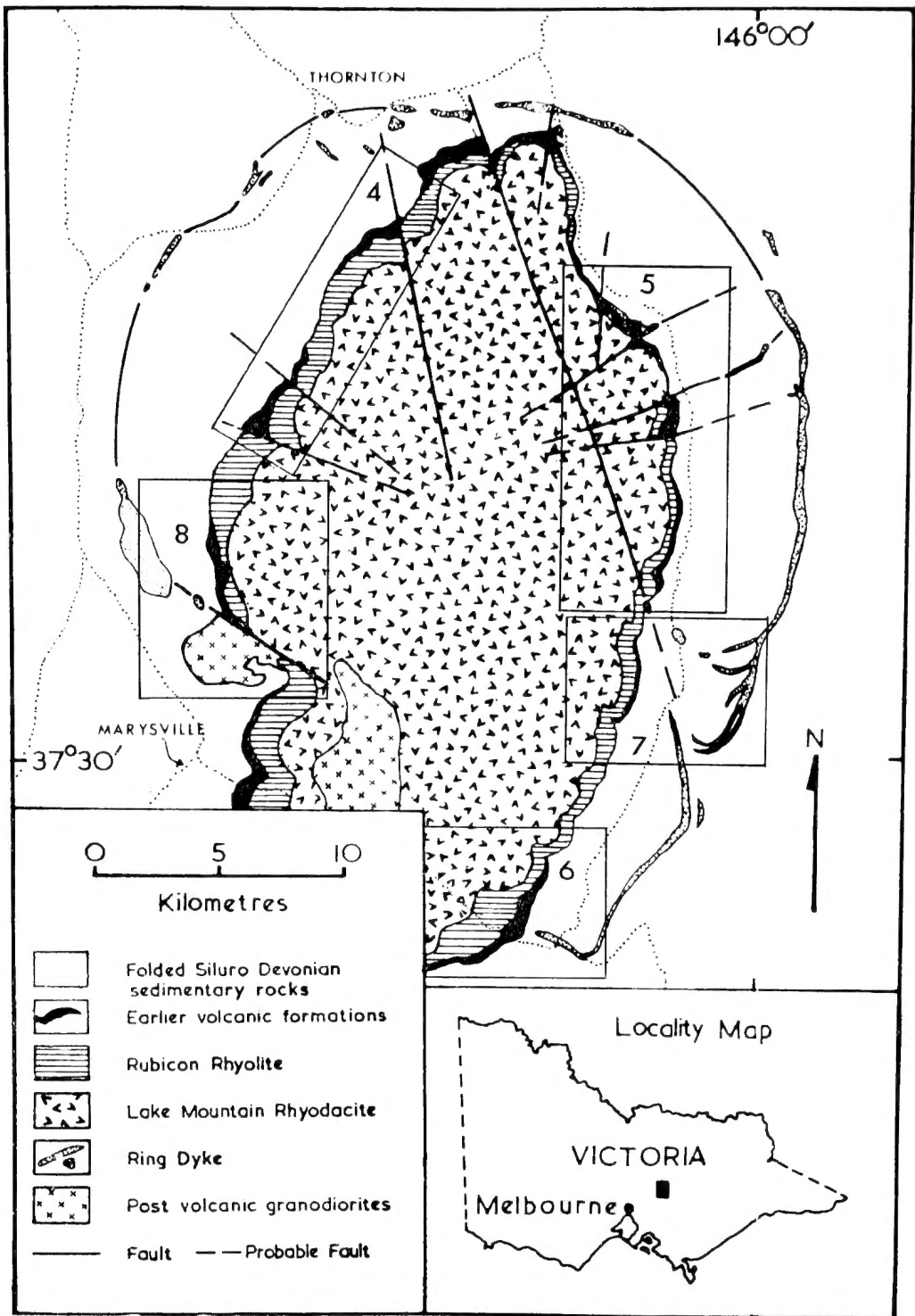


Figure 1—The Cerberian Cauldon, showing its location and the positions of the larger scale maps of the sequence along the margin of the volcanic pile shown in Figs. 4 to 8.

were operative from at least the Lower Ordovician, but possibly as early as Lower-Middle Cambrian, up until Lower-Middle Devonian times.

In the late Middle to early Upper Devonian, the sedimentary fill was folded on a NNW-SSE trend, and intruded by a dyke swarm with mainly lamprophyric and quartz dioritic rock types (the Woods Point Dyke swarm) whilst orogenic forces were still operative (Hills, 1959). Following deformation, large amounts of acid-intermediate magma were emplaced at high levels within the crust, forming a batholith-volcanic province fairly typical of circum-Pacific (Andean) magmatism.

### General Geology

The Cerberean Cauldron is circumscribed by a circular, near vertical, partly dyke-filled ring fracture of 27 km diameter, in combination with a radial fracture pattern focussing at the geometric centre. (See Figs. 1 and 2). The complex has been emplaced through the thick Lower Silurian-Lower or Middle Devonian bedrock of folded sandstones, siltstones and shales. The youngest basement rocks are the Cathedral Range and Koala Creek Sandstones, which outcrop on the western and southeastern sides of the cauldron volcanics respectively, in what appears to have been a northwest to southeast trending structural basin. They are apparently continuous beneath the volcanics (Clarke *et al.*, 1970). Both units form prominent strike ridges within and subparallel to the ring fracture, but are apparently conformable with underlying basement sediments (Dale, 1964; Bell, 1959; Hills, 1929). The units as a whole behaved competently during cauldron formation and have locally influenced the fracture pattern (Fig. 2).

The sequence within the Cerberean Cauldron can be divided into a number of alternating volcanic and sedimentary formations, which have a general inward dip at relatively shallow angles (Fig. 3). These are shown in Table 1 and are based on the subdivision of Thomas (1947) and on more detailed mapping of Birch *et al.* (1970).

The five formations within the Taggerty Sub-

group represent the pre-collapse phase in the cauldron's development.

### *Wightmans Hill Conglomerate*

This is a terrigenous formation comprised mainly of a high-energy, fluvial conglomerate, with well rounded pebbles of indurated quartz sandstone derived from the Palaeozoic bedrock. The pebbles range up to about 30 cm in diameter, but average 3-8 cm.

The formation overlies an irregular basement topography and hence outcrop distribution and thickness are variable. In some places, quartzite pebbles on the surface are its only expression. It is thickest in the northeast (30 m) and most continuous in the Blue Range, east of Taggerty (Fig. 4).

### *Snobs Creek Volcanics*

Volcanic activity in the cauldron began with the emplacement of rhyolitic ash flow tuffs, of relatively small extent. The formation is best developed west of Snobs Creek in the northwest, where it reaches a maximum exposed thickness of 300 m (Thomas, 1947). Its outcrop elsewhere on the western side of the cauldron is fairly continuous but it is generally less than 60 m thick (Fig. 4). Near Snobs Creek, the basal ignimbritic rhyolite, containing carbonized plant remains, grades upwards into a rhyodacite. Overlying this is a band of poorly, or non-welded tuffaceous rocks, with more compact bands of biotite-rich rhyodacite. Tuffs rich in phenocrysts occur at the top of the formation (Thomas, 1947).

The formation is restricted to the west or downthrown side of the Snobs Creek Fault apart from a small exposure on the eastern side of the cauldron (Fig. 5).

### *Blue Range Formation*

This formation consists of sedimentary units of various types, some probably tuffaceous, and represents a definite break in the extrusive activity. The most significant unit is the 'Fish Beds' (Hills, 1929), which reaches a maximum development (about 130 m thick) in the Blue Range, north of Little River (Fig. 4). Here, well-bedded, red and yellow fine-grained, lacustrine sandstones, and brown and greenish

TABLE 1  
Generalized sequence within the Cerberean Cauldron

		INTRUSIVE PHASE	CENTRAL INTRUSIONS Granodiorite Porphyritic microgranodiorite RING DYKES, RADIAL DYKES Porphyritic granodiorite (equivalent to the Lake Mountain Rhyodacite). Porphyritic granite (equivalent to the Rubicon Rhyolite).	
		(collapse phase)	ACHERON VOLCANICS Donna Buang Hypersthene Rhyodacite Warburton Quartz Rhyodacite	NOT REPRESENTED
		CERBEREAN VOLCANICS Lake Mountain Rhyodacite  Rubicon Rhyolite	Ignimbritic rhyodacite (uppermost unit in cauldron). Ignimbritic rhyolite, grading to rhyodacite at top. Lenticulite at the base.	* 900 m 390 m
		TAGGERTY SUBGROUP (pre collapse phase)	ROBLEYS SPUR VOLCANICS	Porphyritic andesite, andesitic basalt, minor basalt in south, some intercalated with underlying Ignimbritic rhyodacite flows. Interbedded non-welded tuff, tuffaceous sediments. Minor agglomerate. Ignimbritic rhyolite flows, associated tuff.
TORBRECK RANGE ANDESITES	Andesite basalt, andesite, minor basalt, basic and intermediate tuff, minor agglomerate.		360 m	
BLUE RANGE FORMATION	Shale and fine sandstone, with fish and plant remains. Some tuffaceous sediments, minor quartzite and hornfels.		120 m	
SNOBS CREEK VOLCANICS	Phenocryst-rich tuff. Non-welded biotite-rich tuff, bands of welded rhyodacite. Ignimbritic rhyodacite with biotite apparently grading into Basal ignimbritic rhyolite.		285 m	
WIGHTMANS HILL CONGLOMERATE	Basal quartzose conglomerate, minor quartzite, unconformable with basement.		30 m	

\* Approximate maximum thickness in metres.

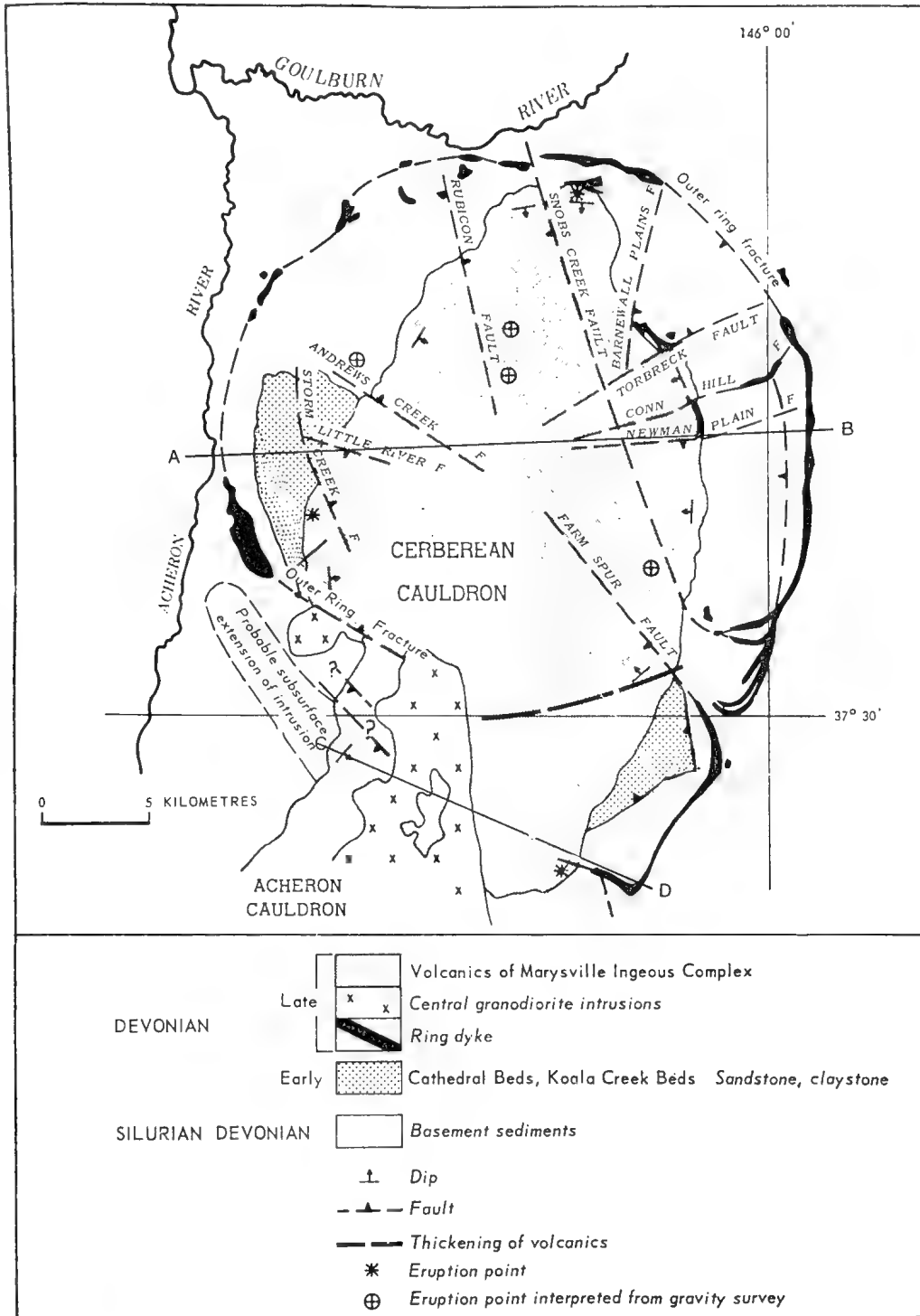


Figure 2—Structural Map of the Cerberean Cauldron. A-B and C-D arc cross section lines for Fig. 3.

shales have yielded a fish fauna and plant remains of Upper Devonian age. (Hills, 1929, 1931). The formation is not well developed at Snobs Creek and only thin conglomerates are recorded by Thomas (1947). On the eastern side of the Cauldron, the stratigraphic position is occasionally represented by thin, compact brown or greenish shales containing mud pellets.

#### *Torbreck Range Andesites*

This is the most extensive of the formations in the Taggerty subgroup, and is the only known occurrence of basic vulcanism (apart from that of the Robleys Spur Volcanics) in any of the Victorian cauldron structures. The formation consists of uniform, dark fine-grained basaltic andesites with minor basic tuffs of various types and occasional agglomerates. The greatest variety of rock types occurs at Snobs Creek (Thomas, 1947).

The formation reaches its maximum thickness and continuity along the eastern side of the cauldron, and the outcrop pattern between the Conn Hill and Newman Plain Faults indicates a thickness of at least 380 m (Fig. 5).

#### *Robleys Spur Volcanics*

Two easily recognized and fairly persistent members characterize this formation. The older consists of dark, phenocryst-poor ash flow rhyolites (the Middle Rhyolite of Thomas, 1947) and the younger is of dark, fragmental rhyodacites (the Fragmental Toscanites of Hills, 1932). There is a wide variety of other rock types in the formation, including tuffs and tuffaceous sediments, particularly on the western side of the cauldron. On the eastern side, the formation is generally less than 20 m thick and the rhyolitic member predominates.

In the south of the Cerberean Cauldron, close to its junction with the Acheron Cauldron, porphyritic andesites are interbedded with acid volcanics, e.g. in the cuttings of the Marysville-Cumberland Road up Robleys Spur and near Cumberland in the southeast of the cauldron (Fig. 6).

#### *Cerberean Volcanics*

This formation represents the catastrophic

collapse phase of the central block and contributes about 80% of the volcanic rocks in the cauldron. The formation has been subdivided into two mappable units but these have no definite structural boundary and represent almost continuous ash flow emplacement (Birch, in prep.).

(1) Rubicon Rhyolite. The Rubicon Rhyolite (Nevadite of Hills, 1932 and Thomas, 1947) is a thick, phenocryst-rich, rhyolitic ash flow averaging 250 m in thickness and with an areal extent of about 400 km<sup>2</sup> in the Cerberean Cauldron. It is thicker on the western side (up to 390 m near Little River, Fig. 4), than on the east, where it may be absent (Fig. 5).

In the north, near Snobs Creek, the Rubicon Rhyolite forms a prominent cliff-forming horizon. A lenticulite horizon occurs at the base, with the vitroclastic texture best developed in the Blue Ranges (Fig. 4). At Snobs Creek, a second lenticulite horizon occurs about half way up the rhyolite indicating at least two cooling units in this particular area. Xenoliths of hornfels, representing country rock, occur most commonly in the lenticulite horizons.

(2) Lake Mountain Rhyodacite. The Lake Mountain Rhyodacite is the uppermost unit in the cauldron, and forms the high-level, dissected plateau of the Cerberean Ranges. It probably reaches the order of 1000 m in thickness at the centre of the cauldron (Fig. 3). There was no apparent gap in extrusive history between the rhyodacite and the Rubicon Rhyolite and textural evidence in general suggests that the two rock types comprised the one cooling unit.

The rhyodacite shows only minor mineralogical and textural variations. The most significant is the presence of lighter-coloured, flattened lenses or schlieren (with similar mineralogy to the host rhyodacite) which may occur at all levels and over its entire areal extent. The term 'Snobite' (Hills, 1932) was applied to the most heterogeneous ('hybrid') varieties of the rhyodacite.

At one locality in the southeast, near the settlement of Cambarville (Fig. 6), the base of the rhyodacite contains small, greenish, rhyolitic, lens-like inclusions. Xenoliths with-

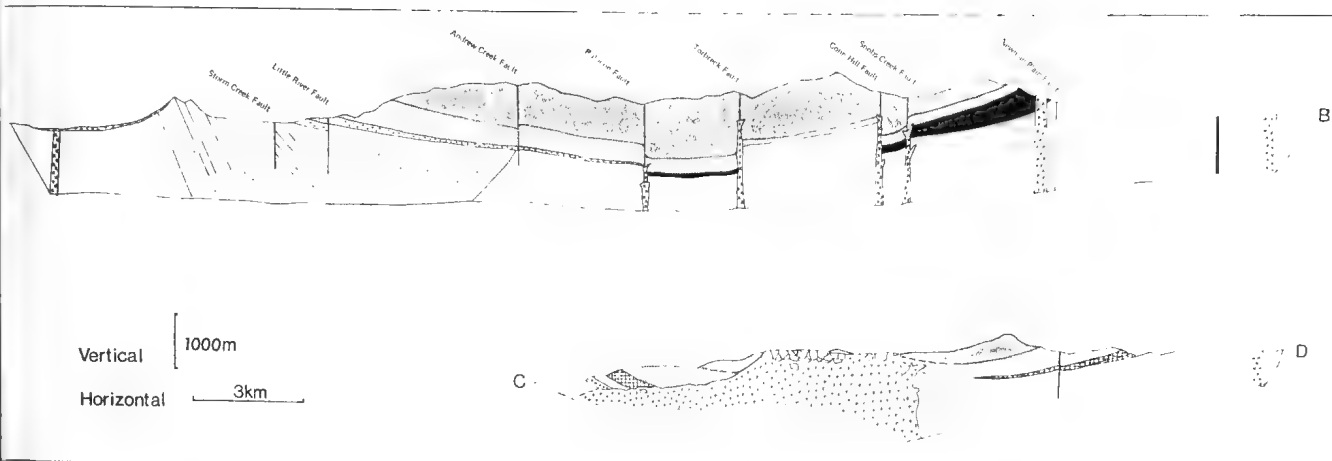


Figure 3—Cross sections of the complex.

KEY (for Figs. 3 - 8).	
<p>JAGGERY SUBGROUP</p> <p>Wightmans Hill Formation.</p> <p>Snobs Creek Formation.</p> <p>Blue Range Formation.</p> <p>Torbreck Range Formation.</p> <p>Robleys Spur Formation.</p>	<p>CERBEREAN VOLCANICS.</p> <p>Rubicon Rhyolite.</p> <p>Lake Mountain Rhyodacite.</p> <p>Ring and Radial Dykes.</p> <p>Central Intrusions.</p> <p>Cathedral and Koala Creek Beds.</p> <p>Basement Siluro-Devonian Sediments, Alluvium.</p>

in the rhyodacite include hornfels and the Rubicon Rhyolite. One piece of graphite was recorded and probably represents carbonized wood (by analogy with the Snobs Creek Rhyolite).

*Ring and Radial Dykes, Satellite Intrusions*

The circular, outer ring fracture is filled for about 70% of its extent, with the dyke ranging from garnetiferous porphyritic granodiorite (which is the more common) to porphyritic granite. In the north-east, the main ring dyke is complicated by several small satellite intrusions in which both rock types may occur, e.g. Christie's Hill.

In the southeast, the dyke undergoes a com-

plex branching (Fig. 7) with fractures curving inwards or backwards on themselves. Further south, the dyke is a continuous body, trending sub-parallel to the strike ridges of the Koala Creek Sandstone. The fracture finally bends westward to cut the volcanics without dyke fill (or significant vertical and horizontal displacement) near Cumberland (Fig. 6). This contrasts with the situation in the southwest, where the ring fracture cuts the volcanics and offsets them by 3000 m horizontally and 500 m vertically (Fig. 8).

Detailed mapping on the northeastern side of the complex revealed an inner ring dyke actually cutting the volcanic pile. In the best exposure, on the Barnewall Plains Road, the

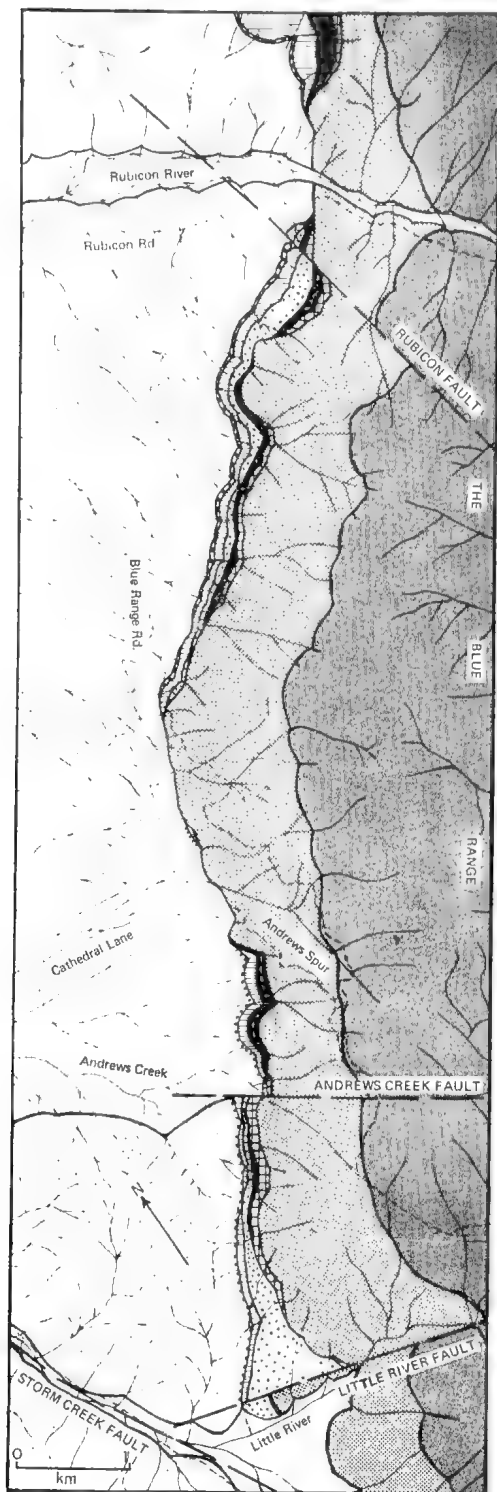


Figure 4—The geology in the Blue Range.

chilled margin is of porphyritic granite, but the bulk of the dyke is of porphyritic granodiorite (Fig. 5). In the extreme north, Thomas (1947) mapped thin branching porphyry dykes intruding the volcanics.

Of the radial faults, only two definitely contain dyke fill. These are the Torbreck and Conn Hill Faults (Fig. 5). Opposite the Newman Plains Fault, Whitelaw (1913) mapped a small, radial, protrusion from the outer ring dyke.

#### Central Intrusions

Intrusion of two texturally-distinct, high-level granodiorites, marked the final stages in the evolution of the Cerberean Cauldron.

(1) Porphyritic Microgranodiorite. The older and less-developed is a fine-grained granodiorite with occasional large orthoclase phenocrysts. It forms a stock, intruding and metamorphosing basement sediments and volcanics, southeast of Buxton (Fig. 8). The intrusion has a small extension to the southeast along the continuation of the outer ring fracture, and within the fault zone the Rubicon Rhyolite has been dragged down and incorporated within the intrusion (Fig. 8). The microgranodiorite also occurs as thin dyke-like bodies intruding the Lake Mountain Rhyodacite in the Keppels Falls area.

(2) Granodiorite. The final high-level granodiorite intrusion was emplaced into the base of the volcanic pile in the Junction region between the Cerberean and Acheron Cauldron. The mass is elongated north-south in outcrop, and its eastern contact with the Lake Mountain Rhyodacite appears fault-controlled (Fig. 6). On the western side, the contact between granodiorite and volcanics is not well exposed, but a shallow westerly dip under the volcanics is suggested.

A significant feature of the intrusion is a complex and not easily interpreted zone ('Hybrid' zone of Hills, 1932), exposed in cuttings on the highest part of the Marysville-Cumberland road, and extending south and west. Large blocks of hornfels, partially granitized, with less common andesite and rhyodacite, are veined by granodiorite and in places the rock Biotite is abundant in the Lake Mountain Rhyodacite, but less common in the Snobs



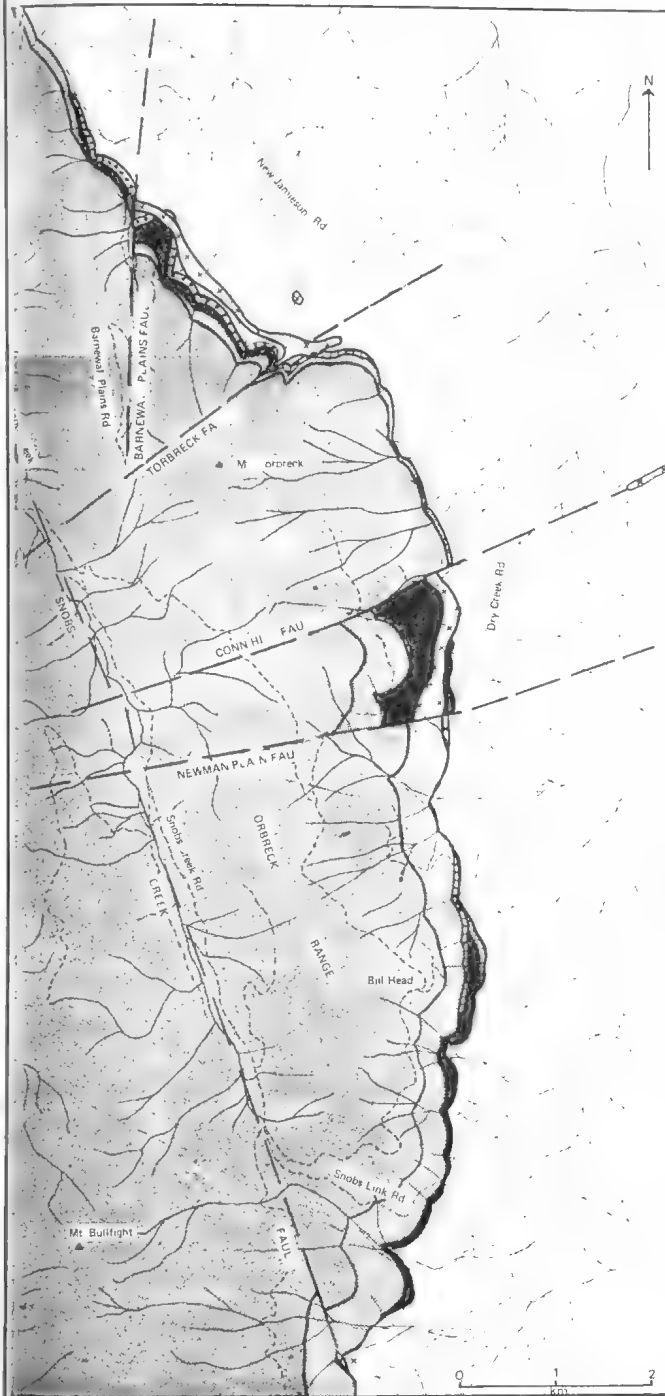


Figure 5—The geology in the Barnewall Plain—Snobs Link Road area.

types are strongly sheared. Bedding preserved in some of the hornfels blocks suggests that little movement relative to the basement has occurred. This hornfels region is at a much higher level than the original surface on which the volcanic rocks in the Cerberean Cauldron to the north were deposited (Fig. 3).

A few thin dykes of late-stage hornblende porphyryite have been described in the Snobs Creek area by Thomas (1947) and Birch *et al.* (1970).

### Petrography of the Major Igneous Rocks

#### *Rhyolites*

Quartz (euhedral to subhedral and embayed) and potassium feldspar (orthoclase to intermediate microcline) are the dominant phenocrysts in the rhyolitic rocks, with less common plagioclase (oligoclase-basic andesine) and biotite. A small proportion (up to 5 modal per cent) of iron cordierite crystals and rare almandine garnets characterize the Rubicon Rhyolite (see Birch and Gleadow, 1974), but these two minerals are absent in the Snobs Creek and Robleys Spur Rhyolites.

All three rhyolites show remnant eutaxitic and vitroclastic textures, as evidence for an ash flow origin. These are best developed in the basal, phenocryst-poor region of the Rubicon Rhyolite. Dense welding, followed by devitrification and recrystallization has tended to obliterate original ignimbritic textures in the quartzo-feldspathic groundmass in all three rhyolites. Both the Snobs Creek and Rubicon Rhyolites are pale grey in colour, but the latter is distinctive due to its high phenocryst content or prominent eutaxitic textures in the low phenocryst varieties. The Robleys Spur Rhyolites are dark and aphanitic, the dark colour being due to finely-divided magnetite in the groundmass.

The Rubicon Rhyolite grades into the overlying Lake Mountain Rhyodacite with increase in phenocryst content and modal proportion of biotite and plagioclase.

#### *Rhyodacites*

Quartz and plagioclase are the dominant phenocryst phases in the rhyodacitic rocks.

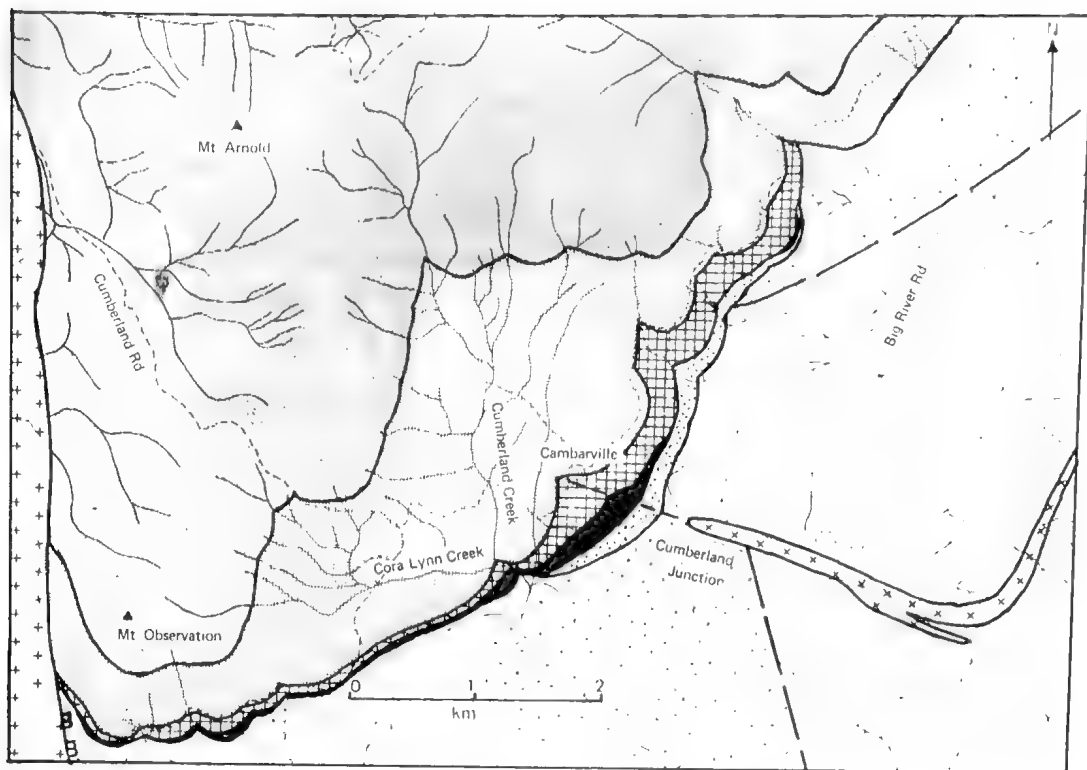


Figure 6—The geology in the Cumberland region.

Creek and Robleys Spur Rhyodacite. Orthoclase is uncommon in all three rhyodacites. Small quantities of hypersthene and almandine characterize the Lake Mountain Rhyodacite.

The groundmass in all three rhyodacites is microcrystalline, and only in the Robleys Spur Rhyodacite are remnant vitroclastic textures preserved. However, the continuity of the Snobs Creek and Lake Mountain Rhyodacites with their underlying ignimbritic rhyolites implies ash flow origins for both. Recrystallization has occurred to the greatest extent in the Lake Mountain Rhyodacite due to autometamorphic effects resulting from its considerable thickness.

The three rhyodacites differ considerably in appearance, with the Snobs Creek Rhyodacite being pale in colour, the Robleys Spur Rhyodacite dark with abundant small phenocrysts, and the Lake Mountain Rhyodacite dark grey and biotite-rich.

### *Basaltic Andesites*

The basaltic andesites of the Torbreck Range Andesites are dark bluish-grey, uniform and finegrained. Prismatic phenocrysts of augite and occasional labradorite occur in a groundmass of small plagioclase lathes, prisms of augite and iron ore grains. Groundmass alteration is widespread however, producing chlorite, actinolite, carbonate and iron oxides.

The basaltic andesites interbedded with the rhyodacites of the Robleys Spur Volcanics near Marysville are dark grey, compact rocks with abundant sub-rectangular phenocrysts of plagioclase showing oscillatory zoning and less common augite, the latter usually altered to a pale green amphibole. The groundmass is similar to that in the Torbreck Range Andesites, although secondary biotite has developed in the sequence near Marysville, due probably to contact metamorphism from the effect of the nearby ring dyke mass.

### *Intrusive rocks*

The porphyritic granite and granodiorite in the ring dykes are the intrusive equivalents of the Rubicon Rhyolite and Lake Mountain Rhyodacite respectively. The granite contains large phenocrysts of quartz, white to pink intermediate microcline perthites and less common saussuritized plagioclase and biotite in a fine-grained, greenish, sericitized, quartzofeldspathic groundmass. Pinitized cordierite is rare. The granodiorite consists of quartz, plagioclase, biotite and orthoclase in a medium grained groundmass. It is characterized by reddish garnets, usually partly altered to biotite, up to 1.5 cm across.

The two rock types forming the central intrusions have normal granodioritic mineralogy. However, the porphyritic microgranodiorite contains large, conspicuous orthoclase phenocrysts up to 3 cm long, and sillimanite and almandine are unusual, if rare, constituents and are probably xenocrystic. The granodiorite

forming the larger intrusion is generally medium-grained and sub-equigranular, although it tends to be more porphyritic in the veins within the complex hornfelsic zone at the junction between the Cerberean and Acheron cauldrons.

### **Structural Development**

#### *Structural pattern*

The Cerberean Cauldron subsidence area is basically a cylindrical block which has subsided along an integrated pattern of circular and radial faults (Fig. 2). Greater subsidence at the centre of the block has led to basining of the volcanic pile, i.e. all formations dip inwards (Fig. 3). Differential movement has also occurred on the radial faults.

Where the Cerberean Cauldron adjoins the Acheron Cauldron there is no clearly defined structural break. The volcanic sequence on the western side is apparently continuous between the two cauldrons.

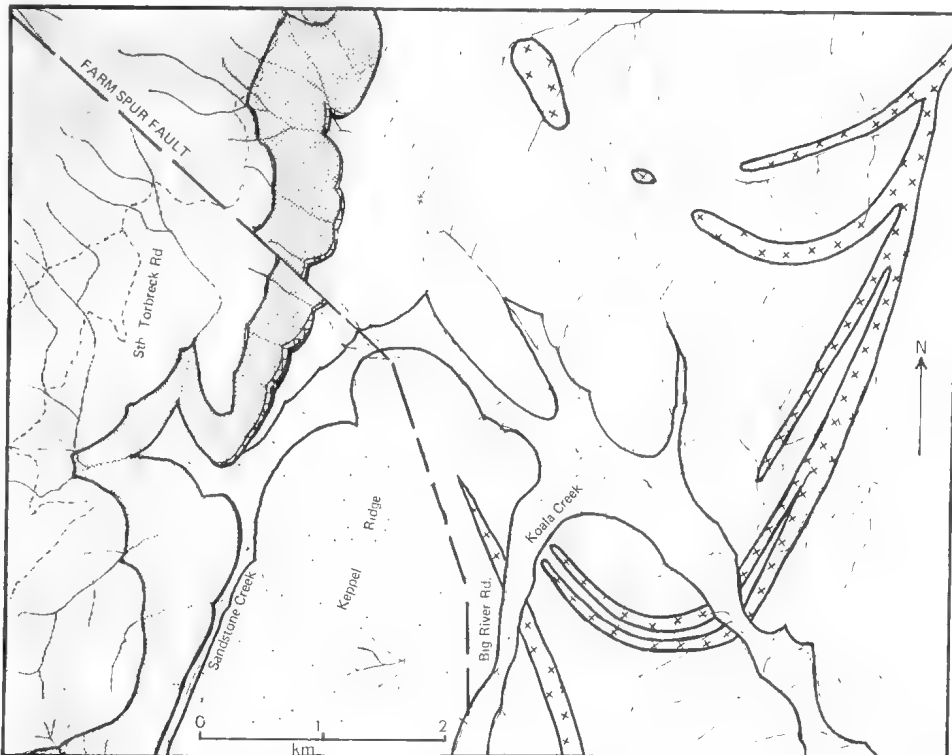


Figure 7—The geology in the region of the complex branching of the ring fracture in the south-east of the Cerberean Cauldron.

### Early faulting

The earliest known fault associated with the cauldron structure is Snobs Creek Fault, which is parallel to and probably controlled by the regional basement trends (Fig. 2). The fault was operative at least as early as the extrusion of the Snobs Creek Formation, since these rocks are restricted to the downthrown, or western side of the fault in the northwest. Of the overlying formations, only the Torbreck Range Formation changes in thickness across the fault. The much greater subsidence on the fault line in the northwest, compared to the southeast, where the vertical displacement is apparently reversed, indicates a hinging effect (Fig. 5).

The inner ring dyke, exposed between pairs of radial faults in the northeast, represents an early-formed fracture. The interpretation of the geology between the Conn Hill and Newman Plain Faults (Fig. 9) requires this fracture being present as a scarp during emplacement of the Torbreck Range Andesites, since thick accumulations of basaltic andesites occur against it (Fig. 5). This scarp was apparently not present at the time between the Barnewall Plains and Torbreck Faults further north. Although interpretation of this ring fracture's history is complicated, it may represent part of the margin of a caldera, of about 9 km diameter, dipping inwards at 50°-60°, and centred on Snobs Creek Fault. The gravity survey by Clarke *et al.* (1970) indicates a probable thickening of the volcanic sequence in this area.

### Later faulting

(1) Ring Fractures. The outer and most continuous ring fracture is almost perfectly circular, with a 27 km diameter. Minor branching is caused by radial and other faults, but only Snobs Creek Fault offsets it.

The complex zone of arcuate fractures developed in the southeast has probably been caused by the intersection of the southeastern end of the Snobs Creek Fault with the outer ring fracture, and influenced by the northwest-southeast regional basement trends. Further to the south, the fracture pattern has been shaped

by the rigid block of Koala Creek Sandstones (Fig. 7).

Minor fractures paralleling the main fracture occur inside it, but are only detectable where dyke-filled. These include the dykes intruding the volcanics in the north (Thomas, 1947) and a partly dyke-filled fracture concentric with the outer ring dyke in the east.

A gravity survey by Clarke *et al.* (1970) near Taggerty, shows an outward dip of 70° for the ring dyke, confirming earlier observations by Hills (1959) and Thomas (1947). The offset of the ring fracture by Snobs Creek Fault in the north also indicates an outward dip. A further gravity and magnetic survey (Clarke *et al.* 1970) near Buxton, indicates an anomalous body dipping outwards at 50°. If this is the sub-surface extension of the ring dyke, its shallow dip could explain the marked thickening of the dyke near Buxton (Fig. 8).

In the southeast, where the ring fracture intersects the volcanic sequence with considerable horizontal and vertical displacement (see Fig. 8), the Rubicon Rhyolite does not change markedly in thickness but has been dragged down across it. Thus, the major subsidence on the ring fracture must have postdated extrusion of the Rubicon Rhyolite.

(2) Radial Fractures. The mapping by Birch *et al.* (1970) disclosed a set of eight radial fractures, which focus at the geometric centre of the outer ring fractures (Fig. 2), implying a close relationship between all fractures. Movement on the radial fractures occurred late in the eruptive history of the Lake Mountain Rhyodacite, as they may offset its base (Figs. 5 and 8). Stream lineaments follow fault lines in the rhyodacite, across the top of the Cerberean Ranges.

The Torbreck Fault (Fig. 5) was probably active at an earlier time, as the volcanic sequence changes across it. Considerable drag on early formations is evident on this fault, and is also shown by the magnetic survey of Clarke *et al.* (1970) near the Barnewall Plain Fault.

### Source Vents

The feeder vents for the Snobs Creek Volcanic were probably associated with Snobs

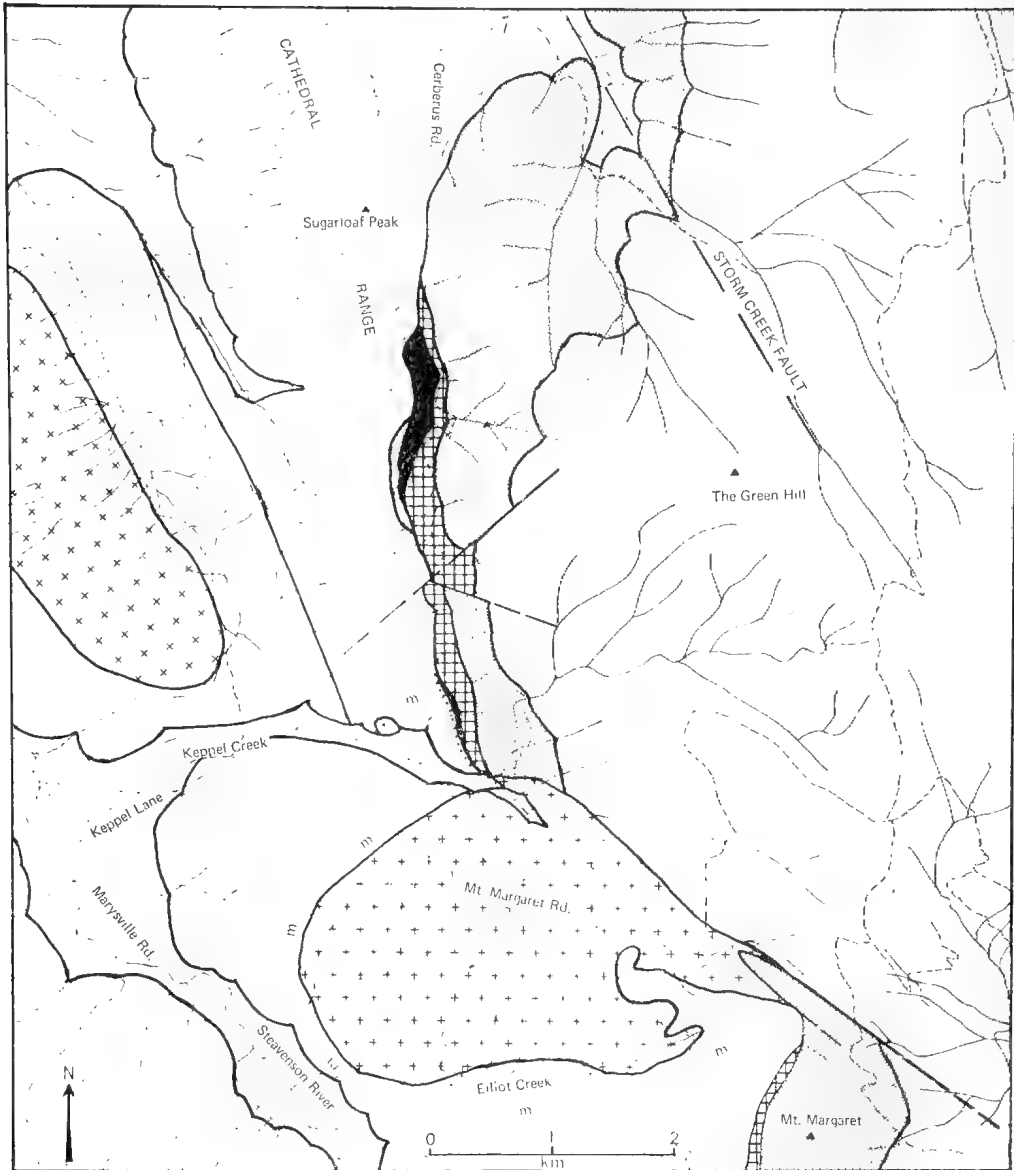


Figure 8—The geology in the Mt Margaret-Little River area.

Creek Fault, as the formation is thickest close to the fault, which was active at the time of emplacement. The suspected caldera now represented by the inner ring dyke may have been a feeder for the thick Torbreck Range Andesites. A coarse, basic agglomerate in the southwest of the cauldron (Fig. 8) with which a magnetic anomaly is associated (Clarke *et al.* 1970), indicates a likely eruption point of a

more minor character. Because of the widespread occurrence of the basaltic andesites, it is likely that more vents such as this existed, but have been hidden by later volcanic eruptions.

Eruption points for the Robleys Spur Formation are probably in part represented by agglomerates, for example, one at Barkers Gully in the north (Thomas, 1947) and one near Cumberland Junction in the southeast (Fig. 6).

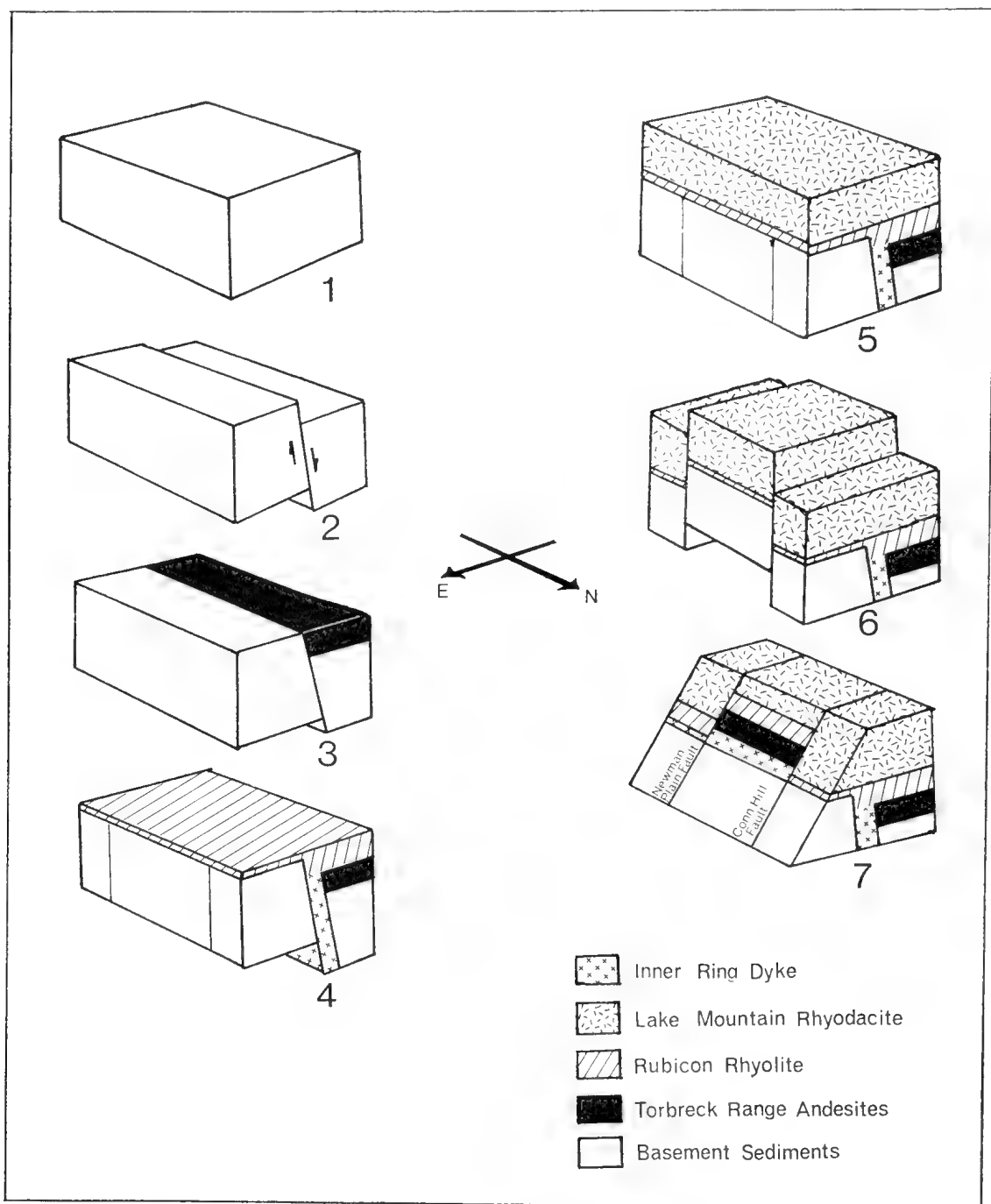


Figure 9—Block diagram illustrating the origin of the outcrop pattern between the Conn Hill and Newman Plain Faults.

Large scale ignimbritic eruptions generally take place from fissures associated with volcanic subsidence structures (Branch, 1967; Roberts, 1967; Ross and Smith, 1961). In the case of the Cerberean Volcanics, the most likely source of the ash flow eruptions is the ring fracture, as it contains intrusive equivalents of both the Rubicon Rhyolite and the Lake Mountain Rhyodacite. Tuffs with rhyolitic fragments are included in the ring dyke at Cumberland Junction. The inner ring dyke may also have been a feeder as it contains intrusive equivalents of both these rock types. Source vents may also have been situated along radial faults. The gravity survey by Clarke *et al.* (1970) indicated several anomalies which may represent buried vents (Fig. 2). A large early-formed central vent may also have developed, evidenced by the focussing of the radial faults.

#### *Nature of the subsidence*

The subsidence of the Cerberean Cauldron can be divided into two components—a basining and a ring fracture subsidence. Early basining is suggested by decreasing inward dip of the volcanics progressively up the sequence (Thomas, 1947) and by the deposition of the Blue Range Formation under lacustrine conditions. Across the southeast, gravity data (Clarke *et al.* 1970) indicates a line of thickening of the volcanics (Fig. 2), suggesting a warp marking the edge of the main cauldron basin. To the south and east of this line, the volcanics are relatively flat lying (Clarke *et al.* 1970).

By restoring the downwarped basin to its original state, a diameter of about 31 km is obtained for the circular block, compared to the present ring dyke of 27 km diameter. The well documented outward dip of the ring dyke means that the 4 km difference between these diameters represents stretching of the central block. Most of this stretching must have occurred before the tensile stress was relieved by failure along the ring fracture. The major subsidence along the ring fracture postdates the Rubicon Rhyolite, but may have taken place progressively throughout emplacement of the Cerberean volcanics. A certain amount of basining occurred after emplacement of the Lake

Mountain Rhyodacite as the base shows some inward dip.

#### *Mechanism of the subsidence*

The mechanism of subsidence of the Cerberean Cauldron has undoubtedly been one of foundering under gravity, following withdrawal of magmatic support due to the extrusion of the Cerberean Volcanics. The relatively coherent subsidence of the downthrown block indicates very rapid evacuation of the magma chamber, as discussed by Williams (1941), and is borne out by the ash flow emplacement of the Cerberean Volcanics as one or two large cooling units. The fracture pattern and stretching of the foundered block suggest that the roof of the magma chamber behaved as a circular plate with a thickness considerably less than its diameter.

The timing and cause of formation of the ring and radial fractures are problematical, but there are two possibilities.

1. Eruption of magma for the Cerberean Volcanics was initiated through central vents in the cauldron area, until enough magma had been withdrawn to enable gravitational collapse of the central block along ring and radial faults.
2. Pressure build-up in the magma chamber led to explosive failure of the roof rocks along ring and radial faults. These would relieve the pressure and act as feeders for the eruption of the Cerberean Volcanics. Subsidence would then occur as the magma chamber was emptied.

In evaluating these possibilities, the following evidence must be considered:

1. The geometry of the fracture pattern is highly regular and is apparently little influenced by regional basement trends.
2. The region was apparently under tension.
3. Chemical evidence (Birch, 1975) suggests that a volatile phase could have been generated at the top of the Rubicon Rhyolite magma at some interval prior to eruption.
4. The ring fracture dips steeply outwards (at the surface).

The first three lines of evidence suggest that a 'point' explosion at depth was responsible

for the fracture pattern. It is difficult to imagine purely gravitational collapse producing a perfectly circular ring fracture through a lineated crustal plate. A fracture pattern produced by an explosion at depth would be extended and enlarged by a rebound effect. Eruptions from those fractures which extended through to the surface could then permit the wedge-shaped fragments to subside into the magma chamber, at the same time initiating or increasing eruptions along the ring fracture.

The evidence from the dip of the ring fracture is inconclusive. While inward dips have been ascribed to pressure build-up by a number of workers (Anderson, 1936; Williams, 1941; Robson and Barr, 1964; Roberts, 1967; Smith and Bailey, 1968), the theoretical treatment of the problem of the fracture patterns derived from either withdrawal of magmatic support or upward magmatic pressure is by no means rigorous. For example, Robson and Barr (1964) suggest that steeply outward dipping ring fractures may result from either mechanism.

#### *Emplacement of high level intrusions*

Following the volcanic episode, with its associated dyke intrusions, came a culminating period of intrusion into the base of the volcanic pile. Such high-level extrusive activity is typically the final magmatic event in similar complexes throughout the world (c.f. Branch, 1966; Kingsley, 1931; Oftedahl, 1952; Jacobson *et al.*, 1958).

The intrusion proceeded in two stages and was largely controlled by pre-existing lines of weakness. The first phase is represented by the porphyritic microgranodiorite. While its intrusion along the main Cerberean ring fracture in the southwest was permissive, its emplacement in the Keppels Falls area, along the continuation of the main boundary fault of the Acheron Cauldron may have produced localized gneissic textures in the Lake Mountain Rhyodacite.

The second-phase granodiorite is more extensive, forming a relatively flat-roofed intrusion. The fault controlling the intrusion's eastern boundary is continuous to the south with the main boundary fracture of the Acher-

on Cauldron (Dudley *et al.* 1971). The apparent shallow westerly dip of the western margin of the intrusion may explain the high degree of contact metamorphism of the sequence on Robleys Spur, east of Marysville.

Intrusion probably occurred by quiet stopping, as the magma apparently caused no resurgent vulcanism, yet cooled within a kilometre of the surface. The region of granitized hornfels described previously was probably a structural high at the time of cauldron formation both to the north (Cerberean) and south (Acheron). That thin volcanic sequences may have been deposited on it is suggested by the occurrence of isolated, flat-lying, metamorphosed remnants of the Lake Mountain Rhyodacite, forming the highest part of the topography (Mt Stinton and Mt Grant, Figs. 2 and 3).

#### **Acknowledgements**

This work was completed as part of the authors' B.Sc. (Hons.) thesis, in 1970. We are grateful for the assistance and advice of Dr R. J. W. McLaughlin and Dr A. Cundari of the Geology Department, University of Melbourne.

#### **Bibliography**

- ANDERSON, E. M., 1936. The formation of cone sheets, ring dykes and cauldron subsidences. *Proc. Roy. Soc. Edinburgh*, 56: 128-157.
- BELL, G., 1959. Jamieson, Victoria. 1: 63 360 sheet. (Geological Survey of Victoria).
- BIRCH, W. D., 1975. *Mineralogy, Geochemistry and Petrogenesis of some Victorian Palaeozoic Rhyolites*. Unpub. Ph.D. thesis, University of Melbourne.
- BIRCH, W. D. and A. J. W. GLEADOW, 1974. The genesis of garnet and cordierite in acid volcanic rocks: Evidence from the Cerberean Cauldron, Central Victoria, Australia. *Contr. Mineral. and Petrol.* 45: 1-13.
- BIRCH, W. D., A. J. W. GLEADOW, B. W. NOTTLE, J. A. ROSS and R. WHATELY, 1970. *An investigation of the Upper Devonian Cerberean Cauldron Complex in Central Victoria*. Unpub. B.Sc. (Hons.) thesis, University of Melbourne.
- BRANCH, C. S., 1966. Volcanic Cauldrons, Ring Complexes and associated granites of the Georgetown Inlier, Queensland. *Bull. Bur. Miner. Res. Geol. Geophys.* 76.



- BRANCH, C. D., 1967. The source of eruption for pyroclastic flows; cauldrons or calderas. *Bull. Volc.*, 30: 41-50.
- CLARKE, G. F., P. B. EDWARDS, D. R. EYLES, A. G. POWER and H. T. WOOD, 1970. *Geophysical studies of the Cerberean Cauldron*. Unpub. Man., University of Melbourne.
- DALE, G. R., 1964. The geology of the Cathedral Range area (Victoria). R.M.I.T. Fellowship Thesis (unpub.).
- DUDLEY, R., J. DUDLEY and A. ROSSITER, 1971. *The geology of the Acheron Cauldron, Victoria*. Unpub. B.Sc. (Hons.) thesis, University of Melbourne.
- HILLS, E. S., 1929. The geology and palaeontology of the Cathedral Range and the Blue Hills in north-western Gippsland. *Proc. Roy. Soc. Vic.*, 41: 176-201.
- , 1931. The Upper Devonian fishes of Victoria, Australia, and their bearing on the stratigraphy of the State. *Geol. Mag.* 68: 206-231.
- , 1932. The geology of Marysville, Victoria. *Geol. Mag.* 69: 145-166.
- , 1959. Cauldron subsidence, granitic rocks and crustal fracturing in south-eastern Australia. *Geol. Rund.* 47: 543-561.
- HOWARD, R. T., 1972. *Acheron Cauldron and Black Range*. Unpub. B.Sc. (Hons.) Thesis, University of Melbourne.
- JACOBSEN, R. R. E., W. N. MACLEOD and R. BLACK, 1958. Ring complexes in the younger granite province of northern Nigeria. *Mem. Geol. Soc. London*, 1.
- KINGSLEY, L., 1931. Cauldron subsidence of the Ossipee Mountains, New Hampshire, *Amer. J. Sci.*, 22: 130-168.
- MARSDEN, M. A. H., 1976. Upper Devonian-Carboniferous. In 'Geology of Victoria', *Geol. Soc. Aust. Spec. Pub.* No. 5, Ch. 5.
- OFTEDAHL, C., 1952. Cauldron subsidences of the Oslo region. *Int. Geol. Cong., 18th Session, Gt. Brit.*, 13: 205-213.
- ROBERTS, J. L., 1967. Ignimbrite eruptions in the Glencoe Cauldron Subsidence. *Geol. J.*, 5: 174-184.
- ROBSON, G. R. and K. G. BARR, 1964. The effect of stress of faulting and minor intrusions in the vicinity of a magma body. *Bull. Volc.*, 27: 314-329.
- ROSS, C. S. and R. L. SMITH, 1961. Ash-flow tuffs, their origin, geologic relations and identification. *Prof. Paper. U.S. Geol. Surv.*, 366.
- SMITH, R. L. and R. A. BAILEY, 1968. Resurgent cauldrons. *Mem. Geol. Soc. Amer.* 116: 613-662.
- THOMAS, D. E., 1947. The geology of the Eildon Dam project. *Mem. Geol. Surv. Vic.* 16.
- VANDEBERG, A. H. M., 1977. Warburton, Victoria. 1: 250 000 sheet (Geological Survey of Victoria).
- WHITELAW, O. A. L., 1913. Unpublished map of region west of Cerberean Cauldron. (Geological Survey of Victoria).
- WILLIAMS, H. 1941. Calderas and their origin. *Bull. Calif. Univ. Dept. Geol. Sci.* 25: 239-346.



# GASTROPODS FROM THE EARLY DEVONIAN BELL POINT LIMESTONE, CAPE LIPTRAP PENINSULA, VICTORIA

By C. B. TASSELL

Albany Residency Museum, Albany, Western Australia

## Abstract

One new genus and five new species of gastropods are described from the late Early Devonian Bell Point Limestone, on Cape Liptrap Peninsula, 150 km south-east of Melbourne. Six other gastropod taxa are recorded. The new genus *Bassotrochus* is assigned to the family Omphalotrochidae. Together with *Orecoxia murrayi* sp. nov., also from the Bell Point Limestone, *Bassotrochus angulatus* sp. nov. represents the earliest known occurrence of this family to date. The other species are *Tropidodiscus waratahensis* sp. nov., *Straparollus (Euomphalus)* sp., ? *Mourlonia* sp., *Gyronema bellense* sp. nov., *Murchisonia (Murchisonia) bassensis* sp. nov., *M. (Murchisonia)* sp. A, *M. (Murchisonia)* sp. B and *M. (Hormotomina)* sp. Also described are *Micromphalus clarkei* (de Koninck) from near Yass, N.S.W. and an indeterminate form from the Waratah Limestone, Cape Liptrap Peninsula.

This shallow water gastropod fauna occurs as both coquinite and non-coquinite assemblages associated with a diverse invertebrate community which includes corals, stromatoporoids, bivalves and brachiopods.

## Introduction

The Bell Point Limestone occurs as a small faulted block on the eastern side of Cape Liptrap Peninsula which is approximately 150 km south-east of Melbourne. Exposed on this peninsula are sections of the Waratah Bay axis, one of a number of such structural axes occurring in Victoria. This axis has been the site of considerable tectonic activity and as a consequence some major faults occur on the eastern side of the peninsula. Besides the Bell Point Limestone, certain other units are also only exposed in a few small areas. These include the Early Devonian Waratah Limestone and the Early Ordovician Digger Island Limestone.

The limestones at Cape Liptrap have been known for some time, Ulrich (1875) being the first to mention them in print. However, it was not until recently that the stratigraphy of the area has become adequately known. The most recent account of the geology being that of Singleton (1968).

McCoy (1877) described the first fossil *Palaeopora interstincta* (Wahl) from the Waratah Bay area. In 1898 Etheridge noted a dorsal valve of a spirifer, some crinoid fragments and a new coral *Tryplasma*. Since then some elements of the limestone fauna including corals, ostracods and brachiopods have been described.

Although abundant at Bell Point, gastro-

pods have only been mentioned in passing until now. Lindner (1953, p. 82) noted 'a trochoform gastropod is the only fossil in the lowest 75 feet'. Above this spiriferid brachiopods occur together with the gastropod. Higher in the section 'several small species of gastropods, including turreted and turbinate forms' occur. Similarly, Teichert (1954) listed gastropods amongst the abundant fauna of the Bell Point Limestone at Bell Point.

Talent (as cited by Singleton, 1968) listed *Bellerophon* and *Coelocaulus* amongst the gastropods occurring in the Waratah Limestone. The gastropods listed for the Bell Point Limestone include *Tropidodiscus*, *Amphelissa isisensis* and 'a new Trochid'.

Bounded by faults and in close proximity to the large Waratah fault, the Bell Point Limestone has been subjected to some stress. Partly as a result of this many of the gastropods are distorted, in addition to the crushing and fragmenting of the shells associated with the initial compaction of the sediment.

As many of the specimens are either crushed, fragmented or distorted the measurements given can only be considered as a general indication of the specimens' original shape. All measurements are in millimetres and the following symbols relating to the measurements have been used: c, number of spiral cords; Hap, height of aperture; Ht, total height of shell; L, length measured at the selenizone in

the bellerophontids, Wap, width of aperture; Wh, total number of whorls in shell; Wt, total width of shell.

All specimens used in this study are lodged in the palaeontological collection of the National Museum of Victoria.

### Age of the Faunas

When Talent (1965) discussed the Bell Point Limestone he commented upon the similarity of the brachiopod fauna to that in the Buchan Caves Limestone. Such a similarity is also found amongst some of the other faunal elements of the two limestones (Vandenberg *et al.*, 1976). Philip and Pedder (1967) recognized their coral-conodont Fauna D in both the Buchan Caves Limestone and the Taemas Limestone. This coral-conodont fauna is now considered to be Early Emsian in age (Strusz, 1972).

In the older Waratah Limestone, Talent (1965) recognized a fauna containing many elements which showed considerable similarity to that found in the Coopers Creek Formation. The coral-conodont Fauna B of Philip and Pedder which has been found in both the Waratah Limestone and the Coopers Creek Formation is now considered to be Late Siegenian in age (Strusz, 1972).

As with previous studies of middle Palaeozoic gastropods in southeastern Australia, this study makes little contribution toward age determinations of the limestones. Certainly *Murchisonia* (*Murchisonia*) sp. A from the Bell Point Limestone is very similar to *Murchisonia* (*Murchisonia*) *turris* de Koninck known to occur in the Emsian 'Receptaculites' Limestone at Taemas, N.S.W. Similarly the indeterminate cyrtoconoid gastropod from the Waratah Limestone would appear to have an affinity with the poorly preserved *Michelia* sp. from the similarly aged Toongabbie Limestone.

What is of considerable interest is the presence of the genera *Orecoxia*, *Bassotrochus* and *Straparollus* (*Euomphalus*) in the gastropod fauna. Both *Orecoxia* and *Bassotrochus* are members of the Omphalotrochidae, a family known principally from the Late Palaeozoic. The presence of these genera at Bell

Point constitutes the earliest occurrence of the family to date. Their presence and that of *Micromphalus clarki* in the Late Silurian sediments of the Yass Basin, indicate an affinity not previously suspected of the Australian gastropod fauna with younger Devonian gastropod faunas of the Northern Hemisphere (Tassell, 1976).

### Palaeoecology

The Bell Point Limestone is a well bedded dark muddy limestone within which minor amounts of lighter grey limestone and black shale occur. Lindner (1953) considered that it was at least 140 feet thick. Although there has been some disagreement about the depth of deposition of the Early Devonian sediments elsewhere in the Melbourne Trough it is generally agreed that the carbonate sediments occurring on the Waratah Bay axis were deposited in shallow water (Singleton, 1968; Vandenberg *et al.* 1976).

Part of the prolific and diverse fauna of the Bell Point Limestone has been described in the past (Hill, 1954; Krommelbein, 1954; Talent, 1956; Pedder, 1965). The fauna includes stromatoporoids, tabulate and rugose corals, brachiopods, bivalves, rostroconchians, gastropods and ostracods. The faunas in this unit are preserved in two ways, either as coquinite assemblages or non-coquinite assemblages. Although less frequent the coquinite assemblages are extremely prominent, for example, assemblages of *Orecoxia murrayi* and *Bassotrochus angulatus* thickly cover surfaces sometimes exceeding 25 sq m in area. A characteristic of these coquinite assemblages is their low faunal diversity. This is true for any such assemblage whether it is composed of gastropods, bivalves or any other faunal component. Similar, almost monospecific, coquinite assemblages have been reported in Eastern North America (McGhee, 1976).

Coquinas composed largely of *O. murrayi* are the most frequently occurring gastropod assemblages in the limestone. They consist of complete specimens of *O. murrayi* ranging in diameter from 4 mm upwards, as well as large quantities of angular shell fragments of

the same species. Both the fragments and the complete shells lack evidence of abrasion and transport. *S. (Euomphalus)* sp. and *B. angulatus* also occur frequently in *O. murrayi* coquinas. Similarly *O. murrayi* occurs in some of the coquinas composed of *B. angulatus* or the presently undescribed bivalves.

In contrast to the spectacular coquinas of *O. murrayi* and *B. angulatus* the coquinas or bedding plane concentrations of *Tropidodiscus waratahensis* are quite restricted, rarely exceeding a sq m in area. Unlike *O. murrayi* which occurs in association with bivalves in some coquinas, those of *T. waratahensis* contain numerous brachiopods. Again, evidence of transport or abrasion is lacking.

The non-coquinite assemblages possess a much greater faunal diversity. For example *M. (Murchisonia) bassensis* occurs in the light grey limestone with rugose corals, bivalves, brachiopods, rostroconchians as well as occasional individuals of *O. murrayi*. *M. (Murchisonia)* sp. B found in a similar limestone is associated with rugose corals, ostracods, bivalves, brachiopods, rostroconchians and infrequent examples of *T. waratahensis*.

The composition of this gastropod fauna differs considerably from any other non-platy-ceratid fauna of similar age known from southeast Australia. Unlike the Lilydale fauna which is dominated by turbiniform and high spired gastropods, notably 'Cyclonema' and some murchisoniaceans, the Bell Point Limestone fauna is dominated absolutely by the medium-sized rotelliform *O. murrayi*. High spired and turbiniform gastropods form only a small component of the fauna in numerical terms although they account for much of the fauna's diversity.

#### Systematic Descriptions

Family	BELLEROPHONTIDAE McCoy, 1851
Subfamily	TROPIDODISCINAE Knight, 1956
Genus	<i>Tropidodiscus</i> Meek and Worthen, 1866

*Type Species: Bellerophon curvilineatus* Conrad, 1842; Lower Devonian; Schoharie, New York.

#### *Tropidodiscus waratahensis* sp. nov.

(Plate 1, figure 1)

*Diagnosis:* small form of genus with subdued dorsal crest and fine closely spaced growth lines.

*Description:* Small form with angular dorsal crest; whorl profile gently rounded between dorsal crest and edge of the umbilicus, then rounds more strongly into the umbilicus; umbilici deep and wide; aperture sub-triangular with a ridge formed by the dorsal crest of preceding whorl on the inner lip; inner lip thin; thick strongly prosocyrct outer lip passes backwards obliquely from the suture to form a moderately deep v-shaped sinus at the dorsal crest, narrow convex selenizone raised above former edges of the slit; fine closely spaced collabral lines.

#### Dimensions:

	L	Wh
P46963	7.5	—
P46964	3	2
P46965	4	3+
P46966	7	3+
P46967	8	—

*Location of Types:* National Museum of Victoria. Holotype, P46963. E. D. Gill Coll.

*Material:* Holotype and 20 other specimens.

*Discussion:* Besides being substantially smaller than the type species, *T. waratahensis* has finer, more closely spaced collabral lines. *T. centrifugalis* (Chapman) from Lower Devonian mudstones at Killara and Loyola in the Melbourne Trough is of similar size to *T. waratahensis*. However, its prominent dorsal crest and widely spaced, frequently foliaceous collabral lines distinguish it from the Bell Point Limestone species. An undescribed species from the Lilydale Limestone is smaller and has more prominent collabral lines than *T. waratahensis*.

Talent (1963) described *Tropidodiscus* sp. A from the Kilgower Member, Tabberabbera. This species does have fine closely spaced prosocyrct collabral lines similar to those of *T. waratahensis*. Poor preservation of the slightly larger Tabberabbera forms precludes further comparisons.

Family EUOMPHALIDAE de Koninck,  
1881  
Genus Straparollus Montfort, 1810  
Subgenus Straparollus (*Euomphalus*),  
J. Sowerby, 1814

*Type Species: Euomphalus pentangulatus* J. Sowerby, 1814; Lower Carboniferous; near Dublin, Ireland.

*Discussion:* The variability of specific characters in this genus has been commented upon by numerous authors (Knight, 1934; Batten, 1966). The latter author cited the example of *S. (E) acutus* (J. Sowerby) which possesses the high spired shell of *S. (Straparollus)* and the well developed angulate whorl of *S. (Euomphalus)*. The limited material from the Bell Point Limestone provides a further example of this variability.

**Straparollus (*Euomphalus*) sp.**  
(Plate 1, figures 15, 21)

*Description:* Medium to large low spired gastropod with angular whorl profile; sutures distinct but variable in form during growth; numerous whorls with profile which varies with growth and the degree of development of the upper keel; initially whorls gently rounded to nearly flat between sutures; with growth, profile flat to gently concave and inward sloping between the upper suture and the variability developed upper keel at the junction of the upper and outer whorl surfaces; the junction of the outer and basal whorl surfaces particularly in the late growth stages forms a prominent narrow thickened peripheral frill; between the upper keel and the basal frill the whorl profile is gently rounded; base gently rounded to circum-umbilical swelling where it becomes more strongly arched; narrow distinct umbilicus; aperture sub-elliptical; short thickened columellar lip slightly oblique outwards; parietal lip thin; outer lip of moderate thickness extends forwards gently from the upper suture to just above the peripheral frill where it rounds gently before crossing the base in a strongly oblique manner; the columellar and outer lips on the base are strongly concave; where a keel is present a shallow concave flexure of the lip may be developed on it; the

closely spaced growth lines range from fine to moderately coarse on both the outer and basal whorl surfaces; the growth lines continue into the umbilicus.

*Dimensions:*

	Ht	Wt	Hap	Wap	Wh
P47503	24	59	7	18	5
P47564	25	53	—	—	3+
P47505	—	—	—	—	6
P47506	15	51	—	—	5+

*Location of Types:* National Museum of Victoria. Figured specimen P47503. Collected T. A. Darragh, 1971.

*Materials:* One figured specimen and eight other specimens all of which are either crushed or distorted.

*Discussion:* The small number of specimens and their poor state of preservation precludes detailed comparisons with other members of the genus and the formal naming of the species. The Bell Point form differs considerably from *S. (Euomphalus) pentangulatus*. The latter is a large discoidal gastropod with a wide umbilicus and thin lips which contrasts with the low spire, narrow umbilicus and thickened lips of the Bell Point form. The shape of both the aperture and lips together with the distinct peripheral frill of *S. (Euomphalus) sp.* also serve to distinguish it from the type species.

The Bell Point form can be distinguished quite readily from the other members of the genus previously described from Victoria. The low spire, narrow umbilicus, aperture shape, thickened lips and relatively few whorls distinguish it from the dextrally coiled *S. (E.) northi* (Etheridge) from the Lilydale Limestone. *S. (S.) serpenteus* Talent from the mudstones of central Victoria differs from the Bell Point form in its smaller size, trochiform shape, more numerous whorls, wider umbilicus, apertural shape, growth line characters and whorl profile.

Talent (cited by Singleton, 1968) included the gastropod *Amphelissa isisensis* in the faunal list for the Bell Point Limestone. Of all the forms known from this limestone, *S. (Euomphalus) sp.* most closely resembles this species. *A. isisensis*, the type species of the genus, was described by Etheridge (1921) from

the Isis River area, Scone district, N.S.W. This gastropod occurs in one of two faunas in the Timor Limestone Member regarded by Voisey and Packham (1969) as Givetian.

Unfortunately the quality of Etheridge's illustrations and the nature of his description makes comparison difficult. Etheridge (p. 2) noted that 'as the individual specimens vary much in their state of preservation it is difficult to select features of a constant character other than those of the strongly angular and upstanding whorls, deeply seated sutures and nearly flat bases'. Subsequently Knight *et al.* (1960) synonymized *Amphelissa* with the subgenus *S. (Euomphalus)*.

Although poorly preserved, in each case the similar sized *S. (E.) isisensis* and *S. (Euomphalus)* sp. do possess certain similarities. Both are low spired with 5 to 6 whorls. Both possess relatively flat bases with a narrow umbilicus. There are also some differences between the two forms. While *S. (E.) isisensis* appears always to possess a distinct angular keel and deep distinctive sutures this is not always the case with *S. (Euomphalus)* sp. Similarly the generally distinct peripheral frill of *S. (Euomphalus)* sp. does appear to be more variably developed on *S. (E.) isisensis*. Certainly it can be clearly seen in one of Etheridge's illustrations (plate 1, fig. 1) accompanying his original description. Other details, notably those of the apertural region are lacking for *S. (E.) isisensis*. *Asterum carinatum* the type species of the genus *Asterum* was described by Heidecker (1959), from Givetian limestones near Charters Towers, north Qld. This large, low spired species possesses a number of characteristics similar to those of the Bell Point form. Both are large, low spired gastropods with sub-elliptical apertures, thickened lips and concave basal and columellar lips on the basal surface. There is also a flexure on the keel. The shallow umbilicus, persistence of the keel through most growth stages, consistent deep sutures and lack of a peripheral frill all distinguish the north Qld. form from *S. (Euomphalus)* sp. If specimens P47512—15 from near Arthur's Peak in the Fanning River District, north Qld. are indicative of the variations in this species then there is considerable varia-

tion in the height of the shell (pl. 1, figs. 16, 19). These specimens are distinctly trochiform in shape, another feature which distinguishes them from *S. (Euomphalus)* sp. A re-examination of the type material of *A. carinatum* is required. Whether this results in this genus being synonymized with *Straparollus (Euomphalus)* or establishes a subgenus of *Straparollus* characterized by features such as its thickening of the columellar and outer lips remains to be seen. Certainly the presence of at least two Devonian low spired euomphalids forms with substantially thickened lips in eastern Australia is of interest.

Genus *Micromphalus* Knight, 1945

*Type Species: Micromphalus turris* Knight, 1945; Lower Carboniferous; Elizabethtown, Kentucky, United States of America.

*Range:* Late Silurian to Lower Carboniferous. The presence of a species of this genus near Yass extends the lower limit of its range from Middle Devonian to Late Silurian.

*Distribution:* North America and Australia. This is the second record of the genus in Australia; Roberts *et al.* (1967) noted *Micromphalus* sp. amongst a fauna from the Frasnian Westwood Member in the Bonaparte Gulf Basin of northern Western Australia.

*Micromphalus clarkei* (de Koninck), 1876  
(Plate 1, figures 20, 23)

1876 *Euomphalus (Omphalotrochus) clarkei* de Koninck, p. 41, pl. 1, figs. 7, 7a-7b.

*Diagnosis:* Large low spired form of genus with strongly embracing whorls and narrow shoulder.

*Description:* Large, low spired trochiform gastropod with each whorl strongly embracing that above; distinct, moderately narrow shoulder; flat to strongly rounded; gently rounded to flat whorl profile from edge of shoulder to angular basal whorl periphery; initially sutures impressed, with growth become canaliculate; base rounded; small umbilicus present; aperture circular or nearly so; reflexed columellar lip; thin parietal inductura, extends forward of aperture; moderately thick irregularly pro-socline outer lip; from upper suture the outer

lip passes backwards to below the shoulder where a distinct but variable shallow concave flexure or sinus is developed; the outer lip then continues more gently to the whorl periphery; the base is gently rounded; shell of moderate thickness; growth lines strongly foliaceous.

*Dimensions:*

	Ht	Wt	Hap	Wap	Wh
P47516	26	58	—	—	4+
P47517	39	59	—	—	5
P47519	32	49	13	14	4+
P47520	36	62	—	—	5

*Location of Types:* 1. *Euomphalus (Omphalotrochus) clarkei*, the specimen figured by de Koninck was apparently destroyed when the Garden Palace in Sydney was burnt on September 22nd, 1882.

2. *Micromphalus clarkei*, National Museum of Victoria.

Hypotypes P47517 and P47519, A. J. Shearsby Coll.

*Type Locality:* 1. *Euomphalus (Omphalotrochus) clarkei*, Yass District, NSW.

2. *Micromphalus clarkei*, Limestone or Der-ringullen Creek, near Yass, NSW.

*Stratigraphic Range:* Although Shearsby's locality data was vague the nature of preservation of the material from Limestone Creek would suggest that it comes from the Bowspring Limestone, a unit containing silicified gastropods and brachiopods (Dr K. S. W. Campbell *pers. comm.*) Brown (1941) has recorded the occurrence of this gastropod in the Bowspring Limestone, near Yass. This unit was considered by Link (1970) to be Middle Ludlovian in age.

*Material:* 2 hypotypes and 4 other specimens.

*Discussion:* When Knight (1945) erected the genus *Micromphalus*, he noted that *M. turris* possessed features similar to both *Orecoxia* and *Straparollus*. That a form should exhibit features suggestive of a position intermediate to the families Euomphalidae and Omphalotrochidae is consistent with Yochelson's (1956) contention that the omphalotrochids were derived from the euomphalids.

*M. clarkei* differs from the type species in possessing a lower spire, narrower shoulder, considerably stronger embracing whorls, more variable sutures and being considerably larger. Both possess the distinctive prosocline outer lip with a shallow sinus and narrow umbilicus.

De Koninck, when describing *M. clarkei*, was aware of its similarity not only with the genus *Euomphalus* but also with the then recently established genus *Omphalotrochus*. As a consequence he placed the species from near Yass in the genus *Euomphalus* and the subgenus *Omphalotrochus*.

Family OMPHALOTROCHIDAE Knight, 1945

Genus *Orecoxia* Knight, 1945

*Type Species:* *Platyschisma ? mccoysi* Walcott, 1884; Upper Devonian; Nevada, United States of America.

*Discussion:* The presence at Bell Point of this genus extends its known distribution. Previously it was confined to Europe and North America. The Bell Point occurrence also extends the lower limit of the generic range from Upper Devonian to Lower Devonian.

***Orecoxia murrayi* sp. nov.**

(Plate 1, figures 6, 8, 12, 13)

*Diagnosis:* Rotelliform member of genus frequently lacking umbilicus, with an ovoidal aperture and variably developed sinus in the outer lip.

*Description:* Medium rotelliform gastropod with a broad shallow rounded sinus in the outer lip; whorls each embracing that above; whorl profile flat to gently arched between sutures; sutures sharp, incised, shallow and irregular; basal periphery strongly rounded; base flat to gently rounded; small variably developed umbilicus sometimes present aperture ovoidal; columellar lip thickened, and strongly oblique outwards thins towards junction with outer lip; parietal inductura of moderate thickness, occasionally developed forward of aperture; moderately thick outer lip with u-shaped sinus of variable depth; from upper suture the outer lip passes backwards before rounding in sinus and passing forwards to the periphery



where it turns roundly before continuing backward, obliquely across the base; below rounded sinus broad forward projection variably developed at or just above the periphery; secondary deposits variably developed in peripheral angle; growth lines fine to foliaceous on both outer whorl surface and base; when umbilicus is open growth lines continue into it; occasional growth rugae occur; no other sculpture developed.

*Dimensions:*

	Ht	Wt	Hap	Wap	Wh
P46987	15	29	—	—	6+
P46988	—	35	5	11	—
P46989	—	15	—	—	—
P46992	—	23	4	8	—
P46993	—	—	6	8	—
P46994	8	15	—	—	8
P46996	11	17.5	3	—	6+
P46999	13	27	—	—	—

*Location of Types:* National Museum of Victoria. Holotype, P46987, Paratypes, P46988, P46989 and P46990. Collected C. B. Tassell, 1975.

*Material:* Holotype, 3 paratypes and more than 100 other specimens, most of which are crushed or fragmented.

*Discussion:* *O. mccoyi* (Walcott) is quite variable in shape, Knight (1945, pl. 80, figs. 1a-g) figured forms ranging from rotelliform to beehive like. In contrast *O. murrayi* is typically rotelliform. Comparison between the Bell Point species and the more rotelliform examples of *O. mccoyi* reveals few differences. *O. murrayi* is generally lower spired with a more ovoidal aperture resulting from a longer more outwardly oblique columellar lip. The frequent absence of an umbilicus, lack of an angulation on the upper whorl surface, and the apparently more variable depth of the sinus in the outer lip also distinguish *O. murrayi* from the type species.

*O. murrayi* has the peripheral angle thickened by secondary deposits. As a consequence the thinnest and weakest section of the base is at the inner edge of the peripheral thickening. When crushed as is frequently the case at Bell Point, the base is broken and fragmented most severely at the inner edge of the peripheral thickening. A similar pattern of fractur-

ing occurs on the base of *Scalaetrochus lindstromi* Etheridge from the Lilydale Limestone (Tassell, 1976). Typically the fragmented thin outer shell layer on the base has been lost.

*Bassotrochus* gen. nov.

*Type Species:* *Bassotrochus angulatus* sp. nov.; Lower Devonian, Bell Point Limestone, Bell Point, Victoria.

*Description:* Trochiform gastropod with distinct peripheral frill; whorl profile gently convexly arched to nearly flat; base gently rounded to flat; broad shallow sinus developed in upper half of outer lip; broad anterior projection developed beneath sinus and above periphery; shell thickened by secondary deposits.

*Stratigraphic Range:* Lower Devonian.

*Distribution:* Bell Point, Victoria.

*Discussion:* This genus was established with some hesitation because of the poor preservation of the material of the type species *B. angulatus*. But the distinctive sinus, albeit shallow, on the upper part of the outer lip and the protruding lower section of the outer lip clearly indicate its familial relationships. The shallow sinus, peripheral frill, whorl profile and lack of an umbilicus all serve to distinguish this genus from any of the other trochiform genera of this family. Of the genera currently assigned to the family Omphalotrochidae, *Babylonites* from the Permian of North America most closely resembles this genus. These two trochiform gastropods have a relatively shallow sinus and weakly developed anterior projection in the outer lip when compared to *Omphalotrochus* and *Orecoxia*. Both *Bassotrochus* and *Babylonites* possess a thickened periphery. In either genus a shallow depression can be developed in the thickened periphery which tends to accentuate the peripheral frill.

However, *Bassotrochus angulatus* lacking an umbilicus but possessing a convex whorl profile differs considerably from the species of *Babylonites* which possess a distinctly concave to nearly flat whorl profile and an umbilicus. The broad anterior projection beneath the sinus on the outer lip of *Bassotrochus* reaches its most anterior development above the periphery, not at the periphery as in *Babylonites*.

Although variably developed the peripheral frill of *Bassotrochus* is generally sufficiently distinct to distinguish it from the blunter periphery of *Babylonites*. The thickened columellar lip and its more strongly prosocline nature also distinguish *B. angulatus* from the American species.

The existence of two genera of the family Omphalotrochidae in the Bell Point Limestone is of considerable interest. The genus *Orecoxia* from the Upper Devonian of North America and Europe has been known for some time (Pedder, 1966). Its occurrence at Bell Point enlarges its range to include the Lower Devonian. The presence of *Orecoxia* and *Bassotrochus* at Bell Point not only extends the range of the family but increases the diversity of the family in the Devonian. However, the continuing absence of forms during much of the Carboniferous means that Yochelson's (1956, p. 201) comment that 'it is impossible to construct any meaningful family phylogeny at this time' is still valid.

The generic name *Bassotrochus* is derived from the trochiform shape of the type species and the close proximity of the Bell Point Limestone to Bass Strait.

***Bassotrochus angulatus* sp. nov.**

(Plate 1, figures 7, 14, 17, 18, 22)

*Description:* Medium to large trochiform gastropod with thickened peripheral frill; sutures distinct, variable from adpressed to being overhung by periphery of preceding whorl; whorl profile gently convex to nearly flat from upper suture to near periphery; shallow depression frequently developed in thickened periphery emphasizes basal peripheral frill; base gently rounded to flat; umbilicus apparently lacking; aperture ovoidal; thickened prosocline columellar lip with very broad shallow sinus; thins towards junction with outer lip; parietal lip thin or wanting; outer lip of moderate thickness with a very shallow broad sinus in the upper part; from the upper suture the upper lip passes backwards a very short distance before rounding in the shallow broad sinus and continuing forwards to just above the peripheral frill where it turns gently before continuing backwards obliquely across

the edge of the peripheral frill and the base; below sinus a broad anterior projection variably developed above the periphery; anterior projection may continue further forward than the contact of the outer lip with the upper suture; thick secondary deposits developed later in periphery; growth lines typically closely spaced and foliaceous on both the outer whorl surface and base; no other sculpture developed.

*Dimensions:*

	Ht	Wt	Hap	Wap	Wh
P47479	7	—	—	—	—
P47480	17	38	—	—	4+
P47482	12	31	4	8	5+
P47483	16	47	—	—	4+
P47485	24	56	—	—	5+
P47486	20	45	—	—	6+
P47489	19	32	—	—	5+

*Location of Types:* National Museum of Victoria. Holotype P47480. Paratypes P47481, P47482, P47502, P47498. Collected C. B. Tassell 1975.

*Material:* Holotype, 4 paratypes, 1 hypotype and more than 90 other specimens all of which are crusted, distorted or fragmented.

*Discussion:* Both *B. angulatus* and *O. murrayi* occur together in abundance in poorly sorted coquinas within the Bell Point Limestone. In each instance many of the shells have been broken and fragmented. However, the two species can be readily distinguished by the differences in their overall shape, nature of their sutures and whorl peripheries, the degree of development of the parietal lips and the position of the anterior projection beneath the sinus on the outer lip. In addition an umbilicus is frequently developed in *O. murrayi*.

Family EOTOMARIIDAE Wenz, 1938

Subfamily EOTOMARIINAE Wenz, 1938

Genus Mourlonia de Koninck, 1883

*Type Species:* *Helix carinatus* J. Sowerby, 1812; Lower Carboniferous; Mountain Limestone, near Settle, Yorkshire, Great Britain.

? *Mourlonia* sp.

(Plate 1, figure 9)

*Description:* Small to medium gastropod with prominent raised selenizone bordered by two

strong spiral cords at whorl periphery; selenizone located at about mid-whorl; basal and apertural regions unknown; from upper suture to selenizone collabral lines prosocyrt; beneath selenizone prosocyrt initially; regular collabral lines strongly developed above and below selenizone; no spiral sculpture developed.

*Dimensions:*

	Ht	Wt	Wh
P46975	—	14	4

*Location of Types:* National Museum of Victoria. Figured specimen P46975. Collected C. B. Tassell 1975.

*Material:* Figured specimen.

*Discussion:* The incomplete preservation of the specimen precludes its confident assignment to the genus. The specimen from Bell Point differs considerably from *M. carinata* (J. Sowerby). Above the selenizone of the larger type species the fine closely spaced collabral lines are weakly prosocyrt to prosocline in contrast to the strong prosocyrt lines of the Bell Point form. The selenizone of the type species with its weaker bordering spiral cords is located lower on the whorl than that of the Bell Point form.

The larger *M. striata* (J. Sowerby), type species of *Ptychomphalina* synonymized with the genus *Mourlonia* by Knight *et al.* (1960) has strongly developed collabral lines above and below a selenizone located high on the whorl in later growth stages. The selenizone is bordered by prominent spiral cords. The collabral lines, position of the selenizone and the cords bordering the selenizone are similar to those developed on the Bell Point form. *M. talboti* (Dickens) described by Batten (1972) from the Permian of Malaya is similar in size to the Bell Point form. The Malayan species also has strong collabral lines and a selenizone bordered by threads located higher on the whorl surface.

Family HOLOPEIDA Wenz, 1938  
Subfamily GYRONEMATINAE Knight, 1956  
Genus Gyronema Ulrich, 1897

*Type Species Trochonema (Gyronema) pulchellum* Ulrich and Scofield, 1897; Middle Ordovician; Chatfield, Minnesota, U.S.A.

*Range:* Ordovician to Middle Devonian.

*Distribution:* North America, Europe, Africa and Australia. The occurrence of a species of this genus at Bell Point extends the generic range to include Australia.

***Gyronema bellense* sp. nov.**

(Plate 1, figures 10, 11)

*Diagnosis:* Typical form of genus with numerous elements of spiral sculpture of only one order and thin inner and outer lips.

*Description:* Medium, turbiniform gastropod with numerous elements of spiral sculpture; whorls rounded between impressed sutures; periphery probably at mid-whorl; base rounded; small variably developed umbilicus sometimes present; aperture circular; no apertural emargination present; columellar lip slightly thickened; thin peripheral inductura developed; outer lip moderately thin; straight and oblique backwards from the upper suture; fine to slightly foliaceous, prosocline collabral lines present; sculpture composed of regularly spaced spiral cords.

*Dimensions:*

	Ht	Wt	Hap	Wap	Wh	C
P46941	—	15	—	4	—	7+
P46945	—	—	16	15	3+	10+
P46954	—	57	28	25	—	10+

*Location of Types:* National Museum of Victoria. Holotype P46945. Paratype, P46941. Collected C. B. Tassell 1975.

*Material:* Holotype, paratype and 13 other specimens which are all crushed or broken.

*Discussion:* The holotype is a crushed incomplete specimen. Some apertural details are preserved as are numerous spiral sculptural elements and evidence of its turbiniform shape. The paratype shows clearly the straight collabral lines.

The species from the Bell Point Limestone is in many ways similar to *G. pulchellum*. Both possess thin lips, fine growth lines, a similar number of strongly developed cords and prominent concave interspaces between the cords, although in a number of specimens from Bell Point the development of the prominent cords has been enhanced by subsequent weathering.

However, *G. bellense* can be quite clearly distinguished from the type species by its very much larger size and differing development of the cords.

In terms of size *G. bellense* is comparable with '*Cyclonema*' *australis* Etheridge from the Lilydale Limestone. *G. bellense* can be distinguished from this species by its thinner lips, lack of growth rugae, single order of cords and relatively fewer cords.

Family MURCHISONIIDAE Koken, 1896  
 Genus Murchisonia D'Archiac and De Verneuil, 1841  
 Subgenus Murchisonia (Murchisonia) D'Archiac and De Verneuil, 1841

*Type Species: Muricites turbinatus* Schlotheim, 1820; Middle Devonian; *Stringocephalus* limestone, near Gladbach in Bergischen, Germany.

**Murchisonia (Murchisonia) bassensis** sp. nov.  
 (Plate 1, figure 4)

*Diagnosis:* Small form of subgenus with well rounded whorl profile selenizone in upper half of whorl; prominent, well-developed collabral lines.

*Description:* Small, high-spined numerous whorled gastropod with a selenizone bordered by two fine cords above the rounded mid-whorl periphery; whorl rounded; impressed sutures moderately deep; base rounded; lacking umbilicus aperture sub-circular; gently arcuate columellar lip of moderate thickness; no suggestion of canal-like constriction at junction of columellar and outer lips; parietal inductura thin; outer lip with angular sinus that forms a slit which generates the selenizone; depth of angular sinus increases with growth; from the upper suture to the selenizone the nearly straight outer lip passes posteriorly with only a slight obliquity; below the selenizone it passes forwards to the edge of the base before continuing backwards across the base; flat selenizone located above mid-whorl periphery; with collabral lines becoming finer but remain strongly developed; no sculpture.

*Dimensions:*

	Ht	Wt	Hap	Wap	Wh
P46969 a	4	1	—	—	7
P46969 b	—	—	0.5	0.5	—
P46971	4	1.5	—	—	7
P46970 a	3	1	—	—	8
P46970 b	—	1.5	0.6	1	—

*Location of Types:* National Museum of Victoria. Holotype P46969a. Paratype P46969b. Collected C. B. Tassell 1975.

*Material:* Holotype, paratype and at least 30 other specimens.

*Discussion:* The principal differences between *M. (M.) bilineata* (Dechen), the type species, and this species are the latter's small size, well rounded whorl profile and selenizone located above mid-whorl. The species from the Bell Point Limestone also possesses more strongly developed collabral lines and weaker spiral cords bordering the selenizone than the type species.

A number of other similar sized members of the subgenus are known from Victoria. In most cases they are inadequately known because of poor preservation or lack of specimens. As a result any comparisons that can be made are limited. *M. (Murchisonia) bassensis* can be distinguished from a number of undescribed murchisoniids from the Lilydale Limestone by its well-rounded whorl profile, strong collabral lines and possession of a selenizone located above mid-whorl. All the specimens from Lilydale possess prominent cords bordering the distinctly concave selenizone in contrast to the subdued cords of *M. (M.) bassensis*.

Chapman (1912) mentioned the presence of a small member of the genus in the Buchan Limestone. From thin sections it was seen to have an angular whorl profile and an umbilicus. Other details, notably the presence of a selenizone, were obtained from a poorly preserved specimen P12873. Typically the genus *Murchisonia* lacks an umbilicus. Whether the specimens in the thin section were the same as the P12873 is open to question, in any case, poor preservation precludes comparison with *M. (Murchisonia) bassensis*.

**Murchisonia (Murchisonia) sp. A.**

(Plate 1, figure 5)

*Description:* Medium, high spired gastropod with a selenizone on a slightly raised narrow keel at the angular periphery; periphery just above mid-whorl; whorl face flat to slightly concave above and below the selenizone; sutures moderately deep; base rounded; umbilical region unknown; columellar lip unknown; moderately thick outer lip with deep angular sinus that forms a slit at the periphery which generates a selenizone from the upper suture to the selenizone the prosocyrte outer lip passes posteriorly with a strong obliquity; below the selenizone it passes forwards to the base less strongly; collabral lines fine; no sculptural elements present.

*Dimensions:*

	Ht	Wt	Wh
P46596	17	7	7+
P46957	18	—	8+

*Location of Types:* National Museum of Victoria. Figured specimen P46956. Collected C. B. Tassell 1975.

*Material:* Figured specimen and 6 other specimens which are all crushed or broken.

*Discussion:* The poor preservation of the specimens limits comparison. The form from the Bell Point Limestone differs from the type species principally in having a selenizone raised upon a keel on a more angular whorl periphery. In this respect it is very similar to *M. (Murchisonia) gracilicrista* Linsley from the Middle Devonian Anderdon Limestone, Michigan. However, *M. (Murchisonia) gracilicrista* has a mid-whorl peripheral selenizone.

The only other form of similar age and shape known from Australia is *M. (Murchisonia) turris* described by de Koninck (1876) from the Yass District. Study of material from the Taemas limestones reveals some differences between *M. (Murchisonia) turris* and the species from Bell Point. *M. (Murchisonia) turris* has a more rounded whorl profile with a concave selenizone located on keel at the periphery. From the upper suture the outer lip does not pass backwards as strongly as in *M. (Murchisonia) sp. A.*

**Murchisonia (Murchisonia) sp. B**

(Plate 1, figure 3)

*Description:* Small, many whorled, high spired gastropod with a selenizone bordered by two prominent coarse cords at the sub-angular mid-whorl periphery; whorl profile sub-angular; whorl surfaces flat above and below selenizone; impressed sutures; base rounded; lacking umbilicus; gently arcuate columellar lip of moderate thickness; parietal inductura thin or absent; flat selenizone located at or just below mid-whorl; no sculpture or collabral lines present.

*Dimensions:*

	Ht	Wt	Hap	Wap	Wh
P46976 a	4	2	—	—	5
P46976 b	7	4	—	—	6
P46977	11	5	—	—	7
P46978	3.6	—	—	—	5
P46980	4	2.5	—	—	6

*Location of Types:* National Museum of Victoria. Figured specimen P46976. Collected C. B. Tassell 1975.

*Material:* Figured specimen and at least 30 other specimens.

*Discussion:* *M. (Murchisonia) bilineata* (Dechen), the type species, is considerably larger than *M. (Murchisonia) sp. B*, from the Bell Point Limestone. Both species possess a distinctive selenizone bordered by two prominent spiral cords at an angular mid-whorl periphery. These features distinguish them from *M. (Murchisonia) bassensis* which occurs at Bell Point.

The poor preservation of the Bell Point form precludes more detailed comparison between it and the type species as also with some undescribed forms from the Lilydale Limestone, similar in size, shape, whorl profile and selenizone development.

Subgenus *Murchisonia* (Hormotomina)  
Grabau and Shimer, 1909.

*Type Species Murchisonia maia* Hall, 1861; Middle Devonian; Columbus limestone, near Dublin, Ohio, U.S.A.

**Murchisonia (Hormotomina) sp.**

*Description:* Medium high spired gastropod with a median spiral thread on mid-whorl sele-

nizone; whorl profile rounded; impressed sutures; base unknown; apertural details poorly known outer lip thick with a shallow concave slit that generates a slightly elevated selenizone bordered on each side by prominent cords; sculpture absent.

*Dimensions:*

	Ht	Wh
P46968	48	8

*Location of Types:* National Museum of Victoria. Mentioned specimen P46968. Collected C. B. Tassell 1975.

*Material:* Mentioned specimen.

*Discussion:* The poor preservation of the specimen from Bell Point Limestone and the type species prevents effective comparison of these similar sized forms. The only similar described form from Victoria is *Gyrodoma etheridgei* (Cresswell) from the Lilydale Limestone. This large high-spired gastropod also has a medium spiral thread developed on a mid-whorl selenizone in some instances. However, this species is characterized by the presence of numerous fine spiral sculptural elements of two or more orders.

High-spired gastropod gen. et sp. indet.  
(Plate 1, figure 2)

*Description:* Small to medium cyrtocoenoid gastropod; numerous whorls with gently convex whorl profile between shallow impressed sutures; no other details preserved.

*Dimensions:*

	Ht	Wt	Wh
P46974	7	4	6

*Location of Types:* National Museum of Victoria. Figured specimen, P46974.

*Type Locality:* Waratah Limestone about 100 m west of Bird Rocks, near Walkerville South.

*Stratigraphic Range:* The Waratah Limestone is considered by Strusz (1972) to be Pragian.

*Material:* Figured specimen and one other specimen.

*Discussion:* *Michelia* sp. described by Talent and Philip (1956) from the similar-aged Toongabbie Limestone, Marble Creek is similar

to the form from the Waratah Limestone. Talent (as cited by Singleton, 1968) included *Coelocaulus* in a faunal list for the Waratah Limestone. This genus had been synonymized with *Michelia* by Knight *et al.* (1960). Thus it is possible that the unidentified form may be a member of the genus *Michelia*.

**Acknowledgements**

I wish to thank Mr T. A. Darragh of the National Museum of Victoria, Melbourne for his discussion and criticism of this work; Dr O. P. Singleton and Dr P. J. Coleman for their helpful comments, criticisms and discussions; Margaret Tassell for the photographs and discussion throughout this study.

**References**

- BATTEN, R. L., 1966. The Lower Carboniferous gastropod fauna from the Hotwells Limestone of Compton Martin, Somerset, pt. 1. *Palaeont. Soc.* 509: 1-52.
- , 1972. Permian gastropods and chitons from Perak, Malaysia. *Bull. Amer. Mus. Nat. Hist.* 147(1): 5-44.
- BROWN, J. A., 1941. The Stratigraphy and structure of the Silurian and Devonian rocks of Yass-Bowring district, New South Wales. *J. Proc. R. Soc. N.S.W.*, 74: 312-341.
- CHAPMAN, F., 1912. Reports on fossils—Middle Devonian of the Buchan district. *Rec. geol. Surv. Vict.* 3(2): 218-222.
- ETHERIDGE, R., 1898. Record of Fossils. *Rep. Prog. geol. Surv. Vict.* 9: 125-126.
- , 1921. Palaeontologia Novae Cambriae Meridionalis—Occasional descriptions of New South Wales fossils—No. 8. *Rec. geol. Surv. N.S.W.* 10(1): 1-11.
- HEIDECKER, E., 1959. Middle Devonian molluscs from the Burdekin Formation of North Queensland. *Pap. Dep. Geol. Univ. Qd.* 5(2): 3-8.
- HILL, D., 1954. Devonian corals from Waratah Bay, Victoria. *Proc. R. Soc. Vict.*, 66: 105-118.
- KNIGHT, J. B., 1934. The gastropods of the St. Louis, Missouri Pennsylvanian outlier: vii. The Euomphalidae and Platyceratidae. *J. Paleont.* 8(2): 139-166.
- KNIGHT, J. B., 1945. Some new genera of Paleozoic gastropoda. *Ibid.* 19(6): 573-587.
- KNIGHT, J. B., R. L. BATTEN and E. L. YOCHELSON, 1960. Descriptions of Paleozoic Gastropoda In Moore, R. C. (Ed.), *Treatise on Invertebrate Paleontology: Part I. Mollusca* (1), Univ. Kansas Press.

- KONINCK, L. G. de, 1876. Recherches sur les Fossiles Paléozoïques de la Nouvelle-Galles du Sud (Australie). *Mem. Soc. Roy. Sci. Liege.* 2, 6. (Translated, 1898, as: Descriptions of the Palaeozoic fossils of New South Wales (Australia). *Mem. geol. Surv. N.S.W., Palaeont.* 6.).
- KROMMELBEIN, K., 1954. Devonische Ostracoden aus der Gegend von Buchan und von der Küste der Waratah Bay, Victoria, Australien. *Senckenbergiana* 35: 119-229.
- LINDNER, A. W., 1953. The Geology of the coastline of Waratah Bay between Walkerville and Cape Liptrap. *Proc. R. Soc. Vict.* 64: 77-92.
- LINK, A. G., 1970. Age and correlations of the Siluro-Devonian strata in the Yass Basin, New South Wales. *J. geol. Soc. Aust.* 16(2): 711-722.
- MCCOY, F., 1877. Record of Fossils. *Rep. Prog. geol. Surv. Vict.* 4: 156.
- MCGHEE, G. R., 1976. Late Devonian benthic marine communities of the central Appalachian Allegheny Front. *Lethaia.*, 9: 111-136.
- PEDDER, A. E. H., 1965. A revision of the Australian Devonian corals previously referred to *Mictriphyllum*. *Proc. R. Soc. Vict.*, 78(2): 201-220.
- , 1966. The Upper Devonian gastropod *Oreocopia* in western Canada. *Palaeontology* 9(1): 142-147.
- PHILIP, G. M. and A. E. H. PEDDER, 1967. A correlation of some Devonian limestones of New South Wales and Victoria. *Geol. Mag.* 104: 232-239.
- ROBERTS, J., P. J. JONES and E. C. DRUCE, 1967. Palaeontology and correlations of the Upper Devonian of the Bonaparte Gulf Basin, Western Australia and Northern Territory. In Oswald, D. H., Ed. *International Symposium on the Devonian System*, Calgary, 1967. 2 vols. Alberta Society of Petroleum Geologists, Calgary.
- SINGLETON, O. P., 1968. Geology of South Gippsland. In McAndrew, J., and Marsden, M. A. H. (Eds.), *Regional guide to Victorian geology*, School of Geology, University of Melbourne, Publication No. 1.
- STRUSZ, D. L., 1972. Correlation of the Lower Devonian rocks of Australasia. *J. geol. Soc. Aust.* 18(4): 427-455.
- TALENT, J. A., 1956. Devonian brachiopods and pelecypods of the Buchan Caves Limestone, Victoria. *Proc. R. Soc. Vict.*, 68: 1-56.
- , 1963. The Devonian of the Mitchell and Wentworth Rivers. *Mem. geol. Surv. Vict.* 24: 1-118, 78 pl.
- , 1965. The Stratigraphic and diastrophic evolution of central and eastern Victoria in middle Palaeozoic times. *Proc. R. Soc. Vict.* 79: 179-195.
- TALENT, J. A. and G. M. PHILIP, 1956. Siluro-Devonian Mollusca from Marble Creek, Thomson River, Victoria. *Ibid.* 68: 57-71.
- TASSELL, C. B., 1976. A Revision of the Gastropod fauna of the Lilydale Limestone (Early Devonian) of Victoria. *Mem. natn. Mus. Vict.* 37: 1-22.
- TEICHERT, C., 1954. Note on Devonian Limestones between the Bluff and Bird Rock, Waratah Bay, Victoria. *Proc. R. Soc. Vict.* 66: 103-104.
- ULRICH, G. H. F., 1875. Observations on the Waratah Bay Limestone. *Rep. Prog. geol. Surv. Vict.* 2: 125-126.
- VANDEBERG, A. G. M., M. J. GARRATT and D. SPENCER-JONES, 1976. Silurian-Middle Devonian. In Douglas, J. G. and Ferguson, J. A. (Eds.), *Geology of Victoria. Spec. Publ. geol. Soc. Aust.* 5.
- VOISEY, A. H. and G. H. PACKHAM, 1969. Sediments of the Tamworth Group. In Packham, G. H. (Ed.), *The Geology of New South Wales. J. geol. Soc. Aust.* 16(1): 1-654.
- YOCHELSON, E. L., 1956. Permian Gastropoda of the south-western United States: I, Euomphalacea, Trochonematacea, etc. *Bull. Amer. Mus. Nat. Hist.* 110: 173-260.

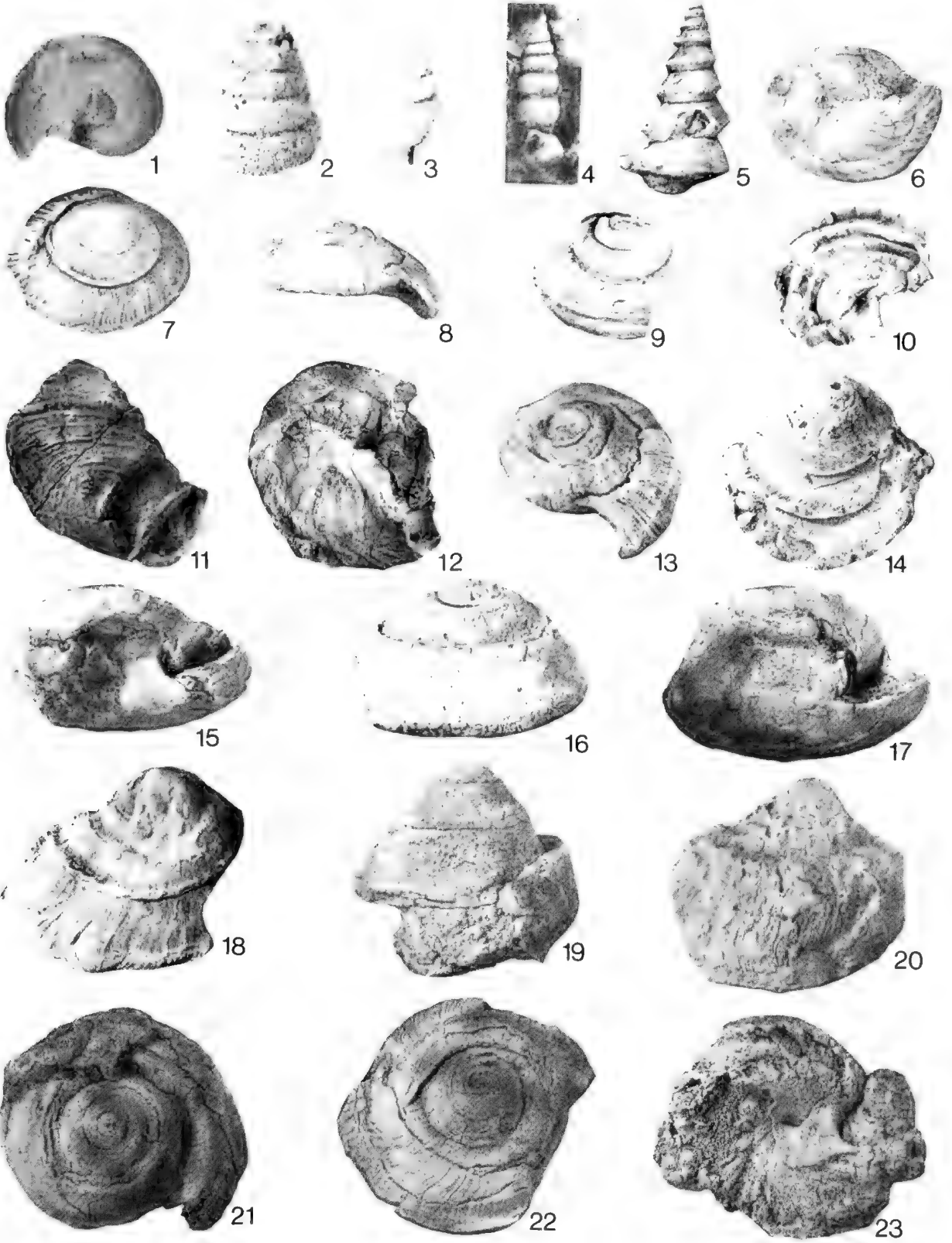
### Explanation of Plate

#### PLATE 1

- Figure 1—*Tropidodiscus waratahensis*, P46963, holotype, x3.
- Figure 2—High-spined gastropod gen. et sp. indet., P46974, x3.
- Figure 3—*Murchisonia* (*Murchisonia*) sp. B., P46976, x5.
- Figure 4—*Murchisonia* (*Murchisonia*) *bassensis*, P46969, holotype, x4. The aperture visible is of another specimen of this species.
- Figure 5—*Murchisonia* (*Murchisonia*) sp. A., P46956, x2.
- Figure 6—*Oreocopia murrayi*, P46990, paratype, x1½. Basal view.
- Figure 7—*Bassotrochus angulatus*, P47502, paratype, x2.
- Figure 8—*Oreocopia murrayi*, P46987, holotype, x1.
- Figure 9—? *Mourlonia* sp., P46975, x1½.
- Figure 10—*Gyronema bellense*, P46941, paratype, x2. Basal view.
- Figure 11—*Gyronema bellense*, P46945, holotype, x1.
- Figure 12—*Oreocopia murrayi*, P46988, paratype, x1. Basal view.
- Figure 13—*Oreocopia murrayi*, P46987, holotype, x1.
- Figure 14—*Bassotrochus angulatus*, P47498, paratype, x1.
- Figure 15—*Straparollus* (*Euomphalus*) sp., P47503, x½. Basal view.
- Figure 16—*Asterum carinatum* Heidecker, P47513, x1. Fanning River district, Queensland.
- Figure 17—*Bassotrochus angulatus*, P47482, paratype, x1½. Basal view.

- Figure 18—*Bassotrochus angulatus*, P47481, paratype, x1.
- Figure 19—*Asterum carinatum* Heidecker, P47514, x1. Fanning River district, Queensland.
- Figure 20—*Micromphalus clarkei* (de Koninck), P47517, x $\frac{1}{2}$ . Derringullen Creek near Yass, N.S.W.
- Figure 21—*Straparollus (Euomphalus)* sp. P47511, x $\frac{1}{2}$ . Basal view.
- Figure 22—*Bassotrochus angulatus*, P47480, holotype, x1.
- Figure 23—*Micromphalus clarkei* (de Koninck), P47519, x $\frac{1}{2}$ . Basal view. Derringullen Creek, near Yass, N.S.W.







# THE OMPHALOCIRRIDAE: A NEW FAMILY OF PALAEOZOIC GASTROPODA WHICH EXHIBITS SEXUAL DIMORPHISM

By ROBERT M. LINSLEY

Department of Geology, Colgate University, Hamilton, New York, USA

## Abstract

A careful study of the gastropod *Hypomphalocirrus rugosus* (gen. et sp. nov.) from the Middle Devonian of Northeastern Michigan demonstrated that in this population two distinct morphotypes are present. Both morphotypes persisted throughout the entire sixty feet of the limestone and over fifty miles of lateral distribution. This suggests that they might possibly be male and female dimorphs. In order to check this as a possible explanation, related species were studied from Germany, Manitoba and Australia. In all cases two morphotypes were present in an approximate one-to-one ratio, but only in Australia was a large enough sample present to be of significance (one hundred specimens from Australia, compared to a dozen specimens from Germany and Manitoba).

This study has resulted in the erection of a new family (the Omphalocirridae), one new genus (*Hypomphalocirrus*), one resurrected genus (*Liomphalus*, Chapman) and one new species (*Hypomphalocirrus rugosus*). The genus *Arctomphalus* Toemachov, 1926, is suppressed as a synonym of *Omphalocirrus*. The discovery of multispiral opercula in place in three of the genera demonstrate conclusively that these snails are dextral rather than sinistral as has frequently been suggested.

The functional significance of the dimorphism is considered a mode of life established for the organisms and the probable evolutionary sequence suggested.

## Sexual Dimorphism in Gastropoda

Sexual dimorphism of shell shape, size and radular form are all well-known phenomena among living archaeogastropods and caenogastropods (Baker, 1926; Lamy, 1937; Robertson, 1971; Sohl, 1969). Most commonly the difference takes the form of a larger average (or maximum) size for the female. Differences in form generally are expressed in a greater rate of expansion of the generating curve in the female which usually results in a relatively lower spired trochoid shell (a 'fatter' shell). Both of these differences are generally thought to be adaptive to accommodate the bulky eggs produced by the female. Radular differences may reflect food differences as in the case of the archaeogastropod *Tricolia (Hilota) variabilis* (Pease) where the female feeds preferentially on brown alga (*Padina*) while the male lives on top of the female's shell preceding and during the mating season, and presumably the radular differences in the male allow it to feed on the epiphytes on the female's shell (Robertson, 1971, p. 77).

Obviously radular differences will be of no help in sexing fossil gastropods. Similarly size

difference by itself will be unrecognizable in fossil populations. However if there are morphologic differences which allow one to sort the population into two samples, then presumably a size distinction could be made.

In the case of the Omphalocirridae a variety of criteria were discovered which allowed the mature members of the population to be divided into two subsets. The most ubiquitous distinction is the type of coiling present. All members of this family are characterized by discoidal shells, but mature members can normally be designated either as orthostrophic or hypostrophic. Other features that may be used to differentiate the two subsets are the degree of development of collabral ornamentation, the degree of development of a keel or spines, the roundness of the whorl profile, and the inclination of the outer whorl face. Sorting of the population on the basis of the above features, either singly or in combination, makes it possible to show that these subsets also exhibit a distinction of the size of the individuals in these subsets. It is assumed in this paper that the subsets of the population containing the largest individuals represent the females.

**Systematic Paleontology**

Class	GASTROPODA Cuvier, 1797
Subclass	PROSOBRANCHIA Milne Edwards, 1848
Order	ARCHAEOGASTROPODA Thiele, 1925
Suborder	MACLURITINA Cox and Knight, 1960
Superfamily	EUOMPHALACEA de Koninck, 1881
Family	Omphalocirridae new family
Type genus	<i>Omphalocirrus</i> , Ryckholt, 1860

*Description:* Large, dextral, discoidal gastropods varying from gently orthostrophic to gently hyperstrophic; whorl profile varying from subcircular to subtriangular, frequently with a marked circumbilical keel or spines on base; base broadly phaneromphalous; aperture subcircular. Early whorls filled with septa at maturity. Operculum disc-shaped, multispiral. All known members exhibiting varying degrees of sexual dimorphism.

*Discussion:* The Omphalocirridae are readily distinguished from the Helicotomidae and Omphalotrochidae in being discoidal, while most members of the latter two families possess elevated spires. The Omphalocirridae also differ from these two families in having an abundance of septa filling the early whorls. The Omphalocirridae resemble the Euomphalidae in these two characters of septation and discoidal form, but are distinguished from the Euomphalidae and all other Euomphalacea in having a calcareous, multispiral operculum and exhibiting sexual dimorphism.

As is true of all Euomphalacea the Omphalocirridae possess an aperture whose plane passes through the axis of coiling ('radial aperture'), and some of the genera possess an angulation near the upper whorl face that is interpreted as exhalent. They resemble the Omphalotrochidae in that some members of both groups possess a second angulation near the base that resembles a siphonal canal or an inhalent angulation. The uniqueness of the form of these angulations suggests that they were developed independently in each of the two

groups. In each of these groups this combination of features suggest that only a single gill exists (Knight, Batten and Yochelson, 1960, p. 1196) and supports the contention that this is the case for the entire superfamily.

The Omphalocirridae also resemble the gastropods presently placed in superfamily Oriostomatacea (Suborder Thochina, Knight, Batten and Yochelson, 1960, p. 1245) in that both groups have radial apertures and multispiral, calcareous opercula. It is probable that the Oriostomatacea should be transferred to the Euomphalacea and, if it could be demonstrated that they exhibit sexual dimorphism, to the Omphalocirridae.

Genus *HYPOMPHALOCIRRUS* gen nov.

*Type species:* *H. rugosus* sp. nov.

*Description:* Large, dextral gastropods with spire very low to hyperstrophically depressed; whorl profile subtriangular with flattened upper, outer and lower faces joining at marked angulations; base broadly phaneromphalous; the juncture between the outer whorl face and the base typically developing canal-like projections which may also occur at juncture between upper and outer whorl faces. Earlier whorls filled with septa at maturity. Operculum disc-shaped, multispiral. Sexual dimorphism strongly developed.

*Discussion:* The most abundant and obvious fossil in the Rogers City Limestone is the large euomphalid gastropod previously known as *Omphalocirrus manitobensis* Whiteaves (Ehlers and Radabaugh, 1938; Ehlers and Kesling, 1970). Close study of about 200 specimens from the collections of the University of Michigan Museum of Paleontology, the U.S. National Museum and Colgate University show that this euomphalid not only is not conspecific with Whiteaves species but that both the Rogers City material and the material from Manitoba are sufficiently distinct from *Omphalocirrus goldfussi* to warrant the establishment of a new genus (also see Yochelson, 1966, p. 41).

This genus is most readily characterized by the subtriangular whorl profile and the angular meeting of the outer whorl face with the base and upper whorl face. It is obviously closely

related to *Omphalocirrus* but this latter genus has a rounded whorl profile. Both of these genera possess the unusual feature of canal-like projections at the juncture of the base and outer whorl face. In addition it bears close similarity to the Australian genus *Liomphalus*, even though the latter lacks the canal-like protuberances.

Two species are assigned to this genus. One (*H. rugosus*) is herein described for the first time, while the second is Whiteaves species *H. manitobensis* (Whiteaves) from the Winnipegosis Limestone of Manitoba, Canada. In addition the specimen described from the Anderdon Limestone of the Michigan Basin (Linsley, 1968) probably also belongs to this genus, but it is too poorly known to describe formally.

***Hymphalocirrus rugosus* sp. nov.**  
(Plates 2-6)

Herein designated type species.

*Omphalocirrus manitobensis* Ehlers and Rada-  
baugh 1938

*Omphalocirrus manitobensis* Anonymous

*Omphalocirrus manitobensis* Ehlers and Kes-  
ling 1970

**Description:** Large, discoidal, dextral gastropods with sub-triangular whorl profile, with angular base bearing canal-like projections or a keel. Nuclear whorls smooth, simple, dextral. Whorl profile sub-triangular in shape with outer whorl face varying from vertical (parallel to axis of coiling) to inclined outward at a 45° angle. Upper whorl face varying from flat and horizontal to roundly dipping into spire; outer whorl face flattened to broadly arched, basal whorl face gently rounding into umbilicus. Junction of upper and outer whorl faces joining at an acute angle forming a smooth keel or distinctly undulating keel. Junction of outer and lower whorl faces typically sharp, occasionally rounded and bearing a series of canal-like projections or flanges which are sometimes replaced by a single or double keel in the adult. Upper suture varying from indistinct to very sharp and deep with considerable overhang of ultimate whorl; umbilical suture sharp and deeply incised, occurring just outside of the umbilical ridge of the preceding whorl. Upper shell surface flattened in youth-

ful stages, but varying in the adult from flattened to a considerably depressed spire. Shell widely phaneromphalous with umbilical angle varying from 120° to 180°, depending on the degree of hyperstrophism. Growth lines on upper whorl face generally opisthocline, beginning perpendicular to suture and culminating at a 45° angle at the periphery; growth lines prosoclyt on outer whorl face, continuing onto base with backward obliquity and backward concavity; normal course of growth line deflected both by undulations on shoulder and canal-like projections on the base. Ornament consisting of strong collabral ornamentation in youth, giving way to simple growth lines at maturity; in mature forms, interruptions in growth frequently resulting in rugose appearance; outer whorl face sometimes developing roughened appearance in adult, even developing low canal-like projections. Shell very thick at junctures of the three whorl faces, thin at centres of each whorl face, resulting in a subcircular inner whorl profile and a subtriangular outer whorl profile. Septa abundant and evenly spaced in the early whorls of mature individuals. Operculum circular, disc-shaped multispiral, expanding counterclockwise, all volutions visible on outer surface; upper surface of each opercular volution inclined inward with slight rounding towards preceding whorl; outer face of opercular whorl parallel to axis of coil, resulting in deep, sharp suture separating each volution; early opercular volutions (first ten or eleven) increasing in size logarithmically; later volutions (last five or ten) more irregular, approximately maintaining constant size and thus increasing in an archimedean rather than logarithmic spiral; inner surface of operculum poorly known.

Holotype measuring 102.6 mm in width and 36.4 mm in height. Largest Paratype measuring 149 mm in width.

**Holotype**—UMMP 22377; **Figured Paratypes**—UMMP 22375, 22378, 22379, 22380, 22383, 22384, 57888, 57889. **USNM** 102939, 213754, 213755, 213756, 213757, 213758, 213759, 213760, 213761, 213762, 213763, 213764, 213765, 213766, 213767, 213768, 213769, 213770, 213772, 213773, 213774, 213775, 213776, 213777, 213778, 213779, 213780, 213781, 213782, 213783. **Unfigured Paratypes**—UMMP 22381, 22382, 22385. **USNM** 213771.

*Discussion:* *Hypomphalocirrus rugosus* is a very large gastropod (150 mm) that rivals the size of the largest Macluritida. Among Palaeozoic Gastropoda only *Straparollus grandis* (Korninck (130 mm) *Pithodea amplissa*, Korninck (140 mm) from the carboniferous of Belgium, *Arctomphalus grandis* Tolmachoff (now *Omphalocirrus goldfussi*) (170 mm) and a Carboniferous euomphalid (210 mm) reported by Yochelson (1966) as being in the British Geological Survey and Museum can compare in size with this new species.

The diagnostic features of this species are the sub-triangular whorl profile, the tendency to develop flanges at the upper angulation of the female, and canal-like projections on the base. However there is considerable variation of each of these features within the population of about two hundred individuals that were studied.

Females of *H. rugosus* can be distinguished from females of *H. manitobensis* (Whiteaves) by the presence of a second row of canal-like projections which the latter bears on the upper angulation. The whorl profile of *H. manitobensis* has the triangular profile tilted so that the outer whorl face is subparallel to the axis of coiling and the periphery of the shell is at the midpoint of the rounded whorl face rather than at the upper angulation as it is in *H. rugosus*. *H. manitobensis* has assumed an almost isotrophic coiling and thus appears to converge on a bellerophon-like form.

The single, poorly preserved specimen of *Hypomphalocirrus* described from the Anderson Limestone (Linsley, 1968) is not well enough known to warrant a formal description. The chief distinction is the bundling of growth lines found in this species. Five or six growth lines are subparallel to each other and all participate in making up a single basal projection. The next set of prominent growth lines then diverge sharply from the preceding set to form the next basal projection.

Within the population of females of *H. rugosus* the degree of hyperstrophism is still highly variable ranging from USNM 213781 (pl. 6, fig. 5) where the upper surface of the penultimate whorl strikes the ultimate whorl about one-third the way down the ultimate

whorl, to UMMP 213758 (pl. 4, fig. 7) where the upper surface of the ultimate whorl strikes the ultimate whorl two-thirds the way down the ultimate whorl. The geometry of the whorl profile is such that variation in the amount of hyperstrophism also is associated with other changes in the whorl profile. As the degree of hyperstrophism increases the entire triangular whorl profile of the shell rotates so that the outer whorl face varies from being inclined almost 45° to the axis of coiling in the male (see USNM 213775, pl. 2, fig. 4) to almost parallel to the axis of coiling in the female (see UMMP 22377, pl. 4, fig. 2). The roundness of the upper whorl face also seems to increase with increased hyperstrophism (UMMP 22377 and USNM 213758, pl. 4, figs. 6, 7) and of course umbilical depth decreases as hyperstrophism increases. UMMP 22377 (pl. 4, figs. 5, 6) has an umbilical angle of 180° while USNM 213759 (pl. 6, fig. 3) has an umbilical angle of about 150° and USNM 213758 (pl. 4, fig. 7) is so depressed that one could talk about an 'umbilical spire'.

Other features, equally variable, do not seem to be related to the degree of hyperstrophism. The proportionate size of the outer whorl face may be rather small (UMMP 22379, pl. 6, fig. 8) or very great USNM 213759 (pl. 6, fig. 3). Some features are obviously related to age. Immature forms of males are very difficult and sometimes impossible to distinguish from those of females. Immature forms tend to have well-developed col-labral ornamentation (UMMP 22375, pl. 5, fig. 7, early whorls of USNM 213760, pl. 5, fig. 3). Immature specimens (UMMP 22375, pl. 5, fig. 7) also tend to have a smooth juncture between the upper and outer whorl faces. Rarely this feature will be carried into maturity in the females (UMMP 57888, pl. 5, fig. 4 and USNM 213781, pl. 6, fig. 5). More frequently this upper juncture develops into a scalloped flange at maturity, either with a gentle fluting (UMMP 22379, pl. 5, fig. 6 and pl. 6, fig. 1) or in a few cases very pronounced, almost grotesque fluting (USNM 213772, pl. 6, fig. 4 and USNM 213754, pl. 6, figs. 10, 11). In the holotype (UMMP 22377, pl. 4, fig. 6) the ultimate whorl is well fluted until the last

‡ volution, when the fluting ceases. There seems to be some tendency for the degree of fluting to be related to the amount of sculpture present on the outer whorl face. In general the greater the fluting, the more sculpture. The sculpture varies tremendously from raised growth lines (USNM 213754, pl. 6, fig. 11) to small ridges perpendicular to the growth lines (USNM 213759, pl. 6, fig. 3) large bumps (USNM 213765, pl. 6, fig. 7) or even canal-like foldings of the growth lines (USNM 213772, pl. 6, fig. 4).

The canal-like projections on the basal angulation are a most persistent feature of the females. Their position on the base is dependent upon the amount of hyperstrophism and the subsequent rotation of subtriangular whorl profile. Where hyperstrophism is not great and outward rotation of the outer whorl face minimal, the projections will appear to be in the middle of the whorl as seen from the base (UMMP 22378, pl. 6; fig. 2 and USNM 213760, pl. 5, fig. 3). When hyperstrophism is strongly developed and outward rotation of the outer whorl face is substantial (UMMP 22377, pl. 4, fig. 5) the projections will appear to be at the periphery of the whorl as seen from the base. The shape of these projections varies from the typical rather slender ones (UMMP 22377, pl. 4, figs. 5, 8 and USNM 213764, pl. 5, fig. 2) to very broad, spade-like projections (USNM 213767, pl. 5, fig. 5).

One specimen, UMMP 22380 (pl. 6, fig. 9) is the most aberrant of the collection. It has a very swollen, rounded whorl profile and thus seems to closely resemble *Omphalocirrus goldfussi*. In all other respects, such as the sculptured, outwardly rotated outer whorl face, etc. it resembles *H. rugosus* and I have thus treated merely as one aberrant member of a very diverse population.

The males of *Hypomphalocirrus rugosus* may be readily distinguished from the females by their flat upper whorl face and by the fact that the spire is flush, with the upper whorl faces continuous with each other rather than the depressed spire so typical in the females.

The males exhibit less variation than the females. The spire profile is very constant,

maintaining an essentially flat upper surface. The outer whorl face occasionally shows a faint, revolving ornamental groove just below the periphery (USNM 213779, pl. 3, fig. 4, USNM 213773, pl. 3, fig. 6 and USNM 213778, pl. 3, fig. 9). The outer whorl face is generally flattened, but a few individuals, especially USNM 213761 (pl. 3, fig. 12) and USNM 213756 (pl. 3, fig. 13) exhibit a very rounded whorl profile. The most marked variation in the males occurs on the base relative to the circumbilical ridge. The ridge develops very early at the end of the second volution. During this early stage canal-like projections develop very much like those of the females. However in the males the projections rarely persist beyond the third whorl. An exception is USNM 213773 (pl. 3, fig. 6) which maintains very large, fully developed spines through maturity. In most mature individuals (USNM 213775, pl. 3, fig. 8 and USNM 213766, pl. 3, fig. 5) the mature whorls have only a relatively sharp ridge, perhaps with only faint suggestions of protrusions (USNM 102939, pl. 3, figs. 1, 11). In at least one example (USNM 213757, pl. 3, fig. 3) a double ridge results. In one other case (USNM 213756, pl. 3, fig. 13) there is no sign of a keel at all, but rather the base is very rounded and the growth lines are unusually rugose at maturity.

Dr G. Arthur Cooper of the U.S. National Museum kindly brought to my attention a collection of gastropods from the Miami Bend Formation of Indiana (Cooper and Phelan, 1966). Most of the collection consists of steinkerns which are generically and specifically indeterminate, but a few molds were collected which can be identified. One of these (USNM 213769, pl. 2, fig. 6) is a partially complete impression of the spire of a male *Hypomphalocirrus rugosus*. This adds one more small piece of evidence to their mass of data supporting their claim for a correlation of the Miami Bend Formation with the Rogers City Limestone.

The wide latitude of variation present in this species is in part explained by the morphological differences between the males and females. The existence of these two subsets of this population can best be seen in the graph

in Fig. 1, which plots size against a measure of the degree of hyperstrophism (umbilical width divided by umbilical depth). This plot demonstrates that though the youthful individuals are inseparable, the adults separate into two distinct populations. This is, of course, perfectly consistent with an interpretation of sexual dimorphism.

Using the degree of hyperstrophism as a criterion for establishing two populations, many other distinctions were discovered which correlate with this character. The following paragraphs are formalized descriptions of the females and males.

*Description of females:* Large, shallowly hyperstrophic gastropods with well-developed canal-like projections at the junction of the outer whorl face with the base. Nucleus smooth, simple and dextral. Whorl profile subtriangular in shape, outer whorl face tilted in slightly from perpendicular. Upper whorl face flattened near periphery, gradually curving downward near preceding whorls and curving downward abruptly at suture, so that inner edge of upper whorl face overhangs upper whorl face of preceding whorl; upper whorl face adjoining outer whorl face at periphery with a marked keel; keel smooth in youthful stages, but at maturity keel tending to develop pronounced periodic undulations; outer whorl face gently rounded, sloping inward and downward from peripherally located junction with upper whorl face; outer whorl face adjoining base forming a keel which develops canal-like projections at a very early stage; canal-like projections generally becoming larger and better developed with maturity; basal whorl face flattened, proceeding upward towards umbilical suture from its junction with outer whorl face. Upper suture fairly deep, sharply incised with ultimate whorl slightly overhanging penultimate whorl; umbilical suture sharp and very deep, occurring outside of the canal-like projections of preceding whorl. Early whorls depressed below mature whorls resulting in hyperstrophic whorl profile. Degree of hyperstrophism quite variable, but generally increasing with maturity. Shell widely phaneromphalous, with umbilical angle varying from 150° to 180° depending on degree of hyperstrophism. Growth lines op-

isthoclinal on upper whorl face, beginning perpendicular to suture and proceeding with a forward obliquity and marked backward concavity; at periphery growth lines variable depending on the position relative to flange; presence of flange causing growth line to bend backward from its opisthoclinal course, making it subparallel to suture once again; growth lines continuing on outer whorl face in prosocylindrical fashion; at junction of outer whorl face and base, growth lines interfered with by canal-like projections; growth lines bending back rather strongly in a U-shape to participate in formation of spine, bending forward in an 'n' shape in front of completed spine, continuing uninterrupted where no spine is present. Ornament consisting of collabral ornament in youth, giving way to growth lines in adult; growth lines becoming crowded during spine formation causing adult to have rugose appearance; flanges or undulations developing along periphery in adult; canal-like projections around base tending to become very strong in adult; outer whorl face tending to become roughened in adult, developing low, rugose, and in extreme cases, even canal-like projections. Shell thickness exceedingly variable, being thin at centre of each whorl face and becoming very thick at junctures of whorl faces, resulting in a subtriangular outer whorl profile and subcircular to elliptical inner whorl profile. Septa abundant in earlier whorls in mature shells, unevenly spaced at about eight to twelve per whorl.

Holotype measuring 102.6 mm in width and 36.4 mm in height. Largest paratype measuring 149 mm in width.

*Holotype*—UMMP 22377; *Figured Paratypes*—UMMP 22375, 22378, 22379, 22380, 22383. *USNM* 213760, 213764, 213758, 213754, 213765, 213772, 213776, 213755, 213768, 213767. *Unfigured Paratypes*—UMMP 22381, 22382, 22385.

*Description of males:* Large, flat-topped orthostrophic gastropods with a subtriangular whorl profile and sharp angular base bearing either a keel or canal-like projections. Nuclear whorls smooth, simple, dextral. Whorl profile resembling an equilateral triangle with upper whorl face horizontal or perpendicular to axis of coiling. Upper whorl face flat, bending



downward very slightly at the surface. Outer whorl face joining upper whorl face at a sharp angle at shell periphery, forming a sharp smooth keel. Outer whorl profile flattened to gently rounded; typically with slight concavities just below peripheral keel and just above basal keel, occasionally gently rounded from keel to keel. Basal whorl face joining outer whorl at sharp angulation and progressing flatly or with gently rounding to umbilical suture. Upper suture varying from indistinct to sharp with slight overhang of inner whorl edge over preceding whorl; umbilical suture sharp, frequently deep, normally just outside circumbilical ridge. Upper shell surface flattened, not depressed. Base widely and deeply phaneromphalous; umbilical angle varying between  $120^{\circ}$  to  $145^{\circ}$ . Growth lines on upper whorl face beginning perpendicular to the suture and proceeding opisthoclinally towards the periphery, intersecting periphery at  $45^{\circ}$  angle; growth lines prosocyrnt on outer whorl face, continuing with strong collabral ornamentation, normally reducing to faint growth lines in adult; strong angular keel at periphery at junction of upper and outer whorl faces; faint revolving groove sometimes developed on outer whorl face, just below periphery. Circumbilical ridge developing early with well-developed canal-like projections; in maturity, circumbilical ridge normally reverting to single or double ridge, rarely retaining canal-like projections to maturity. Shell thick, particularly at keels, resulting in subtriangular outer whorl profile and subcircular to elliptical inner whorl profile. Septa present through much of early portion of mature shell. Shell width of largest paratype 110 mm.

*Androtype*—USNM 102939; *Paratypes*—UMMP 22382, 22384. USNM 213775, 213770, 213762, 213763, 213777, 213757, 213778, 213779, 213773, 213766, 213774, 213769, 213761, 213756, 213780. *Unfigured Paratype*—213771.

*Discussion continued:* Briefly, the main features of each sex can be summed as follows. The females tend to be larger than the males, a feature similar to so many modern gastropods and presumably related to the greater bulk of eggs of the female. The canal-like projections on the base of the males usually de-

generate into a keel while in the female these projections become larger in the adults, presumably remaining functional throughout its life. Assuming that these do indeed facilitate incurrent water, this would again be consistent with the increased oxygen needs of the female in producing the bulky egg masses. In addition the increased hyperstrophicity of the female would appear to be due to, or at least accompanied by, the rotation of the whorl profile. This rotation brings the outer whorl face into a sub-vertical position (parallel to the axis of coiling) thus bringing both incurrent and excurrent openings into a peripheral position which would again facilitate water movement through the mantle. The male, with less critical circulatory demands tends to keep the incurrent opening at a slightly less favourable position in order to better position the anus at the extreme periphery. The male also tends to lose the incurrent canals, which were apparently useful during the rapid growth of youth, but no longer so crucial to success in the adult.

It is possible that the collabral ornamentation of the immature shells served to strengthen those shells. As the shell increased in size it also increases in thickness, apparently to the point where the collabral ornamentation lost its functional significance and so disappears on the adults.

***Hypomphalocirrus manitobensis*** (Whiteaves)  
*Euomphalus manitobensis* Whiteaves 1890, p. 100, pl. 6, figs. 2-26.

*Omphalocirrus manitobensis* Whiteaves 1892, p. 327, pl. 43, figs. 5-7.

(Plate 7, figures 1-8)

*Description:* Large, slightly hyperstrophic gastropods with one or two rows of canal-like extensions at boundaries of outer whorl face. Nucleus poorly known, apparently smooth and dextral. Whorl profile varying from subtriangular in the females, to suboval in shape in the males. In females the upper whorl face meeting outer whorl face to form a keel which may bear long canal-like projections, then proceeds roundly down to suture; outer whorl face of females broadly rounded

and meeting lower whorl face at a keel which also may bear canal-like protuberances similar to those on top; basal whorl face continuing roundly up to the umbilical suture to complete the rounded equilateral triangle. Whorl profile of males more rounded with less distinct keels, bearing canal-like projections only on base. Upper suture deep, sharply incised. Umbilical suture distinct, deeper in females than in males. Aperture, as determined from observations of growth lines, gently opisthocline on upper whorl face, bending back at periphery to form upper rows of canal-like projections, continuing on outer whorl face in prosocyrte fashion and on to the base with a gently backward concavity, again involved with canal formation at the juncture of the base with the outer whorl face. Males with greater hyperstrophism than females; base of males being relatively flat while females deviating only slightly from discoidal. Ornament consisting of strong collabral ornament in males with one row of canal-like projections on the base; ornament in females consisting only of fine growth lines with two rows of canal-like projections both above and below the outer whorl face. Outer whorl face sometimes roughened in adult females. Shell moderately thick, particularly at junctions of whorl faces. Septa fairly abundant in mature individuals. Operculum thin, and disc-shaped, circular in outline, multispiral, expanding counterclockwise with all volutions visible on outer surface.

*Lectotype*—GSC 4173; *Plesiotypes*—GSC 4163a, 4174, 4175, 4176, 4177; *Hypotypes*—USNM 213782, 213783.

*Discussion:* Yochelson (1966, p. 41) has already treated the problems attendant on this species. Whiteaves (1890, p. 100) original specimens of *H. manitobensis* are steinkerns from the Dawson Bay Limestone. These are generically indeterminate. Subsequently, Whiteaves (1892, p. 327, pl. 43, figs. 5-7) re-described this species and reassigned it to the genus *Omphalocirrus*, but this was done primarily on the basis of material obtained from the Winnipegosian Limestone which underlies the Dawson Bay Limestone. There is no certain way of knowing whether or not the specimens from these two units are conspecific. The

above description is based on material from the Winnipegosian Limestone as our knowledge of *Hypomphalocirrus manitobensis* at this time is based entirely on those specimens.

The collection available for study of this species consists of fifteen specimens collected by Linsley and Cottrell in 1968 from locality 18 of the *Field Guide to Devonian Outcrops of Southwestern Manitoba* (McCabe, 1967). This locality is about one mile west of the Narrows, on Lake Winnipegosis. In addition, Whiteaves types (GSC 4174, 4176, 4177) from the Geological Survey of Canada at Ottawa were kindly made available for study. While seventeen specimens do not constitute a large enough collection on which one might base a definitive study, they do suggest that two distinct morphotypes are present and may best be regarded as males and females.

The females (pl. 7, figs. 3, 5, 6, 8) are characterized by a triangular whorl profile and have well-developed canal-like protrusions at both boundaries of the outer whorl face. As this form is regarded as having evolved from *H. rugosus*, it would seem a natural development for the undulating shoulder of the Rogers City females to have developed into the true canals of the Manitoba form, thus perfecting the current flow in and out of the mantle cavity. The females of *H. manitobensis* also resemble the females of *H. rugosus* in having a subvertical outer whorl face, a fair degree of hyperstrophicity, and rugosities on the outer whorl face.

The males of the Winnipegosis Formation differ markedly from the Rogers City forms. The males of *H. manitobensis* are more hyperstrophic than the females which suggests that the degree of hyperstrophism is important *only* as it affects the position of the incurrent or excurrent water streams. The basal canal-like extensions on the males of *H. manitobensis* are positioned only slightly more peripherally than their *H. rugosus* counterparts. The rest of the whorl profile of the *H. manitobensis* males is much more rounded than either the females or the Rogers City forms. However they resemble the males of the Rogers City forms by having much stronger collabral ornament than that possessed by the females.

**Omphalocirrus goldfussi** (Archiac and Verneuil)—(Plate 8)

Knight (1941, pp. 45, 213) and Yochelson (1966, p. 42) have both offered excellent descriptions and synonymies of *Omphalocirrus goldfussi*; (Archiac and Verneuil, 1842) and *Arctomphalus grandis* Tolmachoff, 1926. I am familiar with this genus only through their works and through a careful study of the plastotype material made available to me from the US National Museum. This study has led me to the conclusion that '*Arctomphalus grandis*' is the sexual dimorph (probably male) of *Omphalocirrus goldfussi*. Plate 8, fig. 7 is an illustration of the lectotype of *Arctomphalus grandis* (Specimen A-19229, Paleontologisk Museum of Oslo). Unfortunately the outer volution, represented by the broken line in the figure, is a steinkern and only an impression of the basal suture of the inner whorls remains. However comparison of this remnant with some German material of *Omphalocirrus goldfussi* (see pl. 8, figs. 4, 5, 9) illustrates that all of these specimens are similar in that they are hyperstrophic, have strong collabral ornament and have a circumbilical ridge which develops periodic nodes which are only occasionally developed into canal-like projections. Collectively, these features suggest male characters of *Hypomphalocirrus rugosus* and *H. manitobensis*. The other types of *Omphalocirrus goldfussi* (Pl. 8, figs. 1-3, 6, 8) are quite distinct from those described above. They are all orthostrophic, have much weaker collabral ornamentation and have well-developed, apparently functional canal-like extensions which appear in early youth and persist through maturity. In addition this morphotype has a very pronounced swollen form due to a greater rate of expansion of the generating curve. All of these features are consistent with the interpretation of this form as the female.

To date no opercula have been found associated with *O. goldfussi*, but I fully expect multispiralled opercula to occur in the same beds and with great fortune to be found in a life situation, well back from the aperture. It would also be beneficial if a study could be made on a large population of this species to

ascertain whether or not the dimorphism apparent in the half-dozen specimens at my disposal holds true for the entire population.

Genus *Liomphalus* Chapman, 1916, p. 90

*Type species: Liomphalus australis* by original designation

*Description:* Large, discoidal, septate gastropods with low to hyperstrophically depressed spire. Outer whorl profile varying from sub-circular to subtriangular with circular inner whorl profile. Strong circumbilical ridge with no canal-like projections. Operculum disc-shaped, multispiral. Sexual dimorphism weakly developed.

*Discussion:* Like the other members of the family Omphalocirridae, this genus exhibits sexual dimorphism. However compared to the other genera, the sexual dimorphism of *Liomphalus* seems poorly developed, as though it were an incipient feature. This feature is consistent with its lower stratigraphic position and presumed ancestry to the other members of the family. *Liomphalus* also resembles the other members of this family by being septate, discoidal gastropods which bear a disc-shaped, multispiral calcareous operculum (see also Yochelson and Linsley, 1972). It can readily be differentiated from other members of this family by the presence of a circumbilical ridge without any suggestion of nodes or canal-like extensions on it.

**Liomphalus northi** (Etheridge) 1890  
Plate 9, 10

- 1890 *Oriostoma northi* Etheridge, p. 64, pl. 9, figs. 6-7
- 1894 *Oriostoma northi* Etheridge, p. 151, pl. 9, figs. 1-4
- 1894 *Euomphalus (Oriostoma) northi* Etheridge; Cresswell, p. 157
- 1913 *Euomphalus northi* (Etheridge); Chapman, p. 227
- 1916 *Euomphalus northi* (Etheridge); Chapman, p. 90
- 1916 *Liomphalus australis* Chapman, p. 90, pl. 4, figs. 32-33
- 1959 *Straparollus (Euomphalus) northi* (Etheridge); Philip and Talent p. 50, pl. 7, figs. 1-21, pl. 8, figs. 1-2
- 1972 *Oriostoma northi* Etheridge; Yochelson and Linsley, p. 8, pl. 1, fig. 6, pl. 2, figs. 1-5
- 1976 *Straparollus (Euomphalus) northi* Etheridge; Tassell, p. 9, pl. 1, figs. 7, 8, pl. 2, fig. 11, pl. 3, figs. 1, 2, 7, 8

*Description:* Shells large, discoidal, varying from flatly orthostrophic to slightly hyperstrophic with distinct circumbilical ridge. Nuclear whorls unknown, presumably simple, smooth and dextral. Whorl profile subrectangular in youthful stages, changing to subelliptical or subtriangular in adults. Upper whorl face variable, ranging from broadly arched and confluent with upper whorl face, to gently arched and meeting outer whorl face of a distinct keel; marked keel separating upper and outer whorl faces typically present in immature forms, but disappearing in many members of the adult population; outer whorl face strongly rounded, joined lower whorl face at pronounced circumbilical ridge; lower whorl face with slight concavity inside circumbilical ridge, continuing flatly to umbilical suture. Both upper and umbilical sutures shallow but distinct; depth of sutures varying with degree of spire depression with deeper suture generally present on flattest surface. Shells varying from slightly orthostrophic to slightly hyperstrophic, sometimes bordering on isostrophic, particularly in immature shells. Growth lines orthocline on upper whorl face, opisthoclyt on outer whorl face and slightly prosocline on lower whorl face, opisthoclyt on outer whorl face and slightly prosocline on lower whorl face with gently prosoclyt bendings over keels when present. Ornament of youthful forms consisting of strong collabral lines and two keels above and below the outer whorl face; in adult forms the basal collabral ornamentation and keel invariably persist, but the upper collabral ornamentation gives way to fine, closely spaced growth lines in one-half the population; the keel separating the upper and outer whorl face frequently disappearing in one-half the adult population. Shell thinnest near parietal lip, sometimes present only as a parietal inductura; shell becoming thicker near outer lip and reaching maximum thickness (6 or 7 mm) at circumbilical ridge. Septa abundant in early portion of whorls of adult shells, becoming more widely and unevenly spaced in more mature whorls; may occasionally be placed within one-half whorls distance from the aperture. Opiculum thick, circular, disc-shaped, multispiral, expanding counterclockwise. Shell

width of largest hypotype measuring 98 mm.

*Figured Hypotypes*—NMV P1107, P28373, P28498, P28499, P28707, P28708, P28709, P28710, P28711, P28712, P28713, P28714, P28715, P28716, P28717, P28718 and P28719.

*Description of males:* Shell large, discoidal, slightly hyperstrophic. Nucleus unknown, presumably normal dextral. Whorl profile varying from subelliptical to distinctly subtriangular, typically with marked bilateral symmetry converging to isostrophism. Upper whorl face typically gently arched to the keel-like shoulder separating upper and outer whorl faces; keel-like shoulder occasionally absent with upper and outer whorl faces roundly confluent with one another. Outer whorl face rather strongly convex between upper keel-like shoulder and circumbilical ridge; lower whorl face flattened to umbilical shoulder. Upper suture distinct but not sharply incised; umbilical suture slightly deeper, also sharply incised. Shell basically hyperstrophic but variable in degree. Growth lines orthocline on upper whorl face, opisthoclyt on outer whorl face and slightly prosocline on lower whorl face with gently prosoclyt areas over each keel. Ornament normally consisting of strong collabral ornament and two keels. Normally with strong collabral ornament on upper and lower whorl faces with weaker collabral ornament occasionally absent on upper and outer whorl faces. Normally with keel-like shoulder separating upper from outer whorl faces and with circumbilical ridge separating outer and basal whorl faces; upper ridge occasionally absent. Septa common in early whorls, more rare in mature whorls, but present to within one-half revolution of aperture. Operculum as in orthostrophic individuals. Shell width of largest hypotype measuring 70 mm.

*Hypotypes*—NMV P1107, P28707, P28710, P28713, P28714, P28715, P28717, P28718, P28719, P28708.

*Description of females:* Shell large, discoidal with depressed spire. Nucleus unknown. Whorl profile subelliptical with long axis of ellipse perpendicular to axis of coiling, upper whorl face broadly rounded, usually continuing without interruption to outer whorl face; outer whorl face more sharply rounded. Joining

lower whorl face at marked circumbilical keel; lower whorl face with slight concavity inside circumbilical ridge, then flattened before rounding into umbilical suture. Upper suture shallow but distinct; umbilical suture more shallow but also distinct. Shells basically orthostrophic tending towards planispiral, apical angle varying from  $200^{\circ}$  to  $230^{\circ}$ . Umbilical angle varying from about  $130^{\circ}$  to  $160^{\circ}$ . Growth lines closely spaced and very fine on upper whorl face, generally orthocline becoming very slightly opisthocline on outer whorl face and very slightly prosocline on base resulting in a slight prosoclyt phase over circumbilical ridge. Growth lines becoming strong collabral ornamentation as they cross circumbilical ridge onto base. Ornamentation consisting of growth lines on upper and outer whorl faces, collabral ornamentation on base, with circumbilical ridge invariably present and shoulder separating upper and outer whorl faces only rarely present. Shell thinnest near parietal lip, sometimes present only as parietal inductura, occasionally with some degree of thickness to it. Shell becoming thicker (up to four or five mm) near outer lip and reaching maximum thickness at circumbilical ridge. Septa numerous through early portion of shell, becoming more widely spaced in mature region, but occasionally present to within one-half whorl of the aperture. Operculum thick, circular, disc-shaped, multispiral, expanding counterclockwise (for more complete description, see Yochelson and Linsley, 1972). Shell width of largest hypotype measuring 98 mm.

*Hypotypes*—NMV P28498, P28499, P28373, P28709, P28711, P28712 and P28716.

*Discussion:* Chapman based the genus *Liomphalus* on some very poorly preserved specimens from the Lilydale Limestone which are undoubtedly abraded specimens of Etheridge's species '*Oriostoma northi*'. As a result his original species name of *Liomphalus australis* Chapman is invalid and should be *Liomphalus northi* (Etheridge). However, the generic name '*Liomphalus*' is still a valid and available name, and since the new evidence presented in this paper supports the removal of this species from

either *Oriostoma* or *Straparollus* I have utilized the genus *Liomphalus*.

This species can be easily differentiated from other members of the Omphalocirridae by the fact that its base lacks any nodal swellings or canal-like extensions. In addition, the sexual dimorphism while present, is not as well developed as in the descendant, more advanced members of the family. The adult males of *L. northi* tend to preserve juvenile features such as collabral ornamentation on the upper whorl face in addition to a strong keel separating the upper and outer whorl faces. In addition the males develop only a modest degree of hyperstrophism. The upper surface of the females however lose both the keel and the collabral ornament so that their upper whorl face flows continuously into the outer whorl face and has only closely-spaced, fine growth lines on it. The females also tend to be slightly orthostrophic. However none of these sets of characters are inviolate. In the collection of 104 specimens available of the National Museum of Victoria, Melbourne, there were occasional hyperstrophic forms with a rounded upper whorl face (Pl. 10, fig. 12, NMV P28713) or a faint keel which faded out (Pl. 10, figs. 9, 10), but the great majority of the members of this large population could be separated with ease.

However, this incipient sexual dimorphism, the lack of canal-like projections and the low stratigraphic position of *L. northi* are all consistent with the interpretation that this form is ancestral to *Omphalocirrus* and *Hypomphalocirrus*.

#### Stratigraphic Distribution

The oldest member of the family Omphalocirridae is *Liomphalus northi* of the Lilydale Limestone, Lower Devonian Yeringian of Australia. It is considered to be late Siegenian by Strusz (1972).

Although the next known occurrence of a member of this family is delayed until the Anderdon Limestone of the Michigan Basin, it is probable that further examination of gastropods presently assigned to the family Euomphalidae will uncover other genera and species that should be transferred to this group. The

Anderdon form (Linsley, 1968) of *Hypomphalocirrus* is unfortunately known only from a single fragment of an immature specimen. The Anderdon find represents the first known occurrence of this family in North America. The Anderdon represents a limited facies on the southeastern flank of the Michigan basin and is thought to be Eifelian (see Fagerstrom, 1961, and Linsley, 1968). It is considered to be late Sieyenian by Strusz (1972).

The next occurrence of a member of this family is *Hypomphalocirrus rugosus* from the Rogers City Limestone of the North East corner of the Michigan Basin. This unit has been placed in the lowermost Givetian (Cooper and Phelan, 1966, Ehlers and Kesling, 1970, Linsley 1973). Although this unit does not contain the brachiopod *Stringocephalus*, it does contain other members of the *Stringocephalus* fauna such as *Atrypa arctica*, *Subrensselandia* n. sp., *Liromytilus attenuatus*, *Buechelia tyrellii*, *Carinatina dysmorphostrota* (Ehlers and Kesling, 1970, p. 29) and *Straparollus* (*Straparollus*) *cottrelli* and *S.* (*Euomphalus*) *hoffmani* (Linsley and Yochelson, 1973).

The other occurrence of *Hypomphalocirrus rugosus* in the Miami Bend Formation of Indiana adds to the already substantial array of evidence put forth by Cooper and Phelan (1966) that this unit is directly correlative with the Rogers City Limestone.

The Winnipegosis Formation of Manitoba is also generally considered to be of Lower Givetian age (Ehlers and Kesling, 1970, p. 29, Cooper and Phelan, 1966, p. 28, Baillie, 1951, p. 59) and is generally correlated by these authors as the equivalent of the Rogers City Limestone. However a study of the species of *Hypomphalocirrus* present in these two formations suggests that the Rogers City form is ancestral to the Winnipegosis form and thus must slightly antedate the latter. This view is also supported by the study of the middle Devonian carrier shell, *Straparollus* (Linsley and Yochelson, 1973) which suggests that the Rogers City species are ancestral to the Winnipegosis species. Most certainly the two formations are close in age to each other, but the evidence on hand suggests that the Rogers

City-Miami Bend Formations are very slightly older than the Winnipegosis Formation.

The last known occurrences of members of this family are those of *Omphalocirrus goldfussi* from the Givetian *Stringocephalus* beds of Europe and the lone occurrence of the same species (ex-*Arctomphalus grandis*) from Goose Fiord, Ellesmere Land, from the Blue Fiord Formation of Eifelian age (McLaren, 1963, pp. 324-328).

### General Considerations

The genus *Omphalocirrus*, to which *Hypomphalocirrus* is closely related, has had a checkered career in the literature, with no one being quite certain whether to place the canal-like protrusions on the 'top' or on the 'bottom'. Even within the past thirty years the beast has been flipped three times. Knight (1941, p. 213) considered the canal-like projections to be the base of the organism, but without much conviction for he was not at all certain 'that the orientation employed . . . should not be reversed' (Knight, 1941, p. 213). In 1952 (p. 37) he reversed it, indicating that he considered *Omphalocirrus* to be a sinistrally coiled Macluritacean, and that the canal-like projections served an exhalent function. This view was retained in the Treatise (Knight, Batten and Yochelson, 1960, p. I189). In 1966, E. L. Yochelson (1966, p. 43, 45) broke from the Treatise triumvirate and flipped *Omphalocirrus* once again, placing the projections on the base, assuming them to be purely ornamental with no function, and transferring the genus from the Macluritacea to the Euomphalacea.

In Whiteaves original description of *H. manitobensis* (Whiteaves, 1890, p. 100) he described a steinkern assigned to that species that had an operculum associated with it. Considerable doubt has always surrounded this association. The operculum in this fossil is positioned well back into the shell, away from the aperture and tilted at an angle that would be unusual for an intact operculum (pl. 7, fig. 2). It was impossible to demonstrate that this was not just an operculum that had floated into an empty shell. Added to this is the fact that Whiteaves original description of *H. mani-*

*tobensis* (Whiteaves, 1890) was based on steinkerns from the Dawson Bay Formation that are generically indeterminate and our present understanding of the species is based on material collected from the underlying Winnipegosis Formation and assigned by Whiteaves to *H. manitobensis*. To further complicate matters no opercula of a multispiral form were known either from the Euomphalacea or the Macluritacea, and the operculum ascribed by Whiteaves to *H. manitobensis* did not fit our understanding of either of these groups.

I have been fortunate enough to find opercula in place both in *H. manitobensis* (pl. 7, fig. 1) from the Winnipegosis Formation of Manitoba and in *H. rugosus* from the Rogers City Limestone of Michigan. In both instances the operculum is multispiral, set well back away from the aperture and slightly tilted to the axis of the cone of revolution of the whorl, although not as tilted as in Whiteaves specimen. Thus there can now be no doubt that *Hypomphalocirrus* does indeed possess a multispiral operculum. The discovery also lends credence to Whiteaves claim that his steinkerns (one with a multispiral operculum) from the Dawson Bay Formation are at least related to the material from the Winnipegosis Formation, if not actually conspecific.

In both opercula as seen in place within the aperture, the volutions grow outward in a counter-clockwise fashion thus demonstrating conclusively that *Hypomphalocirrus*, and by inference *Omphalocirrus*, are dextral shells, and that the canal-like projections are really on the base of the shell. Thus the orientation of this enigmatic genus is no longer in doubt and it can finally come to rest, 'spines' down.

However, the solution of the problem of the orientation of the shell of the Omphalocirridae, is only the solution of the orientation for our descriptive purposes. Saying that the beast has finally come to rest 'spines down' only relates to the orientation of figures on a plate for the purposes of comparative morphology and has nothing necessarily to do with the orientation of the shell to the substrate while the organism was living. It allows us to invoke the concepts 'dextral', 'sinistral', 'orthostrophic' and 'hyperstrophic' and to ascertain homologous por-

tions of the shell (inhalent, exhalent, etc.). But the orientation of the shell during life remains as much of an enigma as ever.

In the majority of modern gastropods, i.e. those with either high spires or elongated apertures (cones, mitres, volutes, terebras, etc.) the 'base' of the shell is actually the leading edge or anterior-most portion of the shell relative to the living animal. In low-spired modern gastropods (turbonids, naticids, trochids, etc.) or discoidal shells (planorbids, etc.) the 'outer lip' forms the leading edge of the shell. Thus in this second group the 'base' of the shell is the left side and the spire projects back and to the right side of the animal. In all of these gastropods the shell is held dorsally over the body by the columellar muscle and the plane of the aperture is parallel to the substrate.

If the Omphalocirridae are 'typical' gastropods then the shell would be held in a dorsal position with the coiled portion resting on the operculum of the upper surface of the posterior portion of the foot (the metapodium). However the Omphalocirridae are unlike all of the above-mentioned gastropods in one important aspect. In all of the aforementioned snails the plane of the aperture is tangent to the preceding whorls (a tangential aperture) while in the Omphalocirridae the plane of the aperture transects the axis of coiling of the shell (a radial aperture) with the result that a great portion of the earlier volutions projects beyond the plane of the aperture. This would seem disadvantageous for a gastropod whose aperture is parallel to the plane of the substrate. Perhaps the Omphalocirridae have a very different relationship to the substrate. In fact it has been suggested (Linsley and Yochelson, 1973) on the basis of completely different criteria that some euomphalids [*Euomphalus* (*Euomphalus*), *E. (Straparollus)* and *E. (Serpulospira)*] lived base down with the plane of the aperture perpendicular to the substrate. In this position there would no longer be a need for the aperture to be tangent to the preceding whorls and indeed it seems to be a general character of most euomphalids to have the plane of the aperture intersect at or near the axis of coiling of the shell.

This would be an adaptation suitable for a sedentary gastropod, perhaps a deposit feeder or even a filter feeder. The organism might possibly be capable of hoisting his shell into the normal position for short journeys to new feeding grounds. More probably the shell would just be dragged along during locomotion. It would be expected that the majority of the time would be spent with the shell lying flat on the substrate and the animal largely withdrawn inside the shell, protruding only to obtain food. For such a habit an operculum would be a distinct advantage.

Whether the Omphalocirridae were filter feeders and assumed a living position of the shell lying flat on the substrate, or whether they were active grazers and thus carried the shell erect over their back is not known. Possibly the nature of their spines might afford some clue.

During his investigation of the genera *Omphalocirrus* and *Arctomphalus*, Yochelson (1966, p. 53) remarked that 'the fact that the spines develop gradually from nodes would seem to imply that they served no vital function'. Close examination of these canal-like protuberances in *Hypomphalocirrus* belie that statement. As many as ten to twelve growth lines are involved in making one of the projections, the last of which curve backward in a U-shaped fashion, and upward to form the rim of the canal-like projection (see pl. 4, figs. 5, 8). The next growth line does not bend upward but proceeds across the shell along the normal shell contour, bending forward at the position of the protuberance, thus leaving an opening ('tremata') which I suggest remains functional until the appearance of the next projection, whereupon it is filled in with secondary calcite deposits, very much as are the tremata of *Haliotis*.

However, these canal-like projections cannot be called 'tremata', because tremata (as found in *Tremanotis*, *Polytremaria* and the *Haliotidae*) are associated with the exhalent function and normally mark the position (or the eventual position) of the anus. In *Hypomphalocirrus* the basal position of these projections necessitates that we regard them as inhalent in function, thus resembling the inhalent

(siphonal) canals of many of the modern Caenogastropoda and I propose that they be called 'inhalent tremata'. *Hypomphalocirrus* is not unique among Devonian gastropods in the development of a portion of the aperture for a specialized incurrent function. In the Raphistomatinae alone, both *Tylozone* and *Buechelia* show well developed siphonal canals and the lower lip of *Arizonella* most probably marks the position of the inhalent currents as does the plethospirid *Diplozone*. Even in the Euomphalidae, *Pleuronotus* and *Diploconula* have a basal angulation which would most probably result from a mantle fold which would make an incurrent stream more effective by being localized.

It is probable that the advent of more advanced and efficient groups during the Devonian, such as the Neritacea, the Palaeotrochacea and the Paleozygopleuridae, which would probably be more efficient, increased the pressure on the older, more conservative groups such as the Macluritacea, Euomphalacea and Pleurotomariacea. One temporary solution could be in improvement of the efficiency of water currents as evidenced by *Omphalocirrus*, *Hypomphalocirrus*, *Tylozone* et al. It was a solution that apparently was not tried again until the Pennsylvanian when we find *Knightites*, *Cyclioscapa*, and *Straparollus* (*Amphiscapcha*) developing similar canals or angulations.

The primary water current in *Hypomphalocirrus* thus entered the mantle cavity by way of the incurrent canals on the base, passed the osphradium and left gill and then passed out of the mantle cavity, past the anus which was undoubtedly located at the angulation formed by the junction of the upper and outer whorl faces. In females of *H. manitobensis* this upper angulation is also equipped with a row of canal-like projections which mirror the form of those on the lower angulation, but which served an excurrent rather than an incurrent function. It is possible that the peripheral undulations in the female *H. rugosus* are antecedent to this upper row of projections.

If the interpretation of the current arrangement in *Hypomphalocirrus* given above is correct, this adds support to the concept (Knight,



Batten, Yochelson, 1960) that the Macluritidae and the Euomphalidae suffered a reduction or elimination of the right gill, for there is no morphological evidence in the shell that a comparably effective water current would flow over the right gill which, in *Hypomphalocirrus* would have to be positioned under the upper whorl face.

Therefore, if the spines are indeed functional as incurrent modifications, then the shell of the Omphalocirridae must have either been carried in an upright position or if lying flat on the substrate with the left side bearing the spines (the 'base') uppermost. This latter position would thus be 'upside down' compared with our normal way of depicting these shells.

#### A Summary of Sexual Dimorphism and the Evolution of the Omphalocirridae

Our present knowledge of this family would suggest that *Liomphalus* first developed the diagnostic features of this family and then gave rise to two stocks, one European culminating in *Omphalocirrus* and one North American, furnishing the *Hypomphalocirrus* lineage.

The development of the operculum of this group has already been fully treated (Yochelson and Linsley, 1972). Evolutionarily the thick operculum of *Liomphalus northi* is set at the apertural margin, while in *Hypomphalocirrus rugosus* and *H. manitobensis* the operculum is much thinner and drawn well into the aperture, as far back as one-fourth revolution. It also tends to be slightly rotated in this genus, which is a nice adaptation to allow a circular operculum to fit snugly inside a slightly elliptical whorl profile. The operculum of *Omphalocirrus goldfussi* is unknown but most probably exists and has not been associated with that form.

The varying reasons for the presence of septa in gastropods has also been discussed recently (Yochelson, 1971). In the case of the Omphalocirridae it seems unlikely that the septa are for strengthening the shell or for protection against breakage of the early whorls. Rather the septa would appear only to serve the purpose of body shortening. We do not know if this body shortening would result in

any mass decrease. If the early chambers were filled with water, as is most probable, then presumably the mass of water would closely approximate the mass of flesh. Without a siphuncle and the complex gas-exchange cells of the cephalopods it seems most unlikely that there would be any increase in buoyancy gained by the secretion of septa in gastropods.

The features which are involved in the sexual dimorphism of this family, i.e. size differential, collabral ornamentation, differential development of keel or canals, and hyperstrophism, are all present in *Liomphalus northi* although they are not as fully differentiated in this species as they are in subsequent species. In *Liomphalus northi* the males tend to be hyperstrophic, smaller, with collabral ornamentation on the upper whorl face and a keel separating the upper and outer whorl faces. The females are more orthostrophic, larger, and have no collabral ornamentation or keel on the upper whorl face. In all cases where I have had a sufficiently large population to study, I have assumed that the largest individuals are the females. The one exception to this rule is *Omphalocirrus goldfussi*. In the six examples I have seen from Germany, those that I have called females are indeed the largest individuals. However, this makes Tolmachoff's specimen from Ellesmere Land a male yet this specimen is the largest individual in the entire family. However, as outlined below, I have other reasons for believing that this is a correct interpretation, so until someone has had an opportunity to study a large population of this species I will continue to consider Tolmachoff's specimen as a male.

In the Middle Devonian members of the family, the best indicator of sex is the relative development of the canal-like extensions, the inhalent tremata. In the Rogers City form, the female has very well developed, obviously functional, canal-like inhalent tremata on the base. In addition the junction between the upper and outer whorl face has developed a series of undulations that are presumed to act as a canal, or at least a means of localizing the excurrent flow. The male generally lacks both of these traits. The females from the Winnipegosis Limestone have developed canal-like

extensions both on the top and bottom of the outer whorl face, while the males have inhalent tremata developed only on the base. This would seem an obvious improvement over the Rogers City Form and is the main reason that I consider *Hypomphalocirrus rugosus* ancestral to *H. manitobensis*. As mentioned earlier I believe the basal canals to be incurrent, while the upper canals or shoulder mark the position of the anus and is thus essentially excurrent. It is presumed that the female needs better mantle circulation to enable it to produce the more bulky egg masses. The males in both of these cases have less well developed aids to water circulation. In *H. rugosus* the adult males typically have only a keel where the incurrent canals of the female are located and have an even upper shoulder in place of the undulating shoulder of the female. The males of *H. manitobensis* have only a single set of canals at the incurrent position instead of the double set of both incurrent and excurrent found in the females. Thus the entire evolution of the North American lineage was accompanied by an improvement of water circulation in the mantle, with the females consistently better than the males.

A similar situation exists with the European stock of *Omphalocirrus goldfussi*. In this species the female has very well developed inhalent canals whereas in the males, the canals are not always well developed and are frequently only suggested by nodal swellings on the basal keel.

The Australian representative deviates from the patterns set by its descendents in that the male of *Liomphalus northi* possesses keels above and below while the female has only the lower keel. However these keels have no expression on the inner surface of the aperture and therefore may not be functional relative to water currents as are the well-developed keels of its descendents. I would suggest that this is merely a case of pre-adaptation, where the keels of the ancestral form were selected for one function (possibly strengthening the shell) and secondarily proved useful for a completely different function (isolating water currents). As a result it would not have the

same selective pressures relative to the sexes in *Liomphalus* as it subsequently had in the more highly specialized offspring.

The matter of hyperstrophism is also a perplexing problem in the Omphalocirridae. In *Liomphalus northi*, *Omphalocirrus goldfussi* and *Hypomphalocirrus manitobensis* the males are more hyperstrophic than the females. This leads me to the conclusion that it is not the mode of coiling that is significant in itself, but the effect the coiling has on the positioning of the outer whorl face. In the genus *Hypomphalocirrus* which has a triangular whorl face, the outer whorl face of female is oriented so that it is sub-parallel to the axis of the shell. This places both inhalent and exhalent portions of the aperture on the very periphery of the shell, both placed as far from the axis of coiling as possible. If the shell is positioned in a recumbent position, inhalent tremata up, then they are in the perfect position to obtain clean water while the anus of *Hypomphalocirrus rugosus* would be placed adjacent to the substrate, while excurrent canal of *H. manitobensis* would be thrust down into the substrate. Possibly they buried their faces as does the modern detritus feeder *Xenophora* (Shank, 1969, p. 6).

In the case of *Omphalocirrus goldfussi* and *Liomphalus northi* the whorl profile of the female tends to be more inflated than that of the male, presumably to accommodate the bulkier egg masses. The male, on the other hand, has a less inflated slightly more angular external whorl profile (the internal whorl cross section being subcircular). It is possible that these differences may dictate the hyperstrophic coiling of the males and the ortho-isostrophic coiling of the female.

The final feature is one that is possessed by all members of this family and that is collabral ornamentation in the adult males. In all members the immature forms have strong collabral ornamentation, but only in the males is this juvenile feature carried into the adults. It is probable that this feature serves to strengthen the shell on juveniles and males. It is possible that this becomes unnecessary in females because they possess thicker shells, but I have no direct confirmation of this from

actual observations on shells (a particularly difficult task when ninety per cent of the fauna studied consists of latex impressions).

### Summary and Conclusions

All four species of the Omphalocirridae, *Omphalocirrus goldfussi*, *Liomphalus northi*, *Hypomphalocirrus rugosa* and *H. manitobensis* exhibit considerable dimorphism in their adult shells. The expressed dimorphism is completely consistent with an interpretation of sexual dimorphism in that both dimorphs are always present in all localities where extensive collections have been made and in a more or less one-to-one ratio. All species except *Liomphalus northi* are characterized by having functional inhalent tremata developed as canal-like extensions of the base. These inhalent tremata are consistently better developed in the morphotypes that have been considered as females and it is suggested that this is related to the improved circulation necessary to aerate the bulky egg mass of the females.

### Acknowledgements

This study has been made possible by a series of grants extended to the author by the Sloan Foundation and the Colgate Research Council. These grants were awarded for the summers of 1967, 1968, 1969, 1970 and for a sabbatical semester of 1971 which enabled me to go to Australia to study the fauna of the Lilydale Limestone as represented in the collections at the National Museum of Victoria, Melbourne. I am particularly indebted to Mr Edmund Gill and Mr Thomas Darragh of the National Museum of Victoria for opening their facilities and collections to me and for extending the hospitality of the entire museum. I would also like to thank Dr Gary Batt of the Department of Zoology, University of Auckland for assisting with the photography of the Australian material.

For German material of *Omphalocirrus goldfussi* I am indebted to Dr Ulrich Jux of the University of Cologne for taking the author to a number of collecting sites in the Paffrath area and making available comparative material for study.

Dr Hugh R. McCabe of the Department of Mines and Natural Resources of the Province of Manitoba was most kind in discussing Manitoba Geology with the author and in accompanying the author to outcrops of the Winnipegosis Formation.

The author was first introduced to the Rogers City Formation of Michigan by Dr G. M. Ehlers and Dr R. V. Kestling of the University of Michigan Museum of Paleontology. Both of these men have contributed enormously to the author's understanding of the geology of this area and to his understanding of the Rogers City Limestone in particular. I am deeply indebted for the many hours spent with them discussing both geological and biological aspects of this problem. Access to the Calcite Quarry, Michigan Limestone Operations, U.S. Steel Corporation at Rogers City, Michigan and to the Preque Isle Corporation Quarry, formerly Lake of the Woods Quarry, north of Alpena, Michigan, managed by Mr Roy Hutchinson for a consortium of steel companies, has always been graciously granted.

I would also like to express my deep appreciation to four former students who have been of great assistance in this problem. Mr John Cottrell and Mr John Hoffman spent one summer with me under the auspices of a Colgate Research Council Undergraduate Research Participation grant. They were indefatigable field workers and spent many hours preparing specimens and discussing various aspects of the problems. Cottrell was also able to accompany me to the Manitoba field area near Lake Winnipegosis. Dr Harold B. Rollins and Mr William Arendt also accompanied me to the Rogers City area for field work and in addition Rollins was of inestimable value for the photographic work he did on the Rogers City material.

Dr R. V. Kesling of the University of Michigan Museum of Paleontology, Dr G. Arthur Cooper of the U.S. National Museum and Dr Digby McLaren of the Canadian Geological Survey at Ottawa were very kind in giving the author access to the collections of their respective institutions.

Lastly I greatly appreciate the many hours

of stimulating discussion of this problem provided by Dr John Morton, Department of Zoology, University of Auckland, Dr C. M. Yonge, Department of Zoology, University of Edinburgh and Dr E. L. Yochelson, U.S. Geological Survey.

Abbreviations used in this paper are as follows: USNM—United States National Museum, Washington, D.C.; UMMP—University of Michigan Museum of Paleontology, Ann Arbor, Michigan; GSC—Geological Survey of Canada, Ottawa, Ontario, Canada; NMV—National Museum of Victoria, Melbourne, Victoria, Australia.

### References

- Anonymous, 1960. *Fossils found in Limestone of the Calcite Quarry of Michigan Limestone operations of United States Steel Corp. at Rogers City, Michigan*. U.S. Steel Corp.
- ARCHIAC, E. J. A. D', and E. P. DE VERNEUIL, 1842. On the fossils of the older deposits in the Rhenish Provinces, preceded by a general survey of the fauna of the Palaeozoic rocks, and followed by a tabular list of the organic remains of the Devonian system in Europe. *Trans. Geol. Soc. Lond.*, 6: 303-410, pls. 25-37.
- BAILLIE, ANDREW D., 1951. Devonian geology of Lake Manitoba-Lake Winnipegosis area: Province of Manitoba, Dept. Mines & Nat. Resources, Mines Branch, publ. 49-2.
- BAKER, H. B., 1926. Anatomical Notes on American Helicinidae, *Proc. Acad. Nat. Sci. Phila.*, 78: 35-56.
- COOPER, G. A. and THOMAS PHELAN, 1966. *Stringocephalus* in the Devonian of Indiana, *Smithson Misc. Collns.*, 151(1): 1-20, pls. 1-5.
- COX, L. R. and J. B. KNIGHT, 1960. Suborders of Archaeogastropoda: *Proc. Malac. Soc. Lond.*, 33 (6): 262-264.
- CUVIER, GEORGES, 1797. *Tableau elementaire de l'histoire naturelle des animaux*: xvi + 710 p., 14 pl. (Paris).
- EHLERS, GEORGE M. and ROBERT V. KESLING, 1970. Devonian Strata of Alpena and Presque Isle Counties, Michigan. *Michigan Basin Geological Society Guide Book for Field Trips*. Michigan Basin Geological Society, pp. 1-130, pls. 1-38.
- EHLERS, GEORGE M. and ROBERT E. RADABAUGH, 1938. The Rogers City Limestone, A New Middle Devonian Formation in Michigan. *Pap. Michigan Acad. Sci., Arts, Letters*, XXIII, pp. 441-446, pls. I-II.
- ETHERIDGE, R. Jr., 1890. Descriptions of Upper Silurian fossils from the Lilydale Limestone, Upper Yarra District, Victoria. *Rec. Aust. Mus.*, 1, no. 3, pp. 60-67.
- FAGERSTROM, J. A., 1961. The Fauna of the Middle Devonian Formosa Reef Limestone of Southwest Ontario, *J. Paleont.*, 35, no. 1, pp. 1-48, pl. 1-14.
- KNIGHT, J. BROOKS, 1941. Paleozoic Gastropod Genotypes. *Spec. Pap. Geol. Soc. America*, 32, pp. 1-510, pls. 1-96.
- , 1952. Primitive Fossil Gastropods and their Bearing on Gastropod Evolution, *Smithson. Misc. Collns.* 117, (13): 1-56, pl. 1-2.
- , BATTEN, R. L., and YOCHELSON, E. L., 1960. Treatise on Invertebrate Paleontology (Moore, R. C., editor) Part I, Mollusca 1. Geological Society of America, Inc., Boulder, Colorado and University of Kansas, Lawrence, Kansas, xxiii and 351 pp.
- KONINCK, L. G. de, 1881. Faune du calcaire carbonifere de la Belgique, 3<sup>e</sup> partie, Gasteropodes: *Mus. roy. Histoire nat. Belgique, Ann. sev. paleont.*, 6, pp. 1-170, pl. 1-24 (Bruxelles).
- LAMY, E., 1937. Sur le Dimorphisme Sexuel des Coquilles, *Journ. Conchyliol.*, 81, pp. 283-301.
- LINSLEY, ROBERT M., 1968. Gastropods of the Middle Devonian Anderdon Limestone, *Bull. Amer. Paleont.*, 54, no. 244, pp. 333-465, pl. 25-39.
- , 1973. Paleocological Interpretation of the Rogers City Limestone (Middle Devonian, Northeast Michigan), *Contrib. Mus. Paleont. Univ. Michigan*, 24, no. 11, pp. 119-123.
- and E. L. YOCHELSON, 1973. Devonian Carrier Shells (Euomphalidae) from North America and Germany *U.S. Geol. Surv. Prof. Paper* 824, pp. 1-26, pl. 1-6.
- MCCABE, H., 1967. *Field Guide to Devonian Outcrops of Southwestern Manitoba*.
- MCLAREN, D. J., 1963. Southwestern Ellesmere Island-Goose Fiord to Bjorne Peninsula, p. 310-338 in Fortier, Y. A. and others: Geology of the North-Central part of the Arctic Archipelago, Northwest Territories (operation Franklin), *Mem. Geol. Surv. Canada*, 320.
- MILNE EDWARDS, HENRI, 1848. Note sur la classification naturelle des mollusques gasteropodes, *Ann. Sci. Nat., Zool.*, ser. 3, 9, pp. 102-112 (Paris).
- PHILIP, G. M. and J. A. TALENT, 1959. The gastropod genera *Liomphalus* Chapman and *Scalaetrochus* Etheridge, *J. Paleont.* 33, pp. 50-54.
- ROBERTSON, ROBERT, 1971. Sexually Dimorphic Archaeogastropods and Radulae, *Annual Reports for 1970 of the American Malacological Union*, pp. 75-78.
- RYCKHOLT, P. de, 1860. Revue des genres qui composent la famille des Haliotidae, D'Orbigny, *Jour. Conchyliol.*, 2e ser. 4, pp. 183-188.
- SHANK, PAUL, 1969. The Timorous Carrier Shell, Close Observation of the *Xenophora conchyliophora* Born. *New York Shell Club Notes* 151, pp. 5-7.

- SOHL, NORMAN F., 1969. Gastropod Dimorphism, in Westermann, G.E.G. editor, *Sexual Dimorphism on Fossil Metazoa and Taxonomic Implications*, Intern. Union of Geol. Sciences, Ser. A, 1, pp. 94-100.
- STRUSZ, D. L., 1972. Correlation of the Lower Devonian Rocks of Australasia. *J. Geol. Soc. Aust.* 18(4): 427-455.
- TASSELL, C. B., 1976. A Revision of the Gastropod Fauna of the Lilydale Limestone (Early Devonian) of Victoria, *Mem. Natn. Mus. Vic.* 37: 1-21.
- THIELE, JOHANNES, 1925. *Mollusca—Weichtiere: Handbuch der Zoologie*, gegründet W. Kuenthal, 5, pp. 15-256 (Berlin, Leipzig).
- TOLMACHOFF, I. P., 1926. On the fossil faunas from Per Schie's Series D from Ellesmere Land with exception of brachiopods, corals, and cephalopods: *Report of the second Norwegian Arctic expedition in the 'Fram' 1898-1902*, 38, pp. 1-106, 8 pls.
- WHITEAVES, J. F., 1890. Descriptions of some new or previously unrecorded species of fossils from the Devonian rocks of Manitoba, *Trans. R. Soc. Canada*, VIII, sec. 4, no. 3, pp. 93-110.
- , 1892. The fossils of the Devonian Rocks of the islands, shores, or immediate vicinity of Lakes Manitoba and Winnipegosis, *Geol. Surv. Canada, Contrib. to Cana. Paleont.*, 1, pt. 4, no. 6, pp. 255-359, pls. 33-47, Ottawa.
- YOCHELSON, E. L., 1966. A Reinvestigation of the Middle Devonian gastropods *Arctomphalus* and *Omphalocirrus*, *Årbok norsk Paralinst.* 1965, pp. 37-48.
- , 1971. A new Upper Devonian gastropod and its bearing on the problems of open coiling and septation, *Smithsonian Contr. Paleobiology*, 3, pp. 231-241, pls. 1, 2.
- and R. M. LINSLEY, 1972. Opercula of two gastropods from the Lilydale Limestone (Early Devonian) of Victoria, Australia, *Mem. Natn. Mus. Vict.* 33, pp. 1-14, pls. I-II.

**Explanation of Plates**

**PLATE 2**

- Hypomphalocirrus rugosus* n. sp. All figures are of males. All specimens except Figure 6 from the Rogers City Limestone.
- Figures 1-3—Basal, apical and apertural views (x1.8) of paratype UMMP 22384, from the beach at Rockport. Note flat upper surface, strong collabral ornamentation and 45° inclination of outer whorl face.
- Figure 4—Apertural view of paratype USNM 213775 (x0.75) showing subtriangular whorl profile with flat upper whorl face and inclined outer whorl face.
- Figure 5—Apical view of paratype, UMMP 22383

(x1) exhibiting strengthening of collabral ornamentation near the suture.

- Figure 6—Apical view (x1.1) of paratype USNM 213769 from the Miami Bend Formation in Ohio.
- Figure 7—Apical view (x1.75) of paratype USNM 213770. In this specimen the collabral ornamentation is very strong in the youthful stage and becomes diminished with increasing age.
- Figure 8—Apical view (x0.75) of paratype USNM 213762. Again the collabral ornament becomes weaker with increased age.
- Figure 9—Cross-section (x1.4) of paratype USNM 213763 showing numerous irregularly spaced septa.

**PLATE 3**

*Hypomphalocirrus rugosus* n. sp. All figures are of males from the Rogers City Limestone.

- Figures 1, 11—Oblique basal (x1.5) and basal (x0.8) views of Paratype, USNM 102939 showing flange-like projections of early whorls giving way to a continuous keel on the ultimate whorl.
- Figure 2—Apertural view of Paratype USNM 213777 (x0.75).
- Figure 3—Basal view (x0.65) of Paratype USNM 213757. Note continuous keel on ultimate whorl.
- Figure 4—Adapertural view (0.6) of Paratype USNM 213779 showing slight suggestion of a spiral groove just below the shoulder.
- Figure 5—Oblique basal view (x0.6) of Paratype USNM 213766 very large male with unusually well developed flange-like projections on the base.
- Figure 6—Oblique basal view (x0.6) of Paratype USNM 213773 showing well developed spiral groove just below shoulder.
- Figure 7—Basal view (x0.9) of Paratype USNM 213774.
- Figure 8—Apical view of Paratype USNM 213775 (x0.6) showing well developed collabral ornamentation.
- Figure 9—Oblique basal view (x0.9) of Paratype USNM 213778. Note sharp single keel on base and smooth outer whorl face.
- Figure 10—Basal view (x0.9) of Paratype UMMP 57889, a mature specimen with well-developed keel and deep umbilicus.
- Figure 12, 14—Basal (x0.9) and oblique basal (x0.8) views of Paratype, USNM 213761. This specimen is unusual because of the roundness of the base. Note also the well-developed flanges and the strong collabral ornamentation.
- Figure 13—Basal view (x0.6) of mature specimen, Paratype USNM 213756 with a rounded base with no flanges or keel.

Figure 15—Basal view (x0.6) of Paratype USNM 213780.

#### PLATE 4

*Hypomphalocirrus rugosus* n. gen. and sp. All figures are of females from the Rogers City Limestone.

- Figures 1, 2, 5, 6, 8—Oblique apical (x0.6), apertural (x0.8), basal (x0.8), apical (x0.8) and oblique basal (x0.8) of holotype UMMP 22377. A very large mature female showing well-developed basal flanges, undulating shoulder, high degree of hyperstrophism and rugose, near vertical outer whorl face, all typical features of the adult female.
- Figure 3—Apical view (x0.6) of paratype UMMP 22378 showing smoothness of early whorls and the undulating shoulder.
- Figure 4—Outer surface (x1.25) of operculum, paratype USNM 213768 showing the multi-spiral form typical of the opercula of this family.
- Figure 7—Oblique apical view (x0.75) of Paratype USNM 213758, the most extremely hyperstrophic individual in the entire collection.

#### PLATE 5

*Hypomphalocirrus rugosus* n. gen. and sp. All figures are of females from the Rogers City Limestone.

- Figure 1—Apical view (x0.75) of Paratype, USNM 213755. Note the degree of hyperstrophism and undulating shoulder on this large specimen.
- Figure 2—Oblique basal view (x0.7) of Paratype, USNM 213764 showing well-developed projecting flanges.
- Figure 3—Basal view (x0.85) of Paratype USNM 213760. This mature specimen illustrates the well-developed basal flange-like protrusions of the female, but the collabral ornamentation is better developed than is typical.
- Figure 4—Apical view (x0.6) of Paratype UMMP 57888. This very large female has only moderate hyperstrophism and no development of the undulating shoulder.
- Figure 5—Basal view (x1.0) of Paratype USNM 213767 showing strongly developed, spade-like basal flanges.
- Figure 6—Apical view (x1.1) of Paratype UMMP 22379, showing undulating shoulder.
- Figure 7—Apical view (x3.0) of Paratype UMMP 22375. Very immature specimens such as this are very difficult to sex. This individual has the degree of hyperstrophism which suggests a female, but the well-developed collabral ornamentation suggests a male.

#### PLATE 6

*Hypomphalocirrus rugosus* n. gen. and sp. All figures of females from the Rogers City Limestone.

- Figures 1, 8—Oblique basal (x0.7) and apertural (x1.25) views of Paratype UMMP 22379. A thin individual with undulating shoulder, flanges and roughened outer whorl face.
- Figure 2—Apertural view (x0.6) of Paratype UMMP 22378 showing strong hyperstrophism.
- Figure 3—Oblique basal view (x0.5) of Paratype USNM 213759 with an unusually high outer whorl face.
- Figure 4—Oblique basal view (x0.8) of Paratype USNM 213772 showing well-developed undulations on shoulder and the rugose outer whorl face.
- Figure 5—Apical view (x0.9) of Paratype USNM 213781. This specimen is a female on the basis of its hyperstrophism, but exhibits the male characters of strong collabral ornamentation and smooth shoulder.
- Figure 6—Oblique basal view (x0.7) of Paratype USNM 213776 showing strong flanges on base and undulating shoulder.
- Figure 7—Oblique apical view (x0.75) of Paratype, USNM 213765 showing exceedingly rugose outer whorl face.
- Figure 9—Basal view (x0.6) of Paratype UMMP 22380. This specimen has an unusually round whorl profile and thus greatly resembles *Omphalocirrus goldfussi*.
- Figures 10, 11—Oblique apical (x0.7) and oblique basal views (x0.9) of Paratype, USNM 213754 showing rugose outer whorl face and very strong undulating shoulder.

#### PLATE 7

*Hypomphalocirrus manitobensis* (Whiteaves)

- Figure 1—Oblique apical view (x1.8) of Hypotype, USNM 213783 showing operculum set of an oblique angle inside the ultimate whorl. Coiling of multispiral operculum indicates this is orthostrophic coiling.
- Figures 2, 4—Whiteaves cotype, GSC 4174. The break in this steinkern marks the position of the operculum. This operculum is placed at a greater angle to the axis of the whorl than that found in Fig. 1, indicating that there was some rotation after death.
- Figure 3—Oblique basal view of Whiteaves Plesiotype GSC 4176, a female showing full development of both rows of spines. Also note rugose outer whorl face.
- Figures 5, 6, 8—Apertural, basal and apical views of Whiteaves Plesiotype GSC 4177a. Note the two rows of spines and the pseudo-

isostrophic coiling typical of the female.

Figure 7—Basal view of hypotype USNM 213782, an immature male showing well-developed basal inhalent tremata, collabral ornamentation and hyperstrophic coiling.

#### PLATE 8

All figures of *Omphalocirrus goldfussi* (Archiac and Verneuil)

Figures 1, 2, 9—Oblique basal (x0.8), basal (x0.75) and apical (x0.7) of latex cast (from USNM) of topotype figured by Knight (1941) of a specimen from the Puzo Collection, Ecole de Mine. This specimen is presumably a female characterized by being orthostrophic and having well-developed inhalent tremata present throughout its growth.

Figures 3, 6—Basal (x1.0) and oblique basal (x0.8) views of latex cast (from USNM) of Holotype which is housed in the De Verneuil Collection at the Ecole nationale superieure des Mines, Paris, France. This is presumably a female showing the weak collabral ornamentation of the base.

Figures 4, 5—Oblique basal and basal views (x1.8) of a plaster cast (from USNM) of a specimen from Sotenich, Germany, Stringocephalus Limestone (Givetian). The original of this specimen is from Humboldt Universitat, Berlin, Germany. This is presumably a male and is thus hyperstrophic, with non-functional inhalent tremata and strong collabral ornamentation of the base.

Figure 7—Basal view (x1.0) of plaster cast (from USNM) of holotype of '*Arctomphalus grandis*' Tolmachoff, 1926, specimen No. A 19229 in the Paleontologisk Museum of Oslo, Norway. The total size of this specimen is indicated by the dashed line, but the adult whorls are only represented by a steinkern. The inner whorls indicate the features typical of the male *Omphalocirrus*.

Figure 8—Basal view (x1.1) of plaster cast (from USNM) of a specimen from Vilmar, Germany, Upper Stringocephalus zone. The original of this specimen is in the Humboldt Universitat, Berlin, Germany. This specimen is hyperstrophic and shows the other male characters of incipient nonfunctional inhalent tremata and strong collabral ornamentation.

#### PLATE 9

*Liomphalus northi* (Etheridge). All figures of females from the Lilydale Limestone, Cave Hill Quarry, Lilydale, Victoria, Australia.

Figures 1-3—Apical, basal and apertural views (x2) of an immature female Hypotype NMV P28716. At this young age the females exhibit many of the male characters such as collabral ornament and a faint keel on top as well as bottom. Note however that it is orthostrophic rather than hyperstrophic as is the case with the males (cf. Pl. 10, Fig. 5).

Figure 4—Apical view (x0.7) of Hypotype NMV P28709, showing rounded upper whorl face with no keel and no collabral ornament.

Figures 5, 7, 8—Oblique apical, apical and basal views (x0.7) of Hypotype, NMV P28711, a large female showing strong keel and collabral ornamentation on the base and no keel and no collabral ornamentation on the top.

Figures 6, 9, 10—Oblique apical (x0.7), basal and apical (x0.5) views of Hypotype, NMV P28712.

Figure 11—Cross section (x0.7) of Hypotype, NMV P28499 showing septal filling of early whorls.

Figures 12, 13—Basal (x0.8) and apical (x1) views of Hypotype NMV P28708.

Figures 14, 17—Basal and apical views (x0.7) of Hypotype, NMV 28498. Note flat spire and depressed umbilicus.

Figures 15, 16—Basal and apical views (x0.5) of Hypotype, NMV P28373, the largest specimen in the collection.

#### PLATE 10

*Liomphalus northi* (Etheridge). All figures of males from the Lilydale Limestone, Cave Hill Quarry, Lilydale, Victoria, Australia.

Figures 1-3—Apical, basal and oblique apical views (x1) of Hypotype, NMV P28714, a typical male showing collabral ornamentation and keel on both top and bottom. Also note the degree of hyperstrophism.

Figures 4-6—Apical, apertural and basal views (x2) of Hypotype NMV P28719. This is a small male showing the degree of hyperstrophism typical of the males.

Figure 7—Basal view (x1) of Hypotype NMV P28707 showing very strong basal keel.

Figures 8, 11—Apical and oblique views (x0.7) of Hypotype, NMV P28717. On this strongly hyperstrophic male the upper keel becomes lost on the ultimate whorl, but the collabral ornament continues all of the way.

Figures 12, 17—Apical (x0.9) and basal views (x1) of Hypotype, NMV P28713. This male is unusual for though it is markedly hyper-

strophic it has lost the keel and collabral ornament on the top.

Figures 13, 16—Apical (x1) and oblique apical (x0.7) views of Hypotype, NMV P1107. This large male exhibits all of the typical features; keel and collabral ornamentation top and bottom, and hyperstrophism. Note massive, multispiral operculum in place in the aperture.

Figure 14—Apical view (x0.7) of Hypotype, NMV P28710. This specimen still has the keel on top, but has lost the collabral ornamentation.

Figure 15—Apical view (x0.7) of Hypotype, NMV 28718. This crushed male shows strong collabral ornamentation and well-developed keel.

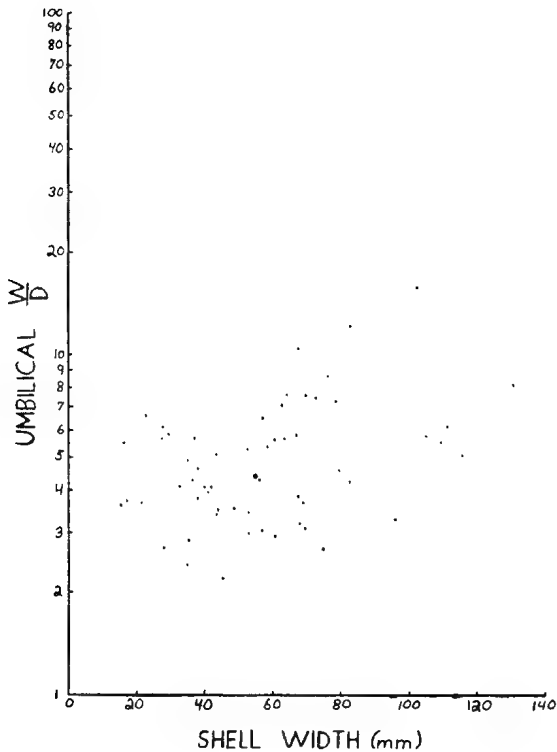
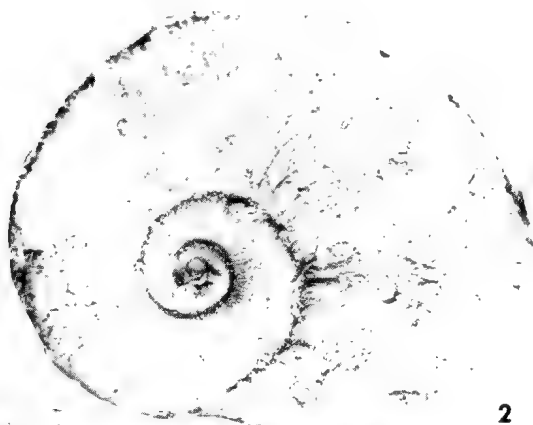


Figure 1—A plot of shell width on the abscissa versus the width of the umbilicus divided by the depth of the umbilicus, a sensitive measure of the degree of hyperstrophicity. Note that in the larger individuals the cloud of points divides into two groups of about equal numbers. This is considered as strong evidence in favour of sexual dimorphism.

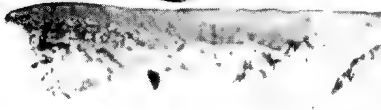




1



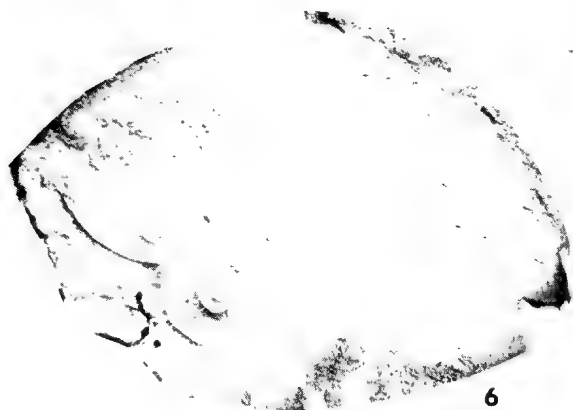
2



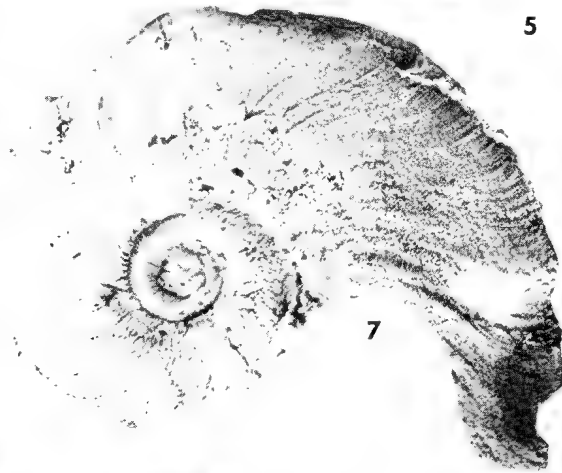
3



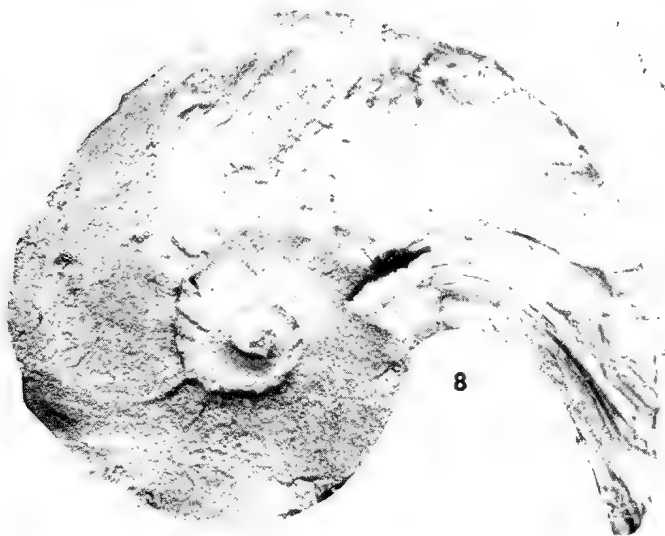
4



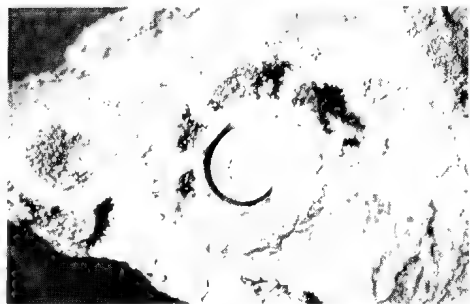
6



7

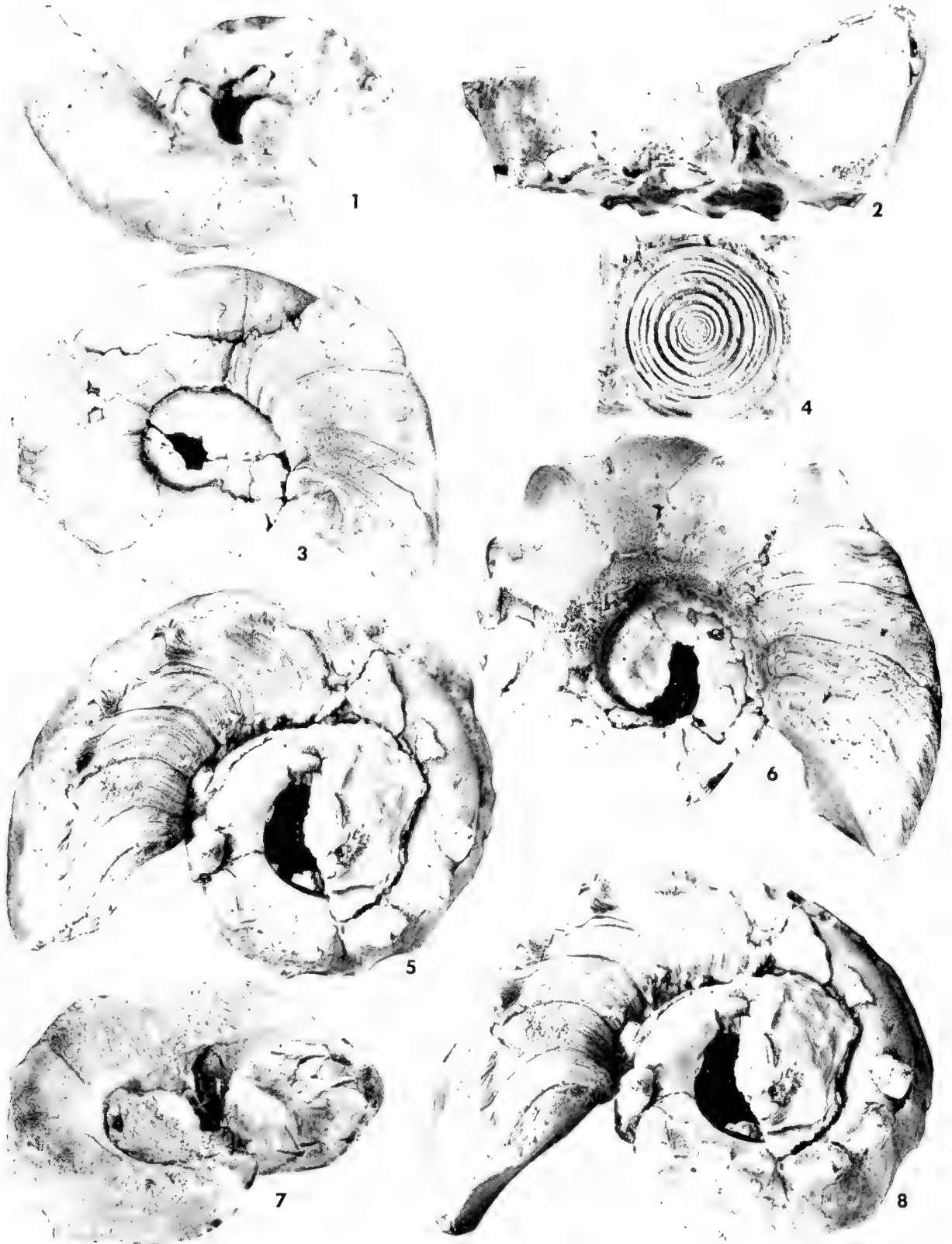


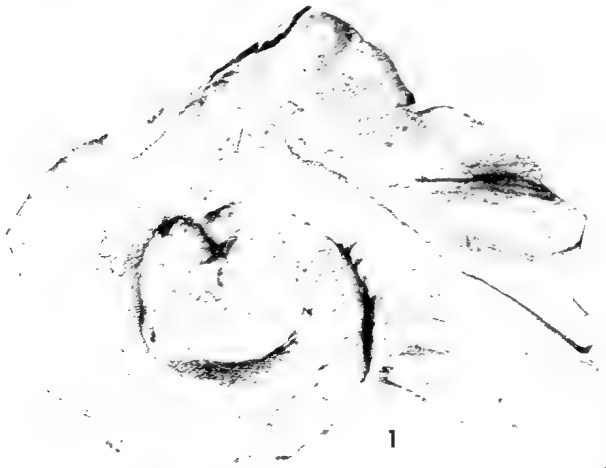
8



9







1



2



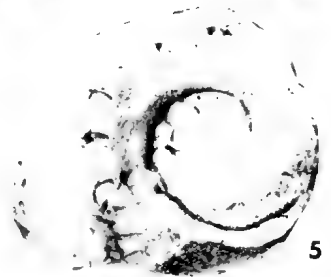
3



4



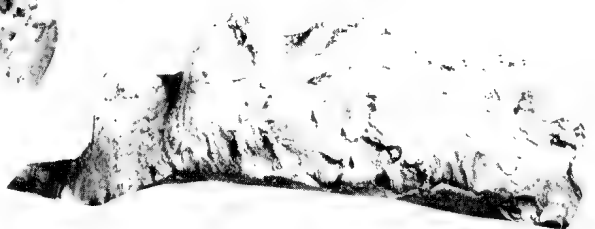
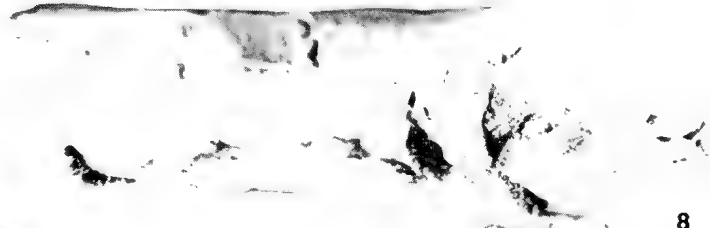
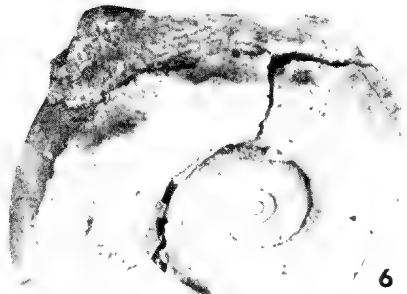
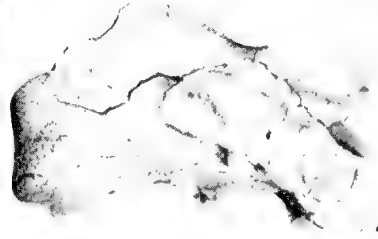
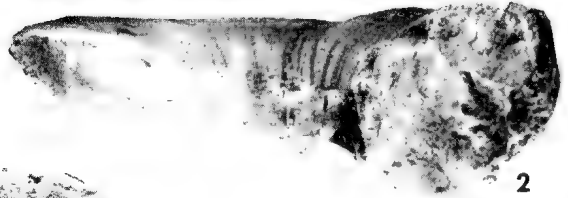
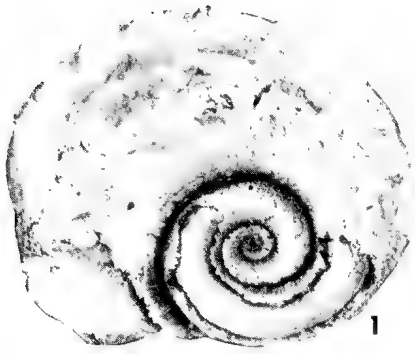
6



5

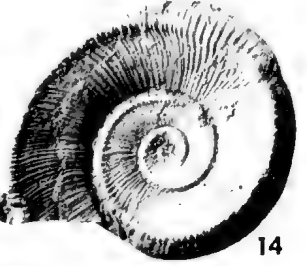
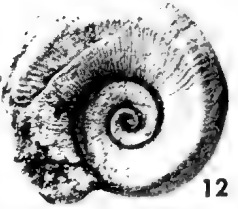
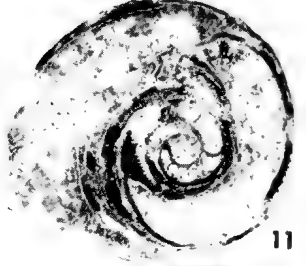
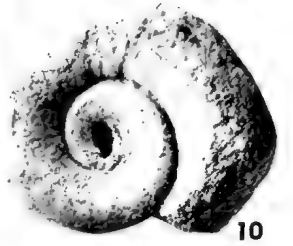
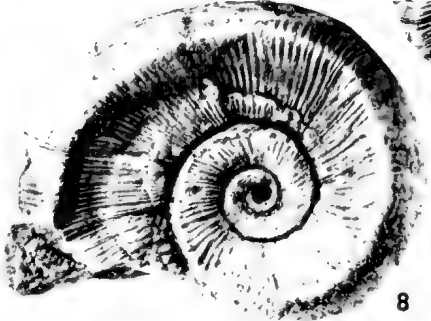
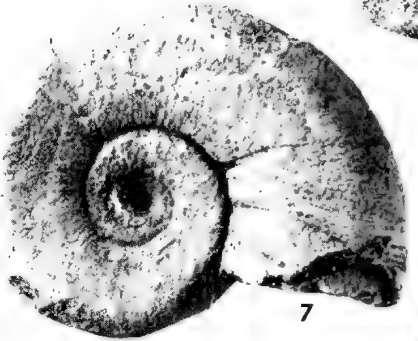
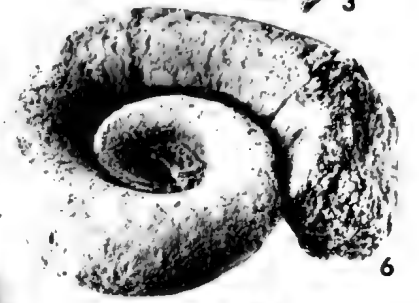
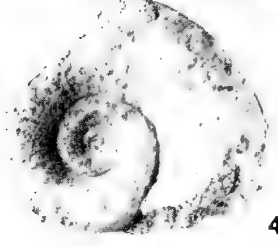
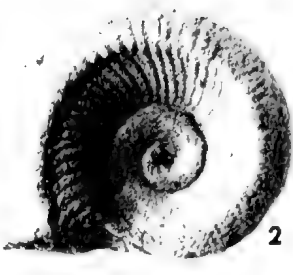


7

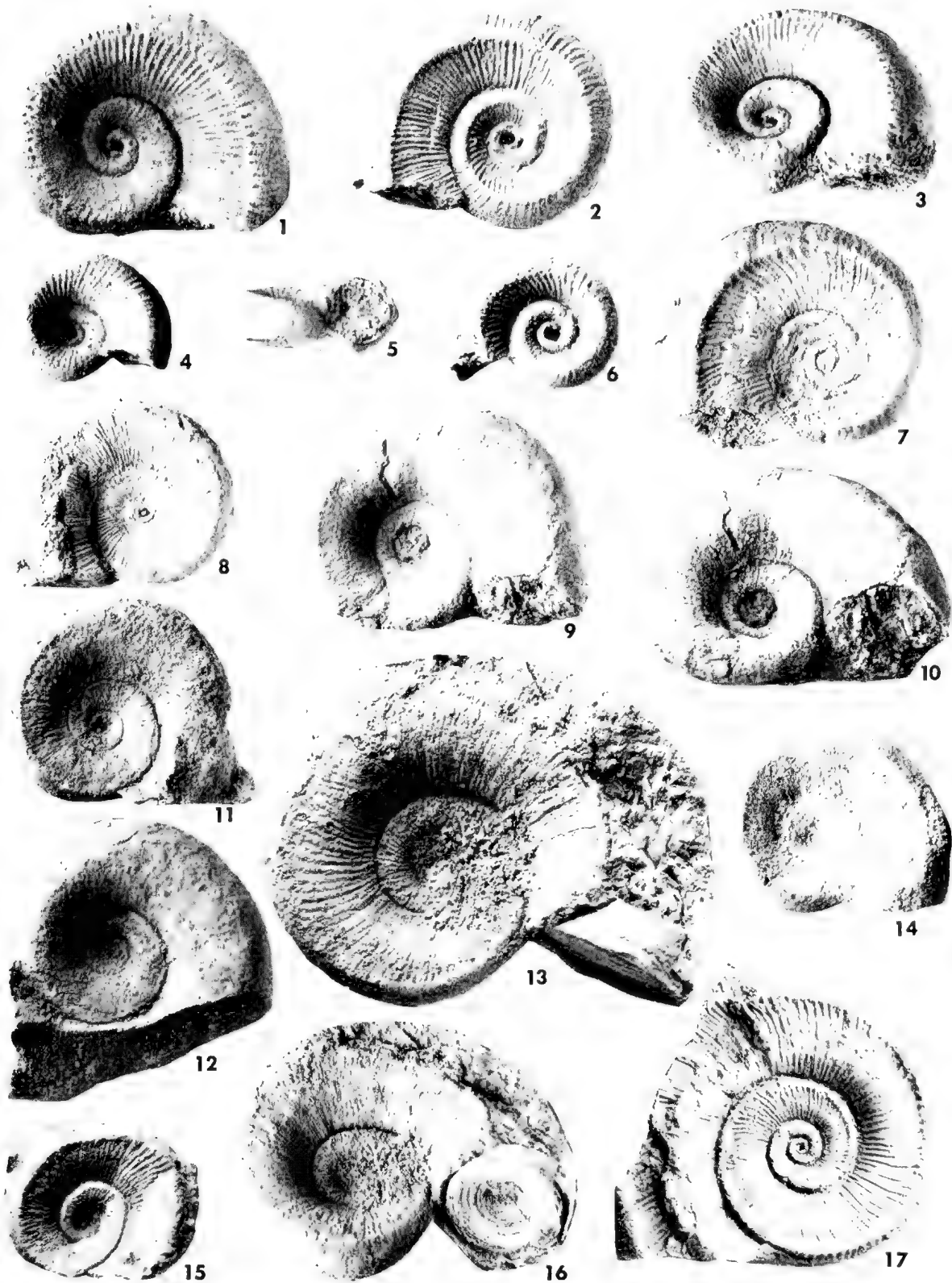














PROPLEOPUS CHILLAGOENSIS, A NEW NORTH QUEENSLAND  
SPECIES OF EXTINCT GIANT RAT-KANGAROO  
(MACROPODIDAE: POTOROINAE)

By MICHAEL ARCHER,\* ALAN BARTHOLOMAI\* and  
LARRY G. MARSHALL†

\* Queensland Museum

† Princeton University

**Abstract**

*Propleopus chillagoensis* is described as a second species in the genus. The genus is rediagnosed. The new species differs markedly in details of premolar and molar morphology from the Pleistocene *P. oscillans* (De Vis), but reveals no additional information about intergeneric relationships. In the unique characters which differentiate it from *P. oscillans*, it is less like structurally ancestral forms such as *Hypsiprymnodon* than is *P. oscillans*, and could be a descendent of the lineage leading to *P. oscillans*. A specimen of *Propleopus* from the Pleistocene Wellington Caves is similar to *P. chillagoensis*, and suggests the possibility that the two species, or lineages leading to them, were contemporaneous during part of the Pleistocene, and probably represent end members of a late Tertiary radiation.

**Introduction**

*Propleopus oscillans* was described on the basis of a single dentary fragment by De Vis (1888). Since then a lower incisor and two additional dentary fragments have been reported (Woods, 1960 and Tedford, 1955), as well as a maxillary fragment (Bartholomai, 1972). All of this Pleistocene material has been referred to *P. oscillans* with little hesitation.

Gill (1953, 1957) described a tooth from the Pliocene Grange Burn local fauna which Ride (1964) and Turnbull and Lundelius (1970) regard as similar to but smaller than *P. oscillans*.

The present material, comprising a maxillary fragment and two isolated premolars represents a second very distinct species. The existence of at least two distinct forms of *Propleopus* in the Pleistocene indicates that there was probably a late Tertiary radiation of the genus.

Registration numbers are those of the Queensland Museum (e.g. F6675, fossil collection; e.g. J6824, modern mammal collection), the National Museum of Victoria (e.g. P15917), the American Museum of Natural History (e.g. AMNH 65279) and Museum of Palaeontology, University of California (e.g. UCMP 51697).

Dental terminology follows that used elsewhere by Archer (1974, 1976). An alternative

nomenclature for individual premolar teeth, as used elsewhere (e.g. by Bartholomai, 1972), is not used here, but not because it has been shown to be any less appropriate than the system used by Archer (1974) and some other authors (e.g. Mahoney and Ride, 1975).

*Rediagnosis of Propleopus Longman, 1924*

Recognition of a second species broadens the concept of *Propleopus* as follows: Potoroine macropodids differing from other potoroine genera in unique extent of subhorizontal wear facet on I<sub>1</sub>; also differ from *Hypsiprymnodon* in having enamel on I<sub>1</sub> covering only lower half of labial and lingual faces; posterior half of P<sub>4</sub> shorter crowned; M<sub>1</sub> trigonid wide; differing from *Caloprymnus* and *Potorous* in distribution of enamel of I<sub>1</sub>, larger more finely serrated and arcuate plagiaulacoid premolars, in having a vestigial tooth immediately posterior to I<sub>1</sub>, and in having lingual cingula (sometimes as rudiments) on upper molars; differing from *Aepyprymnus* in having more arcuate plagiaulacoid premolars, poorly-developed lingual cusp or crest development on P<sup>4</sup>, wider molars, poorly-developed transverse lophs on molars; vestigial tooth immediately posterior to I<sub>1</sub>, obliquely set plagiaulacoid premolars, and lingual cingula (sometimes rudiments) on upper molars; also differing from *Bettongia* in having more arcu-

ate, mesially swollen plagiulacoid premolars with narrow posterior ends on permanent premolars, and a vestigial tooth immediately posterior to  $I_1$ .

***Propleopus chillagoensis* sp. nov.**

(Plate 11, fig. 1)

*Holotype*: P15917, right maxillary fragment with erupting  $P^4$  and erupting and broken  $M^4$ , fragment of  $M^1$ , and  $M^{2-3}$ , donated by Mr Hugh C. Mainwaring in 1910.

*Referred Material*: P15918, isolated  $LP_4$ ; P15919, isolated and broken  $RP^4$ ; both from type locality.

*Type Locality*: Fissure deposit in Chillagoe Formation, Chillagoe District, N.E. Queensland. According to a letter (National Museum of Victoria) from Mr Hugh C. Mainwaring to Professor Baldwin Spencer, 21 July 1910, the specimens came from '... a bluff 800 ft. long, 300 ft. wide and 50 ft. above the plain of the surrounding country. This bluff is being worked [1908-11] as a quarry to supply the smelter with flux. In breaking down the stone a number of small caves were found. These were fitted with material resembling silicified clay in which the fossils were imbedded'. Mr William Morrow (pers. comm.) notes that the locality was 'Smelter's Junction, one mile from Chillagoe Railway Station, along the Mungana line, on the left hand side on the way to Mungana.'

*Origin of Name*: Reference to type locality.

*Diagnosis*: Differs from the only other species in the genus, *Propleopus oscillans*, in having a markedly larger  $P^4$  and  $P_4$ , each with nine vertical ribs; anterior ribs on  $P_4$  are rectilinear rather than curved;  $P_4$  crown base more steeply inclined posteriorly; upper molars shorter, with more swollen bases; lingual cingulum around base of protocone on at least  $M^{2-3}$ ; preprotocrista connects directly with preparacrista; posterior half of upper molar crowns markedly narrower than anterior half.

*Description*:  $P^4$ : Two-rooted tooth; occlusal outline oval, widest at anterior one-half; anterior end gently convex, posterior end blunt. Occlusal cutting edge gently convex, ventrally with maximum convexity occurring towards posterior one-half of edge. Anterior edge of tooth has curved, labially convex, vertical crest

confluent with occlusal cutting crest of tooth. Posterior to this anterior crest are eight pairs (lingual and labial) of prominent vertical ridges which reach the occlusal edge of tooth. Ninth pair fails to extend as far as occlusal edge. Longitudinal spacing between ridges decreases posteriorly. Bases of second pair of ridges bifurcated. Bases of eighth and ninth buccal ridges confluent. Ninth ridges more massive than others and form shallow vertical fossettes between themselves and eighth ridges. Relative ridge lengths as follows 3 subequal to 4, 2 subequal to 5, 6, 7, 8, 9. Eighth ridge interrupted by gap on each side. Base of crown lacks cingula. Judging by position of erupting crown,  $P^4$  probably oriented antero-labially, with respect to long axis of molar row.

$P_4$ : Identical to  $P^4$  except as follows: Posterior edge of crown keeled with non-serrated vertical continuation of occlusal cutting crest; widest part of crown closer to middle of tooth; ninth ridges less massive than corresponding ridge in  $P^4$ ; base of second ridge not bifurcated; base of second and third lingual ridges confluent.

$M^1$ : Crown represented by only posterior one-third. Roots indicate anterior one-half of tooth much wider than posterior one-half, and that lingual one-half of tooth longer than labial one-half, result of evidently very large protocone. Remnant of posthypocrista and postmetacrista linked in arc, middle of which functions as a posterior cingulum. Base of crown very swollen, such that transverse diameter of crown base below hypocene and metacone estimated at three times distance between those cusps.

$M^2$ : Anterior one-half of crown wider than posterior one-half. Lingual and labial sides of crown subequal in length. Protocone, hypocone and paracone subequal in height, and taller than metacone. Preprotocrista and preparacrista connect as an anteriorly convex arc. Postmetacrista and posthypocrista joined as in  $M^1$ . Prehypocrista and postprotocrista linked in barely obtuse angle. Postparacrista and premetacrista become irregular towards middle of crown, and are only just linked by low longitudinal crest. Prominent, transverse lingual

ridges descend flanks of paracone and metacone from longitudinal midline of crown. Poorly-defined transverse labial ridge descends flank of hypocone and meets lingual rib of metacone in longitudinal midvalley. Very poorly-defined anterolingually directed labial ridge descends protocone, but intersects the preprotocrista anterior to the protocone. Labial to point of intersection of postparacrista and premetacrista are two small adjacent cusps along labial end of transverse midline. Prominent lingual anterolingually inclined ridge ascends flank of hypocone to base of protocone, adjacent to small basal lingual cuspule, which in turn is adjacent to lingual end of anterolingual basal cingulum which terminates labially at point where  $M^1$  abuts against  $M^2$ . Very small cingular bulge occurs on posterolingual base of hypocone.

$M^3$ : Anterior one-half of tooth much wider than posterior one-half. Lingual one-half subequal in length to labial one-half. Protocone subequal in height to hypocone, all other than paracone, and much taller than reduced metacone. Prehypocrista, postprotocrista, preprotocrista and preparacrista linked in  $M^2$ . Posthypocrista does not contact vestigial postmetacrista, being separated by posterolabial depression. Poorly developed premetacrista and postparacrista only just fail to contact in transverse midvalley of tooth. Prominent lingual rib descends paracone in posterolabial direction from longitudinal midline of crown. Much more poorly developed lingual and labial ridges descend flanks of metacone and hypocone but just may not meet each other in longitudinal midvalley. Poorly-developed labial ridge descends protocone in same manner as in  $M^2$ . Prominent lingual rib ascends flank of hypocone to base of protocone. Vertical lingual ridge, also descends from base of protocone to point halfway down its flank. Base of this ridge vaguely contacts oblique lingual hypocone ridge and anterolingual basal cingulum on anterior flank of protocone. Anterolingual cingulum terminates labially just short of point at which  $M_2$  abuts  $M_3$ . Poorly-developed (but better than  $M^2$ ) posterior cingulum descends from posterior

flank of hypocone to posthypocrista near its labial end.  $M^3$  less worn than  $M^2$  and reveals fine crenulations over much of crown surface enclosed by principal cusps. Also evidence of accessory vertical crenulations parallel to labial ridges of protocone and hypocone, and connecting posthypocrista with longitudinal midvalley of crown.

$M^4$ : Only anterior one-half of crown remains. From remnant of base of posterior one-half, evident that anterior one-half wider than posterior one-half. Protocone taller than paracone. Preprotocrista connected to preparacrista as in  $M^3$ . Postparacrista not connected to premetacrista. Lingual ridge of paracone prominent and extends transversely to longitudinal midvalley to meet labial ridge of protocone. Some evidence for lingual protocone ridge as in  $M^3$ . Tooth erupting so anterior cingulum not visible, if present. Edge of enamel near posterior base of protocone suggests lingual hypocone ridge present as in  $M^3$ . Very poorly-developed vertical ridge occurs on anterolabial flank of paracone linking preparacrista with base of crown. As in  $M^3$ , clear indications of accessory crenulations occur in crown valleys and on flanks of cusps.

Meristic changes along tooth row: Posteriorly, teeth become relatively narrower and longer; metacone markedly reduces in size; paracone reduces in size but at a slower rate; crests linking metacone to other crests become smaller; transverse midvalley of crown becomes more open at labial end; bases of protocone and hypocone become less swollen; distance between hypocone and metacone diminishes. Tooth eruption sequence indicated suggests  $P^4$  and  $M^4$  erupt at approximately the same time.

*Discussion:* The type specimen of *Propleopus oscillans* is a dentary while that of *P. chillagoensis* is a maxillary fragment. A possibility therefore exists that both specimens represent *P. oscillans*. We have considered this possibility and discounted it for the following reasons. First, Bartholomai (1972) has described F6675 from the Darling Downs, a maxillary fragment with  $LP^4$ - $M^2$ , and referred it to *P. oscillans*. It is specifically distinct from the

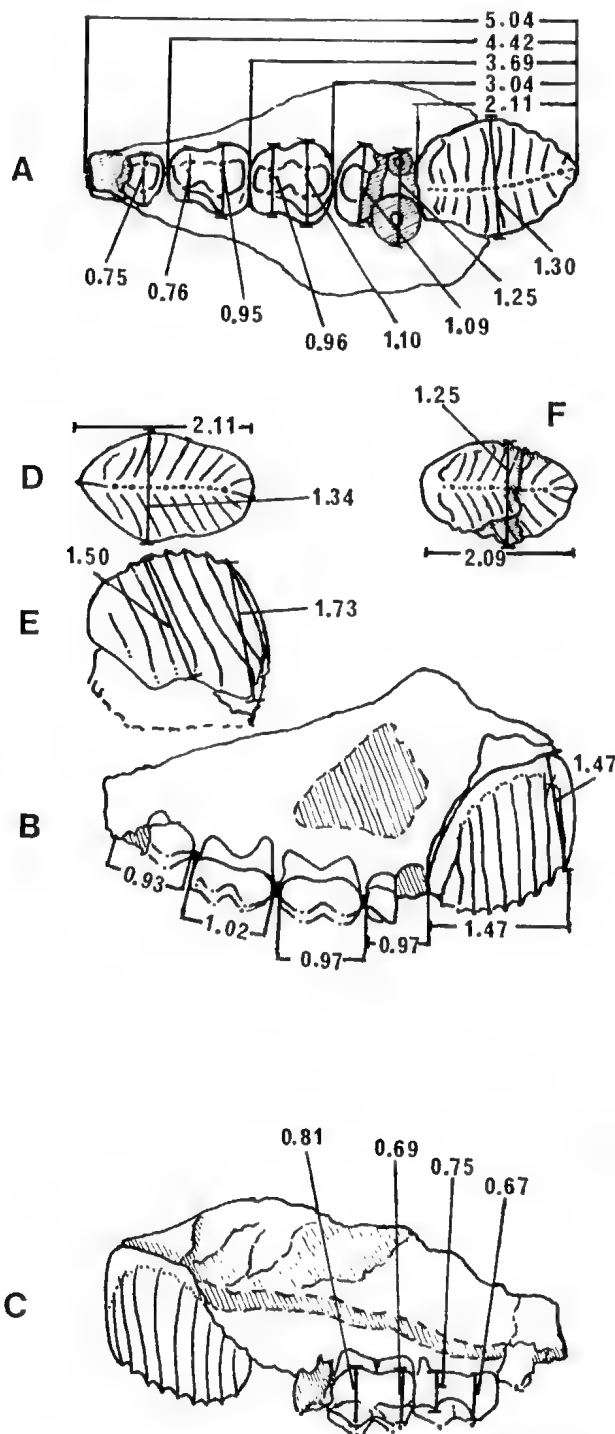


Figure 1—Measurements of specimens of *Propleopus chillagoensis* sp. nov. A-C, P15917, holotype. D-E, P15918, LP<sub>4</sub>. F, P15919, RP<sub>4</sub>. Measurements are in centimetres.

Chillago maxillary fragment, for reasons noted in the diagnosis. In addition, although P<sup>4</sup> of the type of *P. chillagoensis* is larger than P<sup>4</sup> of F6675, its molars are proportionately smaller. For this reason, the size differences in the two maxilla cannot be the result of allometry.

Additional evidence for reference of F6675 to *Propleopus oscillans* comes from the number of ridges on upper and lower adult premolars of living potorines. In modern *Aepyprymnus rufescens*, of twenty-three specimens examined with relatively unworn premolars, nine have the same number of ridges (seven or eight) on the upper and lower premolars, while the remainder differ by only one ridge. Variation in ridge number is as follows: P<sup>2</sup>: one has seven ridges; thirteen have eight; and eight have nine; P<sub>4</sub>: three have seven ridges; thirteen have eight; and three have nine. In *Hypsiprimnodon moschatus*, of all ten specimens with relatively unworn adult premolars, P<sup>2</sup> has six and P<sup>4</sup> seven ridges. Both upper and the single lower premolars of *P. chillagoensis* have nine ridges, while the P<sub>4</sub> of the holotype of *P. oscillans* and P<sup>4</sup> of the referred specimen both appear to have seven ridges. The constancy of ridge number in *Hypsiprimnodon*, the consistently different ridge number in *P. chillagoensis* from the holotype of *P. oscillans*, and the apparently close relationship of *Propleopus* to *Hypsiprimnodon* (see below) which has a species constant number of ridges, convince us of the correctness of Bartholomai's (1972) reference of F6675 to *P. oscillans*. Added to the other morphological characters noted in the diagnosis, it also convinces us of the distinction between the two species of *Propleopus*.

Further, but less convincing evidence for the association suggested by Bartholomai (1972), is the fact that both the holotype of *P. oscillans* and F6675 come from the Darling Downs of southeastern Queensland, while the specimens of *P. chillagoensis* come from far northeastern Queensland.

These data, as well as the close approximation of upper and lower molar sizes, support Bartholomai's (1972) reference of F6675 to *Propleopus oscillans* and convince us that the

Chillagoe material with its nine vertical ridges, and relatively short and wide premolars cannot be referred to *P. oscillans*.

Most authors who have considered the affinities of *Propleopus oscillans* regard it to be closely related to *Hypsiprymnodon*, a conclusion with which we generally agree, although some characters more closely resemble *Bettongia* than *Hypsiprymnodon*. *P. chillagoensis* reveals no characters that more closely ally it with *Hypsiprymnodon* or *Bettongia* than with *P. oscillans*. The characters which differentiate it from *P. oscillans* are unique derived characters and are of neutral value in assessing intergeneric relationships. Because *P. oscillans* retains more structurally primitive character states (i.e. fewer ridges on P<sup>4</sup>, relatively unswollen molars, poorly-developed lingual cingula, and unreduced metacones on the upper molars), and has no derived characters of its own which are not also present in *P. chillagoensis* and hence diagnostic of the genus as a whole, it can be regarded as structurally, if not actually ancestral to *P. chillagoensis*.

The precise age of the eastern Darling Downs specimens within the Pleistocene is in doubt. Similarly, the age of the Chillagoe specimens is in doubt but the presence of *Sarcophilus*, suggests that the Chillagoe deposit is no older than Pleistocene (Bartholomai and Marshall, 1973). Tedford (1967) mentions that the material described here as *P. chillagoensis* is associated with *Sarcophilus* and small macropodines apparently related to living species.

The *Propleopus* specimen (UCMP 45171) figured by Tedford (1967, fig. 5b) as *P. oscillans* from Pleistocene deposits in Wellington Caves, New South Wales, although only a fragmentary dentary lacking P<sub>4</sub>, shows in some respects, the kinds of characters which might be expected in lower molars of *P. chillagoensis*. Compared with *P. oscillans*, the anterior half of M<sub>1</sub> is relatively wider, the molars are somewhat shorter, and most importantly, the talonid of M<sub>4</sub> is narrower as noted by Tedford (1967) and its entoconid is more reduced. The entoconid is the occlusal counterpart of the metacone in the upper molars. Reduction

of one is likely to be reflected by reduction of the other. Its taxonomic position is considered as doubtful until better material becomes available.

Tedford (1967) concludes that the late Pleistocene, Lake Menindee, New South Wales specimen (UCMP51697) of *Propleopus* is referable to *P. oscillans*, a conclusion with which we agree. A second tooth fragment from Menindee (UCMP51698) was compared by Tedford (1967) with the Chillagoe material. It is likely that this specimen is also referable to *P. oscillans*.

These occurrences suggest the possibility that the lineages resulting in *Propleopus oscillans* and *P. chillagoensis* may have been contemporaneous during the Pleistocene and represent parts of a late Tertiary radiation of the genus.

#### Acknowledgements

We thank Dr T. Rich (National Museum of Victoria) for making the Chillagoe specimens available to us. The late Professor R. A. Stirton provided the Queensland Museum with a cast (F3287) of the Wellington Caves specimen. Mr A. Easton and Mr R. Burgess (Queensland Museum) produced the photographs for the plate. Ms J. Utz and Ms R. Owens (Queensland Museum) typed drafts of the paper. Mr S. Van Dyke (Queensland Museum) assisted in study of premolar ridge numbers in modern potorines.

#### References

- ARCHER, M., 1974. The development of the cheek-teeth in *Antechinus flavipes* (Marsupialia, Dasyuridae). *J. R. Soc. West. Aust.* 57: 54-63.
- , 1976. Phascolarctid origins and the potential of the selenodont molar in the evolution of diprotodont marsupials. *Mem. Qd Mus.* 17: 367-71.
- BARTHOLOMAI, A., 1972. Some upper cheek teeth in *Propleopus oscillans* (De Vis). *Mem. Qd Mus.* 16: 211-213.
- , in press. The fossil vertebrate fauna from Pleistocene deposits at Cement Mills, Gore, south-eastern Queensland. *Mem. Qd Mus.* 18.
- BARTHOLOMAI, A., and L. G. MARSHALL, 1973. The identity of the supposed dasyurid marsupial, *Sarcophilus prior* De Vis, 1883, with comments on other reported 'Pliocene' occurrences of *Sarcophilus*. *Mem. Qd Mus.* 16: 369-374.

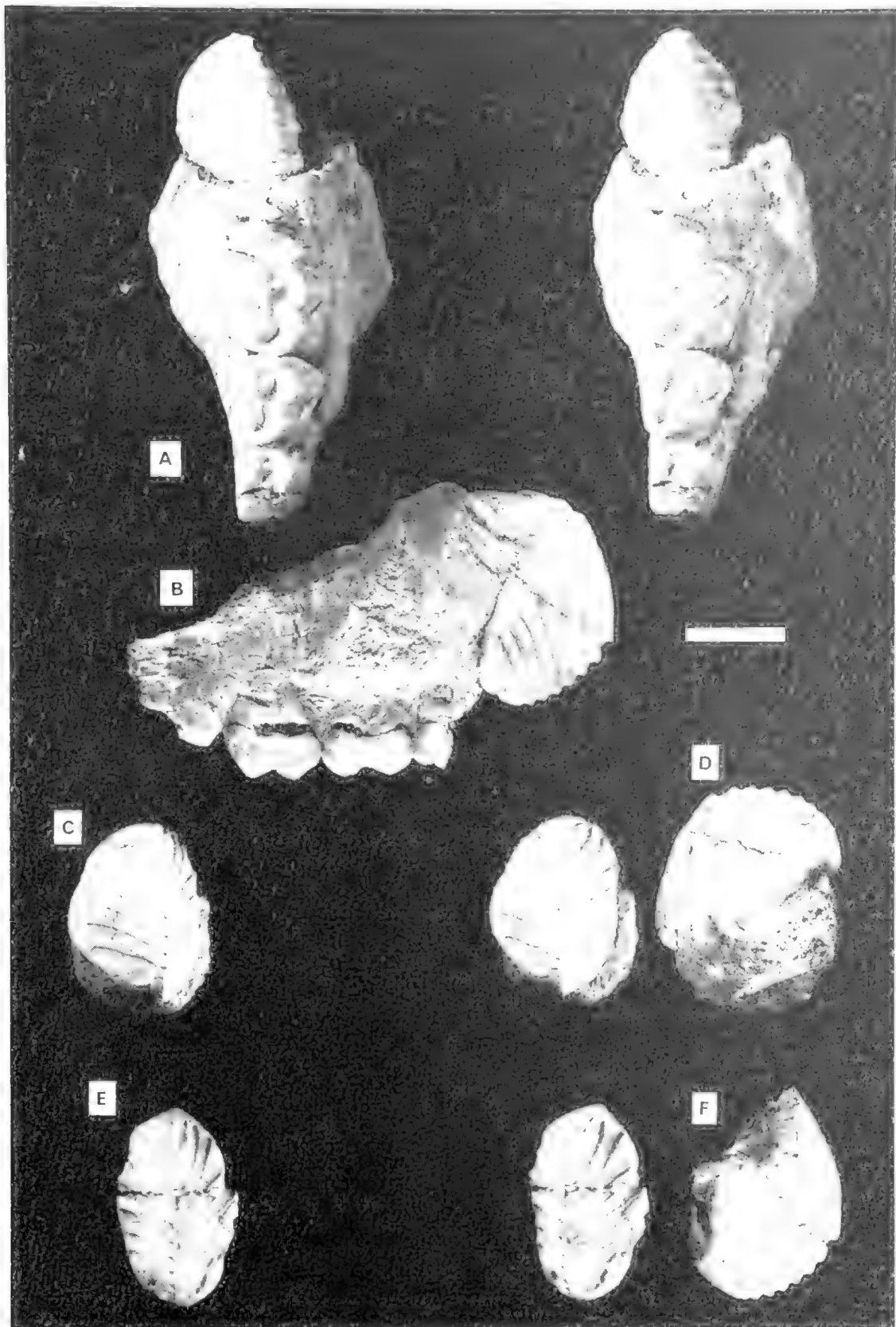
- DE VIS, C. W., 1888. On an extinct genus of the marsupials allied to *Hypsiprymnodon*. *Proc. Linn. Soc. N.S.W.* 3: 5-8.
- GILL, E., 1953. Australian Tertiary marsupials. *Aust. J. Sci.* 16: 106-108.
- , 1957. The stratigraphical occurrence and palaeoecology of some Australian Tertiary marsupials. *Mem. Nat. Mus. Vic.* 21: 135-203.
- MAHONEY, J. A. and W. D. L. RIDE, 1975. Index to the genera and species of fossil Mammalia described from Australia and New Guinea between 1838 and 1968. *Spec. Publs. West. Aust. Mus.* 6: 1-250.
- RIDE, W. D. L., 1964. A review of Australian fossil marsupials. *J. R. Soc. West. Aust.* 47: 97-131.
- TEDFORD, R. H., 1955. Report on the extinct mammalian remains at Lake Menindee, New South Wales. *Rec. S. Aust. Mus.*, 11: 299-305.
- , 1967. The fossil Macropodidae from Lake Menindee, New South Wales. *Univ. Calif. Publ. Geol. Sci.*, 64: 1-156.
- TURNBULL, W. D., and E. LUNDELIUS, Jnr., 1970. The Hamilton fauna—a late Pliocene mammalian fauna from the Grange Burn, Victoria, Australia. *Fieldiana (Geology)* 19: 5-84.
- WOODS, J. T., 1960. The genera *Propleopus* and *Hypsiprymnodon* and their position in the Macropodidae. *Mem. Qd Mus.* 13: 199-212.

### Explanation of Plate

#### PLATE 11

*Propleopus chillagoensis* sp. nov. A, stereopair, occlusal view, P15917, holotype, RP<sup>4</sup>-M<sup>4</sup>. B, labial view, P15917, holotype. C, stereopair, occlusal view, P15918, LP<sub>4</sub>. D, labial view, P15918, E, stereopair, occlusal view, P15919, RP<sup>4</sup>. F, labial view, P15919. White line is one cm in length.







DETAILED COMPARISONS OF THE DENTITIONS OF EXTANT  
HEXANCHID SHARKS AND TERTIARY HEXANCHID TEETH  
FROM SOUTH AUSTRALIA AND VICTORIA,  
AUSTRALIA (SELACHII: HEXANCHIDAE)

BY NOEL R. KEMP

Tasmanian Museum, G.P.O. Box 1164M, Hobart, 7001, Australia

**Abstract**

In extant hexanchid sharks except for (usually) a bigger primary cusp, isolated teeth of a given size of the smaller species *Hexanchus vitulus* (Springer and Waller) may be confused with those of *H. griseus* (Bonnaterre). This specific size difference has significance in the fossil record. *Heptranchias perlo* (Bonn.) differs in its more slender and relatively larger primary cusp with basal denticles (not serrations as in *Hexanchus*) on its mesial margin and fewer crownlets increasing and then decreasing in size distally. *Notorynchus cepedianus* (Péron) differs mainly in its more robust primary cusp and crownlets which are fewer in number than in *Hexanchus* and which decrease evenly in size distally, like *Hexanchus*. Californian specimens of *Notorynchus* are included in the monotypic *N. cepedianus* until the taxonomic significance of the variability of the upper medial teeth is established and defined. *N. cepedianus* is recorded from the fossil record for the first time. *Heptranchias haswelli* Ogilby is regarded as a *species inquirenda*. *Hexanchus agassizi* Cappetta is expanded to include the Eocene *Hexanchus* teeth from South Australia. *Heptranchias howellii* (Reed) from the South Australian Eocene and *Notorynchus primigenius* (Agassiz) from the Victorian Miocene are recorded and described from Australia for the first time.

**Introduction**

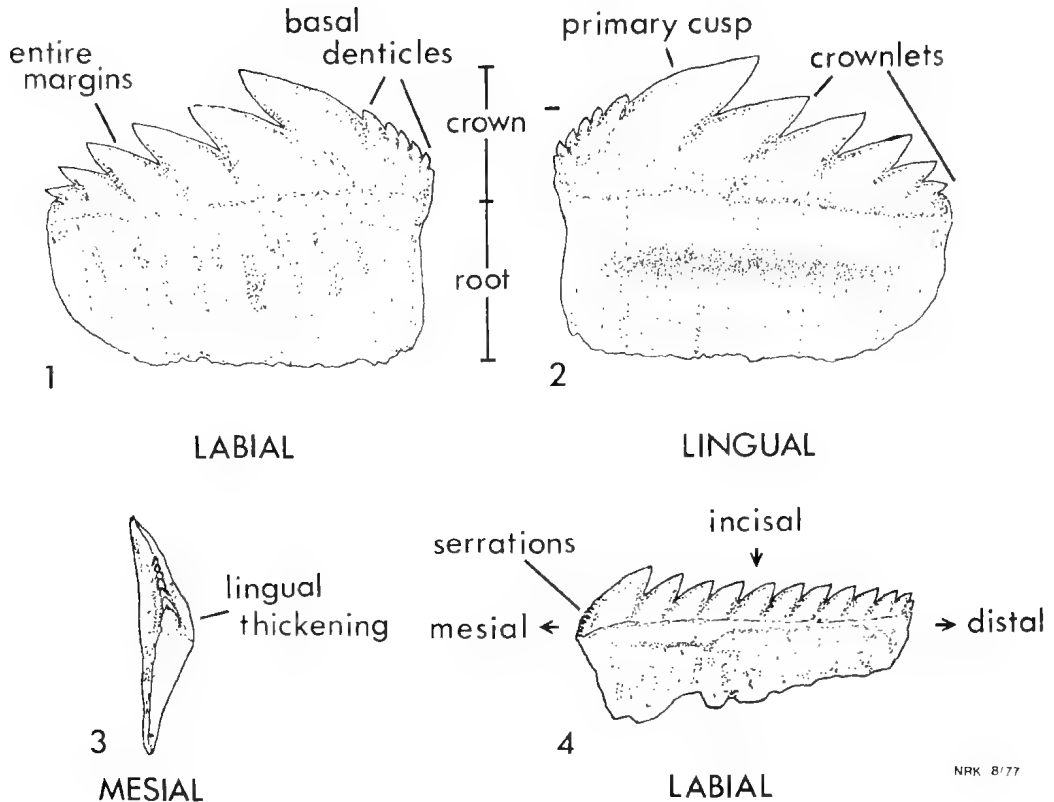
The sixgill and sevengill sharks of the family Hexanchidae, although a relatively small group, are well represented in the fossil record, especially outside Australia, for example Woodward (1886), Jordan (1907), Leriche (1910, 1927, 1957) and are common in modern seas, for example Garman (1913), Bigelow and Schroeder (1948), Whitley (1968), Bass, D'Aubrey and Kistnasamy (1975). Taxonomically, however, they are not a stable group (see below).

Less than a dozen fossil hexanchid teeth have been described from the Australian fossil record (Pledge, 1967; Kemp, 1970). Three teeth and several fragments from the Eocene of South Australia were assigned by Pledge (1967) to '*Notidanus* *serratissimus* Ag., '*N*' cf. *serratissimus* and '*N*? *serritissimus*. The three fragments from the Miocene of Victoria were described by Kemp (1970) as *Notorynchus* cf. *primigenius*. In light of recent publications (Welton, 1974; Cappetta, 1976) and with the recovery of further specimens from the South Australian Eocene during the last decade, the present study shows that the three extant genera are represented in the South Australian and Victorian Tertiary material.

Compagno (1973) lists two families in the suborder Hexanchoidei: Hexanchidae, with two genera, *Hexanchus* and *Notorynchus* and Heptranchidae with the monotypic genus *Heptranchias*. He based this separation of *Heptranchias* into its own family on a suggestion by Dr Shelton P. Applegate 'because of many differences in cranial and external morphology between it and the other hexanchoids (*Hexanchus* and *Notorynchus*)' (Compagno, 1973:33). Recently Bass *et al.* (1975) suggest that more detailed anatomical studies of the six- and sevengill sharks may show that the smaller species of *Hexanchus*, *H. vitulus*, may have more in common with *Heptranchias perlo* than with the larger species, *Hexanchus griseus*. *H. griseus*, on the other hand, may have more in common with *Notorynchus cepedianus*. Until these suggestions are confirmed or repudiated by further detailed work the suprageneric classification adopted here is that of Patterson (1967).

**Terminology**

The tooth types medials, laterals and posteriors are used in the sense of Applegate (1965a). The faces of a tooth are termed labial and lingual and the margins mesial and



Figures 1-4—Terminology.

1-3. *Notorynchus cepedianus* (Péron), lower right second lateral tooth (Figs. 1, 2, x2; Fig. 3, x1.5).

4. *Hexanchus agassizi* Cappetta, lower left lateral of about fourth, fifth or sixth row (x1.5).

distal as defined by Hoojier (1954). In the cockscomb-like dentition of the hexanchids the larger primary cusp is followed by a number of crownlets (Applegate, 1965b). The mesial margin of the primary cusp may be serrated, or, if the serrations are relatively large, they are termed basal denticles. A character of the family is the presence of one series of functional teeth in both jaws except for the upper medials which have two or three and the posteriors of both jaws which have two to four functional series. The description of dentition of *Hexanchus griseus* is given in detail as a datum for the diagnoses of the other species.

#### Abbreviations

The following abbreviations are used: AMS, Australian Museum, Sydney; AUGD, University of Adelaide, Department of Geology; CM, Canterbury Museum, Christchurch, New Zealand; MUGD, University of Melbourne, Department of Geology; NMV, National Museum of Victoria, Melbourne; NZNM, National Museum of New Zealand, Wellington; RJFJ, private collection of Dr R. J. F. Jenkins, South Australia; SAMD, South Australian Department of Mines; SAM, South Australian Museum, Adelaide; TFF, private collection of Mr T. F. Flannery, Beaumaris, Victoria; USNM, United States National Museum, Washington.

#### Systematics

Order    HEXANCHIFORMES  
Suborder   HEXANCHOIDEI  
Family    HEXANCHIDAE

The Hexanchidae are characterized by six or seven gill-openings and heterodont denti-

tion, that is the teeth are of dissimilar shape both within and between the two jaws. Except for another two families all other sharks have only five gill openings.

The Chlamydoselachidae, or frill shark, of which only one specimen has been recorded from Australian waters, in 1976 (J. R. Paxton, pers. comm.), has a terminal mouth compared with the subterminal mouth of all other sharks and six gill openings with the first opening continuous across the throat. The remaining five openings are interrupted on the ventral surface. The dentition of *Chlamydoselachus*, the single genus of the family, is homeodont, that is all the teeth are of similar shape both within and between the two jaws.

The Pristiophoridae, or saw sharks, has a sixgill genus, *Pliotrema*, which has yet to be found in Australian waters. It is easily separated from the sixgill hexanchid species by its two dorsal fins, rostral snout with barbells and marginal teeth, homeodont dentition and no anal fin. The hexanchids have only one dorsal fin, no rostral snout and possess an anal fin.

#### Main characters

One dorsal fin, always posterior to pelvics; anal fin present; caudal fin with a definite lobe and well marked subterminal notch; pre-caudal pit absent; six or seven gill-openings not connected ventrally, last gill opening in front of and extending below pectoral origin; spiracle present but small; nictitating membrane absent; upper labial furrow absent, lower labial furrow present, developed to varying degrees.

Dentition heterodont: upper jaw, teeth with slender primary cusp and a variable number of small crownlets; small medial tooth present or absent; lower jaw, teeth basically trapezoidal in outline and multicusped; small medial tooth present. Small undifferentiated posterior teeth present in both jaws.

As all species of hexanchids possess a similar pavement-like dentition formed by the posteriors in both jaws and as they are rarely recognized in the fossil record, teeth of this type are omitted in the following descriptions and diagnoses.

#### Genera

Rafinesque (1810) erected two genera, *Hexanchus* and *Heptranchias*, based on six- and seven-gill sharks respectively. Cuvier (1817, *vide* Bigelow and Schroeder, 1948) included both of these genera in his new genus *Notidanus*. This genus also came to include another seven-gill shark, *Notorynchus*, both before and after Ayres (1855) described it as a new genus. Subsequent studies showed that the three genera of Rafinesque and Ayres were valid and Cuvier's *Notidanus* has not been used for extant sharks for more than half a century. Palaeontologists have until recently used *Notidanus* as an encompassing genus, for example Leriche (1957), Casier (1966), Cappetta *et al.* (1967) (*vide* Cappetta 1970), Pledge (1967), as it was widely held that separation of the genera of hexanchids was only possible on the basis of the anatomy of their soft parts. A number of authors, however (Applegate 1965b; Waldman 1970; Welton 1974; Cappetta 1975) have noted some of the salient dental differences, mainly in the lower lateral teeth, between these three genera. Antunes and Jonet (1969), in describing Miocene teeth from Portugal, include in the family Hexanchidae only two genera, *Hexanchus* Rafinesque and *Heptranchias* Rafinesque. They include *Notorynchus* Ayres in the latter genus but give no reason for this.

As set out in the key below the sixgill genus is readily separated from the two seven-gill genera which differ from each other in the shape and size of their snouts. The descriptions under each genus further differentiates them on their dental characteristics.

#### KEY TO LIVING GENERA

(After Bigelow and Schroeder, 1948).

- 1A Six gill-openings . . . . . *Hexanchus*
- 1B Seven gill-openings . . . . . 2
- 2A Head narrow; snout tapering; horizontal diameter of eye considerably greater than distance between nostrils . . . . . *Heptranchias*
- 2B Head broad; snout broadly rounded; horizontal diameter of eye consider-

ably smaller than distance between nostrils. . . . . *Notorynchus*

Genus *HEXANCHUS* Rafinesque, 1810  
*Hexanchus* Rafinesque, 1810:14; type species  
*Squalus griseus* Bonnaterre, 1788.

#### Generic Diagnosis

Six gill-openings, not joining across the ventral surface; lower labial furrow well developed.

No central medial tooth in upper jaw; lower laterals with 5 to 6 crownlets in specimens of about 500 mm total length, increasing up to 10 to 12 in specimens of about 4000 mm total length. Characters otherwise those of family.

#### Living Species

Two species of the genus *Hexanchus* are recognized (Springer and Waller, 1969), *H. griseus* and *H. vitulus*. The larger species, *H. griseus*, which reaches sexual maturity at about 4500 mm has 5 lower lateral teeth on each side of the jaw. The smaller species, *H. vitulus*, which reaches sexual maturity at about 1400 mm to 1750 mm has 6.

#### KEY TO LIVING SPECIES OF *HEXANCHUS* (After Springer and Waller, 1969)

- 1A Five rows of large trapezoidal teeth on each side of the lower jaw  
. . . . . *griseus* Bonnaterre, 1788
- 1B Six rows of large trapezoidal teeth on each side of the lower jaw  
. . . . . *vitulus* Springer and Waller, 1969

Bass *et al.* (1975) list a number of apparent differences between the two species. One of these differences, relating to the shape of the symphyseal region of the upper jaw, may be a post-mortem artifact caused either by drying of the removed jaws or by fixation of *in situ* jaws in spirit collections. In *H. griseus* the upper medial teeth are set approximately in line with the general curvature of the jaw whereas in *H. vitulus* the upper medials bulge markedly forward from the line of the rest of the jaw (Bass *et al.*, 1975:7, Pl. 3A, 3B).

In three of the five jaws of *H. griseus* in the present study, AMS I19110-001, USNM 188048 and NMV A235 the upper medials

bulge forward exactly as shown by the South African *H. vitulus* (Bass *et al.*, 1975, Pl. 3B). In one specimen of *H. vitulus* (USNM 112600) the upper medials do protrude but only slightly, much less so than in the Victorian *H. griseus*. These jaws are still *in situ*, the shark being preserved in the National Museum of Victoria's spirit collection.

#### *Hexanchus griseus* (Bonnaterre, 1788)\*

\* The date of Bonnaterre's *Squalus griseus* is often quoted in post-1948 literature as 1780. This error seems to stem from Bigelow and Schroeder's (1948) incorrect date on page 80. The correct date is used on pp. 78 and 85.

Bluntnose sixgill shark, Mud shark, Cow shark  
(Plate 12, figures 1-4)

*Squalus griseus* Bonnaterre, 1788: 9.

*Notidanus griseus* (Cuvier, 1817); Agassiz, 1835, Pl. E, figs. 2-4; 1838: 92; 1843: 218.

*Notidanus griseus* Cuvier, 1817; Agassiz, 1870: 397.

*Notidanus griseus* (Linné-Gmelin, 1788); Leriche, 1910: 225, Fig. 70.

*Hexanchus griseus* (Bonnaterre, 1788); Clemens and Wilby, 1946: 52, Fig. 12; Parrott, 1958: 83, text fig.; Whitley, 1968: 5; Welton, 1974: 2, Pl. 1E; Bass *et al.*, 1975: 8, Fig. 5, Pl. 1, 3A.

*Hexanchus griseus* (Bonnaterre, 1780); Bigelow and Schroeder, 1948. 80 (*part*), Figs. 8, 9 (*non* Fig. 9A = *H. vitulus*, S. Springer, pres. comm.); Lynch 1963: 295, Figs. 1-5; Springer and Waller, 1969: 169, Figs. 2B, 5-7.

*Hexanchus griseum* (Bonnaterre, 1788); Springer and Garrick, 1964, Table 1.

? *Isurus oxyrinchus* Rafinesque, 1810; Antunes and Jonet, 1969: 136 (*part.*), Pl. 7, fig. 22 (*non* Fig. 24).

(*non*) *Hexanchus* cf. *griseus* (Bonnaterre, 1780); Antunes and Jonet, 1969: 130, Pl. 4, figs. 1-3.

*Extant Material Examined.* 2187 mm female taken in 200 m off Port Fairey, Vict., Mar., 1963 (NMV A235, spirit collection); jaws of 4250 mm specimen taken in 450 m off Norah Head, N.S.W., June, 1976 (AMS I19110-001); photographs of jaws of 4330 mm female, Gulf

of Mexico (USNM 188048) (Springer and Waler, 1969: 169); photographs of tooth sets (Applegate, 1965a) of one side of jaws of eight specimens ranging from 696 mm to 4346 mm from California, U.S.A.

### Dentition

Dental formula of AMS I191100-001 (Pl. 12, figs. 1-4)  $\frac{P8\ L9\ M4\ L9\ P8}{P8\ L6\ M1\ L6\ P9}$ . Numerical variation

is restricted to the upper laterals, from 7 to 9 rows on each side. The number of upper and lower medials and lower laterals is constant in the above material and in the figured dentitions e.g. Bigelow and Schroeder, 1948, Fig. 8E; Bass *et al.*, 1975, Pl. 1. Bigelow and Schroeder (1948: 82, footnote) record a small Mediterranean specimen in which there is no lower medial tooth.

In all teeth the crown and its subdivisions—cusps, crownlets, basal denticles or serrae—are equally biconvex labio-lingually. The root is simple, not branching, approximately square or trapezoidal in outline and is wedge-shaped, thinning from the base of the crown to the basal margin.

### Upper Jaw

*Medials.* Four rows with lanceolate crowns curved away from the symphysis, two rows on each side. Margins entire except in large specimens about 2-3 m or more in length which may have margins serrated or even with basal denticles. Root rhomboidal in outline and with a pronounced thickening labio-lingually.

*Laterals.* From 7 to 9 rows on each side of the jaw. Teeth of first row about as high as broad with a slightly inclined, curved primary cusp and 1 or 2 crownlets distally. Basal half of mesial margin serrated. Teeth of last rows about twice as broad as high with a more inclined and almost straight primary cusp only slightly bigger than the first crownlet; 3 to 6 more crownlets decreasing evenly in size distally. Basal two-thirds of mesial margin of tooth finely serrated. Other laterals grading in size and shape between these end members.

Teeth from specimens of about a metre or less in length show less variation. Mesial margin may be entire and distal margin may have only small crownlets, perhaps only 2 or 3, even in rows nearest jaw articulation.

### Lower Jaw

*Medial.* Tooth about as high as broad with from 3 to 6 laterally directed secondary cusps and either with or without a central cusp. Central cusp when present may be bifurcated and symmetrical or single and asymmetrical. Root approximately square in outline.

*Laterals.* Six rows on either side of the medial, lower laterals largest in a set of jaws; basically trapezoidal in shape and about twice as broad as high. Crown divided into a primary cusp only slightly bigger than the following crownlets which decrease evenly in size distally. From 6 to 8 or 9 crownlets in specimens about 2 m or less in length. In larger specimens the number of crownlets increases from 9 to 10 in first rows through to 10 to 12 in last rows. Inclination of crownlets more or less constant throughout laterals. Mesial margins smooth in small specimens. Basal two-thirds finely serrated in specimens about 1.5 m in length and more coarsely serrated in larger specimens. Serrations coarsest midway along mesial margin, serrations of first rows coarser than those of last. Root more or less rectangular in outline.

*Discussion.* In all hexanchids the upper lateral rows towards the jaw articulation are similar in shape to their lower equivalents. Common to the three genera however are differences which may serve to differentiate these respective tooth types. In the uppers the primary cusp may be relatively higher and broader than in the lowers. The mesial margin of the primary cusp is usually more than half the length of the upper tooth whereas in the lowers it is less than half and often near one-third, i.e. the primary cusp in the uppers is more centrally placed. There are always more crownlets in the lowers than in the uppers—this may be less significant with isolated teeth.

Three Upper Miocene hexanchid teeth are referred to *Hexanchus* cf. *griseus* by Antunes and Jonet (1969). The crowns of the two upper medials (Antunes and Jonet, 1969, Pl. 4, figs. 1, 2) are too slender and too obliquely curved to be *H. griseus*. The lower lateral tooth (Antunes and Jonet, 1969, Pl. 4, fig. 3) has a large primary cusp with reasonably coarse serrations on the mesial margin followed by six well developed crownlets. The low number and relatively large size of the crownlets compared with the size of the tooth strongly suggests a notorynchid tooth, probably *Notorynchus primigenius*. The tooth figured by Antunes and Jonet (1969, Pl. 7, fig. 22) as an abnormal *Isurus oxyrinchus* is very similar to an upper medial in an Australian *Hexanchus griseus* (AMS I19110-001, Pl. 12, fig. 2) in its size, shape and obliquity of the crown and the presence of small denticles at the base of the mesial margin and is probably referable to that species.

**Distribution.** *Hexanchus griseus* occurs in the Atlantic, Pacific and Indian Oceans and in the Mediterranean Sea inhabiting both tropical and temperate water (Bigelow and Schroeder, 1948). Bass *et al.* (1975) note that *H. griseus* and *Hexanchus vitulus* of equivalent size occupy different ranges. The young of *H. griseus* inhabit temperate regions while *H. vitulus* occupies the tropical areas.

*H. griseus* is often taken on long lines at about 200 m and as deep as 1400 m; it is also known from shoal waters (Bigelow and Schroeder, 1948). Springer and Waller (1969) suggest that it lives on the continental slopes at depths of 350 m or more, occasionally moving into shallower waters. Vaillant recorded a 4.5 m female being taken in shallow water on a bar off Archachan in the Bay of Biscay (*vide* Springer and Waller, 1969).

**Hexanchus vitulus** Springer and Waller, 1969  
Bigeye sixgill shark  
(Plate 12, figure 5)

*Hexanchus vitulus* Springer and Waller 1969:  
160, Figs. 1, 2A, 3, 4; Bass *et al.*, 1975: 9,  
Fig. 6, Pl. 2, 3B.

**Extant Material Examined.** Photographs of

teeth *in situ* of two dried jaws: no data (USNM 110900); 1630 mm female taken at 275 m, Bahamas, 1948 (USNM 112600).

#### Dentition

Tooth counts (Springer and Waller, 1969; Bass *et al.*, 1975) show a range of P<sub>8-9</sub> L<sub>7</sub> M<sub>4</sub> L<sub>7</sub> P<sub>9</sub>. These data represent at least ten P<sub>3-5</sub> L<sub>5</sub> M<sub>1</sub> L<sub>5</sub> P<sub>5</sub> jaws which suggests that the number of upper laterals is constant (cf. *H. griseus*) and numerical variation is restricted to the posteriors of both jaws.

**Diagnosis.** Teeth small, basically similar to those of *H. griseus*.

#### Upper Jaw

**Medials.** Crowns may be more curved than in *H. griseus* and margin between top of root and base of crown, distally, more strongly arcuate.

**Laterals.** Similar to *H. griseus* but primary cusp proportionately bigger than distal crownlets and mesial margin more finely serrated.

#### Lower Jaw

**Medial.** Similar to medial of *H. griseus* including variability of central cusp.

**Laterals.** Primary cusp usually proportionately bigger than distal crownlets compared with *H. griseus*.

**Discussion.** An important feature demonstrated by the dentition of these two species of *Hexanchus* is that of size difference. The largest tooth from a large, sexually mature *H. vitulus* rarely exceeds 22 to 25 mm whereas that from a large, sexually mature *H. griseus* could be from 45 to 50 mm in length. Isolated teeth of the same size and of the same jaw position could be difficult to refer to one species or the other. However, with a random sample of teeth such as in the fossil record, if the two species were present at the time of deposition one would expect a size difference in the teeth to be apparent thus demonstrating the existence of the two species.

The size difference could also be interpreted as simply being teeth from juvenile and adult specimens of *H. griseus*. Allometric



growth patterns would enable the differentiation of a tooth of a juvenile *H. griseus* from a tooth of an adult *H. vitulus*, for example there would be more crownlets on the *H. vitulus* tooth than on the similar-sized *H. griseus* specimen.

Empirically though, in any one species of fossil teeth there is a tendency to size clustering, especially in smaller samples. (In contrast, however, in the National Museum of Victoria's collection of sharks' teeth there are 3-4000 teeth of *Isurus hastalis* (Agassiz, 1838) and a size range of juvenile to adult teeth is apparent, but, the majority of specimens represent large sharks; a collecting bias may favour this size distribution). There are many variables involved to produce this result but one dominating factor could be that the teeth shed by living sharks are insignificant in the fossil record compared with those from a dead adult. If an adult dies, immediately there is the potential of hundreds of teeth and crowns being preserved. In *Notorynchus cepedianus* for example there would be about one hundred while in a species such as *Odontaspis taurus* Rafinesque, 1810—the grey nurse shark, in Australia—it could be as high as three to four hundred.

**Distribution:** *H. vitulus* has been recorded from the south-eastern Indian Ocean between Kenya and Natal (Bass *et al.*, 1975), from Florida—Gulf of Mexico-West Indies region—and from the Philippines (Springer and Waller, 1969). Müller and Henle's (1841) records of *H. griseus* from the Atlantic and Mediterranean may well include *H. vitulus* as they state that their specimens had 5 or 6 rows of broad teeth in the lower jaws (*vide* Springer and Waller, 1969).

*H. vitulus* is a tropical to subtropical demersal species being taken at depths between 90 and 600 m with one specimen being netted just off shore in Natal. It is rarely taken in temperate waters (Bass *et al.*, 1975).

#### **Hexanchus agassizi** Cappetta, 1976

Plate 14, figures 4-11; Plate 15, figures 1-3  
*Hexanchus agassizi* Cappetta, 1976: 553, Pl. 1, figs. 5-8.

*Notidanus serratissimus* Agassiz: Woodward, 1886: 216, Pl. 6, figs. 24, 25, 26 (*non* fig. 23); Woodward, 1899: 6, Pl. 1, fig. 7 (*non* fig. 6); Casier, 1966: 44, Pl. 1, figs. 10-12 (*non* figs. 1-9).

'*Notidanus*' *serratissimus* Agassiz: Pledge, 1967: 140, Pl. 1, fig. 1.

'*Notidanus*' cf. *serratissimus* Agassiz: Pledge, 1967: 140, Pl. 1, fig. 2.

'*Notidanus*' ? *serratissimus* Agassiz: Pledge, 1967: 140, fig. 3, two top specimens only (*non* bottom two specimens).

**Fossil Material Examined.** Four teeth (SAMD V34; UAGD F17262; SAM P19552, P19643) Vand a dozen broken teeth and fragments (SAMD V60; SAM P19552).

**Occurrence.** Knight Formation equivalents, E and WS, Naracoorte No. 5 Bore, 135-145 m, Naracoorte, South Australia; Blanche Point Marl at Blanche Point and Port Noarlunga, South Australia.

**Age.** Knight Formation equivalents, Middle Eocene; Blanche Point Marl, Upper Eocene (Pledge, 1967).

**Diganosis.** Teeth up to 23 mm long, very similar to those of the extant *H. vitulus* but with the primary cusp nearer in size to the distal crownlets. The primary cusp of the uppers may be more attenuated and sinuous than in *H. vitulus*.

**Description.** One tooth (Pl. 15, fig. 2 = Pledge, 1967, Pl. 1, fig. 1) shows clearly the main characters of *H. agassizi*: the crownlets which decrease evenly in size distally from the slightly larger primary cusp with its finely serrated mesial margin; the slight lingual concavity of the tooth when viewed incisally. The length of the specimen is twice that stated in Cappetta's (1976) diagnosis. As with Cappetta (1976) upper teeth are poorly represented in the collection on hand.

One almost complete tooth (Pl. 14, fig. 4) possesses the slender, sinuous primary cusp with a serrated mesial margin and the second distal crownlet, the first crownlet being lost. The presence of only 2 crownlets suggests that the tooth is from the first or second row of the laterals. The two incomplete crowns (Pl. 14,

figs. 5, 6) show that the difference in size between the primary cusp and the first crownlet is less marked than in the equivalent teeth of the extant *H. vitulus*.

A broken lower tooth possessing only the primary cusp, first crownlet and part of the root (Pl. 14, figs. 10, 11) has one denticle on the base of the medial margin of the first crownlet. This feature has not been seen before in an hexanchid tooth and probably represents an individual variation.

A well preserved tooth (Pl. 15, fig. 1 = Pledge, 1967, Pl. 1, fig. 2) differs slightly from other teeth of *H. agassizi* in having a relatively broad and more upright primary cusp. The length of the mesial margin of this cusp is not great enough for the tooth to be an upper lateral and this with the large number of crownlets—10—suggests a lower lateral. Further material may show such differences to be within the range of normal variation of the species.

*Discussion.* The diagnosis by Cappetta (1976) for his *H. agassizi* from the London Clay states that the teeth do not exceed 13 mm in length and that they have from 7 to 10 crownlets including the principal cusp. A tooth from the London Clay figured by Woodward (1886, Pl. 6, fig. 25) under the name *Notidanus serratissimus* is 18 mm in length and has 11 crownlets. Two teeth from South Australia figured by Pledge (1967, Pl. 1, figs. 1, 2) as '*Notidanus*' *serratissimus* and '*N.*' cf. *serratissimus*, respectively, both exceed 20 mm in length and have 12 crownlets each. These three specimens are included in Cappetta's (1976) synonymy but the discrepancies in size and number of crownlets are not discussed.

The two South Australian localities of Middle and Upper Eocene age are stratigraphically younger than the London Clay which is Lower Eocene. An increase in tooth size of a taxon as the geological age of the specimens decreases has been demonstrated before in sharks' teeth e.g. in *Odontaspis macrota* (Agassiz) from the Lower Tertiaries of Europe and Angola, Darteville and Casier (1943) and Casier (1946, 1966). The South Australian teeth are morphologically similar to those from the

London Clay except for their greater size and an increase in the number of crownlets—up to 12 compared with 7 to 10 in the Lower Eocene teeth. This increase is to be expected as such allometric growth patterns are seen in extant hexanchids (see *H. griseus*, above).

Until specimens of either Lower Eocene age from Australia or Middle and Upper Eocene age from Europe, or elsewhere, become available the teeth from South Australia should be included in Cappetta's *H. agassizi*. Additional specimens may show the existence of two fossil species, which, like the dentition of the two extant *Hexanchus* species, are separable primarily on the basis of size.

*Distribution.* *H. agassizi* is found in Middle and Upper Eocene beds from South Australia and has been recorded from the Eocene of Russia (Menner, 1928; Glyckman, 1964, *vide* Cappetta, 1976), the Lower Eocene of the London Basin and from North America (Cappetta, 1976).

Genus *Heptranchias* Rafinesque, 1810

*Heptranchias* Rafinesque, 1810: 13; type species *Heptranchias cinereus* Rafinesque equals *Squalus perlo* Bonnaterre, 1788 (*vide* Bigelow and Schroeder, 1948).

#### *Generic Diagnosis*

Seven gill openings; lower labial furrow poorly developed; snout narrow and tapering, length always more than 1.5 x distance between nostrils; horizontal diameter of eye always greater than distance between nostrils.

No central medial tooth in upper jaw; medial tooth in lower jaw with central cusp, which may be asymmetrical; first rows of lower laterals with from 4 to 5 or 6 crownlets; primary cusp markedly bigger than distal crownlets its mesial margin with from 1 to 4 basal denticles. Characters otherwise those of family.

#### *Living Species*

One species, *Heptranchias perlo*, of worldwide range. Garrick and Paul (1971) have shown the Australian nominal species *H. dakini* Whitley, 1931 to be conspecific with *H. perlo*. They also note that some New Zealand specimens of *H. perlo* have 6 lateral teeth on

each side of the lower jaw compared with the usual 5. Specimens of *H. perlo* from south western Indian Ocean represent an isolated population in that they have very different vertebral counts from those of Australian and Western North Atlantic specimens (Bass *et al.*, 1975).

***Heptranchias perlo*** (Bonnaterre, 1788)  
Sharpsnout sevengill shark; Perlon shark  
(Plate 13, figure 1)

*Squalus perlo* Bonnaterre, 1788: 10.

*Notidanus cinereus* Cuvier, 1829; Günther, 1870: 398; Agassiz, 1843: 218.

*Heptranchias perlo* (Bonnaterre, 1788); McCulloch, 1911: 2, Pl. 1, fig. 1; McCulloch, 1919: 219, Pl. 16, fig. 4a; McCulloch, 1929: 3; Fowler, 1941: 9; Bigelow and Schroeder, 1948: 88, Figs. 10, 11; Parrott, 1958: 86, text fig.; Applegate and Uyeno, 1968: 197, Pl. 1B; Garrick and Paul, 1971: 1, Pl. 1, 2; Welton, 1974: 6, Fig. 1C, Pl. 1; Bass *et al.*, 1975: 11, Fig. 7, Pl. 4.

*Heptranchias dakini* Whitley, 1931a: 310; Fowler, 1941: 5; Munro, 1956: 2, Fig. 4; Scott, 1962: 19, text fig.; Whitley, 1968: 5; Scott *et al.*, 1974: 23, text fig.

(*non*) *Heptranchias cf. perlo* (Rafinesque); Antunes and Jonet, 1969: 131, Pl. 4, fig. 4.

**Extant Material Examined.** 695 mm female, Victorian coast (AMS I10825) (possible holotype of *H. dakini* Whitley, 1931, see Garrick and Paul, 1971); 720 mm female, off Barrenjoey, N.S.W., Jan., 1955, J. E. Smith (AMS IB3277); 778 mm female, taken at 100 m, N.E. of Cape Solander, N.S.W., 1916, State Trawling Department (AMS I13929); 845 mm male, taken at 120-140 m, 100 km S. of Cape Everard, Victoria, 1910, 'Endeavour' (AMS I10794 (paratype of *H. dakini* Whitley, 1931, see Garrick and Paul, 1971); 720 mm male, taken at 620 m, 56 km S.E. of Newcastle, N.S.W., 33° 11'S, 152° 23'E, 29 Apr., 1971, F.R.V. 'Kapala', prawn trawl (AMS I15975-014); 810 mm female, trawled off Botany Bay, June, 1943, G. P. Whitley (AMS IB1341); 890 mm female, taken at 177 m, 32 km, S.E. Port Stephens, N.S.W., Dec., 1975, 'Kaiyo Maru'

(TM D1245); 887 mm female, same data as TM D1245 (TM D1247); 870 mm male, same data as AMS I10794 (NMV E1184).

#### Dentition

Dental formula of *H. perlo* TM D1245  
P<sub>10</sub> L<sub>8</sub> M<sub>4</sub> L<sub>7</sub> P<sub>9</sub> . The number of upper and lower P<sub>9</sub> L<sub>5</sub> M<sub>1</sub> L<sub>5</sub> P<sub>10</sub> medials is constant while upper laterals may vary between 7 and 9 on each side. As noted above some New Zealand specimens have 6 lower laterals on each side.

**Diagnosis.** Teeth small with the largest—the 4th or 5th row of lower laterals—not exceeding 25 mm in length, and showing a similar heterodonty to *Hexanchus griseus* but differing significantly in detail.

#### Upper Jaw

**Medials.** Crown more finely attenuated, much flatter labio-lingually, more strongly sinuous and curved away from the jaw midline than in *H. griseus*. Similar to *H. vitulus* especially the arcuate distal margin, but crown more inclined and tooth much broader.

**Laterals.** Primary cusp more slender and relatively much larger than the distal crownlets compared with both extant species of *Hexanchus*. One or 2 small crownlets in first row increasing to 2 to 4 in last row. Mesial margin smooth or with small basal denticles in first row. Subsequent rows with 1 or 2, increasing to 2 or 3, may be 4, basal denticles about equal in size to distal crownlets, i.e. differing markedly from the upper laterals of *H. griseus* and *H. vitulus* which have a finely serrate mesial margin and a greater number of relatively larger distal crownlets.

#### Lower Jaw

**Medial.** Tooth with only 2 or 3 cusps on mesial and distal margins, much less inclined than in *H. griseus* and *H. vitulus*. Central cusp relatively larger and approximately symmetrical.

**Laterals.** Primary cusp about twice as high as first crownlet and more finely attenuated than in *H. griseus* and *H. vitulus* and primary cusp and crownlets more upright than in those species. From 4 to 5 or 6 crownlets in first row to 6 to 8 in last row; crownlets increase in size distally then gradually decrease, the last 2 or

3 in each tooth being markedly smaller than the third or fourth last. This is contrast to the even decrease in size from the first to last crownlet in *Hexanchus* spp. Mesial margin with from 2 to 4 basal denticles in first rows to 1 or 2 in last; basal denticles relatively large, in last rows largest may be almost as big as first crownlet.

*Discussion.* Bigelow and Schroeder (1948) note a difference in the number of crownlets in the lower laterals between a male and their female specimens. In the present study material this sexual dimorphism is not apparent, the number of crownlets showing a similar range between the two sexes.

The largest tooth seen in the present study is a fifth lower lateral 20 mm in length from a 1340 mm female (NZNM 2180). In a slightly longer specimen, a 1365 mm female, also from New Zealand (CM 418) the fifth lower lateral is only 17.8 mm while the fourth is 19 mm (G. A. Tunnicliffe, pers. comm.). With one exception this is the largest specimen of *H. perlo* seen recorded in the literature. Günther (1870: 398) notes an 'Adult male; stuffed, 7 feet long. From the Antarctic Expedition' under the name *Notidanus cinereus*. This specimen is actually 6 ft 8 in (2030 mm) long, has no teeth, the mouth and gill slits are sewn up and 'it is not possible to identify to species for certain due to its shocking condition' (Mr A. Wheeler, pers. comm.). In light of this Günther's (1870) record for a maximum size of *H. perlo* is regarded as dubious.

Antunes and Jonet (1969) assign a Late Miocene upper right anterior (= medial) hexanchid tooth to *Heptranchias* cf. *perlo*. The thickness of the tooth labio-lingually separates it immediately from Rafinesque's *H. perlo* as does the less sinuous crown and the less curved distal margin.

Garrick and Paul (1971) have shown that the differences between the nominal *H. dakini* Whitley and *H. perlo* (Bonnaterre) are due to sexual dimorphism. The main differences are in the relative position of the dorsal, pectoral and anal fins. In females the anal fin origin is below about the middle of the base of the dorsal fin,

in males it is below the end of the dorsal base. Also, the pelvic fin is situated further back in females resulting in a shorter pelvic-anal distance than in males (Garrick and Paul, 1971). In the following Table 1 are compared selected dimensions of one male and two female *H. perlo*. The latter were taken off N.S.W. (TM D1245, TM D1247) while the male was taken off southern Victoria (NMV E1184) by the *Endeavour* in 1910 along with the holo- and paratype of Whitley's *H. dakini*.

Although differing in detail these data demonstrate the same trends of fin placement characteristic of each sex as shown by Garrick and Paul (1971, Table 1).

The two *H. perlo* from off Port Stephens, N.S.W. gave the following vertebral counts:

	TM D1247	TM D1245
Precaudal	93	91
Caudal	56	54
Total	149	145

These counts fall within the range of other Australian and New Zealand specimens of *H. perlo* (Garrick and Paul, 1971) and agree closely with those of three specimens from the western North Atlantic (Springer and Garrick, 1964). They differ from the average counts given by Bass *et al.* (1975) of 75 precaudal and 53 caudal.

*Distribution.* *H. perlo* has been recorded from the western and eastern North Atlantic, the Mediterranean, the Cape of Good Hope and Japan (Bigelow and Schroeder, 1948), from Australasia (Garrick and Paul, 1971), from the eastern South Atlantic and southwest Indian Ocean (Bass *et al.*, 1975).

It appears to be a shelf-edge species as it is usually taken at depths between 100-400 m; some specimens have been taken in shallow water—about 50 m—in New Zealand. Shallow water records are probably due to confusion with the broadsnout sevengill genus, *Notorynchus* (Garrick and Paul, 1971). Bass *et al.* (1975) also record *H. perlo* from depths of 50-400 m but note that most were taken from the deeper part of this range.

TABLE 1

Sex and total length	Catalogue no.	% dorsal base anterior to anal fin origin	Predorsal length as % tl.	Preanal length as % tl.	Prepelvic length as % tl.	Pelvic origin to anal fin origin as % tl.
Female 887	TM D1247	82.8	50.2	55.5	41.1	14.4
Female 890	TM D1245	61.6	51.1	55.6	41.9	13.7
Mean of females		72.2	50.7	55.6	41.7	14.1
Male 870	NMV E1184	93.0	50.3	56.9	40.8	16.1

***Heptranchias howellii*** (Reed, 1946)

Plate 15, figures 4-7

*Notidanion howellii* Reed, 1946: 1, figs. 1-3, Fig. 4.'*Notidanus*' ? *serratissimus* Ag.; Pledge, 1967: 140 (part.), Pl. 1, fig. 3, bottom two specimens (non top two specimens).*Heptranchias ezoensis* Applegate and Uyeno, 1968: 195, Pl. 1A.*Heptranchias* Waldman, 1971: 166, Pl. 1, figs. 1, 2.*Heptranchias howellii* (Reed); Welton, 1974: 1, Fig. 1A, B, Pl. 2A, B.**Fossil Material Examined.** Four incomplete crowns (RJFJ no. 121; SAM P19573; UAGD F17284).**Occurrence.** Blanche Point Marl, Blanche Point, South Australia.**Age.** Upper Eocene.**Diagnosis.** Based on lower laterals, the only tooth type of this species so far identified. Teeth similar to the extant *H. perlo* but larger, up to 25 mm in length (Waldman, 1971) and with mesial basal denticles, primary cusp and distal crownlets all relatively broader and less attenuated than in the extant species. The primary cusp of *H. perlo* is always relatively higher. *H. howellii* may have up to 5 basal denticles, *H. perlo* from 1 to 4.**Description.** Three incomplete crowns (Pl. 15, figs. 4, 5, 7) represent mesial portions of teeth, each having the primary cusp and two crownlets with the second crownlet being characteristically larger than the first. The re-

maining specimen (Pl. 15, fig. 6) is the distal portion of a tooth with the crownlets increasing in size distally until the last two which decrease, the most distal being very much smaller.



Figure 5—Locality map showing occurrences of fossil hexanchid teeth in S.E. Australia.

*Discussion.* A tooth of *H. howellii* figured by Welton (1974, Pl. 2B) although very close morphologically to an *H. perlo* lower lateral, e.g. row 2 (Pl. 13, fig. 1), still has a more robust shape, a primary cusp not as high and cusp and crownlets inclined and straight rather than inclined and slightly curved as found in the extant species. The other tooth (Welton, 1974, Pl. 2A) is nearer to Reed's (1946, Figs. 1-4) holotype of *H. howellii* and similar to the four incomplete crowns from South Australia.

Reed (1946) did not compare her new species with *H. perlo* but Welton (1974) differentiates *H. perlo* from *H. howellii* on the basis of the former species having a higher primary cusp and no more than 3 basal denticles on the lower laterals. Lower laterals of both left and right rows of two jaws to hand (TM D1245; TM D1247, Pl. 13, fig. 1) have 4 basal denticles on the mesial margin. The main criteria to separate *H. perlo* from *H. howellii* are the higher primary cusp in the extant species, as Welton (1974) notes, but also the generally broader and less attenuated basal denticles, primary cusp and crownlets of *H. howellii*.

Applegate and Uyeno (1968) did not compare their *H. ezoensis* with *H. howellii*. The figured holotype of *H. ezoensis* is very similar to some figured specimens of *H. howellii*, e.g. Pl. 15, fig. 7; Welton (1974, Pl. 2B) except that it has only 2 basal denticles and the primary cusp and crownlets are more inclined. Such differences however are within the normal range of variation seen between the first and last rows of lower laterals of *H. perlo* (Pl. 13, fig. 1) and is in accord with Applegate and Uyeno's own interpretation of the tooth being referable to the fifth lower lateral row. For these reasons *H. ezoensis* is included in the synonymy of *H. howellii*.

The size of teeth of *H. howellii* is comparable to those of *H. perlo* suggesting that the fossil shark too may have grown to a maximum length of less than 2 m. The type specimen is 13 mm in length (Reed, 1946), Welton (1974) records four teeth ranging from 6 mm to 17 mm and Waldman's (1971) two specimens are 19 mm and 25 mm long. The four South Australian fragments are all incomplete

but by comparison with the above specimens—measuring from the mesial margin to the apex of the second crownlet—they fall within this size range.

*Distribution.* Although teeth of *H. howellii* are apparently rare in the fossil record—only about a dozen having been described, including the four in the present study—they are reasonably widespread geographically. In North America they are recorded from the Eocene of New Jersey (Reed, 1946) of Oregon and Washington (Welton, 1974) and British Columbia (Waldman, 1971; Welton, 1974). The tooth from Japan is from the Upper Oligocene (Applegate and Uyeno, 1968) while the South Australian specimens are of Upper Eocene age.

#### Genus *Notorynchus* Ayres, 1855

*Notorynchus* Ayres, 1855: 76; type species *Notorynchus maculatus* Ayres, 1855, California.

#### *Generic Diagnosis*

Seven gill openings; spiracles small; lower labial furrows well developed; snout broadly rounded, length always less than 1.5 x distance between nostrils; horizontal diameter of eye 2 x or 3 x distance between nostrils; dorsal surface of body and paired fins with small dark splotches, white spots may or may not be present.

Central tooth in both upper and lower jaws, except in some specimens, e.g. off California, which have a variable number of medials either on or either side of the upper symphysis (see below); lower medial without central cusp or, if present, small and strongly asymmetrical; lower laterals with 4 to 7 distal crownlets. Characters otherwise those of family.

#### *Living Species*

Possibly only one species *Notorynchus cepedianus* (Péron, 1807) of world-wide range. The taxonomic status of the group at the sub-generic level is particularly confused.

*N. macdonaldi* Whitley (1931b) was later included by Whitley (1934) himself in the synonymy of *N. cepedianus* when he found that Péron's species had priority. Bass *et al.* (1975) note that the white spots on the dorsal

surface of *N. macdonaldi* described by Whitley (1931) had not been reported on further specimens. In fact this coloration seems to be quite widespread as it has been recorded from a number of localities such as Bass Strait (Macdonald and Barron, 1868); New Zealand (Phillips, 1924) and eastern Pacific (no detailed localities given) (Kato *et al.*, 1967). The size of the spots is about that of the eye (Whitley, 1931B; Kato *et al.*, 1967: 6). On the two local specimens caught recently (TM D1291 and TM D1292) the white spots were randomly scattered over the dorsal surface and ranged from 7-30 mm in diameter. Macdonald and Barron (1868) suggested that the spots on their specimen might be the result of disease. An examination of the white spots on the two local specimens revealed no pathological disturbance (B. Munday, pers. comm.)

The presence or absence of a central cusp on the lower medial tooth, the degree of serration of the mesial margin of the lower laterals and the presence or absence of a medial tooth on the symphysis of the upper jaw have been the main criteria used in differentiating the nominal species of *Notorynchus* by a number of authors, for example Günther (1870), Garman (1913), Fowler (1941). The first two characters are variable within the species (see below) but the presence or absence of a tooth on the symphysis of the upper jaw is a difference whose taxonomic status has yet to be established. Many authors such as Agassiz (1835), Müller and Henle (1841), Macdonald and Barron (1864), Garman (1884), Lahille (1928), Whitley (1931), Sadowsky (1970) and Bass *et al.* (1975) either figure or describe in detail the presence of a central upper medial tooth with a single medial on each side.

The issue is confused by some authors, for example Garman (1913), Fowler (1941), who include in the synonymies of their species of *Notorynchus* supposedly lacking an upper central medial, references which actually figure this tooth, for example Agassiz (1835), Müller and Henle (1841). In addition Fowler (1941) includes a number of Australian references in his synonymy of *Heptranchias cepedianus* (Péron), the species supposedly lacking an up-

per central medial. All Australian specimens so far described in the literature and specimens seen by the present writer possess this tooth. Fowler's single example, *H. cepedianus*, from southern Africa ('Cape Colony coast', Fowler, 1941: 7) was actually a skinned out specimen, thus presumably the jaws were not examined. Bass *et al.* (1975) note that all southern African specimens do possess a tooth on the upper symphysis. Tenore's (1810) description of his new species, *Squalus platycephalus*, from the Mediterranean, gives no clear indication of the number or placement of teeth in the symphyseal area of the upper jaw, 'Superior prominentia intermedia dentibus decem triplici serie dispositis . . .' (Tenore, 1810: 258).

Two sets of jaws of the broadsnout seven-gill shark from off the Californian coast recently received at the Tasmanian Museum (see below) have a pair of medials on either side of the upper symphysis. The type of *Notorynchus maculatus* Ayres, 1855 is from California. However, in the description of the teeth of the upper jaw of the type it is not clear whether there is a tooth on the symphysis or not 'Those of the center are narrow, acute, without denticles at the base . . .' (Ayres, 1855: 76-77). Some Californian specimens of *Notorynchus* do have an upper central medial but a range of from 0-2 on each side of the symphysis is known (B. J. Welton, pers. comm.). In the description of tooth types (see below) only the more common condition of three upper medials with one on the symphysis is included as the writer has not seen the complete range of variation present in the Californian specimens. Further detailed comparative studies may show the dental variation of the upper symphyseal area of *Notorynchus* from California and perhaps the Northern Hemisphere in general to be of specific value. If a second species is established and clearly defined only then can the synonymies of this genus be unravelled.

*Heptranchias haswelli* Ogilby, 1897 was erected on the basis of a set of jaws then in Macleay Museum University of Sydney. Material in this Museum was eventually handed over to the Australian Museum but the type jaws are now lost (J. R. Paxton, L. Bushell,

pers. comm.). From the description (Ogilby, 1897) the jaws definitely were of hexanchid (see below) but its status must now remain as a *species inquirenda*.

**Notorynchus cepedianus** (Péron, 1807)

Broadsnout sevengill shark

(Plate 13, figure 2)

- Squalus cepedianus* Péron, 1807: 337.  
*Squalus platycephalus* Tenore, 1810: 241, 258.  
*Notidanus indicus* Agassiz, 1835, Pl. E, fig. 1; Agassiz, 1838: 92; Agassiz, 1843: 217; Günther, 1870: 398; Hutton, 1873: 271; Day, 1878: 723, Pl. 189, fig. 4; Johnston, 1882: 138; Johnston, 1890: 38.  
*Heptanchus indicus* Müller and Henle, 1841: 82, Pl. 32.  
*Notorynchus maculatus* Ayres, 1855: 72; Gill, 1862: 495; Herald, 1968: 412.  
*Notorynchus borealis* Gill, 1864: 150.  
*Heptranchus indicus* McDonald and Barron, 1868: 371, Pl. 32, figs. 1-6; Castlenau, 1872: 217; Haswell, 1880: 96; Haswell, 1884a: 88, Pl. 1, fig. 5; Haswell, 1884b: 381, Pl. 10, fig. 1, 2; Ogilby, 1889: 179.  
*Heptranchus griseus* McDonald, 1873: 312.  
*Notidanus (Heptanchus) indicus* McCoy, 1880: 16, Fig. A, B, Pl. 43, fig. 2.  
*Heptranchias pectorosus* Garman, 1884: 56; Lahille, 1928: 299, Figs. 1, 2; Fowler, 1941: 7.  
*Notorhynchus maculatus* Jordan and Evermann, 1896: 17; Jordan and Evermann, 1900, Pl. 2, fig. 7; Welton, 1974: 3, Fig. 1D.  
*Heptranchias indicus*; Waite, 1907: 6; McCulloch, 1911: 2.  
*Notorhynchus indicus*; Zeitz, 1908: 289.  
*Heptranchias platycephalus* (Tenore, 1810); Lahille, 1928: 300, 302.  
*Notorynchus platycephalus* Garman, 1913: 18.  
*Heptranchias spilotus* Lahille, 1913: 26, Figs. 1-3, Pl. 8, fig. 1.  
*Notorhynchus pectorosus*; McCulloch, 1919: 219, Pl. 6, fig. 3a; Waite, 1921: 10, Fig. 5; Waite, 1923: 24, three Figs; Phillips, 1924: 259, Fig. 1.  
*Notorynchus griseus* (McDonald, 1873); McCulloch, 1929: 3.

*Notorynchus macdonaldi* Whitley, 1931b: 138, Pl. 20, figs. 3-5; Phillips, 1935: 236, Fig. 1.

*Notorynchus cepedianus*; Whitley, 1934: 181, 197; Whitley, 1940: 70, Figs. 4, 50, 51; Clemens and Wilby, 1946: 51, Fig. 11; Graham, 1953: 62, one Fig.; Scott, 1962: 19, one Fig.; Whitley, 1968: 5; Scott *et al.*, 1974: 23, three Figs; Bass *et al.*, 1975: 14, Fig. 8, Pl. 5.

*Heptranchias cepedianus*; Fowler, 1941: 6; Parrott, 1958: 84, one Fig.

*Notorhynchus cepedianus*; Munro, 1956: 2, Fig. 5.

*Notorhynchus pectorosus*; Garman, 1913: 20; Sadovsky, 1970: 33, Fig. 1.

(*non*) *Heptranchias haswelli*; Ogilby, 1897: 62.

*Extant Material Examined*. 555 mm female, Altona, Vict. (NMV A106); 2391 mm female, mounted specimen (NMV); dried jaws, no data (NMV); 910 mm male, State Fisheries, N.S.W., 1920, no data (AMS 16813); head of specimen taken off Babel Is., N.S.W. at 130 m, 26 June, 1911 (AMS E2161); dried jaws, no data (MUGD); 1520 mm male, Storm Bay, S.E. Tasmania, Safcol (Tas.) Pty. Ltd., May, 1977 (TM D1291); 1648 mm male, same data as TM D1291 (TM D1292) (jaws only of these two specimens retained); dried jaws, 1310 mm immature female, Berkeley Flats, San Francisco Bay, California, U.S.A., B. J. Welton, June, 1976 (TM D1302); dried jaws, 2180 mm immature female, California, U.S.A., B. J. Welton, Jan., 1977 (TM D1303).

*Fossil Material Examined*. One incomplete tooth (TM Z1991).

*Occurrence*. Jemmy's Point road cutting, 5 km E of Lakes Entrance, Victoria.

*Age*. Early Pliocene (Abele *et al.*, 1976).

**Dentition**

Dental formula of dried jaws, MUGD (Pl. 13, fig. 2):  $\frac{P_{13} L_6 M_3 L_6 P_{11}}{P_9 L_6 M_1 L_6 P_8}$ . The number of medials and laterals in both jaws is in most specimens usually constant (except in Californian specimens, see above), but some variation does occur in the laterals, e.g. Bass *et al.* (1975) record one specimen with 7 upper laterals on one side. The 555 mm male from Victoria has



7 lower laterals on the right but the usual 6 on the left. As in *Hexanchus* the number of crownlets, especially in the lower laterals and the degree of denticulation of the mesial margin of all teeth increases with age, and thus the size of the tooth. On the mesial margin of teeth of a given size the basal denticles of *Notorynchus* are larger and more developed than are the serrations of *Hexanchus*. The basal denticles of *Heptranchias* are relatively larger again than those of *Notorynchus*. In both *Notorynchus* and *Heptranchias* the basal denticles extend only half to one-third along the mesial margin, in *Hexanchus* the serrations extend along about two-thirds. The basal denticles of *Heptranchias* are relatively larger again than those of *Notorynchus*.

**Diagnosis.** Teeth small with the largest—usually the 2nd lower lateral row—probably not exceeding 25 mm in length, and showing a similar heterodonty to *Hexanchus griseus* but differing significantly in detail.

#### Upper Jaw

**Medials.** Three rows, the central one of which is on the symphysis and is usually upright but may be slightly inclined to either the right or left. Serrations or basal denticles not usually present on margins of central medial. Basal denticles present on both margins of the two lateral medials but may be absent in juvenile specimens. Crown of medials of *Heptranchias perlo* much more slender and inclined than in *Notorynchus cepedianus*. Root more or less square or slightly tapering basally in outline when viewed labially.

**Laterals.** Teeth in first rows a little higher than broad ranging through to a little broader than high in last rows. Teeth of *Hexanchus* are lower and broader in comparison. Primary cusp similar to *H. griseus* but with fewer crownlets distally, ranging from only 1 in first row to 4 to 5 or 6 in the last row. Primary cusp and crownlets all relatively broader and larger than in *Heptranchias perlo*.

#### Lower Jaw

**Medial.** Tooth similar to that of *Hexanchus griseus* but usually lacking a central cusp. Medials of some specimens, not necessarily

large or small, may be quite asymmetrical having one or two more cusps on one side than the other and a strongly oblique central cusp.

**Laterals.** Teeth about constant breadth and only one-third to one-half broader than high from first to last row. In *Hexanchus* they are about twice as broad as high while in *Heptranchias perlo* they range from a little broader than high in the first row to more than twice as broad as high in the last. Primary cusp with 4 to 6 or 7 basal denticles on mesial margin and 4 to 5 or 6 crownlets which decrease evenly in size distally. Both extant *Hexanchus* species have a greater number of crownlets, from 6 to 12, depending on tooth size, and a serrated mesial margin. *Heptranchias perlo* has about the same number or slightly more than in *Notorynchus cepedianus* but they increase in size distally in the former before decreasing, and then rapidly in the last 1 to 3 crownlets. The primary cusp of *H. perlo* is relatively higher and more attenuated than in the other three species of the family.

**Description.** Table 2 gives the measurements as per cent of total length of two male topotypes of *N. cepedianus*. Péron's specimen was from Adventure Bay, a bay on Bruny Island which is in Storm Bay, SE Tasmania. No detailed measurements of Australasian material has previously been published to the author's knowledge. Both specimens were light grey above grading to off-white below with numerous dark grey to black splotches about 2-10 mm across on the dorsal surface and paired fins. Also on the dorsal surface of each shark were about a dozen white spots from 7-30 mm diameter, randomly distributed.

Dental formula: TM D1291  $\frac{P_9 L_6 M_3 L_6 P_{11}}{P_7 L_6 M_1 L_6 P_8}$   
 TM D1292  $\frac{P_{13} L_6 M_3 L_6 P_{11}}{P_9 L_6 M_1 L_6 P_{10}}$ . The lower medial of TM D1291 is symmetrical with no central cusp while in TM D1292 the lower medial is asymmetrical with a very small oblique central cusp.

**Discussion.** Ogilby (1897) placed his new species of hexanchid in the genus *Heptranchias*, *H. haswelli*, on the basis of a central cusp, inclined to the right, on the lower medial tooth. He also described in the upper jaw:

TABLE 2  
Dimensions of *Notorynchus cepedianus* as per cent of total length

		Male TM D1291 1520 mm	Male TM D1292 1648 mm
<i>Total length</i>			
Snout tip to:	outer nostrils	1.3	1.6
	mouth	3.8	3.8
	eye	4.1	4.4
	spiracle	10.2	10.7
	1st gill opening	13.2	13.9
	4th gill opening	15.3	16.3
	7th gill opening	16.0	17.1
	pectoral origin	16.0	17.1
	pelvic origin	41.5	40.1
	dorsal origin	49.2	48.3
	anal origin	54.9	54.3
	upper caudal origin	66.5	66.2
Nostrils:	distance between inner ends	4.4	4.4
	length	1.1	1.2
Eye:	horizontal diameter	1.3	1.3
Mouth:	breadth	12.7	11.8
	height	6.5	6.3
	lower labial furrow	4.4	4.2
Gill openings, length of:	1st	5.6	5.4
	4th	4.9	4.4
	7th	2.8	3.2
Pectoral fin:	outer margin	13.7	13.5
	inner margin	5.7	5.7
	distal margin	11.1	11.4
	length of base	7.6	7.8
Pelvic fin:	origin to lateral lobe	5.7	6.4
	origin to median tip	8.9	10.4
	length of claspers	5.6	6.4
Dorsal fin:	length of base	6.6	7.7
	length of rear tip	2.0	2.3
	vertical height	4.1	4.3
Anal fin:	length of base	4.5	6.0
	length of rear tip	1.6	1.9
	vertical height	2.4	2.7
Caudal fin:	length of upper margin	33.7	34.5
	length of lower margin	8.7	9.4
	base of notch to tip	7.5	6.8
Interspace between bases of:	dorsal and caudal	10.3	10.6
	anal and caudal	7.0	6.0
Distance from origin to origin:	pectorals and pelvics	25.5	23.1
	pelvics and anal	15.5	14.2

- 3 medial teeth, the outer 2 with basal denticles on both margins, the central tooth with entire margins;

- 8 rows of laterals with an increasing number of basal denticles and crownlets from

symphysis to articulation, the last 2 rows being lower and broader than the first rows;

- 10 rows of posteriors on each side; in the lower jaw:

- a medial tooth with an inclined strong central cusp and 4 lateral secondary cusps on each side;
- lateral teeth, the number of which is not given, with 5 to 7 basal denticles on the mesial margin of the primary cusp, followed by 5 to 6 crownlets which decrease regularly in size distally;
- 10 rows of posteriors on each side.

Except for the inclined, strong, central cusp on the lower medial and 8 upper laterals on each side the description is that of *Notorynchus cepedianus*. *Heptranchias perlo* does and both *Hexanchus* species may have a strong central cusp on the lower medial tooth. An asymmetrical lower medial in *N. cepedianus* may have a central inclined cusp but in comparison with *Hexanchus* and *Heptranchias* the central cusp could not be called 'strong' (Ogilby, 1897: 63). Eight upper laterals have not been recorded before from *N. cepedianus* but 8 or 9 are common in both *Hexanchus griseus* and *Heptranchias perlo*. Because the type jaws are lost *H. haswelli* must then remain a *species inquirenda*.

An abnormality in the form of bifid teeth (Pl. 14, fig. 3) is noteworthy in that in each case the two 'teeth' both show the basic morphology of *N. cepedianus* teeth. Peyer (1968: 42) tends to 'deny the deeper morphological significance of the presence or absence of accessory cusps'. The anlage, in this case of the first lateral row of the lower jaw of this specimen of *N. cepedianus*, did continue to produce teeth of a morphology characteristic of this species including the basal denticles and the crownlets which decrease evenly in size distally. The mesial 'tooth' has 4 basal denticles on the mesial margin of the primary cusp which is a little larger than the remaining 3 crownlets. The distal 'tooth' which is about one-third the width of the mesial portion, has only 1 basal denticle on the mesial margin of the primary cusp which is noticeably larger than the 3 crownlets. Gudger (1937) noted similar abnormalities in other species of sharks, e.g. *Galeocerdo cuvieri*. The causative mechanism may be a foreign object such as a fish spine being imbedded in the anlage which is subsequently divided as each tooth advances.

The largest definite record of *Notorynchus cepedianus* seen in the literature is that given by Phillips (1935) of a 2888 mm—'9 ft 5.5 in' (Phillips, 1935: 236)—specimen taken in Oriental Bay, New Zealand; the size of the teeth is not recorded. The 2nd lower lateral of the 2391 mm mounted specimen in the National Museum of Victoria is 22 mm in length.

The dental sexual dimorphism in *N. cepedianus* illustrated and noted by Macdonald and Barron (1868) and briefly reiterated by Phillips (1935) has not been seen in any other literature nor in any of the present study material. Indeed, the hand-drawn illustration by Macdonald (Macdonald and Barron, 1868, Pl. 33, fig. 3a, 3d) of the teeth of a female *N. cepedianus*, with the basal denticles of the mesial margins of the lower laterals nearly equal in size to the primary cusp and crownlets, is more akin to teeth of the Upper Cretaceous *N. pectinatus* (Agassiz, 1843: 221; Agassiz, 1844, Pl. 36, fig. 3a; Applegate, 1965b, Figs. 1, 2) than to Péron's extant species and must be regarded as a subjective interpretation of their specimen.

The Early Pliocene tooth (TM Z1991) representing a lower lateral from the 2nd or 4th row is, to the author's knowledge, the first fossil occurrence of this species. Although the basal denticles and the first two crownlets are missing, the tooth, on the basis of the shape of the root and the relative proportions and curvature of the primary cusp and remaining crownlets, can be definitely assigned to the extant species. *N. cepedianus* and *N. primigenius* (see below) were contemporaneous species, but until further fossil specimens of the former species are recognized discussion of their relative geographical distribution would be speculative only.

*Distribution.* *Notorynchus cepedianus* is recorded from the Pacific Ocean, California to British Columbia (Clemens and Wilby, 1946) and British Columbia to Chile, excluding the tropics (Kato *et al.*, 1967), from Japan and Taiwan (Matsubua, 1936 and Chen, 1963, respectively, *vide* Bass *et al.*, 1975), from New Zealand (Phillips, 1935) and from Australia, but only from southern waters, e.g. McDonald and Barron, 1868, McCulloch, 1919, Waite,

1921, Scott *et al.*, 1974, no specimens having ever been recorded from northern waters. J. D. Ogilby (*vide* Whitley, 1931) states that *N. cepedianus* does not occur in Queensland waters; the Atlantic Ocean, from Argentina (Lahille, 1928) and Brazil, but not from other parts of the Atlantic (Sadowsky, 1970) and the Indian Ocean (Day, 1878). This report by Day, of a specimen taken off Madras appears to be the most tropical occurrence (about 14° N) of *N. cepedianus*. The broadsnout sevengill shark is commonly taken in shallow coastal waters in South Africa (Bass *et al.*, 1975) and Australia. Phillips (1935) records a 3 m female being taken off a swimming beach in Wellington, New Zealand, but also notes that it is an open ocean shark sometimes entering harbours and inlets. Herald and Ripley (1951) report that while smaller specimens, less than 1.8 m, are common in the shallower waters of San Francisco Bay, larger specimens live in deeper water out of the Bay.

*Notorynchus primigenius* (Agassiz, 1835)

(Plate 15, figures 8-10)

*Notidanus primigenius* Agassiz, 1835, Pl. 27, figs. 6-8, 13-17 (*non* figs. 4, 5); Agassiz, 1843: 218; Woodward, 1886: 216, Pl. 6, figs. 19-22; Davis, 1888: 33, Pl. 6, fig. 6; Leriche, 1905: 207, Fig. 62; Chapman, 1914: 271; Leriche, 1926: 388; Leriche, 1927: 8, Pl. 1, fig. 1; Leriche, 1957: 22, Pl. 1, figs. 1-6 (synonymy).

*Notidanus marginalis* Davis, 1888: 34, Pl. 6, fig. 8 (*non* fig. 7); Chapman, 1914: 268, 271, Fig. 130A; Chapman, 1918: 4, Pl. 6, fig. 8 (?Pl. 9, fig. 1).

*Hexanchus cf. griseus* (Bonnaterre); Antunes and Jonet, 1969: 130 (*part.*), Pl. 4, fig. 3 (*non* figs. 1, 2).

*Hexanchus primigenius* (Agassiz); Cappetta, 1970: 16, Pl. 4, figs. 11-19.

*Fossil Material Examined.* Four incomplete crowns (TMZ 1992; NMV P27410, P27411, an unnumbered fragment).

*Occurrence.* Batesford Limestone, Batesford, Vict. Muddy Creek Marl, Clifton Bank, Muddy Creek, Hamilton, Vict.

*Age.* Batesford Limestone, Lower Miocene; Muddy Creek Marl, Middle Miocene (Abele *et al.*, 1976).

*Diagnosis.* Teeth similar to *N. cepedianus* but larger in size, up to 30 mm (Leriche, 1910), and with the primary cusp and crownlets generally straighter and more erect and broader and more robust.

*Description.* Two specimens (Pl. 15, figs. 8, 9) represent lower lateral teeth, a third specimen (Pl. 15, fig. 10) possibly a lower lateral while a fourth, of only 2 crownlets, cannot be placed in the jaw. One incomplete crown (Pl. 15, fig. 10) consists of a primary cusp with 2 basal denticles—a fracture surface suggests that there were more—and the first crownlet. Both cusp and crownlet are relatively broad, not markedly attenuated and with the cusp about half as high again as the crownlet. The other incomplete crown (Pl. 15, fig. 8) consists of only the primary cusp with 4 basal denticles on the mesial margin. The largest basal denticle is nearly twice the size of the first. The distal portion of a tooth (Pl. 15, fig. 9) has 5 crownlets which evenly decrease in size distally. The root is flat labially with an angular longitudinal ridge on the lingual face about two-thirds up from the base; basal margin very thin labio-lingually.

*Discussion.* The relatively large, broad primary cusps and crownlets differentiates these fragments from those of both *Hexanchus* and *Heptranchias*. They can be further separated from *Hexanchus* by the relative size difference of the primary cusp and first crownlet; the presence of basal denticles on the mesial margin and cusps and crownlets being more or less straight. In contrast, in *Hexanchus*, the size of the primary cusp is nearer that of the first crownlet; the mesial margin is serrated rather than denticulated and the cusps and crownlets are slightly curved. Additional features separating the fragments from *Heptranchias* are the smallest basal denticle being only about half the size of the biggest and crownlets evenly decreasing in size distally. In contrast, in *Heptranchias*, the smallest basal denticle is only about one-fifth the size of the biggest and the

last one or two crownlets decrease rapidly in size from the third or fourth last.

The shape and dimensions of the 2 crownlets of the fourth specimen are conspecific with the other four fragments. All the fragments differ from the extant *N. cepedianus* in their more erect cusp and crownlets. On the basis of the broad, robust and only slightly oblique cusp and crownlets the specimens are assigned to Agassiz's *N. primigenius*. Chapman's (1918) emended description of the lectotype of *Notidanus marginalis* Davis, 1888 is based on an incomplete lateral tooth of a notorynchid. In the figure of the lectotype the primary cusp, which is missing, has been drawn in as a dotted outline, but of a slightly smaller size than the first crownlet. It appears that this interpretation forms the basis for his differentiation (Chapman, 1918: 5) '*N. marginalis* differs essentially in the almost equal size of the two anterior cones, those of *N. primigenius* and *N. serratissimus* being graduated'. Such a character is not found in any hexanchid and as all the characters of the lectotype—the basal denticles showing a small size range and the 6 relatively broad, robust, slightly oblique crownlets decreasing evenly in size distally—are typical of *Notorynchus primigenius*, *Notidanus marginalis* is here included in that species.

*Distribution.* *Notorynchus primigenius* is a widespread fossil species ranging from the Middle Eocene through to the Pleistocene. In Europe it is recorded from the Middle Eocene, Lower Oligocene, Miocene and Pliocene of Belgium (Leriche, 1905, 1910, 1926), from the Miocene of France (Leriche, 1957, Cappetta, 1970), from the Upper Miocene of Portugal as *Hexanchus* cf. *griseus* (Antunes and Jonet, 1969) and from the Middle Eocene, Miocene and Pleistocene of England (Woodward, 1886). Davis (1888) and Chapman (1918) note its presence in the Miocene of New Zealand under the name *Notidanus marginalis*.

The occurrence of *Notorynchus primigenius* in the Lower Miocene Batesford Limestone and the Middle Miocene Muddy Creek Formation is the first record of the species from the Australian Tertiary deposits.

### Addendum

A jaw of a notorynchid shark (specimen with no number labelled "Cook Strait, *Hexanchus raberi*, 9.5.1944") seen recently in the National Museum, Wellington, New Zealand has the dental formula:

P10—L7—M4—L7—P14.

P11—L6—M1—L6—P10

This occurrence of a *Notorynchus cepedianus* with 4 medial teeth in the upper jaw, outside the Californian coast region, does suggest that such a difference may be due only to individual variation within the species.

A fossil tooth from South Australia recently to hand and referable to *Hexanchus agassizi* Cappetta has been noted by Pledge (pers. comm.; Pledge, N.S., 1977. *Metasqualodon harwoodi* (Sanger, 1887.—A redescription. Rec. S. Aust. Mus. Adelaide, 17 (17): 285-297, 3 Figs). The tooth (SAM P10867) from the River Murray Cliffs near Wellington is a lower lateral, 20 mm long and 9.4 mm high with 10 crownlets which decrease evenly in size distally and a primary cusp with a denticulated mesial margin. Pledge (1977) shows it to be from the Ettrick Formation which is of Late Oligocene age. This then is the youngest occurrence of *H. agassizi* so far on record.

### Acknowledgements

The author wishes to thank Dr O. P. Singleton, University of Melbourne for suggesting the initial project which was the basis of a M.Sc. thesis under his supervision and from which the present study arose. The following people greatly assisted by allowing access to or loan of specimens in their care: Miss J. M. Dixon, National Museum of Victoria; Mr T. F. Flannery, Beaumaris, Victoria; Mr J. M. Lindsay, Department of Mines, South Australia; Dr J. R. Paxton, Australian Museum, Sydney; Mr N. S. Pledge, South Australian Museum, Adelaide and Dr T. H. Rich, National Museum of Victoria. Appreciation is expressed to those who donated specimens, photographs or supplied information especially Dr J. A. Bass previously Oceanographic Research Institute, Durban, South Africa; Dr H. Cappetta, Lab-

oratoire de Paléontologie, Montpellier, France and Mr B. J. Welton previously University of California, Berkeley, U.S.A. and now Natural History Museum, Los Angeles, U.S.A. as well as Mrs L. Bushell, Macleay Museum, University of Sydney, N.S.W.; Mr M. J. Cooper, University of Melbourne; Mr T. A. Darragh, National Museum of Victoria; Professor J. A. F. Garrick, Victoria University of Wellington, New Zealand; Dr. D. F. Hoese, Australian Museum, Sydney; Mr J. M. Morland, National Museum of New Zealand, Wellington; Mr S. Springer, previously Bureau of Commercial Fisheries, U.S.A.; Dr V. G. Springer, United States National Museum, Washington; Mr G. A. Tunnicliffe, Canterbury Museum, Christchurch, New Zealand; Mr D. Ward, London, U.K.; Mr B. F. Webb, Marine Research Laboratories, Taroona, Tasmania and Mr A. Wheeler, British Museum (Natural History), London. Radiographs of two sharks were kindly made by Dr A. J. McIntosh, Hobart, Tasmania and Mr B. Munday, Department of Agriculture, Launceston, Tasmania carried out the pathological examination of the shark skin. Thanks are also due to Mr R. F. Durham, Black Rock, Victoria for his constant enthusiasm and assistance in the initial stages of the photography. Acknowledgement is gratefully made to the Director and Trustees of the Tasmanian Museum for the use of the Museum's time and facilities.

### References

- ABELE, C. *et al.*, 1976. Tertiary. In Douglas, J. G. and Ferguson, J. A. (Eds.) *Geology of Victoria*: i-xi, 1-528. Geological Society of Australia, Special Publication No. 5. Melbourne.
- AGASSIZ, L. J. R., 1833-1844. *Research sur les poissons fossiles*. 3: i-viii, 1-390, Atlas: 1-34, 83 pls. Neuchâtel.
- ANTUNES, M. T. and JONET, S., 1969. Requins de l'Helvétien supérieur et du Tortonien de Lisbonne. *Rev. Fac. Ciênc. Lisboa*, (2, C) 16 (1): 119-280, 14 Figs., 20 pls.
- APPLEGATE, S. P., 1965a. Tooth terminology and variation in sharks with special reference to the sand shark *Carcharias taurus* Rafinesque. *Contr. Sci., Los Angeles Co. Mus.* 86: 1-18, 5 Figs.
- , 1965b. A confirmation of the validity of *Notorhynchus pectinatus*; the second record of this Upper Cretaceous cowshark. *Bull. Sth. Calif. Acad. Sci.* 64, (3): 122-126, 1 Fig.
- and T. UYENO, 1968. The first discovery of a fossil tooth belonging to the shark genus *Heptranchias*, with a new *Pristiophorus* spine, both from the Oligocene of Japan. *Bull. Nat. Sci. Mus. Tokyo* 11(2): 195-200, 1 pl.
- AYRES, W. O., 1855. *Notorhynchus maculatus*—Ayres. *Proc. Calif. Acad. Sci.* 1: 76-77.
- BASS, A. J., J. D. D'AUBREY and N. KISTINASAMY, 1975. Sharks of the east coast of southern Africa. v. The families Hexanchidae, Chlamydoselachidae, Heterodontidae, Pristiophoridae and Squatinidae. *Invest. Rep. oceanogr. Res. Inst., Durban* (43): 1-50, 8 pls.
- BIGELOW, H. B. and W. C. SCHROEDER, 1948. Fishes of the Western North Atlantic, I. Lancelets, Cyclostomes, Sharks. *Mem. Sears. Fdn. mar. Res., New Haven*, 1: 1-576, 106 Figs.
- BONNATERRE, J. P., 1788. *Tableau encyclopédique et méthodique, Ichthyologie*. Paris: i-vi, 1-215, 102 pls.
- CAPPETTA, H., 1970. Les sélaciens du Miocène de la région de Montpellier. *Mem. Ext. Palaeovertebrata, Montpellier*: 1-139, 22 Figs.: 1-19, 27 pls.
- , 1975. Sélaciens et Holocéphale du Gargasien de la région de Gargas (Vaucluse). *Géol. Méditerran.*, Aix-en-Provence, 2(3): 115-134, 10 Figs., 2 pls.
- , 1976. Sélaciens nouveaux du London Clay de l'Essex (Ypresien du Bassin de Londres). *Geobios*, Lyon, 9(5): 551-575, 1 Fig., 4 pls.
- CASIER, E., 1966. Faune ichthyologique du London Clay. *Brit. Mus. (Nat. Hist.)*: 1-496, 82 Figs., 68 pls.
- CASTELNAU, F. L., 1872. Contribution to the ichthyology of Australia. *Proc. Zool. Acclim. Soc. Vict.* 1: 29-248.
- CHAPMAN, F., 1914. *Australasian Fossils*: 1-341, 150 Figs. Melbourne.
- , 1918. Descriptions and revisions of the Cretaceous and Tertiary fish-remains of New Zealand. *Palaeont. Bull.*, Wellington, 7: 1-45, 9 pls.
- CLEMENTS, W. A. and G. V. WILBY, 1946. Fishes of the Pacific Coast of Canada. *Bull. Fish. Res. Bd. Can.* 68: 1-368, 253 Figs.
- DAVIS, J. W., 1888. The fossil fish remains from the Tertiary Formations of New Zealand. *Sci. Trans. R. Dubl. Soc.*, Dublin (2), 4: 1-48, 7 pls.
- DAY, F., 1878. *The fishes of India*. London, 1: 1-778, 2, 198 pls.
- FOWLER, H. W., 1941. Contributions to the biology of the Philippine Archipelago and adjacent regions. *Bull. U.S. natn. Mus.*, Washington, (100) 13: 1-879.
- GARMAN, S., 1884. A species of *Heptranchias* supposed to be new. *Bull. Essex. Inst.* 16: 56-57.
- , 1913. The Plagiostomia (Sharks, Skates and Rays). *Mem. Mus. Comp. Zool. Harvard* 36: 1-528, 77 pls.

- GARRICK, J. A. F. and L. J. PAUL, 1971. *Heptranchias dakini* Whitley, 1931, a synonym of *H. perlo* (Bonnaterre, 1788), the sharpsnouted sevengill or Perlon shark, with notes on sexual dimorphism in this species. *Zoology Publs. Vict. Univ. Wellington* 54: 1-14.
- GILL, T., 1864. Second contribution to the Selachology of California. *Proc. Acad. nat. Sci. Philad.* 16: 147-151.
- GRAHAM, D. H., 1953. *A treasury of New Zealand fishes*. Wellington: 1-404.
- GUDGER, E. W., 1937. Abnormal dentition in sharks, Selachii. *Bull. Am. Mus. nat. Hist.*, New York, 72(2): 249-280, 21 Figs.
- GÜNTHER, A., 1870. Subclass IV. Chondropterygii. In: Catalogue of the Phystomi, containing the families Gymnotidae, Symbranchidae, Muraenidae, Pegesidae, and of the Lophobranchii, Plectognathi, Dipnoe, Ganoidei, Chondropterygii, Cyclostomata, Leptocardii, in the British Museum. London: 1-549.
- HASWELL, W. A., 1880. Notes on *Galeocерdo rayneri* with a list of other sharks taken in Port Jackson. *Proc. Linn. Soc. N.S.W.* 5: 95-97, 1 pl.
- , 1884a. Studies on the elasmobranch skeleton. *Proc. Linn. Soc. N.S.W.* 9(1): 71-119, 1 pl.
- , 1884b. Note on the claspers of *Heptanchus*. *Proc. Linn. Soc. N.S.W.* 9(2): 381-382, 1 pl.
- HERALD, E. S., 1951. The relative abundance of sharks and bat stingrays in San Francisco Bay. *Calif. Fish Game* 37(3): 315-329.
- HOOIJER, D. A., 1954. Pleistocene vertebrates from Celebes. Elasmobranch. *Proc. K. Ned. Akad. Wet.*, Leiden, (B), 57: 475-485, 2 pls.
- HUTTON, F. W., 1873. Contributions to the ichthyology of New Zealand. *Trans. N.Z. Inst.* 5: 259-272.
- Johnston, R. M., 1882 (1883). The fishes of Tasmania. *Pap. R. Soc. Tasm.*: 54-153.
- , 1890 (1891). Further observations upon the fishes and fishing industries of Tasmania, together with a revised list of indigenous species. *Pap. R. Soc. Tasm.*: 22-46.
- JORDAN, D. S., 1907. The fossil fish of California with supplementary notes on other species of extinct fishes. *Univ. Calif. Publs. Bull. Dep. Geol.*, Berkeley, 5(7): 95-144, 2 pls.
- and B. W. EVERMANN, 1896. The fishes of North and Middle America. *Bull. U.S. natn. Mus.*, Washington, 47(1): I-LX, 1-1240.
- , 1900. The fishes of North and Middle America. *Bull. U.S. natn. Mus.*, Washington, 47(4): I-CI, 3137-3313, 392 pls.
- KATO, S., S. SPRINGER and M. H. WAGNER, 1967. Field guide to Eastern Pacific and Hawaiian sharks. *Circ. Fish Wildl. Serv. Wash.* 271: 1-47, 75 Figs.
- KEMP, N. R., 1970. *Studies on the dentition of Australian Tertiary and Recent sharks*. Unpublished M.Sc. thesis, University of Melbourne: 1-354, 63 pls.
- LAHILLE, F., 1913. Nota sobre los géneros *Heptranchias* y *Hexanchus*. *An. Mus. nac. B. Aires*. 18: 25-32. 3 Figs., 2 pls.
- , 1928. Nota sobre unos peces elasmobranchios. *An. Mus. nac. B. Aires* 34: 299-340, 27 Figs., 5 pls.
- LERICHE, M., 1905. Les poissons éocène de la Belgique. *Mem. Mus. r. Hist. nat. Belg.*, Bruxelles, 3(11): 49-228, 9 pls.
- , 1910. Les poissons oligocènes de la Belgique. *Mem. Mus. r. Hist. nat. Belg.*, Bruxelles, 5: 229-363, 27 pls.
- , 1926. Les poissons néogène de la Belgique. *Mem. Mus. r. Hist. nat. Belg.*, Bruxelles, 32: 368-472, 14 pls.
- , 1927. Les poissons de la Molasse suisse. *Abh. Schweiz. paläont. ges.*, Basel, 46: 1-56, 7 pls., 47: 57-120, 7 pls.
- , 1957. Les poissons néogènes de la Bretagne de l'Anjou et de la Touraine. *Mem. Soc. geol. Fr.*, Paris, (5) 81: 1-64, 4 pls.
- LYNCH, D. D., 1963. First Australian record, *Hexanchus griseus* (Bonnaterre, 1780). The Six-gilled Shark. *Mem. Natn. Mus. Vict.* 26: 259-260, 1 pl.
- McCoy, F., 1880. *Prodromus Zool. Vict.*, Melbourne 5: 1-58, 10 pls.
- MCCULLOCH, A. R., 1911. Report on the fishes obtained by the F.I.S. 'Endeavour' on the coasts of New South Wales, Victoria, South Australia and Tasmania. *Zool. Res. Endeavour* 1(1): 1-87, 26 pls.
- , 1919. Check-list of the fish and fish-like animals of New South Wales. Part i. *Austr. Zool.* 1(7): 217-229, 3 pls.
- , 1929. A check-list of the fishes recorded from Australia. *Aust. Mus. Mem.* 5(1): 1-144.
- MACDONALD, J. D., 1873. A communication . . . containing descriptions of two sharks taken off Flinders Island, Bass's Straits, during the voyage of H.M.S. 'Herald' in the South Seas. *Proc. Zool. Soc. (Lond.)*: 312.
- MACDONALD, J. D. and C. BARRON, 1868. Notes on *Heptranchus indicus*, chiefly as regards sexual characters. *Proc. Zool. Soc. (Lond.)*: 371-373, 1 pl.
- MÜLLER, J. and F. G. HENLE, 1841. *Systematische Beschreibung der Plagiostomen*. Berlin: i-xxii, 1-200, 60 pls.
- MUNRO, I. S. R., 1956. Handbook of Australian fishes. *Fisheries Newsletter, Australia*, 1: 1-8, 56 Figs.
- OGILBY, J. D., 1889. List of the Australian *Palaeichthyas*, with notes on their synonymy and distribution. *Proc. Linn. Soc. N.S.W.* 4(1): 178-186.
- , 1897. New genera and species of Australian fishes. *Proc. Linn. Soc. N.S.W.* 22(1): 62-95.

- PARROTT, A. W., 1958. *Big game fishes and sharks of New Zealand*: 1-127. London.
- PATTERSON, C., 1967. Classes Selachii and Holocephali. In W. B. Harland *et al.* (Eds.) *The Fossil Record*. London (Geological Society): 666-675.
- PERON, F., 1807. *Voyage de Decouverts Aux Terres Australes*. 1: 1-496. Paris.
- PEYER, B., 1968. *Comparative Odontology*. R. Zangerl, Trans. and Ed.: 1-347, 95 pls. Chicago and London.
- PHILLIPS, W. J., 1924. A review of the elasmobranch fishes of New Zealand, *N.Z. J. Sci. Tech.* 6(5-6): 257-269, 14 Figs.
- , 1935. Sharks of New Zealand; No. 4, *N.Z. J. Sci. Tech.* 16: 236-241, 3 Figs.
- PLEDGE, N. S., 1967. Fossil elasmobranch teeth of South Australia and their stratigraphic distribution. *Trans. R. Soc. S. Aust.* 91: 135-160, 4 pls.
- RAFINESQUE, C. S., 1810. *Caratteri di alcuni nuovi generi e nuovi specie de animali (Presci) . . . della Sicilia*: 1-105, 20 pls. Palerme.
- REED, M. D., 1946. A new species of fossil shark from New Jersey. *Notul. Nat.*, Philadelphia, 172: 1-3, 1 pl.
- SADOWSKY, V., 1970. First record of broad-snouted seven-gilled shark from Cananéia, coast of Brazil. *Bolm Inst. oceanogr. S. Paulo* 18(1): 33-35, 1 Fig.
- SCOTT, T. D., 1962. *The marine and fresh water fishes of South Australia*. Adelaide: 1-338.
- , C. J. M. GLOVER and R. V. SOUTHCOTT, 1974. *The marine and fresh water fishes of South Australia*. Adelaide: 1-392.
- SPRINGER, S. and R. A. WALLER, 1969. *Hexanchus vitulus*, a new sixgill shark from the Bahamas. *Bull. mar. Sci.* 19(1): 159-174.
- SPRINGER, V. G. and J. A. F. GARRICK, 1964. A survey of vertebral numbers in sharks. *Proc. U.S. natn. Mus.*, Washington, 116: 73-96.
- TENORE, M., 1810. Sopra una nuova specie di Squadro pescato nelle acque della riviera di Chiaja del litorale di Napoli. *Mem. Acad. Pont.* Naples, 1: 241-265.
- WAITE, E. R., 1907. A basic list of the fishes of New Zealand. *Rec. Cantab. Mus.*, Christchurch, 1: 3-39.
- , 1921. Catalogue of the fishes of South Australia. *Rec. S. Aust. Mus.*, Adelaide, 2: 1-208, 332 Figs., 1 pl.
- , 1923. *The Fishes of South Australia*. Adelaide: 1-243.
- WALDMAN, M., 1971. Hexanchid and orthacodontid shark teeth from the Lower Tertiary of Vancouver Island, British Columbia. *Can. J. Earth Sci.* 8(1): 166-170.
- WELTON, B. J., 1974. *Heptranchias howellii* (Reed, 1946) (Selachii: Hexanchidae) in the Eocene of the United States and British Columbia. *Paleobios*, Berkeley, Calif., 17: 1-15, 2 Figs., 2 pls.
- WHITLEY, G. P., 1931a. New names for Australian fishes. *Austr. Zool.* 6: 310-334, 1 Fig., 3 pls.
- , 1931b. Studies in ichthyology, No. 5 *Rec. Austr. Mus.*, Sydney, 18(4): 138-160, 2 Figs., 2 pls.
- , 1934. Notes on some Australian sharks. *Mem. Qd. Mus.*, Brisbane, 10(4): 180-200, 4 Figs., 3 pls.
- , 1940. *The fishes of Australia. Part 1. The sharks, rays, devil fish and other primitive fishes of Australia and New Zealand*. Sydney (Royal Zoological Society): 1-280, 302 Figs.
- , 1968. A check-list of the fishes recorded from the New Zealand region. *Austr. Zool.* 15(1): 1-102.
- WOODWARD, A. S., 1886. On the palaeontology of the Selachian genus *Notidanus* Cuvier. *Geol. Mag.*, London (3) 3: 205-217, 253-259, 1 pl.
- ZEITZ, A. A synopsis of the fish of South Australia. Part 1 *Trans. R. Soc. S. Aust.* 32: 288-293.

### Explanation of Plates

All photographs by the author

#### PLATE 12

Figures 1-4—*Hexanchus griseus* (Bonnaterre). Teeth *in situ* of 4250 mm specimen from N.S.W. (AMS I19110-001).

1. Photomontage of labial view of replacement series of right side of upper and lower jaws including medial rows of left side of upper jaw and lower medial row. Functional series of upper jaw is seen inciso-lingually.
2. Incisal and labial views of functional series of medial rows of upper jaw. Note basal denticles on medial margin especially of first right medial row (x1).
3. Labial view of replacement series of medial rows of upper jaw. Note large basal denticles on distal margins of first right (apex of crown broken) and second left medial teeth. First left row is almost obscured due to shrinkage of jaw in symphyseal region (x1).
4. Lower medial replacement row. Note first tooth with bifurcated central cusp while second tooth has no central cusp (x1).

Figure 5—*Hexanchus vitulus* (Springer and Waller). Labial view of teeth of 1550 mm male from Natal, South Africa; right side of upper and lower jaws including lower medial tooth. From Bass *et al.*, 1975, with permission.



## PLATE 13

Figure 1—*Heptranchias perlo* (Bonnaterre). Labial view of teeth of 887 mm female from N.S.W.; right side of upper and lower jaws including lower medial tooth; posteriors, except for first upper, are not shown (TM D1247).

Figure 2—*Notorynchus cepedianus* (Péron). Labial view of teeth of right side of upper and lower jaws including upper central and lower medial teeth; posteriors, except for first upper, are not shown (NMV).

## PLATE 14

Figures 1-3—*Notorynchus cepedianus* (Péron).

1. Symphyseal area of upper jaw of specimen from California, U.S.A. showing medial and first lateral rows. Note two medial rows on either side of symphysis (TM D1303) (x1.5).
2. Symphyseal area of upper jaw of specimen—topotype—from Storm Bay, S.E. Tasmania showing medial and first lateral rows. Note central medial row on the symphysis (TM D1291) (x2).
3. Abnormal, bifid tooth of first lateral row of lower jaws (NMV) (x2).

Figures 4-11—*Hexanchus agassizi* (Cappetta).

- 4-8 From Naracoorte No. 5 Bore, 135-145 m (x2).
4. Upper lateral, labial face, lingual face (SAM P19552a).
5. Upper lateral, labial face, lingual face (SAM P19552b).
6. Upper lateral, labial face, lingual face (SAM P19552c).

7. Lower lateral, labial face, lingual face (SAM P19552d).
8. Lower lateral, labial face, lingual face (SAM P19552e).
9. Lower lateral, labial face, lingual face. Blanche Point Marl (RJFJ no. 121a) (x2).
- 10-11. Lower lateral, Blanche Point Marl (RJFJ no. 121b).
10. Labial face, lingual face (x2).
11. Labial face; note basal denticle on first crownlet (x12).

## PLATE 15

(all teeth x2)

Figures 1-3—*Hexanchus agassizi* Cappetta.

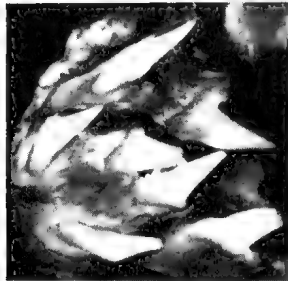
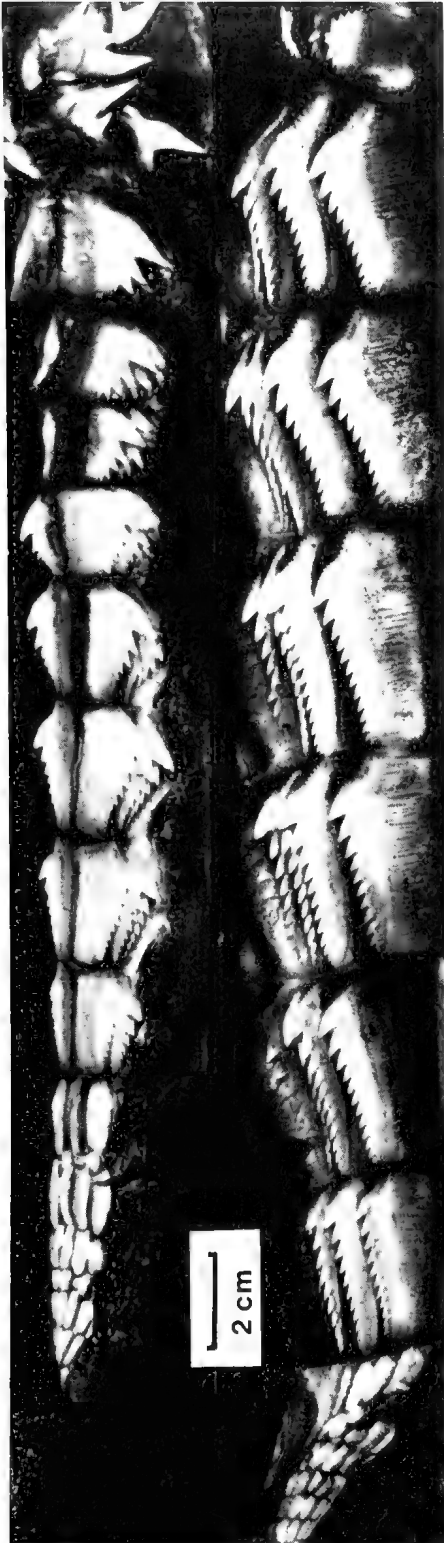
1. Lower lateral, labial face, lingual face, Naracoorte No. 5 Bore, 135-145 m (SAMD V34).
2. Lower lateral, labial face, lingual face, Blanche Point Marl (UAGD F17262).
3. Lower lateral, labial face, lingual face, London Clay, Isle of Sheppey, U.K.; for comparison (NRK).

Figures 4-7—*Heptranchias howelli* (Reed). Lower laterals, labial face, lingual face, Blanche Point Marl.

4. (SAM P19572).
5. (UAGD F172284a).
6. (UAGD F17284b).
7. (SAM P19573).

Figures 8-10—*Notorynchus primigenius* (Agassiz). Lower laterals, labial face, lingual face.

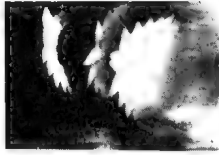
8. Muddy Creek Marl (TFF).
9. Batesford Limestone (NMV P27411).
10. Batesford Limestone (NMV P27410).



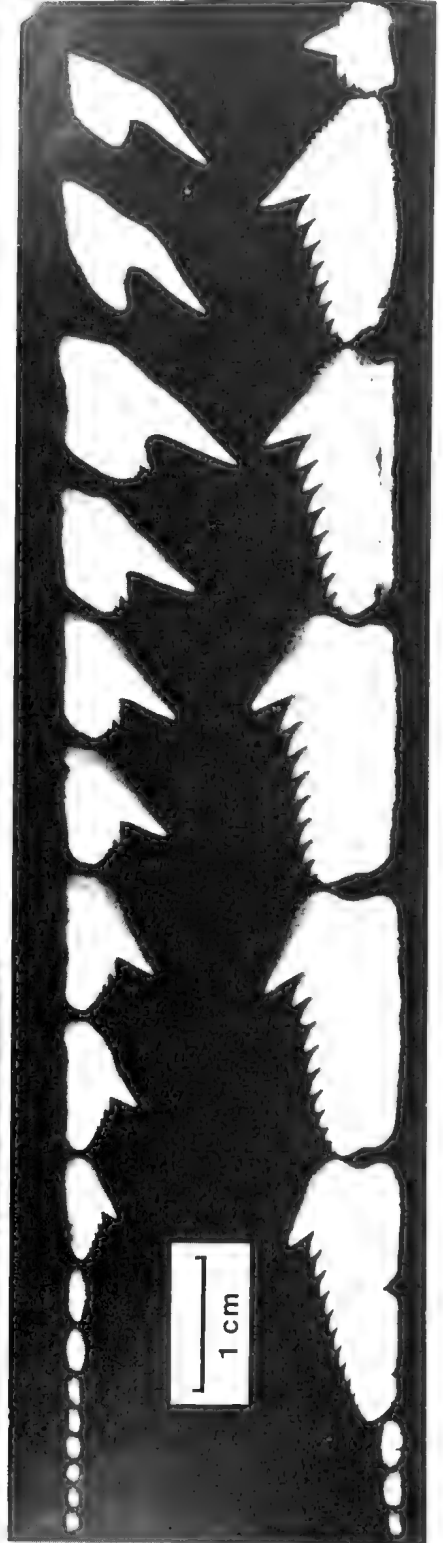
2



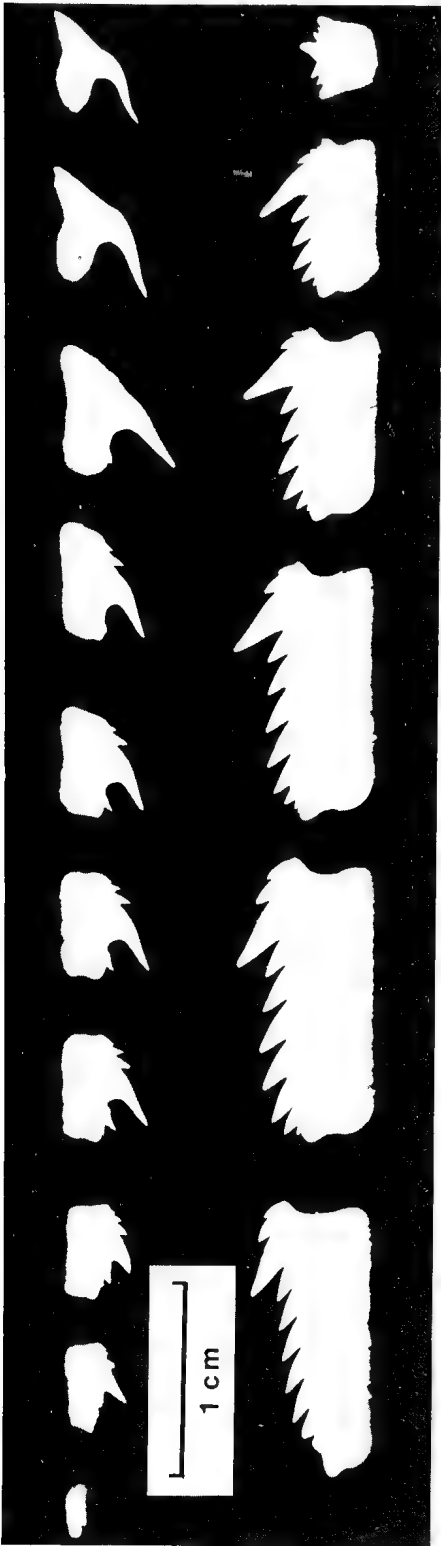
3



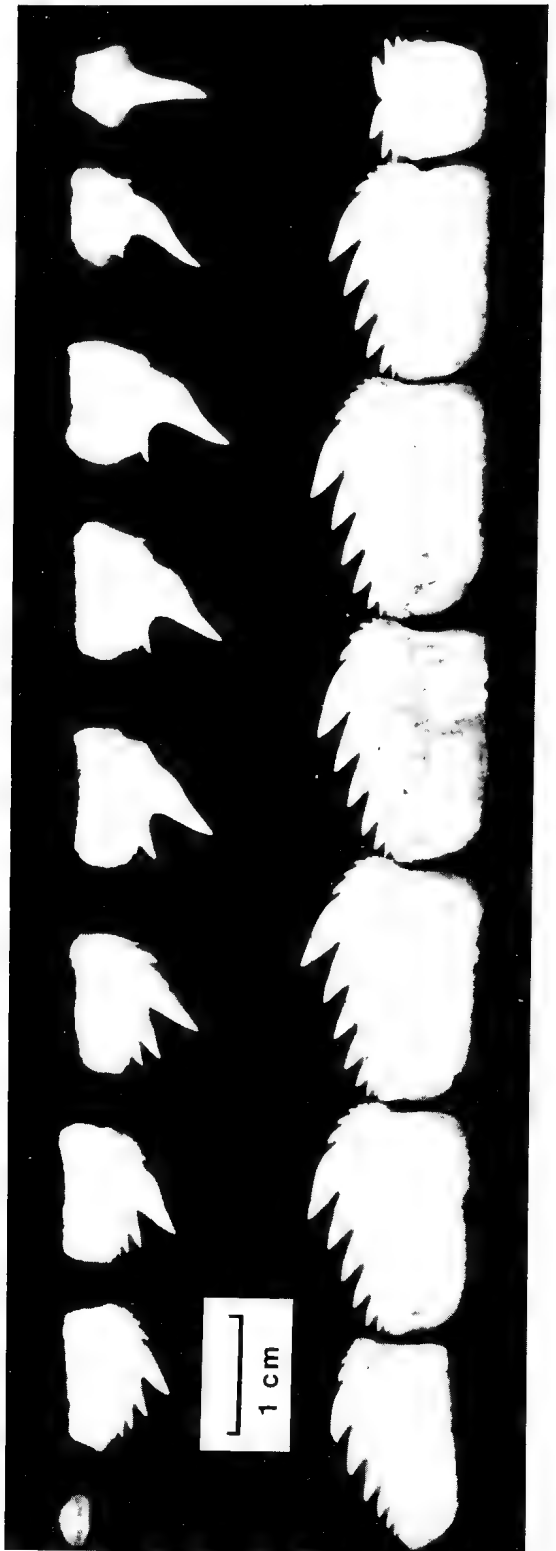
4



1



2



1



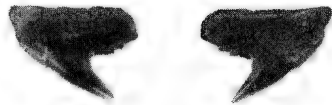
3



2



4



5



6



7



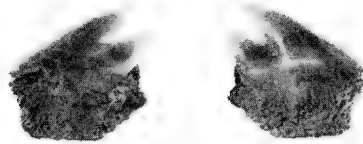
8



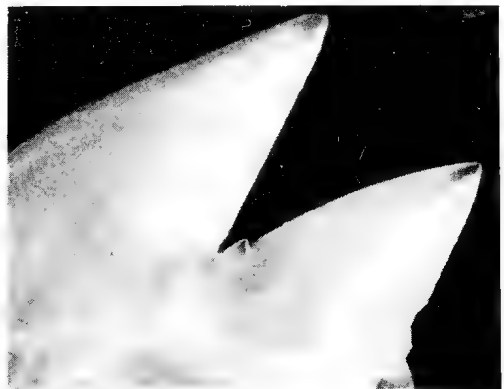
9



10

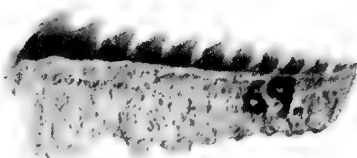


11





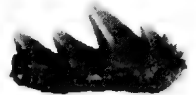
1



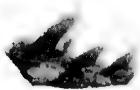
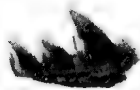
2



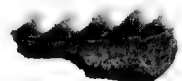
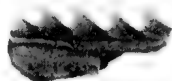
3



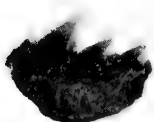
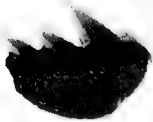
4



5



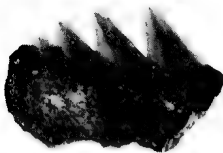
6



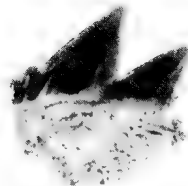
7



8



9



10



*RAEMEOTHERIUM YATKOLAI*, gen. et sp. nov.,  
A PRIMITIVE DIPROTODONTID FROM THE MEDIAL MIOCENE  
OF SOUTH AUSTRALIA

By THOMAS H. RICH,<sup>1</sup> MICHAEL ARCHER,<sup>2</sup> and RICHARD H. TEDFORD<sup>3</sup>

<sup>1</sup> National Museum of Victoria

<sup>2</sup> Queensland Museum, Brisbane

<sup>3</sup> American Museum of Natural History, New York

### Abstract

A new genus and species, *Raemeotherium yatkolai*, from the medial Miocene Namba Formation in South Australia, is the most primitive member of the Diprotodontidae yet described. On its most anterior lower molar is a well-developed paracristid and protocristid. This, together with a strong cristid obliqua on all lower molars suggests derivation of diprotodontids from selenodont rather than quadritubercular ancestors.

### Introduction

In September 1976, Mr Ian Stewart (National Museum of Victoria) discovered the diprotodontid dentary here described as *Raemeotherium yatkolai* (SAM P19764). It was found at the south end of Lake Pinpa, South Australia, in the medial Miocene Namba Formation. Only one or two centimetres away at the same level was a mandible of a species of pseudocheirine similar generically to that Tedford *et al.* (1976, p. 56) characterized as '... the most abundant mammal in the Pinpa Fauna . . .', (NMV P48616, see pl. 16, fig. 10).

Three additional isolated teeth referred to *Raemeotherium yatkolai* were collected ten kilometres to the south on the west side of Lake Namba at a site in the Namba Formation designated as South Prospect B by Woodburne and Tedford (1975). A single isolated upper incisor of *R. yatkolai* was found at Ericmas Quarry, four kilometres to the north on the west side of the same lake, again in the Namba Formation.

Callen and Tedford (1976, p. 135) and Tedford *et al.* (1977, pp. 56-57) discuss the basis for assigning a medial Miocene age to the Namba Formation.

### Abbreviations

AM Australian Museum, Sydney.  
AMNH American Museum of Natural History, New York.  
BMNH British Museum (Natural History), London.

NMV National Museum of Victoria, Melbourne.  
SAM South Australian Museum, Adelaide.

### Terminology and Measurements

Mandibular terminology follows Stirton (1967), dental terminology is modified from Archer (1976) (see fig. 1), and enumeration of the teeth follows Archer (in press) (see fig. 1, 2). The system of tooth enumeration used here departs radically from all previously proposed. In it, the permanent cheek teeth of diprotodontids are P3, M2, M3, M4, M5. In contrast, in the two systems previously employed by Twentieth Century authors, the same teeth are designated P3 or P4, M1, M2, M3, M4.

Measurements were made with a Wild microscope equipped with a mechanical stage, enabling an accuracy of 0.1 millimetres.

### Systematics

The following diagnoses are not intended to be exhaustive at each taxonomic level, but rather are restricted to those features which can be observed on the type and referred specimens of *Raemeotherium yatkolai*.

Class MAMMALIA Linnaeus, 1758  
Subclass THERIA Parker and Haswell, 1897  
Infraclass METATHERIA Huxley, 1880

Superorder Marsupialia Illiger, 1811  
Order Diprotodonta Owen, 1866  
Family Diprotodontidae Gill, 1872

*Diagnosis:* Distinguished from all other Marsu-

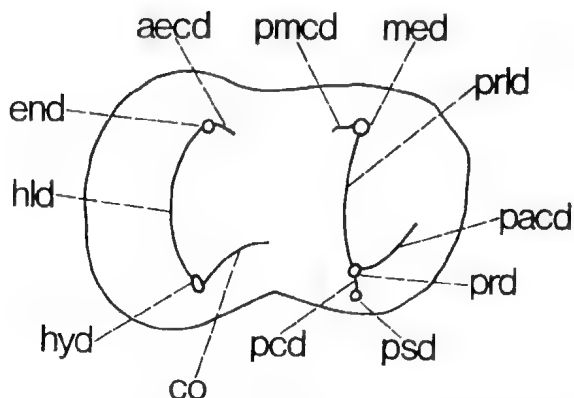


Figure 1—Schematic diagram of diprotodontid lower molar showing terminology employed. Abbreviations: aecd, anterior entocristid; co, cristid obliqua; end, entocristid; hld, hypolophid; hyd, hypoconid; med, metaconid; pacd, paracristid; pcd, protocristid; pmcd, posterior meta-cristid; prd, protoconid; prld, protolophid; psd, protostylid. Modified from Archer (1976).

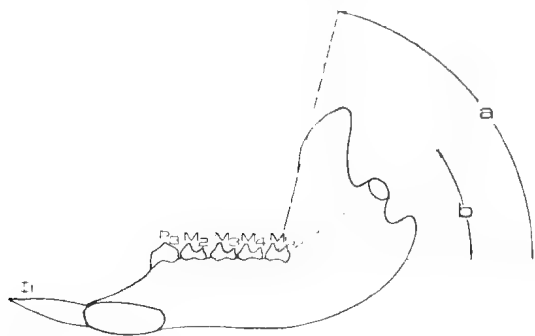


Figure 2—Schematic diagram of a diprotodontid mandible illustrating system of numbering teeth employed in this paper and method of measuring inclination of anterior border of ascending ramus (angle *a*) and elevation of condyle (angle *b*).

pialia by the presence of four simultaneously functional bilophodont molars lacking fore and midlinks and absence of a masseteric canal in the dentary.

Subfamily Zygomaturinae Stirton, Woodburne, and Plane 1967.

**Diagnosis:** Most members, including *Raemetherium yatkolai*, distinguished from all other diprotodontids by the presence of a distinct paracristid on  $M_2$ .

### *Raemetherium* gen. nov.

**Type species:** *Raemetherium yatkolai* sp. nov.

**Known distribution:** Medial Miocene, Tarkarooloo Basin, South Australia.

**Diagnosis:** Distinguished from all other diprotodontids by the presence of a distinct crest, the protocristid, directed buccally from the protoconid on  $M_2$ ; a well-developed anterior entocristid on  $M_{2-5}$ ; and the ascending ramus more recumbent than in other species.

**Etymology:** RAEME, acronym for the Royal Australian Electrical and Mechanical Engineers; *θηριον*, Greek, beast.

### *Raemetherium yatkolai* sp. nov.

Plate 16, figures 1-5, 7, 8, 11)

**Holotype:** SAM P19764, right dentary fragment with  $I_1$ ,  $M_{2-5}$ , and alveoli for  $P_3$ . It lacks the  $P_3$ , condyle, and angular region and has been crushed in a mediolateral direction so that traces of many structures on the medial side such as the digastric fossa have been obliterated.

**Type locality and stratigraphic position:** Namba Formation, southwest corner of Lake Pinpa, grid zone 6, grid reference 317146 on the Curnamona topographic series SH 54-14, 1: 250,000 (1965, South Australia),  $31^{\circ} 8\frac{1}{2}'S$ ,  $140^{\circ} 13'E$ .

**Diagnosis:** That of the genus until other species are described.

**Etymology:** Named in honour of the late Mr Daniel A. Yatkola, a student of mammalian palaeontology.

**Referred specimens:** NMV P48537, isolated right  $M_4$  or  $M_5$ . NMV P48538, isolated right  $I^3$ . AMNH 102186, isolated left  $M_4$ . Collected from the Namba Formation, South Prospect B, Lake Namba, grid zone 6, grid reference 320135, Curnamona topographic series SH 54-14, 1:250,000 (1965, South Australia),  $31^{\circ} 14'S$ ,  $140^{\circ} 14'E$ . They were found in the white coloured unit described by Woodburne and Tedford (1975, p. 3) as a '... very fine sand ...', developed as lenses within the '... thin-bedded black claystone ...', at South Prospect B.



AMNH 102183, isolated right I<sup>3</sup>. Collected from the Namba Formation, Ericmas Quarry, Lake Namba, grid zone 6, grid reference 320140, Curnamona topographic series SH 54-14, 1:250,000 (1965, South Australia), 31° 12'S., 140° 14'E. It was found in a channel deposit formed of white quartzose sand containing green limonite-cemented clayballs.

TABLE 1

Measurements (mm) of lower molars of *Raemetherium yatkolai*

	Length	Width Anterior Moiety	Width Posterior Moiety
SAM P19764			
M <sub>2</sub>	10.7	5.9	6.7
M <sub>3</sub>	11.0	6.5	7.4
M <sub>4</sub>	11.1	7.1	7.1
M <sub>5</sub>	11.2	7.2	7.0
NMV P48537			
M <sub>4</sub> or M <sub>5</sub>	11.0	7.6	7.3
AMNH 102186			
M <sub>4</sub> or M <sub>5</sub>	11.0	7.7	7.8

TABLE 2

Measurements (mm) of the mandible of SAM P19764, type specimen of *Raemetherium yatkolai*

Length, diastema I <sub>1</sub> -P <sub>3</sub> : 15 <sup>a</sup>
Depth, horizontal ramus at anterior end of P <sub>3</sub> : 19.0
Depth, horizontal ramus at middle of M <sub>2</sub> : 25 <sup>a</sup>
Depth, horizontal ramus at middle of M <sub>4</sub> : 26 <sup>a</sup>
Length, M <sub>2-5</sub> : 44.2 <sup>a</sup>

<sup>a</sup> = approximately.

### Description

**Mandible:** The mandible is remarkably delicate compared with other diprotodontids and in this respect resembles those of similar-sized macropodids. The diastema between I<sub>1</sub> and P<sub>3</sub> is only about a third the length of the lower molar row. In outline, the symphysis is almost elliptical. Its major axis is about 25 mm in length and dips posteriorly at an angle of 35° with respect to the dorsal edge of the horizontal ramus. Its posterior edge is below the posterior root of P<sub>3</sub>. The length of the minor axis is 13 mm. The surface of the symphysis is rough and there is no indication of its having been fused with the left mandible. The genial pit, for

the insertion of the geniohyoideus muscle, disrupts the outline of the symphysis at its posterior end as a notch of smooth bone. The mental foramen is located 1.7 mm anterior of the anterior edge of P<sub>3</sub>, and 8.1 mm below the dorsal edge of the horizontal ramus. It is elliptical in outline with the major axis 4.2 mm in length and gently inclined anteriorly; the minor axis is 2.8 mm. Above and somewhat posterior to the mental foramen is a much smaller foramen. The ventral edge of the horizontal ramus below the molar row is gently convex downward. Posterior to that region, the shape of the ventral border is uncertain owing to crushing.

In the badly crushed posterior area of the mandible, part of the opening for the mandibular foramen is preserved 24 mm behind M<sub>5</sub> and about 3 mm below the level of the dorsal edge of the horizontal ramus. Distortion in this area is so great that the position in life of this foramen might have been several millimetres away. Despite the shattered nature of the posterior part of the mandible, there is no doubt that a masseteric canal was not present. The anterior edge of the ascending ramus is posteriorly inclined. Angle *a* as defined in Figure 2 is 62°. Although the condyle is not preserved on this specimen, because the dorsal part of the posterior edge of the coronoid process is intact, angle *b* as defined in Figure 2 could not have been more than 34°.

**Lower dentition, I<sub>1</sub>:** The thin layer of enamel on this tooth is confined to the buccal and ventral surfaces above the alveolar border. Along the dorsal border of the enamel, a well-developed wear facet extends from the tip to about midway along the posterior edge of the enamel. An appression fossette is developed on the ventromedial surface of the enamel where this tooth contacted the left I<sub>1</sub>. As on the molars behind, the enamel surface when unworn is wrinkled with gentle, irregular sinuous folds. The posterior end of the root is open and located beneath the middle of P<sub>3</sub>.

**P<sub>3</sub>:** This tooth is not preserved but its two alveoli are present in the type specimen. On the basis of the alveoli, this tooth, although much smaller, was similar to the P<sub>3</sub> of *Kolopsis torus*

in the ratio of its length to that of  $M_2$ , and in the markedly greater posterior than anterior width.

$M_2$ : Unlike  $M_{3-5}$ , a distinct trigonid is developed on the anterior moiety of the  $M_2$ . A well-developed paracristid extends from the protoconid anterior to the forward margin of the tooth. A paraconid is not present at the anterior end of the paracristid, but a cingulum begins at that point and extends posterolingually along the margin of the tooth, terminating at the anterior end of the swelling at the base of the metaconid. Part of the metaconid is missing but enough remains to confirm that the protolophid extends from the protoconid to the medial and slightly posteriorly positioned metaconid. A short ridge or cristid, the protocristid is directed posterobuccally from the tip of the protoconid. At the buccal end of the protocristid, there is a slight swelling to indicate the possible presence of a distinct cusp, the protostylid.

The cristid obliqua is directed anterolingually to abut against the posterior side of the trigonid at a point directly below and behind the protoconid. The hypoconid and entoconid are further apart from one another than the protoconid and metaconid. The hypolophid, connecting the hypoconid and entoconid, is convex posteriorly. A short anterior entocristid extends anterobuccally from the entoconid. Although present in other diprotodontids such as *Kolopsis torus*, this anterior entocristid is best developed in *Raemotherium yatkolai*. Along the posterior margin of the tooth is a well-developed, slightly crenulated postcingulum. Near the centre of the cingulum is a small cuspule. An extremely weak vertical ridge or prominent crenulation extends up the posterior slope of the hypolophid from this cuspule, and merges with the hypolophid wear facet. A definite wear facet extends the length of this ridge. The small cuspule is likewise truncated by a wear facet. None of the nearby crenulations display any significant degree of wear. Of the four principal cusps, the protoconid is the tallest and the other three (metaconid, hypoconid, and entoconid) are subequal in height. In occlusal view, the trigonid and transverse valley are subequal in

width and distinctly narrower than the talonid.  $M_{3-5}$ : The anterior moieties of these teeth are quite different from that of  $M_2$ . In contrast, the posterior moieties of all molars are similar. A well-developed precingulum extends from the anterobuccal side of the protoconid base to the anterior side of the metaconid base. Unlike the  $M_2$ , the paracristid forms only a poorly-defined vertical crest from the tip of the protoconid to its base, and because of this the anterior moiety is not distinctly triangular in outline when viewed from above. Between the protoconid and metaconid is a well-developed protolophid that is convex posteriorly in occlusal view. Projecting a short distance posterolingually from the tip of the metaconid is a small posterior metacristid. This structure is somewhat weaker on  $M_5$  than on  $M_{3-4}$ . If it was present on  $M_2$ , damage to that area of the tooth has removed all trace of the structure.

Because of the similarity in the posterior moiety of all lower molars, only differences from the condition of  $M_2$  will be noted. The anterior entocristid becomes less-prominent posteriorly until on  $M_5$  it has all but disappeared. The postcingulum is wider and extends further towards the lingual and buccal margins of the tooth than on  $M_2$ . Cuspules are developed posterior and slightly buccal to the entoconid on the postcingulum. Only on  $M_3$  however, is there a homologue of the ridge connecting the postcingulum with the crest of the hypolophid such as occurs on  $M_2$ , and even here it is not as well-developed as it is on  $M_2$ .

In order of decreasing height, the four principal cusps are the protoconid, metaconid, hypoconid, and entoconid.

TABLE 3  
Measurements (mm) of  $I^3$ s of  
*Raemotherium yatkolai*

	Length	Width
NMV P48538	4.6	4.6
AMNH 102183	5.0	4.4

*Upper dentition,  $I^2$* : In occlusal view, this tooth has the outline of an isosceles right triangle, the corners of which are rounded, and the hypotenuse of which forms the posterolingual side. On the buccal side of the tooth is a broad, dor-

soventral groove and on the anterior side, a well-developed appression fossette resulting from contact with I<sup>2</sup>. This tooth is quite similar in morphology to the homologous ones in *Ngapakaldia tedfordi*, *Neohelos tirarensis*, and *Plaisodon centralis*.

Compared with measurements of *Ngapakaldia tedfordi* (Stirton 1967), *Kolopsis torus* (Woodburne 1967), and *Plaisiodon centralis* (Woodburne 1967), the I<sup>3</sup>s described here are about the proper size to correspond with the molars of *Raemeotherium yatkolai*. Because no other diprotodontids of this size are known from the Namba Formation and two referred molars of *R. yatkolai* were found in the same site and level as one of the two incisors (NMV P48538 at South Prospect B), we are confident that reference here to *R. yatkolai* is justified.

### Discussion

*Raemeotherium yatkolai* is unique within the Diprotodontidae and the most primitive member in that the paracristid and protocristid are well-developed on M<sub>2</sub>. The well-developed paracristid on M<sub>2</sub> is a feature of tribosphenic marsupials as well as some diprotodonts such as the selenodont possums. Archer (1976) suggested the possibility that lophodont marsupials (hence diprotodontids) may have been descended from selenodont or subselenodont possums. The well-developed paracristid on M<sub>2</sub>, and the well-developed cristid obliqua on M<sub>2-5</sub> in *Raemeotherium yatkolai* at least suggest that diprotodontids did not descend from bunodont possums, but do not prohibit derivation from pre-selenodont tribosphenic ancestors, such as perameloids.

On the M<sub>2</sub> of selenodont diprotodonts buccal to the protoconid there is a variably-developed cusp that represents a protostylid; e.g. *Phascolarctos cineris* (NMV C2660, see pl. 16, fig. 9), and *Pseudocheirus peregrinus* (NMV C13937, see p. 16, fig. 6). On the M<sub>2</sub> of *Raemeotherium yatkolai*, the protocristid appears to have terminated in a protostylid (see pl. 16, fig. 7). Apparently the protostylid appeared as a neomorph on the M<sub>2</sub> of selenodont diprotodonts and their descendants secondarily reduced and then lost it independently in dif-

ferent lineages. Evidence for the presence of this cusp as the primitive condition in groups descendant from the selenodont diprotodonts is to be found not only in *R. yatkolai* in the case of the diprotodontids, but in an undescribed Miocene macropod as well.

Primitive diprotodontid features found in *Raemeotherium yatkolai* that are shared with some other members of the Diprotodontidae include the posteriorly inclined ascending ramus, the low position of the condyle on the dentary, all molars nearly the same size rather than markedly increasing in length and width posteriorly, and the well-developed anterior entocristid on M<sub>2-5</sub>. Inclination of the ascending ramus is a quite variable feature within a given diprotodontid species. However, the recumbent angle ( $a$  in fig. 2) of *R. yatkolai*, 62°, is so much less than in any other diprotodontid that the differences can be confidently regarded as significant. *Kolopsis torus* with a minimum recumbent angle of 70° is the most similar diprotodontid, others fall in the range 80°-100°.

The ratio of M<sub>2</sub> to M<sub>4</sub> length typifies the difference between *Raemeotherium yatkolai* and other diprotodontids in molar lengths. In *R. yatkolai*, this ratio is 0.96, practically unity. The closest other diprotodontids are *Ngapakaldia tedfordi* where the ratio ranges from 0.78 to 0.89 in three specimens measured by Stirton (1967), 0.84 to 0.86 in three specimens of *Palorchestes painei* measured by Woodburne (1967), and 0.85 in one specimen (AM F44471) of *Kolopsis rotundus*. All other known diprotodontids in which this feature can be measured, have a ratio of less than 0.85. In the same manner, the degree of primitiveness of *R. yatkolai* in each of the remaining features listed in the preceding paragraph cannot be exceeded in another diprotodontid.

Some slight doubt remains as to whether *Raemeotherium yatkolai* is properly assigned to the Diprotodontidae because, as far as now known, the species has no derived or advanced character states which preclude its inclusion as a primitive member of the Macropodoidea. Although the presence of a masseteric canal, a derived condition within the Diprotodonta, is

a feature unique to macropodoids, the oldest member of the superfamily may well have lacked one. On the basis of parsimony, the last common ancestor of the macropodoids and their immediate sister-group, whatever that may have been, presumably lacked a masseteric canal, this lack being the primitive condition. This means that at the time of their separation, unless the masseteric canal appeared as a part of that particular speciation event, there would have been an ancestral macropodoid which lacked that structure. *R. yatkolai* could conceivably have been a descendant of such a primitive macropodoid or near-macropodoid. Hence allocation to the Diprotodontidae must be regarded as tentative although highly probable, pending discovery of better preserved specimens of *R. yatkolai*.

Assignment of *Raemeotherium yatkolai* to the Zygomaturinae within the Diprotodontidae must also be tentative because it is based on a primitive character state. By all the credible phylogenetic hypotheses that have been proposed for the Marsupialia, the presence of a strong paracristid on the  $M_2$  is primitive within the diprotodontids. Hence, it is to be expected in the common ancestor of the family and could therefore be the condition in primitive, as yet unknown members of the other subfamilies. Discovery of a single  $P^3$  of *R. yatkolai* would probably settle the matter because all the undoubted Zygomaturinae share a unique derived morphology of that tooth.

Only one diprotodontid specimen is significantly older than *Raemeotherium yatkolai*. This is a form tentatively regarded as a palorchestine by Tedford *et al.* (1975) who reported its presence in the late Oligocene or older Geilston Bay local fauna collected near Hobart, Tasmania. Unfortunately, this specimen (BMNH 40157) is not directly comparable with any known material of *R. yatkolai*, being a maxilla with part of  $M^2$  and  $M^{3-5}$ . However, the lengths of the respective tooth rows indicate that these two diprotodontids are about the same size and the smallest members of the family. They likewise show molars of similar length without conspicuous backward increase in size typical of later diprotodontids.

### Literature Cited

- ARCHER, M., 1976. Phascolarctid origins and the potential of the selenodont molar in the evolution of diprotodont marsupials. *Mem. Qd Mus.* 17 (3): 367-371.
- , (in press). The nature of the molar-premolar boundary in marsupials and a reinterpretation of the homology of marsupial cheekteeth. *Mem. Qd Mus.* 18.
- CALLEN, R. A. and R. H. TEDFORD, 1976. New late Cainozoic rock units and depositional environments, Lake Frome area, South Australia. *Trans. R. Soc. S. Aust.* 100(3): 125-168.
- STIRTON, R. A., 1967. The Diprotodontidae from the Ngapakaldi fauna, South Australia. Pp. 1-44 in Stirton, R. A., M. O. Woodburne, and M. D. Plane, Tertiary Diprotodontidae from Australia and New Guinea. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 87.
- TEDFORD, R. H., M. R. BANKS, N. R. KEMP, I. MCDUGALL, F. L. SUTHERLAND, 1975. Recognition of the oldest known fossil marsupials from Australia. *Nature* 255 (5504): 141-142.
- TEDFORD, R. H., M. ARCHER, A. BARTHOLOMAI, M. PLANE, N. S. PLEDGE, T. RICH, P. RICH and R. T. WELLS, 1977. The discovery of Miocene vertebrates, Lake Frome area, South Australia. *Bur. Miner. Resour. Jour. Aust. Geol. Geophys.* 2: 53-57.
- WOODBURNE, M. O., 1967. Three new diprotodontids from the Tertiary of the Northern Territory. Pp. 53-103 in Stirton, R. A., M. O. Woodburne, and M. D. Plane, Tertiary Diprotodontidae from Australia and New Guinea. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 87.
- WOODBURNE, M. O. and R. H. TEDFORD, 1975. The first Tertiary monotreme from Australia. *Am. Mus. Novit.* 2588: 1-11.

### Acknowledgements

National Geographic Society grant no. 1562 to Rich made possible the 1976 expedition during which the type and two of the referred specimens were discovered. Essential groundwork for this expedition was laid in 1974 by Rich in collaboration with a contingent of the Third Royal Australian Electrical and Mechanical Engineers Group of the Army under the command of Capt. Norman Moxey. Rich's interest in the general area east of Lake Frome stemmed from having been to the region as a member of Tedford's 1971 party supported by National Science Foundation Grant GB 18273X. Tedford was further supported by the

same agency and grant in 1973 when he revisited the area and discovered the first referred specimens.

Messrs. Roy Linke and Buddy Napier, managers of Frome Downes Station, and their families were most hospitable and provided facilities necessary for the success of our field programmes.

Mr. Frank Coffa took the photographs and Mr. Alex Jelowyi did the lettering for the plate, Miss Jeanette Cook drew fig. 1 and Mr Harley Veitch, fig. 2.

### Explanation of Plate 16

*Raemeotherium yatkolai*. SAM P19764, type, right mandible, Lake Pinpa, South Australia, fig. 4, lateral

view, x1; fig. 5, medial view, x1; fig. 7, occlusal view of  $M_{2-5}$ , x2; fig. 11, occlusal view x1. NMV P48537, isolated right  $M_4$  or  $M_5$ , South Prospect B, Lake Namba, South Australia, fig. 1, occlusal view, x2. AMNH 102186, isolated left  $M_4$  or  $M_5$ , South Prospect B, Lake Namba, South Australia, fig. 2, occlusal view, x2. NMV P48538, isolated right  $I^3$ , South Prospect B, Lake Namba, South Australia, fig. 3, occlusal view; fig. 8, lateral view, all x2.

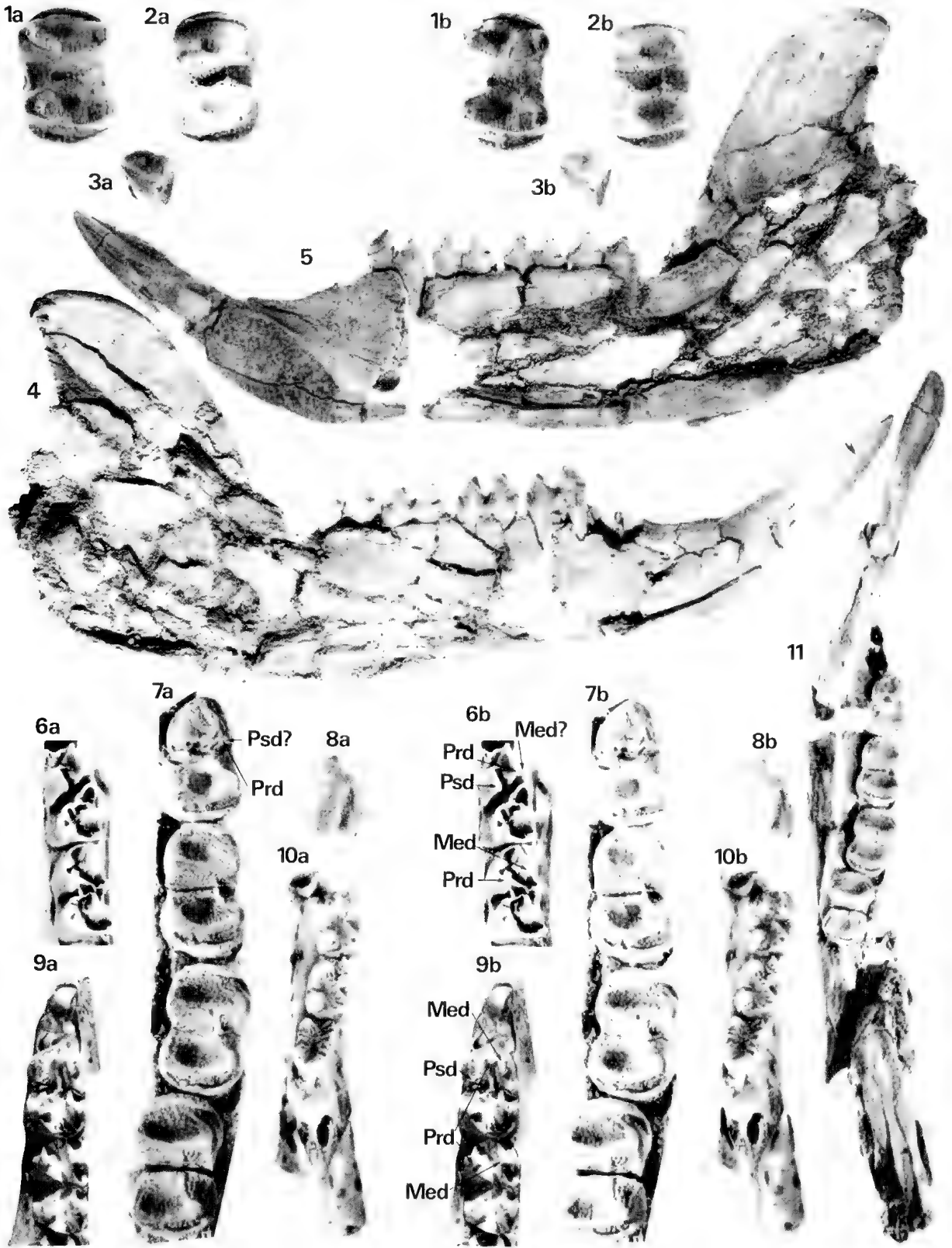
*Pseudocheirine*, NMV P48616, right mandible, found one or two centimetres from type specimen of *Raemeotherium yatkolai*, Lake Pinpa, South Australia, fig. 10, occlusal view, x4.

*Pseudocheirus peregrinus*, NMV C13937, left mandible, juvenile, fig. 6, occlusal view of  $M_{2-3}$ , x4.

*Phascolarctos cinereus*, NMV C2660, left mandible, juvenile, fig. 9, occlusal view of  $P_3-M_3$ , x2.

Abbreviations: med, metaconid; prd, protoconid; psd, protostylid.









SYNONYMY OF THE FOSSIL WOMBAT *VOMBATUS PLIOCENUS*  
(MCCOY) WITH THE LIVING SPECIES  
*VOMBATUS HIRSUTUS* (PERRY)

By H. E. WILKINSON

**Abstract**

The type specimens of the fossil wombat species *Vombatus pliocenus* (McCoy) are re-described, and evidence presented for synonymy of this species with the living Common Wombat, *Vombatus hirsutus* (Perry). It is demonstrated that McCoy's description of this species was based principally on a specimen from Lake Bullenmerri of Holocene age. It is concluded that acceptance of the validity of this species has been strongly influenced by the presumed Pliocene age of the type specimen from Dunolly. The sediments from which this fossil came may be as old as Late Miocene, but it is suggested that the fossil could have been an intrusive burial.

**Introduction**

The discovery of a fossil wombat jaw at Dunolly in 1856 caused considerable interest, and some newspaper publicity, but it was not until 1861 that the fossil was recorded in the scientific literature by Professor Frederick McCoy. He said (p. 168) 'I have likewise recognised the bones of the Wombat (*Phascolomys*) in the solid, hard, stony, ferruginous, auriferous drift called "cement" by the gold diggers, at a great depth in the sinkings at Dunolly, the material being so hard that the jaws could only be cleared by a stonemasons chisel; this determination enables me to say that the age of the gold drift of Victoria, like that of Russia, is as Sir Roderick Murchison showed for the latter country, that of the "Mammiliferous crag" of England'.

McCoy named the fossil *Phascolomys pliocenus* in an essay for the Intercolonial Exhibition of 1866, the first printing of which appeared in a French translation in 1866, but it was not until 1874 that a full description and illustrations appeared in the first decade of his *Prodromus of the Palaeontology of Victoria*. The occurrence of this fossil wombat was quoted by authors such as Barkly (1869) and Smyth (1874, 1876) as the chief evidence for the Pliocene age of the gold drifts. It was referred to by Howitt (1913) and Walcott (1920) mentioned the occurrence in a paper on the age of the mammal bearing gold drifts of Australia. It was listed in the fossil catalogue prepared by Etheridge (1878) and illustrated in *Australasian Fossils* (Chapman, 1914).

Tate (1951) accepted the species as valid when he reviewed the family Vombatidae, and placed it in the genus *Vombatus*, a generic determination accepted by Stephenson (1967) in a later review. Gill (1972) presented evidence for a probable Upper Pliocene age for the Dunolly fossil wombat, and briefly reviewed the circumstances of its discovery, and the literature concerning it.

The validity of the species has never been called into question, at least as far as the literature is concerned, and the name has been applied to several other fossil wombats of varying age from Victoria. The significance of the type specimens from Lake Bullenmerri has not previously been recognized. As part of a review of the family Vombatidae, the author has made a careful examination of the type specimens. Comparisons have been made with living and fossil wombats of comparable size to the living species. All the specimens referred to are in the collection of the National Museum of Victoria, and are numbered with the prefix P.

**Provenance and age of the Type Specimens**

P7422, DUNOLLY, VICTORIA.

The earliest known reference to the Dunolly fossil wombat is in *The Courier of Mines and Bendigo Daily Mail* of 30 September 1856, No. 253, p. 2, col. 6, in which a Mr Ferguson of the firm of Dennis and Ferguson at Dunolly reported the discovery of a jaw bone in cement at 30 feet. (Cement was the miners' term for silicified or ferruginized gold bearing conglom-

merates). In the same journal on 8 October 1856, No. 260, p. 4, col. 1, there is a report of Warden J. A. Panton receiving the fossil at Bendigo, via 'Mr. Dixon of the Shamrock' (Hotel), and mentioning 50 ft. as the depth. Panton thought it to be a kangaroo. Flett (1956, p. 33) records that the fossil was dug up from the hard cement of Gooseberry Hill, and displayed for a time in the window of Mantell and Wills, gold brokers at Dunolly, but does not cite the source of this information.

Panton forwarded the specimen to Melbourne, but the details of the acquisition are not known. The Mining Commission Letterbook at the National Museum contains a copy of a letter from the clerk G. Ulrich to Panton (30 June 1857, p. 34) advising that the Palaeontologist of the Geological Survey (F. McCoy) had determined the fossil as *Phascolumys*, and requesting Panton to provide details of its 'exact position, depth and circumstances'. This information may have been duly provided by Panton, but there is no evidence that it was.

McCoy's earliest reference (1861) gives the locality as being 'at a great depth in the sinkings at Dunolly'. The depth is not stated in this, or any other of McCoy's references (1862, 1866, 1868, 1874), nor is a precise locality given. There is now no original label with the specimen, although Walcott (1920) refers to one. A letter written by A. R. C. Selwyn, Government Geologist, to the Editor of *The Age*, published on 28 February 1861, includes a quotation from this label 'Phascolumys. From the "cement" of the gold drifts of Dunolly, 30 feet deep. Pliocene tertiary. Presented by Mr Panton'. (This letter was written to refute a claim by R. Brough Smyth that kangaroo fossils found in Canard's claim at Yandoit in 1861 were the first which would enable the age of the auriferous deposits to be determined).

Gill (1972) stated that the fossil came from a depth of 50 feet (15 metres) at the bottom of a shaft on Slaughteryard Hill, Dunolly. This locality was given by W. H. Ferguson in an unpublished MS on Dunolly. Gill was aware that Flett (1956) had quoted Gooseberry Hill as the locality, but thought that this was an alter-

native name for Slaughteryard Hill. The position is further complicated by the fact that the shaft he was shown is actually on Spiller's Hill, as is made clear by comparing the sketch plan provided for him by Mr John Flett of Dunolly, with the Geological Parish Plan of Dunolly. Mr James Flett has been unable to relocate the source of his Gooseberry Hill reference, and no other contemporary references to the site have been located, despite an intensive search (T. A. Darragh, pers. comm.).

The question of exact locality is largely academic, since all three hills are essentially similar in their geological formation. They are part of a line of hill top cappings of Upper Tertiary gravel deposits, which extend from Goldsbrough to Betley, paralleling the present day Burnt Creek. Gooseberry Hill is at the western end, followed by Spiller's Hill, and Graveyard Hill with Slaughteryard Hill at the eastern end. The gravels overlie tightly folded Lower Ordovician bedrock, into which the ancestral Burnt Creek was incised. Lithification of these old river gravels has left them more resistant to erosion than the surrounding bedrock, and they now stand in low relief above the valley of Burnt Creek.

Gill (1964) presented evidence for an Upper Pliocene or Lower Pleistocene age for the Dunolly wombat. This was based on its alleged presence in post-Timboon Terrain stream sediments, which had accumulated following the main movements of the Plio-Pleistocene Kosciusko Uplift.

The gravels at Dunolly are equivalent to the White Hills Gravels at Bendigo (Wilkinson, 1977) and like them consist essentially of quartz gravel, which contained rich concentrations of alluvial gold. (The fossil was found during the Burnt Creek rushes of the mid 1850s). Similar gravels at Axedale, about 20 km east of Bendigo, underlie a basalt flow recently dated at  $6.95 \pm 0.7$  m.y. (Department of Minerals and Energy sample VAD 56, Amdel). This puts a minimum age of Late Miocene on these gravels. P.G. Macumber (pers. comm.) considers that the White Hills Gravels and their correlatives are equivalent to the Calivil Formation of the Deep Leads and Murray

Basin. Palaeontological evidence is consistent with a Late Miocene age for this formation also.

The Tertiary age of the sediments is not in doubt, but there is the possibility that the fossil may be intrusive. Living wombats burrow extensively, and burrow lengths of up to 20 m are known. Quite a few fossil wombats are known to be intrusive, and to represent individuals trapped in burrow collapses. An example is a fossil wombat skeleton recovered from a burrow in marine fossiliferous marl at Modewarre near Geelong in 1884 (P1917). In this case the marl is Upper Miocene in age, but the fossil is unlikely to be much older than Late Pleistocene. Although McCoy identified it as *pliocenus*, it is in fact *Vombatus hirsutus*.

The gravels at Dunolly are only partially lithified at depth, and would have represented no great obstacle to a burrowing wombat. If it were absolutely certain that the fossil came from the stated depth, this explanation might be argued against on the grounds that no living wombat has been known to burrow so deep. However, the circumstances surrounding the discovery of the fossil are almost totally unknown, and there is conflicting evidence as to locality and depth. The fossil certainly has an appearance of some antiquity, because of the encrusting matrix, but this can be matched on fossil wombats which are known to be geologically much younger than the gravels at Dunolly. For example, there is a partly matrix encrusted mandible from the ?Upper Pliocene-Pleistocene Shepparton Formation at Bung Bong near Maryborough, Victoria (P7420) which shows some strong similarities to the Dunolly specimen in the degree of mineralization and lithification of matrix. This specimen was collected in 1875, and was also determined by McCoy as *pliocenus*. It too is referable to

*Vombatus hirsutus*.

P7441, P7442, LAKE BULLENMERRI, NEAR CAMPERDOWN, VICTORIA.

The specimens from Lake Bullenmerri are very lightly mineralized, and free of carbonate encrustation. They are typical of fossils which have been collected from the shores of Lake

Bullenmerri since the early days of settlement. The Lake Bullenmerri fauna consists of extant species, although this does include *Sarcophilus ursinus* (Tasmanian Devil) now extinct on the mainland. Gill (1953) pointed out that all the Western District post-tuff faunas he had examined contained extant species only, including Lakes Bullenmerri, Gnotuk and Keilambete. Lake Bullenmerri formed in the Holocene period, and the fossils are not likely to be more than a few thousand years old, and may be much younger. The latter possibility is supported by observation of the rapidity with which bones of domestic animals on the shores of Lake Bullenmerri have become mineralized in the 130 years or so of European occupation. The fossil bones are being washed up on the present beach level, presumably from erosion of an earlier terrace below present water level.

No information is recorded of the circumstances involved in the collection of the specimens. McCoy (1874) stated that they were 'From the shores of Lake Bullenmerri near Camperdown'. The drawing used in the *Prodromus* was completed in 1862, and it appears probable that the specimens were collected by Selwyn when he visited Lake Bullenmerri (T. A. Darragh, pers. comm.).

#### Selection of Lectotype and Lectoparatypes

Gill (1953) listed the type specimens of *pliocenus* as syntypes. Mahoney and Ride (1975) list the Dunolly specimen as the holotype, although McCoy did not designate a type specimen in his 1866 description, nor was there any illustration. It is known that Plates 3-4 of his 1874 description were completed by Ludwig Becker in 1858, and Plate 5 was completed by A. Bartholomew in 1862. It is clear therefore that McCoy had all three specimens to hand when he published the first brief description in 1866. The one character which he offered as a diagnosis of his new species cannot be measured on the Dunolly specimen, although a rough estimate can be made. It seems rather unlikely that McCoy based his new species on the Dunolly specimen alone, even though it is the only one referred to by locality.

It is therefore proposed to designate P7441 from Lake Bullenmerri as the Lectotype. This is the only one of the three specimens used by McCoy on which his key diagnostic character is adequately preserved (see below), and the evidence that he used this specimen in 1866 is very strong. P7442 from Lake Bullenmerri, and P7422 from Dunolly are designated as Lectoparatypes. The name *pliocenus* is therefore fixed on the best preserved specimen, which shows the one diagnostic feature given by McCoy in 1866, and all the additional features given in 1874.

#### Systematic Description

Order	Marsupialia
Family	Vombatidae Iredale and Troughton 1934
Genus	<i>Vombatus</i> Geoffrey 1803
Type species	<i>Vombatus ursinus</i> (Shaw) 1800

#### *Vombatus pliocenus* (McCoy) 1866

(Plate 1, figures 1, 4. Plate 2, figures 1-2)

*Phascolomys pliocenus* McCoy, 1866. *Notes sur le zoologie et la palaeontologie de Victoria*: 21-22.

*Phascolomys pliocenus* McCoy, 1874. *Prod. Pal. Vict.* Dec. 1: 21-22, Pls. 3-5.

*Vombatus pliocenus* (McCoy) Tate, 1951. *Am. Mus. Novitates* No. 1525: 5.

1. Lectotype: P7441. Pl. 17, figs. 3-4. Incomplete mandible with incisors, diastemal region and left ramus with  $\overline{p4-m4}$  preserved. Locality: From shore of Lake Bullenmerri, Camperdown, Victoria. Collected prior to 1862. Age: Holocene.
2. Lectoparatype: P7442. Pl. 17, figs. 1-2. Incomplete mandible with incisors and right molar row preserved, minus  $\overline{m4}$ . Locality: From shore of Lake Bullenmerri, Camperdown, Victoria. Collected prior to 1862. Age: Holocene.
3. Material: Lectoparatype: P7422. Plate 18, figs. 1-2. Almost complete mandible with both molar rows preserved, but the incisors obscured by matrix.

Locality: From a depth of either 30 or 50 feet (9.1 or 15.2 metres) in an alluvial shaft on either Gooseberry or Slaughter-yard Hill, near Burnt Creek, Dunolly, Victoria. Collected in 1856, and presented to National Museum by J. A. Pantou. (See discussion above).

Age: The containing sediments are probably Late Miocene in age, but the fossil may be intrusive and therefore younger.

#### Descriptions and Comparisons

The lectotype specimen from Lake Bullenmerri (P7441) is a lightly mineralized incomplete mandible, free of encrusting matrix. The right ramus is well preserved, with a complete molar row. The diastemal region has lost some of its bone, but both incisors are preserved. The premolar and first molar of the left ramus are also preserved, but the remainder has broken away. The teeth are near perfect in preservation.

The lectoparatype from Lake Bullenmerri (P7442) is an incomplete mandible, with most of the left ramus missing. It is less complete on the right side, and  $\overline{m4}$  is missing. It is better preserved in the diastemal region than P7441.

The lectoparatype specimen from Dunolly (P7422) is an almost complete, partly matrix encrusted, heavily mineralized mandible. The left ramus has been freed of matrix, but the outer side of the right ramus, and the incisor region are still encrusted with a calcareous, ferruginous, silty matrix. Both molar rows are present, but all the occlusal surfaces are hollowed out. The left ascending ramus is preserved, but the right is missing. The fossil was originally very nearly complete, but appears to have been damaged during the attempt to clear it of matrix.

All three mandibles have in common features which clearly show that they belong to the genus *Vombatus*. These include the V-shaped inter-lobe valleys of the molars, the obliquely set, antero-posteriorly elongated premolars, and the position of the anterior root of the coronoid opposite the anterior lobe of  $\overline{m4}$ .

McCoy recognized that *pliocenus* was com-

parable to the living '*Phascolomys platyrhinus*' (= *Vombatus hirsutus*) in size, position of symphysis and 'the whole length of the dental series from edge of incisor to hind alveolus of last molar'. He claimed that his new species could be '... easily distinguished by the great size of the molar series, these teeth being not only larger transversely, occupying a longer fore and aft space, but extending so very much nearer to the edge of the incisors as to afford an easy mode of discriminating the species'. He laid great stress on the comparatively short diastema between the incisor and premolar, although this region is obscured by matrix in the Dunolly specimen. He also differentiated *pliocenus* on the basis of 'the lower outline of the mandible being rounded with a more uniform curve'; diastema being narrower between the molars; 'outlet of dental canal' (mental foramen) being closer to the 'anterior molar' (pre-molar) and the incisors being more nearly equal in vertical and transverse diameters.

Comparison by McCoy with other fossil wombats was confined to *Vombatus mitchellii* (Owen) from which McCoy stated that *pliocenus* differed in having much larger molars, and in the symphysis extending further back. It has been shown elsewhere (Wilkinson, 1973; in prep.) that Owen's concept of *mitchellii* included specimens of *Lasiorhinus krefftii*. The differences in position of the symphysis and size of molars referred to by McCoy are in fact features of generic distinction between *Vombatus* and *Lasiorhinus*.

**Examination of the characters regarded by McCoy as diagnostic of *pliocenus*, with comments on their validity**

(a) 'Great size of the molar series'

The length of the alveoli of  $\overline{p4}$  to  $\overline{m4}$  in the type specimens is 55.9 mm in P7422, 56.2 mm in P7441 and 56.1 mm in P7442. The author has measured a specimen of *V. hirsutus* with an alveolar length from  $\overline{p4}$  to  $\overline{m4}$  of 57.2 mm, but even this is exceeded by the largest specimens in the sample examined by Merrillees (1967, Figs. 1 and 2), which reach about 58 mm. The *pliocenus* types all fall well within

the range of variation in *V. hirsutus* in this feature.

(b) 'Ratio of length of molar row to 'whole length of dental series''

McCoy stated that the ratio of the length of  $\overline{p4}$  to  $\overline{m4}$  to the 'whole length of the dental series from hind edge of last molar alveolus to front edge of incisor' was 55:100 in *pliocenus* but only 45:100 in *platyrhinus* (= *hirsutus*). In effect he was saying that the living species had a relatively shorter molar row and longer diastema than the fossil. This is the feature on which he laid greatest stress, and claimed that it gave '... an easy mode of discriminating the species'. This was tested by measuring the same characters on specimens of *Vombatus hirsutus* and expressing the result as a percentage, for comparison with the percentages obtained from the types. In P7422, the incisors are damaged, and matrix obscured, and the ratio can only be estimated. The length from the tip of  $\overline{I1}$  to posterior alveolus of  $\overline{m4}$  is estimated to have been about 100 mm, and the percentage of the order of 54 to 56%. In P7441 the corresponding figures are 101.9 mm and 55.5% and in P7442 they are 103.0 mm and 54.5%. The range in a sample of specimens of *V. hirsutus* examined by the author was 95.8 to 112.7 mm and the percentages range from 51.7% to 54.7%. Although the percentage figure for P7441 is slightly higher, overlap between *pliocenus* and *hirsutus* in this feature is demonstrated, and McCoy's claim of an easy distinction is therefore invalid. No *hirsutus* specimen with a percentage as low as 45% has been seen by the author.

(c) 'Diastema narrower between the molars'

McCoy measured the distance between the posterior lobes of the 'second molar' or  $\overline{m1}$ , to support his contention that 'the diastema is narrower between the molars'. In P7422 this is 24.5 mm; in P7441 it is estimated to have been 20.5 mm, and in P7442 it is 19.4 mm. In modern *V. hirsutus* the range is from <18 mm to >28 mm. Once again, the *pliocenus* types fall within the range of variation of the living species.

(d) *Shorter diastema*

McCoy claimed that the diastema was 'much shorter in the fossil'. This was tested by measuring the length of the diastema between  $p_4$  and  $l_1$ . In P7422 this is estimated to have been about 27 mm, in P7441 it is 30 mm and in P7442 it is 29 mm. In a small sample of modern *V. hirsutus*, the diastema varied from 26.3 mm, to 32.6 mm. The *pliocenus* types therefore fall completely within this range.

## (e) 'Lower outline of the mandible rounded with a more uniform curve'

This is a subjective judgement, difficult to quantify. However it follows that specimens with a relatively short diastema will tend to look more uniformly rounded, whereas long diastema mandibles tend to have the lower outline more elongated and angular. It is a variable feature of very dubious value for specific distinction.

(f) *Anterior outlet of 'dental canal' (= mental foramen) closer to 'anterior molar' (= premolar).*

This feature is not visible on P7422, but in P7441 the mental foramen is 5.3 mm from the premolar, and in P7442 the distance is 4.0 mm. This is a very variable feature, which varies from as little as 4 mm to in excess of 8 mm in living *V. hirsutus*. The *pliocenus* types P7441, P7442 are within the range of variation in this feature also.

(g) *Greater compression of incisors*

Examination of a large range of specimens makes it clear that incisor cross section is rather variable in *V. hirsutus*. The difference between P7441 and P7442 in this regard is typical of the degree of variation. Incisor cross section cannot be determined on the Dunolly specimen, P7422. Height expressed as a percentage of width is 74.4% in P7441, and 87.2% in P7442. In modern *V. hirsutus*, the range observed is from 70% to almost 100%. The figures calculated for the types of *pliocenus* fall within this range.

The type specimens of *pliocenus* fall within the range of variation of *Vombatus hirsutus* in all the features regarded by McCoy as diagnos-

tic of his new species. He was probably influenced by his belief that all three specimens belonged to the extinct fauna, and the number of comparative specimens of the living species available to him was no doubt very limited. He could hardly have been aware of the degree of variability in *Vombatus hirsutus*. Merrilees (1967) stated that 'Variability is a striking characteristic of modern wombats', and gave details of the abnormalities encountered in 35 out of 52 individuals in the sample examined by him from Dingo Dell—'Fairbank', A.C.T. This was a breeding population, in which variation would be expected to be lower than in the species as a whole.

Other fossil species of *Vombatus* are in doubt for the same reason. Merrilees (1967) has already shown that *Vombatus parvus* (Owen) is a juvenile *V. hirsutus*, and it is almost certain that the same is true of *V. thompsoni* (Owen). Owen's fossil species *V. mitchellii* is based partly on specimens of *Lasiorchinus krefftii* (Wilkinson, 1973). The status of these species is currently under review (Wilkinson, in prep.), and preliminary studies suggest that *Vombatus mitchellii* may also be synonymous with *hirsutus*, although possibly subspecifically distinct. The only other fossil species of *Vombatus* is *V. hacketti* described by Glauert (1910) from Western Australia. It is readily distinguished from the *pliocenus* types and *V. hirsutus* by its narrower molars with more rounded lobes.

Given the degree of variability in modern *V. hirsutus* and the doubtful status of most of the fossil species of *Vombatus*, the conclusion seems inescapable that *Vombatus pliocenus* (McCoy) is a junior synonym of *Vombatus hirsutus* (Perry).

### Conclusion

All the diagnostic features given by McCoy in defining *pliocenus* have been carefully examined, and found to be invalid. No other character is evident on any of the types which would warrant their specific separation from *hirsutus*. The lectotype and lectoparatype from Lake Bullenmerri are of Holocene age, and there can be no doubt that they represent the living species. The lectoparatype specimen

from Dunolly cannot be differentiated from *hirsutus* either, although acceptance of *Vombatus pliocenus* McCoy as a valid species appears to have been strongly influenced by its presumed Pliocene age. It has been shown above that this is an assumption which is not supportable by direct evidence, and the possibility of the fossil being intrusive, and therefore younger, must be considered. If it is contemporary with the sediments, then this has important implications for studies of wombat speciation. It could be argued for example that *Vombatus* evolved in the late Miocene, and that the mandible has remained virtually unchanged since then, although other elements of the skeleton might show significant differences. Until better material of known age and provenance becomes available, this cannot be resolved, and it is better to regard the Dunolly specimen in the same light as the Lake Bullenmerri specimens. That is, *Vombatus pliocenus* (McCoy) is a junior synonym of the rather variable modern species *Vombatus hirsutus* (Perry).

#### Acknowledgements

The author wishes to thank the following people for their help in preparing this paper. Mr T. A. Darragh, Deputy Director, National Museum of Victoria, has been particularly helpful in tracking down early references to the Dunolly wombat, including unpublished material in the Museum Archives. Dr Duncan Merrilees, Western Australian Museum, and the author made a joint study of problems involving *Vombatus pliocenus*, *Vombatus Mitchellii*, and *Lasiiorhinus krefftii* in 1968. Grateful acknowledgement is made to his contribution to this paper in the form of valued discussions and follow up correspondence, although the author accepts full responsibility for the views expressed. Benefit has also been gained from discussions with E. D. Gill, and P. G. Macumber on the age of the sediments.

Thanks are due to the Director of the National Museum, Mr J. McNally, and the Museum staff for assistance with specimens (T. A. Darragh, T. Rich, I. Stewart, J. M. Dixon, A. J. Coventry). The photographs were taken

by Frank Coffa of the National Museum. Thanks are also due to Dr D. Spencer-Jones, Director, Geological Survey Division, who allowed time towards completion of this project, commenced while I was on the Museum staff, and granted permission for its publication.

#### References

- BARKLY, H., 1865. Anniversary Address. *Trans. Roy. Soc. Vict.* 6: XIX-XXIV.
- CHAPMAN, F., 1914. 'Australasian Fossils', Melbourne (p. 290, Fig. 142).
- ETHERIDGE, R., 1878. *A catalogue of Australian Fossils*, Cambridge (p. 190).
- FLETT, J., 1956. *Dunolly*. Melbourne, p. 33.
- GILL, E. D., 1953a. Geological Evidence in Western Victoria relative to the Antiquity of the Australian Aborigines. *Mem. Natn. Mus. Vict.* 18: 25-92.
- , 1953b. Catalogue of Quaternary Types and Figured Specimens in the National Museum, Melbourne. *Ibid.* 18: 157-168.
- , 1964. Rocks contiguous with the basaltic cuirass of Western Victoria. *Proc. Roy. Soc. Vict.* 77(2): 331-355.
- , 1972. The Dunolly fossil wombat. *Victorian Nat.* 89(3): 64-66.
- GLAUERT, L., 1910. The Mammoth Cave. The wombat *Phascolomys hacketti* sp. nov. *Rec. W. Aust. Mus.* 1(1): 15-29.
- HOWITT, A. M., 1913. The Maryborough Goldfield. *Mem. Geol. Surv. Vict.* 11: 7.
- MAHONEY, J. A. and W. D. L. RIDE, 1975. Index to the genera and species of fossil mammalia described from Australia and New Guinea between 1838 and 1968. *W. Aust. Mus. Spec. Publ.* No. 6.
- MCCOY, F., 1861. Note on the ancient and recent natural history of Victoria. (in) *Catalogue of the Victorian Exhibition*, Melbourne, p. 168.
- , 1862. Note on the ancient and recent natural history of Victoria. *Ann. Mag. Nat. Hist.* 9 (3rd Ser.): 137-150.
- , 1866. *Notes sur la zoologie et la palaeontologie de Victoria*, Melbourne, 35 pp.
- , 1867. On the recent zoology and palaeontology of Victoria (Intercolonial Exhibition Essay No. 7). Pp 307-330. Melbourne.
- , 1868. On the species of wombats. *Trans. Proc. Roy. Soc. Vict.* 8(2): 266-270.
- , 1874. *Phascolomys pliocenus* (McCoy). *Prodromus of the Palaeontology of Victoria*, Decade 1: 21-22, pls. 3-5.
- MERRILEES, D., 1967. Cranial and mandibular characters of modern mainland wombats (Marsupialia Vombatidae) from a palaeontological Viewpoint, and their bearing on the fossils called *Phascolo-*

- mys parvus* by Owen (1872) *Rec. S. Aust. Mus.* 15(3): 399-418.
- OWEN, R. (in) T. L. MITCHELL, 1838. *Three expeditions into the interior of eastern Australia, with descriptions of the recently explored region of Australia Felix, and of the present colony of New South Wales.* London, Vol. 2: 362-363, pl. 30, figs. 4-7.
- OWEN, R. 1872. On the fossil mammals of Australia—Part VI. Genus *Phascalomys*, Geoffr. *Phil. Trans R. Soc.* 162: 173-196, pls. 17-23.
- SMYTH, R. B., 1874. *Geol. Surv. Vict. Rept. Prog.* 1: 36.
- SMYTH, R. B., 1876. *Ibid.* 3: 74.
- STEPHENSON, N. G., 1967. Phylogenetic trends and speciation among wombats. *Aust. J. Zool.* 15: 873-880.
- TATE, G. H. H., 1951. The Wombats (Marsupialia, Phascalomyidae) *Am. Mus. Novitates* No. 1525, 18 pp.
- WALCOTT, R. H., 1920. Evidence of the age of some Australian gold drifts, with special reference to those carrying mammalian remains. *Rec. Geol. Surv. N.S.W.* 9(2): 66-97 (p. 69).
- WILKINSON, H. E. (in) MERRILEES, D., 1973. Fossiliferous deposits at Lake Tandou, New South Wales, Australia. *Mem. Natn. Mus. Vict.* 34: 177-182 (see pp. 180-181).
- WILKINSON, H. E., 1977. Geology of the Bendigo Area. *Geol. Surv. Rept.* 1977/3.
- (in prep.) Re-examination of the fossil wombat species *Vombatus mitchellii* (Owen) and *Lasiorhinus krefftii* (Owen), and clarification of their taxonomy.

### Explanation of Plates

#### PLATE 17

##### *Vombatus pliocenus* (McCoy)

Figure 1—Labial view of lectoparatype, left mandible P7442 from Lake Bullenmerri, Victoria; Holocene.

Figure 2—Occlusal view of same specimen.

Figure 3—Labial view of lectotype, left mandible P7441 from Lake Bullenmerri, Victoria; Holocene.

Figure 4—Occlusal view of same specimen.

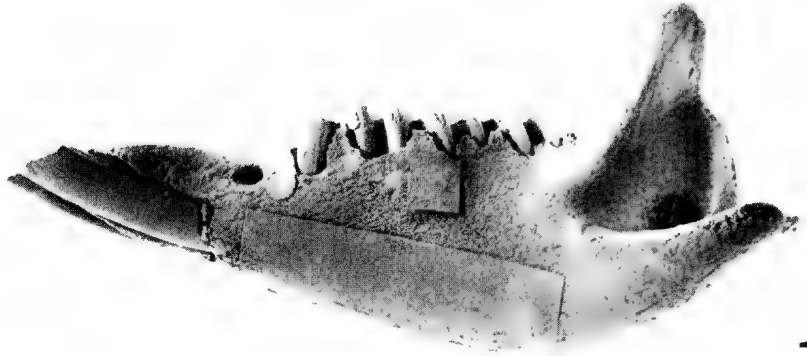
#### PLATE 18

##### *Vombatus pliocenus* (McCoy)

Figure 1—Labial view of lectoparatype mandible P7422 from Dunolly, Victoria; ? Late Miocene.

Figure 2—Occlusal view of same specimen. (All specimens  $\frac{1}{2}$  natural size)





1



2



3



4



1



2

# COMMENTS ON THE SPECIES CONCEPT IN SOME AUSTRALIAN *ANISOPS* SPINOLA (HEMIPTERA: NOTONECTIDAE)

By I. LANSBURY

Hope Department of Entomology, University Museum, Oxford

## Introduction

Twenty-five species of *Anisops* are recorded from Australia and Tasmania, 16 are endemic. A few species are taxonomically confusing as they occur in more than one form. *Anisops* is compared with *Buenoa* Kirkaldy which replaces *Anisops* in the New World.

The species concept is discussed, especially of those with an extra-Australian distribution which tend to be superficially distinct at the periphery of their range.

Figures and short descriptions are given of little known species from New Guinea which may eventually be found in Australia. Finally a new species is described from Lihir, Bismarck Archipelago.

## Species Concept

### *Alpha taxonomy*

To understand the problems posed by various species of *Anisops*, it is necessary to consider the species concept in the genus. With few exceptions, only the males can be named with reasonable certainty.

Attempts by Sweeney (1965) and Lansbury (1969) to devise reasonably easy keys to the Australian *Anisops* have not been completely successful. The occasional failure of my 1969 key is caused by trying to key out forms of species which were not available to me when the key was prepared. The key couplet referring to the comparative width of the head to the pronotum has proved unreliable when dealing with species which vary in the degree of development of the flight musculature.

There are over one hundred described and seemingly valid species of *Anisops*, some of them with a widespread distribution. The characters used to divide up the genus into manageable proportions vary greatly in their reliability. Structural peculiarities of the head and rarely the pronotum easily distinguish a small number from most of the genus. Aus-

tralian species with reliable 'spot' characters are *stali* Kirkaldy; *calcaratus* Hale; *nasuta* Fieber; *semita* Brooks; and *tahitiensis* Lundblad. Of the remainder, *thienemanni* Lundblad; *nodulata* and *canaliculata* Brooks are easily recognized by abnormally shaped rostral prongs.

The characters used by Brooks (1951) to separate species fall into two categories (1) morphometrica of the head capsule and the pronotum; (2) presence of grooves, ridges or prolongations of the head capsule especially the facial tubercle. Secondary sexual characters with combinations of the primary features are reworked to enable species to be keyed out. The measurements of the head and pronotum are not easy to make as the structures are nearly all convex. The chaetotaxy of the male front leg, number of pegs in the stridulatory row and distribution of spines and setae on the front tibia and tarsus are used. The rostral prongs which are projections borne either side of the third rostral segment are also important.

### *Wing polymorphism*

The terminology used to indicate if an *Anisops* can fly or not is rather confusing. No problem arises over the term macropterous, but brachypterous can be misleading. All Australian *Anisops* have fully developed fore wings and hind or metathoracic wings. Despite the presence of wings, most species produce forms with the wing musculature undeveloped, in its place parenchymatous tissue. Young (1962) uses the term 'normal' for individuals capable of flight and 'flightless' for those which although possessing full sized wings, have not developed flight muscle.

The term 'brachyelytrous' has been suggested, although possibly quite suitable, some confusion may arise as this term is also applied to the Staphylinidae and Dermaptera with their characteristic short elytra, a condition not oc-

curing in *Anisops*. To avoid confusion, the terminology of Young (1962) is followed in these notes.

The normal forms with fully developed flight musculature are easily recognized by the pigmented scutellum, the clavus and corium also coloured, most commonly black, brown, red or yellow, usually a subtle combination of two or three colours. The metanotum is black or dark brown. Flightless forms (always with fully developed metathoracic wings in Australian species) have hyaline scutellums, the dorsal pigmentation showing through, likewise the clavus and corium. The metanotum is not pigmented, but occasionally dark brown at the wing bases. The following descriptions are taken from Young (1962) and refer to *assimilis* and *wakefieldi* White, both endemic to New Zealand. The macropterous form of both sexes have the lateral margins of the pronotum divergent. The males of the brachypterous forms have more-or-less parallel sided pronotums and females with slightly divergent pronotums. A check of Brooks (1951) and Lansbury (1964) shows that they often described two colour forms of a species but did not comment on the shape of the pronotum. A further complication has been found in a number of species which are isolated from the rest because the head is as wide or wider than the pronotal humeral width, these are: *evansi* Brooks (Tasmania) *robusta* Hutchinson (E. Africa) *leucothea* Esaki (Samoa and elsewhere) *doris* Kirkaldy (Australia) *tasmaniaensis* Brooks (Tasmania) *philippinensis* Brooks (Philippines and elsewhere) and *assimilis*. Young's (1962) description of *assimilis* differs from Brooks, the head irrespective of the form is always narrower than the pronotal humeral width. It seems to be a general rule in *Anisops* that the lateral margins of the pronotum of flightless males are more-or-less parallel sided, therefore the taxonomic value of the head-pronotal width is of limited use in those species which have more voluminous eyes. Series of *evansi* from Tasmania and the mainland show both forms to be present, where females can safely be associated with males, the head is always narrower than the humeral width.

In *B. limnocastris* Hungerford and other species, both sexes of the flightless forms have the head as wide or wider than the pronotal humeral width, normal forms of both sexes have the head narrower than the humeral width. Truxal (1953) describing the wing polymorphic forms of *limnocastris* found that the scutellum of the normal form was longer than the median length of the pronotum, that of the flightless form clearly shorter. These differences have not been found so far in *Anisops*.

### Colour

It is not known how much the colour of *Anisops* species can vary. Young (1962) found a direct correlation between colour and flight musculature. There is some evidence that in some circumstances *Anisops* exhibit a phenomenon rather better known in the Corixidae (see *deanei*). Specimens from turbid water with a peaty or dark substrate frequently have a much larger area of the hemelytra with dark brown transverse markings, the pronotum is often more heavily pigmented. The same species of corixid from a sandy or gravel substrate are much paler. The significance of colour in *Anisops* where it impinges on food gathering and its role in enabling *Anisops* to merge with the background are poorly documented. The differences noted by Young (1962) refer almost exclusively to the colour of the scutellum. The pale flightless *Anisops* with little dorsal pigmentation may be difficult for a predator to locate visually, the normal form with a pigmented scutellum and intensified colouring of the hemelytra may be easier for a predator to see. Both forms would be equally at risk viewed from any position sub-surface when ascending to the surface to renew their gas supply or at risk from predators which use other senses than sight to locate their prey. Bayly, Ebsworth and Wan (1975) present data from which it can be inferred that within closed systems such as exist on Fraser Island, Qld., that fish and water-bugs are mutually exclusive. They postulate that either the fish eliminate the bugs by feeding on them, or the fish out-compete the bugs for the available food supply. Young's (1962) data on *assimilis* shows that both forms were found in almost equal numbers. The num-

ber of habitats where only the normal form were found was almost the same as the flightless form. The total number of habitats with both forms present being just over double the number of those where only one form was present. *Anisops wakefieldi* differed, the normal form was ten times more common than the flightless and four times as many habitats were populated by the normal form compared with the flightless form. Both species were found together in 'swarms', *assimilis* having a greater tolerance of habitat types. In the more stable weedy habitats with little open water *wakefieldi* was the dominant species.

### Genitalia

The genitalia of *Anisops* are of very limited value at the species level. Brooks (1951) figured the left and right parameres but made no reference to them. Young (1962) did not figure or comment on the New Zealand species. Truxal (1953) figured the parameres of seven *Buenoa* species which closely resemble *Anisops* in general plan. The female genitalia of *Anisops* are of less taxonomic value than the male, the same seems to apply to *Buenoa* although *hungerfordi* Truxal differs from the others in the shape and distribution of large setae on the first gonapophysis, *hungerfordi* oviposits in rock crevices rather than plant tissue as do most other species of *Buenoa* and, as far as is known, all *Anisops*. The figures of the male genitalia (Figs. 43-58) are slightly misleading as they tend to show differences which do not exist, this is because some difficulty was experienced in placing the parameres on identical planes on the slides leading to some distortion. The apex of the left paramere is rather variable, the tip sometimes being curved inwardly, thus when viewed from the side, the tip is not visible. The right paramere is a simple flat plate.

### Isolating mechanisms

As it seems that the genitalia and the distinctions contrived by the taxonomists using the morphometrics of the head and pronotum are of limited value, the problem arises of what in certain circumstances constitutes a species in *Anisops*. Since *Buenoa* are so very much

alike *Anisops*, one of the main differences being that the male *Buenoa* has two segmented front tarsi, whereas *Anisops* males have one-segmented tarsus. It is felt that the behaviour of *Buenoa* and *Anisops* are probably rather similar. In laboratory experiments it has been found that *B. limnocastris* males will pair with *macrotibialis* Hungerford females, the F<sub>1</sub> generation are sterile, males morphologically intermediate, their acoustical behaviour similar to that of their male parents. Stimson Wilcox (n.d.) (1975). Truxal (1953) descriptions of the stridulatory apparatus of *Buenoa* species, especially the number of stridulatory pegs shows that within a species, the variation found is less than in *Anisops*. Young (1962) found that in *assimilis* males, the shape and number of stridulatory pegs was fairly constant; the size and arrangement in *wakefieldi* could be variable (28 and 15 pegs respectively). The short peg row of *wakefieldi*, rostral prong and expanded facial tubercle would produce a different sound than the longer peg row of *assimilis* drawn across a larger rostral prong. The expanded facial tubercle of *wakefieldi* would greatly hinder their attempts to pair with *assimilis* females. Presumably in New Zealand where *Anisops* has been geographically isolated for a long period and the number of species small, stable populations would develop. Sound production in *Buenoa* is assisted by the body which in whole or part acts as a frequency generator. Experimental work with *Buenoa* shows that acoustical behaviour is important in reproductive isolation amongst coexistent species, Stimson Wilcox (n.d.), (1975). No information is available on *Anisops*. Acoustical behaviour as an isolating mechanism in mixed populations is well known in other groups. Ragge (1965) describing British Acrididae (*Orthoptera*) likely to be found in the same general habitat states that *Chorthippus brunneus* (Thunberg) has 50-90 stridulatory pegs on each hind femora; *C. parallelus* (Zetterstedt) 70-130 and *Myrmeleotettix maculatus* (Thunberg) 130-180 pegs etc. Ragge's diagrams of the songs of these and other species shows that irrespective of the number of pegs, the songs of the males of each species remain consistent in volume

and duration. It is reasonable to assume from this that *Anisops* males only utilize sufficient pegs to produce a consistent species signal. This factor also tends to reduce the taxonomic value of minor variations in the number, size and arrangement of the stridulatory comb. This variation seems to be a feature of a number of nondescript species with an extensive geographical distribution.

Assuming that part of any population of an *Anisops* species living in ponds, dams and ephemeral pools contains a percentage of individuals with fully developed musculature, it is essential that should conditions deteriorate sufficiently to induce flight, the migrant population should produce and recognize acoustic signals from the same species in the habitat emigrated to, otherwise discrete populations would form in the same habitat. Exceptional habitats such as Lake Tengano, Rennell Island only seem to produce flightless forms see '*capitata*'.

*Anisops elstoni, deanei* and *philippinensis*  
Brooks

Under *elstoni* material from various localities in different countries is compared. With one or two exceptions nothing is known about the type of habitat, population density, species diversity or basic chemical and physical properties of the habitats where *elstoni* was collected. The genetic aspects remain totally unknown. As more material becomes available it has become increasingly difficult to confine the species to its original concept which, lacking secondary sexual characters, reproductive organs indistinguishable from other species and where the morphometrics are complicated by structural changes caused by wing polymorphism. The discontinuous distribution of *elstoni* and other species suggest that the species concept is not fully understood or the term 'super species' might be appropriate.

In Tasmania which has five species of *Anisops*, unpublished data shows that where two or more species are found in the same habitat, one at least is easily recognized by its larger size and/or secondary sexual characters leaving the remaining species to be easily recognized by their lack of secondary features. Con-

ditions in Tasmania tend to be rather different from those on the mainland with its greater diversity of species. The carrying capacity of habitats, especially species diversity rather than the total population of water-bugs etc. is not too well known. In Tasmania, out of 175 samples, only one habitat had eight species of water-bug present (Blackmans Lagoon). Three habitats with six species and six with five. The great majority of samples composed of two-three species. These figures may reflect vagaries of sampling rather than an accurate reflection of these habitats. There are 24 species of water-bugs in Tasmania, 28 if the Saldidae, Ochteridae and Gelastocoridae are included.

Fraser Is., Qld. has been studied in some detail (Bayly *et al.*, 1975). Four species is the maximum recorded from Boomerang South Lake, 13 lakes sampled. Bensink and Burton (1975) on the littoral fauna of Blue and Brown Lakes on Stradbroke Is., Qld. found five and nine species respectively. Brown Lake being sampled more often than Blue Lake. Some of the *Anisops* listed in Bayly *et al.* (1975) and Bensink and Burton (1975) are discussed in the taxonomic section of these notes.

The problem arises of deciding whether the material from Tasmania is conspecific with those from mainland localities in Australia and further north in New Guinea etc.

The data can be interpreted in one of two ways, *elstoni* may be a complex of races which because of geographical isolation are in the process of evolving into distinct species or it may be a widespread 'plastic' species which has spread from south east Asia into Australasia, each population still linked by common genetic factors.

*Anisops deanei* is confined to Australia and a closely allied form or species is rather common in Tasmania, much more so than *elstoni*. Non-Tasmanian *deanei* varies rather more than *elstoni*. In Tasmania they are both sometimes found in the same habitat, but do not seem to be so on the mainland.

Where two or more species occur in the same habitat, acoustic behaviour, phased life

cycles and a subtle niche preference not so far revealed by sampling seem to enable *Anisops* species to coexist and avoid competition for the available food supply.

#### *Habitat and distribution*

Lack of data makes it difficult to be precise about the habitat preferences of Australian *Anisops* species. Sweeney (1965) describes *elstoni* as rare and confined to the south east, the most westerly record being Narrandera, N.S.W. Most Australian *Anisops* are found along the eastern coastal zone, a few are confined to the more arid interior. Some species typified by *thienemanni*, *stali* and *hyperion Kirkaldy* are found across the continent. The coastal zone from Brisbane northwards has a number of species with prominent secondary sexual characters and not related to the New Guinea fauna. Species of the more temperate areas are less well endowed with such features. *Anisops philippinensis* appears to be a relative newcomer to the Queensland fauna rather like *tahitiensis* Sweeney (1965).

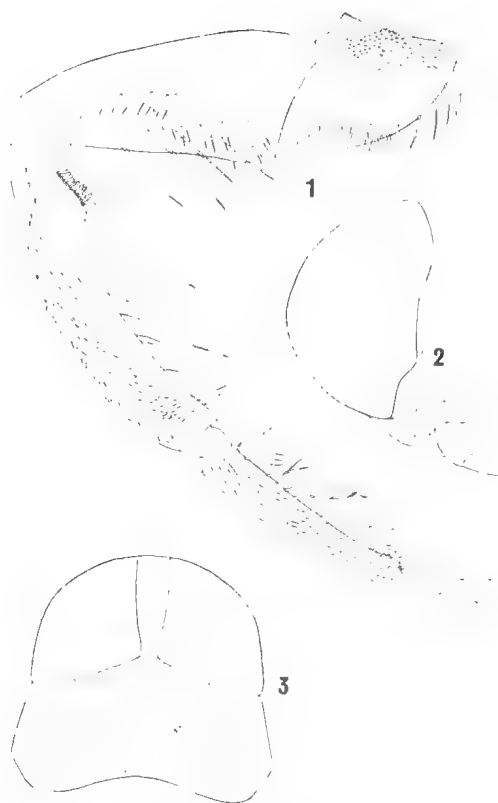
#### *Taxonomy*

##### ***Anisops elstoni* Brooks, 1951**

Figures 1-15, 43-50 and 59-61

This species was described from Myponga, South Australia; The Dorrigo, 3,000', New South Wales; Brisbane, Queensland and Szechuan, Suifu, China. Brooks compared *elstoni* with *exigera* Horvath (New Guinea). His figures of the male front leg are misleading as he omits to include the large spine on the inner proximal margin of the front tarsus (Figs. 1, 4, 7, 10 and 13) and he overlooked it in his description. Fortunately, he mentioned it in the key to species. He does mention the pronotal depression which is helpful in isolating *elstoni* from related species (Figs. 3, 6, 9, 11 and 14). The material studied has been found to vary from various localities in Tasmania, Australia, New Guinea, Vietnam and possibly Rennell Island.

A male from Charters Towers Qld., Coll. Sedlacek (Bishop Museum) has a bright red scutellum. Eyes orange-brown and pronotum straw yellow. The hemelytra are hyaline except for the inner claval margin adjacent to the



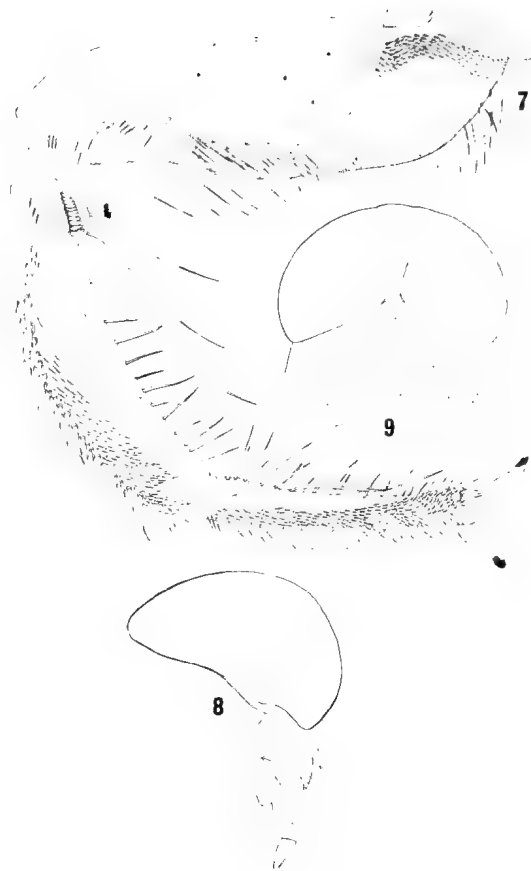
Figures 1-3—*Anisops elstoni* Brooks ♂, Myponga, S.A.: 1, front leg. 2, head from side. 3, head and pronotum from above.

scutellum which is carmine. Metanotum dark reddish brown, tergites black, posteriorly margined with yellow. Sternites other than keel black.

A small series mostly females from Caddies Creek, N.S.W. vary between the colour of the Charters Towers male through to the pale yellowish form. The hemelytra are hyaline, metanotum pale yellow. Pronotal shape the same regardless of colouration. A series from Valley Heights near Katoomba are a uniform greyish black. The lack of pigment may be because they were kept in alcohol for an unknown period. The eyes appear to be rather more elongate than usual and give the impression of being wider than the humeral width, they are consistently narrower, a ratio of 41:43. A similar phenomenon is found in the Fraser Island population from Lake 'AB' (Fig. 9). The rostral prong of the Fraser Is-



Figures 4-6—*A. elstoni* ♂, upper reaches of Sorrel River, Tasmania: 4, front leg. 5, head from side. 6, head and pronotum from above.



Figures 7-9—*A. elstoni* ♂, Fraser Island, Qld.: 7, front leg. 8, head from side. 9, head and pronotum from above.

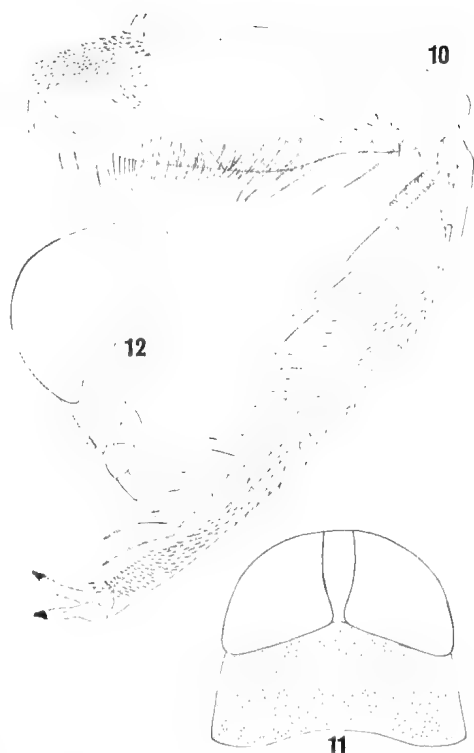
land males is much more sharply separated from the third rostral segment as it is differentially coloured (Fig. 8). A male from North Stradbroke Island, Qld. Brown Lake, 7.iv.1974, Macfarlane and Sweeney (Site 9c) closely resembles the highly coloured form from Charters Towers (Figs. 10-12) and is clearly the macropterous form. The male from Vietnam does not differ much from the Australian form (Figs. 13-15). It is now certain that *A. depressa* Lansbury (1962) described from Dutch New Guinea is a synonym of *elstoni*. The differences outlined in Lansbury (1964) are not sufficient to justify the separation of *depressa* from *elstoni*. The presence of *elstoni* in New Guinea is a useful link between Vietnam, China and Australia.

The male genitalia (Figs. 43-50) show minor variations in the shape of the parameres. The first gonapophysis of the females (Figs. 59-61) are all remarkably similar. One feature of *elstoni* is the increase in size of the front tarsal spine from north to south, the Vietnam male having the least conspicuous (Fig. 13). The Myponga (Fig. 1) and Tasmanian, Sorrel River (Fig. 4) the largest. *Anisops elstoni* is rare in Tasmania, besides the Sorrel River, material has been studied from a creek 6 miles from Interlaken on the Bothwell Road; Blackmans Lagoon; Flinders Island. All the material pale yellowish brown and preserved in alcohol.

***Anisops 'capitata'* Lansbury, 1968**  
(Figures 16-18)

This species has very close affinities with





Figures 10-12—*A. elstoni* ♂, N. Stradbroke Island, Qd.: 10, front leg. 11, head and pronotum from above. 12, head from side.

Figures 13-15—*A. elstoni* ♂, Vietnam, 19 km N.W. of Dalat, 1300 m., May, 1960: 13, front leg. 14, head and pronotum from above. 15, head from side.

*elstoni*, especially the form from Fraser Island. In Brooks (1951) key it keys out with *rigoensis* and *biroi* Brooks, but does not seem to be related to them. In Lansbury (1969) it keys out with *evansi* and *doris* because the head is wider than the pronotal humeral width. Like *elstoni*, the pronotal disk is depressed. The specimens collected by E. S. Brown from Lake Tengano are rather more yellowish than those obtained by Torben Wolff from the same general habitat which are relatively paler, the hemelytra are hyaline, the costal margin near the pronotum being infuscated smokey brown. The colour approaches that of the *deanei* population from North Stradbroke Island.

Although treated as a distinct species, it is very probable that *capitata* is a brachypterous form of *elstoni*. Andersen (1975) relegated

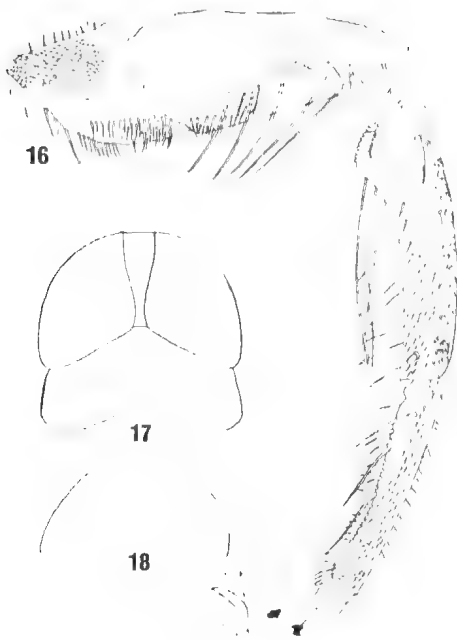
*Limnogonus rennellensis* Brown (Gerridae) to a subspecies of *L. fossarum* F. a widespread Indo-Australian and Pacific species, *capitata* is almost certainly at least in the same category.

**Anisops philippinensis** Brooks, 1951

Figures 19-29, 53 and 54

Described from a series of 90 specimens from the Philippine Islands, Mindanao, Lake Linao, North Slope, Mt Apo Davao Province, 7800'. H. Hoogstraal and F. G. Werner. Most of type series in Field Museum, Chicago.

Brooks compared *philippinensis* with *tahitiensis*, the latter is easily recognized by the carinate frons. Brooks commented that the scutellum was either testaceous or black with anterior margin testaceous. Because of the varia-



Figures 16-18—*A. 'capitata'* Lansbury ♂, Rennell Island: 16, front leg. 17, head and pronotum from above. 18, head from side.

tion in the morphometrics of the head and pronotum, Brooks found it necessary to key *philippinensis* out in three separate couplets. Like *elstoni*, *philippinensis* is a nondescript species with no obvious secondary sexual characters to distinguish it from other similar size species. The Australian material referred to this species constitutes a new record for Australia.

Figures 19-21 are based on a study of two male paratypes and differ in several details from Brook's figures, especially the chaetotaxy of the front tarsus and shape of the rostral prong. Comparing these figures with those of a single male (Figs. 25-29) from Fraser Island, Boomerang South Lake (No. 5) I. A. E. Bayly (Bayly *et al.*, 1975) shows a remarkable similarity between the two forms. The Fraser Island male differs by having the head about 9x wider than the anterior width of the vertex and fractionally wider than the pronotal humeral width. The pronotum is pale yellow,

hemelytra hyaline. There seems no doubt that this male is a flightless form of *philippinensis*. The minor variations in the chaetotaxy of the front leg are not considered significant, especially as the paratype(s) do not agree with the figure by Brooks.

A pair from N.E. New Guinea, Wau, Morobe District, 1100 m., 9.ix.1961, J. Sedlacek (Bishop Museum) (Figs. 22-24) are rather more like the form from the Philippines although the chaetotaxy of the front tarsus is dissimilar. The head is 7.5x anterior width of the vertex, Brooks gives the head width as 10x anterior width of vertex.

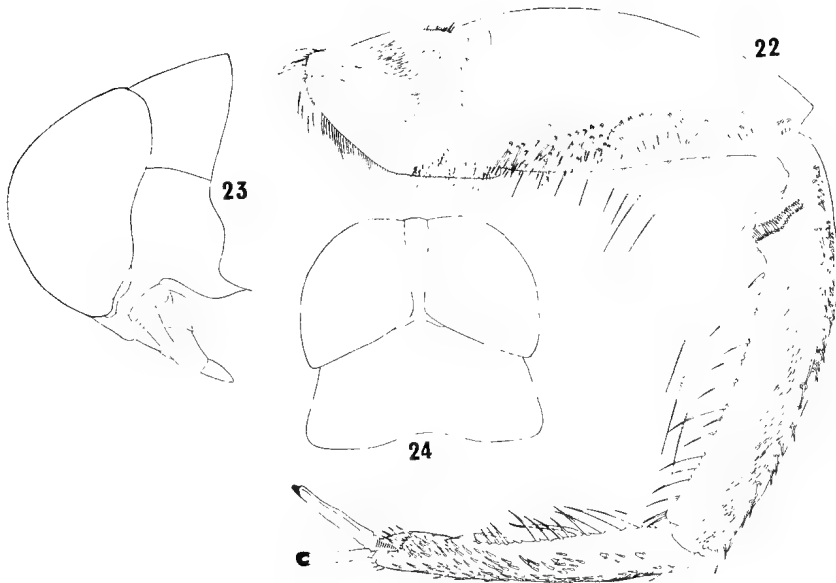
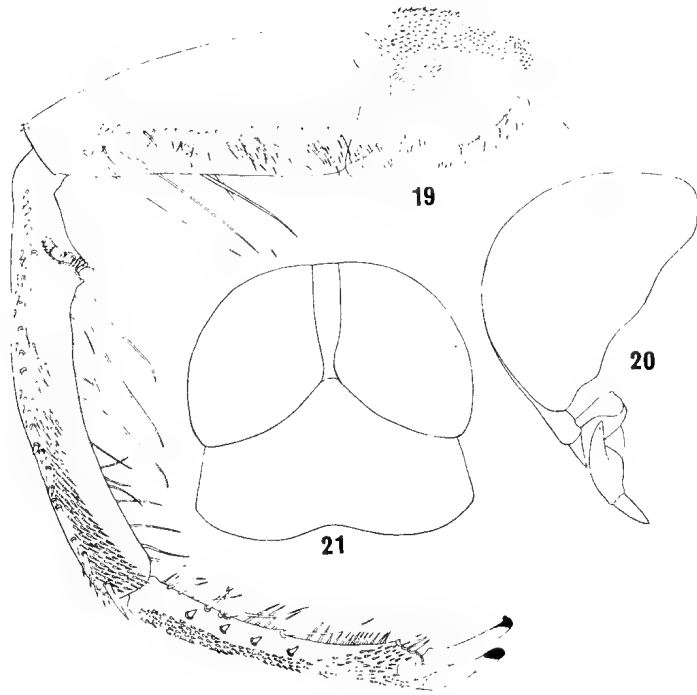
### *Anisops deanei* Brooks, 1951

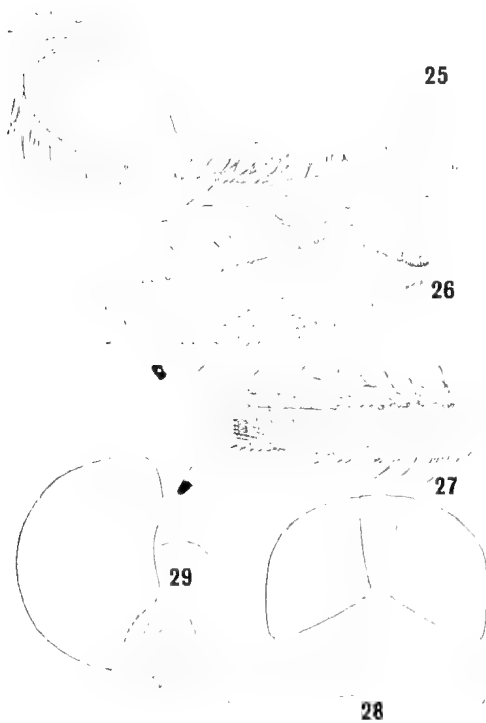
Figures 30-32

A small series from North Stradbroke Island, Brown Lake, September, 1972, G. Monteith are quite unlike the usual form of *deanei* (Lansbury, 1964). The eyes are dark brown-black. The head between the eyes, facial tubercle and labrum black. Pronotum and scutellum almost hyaline, pale yellow of thorax showing through. Pronotal fovea dark brown and tomentose. Hemelytra hyaline, infuscated along the costal margin. Abdomen black, legs dark brown—black and shining. Because of its unusual appearance this population puzzled me. The eyes are large and the head is as wide or wider than the pronotum and 11x the anterior width of the vertex; *deanei* normally always has the head narrower than the pronotum and the head width 6-7x anterior width of the vertex. The synthipsis is wide, half the anterior width of vertex. Lateral margins of pronotum almost parallel and slightly concave in some specimens (Fig. 31). The rostral prong is rather more sinuate than usual and the base of the third segment is not much wider than the apex of the fourth (Fig. 32). The chaetotaxy of the male front leg (Fig. 30) is similar to

Figures 19-21—*A. philippinensis* Brooks ♂ paratype.: 19, front leg. 20, head from side. 21, head and pronotum from above.

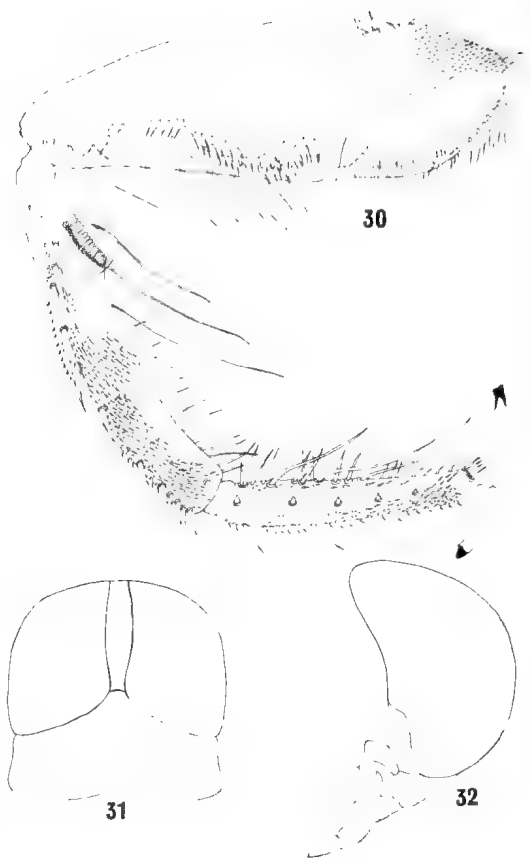
Figures 22-24—*A. philippinensis* ♂ New Guinea: 22, front leg. 23, head from side. 24, head and pronotum from above.





Figures 25-29—*A. philippinensis* ♂, Fraser Island, Qd., Boomerang South: 25, front femur. 26, tibia. 27, tarsus, 28, head and pronotum from above. 29, head from side.

typical *deanei*. In Brooks (1951) this form keys out to couplet 53 (*philippinensis* and *windi* Brooks) the latter is distinguished by having the synthlipsis almost the same width as the anterior width of the vertex. In Lansbury (1969) it keys out as either *deanei* or *nabilla* Lansbury. The rostral prong of *nabilla* is smaller, rather slender, apically acuminate and the front femur is broader distally than in *deanei*. Bensink and Burton (1975) refer to a species 'near *philippinensis*' Det. Lansbury from Blue and Brown Lakes on North Stradbroke Island. This is the brachypterous form of *deanei* and forms an interesting parallel with those described by Young (1962) for New Zealand species. Bensink and Burton (1975) found as on Fraser Island (Bayly *et al.*, 1975) that no fish were present in the lake with the more diverse water-bug fauna (nine species) Brown Lake;



Figures 30-32—*A. deanei* Brooks ♂, N. Stradbroke Island, Qd: 30, front leg. 31, head and pronotum from above. 32, head from side.

whereas Blue Lake with fish present had five species present including *deanei*. Almost three times as many collections were made from Brown Lake therefore Bensink and Burton's data is not conclusive.

The water-bug fauna of Brown Lake is of interest as it shows the low species diversity in a lake with a surface area of c. 25 ha and a maximum depth of 6.4 m. The pH varying between 3.95 and 5.4. Bensink and Burton (1975) distinguish two groups of aquatic invertebrates: Zooplankton, one water-bug, *deanei* and the littoral fauna; *deanei*, *elstoni* corixidae *Micronecta* sp.\*; Nepidae *Ranatra diminuta*, *R. dispar* Montandon and *Laccotrephes tristis* Stål; Naucoridae *Naucoris australicus*

\* *Micronecta lansburgii* Wroblewski

Stål; Gerridae *Rhagodotarsus* sp., *Limnogonus fossarum* (Fabr.). With the exception of *Micronecta*, all the water bugs listed are entirely predatory. Bensink and Burton (1975) comment that *deanei* readily fed on *Chaoborus* in the laboratory as do the fish in Blue Lake which has a low species diversity.

The colour of *deanei* from Brown Lake which is described as humic brown due to accumulated dissolved organic matter does support the suggestion that the colour of the water and substrate influences the colouration of the *Anisops* species present although fish predators were absent. Potential predators of *Anisops* would include nepids, other notonectids, Coleoptera and Odonata nymphs.

### *Anisops rigoensis* Brooks, 1951

Figures 33-36

Small species 4.4-5 mm long, maximum width 1.1-3 mm.

Originally, description based on specimens from New Guinea: N.G., Rigo, Luglio [July], 1889, L. Loria; N.G., Lemian Berlinhafen 1896, Biro and N.G. Friedrich-Wilh.-hafen, 1896, Biro in the Snow Entomological Collections, Lawrence Kansas.

*Material examined.* 1♂ 1♀ paratype N.G. Rigo, Luglio, 1889 and 11♂ 1♀ New Guinea: Neth. Genjam 40 km west of Hollandia, 100-200 m; 1-10.iii. T.C. Maa by courtesy of the Snow Ent. Coll. and Bishop Museum respectively.

The description given by Brooks is rather confusing. The two paratypes do not agree with the original description. The synthlipsis of the male is not 1/5-1/3 anterior width of vertex as stated by Brooks, but 1/9-1/12 anterior width of vertex. The vertex is feebly carinate, commencing at the synthlipsis and extending about 1/3 median head length between the eyes. The development of the carina is rather variable and difficult to see. Brooks gives a muddled description of the morphometrics of the head and pronotum. The ratios in the series examined have the head length about the same as the median pronotal length, pronotal humeral width just under twice the median length. Brooks comparing *biroi* with *rigoensis* states that *rigoensis* has three small setae on the inner surface of the male front tarsus, they are not shown in his figure and in his key, couplet 93 he

specifically excludes *biroi* and *rigoensis* from the remaining species by the absence of setae on the front tarsus. The rostral prong of *rigoensis* is rather variable (Figs. 34, 36). Chaetotaxy of the male front leg (Fig. 33).

### *Anisops biroi* Brooks, 1951

Figures 37-39

Small species (Brooks states males 4.2-4.3 mm long, maximum width 1.2-1.3 mm).

Original description based on 3♂ 2♀ from New Guinea, Seleo Berlinhafen. '96 (Biro). Type series in the Snow Entomological Collections, Lawrence Kansas.

*Material examined:* 1♂ 1♀ paratype; male 5 mm long, female 4.9 mm long. By courtesy of the Snow Ent. Coll.

Brook's description is brief but adequate to distinguish *biroi* from *rigoensis*. The synthlipsis of *biroi* is wider than that of *rigoensis* and the male examined lacks a carinate vertex. The chaetotaxy of the front leg (Fig. 37) hardly differs from *rigoensis*. The rostral prong is a little longer, Brooks states that the prong of *biroi* is at least as long as the third segment whereas in *rigoensis* the prong is shorter than the third rostral segment. Comparison of figure 38 with figures 34 and 36 do not wholly support Brooks diagnosis. The eyes of *rigoensis* are larger (Figures 34-36) than those of *biroi* (Figs. 38, 39).

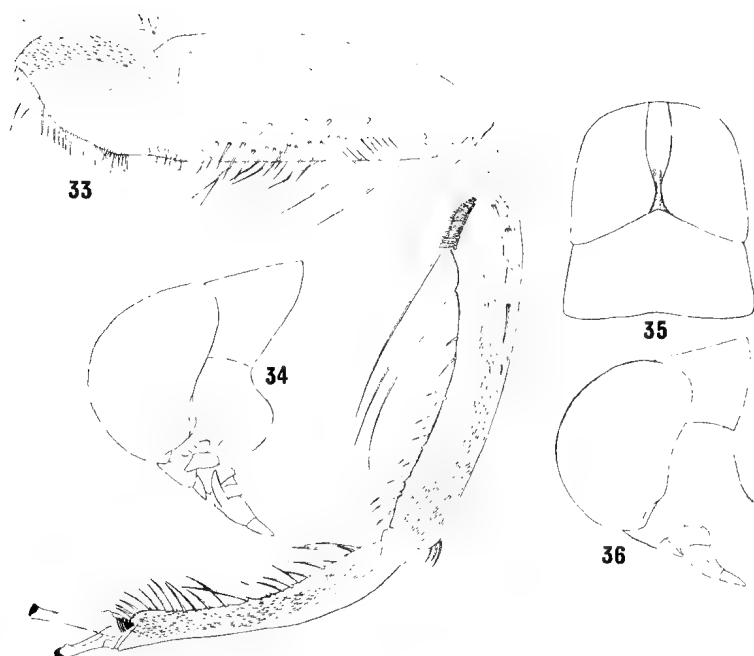
*Anisops rigoensis* and *biroi* are similar in general appearance, chaetotaxy of the front legs and shape of the rostral prong. The only real difference is that *rigoensis* has a feebly carinate vertex and a very narrow synthlipsis. Because of a lack of data on other species, it is not possible to comment on the differences in eye size between these two species.

### *Anisops lihiriensis* sp. n.

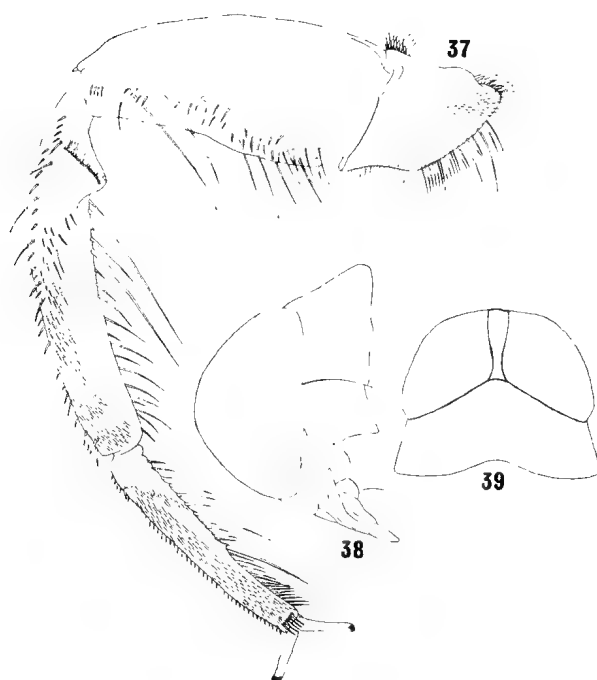
(Figures 40-42 and 51, 52)

Males, 5.5 mm long, maximum width 1.75 mm.

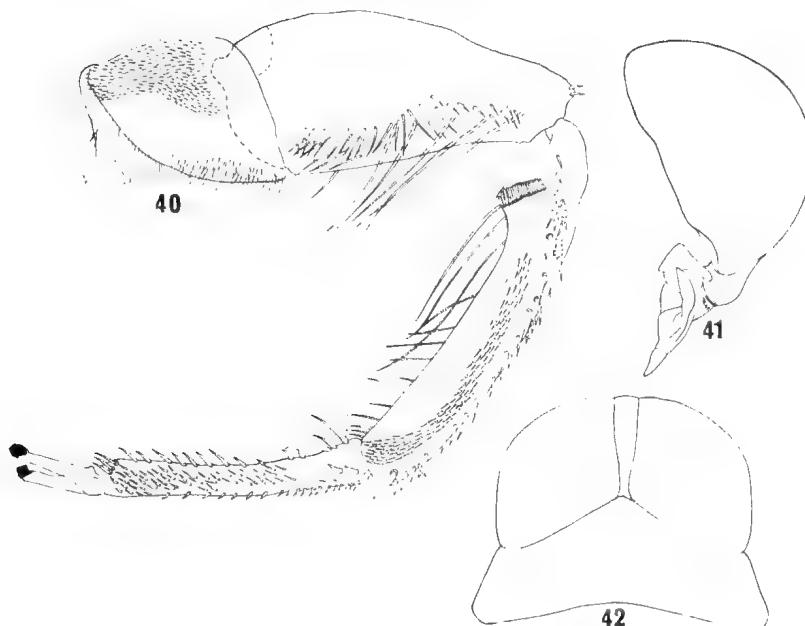
Colour, eyes grey, vertex, pronotal fovea and pronotum yellowish white. Scutellum basally broadly brown, apex yellowish white. Hemelytra hyaline, claval margins and hemelytral com-



Figures 33-36—*A. rigoensis* Brooks ♂, 33-35, paratype. 36, Genjam, N.G.: 33, front leg. 34, head from side. 35 and 36, head and pronotum from above.



Figures 37-39—*A. biroi* Brooks ♂, paratype: 37, front leg. 38, head from side. 39, head and pronotum from above.



Figures 40-42—*A. lihiriensis* sp. n. ♂ paratype, Lihir: 40, front leg. 41, head from side. 42, head and pronotum from above.

missure pale red. Abdomen dark brown to black, legs pale yellow. Originally preserved in alcohol.

Structure, greatest width of head between ten and twelve times the anterior width of the vertex, narrower than pronotal humeral width. Synthlipsis about half the anterior width of vertex. Median head length slightly shorter than the pronotum. Humeral width about two and a half times median pronotal length. Facial tubercle prominent.

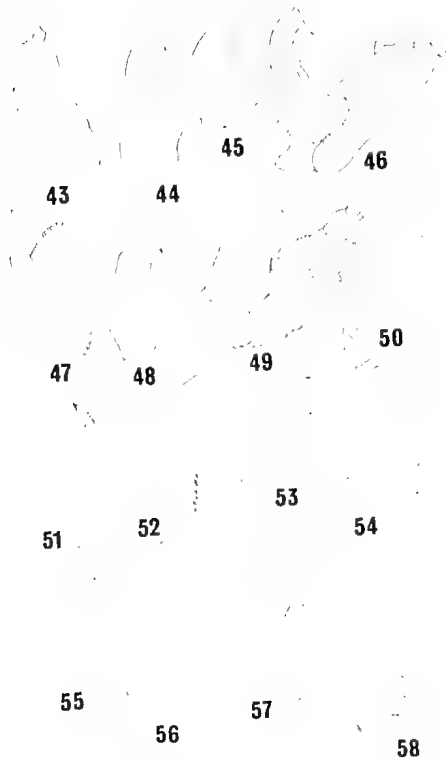
Keys out to couplet 53 in Brooks (1951) similar to *philippinensis* and *windi*, *lihiriensis* differs from them by having an inflated facial tubercle, the rostral prong is rather stouter and the front tibia does not have the setae characteristic of these species. In Lansbury (1969) *lihiriensis* keys out with *deanei*, the same differences apply. Parameres (Figs. 51, 52).

Holotype ♂, 2 ♂ paratypes: Bismarck Archipelago, Lihir, Put Put, pig wallows, 10' diameter, bottom muddy, water opaque 3" deep, 30.vi.1965, A. W. Sweeney (Oxford).

On the same island on the 13.vi.1965, A. W. Sweeney collected a long series of *tahitiensis*. This species has spread over much of the Indo-Australian Pacific region. Originally described from Tahiti. It is common in the New Hebrides, New Guinea, Solomons, Malaya etc. Sweeney (1965) recorded *tahitiensis* from Queensland. *Anisops nasuta* Fieber has a similar distribution although it does not extend so far across the Pacific. Known from Tonga Is. (Nova Pou Is.) New Hebrides, New Caledonia, New Guinea, Solomons, Malaya, Java, Bismarck Archipelago and northern Australia. The first gonapophysis of the female (Fig. 62) drawn to the same scale as figures 59-61 shows that although *nasuta* is larger than *elstoni* 6-7.5 mm compared with 5 mm, the gonapophysis is not significantly larger.

#### Acknowledgements

I wish to thank Dr P. S. Lake, Zoology Department, Monash University, Victoria for the loan of many samples of water bugs from Tas-



Figures 43-58 *Anisops* parameres. Figures 43-50 *elstoni*; 43-44 *myponga*; 45-46 Sorrell River; 47-48 Stradbroke Island; 49-50 Fraser Island. Figures 51-52 *lhiriensis*. Figures 53-54 *philippinensis*, Fraser Island. Figures 55-56 *deanei*, Stradbroke Island. Figures 57-58 *Nasuta*, Fraser Island.

mania. Dr A. Neboiss for the loan of material from Blackmans Lagoon, Tasmania. The Bernice P. Bishop Museum, Honolulu for the loan of important material. Dr G. Byers of the Snow Entomological Collections, Lawrence, Kansas for the loan of specimens from the type series of species described by G. T. Brooks. Lastly Mr A. W. Sweeney for the gift of material from the Bismarck Archipelago.

## References

- ANDERSEN, N. M., 1975. The *Limnogonus* and *Neogerris* of the Old World. *Entomologica Scandinavica*, Supplementum 7: 1-93.
- BAYLY, I. A. E., E. P. EBSWORTH and HANG FONG WAN, 1975. Studies on the lakes of Fraser Island, Queensland. *Aust. J. Mar. Freshwat. Res.*, 26: 1-13.
- BENSINK, A. H. A. and H. BURTON, 1975. North Stradbroke Island a place for freshwater invertebrates. *Proc. R. Soc. Qd.* 86(7): 29-45.
- BROOKS, G. T., 1951. A revision of the genus *Anisops* (Notonectidae, Hemiptera). *Kans. Univ. Sci. Bull.* 34: 301-519.
- LANSBURY, I., 1962. Notes on the genus *Anisops* in Bishop Museum. *Pacific Insects*. 4: 141-151.
- , 1964. The genus *Anisops* in Australia (Hemiptera: Notonectidae). *J. ent. Soc. Qd.* 3: 52-65.
- , 1968. Notonectidae (Hemiptera-Heteroptera) of Rennell Island. *The Natural History of Rennell Island 5 (Zoology)*, pp. 95-98.
- , 1969. The genus *Anisops* in Australia (Hemiptera-Heteroptera Notonectidae). *J. nat. Hist.* 3: 433-458.
- RAGGE, D. R., 1965. Grasshoppers, Crickets and Cockroaches of the British Isles, F. Warne, London.
- STIMSON WILCOX, R. (not dated). Abstract 'Acoustical behaviour, sound producing-structures and biology of *Buenoa* (Hemiptera, Notonectidae).' Thesis, Department of Zoology, University of Michigan, Ann Arbor, Michigan, 271 pages.
- , 1975. Sound producing mechanisms of *Buenoa macrotibialis* Hungerford (Hemiptera: Notonectidae), *Int. J. Insect Morphol & Embriol.* 4(2): 169-182.
- SWEENEY, A. W., 1965. The distribution of the Notonectidae (Hemiptera) in south-eastern Australia. *Proc. Linn. Soc. N.S.W.* 90(1): 87-94.
- TRUXAL, F. S., 1953. A revision of the genus *Buenoa* (Hemiptera Notonectidae). *Kans. Univ. Sci. Bull.* 35: 1351-1523.
- YOUNG, E. C., 1962. The Corixidae and Notonectidae (Hemiptera-Heteroptera) of New Zealand. *Rec. Canterbury Mus.* 7(V): 327-374.





Figures 59-62—*Anisops* gonapophyses. Figure 59, *elstoni*, Myponga. Figure 60, *elstoni*, Sorrel River. Figure 61, *elstoni*, Fraser Island. Figure 62, *nasuta*, Fraser Island.



# REVISION OF THE AUSTRALIAN EUAESTHETINAE (COLEOPTERA: STAPHYLINIDAE)\*

By VOLKER PUTHZ

Limnologische Flusstation des Max-Planck-Instituts für Limnologie, D-6407 Schlitz/Germany

\* 25th contribution to the knowledge of Euaesthetinae.

## Abstract

This paper revises all Australian Euaesthetinae hitherto described (4 genera, 9 species, 1 syn. nov.). It deals with the lectotypology of one Oke species, and includes descriptions of one new genus and nine new species (*Mesoesthetus tasmanicus*, *Tasmanosthetus okei* gen. et sp. nov., *Austroesthetus tasmanicus* n. sp. *Edaphus australicus*, *E. brittoni*, *E. invidiosus*, *E. nevoissi*, *E. zwicki*, *E. zwickianus*). Three species are described from Tasmania and are the first records of the Euaesthetinae for that state. Tentative zoogeographic and phylogenetic analysis shows that there is a remarkable endemism at the generic level, that the fauna of Tasmania is very close to that of Victoria, and that the new genus *Tasmanosthetus* represents a gondwanian element, close to another genus of the subfamily from Chile.

## Introduction

With at present 25 genera, the staphylinid subfamily Euaesthetinae has a world wide distribution. All species are tiny, mostly less than 2 mm in length, many are wingless and microphthalmous-anophthalmous. Our knowledge of their ecology is very poor; most species belong to the humicolous fauna, some live in soil.

So far nine taxa have been described from Australia. The present revision is based on the holotypes of all described species, undescribed specimens from the collection of the National Museum of Victoria, Melbourne, and on material recently collected by H. Franz and P. Zwick.

These are the results:

1. First record of Euaesthetinae from Tasmania.
2. There are six genera in Australia of which two are new.
3. In total there are now 21 known species, of which six remain unnamed for various reasons. Nine new species are described.
4. *Edaphus melculus* var *camponoti* (Oke) is a junior synonym of *E. termitophilus* Bernhauer.

## Discussion

A substantial zoogeographic and phylogenetic analysis of the Australian Euaesthetinae cannot be given now. I am sure that only a

small proportion of the existing species has been collected so far. Some remarks, however, can be made:

- (a) The Australian fauna contains the highest number of endemic genera found in any continent. Except *Edaphus* Motschulsky the other five genera (Gen. spec.; *Mesoesthetus* Cameron; *Tasmanosthetus* n. gen; *Austroesthetus* Oke; *Geosthetus* Oke) are restricted to Australia, for comparison: one genus is endemic in New Zealand (*Agnosthaetus Bernhauer*), three genera are endemic in Chile (*Chilioesthetus* Saiz, *Notoesthetus* Saiz, *Alzadesthetus* Kistner), one in the Himalaya (*Orosthetus* Puthz), one in Madagascar (*Coiffaitia* Kistner and Shower), one in East Africa (*Gerhardia* Kistner), one in North America (*Fenderia* Hatch), and two in the mediterranean region (*Ctenomastax* Kraatz, *Euaesthetotyphlus* Coiffait and Decou).
- (b) The five endemic genera of Australia are restricted to the Bassian faunal province, but no species is so far known from Western Australia.
- (c) Two of the endemic genera are represented in Victoria and Tasmania, which support the view that the fauna of Tasmania is close to that of S.E. Australia.

- (d) The apterous new genus *Tasmanosthetus* is possibly phylogenetically near to *Chilioesthetus* Saiz. It represents a southern (gondwanian) element.
- (e) *Edaphus* Motschulsky is recorded from Northern Queensland to Adelaide, but has not been found in Tasmania. This genus has a worldwide distribution and is also known from various oceanic islands. It is probable that the insects have been dispersed as aerial plankton on prevailing winds. The Australian *Edaphus* undoubtedly represent younger northern elements.

I think that these tentative remarks make it clear that careful collecting of Euaesthetinae (mainly by sifting plant debris and by using the Berlese-method, especially in native forests) should be of great value in solving phylogenetic and zoogeographical questions of general interest. I am always prepared to study such materials.

In the key given below I have included those species which have not been named. In relation to the descriptions of *Edaphus* species I refer the reader to my remarks on the taxonomic characters of this genus (Puthz 1974).

#### Tribe STENAESTHETINI

##### 1. Gen. spec. ?

There is one female in the collection of the National Museum of Victoria which has no locality label. The species has the tarsal formula 5-5-4 and the abdomen immargined. The antennae are 11-segmented and distinctly enlarged towards club, labrum denticulate at anterior margin, labium with rounded lobes and a triangular median excision.

Without any doubt this species belongs to the tribe Stenaesthetini and is distinctly different from *Stenaesthetus* Sharp, *Aulacosthaetus* Bernhauer, and *Gerhardia* Kistner. Because the sole remaining genus of the tribe, *Agnosthaetus* Bernhauer (New Zealand), is insufficiently described, a clear decision on the generic status of this female is impossible at present. But it is highly probable (following the description of *Agnosthaetus*) that the Australian specimen represents a new genus.

#### Tribe AUSTROESTHETHINI

##### Genus *Mesoesthetus* Cameron.

*Mesoesthetus* Cameron, 1944, *Ann. Mag. nat. Hist.* (11)11: 68.

*Type species: Mesoesthetus wilsoni* Cameron, 1944.

2. *Mesoesthetus wilsoni* Cameron, 1944  
*Mesoesthetus wilsoni* Cameron, 1944, *Ann. Mag. nat. Hist.* (11) 11: 69f.

*Material examined:* ♂-holotype: Victoria: Warburton, 4000', in tussocks, 20.XI.1927, F. E. Wilson (BMNH); 1 ♀: Victoria: Cumberland Falls, 1.XI.1966, J. Ramsay (NMV).

Proportional measurements of the ♂-holotype: Width of head: 47; width of pronotum: 48.5; length of pronotum: 50; greatest width of elytra: 50; greatest length of elytra: 33; sutural length: 25. Length of body: 1.7-2.1 mm. *Male:* 8th sternite with a deep notch in posterior half (length of sternite: depth of notch = 47:27). Aedeagus (figs. 1, 2).

##### 3. *Mesoesthetus tasmanicus* sp. nov.

Ferruginous, slightly shining, densely coriaceous, densely pubescent. Antennae, palpi, and legs reddish yellow.

*Length:* 1.8-2.2 mm.

♂-holotype and ♀-paratype: Tasmania: 'Parawee' (Parrawe), XII. 1939, F. E. Wilson.

Because the new species is very close to *M. wilsoni* Cam. a full description is not necessary. A detailed comparison should be sufficient to characterize this new species.

Proportional measurements of the holotype: Width of head: 49; length of frontoclypeus: 35; distance between eyes: 39; width of pronotum: 50; length of pronotum: 52; greatest width of elytra: 51; greatest length of elytra: 35; sutural length: 25.

Eyes as large or slightly larger than temporal depression, sculpture of frons slightly denser than in *M. wilsoni*. Pronotum about as in *M. wilsoni* but the sides posteriorly slightly concave, basally on each side with two impressions, the inner one distinctly smaller than the lateral one, about as large as largest cross section of 2nd antennal segment. No further

impressions (in *M. wilsoni* there are two shallow longitudinal impressions in the posterior half of pronotum). Sculpture slightly denser than in *M. wilsoni*. Elytral sculpture less dense and more shallow than that of pronotum, with a moderately fine, indistinct punctation. Abdominal sculpture somewhat denser than in *M. wilsoni*.

*Male*: 7th sternite broadly emarginated at posterior margin. 8th sternite with a deep oval notch, which is slightly longer than half of the sternite and has a membraneous margin basally. 9th sternite sharply pointed at apex. Aedeagus (figs. 3, 4) distinctly broader than in *M. wilsoni*; no distinctly separated parameres.

Holotype in the National Museum of Victoria, paratype in the author's collection.

#### *Tasmanosthetus* gen. nov.

*Type species: Tasmanosthetus okei* sp. nov.

This new genus belongs to the tribe Austroesthethini because all the tarsi are 4-segmented and the abdomen is immargined.

Head large, eyes extremely small, consisting of about three ommatidia, frons regularly rounded, deeply shagreened, neck distinctly separated. Gular sutures distinctly separated anteriorly, not so in posterior portion. Labrum (fig. 14) distinctly denticulate anteriorly, mandibles (fig. 13) long and slender, acute and with an acute tooth near middle. Maxillae resembling those of *Geosthetus* (Oke 1933 fig. 37), palpi 4-segmented: 1st segment slightly shorter than 2nd, both slender, 3rd segment large, about as long as 2nd but nearly twice as broad, 4th very small, subulate. Labium slightly broader than long, anterior margin subtriangularly emarginate, sides rounded, palpi with 3 segments, 1st small, 2nd large, 3rd thin, subulate. Antennae (fig. 12) 11-segmented, basal 2 segments larger than the following ones, club distinct, last segments distinctly separate.

Pronotum about as broad as head, with a small basal fovea laterally and four shallow longitudinal impressions dorsally. Anterior margin of prosternum indistinctly crenulate, not distinctly denticulate, prosternal process short and narrow. Elytra very short, epipleurae separated from dorsal surface by a narrow but

distinct margin, no sutural margination. Wings absent. Mesosternum about as long as metasternum, mesosternal process short, narrow, acute, mesocoxae posteriorly contiguous. Metasternum smooth but basally with a median carina, metasternal process short, posterior coxae distinctly separate.

Abdomen ellipsoid, very elongate, longer than fore body, immargined except segments 7 and following. 7th sternite without an apical membraneous fringe. Valvifera apically pointed.

Legs short, tibiae apically with a row of stronger setae, tarsi 4-segmented.

*Male*: unknown.

*Female*: 8th sternite apically moderately narrowly rounded. Spermatheca weakly sclerotized, inconspicuous.

*Tasmanosthetus* n. gen. can be distinguished from other Euaesthetine genera which have 4-segmented tarsi and an immargined abdomen as follows: from *Mesoesthetus* Cameron by smaller eyes and not impressed temporal region of head, from *Austroesthetus* Oke by smaller eyes, differently shaped antennae, rounded labial lobes, and the lateral margin of elytra, from *Chilioesthetus* Saiz by the distinctly separated segments of the antennal club and the immargined 3rd abdominal segment.

Unfortunately no male of the new genus is known. At present from exoskeletal characters, *Chilioesthetus* Saiz is regarded as very closely related to *Tasmanosthetus*.

#### 4. *Tasmanosthetus okei* sp. nov.

Apterous, very slender, testaceous, rather shining. Antennae, palpi, and legs yellowish. Head and pronotum densely shagreened, elytral sculpture less dense, more irregular and more shining, abdomen with the ground sculpture pineapple-like, the most shining portion of the insect.

*Length*: 1.3-1.9 mm (extended).

♀-holotype and ♀-paratype Tasmania: Mt. Wellington, Oct., C. Oke.

Head nearly as broad as elytra (28:29), length of front (from anterior margin up to beginning of neck: 23), ocelli slightly smaller than minute eyes, distance between ocelli and

eyes about the same. Antennal tubercles moderately prominent. Front without any impression, extremely densely shagreened, rather dull.

Pronotum about as broad as head (28, 5: 28), somewhat longer than broad (31: 28.5). Impressions (see above). Ground sculpture about as on head, very slightly less dense, that of the sides somewhat granulate.

Elytra much broader than long (29: 19), shoulders rounded off, sides nearly parallel in posterior half, posterior margin broadly emarginate (sutural length: 14). Ground sculpture irregular, distinctly less dense than that of pronotum, slightly granulate.

Abdomen very long and broad, densely pubescent. Ground sculpture resembling that of a pineapple surface, somewhat less dense than that of elytra.

Legs moderately slender, meta tarsi about three-fifths as long as metatibiae, 1st segment of the simple tarsi nearly as long as the 4th.

*Female*: 8th tergite with a small rounded median posterior process. 8th sternite narrowly rounded posteriorly. Valvifera apically pointed.

I dedicate this remarkable new species to the late Charles Oke, specialist of Australian Staphylinidae.

Holotype in the National Museum of Victoria, paratype in the author's collection.

Genus *Austroesthethus* Oke.

*Austroesthethus* Oke, 1933, *Proc. r. Soc. Vict.* 45: 112.

*Type species: Austroesthethus passerculus* Oke, 1933.

5. *Austroesthethus passerculus* Oke, 1933

*Austroesthethus passerculus*, Oke 1933, *Proc. r. Soc. Vict.* 45: 112 f. figs.

*Austroesthethus passerculus*; Neboiss, 1964, *Mem. natn. Mus. Vict.* 26: 147.

*Male*: 8th sternite with a broad emargination in about posterior 6th. 9th sternite as in fig. 11. Aedeagus (fig. 8).

*Material examined*: ♂-holotype: Victoria: Warburton, 4080', 15.II.1931, C. Oke; 1 ♀-paratype: Vic., Belgrave—Mt. Kosciusko NSW (two labels), C. Oke; 1 ♂-paratype: Belgrave, 2.VII.1921, C. Oke; 1 ♂, 1 ♀-paratypes: Belgrave, 1.VII.1921, C. Oke, in moss

with ants on stone; 1 ♀-paratype: Ferntree Gully, 16.IV.1927, C. Oke; 1 ♀: ibidem, 9.VII.1921, F. E. Wilson; 1 ♀: Warburton, 25.IV.1920, from moss, F. E. Wilson; 1 ♀: Healesville, V.1929, F. E. Wilson; 1 ♂: 9 mi. W. Cement Creek, Acheron River, 8.IV.1972, P. Zwick; 1 ♂: Belgrave, Sherbrook Forest, 21.VII.1972, P. Zwick; 1 ♂, 2 ♀♀: Dandenong Ranges, Belgrave, 21.VII.1972, P. Zwick (NMV, Museum Geneva, the author's collection).

6. *Austroesthethus gippsensis* oke, 1933

*Austroesthethus gippsensis*, Oke 1933, *Proc. r. Soc. Vict.* 45: 114 figs.

*Austroesthethus gippsensis*; Neboiss, 1964, *Mem. natn. Mus. Vict.* 26: 138.

*Male*: 8th sternite with a deep and broad notch in about posterior 3rd (length of sternite: depth of notch = 44:16). Aedeagus (figs. 5, 6).

*Material examined*: ♂-holotype: Victoria: Pakenham, 21.IX.1925, C. Oke; 1 spec. (Last abdominal segments missing): ibidem, 20.X.1925, C. Oke; 3 ♀♀: no locality (NMV, 1 ♀ in the author's collection).

7. *Austroesthethus tasmanicus* sp. nov.

Brachypterous, ferruginous, abdomen darker, castaneous; moderately shining. Antennae, palpi, and legs reddish yellow. Head and pronotum moderately finely and moderately densely punctate, elytral punctation very fine and sparse. Pubescence of fore body sparse, that of abdomen moderately long and dense.

♂-holotype and ♀-paratype: Tasmania: 'Parawee' (Parrawe), XII.1936, F. E. Wilson; 1 ♀-paratype Mt. Wellington, 4.X.1954, C. Oke.

Head about as broad as elytra (46: 45), distance between eyes: 35. Eyes large, coarsely faceted, temples distinct, about one-third as long as eyes (seen from above). Front strongly and densely shagreened and with a moderately fine and moderately dense punctation.

Antennae about as in *A. passerculus* Oke.

Pronotum slightly narrower than head (44: 46), about as long as broad, widest about anterior half, sides towards anterior margin convex, towards posterior margin strongly, somewhat concavely narrowed. Base on each side with a moderately large impression, be-

tween lateral impressions with about 6 small fovea. Punctuation about as on head but microsculpture less deep and less dense: pronotum more shining than head.

Elytra slightly narrower than head (45: 46), distinctly broader than long (45: 38), shoulders rounded off, sides arcuate, slightly constricted posteriorly, posterior margin broadly emarginated (sutural length 26). A fairly narrow and deep sutural impression can be seen. Microsculpture even shallower than on pronotum, and irregular, punctuation very fine and sparse, indistinct.

Abdomen moderately coarsely and very closely granulate-punctate.

*Male*: 7th sternite with a small triangular process in the middle of the posterior margin. 8th sternite with a semicircular emargination in about posterior 5th (length of sternite: depth of emargination = 37:8). 9th sternite sharply pointed. Aedeagus (fig. 7), internal sac with expulsion mechanisms which are strongly sclerotized.

*Female*: 8th sternite narrowly rounded at posterior margin.

*Austroesthethus tasmanicus* n. sp. can be distinguished from *A. gippsensis* Oke by its smaller eyes and punctate fore body, from *A. passerculus* Oke by the densely shagreened pronotum, and from *A. punctatus* Oke by its colouration, very fine and indistinct elytral punctuation, and denser sculpturation of the abdomen, from all these species by its sexual characters.

Holotype and 1 paratype in the National Museum of Victoria, 1 paratype in the author's collection.

#### 8. *Austroesthethus punctuatus* oke, 1933

*Austroesthethus punctatus*, Oke 1933, *Proc. r. Soc. Vict.* 45: 114 f.

*Austroesthethus punctatus*; Neboiss, 1964, *Mem. natn. Mus. Vict.* 26: 149.

*Male*: 8th sternite with a moderately broad and deep notch in about posterior third (length of sternite: depth of notch = 41: 12). 9th sternite (fig. 11). Aedeagus (figs. 9, 10).

*Material examined*: ♂-holotype: Victoria: Grampians, C. Oke. (NMV).

Genus. *Geosthethus* Oke.

*Geosthethus* Oke, 1933, *Proc. R. Soc. Vict.* 45: 111.

*Type species*: *Geosthethus attenuatus* Oke, 1933.

#### 9. *Geosthethus attenuatus* oke, 1933

*Geosthethus attenuatus*, Oke 1933, *Proc. r. Soc. Vict.* 45: 111 f. figs.

*Geosthethus attenuatus*, Neboiss 1964, *Mem. natn. Mus. Melb.* 26: 130.

Oke says that he also found this species at Warburton: probably that specimen has been dissected by him. I dissected the holotype; its labrum, labium, and one maxilla (exactly as figured 1933 by Oke) are now mounted on a microscope slide.

*Proportional measurements*: Width of head: 20.5; length of frontoclypeus (up to beginning of neck): 16; width of pronotum: 19; length of pronotum: 21; greatest width of elytra: 20; greatest length of elytra: 16; sutural length: 12.

Length of body: 1.1-1.4 mm.

*Material examined*: ♀-holotype: Victoria: Belgrave, 19.IV.1927, C. Oke (NMV).

Tribe EUAESTHETINI

Genus *Edaphus* Motschulsky

*Edaphus* Motschulsky, 1857, *Etud. ent.* 5: 7.

*Type species*: *Edaphus nitidus* Motschulsky, 1857.

#### 10. *Edaphus zwicki* sp. nov.

Brachypterous, castaneous, shining, very finely punctate, distinctly pubescent. Antennae light brown, 11th segment can be paler. Palpi and legs yellowish brown.

*Length*: 1.4-1.7 mm.

♂-holotype and 1 ♂-paratype: Victoria: Dandenong Range, Belgrave, 21.VIII.1972, P. Zwick.

1 ♂-paratype: Queensland: Dividing Range, highway to Warwick, 800 m, rain forest, sifting debris, 13.IX.1970, H. Franz.

Head distinctly narrower than pronotum (28:32), eyes moderately large, temples short but distinct, somewhat prominent, posterior furrow of front distinct, distance between eyes: 19.5, lateral anterior furrows distinct, con-

vergent, median frontoclypeus slightly broader than each of the side portions, slightly elevated. No punctation. Antennae robust, club distinctly 2-segmented, 10th segment distinctly but slightly broader than long, 11th segment nearly twice as long as 10th.

Pronotum about as broad as long (32:33), moderately constricted behind, base with distinct lateral carinae, a fine median carina extending to base proper, and four moderately large foveae, the lateral ones distinctly broader than the median two (can be indistinctly divided into two smaller foveae: in this case pronotum with 6 basal foveae!). Punctation very fine and sparse.

Elytra short, trapezium-like, distinctly broader than pronotum (41:32) and much broader than long (41:31), shoulders rounded off, sides moderately divergent towards posterior margin, posterior margin broadly and shallowly emarginated (sutural length 26). Sutural margination distinct though very fine, humeral impression distinct. Punctation fine (but less fine than on pronotum), shallow, and sparse, distinct. Abdomen with a fine and moderately dense punctation.

*Male*: 8th sternite (fig. 22). Aedeagus (fig. 25) relatively large. 'Sperm pump' (Puthz, 1973) about 1.5 x as long as the median lobe.

Variability: the paratype from Queensland has a slightly narrower, more parallel anterior frontoclypeus and 6 basal foveae of the pronotum.

This new species is warmly dedicated to my friend, its collector, Dr P. Zwick, Schlitz.

Holotype in the National Museum of Victoria, paratypes in coll. H. Franz (Vienna), and in the author's collection.

#### 11. *Edaphus* spec. A

In the National Museum of Victoria there is one female without a locality label, which belongs to a species clearly different from all other Australian *Edaphus*. It resembles closely the holarctic *E. beszedesi* Reiter, but the antennal club is longer, the middle foveae at base of pronotum are shorter, the elytral punctation is distinctly finer.

A description should be postponed as the male and the locality are unknown.

#### 12. *Edaphus* spec. B

An almost impunctate, reddish yellow species with 4 basal foveae and no complete median carina at pronotum, very close to numerous Oriental species. In the absence of the male a description should be postponed.

*Material examined*: 1 ♀: N. Queensland: Coen, 16.V.1951, C. Oke (NMV).

In coll. H. Franz (Vienna) there is a female from New Caledonia labelled 'Tiouandé near Hyenghene, sifting decaying wood and debris in forest, 1.IX.1970, H. Franz', which could belong to the same species.

#### 13. *Edaphus* spec. C

Ferruginous, abdomen brown, posterior margin of tergites lighter, finely and densely punctate, densely pubescent. Antennae, palpi, and legs yellowish brown.

*Length*: 1.1-1.4 mm.

*Material examined*: 1 ♀: S. Australia: env. Adelaide, savanna, 18.IX.1970, H. Franz.

Head slightly narrower than pronotum (30:31.5), eyes large, without distinct temples, posterior furrow of front distinct, straight, distance between eyes: 19.5, lateral anterior furrows indistinct, median frontoclypeus about twice as broad as each of the side portions, slightly elevated, punctate anteriorly. Vertex (behind transverse posterior furrow) and lateral portions finely, densely, and distinctly punctate. Antennae moderately slender, short, club distinctly 2-segmented, 10th segment somewhat longer than broad, 11th segment about 1.7 x as long as the 10th.

Pronotum slightly broader than head (31.5:30), somewhat broader than long (31.5:28), moderately constricted behind, base with distinct lateral carinae, a median carinae extending to base proper, and 6 small foveae (middle foveae twice as long as broad, lateral foveae less distinct). Punctation distinct, fine, and dense, punctures nearly as large as facets of eyes.

Elytra distinctly broader than pronotum (42:31.5), as long as broad, shoulders moderately prominent, sides moderately divergent, slightly constricted behind, posterior margin broadly emarginate (sutural length: 35). No



special humeral characters. Sutural margination fine, distinct. Punctuation similar to that of pronotum but somewhat more dense. Abdomen finely and densely punctate.

*Male*: unknown.

*Edaphus spec. C.* resembles *E. loebli* Comellini, but its pronotal punctuation is less coarse and less dense, and the anterior frontoclypeus is not divided by a transverse furrow.

#### 14. *Edaphus nevoissi* sp. nov.

Ferruginous, hind margin of elytra lighter, shining, finely punctate, moderately densely pubescent. Antennae reddish yellow, palpi and legs yellowish.

*Length*: 1.3-1.6 mm.

*♂-holotype*: S. Australia: Englebrook Nat-Trust Res. near Adelaide, 17.IX.1970, H. Franz; 1 *♂-paratype*: Victoria: Dandenong Ranges, Monbulk, 13.VIII.1972, P. Zwick.

Head distinctly narrower than pronotum (31:35), eyes large, temples extremely short, indistinct, posterior furrow of front distinct, distance between eyes: 21.5, lateral anterior furrows distinct, median frontoclypeus about as broad as each of the side portions, slightly elevated, impunctate. Vertex (behind transverse posterior furrow) and anterior lateral portions very finely punctate. Antennae moderately slender, short, club distinctly 2-segmented, 10th segment as long as broad, 11th segment twice as long as 10th.

Pronotum distinctly broader than head (35:31), as long as broad, pretty constricted behind, base with distinct lateral carinae, a median carina extending to base proper, and 6 small foveae (middle foveae more than twice as long as broad, lateral foveae can be indistinctly separate, confluent). Punctuation fine and dense, punctures nearly as large as one facet of eye.

Elytra much broader than head (51:31), about as long as broad, shoulders prominent, sides feebly arcuate, posterior margin broadly emarginated (sutural length: 41). No special humeral characters. Sutural margination very narrow. Punctuation similar to that of pronotum but shallower and slightly denser. Abdomen very finely, densely punctate.

*Male*: 8th sternite (fig. 21). Aedeagus (fig. 28). 'Sperm pump' nearly three times as long as aedeagus.

*Variability*: The paratype has an indistinct elytral punctuation, the punctuation of front is subobsolete.

I dedicate this new species to Dr A. Neboiss, NMV, to whom I am greatly indebted for his kind help in sending me Euaesthetinae from the collections of the National Museum of Victoria.

Holotype in coll. H. Franz (Vienna), paratype in the National Museum of Victoria.

#### 15. *Edaphus spec. D*

Castaneous, shining, elytra finely punctate, pubescence distinct. Antennae and legs reddish yellow, palpi yellowish.

*Length*: 1.5-1.7 mm.

*Material examined*: 1 *♂*: Queensland: Dividing Range, highway to Warwick, 800 m, rain forest, sifting debris, 13.IX.1970, H. Franz.

Head distinctly narrower than pronotum (36:41), eyes large, minute temples acutely prominent, posterior furrow of front distinct, distance between eyes: 23, lateral anterior furrows distinct, median frontoclypeus slightly broader than each of the side portions, slightly elevated. Impunctate. Antennae robust, short, with a large 2-segmented club, 10th segment slightly broader than long, 11th segment about twice as long as 10th.

Pronotum distinctly broader than head (41:36), slightly broader than long (41:38), moderately strongly constricted behind, base with distinct lateral carinae, a median carina extending to base proper, and 6 foveae, middle foveae more than twice as long as broad. Anterior to the median carina there can be seen a narrow and very shallow impression. No distinct punctuation.

Elytra large, much broader than pronotum (62:41), about as long as broad (60:62), shoulders strongly prominent, sides feebly rounded, distinctly constricted behind, hind margin shallowly emarginate (sutural length: 50). No special humeral characters. Suture finely margined. Punctuation fine and moderately sparse, distinct. Abdomen finely and densely punctate.

*Male*: 7th sternite shallowly emarginated at posterior margin. 8th sternite with a semicircular emargination in about posterior third. Aedeagus (fig. 26).

#### 16. *Edaphus melculus* (Oke, 1933)

*Edaphellus melculus*, Oke 1933, *Proc. r. Soc. Vict.* 45: 110 f. figs.

*Edaphellus melculus*; Neboiss, 1964, *Mem. natn. Mus. Melb.* 26: 143.

*Proportional measurements* ( $\delta$  from Evelyn): Width of head: 38; distance between eyes: 27; width of pronotum: 42; length of pronotum: 39; greatest width of elytra: 62; greatest length of elytra: 60; sutural length: 49.

*Length of body*: 1.5-1.8 mm.

Eyes large, temples minute, not very distinct, median frontoclypeus about as broad as each of the side portions. No punctation. Last antennal segments ( $\delta$ ) (fig. 16). Pronotum moderately strongly constricted behind, at base with distinct lateral carinae, a median carina extending to base proper, and 6 small foveae. No punctation. Elytra indistinctly punctate.

*Male*: 7th sternite broadly emarginate at posterior margin. 8th sternite (fig. 17). Aedeagus (fig. 24).

*Edaphus melculus* Oke very much resembles *E. termitophilus* Bernhauer. For sure identification antennal and genital characters of the males should be used.

*Material examined*: ♀-type: Victoria: Belgrave, 2.VII.1921, in moss with ants on stone, C. Oke; ♀-paratype: ibidem, 1.VII.1921, C. Oke; 1 ♂: Evelyn, 5.VI.1922, C. Oke; 3 ♀♀: Ferntree Gully, 6.IX.1919, F. E. Wilson; 1 ♀: ibidem, 27.IX.1919; 1 ♂: Nariel, 12.II.1963, A. Neboiss (NMV).

#### 17. *Edaphus termitophilus* Bernhauer, 1916

*Edaphus termitophilus*, Bernhauer 1916, *Ark. Zool.* 10 no. 5: 2 f.

*Edaphellus melculus* var. *camponoti*, Oke 1933, *Proc. r. Soc. Vict.* 45: 111 nov. syn.

*Edaphellus melculus* var. *camponoti*, Neboiss, 1964, *Mem. natn. Mus. Vict.* 26: 133.

In coll. Oke there are only specimens with the label '*Edaphellus melculus* Oke'. Following his description of *melculus* and *melculus* var. *camponoti* the specimens listed below were syntypes of *melculus* var. *camponoti* except 1 ♂ from Evelyn which is a true *mel-*

*culus*. I designated a lectotype and paralectotypes see below). Although no male was found among the syntypes of *E. termitophilus* Bernhauer, a detailed comparison of the respective material led to the result that *E. melculus* var. *camponoti* is a junior synonym of *E. termitophilus*. In addition, both seem to live with ants. Contrary to Oke's note (1933: 110) the figure given by Bernhauer (1916) is not taken from *E. termitophilus* but from *E. mjobergi* Bernhauer.

*Proportional measurements* ( $\delta$  from Fern-tree Gully): Width of head: 30; distance between eyes: 20; width of pronotum: 33.5; length of pronotum: 30; greatest width of elytra: 47; greatest length of elytra: 46; sutural length: 36.

*Length of body*: 1.2-1.6 mm.

*Male*: 7th sternite broadly emarginated posteriorly. 8th sternite (fig. 20). Aedeagus (fig. 23) with strongly sclerotized expulsion mechanisms. Last antennal segments (fig. 15).

*Material examined*: 3 ♀♀-syntypes: Queensland: Blackall Range, Mjöberg (Field Museum of Natural History, Chicago and Naturhistorisk Riksmuseet, Stockholm); 1 ♂: S. Australia: Mt. Torrens E. of Adelaide, 600 m, savannah woodland, 18.IX.1970, H. Franz (coll. H. Franz); 1 ♂ (lectotype of *E. melculus* var. *camponoti* (Oke)): Victoria: Ferntree Gully, 26.VIII.1930, C. Oke (genitalia dissected, embedded in a medium soluble in alc. abs.); 2♂♂, 2♀♀ (paralectotype of *E. melculus* v. *camponoti*): ibidem, 23.VII.1922, Sept., in tussocks, C. Oke; 1 ♀ (paralectotype as above): Lilydale, 1.IV.1928, C. Oke; 2 ♀♀: Warburton, C. Oke; 1 ♀: Beaconsfield, 26.XII.1921, F. E. Wilson; 1 ♂, 3 ♀♀: Coburg, 16.V.1925, C. Oke; 1 ♀: Lorne, 28.X.1918, host: *Aphaenogaster longiceps*, F. E. Wilson; 1 ♀ (det.?): Ringwood, 2.VII.1922, under leaves, C. Oke (NMV and author's collection).

#### 18. *Edaphus Invidiosus* sp. nov.

Brownish, shining, extremely finely, indistinctly punctate, densely pubescent. Antennae light brown, palpi and legs yellowish brown.

*Length*: 1.2-1.4 mm.

♀-*holotype* and 3 ♀♀-*paratypes*: Queensland: Dividing Range, highway to Warwick, 800 m, rain forest, sifting debris, 13.IX.1970, H. Franz.

Head distinctly narrower than pronotum (26.5:31), eyes moderately large, temples

minute, posterior furrow of front distinct, distance between eyes: 18, lateral anterior furrows confluent with a transverse furrow at frontoclypeus, median frontoclypeus about as broad as each of the side portions, moderately elevated. Punctuation extremely fine, indistinct. Antennae short, with a distinctly 2-segmented club, 10th segment about as long as broad, 11th segment about twice as long as 10th.

Pronotum distinctly broader than head (31:26.5), slightly broader than long (31:29), moderately constricted behind, base with distinct lateral carinae, a median carina extending to base proper, and 6 small foveae, middle ones more than twice as long as broad. Punctuation extremely fine, sparse, indistinct.

Elytra much broader than pronotum (46:31), somewhat broader than long (46:43), shoulders prominent, sides moderately divergent posteriorly, moderately constricted behind, posterior margin shallowly emarginate (sutural length: 34). No special humeral characters. Sutural margination distinct though very fine. Punctuation very fine, nearly indistinct. Abdomen very finely punctate.

*Male*: unknown.

*Edaphus invidiosus* n. sp. is distinguished from all other Australian *Edaphus* by the anterior middle of front which is completely margined all around (i.e. clypeus is separated from frons).

Holotype and 1 paratype in coll. H. Franz (Vienna), paratypes also in the National Museum of Victoria, and in the author's collection.

#### 19. *Edaphus zwickianus* sp. nov.

Ferruginous, abdomen slightly darker, moderately shining, finely and densely punctate, densely pubescent. Antennae reddish yellow, club infusate. Palpi yellow. Legs yellowish brown.

*Length*: 1.4-1.6 mm.

♀-holotype: Victoria: Tolmie near Whitfield, 1.IX.1972, P. Zwick.

Head distinctly but slightly narrower than pronotum (34:37), eyes moderately large, temples small but distinct, not prominent, posterior furrow of front sharp and straight, distance between eyes: 23, lateral anterior fur-

rows distinct, parallel, median frontoclypeus about as broad as each of the side portions; moderately elevated. Impunctate. Antennae with a distinctly 2-segmented club, 10th segment about as broad as long, 11th segment about twice as long as 10th.

Pronotum distinctly broader than head (37:34), slightly broader than long (37:35), moderately constricted behind, base with distinct lateral carinae, a median carina extending to base proper, and 6 small foveae of about the same size, the two lateral ones can be indistinctly separate. Punctuation dense and very fine, distinct.

Elytra much broader than pronotum (51:37), about as long as broad (50:51), shoulders prominent, sides moderately divergent, posteriorly slightly constricted, posterior margin very shallowly emarginate (sutural length: 40). No special humeral characters. Sutural margination fine, distinct. Punctuation fine and very dense, diameter of punctures about as large as one facet of eye. Abdomen very finely and moderately densely punctate.

*Male*: unknown.

I am pleased to name this new species after Drs Peter and Heide Zwick, who made fine collections in Australia.

Holotype in the National Museum of Victoria.

#### 20. *Edaphus brittoni* sp. nov.

Ferruginous, shining, punctuation fine, elytral punctuation distinct, pubescence moderately dense. Antennae brownish, palpi yellowish, legs yellowish brown.

*Length*: 1.2-1.4 mm.

♀-holotype (somewhat immature, coloration light ferruginous): Queensland: Wine-scrub forest near Maipoton, 350 m, sifting debris, 11.IX.1970, H. Franz; 1 ♀-paratype: Dividing Range, highway to Warwick, 800 m, rain forest, sifting debris, 13.IX.1970, H. Franz.

Head distinctly narrower than pronotum (28:36), eyes moderately small, temples distinctly developed, about one-third of the length of eyes (seen from above), rather prominent,

posterior furrow of front distinct, distance between eyes: 22 (front broad!), lateral anterior furrows distinct, median frontoclypeus about as broad as each of the side portions, feebly elevated. Some very fine scattered punctures on anterior lateral portions. Antennae short, club distinctly 2-segmented, 10th segment slightly transverse, 11th segment about twice as long as broad.

Pronotum distinctly broader than head (36:28), slightly broader than long (36:34), strongly constricted behind, base with distinct lateral carinae, a median carina extending to base proper, and 4 basal foveae. Punctuation very fine, nearly indistinct.

Elytra distinctly broader than pronotum (50:36), distinctly broader than long (50:44), shoulders moderately prominent, sides distinctly but not strongly divergent towards posterior margin, moderately constricted behind, posterior margin shallowly emarginate (sutural length: 36). No special humeral characters. Sutural margination distinct though very fine. Punctuation fine, shallow, and moderately dense, punctures nearly as large as one facet of eyes. Abdomen finely punctate.

*Male*: unknown.

This new species is kindly dedicated to Dr E. B. Britton (CSIRO Canberra).

Holotype in coll. H. Franz (Vienna), paratype in the author's collection.

#### 21. *Edaphus mjobergi bernhauer*, 1916

*Edaphus Mjobergi*, Bernhauer 1916, *Ark. Zool.* 10 no. 5: 3 f. fig.

*Edaphus mjobergi*; Oke 1933, *Proc. r. Soc. Vict.* 45: 110.

This is the most remarkable *Edaphus* from Australia because its prominent temples and its very sparse pubescence.

*Material examined*: ♂-holotype: Queensland, Blackall Range, Mjöberg (Naturhistorisk Riksmuseet, Stockholm).

*Proportional measurements*: Width of head: 38; distance between eyes: 28; width of pronotum: 49; length of pronotum: 41; greatest width of elytra: 66; greatest length of elytra: 61; sutural length: 50.

*Length*: 1.6-1.9 mm.

Eyes flat, very slightly prominent, temples about one-third of the greatest length of eyes (seen from above), remarkably prominent. Front posteriorly with a distinct, moderately broad, transverse furrow, which is interrupted medially by a very small fovea, anterior lateral furrows become indistinct anteriorly, median frontoclypeus distinctly elevated in posterior middle where it has the above described small fovea. Base of pronotum with 4 foveae.

*Male*: 7th sternite broadly emarginate at posterior margin. 8th sternite with a deep, parallel notch nearly in posterior half. Aedeagus (fig. 30).

#### 22. *Edaphus australicus* sp. nov.

Ferruginous, strongly shining, impunctate, very sparsely pubescent. Antennae light brown, palpi yellow, legs yellowish brown.

*Length*: 1.1-1.5 mm.

♂ -holotype and 3 ♂♂, 8 ♀♀ -paratypes: Queensland: Winescrub forest near Maipoton, sifting debris, 11.IX.1970, H. Franz; 1 ♂, 7 ♀♀ -paratypes: Dividing Range, highway to Warwick, 800 m, rain forest, sifting debris, 13.IX.1970, H. Franz; 1 ♀ -paratype: Ather-ton, VI.1951, C. Oke.

Head distinctly narrower than pronotum (26:32.5), eyes moderately large, minute temples distinct, somewhat prominent in the male, posterior furrow of front distinct, distance between eyes: 20, lateral anterior furrows distinct, median frontoclypeus distinctly broader than each of the side portions, slightly elevated (see also below). Some 2 or 3 very fine punctures anteriorly or impunctate. Antennae short, club distinctly 2-segmented, 10th segment distinctly but slightly transverse, 11th segment nearly twice as long as 10th.

Pronotum distinctly broader than head (32.5:26), somewhat broader than long (32.5:29), strongly constricted behind, base with distinct lateral carinae, a median carina extending to base proper, and 4 small foveae, the lateral ones broader than the middle ones. No punctuation.

Elytra distinctly broader than pronotum (43:32.5), slightly (or not) broader than long,

shoulders prominent, sides moderately divergent posteriorly, moderately constricted behind, posterior margin shallowly emarginate (sutural length: 35). No special humeral characters. Sutural margination distinct though very fine. Punctuation extremely fine, indistinct. Abdomen very finely and sparsely punctate.

*Male*: 8th sternite (fig. 18). Aedeagus (fig. 27). 'Sperm pump' about 1.5 x as long as the medianlobe.

*Variability*: One ♀-paratype from Dividing Range has the median frontoclypeus distinctly elevated.

*Edaphus australicus* n. sp. very much resembles *E. pygmaeus* Szekessy from New Guinea, but can be distinguished from it by its broader front (*pygmaeus*-♂: width of head: 25.5, distance between eyes: 16.5), smaller eyes, its length, and the genitalia.

Holotype and paratypes in coll. H. Franz (Vienna), paratypes also in the National Museum of Victoria, and in the author's collection.

### 23. *Edaphus* spec. E

This species is very similar to *E. australicus*. A full description is not necessary, a detailed comparison should be sufficient.

Ferruginous, shining, indistinctly punctate, moderately sparsely pubescent. Antennae brownish, palpi and legs yellowish.

*Length*: 1.1-1.4 mm.

*Material examined*: ♂: Queensland: Dividing Range, highway to Warwick, 800 m, rain forest, sifting debris, 13.IX.1970, H. Franz.

*Proportional measurements*: Width of head: 27; distance between eyes: 18; width of pronotum: 29; length of pronotum: 25; greatest width of elytra: 44; greatest length of elytra: 44; sutural length: 36.

Slightly less robust than *E. australicus*, median frontoclypeus slightly narrower than each of the side portions, more elevated, 11th antennal segment shorter, about 1.5x as long as the 10th. Pronotum distinctly narrower. Elytra with a very fine, nearly indistinct punctuation.

*Male*: 8th sternite (fig. 19). Aedeagus (fig. 29; note scale), very small.

### KEY TO THE AUSTRALIAN SPECIES OF *EUAESTHETINAE*

(including unnamed taxa mentioned in this paper)

- 1 (2) Tarsal formula 5-5-4, abdomen immargined. 3.0 mm. . . gen. spec. ?
- 2 (1) Tarsal formula 4-4-4.
- 3 (16) Abdomen not margined.
- 4 (7) Temporal region of head with a large impunctate depression limited all around by a fine raised keel. . . *Mesoaesthetus* Cameron
- 5 (6) Eyes distinctly smaller than temporal depression. Base of pronotum on each side with one distinct impression. Sculpture of fore body slightly less dense. ♂: aedeagus (figs. 1, 2). 1.7-2.1 mm. Victoria . . . *Mesoaesthetus wilsoni* Cameron
- 6 (5) Eyes as large as or slightly larger than temporal depression. Base of pronotum with two impressions on each side, the inner one distinctly smaller than the lateral one. Sculpture of fore body extremely dense. ♂: aedeagus (figs. 3, 4). 1.8-2.2 mm. Tasmania . . . *Mesoaesthetus tasmanicus* n. sp.
- 7 (4) Temporal region of head normal, without impunctate depression.
- 8 (9) Microphthalmous species, elytra with a narrow lateral margin. Antenna (fig. 12), club narrow. Very narrow and elongate species. Male unknown. 1.3-1.9 mm. Tasmania . . . *Tasmanosthetus okei* n. gen. n. sp.
- 9 (8) Macrophthalmous species, elytra without lateral margin. Antennae with conspicuously enlarged club (Oke 1933, fig. 32). More robust species. . . . . *Austroesthetus* Oke
- 10 (13) Pronotum impunctate or almost impunctate.

- 11 (12) Eyes very large, no distinct temples. Head indistinctly punctate. ♂: notch of 8th sternite longer than broad, aedeagus (figs. 5, 6).  
2.0-2.4 mm. Victoria  
.....*Austroesthetus gippsensis* Oke
- 12 (11) Eyes smaller, temples about one-third the length of eyes. Head distinctly punctate. ♂: notch of 8th sternite broader than long, aedeagus (fig. 8).  
1.8-2.5 mm. Victoria  
.....*Austroesthetus passerculus* Oke
- 13 (10) Pronotum distinctly punctate.
- 14 (15) Eyes very large, no distinct temples. Elytra distinctly punctate. ♂: aedeagus (figs. 9, 10).  
1.8-2.1 mm. Victoria  
.....*Austroesthetus punctatus* Oke
- 15 (14) Eyes smaller, temples about one-third to one-fourth the length of eyes. Elytra almost impunctate. ♂: aedeagus (fig. 7).  
2.0-2.2 mm. Tasmania  
.....*Austroesthetus tasmanicus* n. sp.
- 16 (3) Abdomen margined throughout.
- 17 (20) Narrow and elongate species. Head without impressions. Pronotum without foveae or carinae at base.
- 18 (19) Labium at its anterior margin with a median triangular process (Oke 1933, fig. 35). Male unknown.  
1.1-1.4 mm. Victoria  
.....*Geosthetus attenuatus* Oke
- 19 (18) Labium anteriorly deeply emarginate (Coiffait 1958, fig. 5).  
.....(*Octavius* Fauvel)  
Distribution worldwide (see map: Puthz 1977), no record, however, so far from Australia, but known from New Guinea and neighbouring islands; probably also in Australia.
- 20 (17) Broader, less elongate species. Head mostly with furrows or impressions. Pronotum cordiform, its base with small carinae and (mostly) small foveae.  
.....*Edaphus* Motschulsky  
Worldwide distribution, mainly in the tropics. For details concerning exoskeletal characters see Puthz 1974.
- 21 (22) Brachypterous, elytra at suture shorter than the pronotum. ♂: 8th sternite (fig. 22), aedeagus (fig. 25).  
1.4-1.7 mm. Victoria, Queensland.....*Edaphus zwicki* n. sp.
- 22 (21) Macropterous, elytra at suture longer than pronotum.
- 23 (26) Median basal carina of pronotum not extending to base proper. To observe this character specimens should be clean and magnification at least 60x.
- 24 (25) Base of pronotum with 6 small foveae.  
1.2 mm.....*Edaphus* spec. A
- 25 (24) Base of pronotum with 4 small foveae.  
1.2-1.4 mm. N. Qld.  
.....*Edaphus* spec. B
- 26 (23) Median basal carina of pronotum extending to base proper.
- 27 (40) Base of pronotum with at least 6 small foveae.
- 28 (33) Pronotum distinctly punctate, punctures nearly as large as one facet of eye.
- 29 (30) Lateral portions of front (especially anteriorly) densely and very finely punctate. Male unknown.  
1.1-1.4 mm. S. Australia  
.....*Edaphus* spec. C.
- 30 (29) Lateral portions of front only with very few very small punctures or impunctate.

- 31 (32) The two middle foveae at base of pronotum much longer than the lateral foveae, more than twice as long as broad. Elytral punctation somewhat less dense or indistinct. ♂: 8th sternite (fig. 21), aedeagus (fig. 28). 1.3-1.6 mm. S. Australia, Victoria . . . . . *Edaphus neboissi* n. sp.
- 32 (31) The two middle foveae at base of pronotum slightly longer than the lateral foveae, not quite twice as long as broad. Elytra more densely punctate. Male unknown. 1.4-1.6 mm. Victoria . . . . . (*Edaphus zwickianus* n. sp.)
- 33 (28) Pronotal punctation considerably finer, indistinct, or absent.
- 34 (35) Elytra distinctly punctate. Larger species with acutely prominent minute temples. ♂: aedeagus (fig. 26). 1.5-1.7 mm. Queensland . . . . . *Edaphus* spec. D.
- 35 (34) Elytra impunctate or at most extremely finely, indistinctly punctate.
- 36 (39) Median frontoclypeus simple. Two very similar species.
- 37 (38) Somewhat larger, more shining species, last two segments of antennae broader (fig. 16). ♂: 8th sternite (fig. 17), aedeagus (fig. 24). 1.5-1.8 mm. Victoria . . . . . *Edaphus melculus* Oke
- 38 (37) Somewhat smaller, less shining species, last two segments of antennae narrower (fig. 15). ♂: 8th sternite (fig. 20), aedeagus (fig. 23). 1.2-1.6 mm. (extended). Victoria, Queensland . . . *Edaphus termitophilus* Bernhauer
- 39 (36) Median frontoclypeus with distinct transverse furrow, confluent with the anterior lateral furrows to form a horseshoe-shaped line. Male unknown. 1.2-1.4 mm. Queensland . . . . . *Edaphus invidiosus* n. sp.
- 40 (27) Base of pronotum with 4 small foveae.
- 41 (44) Elytra distinctly but very finely punctate.
- 42 (43) Elytral punctation very dense, surface only moderately shining. Pronotum with dense and very fine punctation. 1.4-1.6 mm. Victoria . . . . . *Edaphus zwickianus* n. sp.
- 43 (42) Elytral punctation less dense, surface more shining. Pronotum extremely finely and sparsely, almost imperceptibly punctate. Male unknown. 1.2-1.4 mm. Queensland . . . . . *Edaphus brittoni* n. sp.
- 44 (41) Elytra impunctate or indistinctly punctate.
- 45 (46) Head posteriorly widened, widest behind eyes. Pronotum very strongly constricted at base. Large species. ♂: aedeagus (fig. 30). 1.6-1.9 mm. Queensland . . . . . *Edaphus mjobergi* Bernhauer
- 46 (45) Head not widened posteriorly, broadest across eyes. Pronotum less constricted at base. Smaller and very similar species.
- 47 (48) Pronotum distinctly broader than head (f.e. 32.5: 26). ♂: 8th sternite (fig. 18), aedeagus (fig. 27). 1.1-1.5 mm. Queensland . . . . . *Edaphus australicus* n. sp.
- 48 (47) Pronotum slightly broader than head (f.e. 29: 27). ♂: 8th ster-

nite (fig. 19), aedeagus (fig. 29).  
1.1-1.4 mm. Queensland  
.....*Edaphus* spec. E.

### Acknowledgements

My thanks are due to Drs H. S. Dybas (Field Museum of Natural History, Chicago), Prof. H. Franz (Vienna), P. M. Hammond (British Museum Natural History, London), I. Löbl (Museum d'Histoire naturelle de Genève), A. Neboiss (National Museum of Victoria, Melbourne), T. Nyholm (Naturhistoriska Riksmuseet, Stockholm), and P. Zwick (Schlitz).

### References

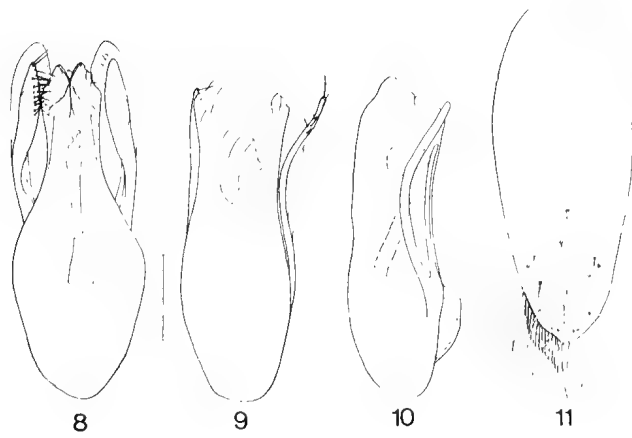
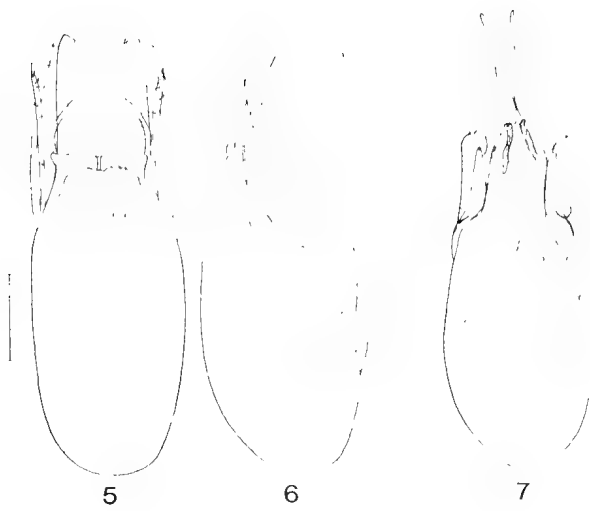
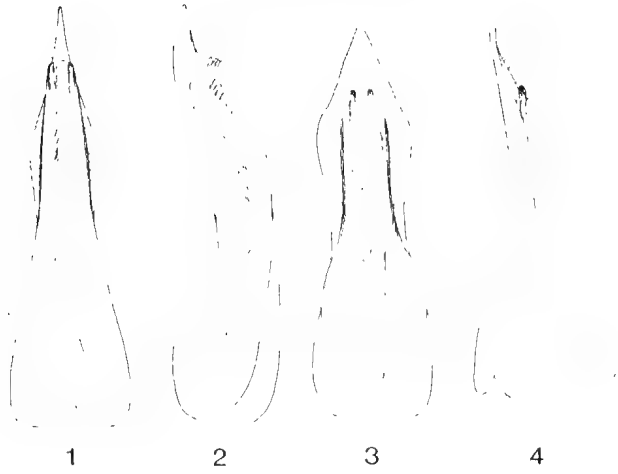
- BERNHAEUER, M., 1916. Results of Dr. E. Mjöberg's Swedish Scientific Expeditions to Australia 1910-1913. 7. Staphyliniden. *Ark. Zool.* 10 no. 5: 1-7.
- , 1939. Neue Staphyliniden (Coleoptera) aus Neu-Seeland. *Ann. Mag. nat. Hist.* (11) 4: 193-216.
- BRITTON, E. B., 1970. Coleoptera. in: *The Insects of Australia. A Textbook for Students and Research Workers*, pp. 495-621. Melbourne University Press.
- CAMERON, M., 1944. Description of a new Genus of Euaesthetinae (Col., Staph.). *Ann. Mag. nat. Hist.* (11) 11: 68-70.
- COIFFAIT, H., 1958. Révision du genre *Octavius* Fauvel (Col. Staphylinidae). *Revue fr. Ent.* 25: 78-98.
- FRANZ, H., 1970. Die geographische Verbreitung der Insekten. *Handb. Zool., Berlin*, 4(2) 1/6: 1-111.
- KEAST, A., 1959. The Australian environment, in *Biogeography and Ecology in Australia*, *Monogr. biol.* 8: 15-35.
- MACKERRAS, I. M., 1970. Composition and Distribution of the Fauna, in *The Insects of Australia A Textbook for Students and Research Workers*, pp. 187-203. Melbourne University Press.
- NEBOISS, A., 1964. Summary of entomological work of C. G. Oke, with information on types now included in the National Museum of Victoria collection. *Mem. natn. Mus. Melb.* 26: 125-156.
- OKE, C., 1933. Australian Staphylinidae. *Proc. r. Soc. Vict.* 45: 101-136.
- PUTHZ, V., 1973. On Some Neotropical Euaesthetinae (Coleoptera, Staphylinidae). *Stud. Neotrop. Fauna* 8: 51-73.
- , 1974. Bemerkungen über die Gattung *Edaphus* Motschulsky und über Kistnersche *Edaphus*-Arten nebst neuen und alten afrikanischen Euaesthetinen (Coleoptera, Staphylinidae) 15. Beitrag zur Kenntnis der Euaesthetinen. *Revue Zool. afr.* 88: 749-770.
- , 1977. Die Gattung *Octavius* Fauvel (Coleoptera-Staphylinidae) weltweit verbreitet! *Opusc. zool. Bpest* 14: 105-126.
- , in press. Eine neue Euaesthetinengattung aus dem Himalaya (Coleoptera, Staphylinidae) 24. Beitrag zur Kenntnis der Euaesthetinen. *Reichenbachia* 17: 000-000.
- SAIZ, F., 1968. *Chilioesthetus*, nuevo genero de la subfamilia Euaesthetinae (Col. Staphylinidae). *Revta chil. Ent.* 6: 73-79.
- SCHERPPELTZ, O., 1974. Coleoptera : Staphylinidae (exclus. Subfam. Paederinae, except. pars min.). *S. afr. anim. Life* 15: 43-394.
- SZEKESSY, W., 1939. Die *Edaphus*-Arten Neu-Guineas (Coleopt., Staphyl.). *Nova Guinea N.S.* 3 *Zool.*: 97-105.
- WILLIAMS, W. D. (ed.), 1974. Biogeography and Ecology in Tasmania. *Monogr. biol.* 25: X and 498 pp.

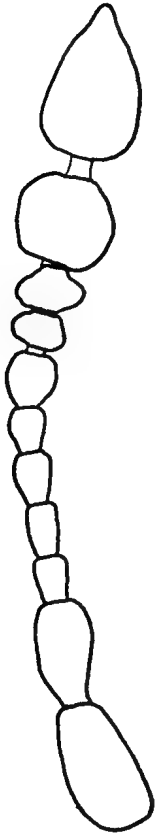
Figures 1-4—Ventral (1, 3) and lateral (2, 4) aspect of aedeagus.  
1, 2—*Mesoaesthetus wilsoni* Cameron (holotype).  
3, 4—*Mesoaesthetus tasmanicus* n. sp. (holotype).  
Scale = 0.1 mm.

Figures 5-7—Ventral (5, 7) and lateral (6) aspect of aedeagus.  
5, 6—*Austroesthetus gippsensis* Oke (holotype).  
7—*Austroesthetus tasmanicus* n. sp. (holotype).  
Scale = 0.1 mm.

Figures 8-11—Ventral (8, 9) and lateral (10) aspect of aedeagus, 9th sternite of male (11).  
8—*Austroesthetus passerculus* Oke (internal sac somewhat expelled) (Belgrave).  
9-11—*Austroesthetus punctatus* Oke (holotype).  
Scale = 0.1 mm.







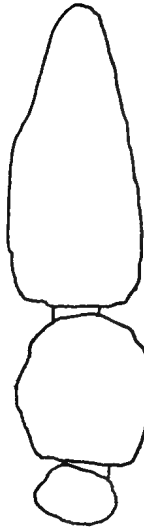
12



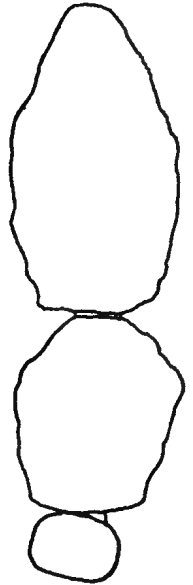
13



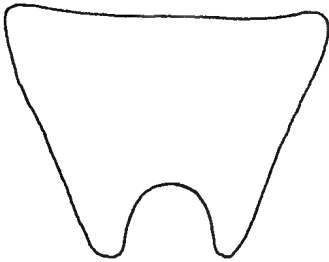
14



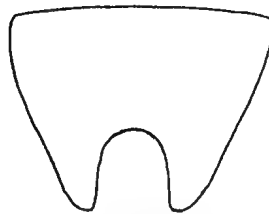
15



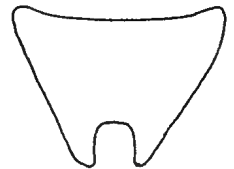
16



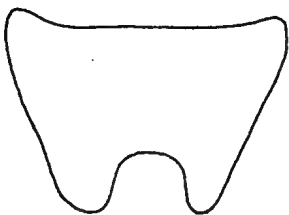
17



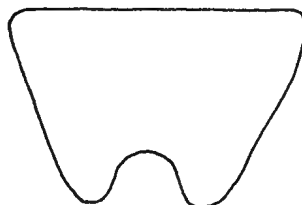
18



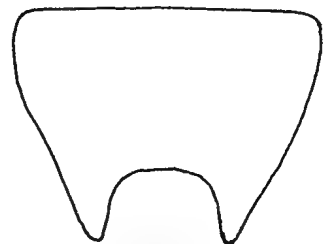
19



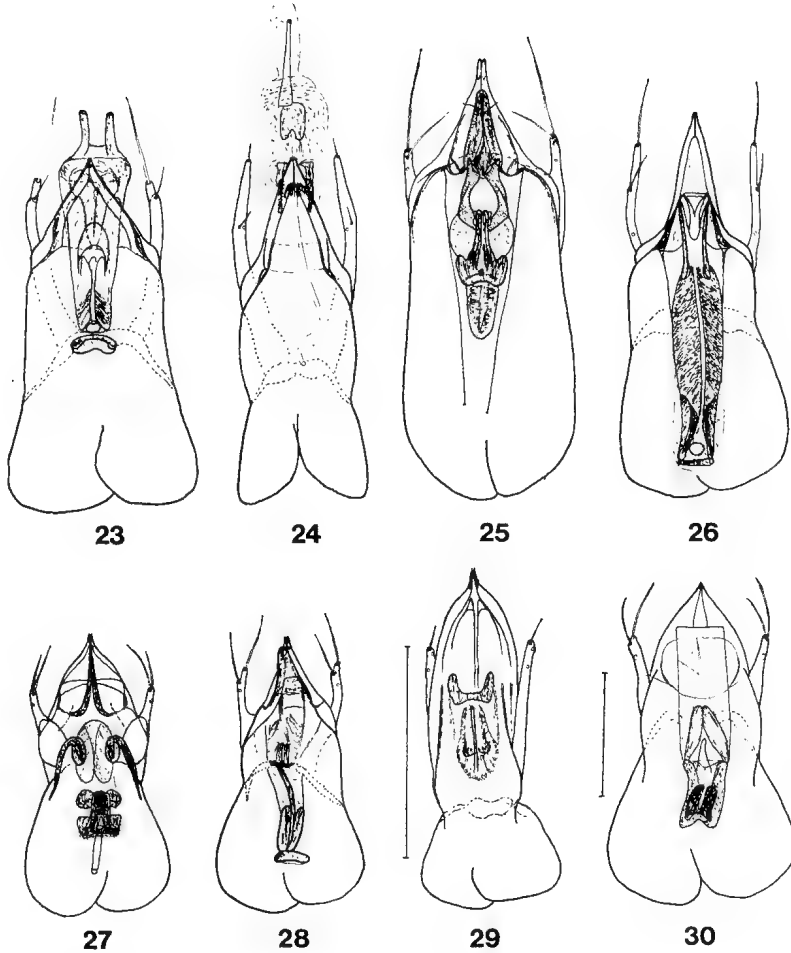
20



21



22



Figures 12-14—Antenna (12), mandible (13), and labrum (14) of *Tasmanosthetus okei* n. gen. n. sp. (paratype).

Figures 15, 16—Last 3 antennal segments of *Edaphus termitophilus* Bernhauer (Coburg) and *Edaphus melculus* Oke (Nariel), males.

Figures 17-19—8th sternite of male. 17: *Edaphus melculus* Oke. 18: *E. australicus* n. sp. 19: *E. spec. E.* 20: *E. termitophilus* Bernhauer. 21: *E. nevoissi* n. sp. 22: *E. zwicki* n. sp. Scale = 0.1 mm.

Figures 23-30—Ventral (23-26, 28-30) and dorsal (27) aspect of aedeagus. 23: *Edaphus termitophilus* Bernhauer (Ferntree Gully). 24: *E. melculus* Oke (Evelyn). 25: *E. zwicki* n. sp. (holotype). 26: *E. spec. D.* 27: *E. australicus* n. sp. (paratype). 28: *E. nevoissi* n. sp. (holotype). 29: *E. spec. E.* 30: *E. mjobergi* Bernhauer (holotype). Scale = 0.1 mm.



LEPTANTHURA AND NEW RELATED GENERA  
(CRUSTACEA, ISOPODA, ANTHURIDEA)  
FROM EASTERN AUSTRALIA

By GARY C. B. POORE

Marine Studies Group, Ministry for Conservation, 605 Flinders Street Extension,  
Melbourne, Victoria, Australia 3000.

**Abstract**

Diagnoses are presented for the genus *Leptanthura* and its three species from eastern Australia: *L. diemenensis* (Haswell), *L. nunana* n. sp. and *L. kapala* n. sp. Two related blind genera, *Bullowanthura* n.g. and *Ulakanthura* n.g., are described. One species of *Bullowanthura*, *B. pambula* n. sp., and six of *Ulakanthura*: *U. crassicornis* (Haswell), *U. colac* n. sp., *U. cooma* n. sp., *U. lara* n. sp., *U. namoo* n. sp. and *U. wanda* n. sp.; are described from coastal environments of southern Queensland, New South Wales and Victoria. Keys to Australian species of *Leptanthura* and *Ulakanthura* are presented and the relationships of the three genera discussed. All species and the two new genera are endemic to Australia. *Ulakanthura* shows a high degree of speciation, typical of peracarid genera in the region. *Paranthura australis* is designated nomen dubium.

**Introduction**

Discovery of numerous species of isopods of the family Paranthuridae in collections of soft-bottom benthos from southern and eastern Australia has led to a re-examination of existing Australian species. In the 1880s W. A. Haswell described three species of *Paranthura* which were subsequently placed in *Leptanthura* by K. H. Barnard in 1925. The 'types' of only two of these remain. One is indeed a *Leptanthura*, the other belongs to a hitherto undescribed genus, and the third of Haswell's species remains unknown.

The Paranthuridae are anthuridean isopods with elongate pointed mouthparts. This paper deals with three genera which lack eyes and have small, triangular articles 5 on pereopods 4-7. Three species of *Leptanthura*, two of which are new, are described and a new generic diagnosis presented. Two new related genera are diagnosed, *Bullowanthura* with one species and *Ulakanthura* with six species. The relationships between the three genera within the Paranthuridae are discussed and keys to Australian species of *Leptanthura* and *Ulakanthura* are given.

Nomenclature used is similar to that in Barnard's (1925) review of the Anthuridea and in my previous study of anthurids (Poore, 1975). The only difference is in referring to the num-

ber of articles in the maxillipedal palp rather than those of the whole maxilliped. In all anthurideans the first article of the maxilliped is fused to the head and, in *Leptanthura* and some other genera, the second (the basis), is also. The remaining articles, which constitute the palp, are free. Unless otherwise marked all scales on the figures are equivalent to 0.1 mm.

Material for this study has come from the following surveys and institutions:

Port Phillip Bay Environmental Study (PPBES) and Crib Point Benthic Survey (CPBS), both carried out by the Marine Studies Group, Fisheries and Wildlife Division, Ministry for Conservation, Melbourne, Victoria;

Shelf Benthic Survey (AMSBS) and Hunter District Water Board Survey (HDWBS) both carried out by the Australian Museum, Sydney, New South Wales;

N.S.W. State Pollution Control Commission (SPCC) survey of Botany Bay, 1976-77 (material lodged in the Australian Museum);

Moreton Bay benthic studies (QUBS) of the Department of Zoology, University of Queensland, Brisbane, Queensland.

Material has been deposited in the National Museum of Victoria (NMV), Melbourne, the Australian Museum (AM), Sydney, and the Queensland Museum (QM), Brisbane.

## PARANTHURIDAE Menzies and Glynn

*Leptanthura* Sars

*Leptanthura* Sars, 1899: 47-48.—Barnard, 1925: 149-150.—Wolff, 1956: 137.—Menzies, 1962: 193.—Birstein, 1963: 138.

*Diagnosis:* Paranthuridae without eyes. Pereon with feeble dorsolateral grooves, otherwise smooth; pereonites 4-6 sometimes with small dorsal pits. Pleonites distinct. Telson thin, concave dorsally, not indurated; a single statocyst opening by a dorsal pore proximally. Uropodal endopod usually barely exceeding telson, exopod usually broad and erect. Antenna 1 flagellum rudimentary, of 3-4 articles. Antenna 2 flagellum rudimentary, of 4-5 articles. Mandible with a 3-articulate palp, article 2 the longest, article 3 short and narrow and with 1-2 terminal spines. Maxilliped elongate, basis fused on to head; endite obsolete; palp less than  $\frac{1}{3}$  of total length and of up to 3 poorly-separated setose articles. Pereopod 1 stout, subchelate, palm entire or with a proximal thumb, axial to oblique. Pereopods 2, 3 less well developed than first. Pereopods 4-7 with article 5 triangular and lacking a free anterior margin. Pleopod 1 operculiform, not or only slightly indurated. Adult male characterized by more elongate form than juvenile or female and bearing a multi-articulate setose flagellum on antenna 1. Females with oostegites on pereonites 2-5.

*Type species:* *Paranthura tenuis* Sars, 1872.

*Remarks:* *Leptanthura* is a clearly defined genus of about 19 remarkably similar species. The diagnosis given here is essentially that of Barnard (1925) and of Menzies (1962). Differences are in allowance for dorsal pits which are noted on Australian species and a less rigid definition of the number of articles in the maxilliped. The maxillipedal palp was defined as a single article by Barnard (1925) but more recent authors (Birstein, 1963; Kensley, 1975) have noted additional minute articles on this appendage. These terminal articles could easily have been overlooked by earlier authors. Barnard (1925) placed great value in use of the number of articles in the maxilliped

in generic definitions of the Anthuridea. Over-reliance on this character in the Paranthuridae may not be warranted. In spite of variability in this character the genus *Leptanthura* at least remains fairly homogeneous. The structure of the mandibular palp, lack of eyes and the form of the limbs are consistent throughout the genus.

Species of *Leptanthura* are known from shelf and bathyal waters of most areas of the world except around North and South America. The Australian species, *L. diemenensis*, is the only one known from the intertidal zone (Haswell, 1884).

KEY TO AUSTRALIAN SPECIES OF  
*LEPTANTHURA*

- 1 Exopod of uropod acute, lanceolate; telson reaching little beyond base of endopod . . . . . *L. nunana*
  - Exopod of uropod wider than long; telson reaching at least halfway along endopod . . . . . 2
  - 2 Exopod of uropod apically notched; telson apically rounded; intertidal to sublittoral . . . . . *L. diemenensis*
  - Exopod of uropod not apically notched; telson acute; bathyal . . . *L. kapala*
- Leptanthura diemenensis* (Haswell)**

## Figures 1-3

*Paranthura diemenensis* Haswell, 1884: 1011, pl. 52, figs. 6-13, (misspelling in text; correct spelling is used in figure captions).

*Leptanthura diemenensis*. — Barnard, 1925: 151.

*Leptanthura dienenensis* (Haswell). — Nierstrasz, 1941: 242 (misspelling).

*Description:* Head a little wider than long, about  $\frac{1}{2}$  as long as pereonite 1; rostrum broadly triangular,  $\frac{1}{2}$  length of lateral lobes; eyes absent. Pereonite lengths as follows:  $1 = 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with obsolete dorsolateral grooves, obsolete dorsal pits on pereonites 4-6. Pleon about as long as pereonite 7, pleonites distinct.

Antenna 1 flagellum of 3-4 articles, first the longest, shorter than last two articles of peduncle. Antenna 2 flagellum rudimentary, of 4-5 short setose articles.

Mandible with an acute incisor, palp not reaching to end of incisor; palp article 2 three times length of first, bearing 1 (up to 3 on large specimens) setae distally; palp article 3 small with 2 stout, barbed spines terminally. Maxilla a slender serrated spine. Maxilliped basis not distinct from head, bearing 2 (up to 4) ventral setae distally; maxillipedal palp of 3 articles (but not clearly distinct), article 1 about  $\frac{1}{3}$  length of basis, bearing 1 dorsal and 2-3 ventral setae distally, articles 2 and 3 minute, together with 4-7 setae.

Pereopod 1 stout; palm axial and with a broadly-based thumb proximally. Article 5 of pereopod 1 with 2-3 spines; palm of article 6 with 7-9 spines laterally, a simple stout seta after the second spine, and 9-10 simple setae mesially. Pereopods 2, 3 similar to first but less stout, more elongate and palms with smaller spines. Pereopods 4-7 progressively a little more elongate; article 5 small, triangular and bearing 2-3 spines; article 6 with setae and 3-4 spines posteriorly; dactyl about as long as palm of article 6.

Uropodal endopod triangular, setose, about  $\frac{2}{3}$  length of peduncle; exopod divided by a deep notch into an acute ventral lobe and a larger, erect dorsal lobe with setose margins. Telson little shorter than uropod, dorsally concave, its lateral margins curved to an evenly rounded apex; statocyst opening by a proximal pore; 2 long erect setae and several smaller setae dorsally, 2 small setae at apex, sometimes in a minute notch.

*Male:* Differs from description given above in more elongate form; multi-articulate, setose flagellum of antenna 1 with about 20 articles reaching back to end of pereonite 1; more elongate pereopods; palm of pereopods with more simple setae laterally and highly setose mesially; appendix masculinis with a tapering flagellum extending beyond the inner ramus of pleopod 2.

In sub-males the multi-articulate flagellum of antenna 1 lacks setae and the appendix masculinis is missing or lacks its flagellum.

*Material examined:* 19 males, 71 females, 531 juveniles; 5-20 mm.

*Holotype:* AM P3317, juvenile, 13.1 mm.

*Type locality:* TASMANIA, Hobart, 'between tide marks'.

*Other material:*

QUEENSLAND. Middle Banks, Moreton Bay, QUBS stn 5, December 1972 (1 specimen).

N.S.W. Burwood Beach, 3.5 km S. of Hunter R., 14 m, HDWBS samples: AM P24027 (1 specimen).

E. of Malabar, Sydney, 31-192 m, AMSBS stations: stn A1, AM P24350 (9); stn D2, AM P22791 (1); stn 2E, AM P22792 (4); stn 4E, AM P22793 (1); stn III, AM P22782 (6), AM P22783 (7); stn V, AM P22785 (3), AM P22786 (1); stn 31, AM P22788 (1); stn 44, AM P22787 (5).

2 km E. of Long Bay, Sydney, 66 m, AMSBS stn IV, AM P22784 (3).

E. of North Head, Sydney, 20 m, AMSBS samples collected in association with the sponge *Polymastrea craticia*: AM P22813 (1), AM P24362 (1). AMSBS station 22, AM P22789 (1).

Near Kurnell, Botany Bay, AM P8965 (1).

Near Sow and Pigs Reef, Port Jackson, AM P8969 (2).

VICTORIA. Port Phillip Bay, 5-22 m, NMV J475, PPBES stations: stn 906 (3 specimens); stn 907 (11); stn 913 (32); stn 918 (29); stn 921 (1); stn 922 (7); stn 925 (1); stn 927 (2); stn 928 (3); stn 932 (2); stn 945 (4); stn 954 (2); stn 955 (1); stn 959 (2); stn 961 (1); stn 968 (1); stn 977 (1); stn 978 (1); stn 983 (1); stn 984 (67); stn 985 (10); stn 1224 (2); stn 1226 (1).

Western Port, 2-19 m, 1964 CPBS stations, NMV J476: stn A1 (3); stn A4 (2); stn B2 (4); stn B3 (4); stn B4 (1); stn C1 (3); stn C2 (1); stn C4 (2).

1965 CPBS stations, NMV J477: stn 01S (21); stn 02N (1); stn 03S (3); stn 10E (2); stn 11N (49); stn 11S (24); stn 12N (1); stn 200 (8); stn 21N (10); stn 21S (10); stn 22N (6); stn 22S (16); stn 23N (6); stn 26N (1); stn 26S (6); stn 300 (8); stn 31N (6); stn 31S (6); stn 31E (1); stn 32N (15); stn 32S (1); stn 33N (14); stn 34N (4); stn 35N (1); stn 400 (1); stn 41N (4); stn 41S (5); stn 42S (2); stn 51N (21); stn 51S (9); stn 52N

(7); stn 600 (13); stn 61N (6).

1966-70 CPBS stations, NMV J478: stn 300 (4); stn 31N (17); stn 31S (12); stn 32N (34); stn 32S (13).

*Distribution:* Southern Queensland, New South Wales, Victoria and Tasmania; intertidal region to 192 m, on fine to coarse sandy sediments, often with shell. Specimens from N.S.W. were taken in association with the sponge *Polymas-tea crificia*.

*Remarks:* *Leptanthura diemenensis* is the most common paranthurid in benthic collections from the south-eastern Australian coast. It is most easily distinguished by the notched exopod on the uropod and the broad, rounded, dished telson. Specimens may be confused with *Bullowanthura pambula* with which it co-occurs.

*L. diemenensis* is most closely related to *L. laevigata* (Stimpson) from South Africa (Barnard, 1925) the only other species reported to have an apical notch in the uropodal exopod. The species differ in the form of pereopods 1.

#### ***Leptanthura nunana* sp. nov.**

Figures 4, 5

*Description:* Head as wide as long, about  $\frac{1}{2}$  length of pereonite 1; rostrum triangular, almost as long as lateral lobes; eyes absent. Pereonite lengths as follows:  $1 = 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with obsolete dorsolateral grooves, obsolete dorsal pits on pereonites 4-6. Pleon almost twice as long as pereonite 7, pleonites distinct.

Antenna 1 flagellum of 4 articles, first article very short and surrounding second laterally, flagellum shorter than last article of peduncle. Antenna 2 flagellum rudimentary, of 5-7 short, setose articles, as long as elongate last article of peduncle.

Mandible with an acute incisor, palp not reaching to end of incisor; palp article 2 three times length of first, without setae; palp article 3 small with 2 stout, barbed spines terminally. Maxilla a slender, serrated spine. Maxilliped basis not distinct from head, bearing 1 ventral seta distally; maxillipedal palp of 3 almost-fused articles, article 1 about  $\frac{1}{4}$

length of basis, bearing 1 dorsal and 2 ventral setae distally, articles 2 and 3 minute, together with 5 setae.

Pereopod 1 stout; palm oblique and with a triangular thumb proximally. Article 5 of pereopod 1 with 1 spine; article 6 with 12-14 spines laterally, a simple stout seta after the third spine, and simple setae mesially. Pereopods 2, 3 similar to first but much less stout, more elongate and palms with smaller and fewer spines. Pereopods 4-7 subequal; article 5 small and triangular, bearing 1 spine; article 6 with 3-4 spines posteriorly; dactyl a little shorter than palm of article 6.

Uropodal endopod elongate, extending well beyond telson, setose, about  $\frac{2}{3}$  length of peduncle; exopod lanceolate and with an acute apex, with setose margins. Telson little longer than uropod peduncle, dorsally convex, lateral margins parallel and apex evenly rounded; statocyst opening to a proximal dorsal pore; several setae dorsally and apically.

*Male:* Differs from description given above in more elongate form; multi-articulate, setose flagellum of antenna 1 with about 9 articles reaching back little beyond end of head; more elongate pereopods; palm of pereopod 1 setose mesially; appendix masculinis with a curved end extending well beyond the outer ramus of pleopod 2.

*Material examined:* 1 male, 1 female, 7 juveniles; 6-10 mm.

*Holotype:* NMV J479, juvenile, 9.7 mm.

*Type locality:* VICTORIA, Altona Bay, Port Phillip Bay, PPBES stn 901, sandy sediment, 8 m, 7 June 1971.

#### *Paratypes:*

VICTORIA. Port Phillip Bay, PPBES stations: stn 933, AM P25373, 25374 (2 specimens); stn 954, NMV J480, 481 (2); stn 955, NMV J482 (1); stn 983, NMV J483 (1).

#### *Other material:*

VICTORIA. Port Phillip Bay, PPBES stations: stn 914, NMV J484 (1 specimen); stn 934, NMV J485 (1).

*Distribution:* Port Phillip Bay, Victoria, clayey-sand to sandy sediments, 8-22 m.



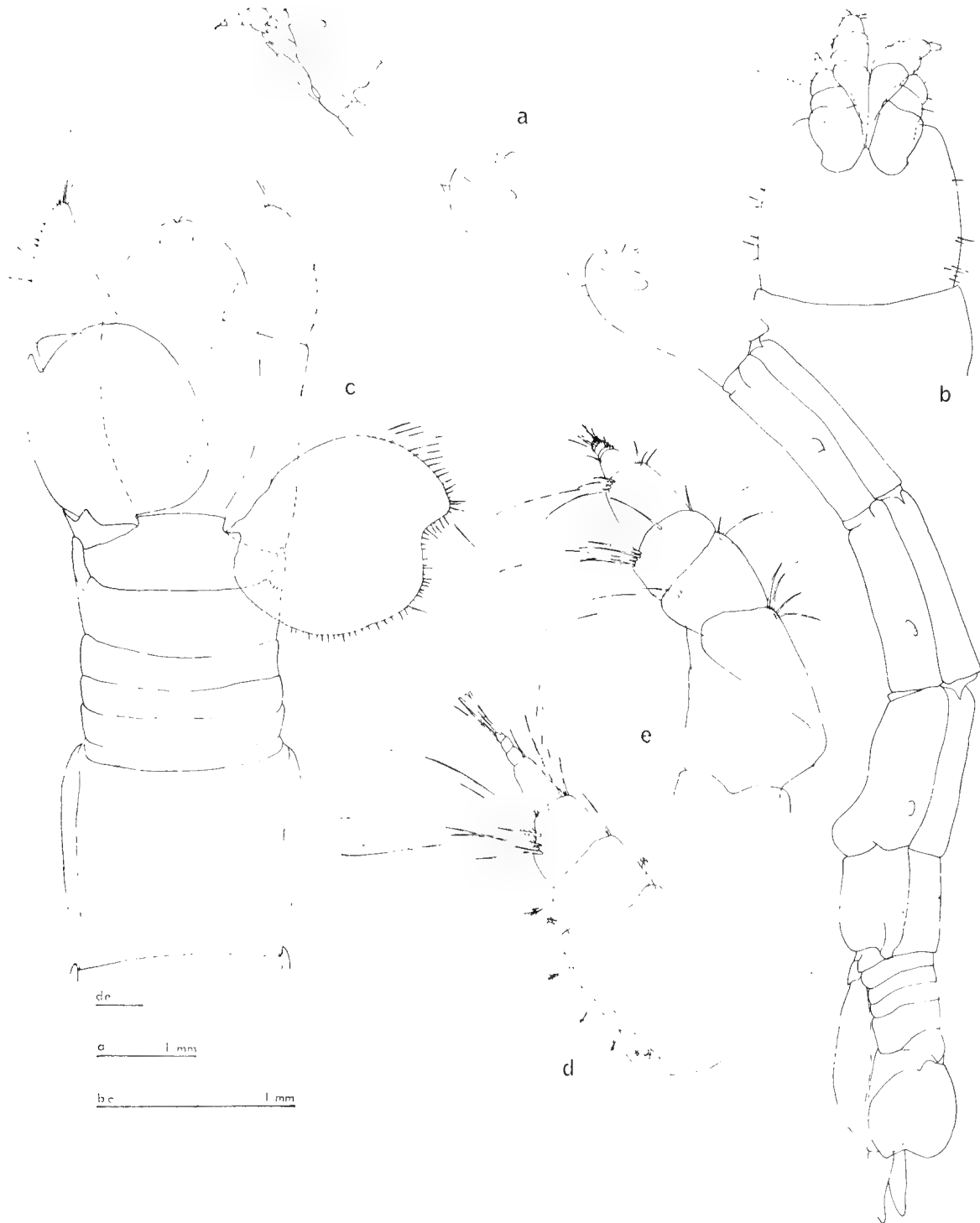


Figure 1—*Leptanthura diemenensis*. Female (NMV J 475, PPBES stn 983): a, lateral (limbs omitted); b, head; c, pereonite 6, pleon and tail fan; d, e, antennae 1, 2.

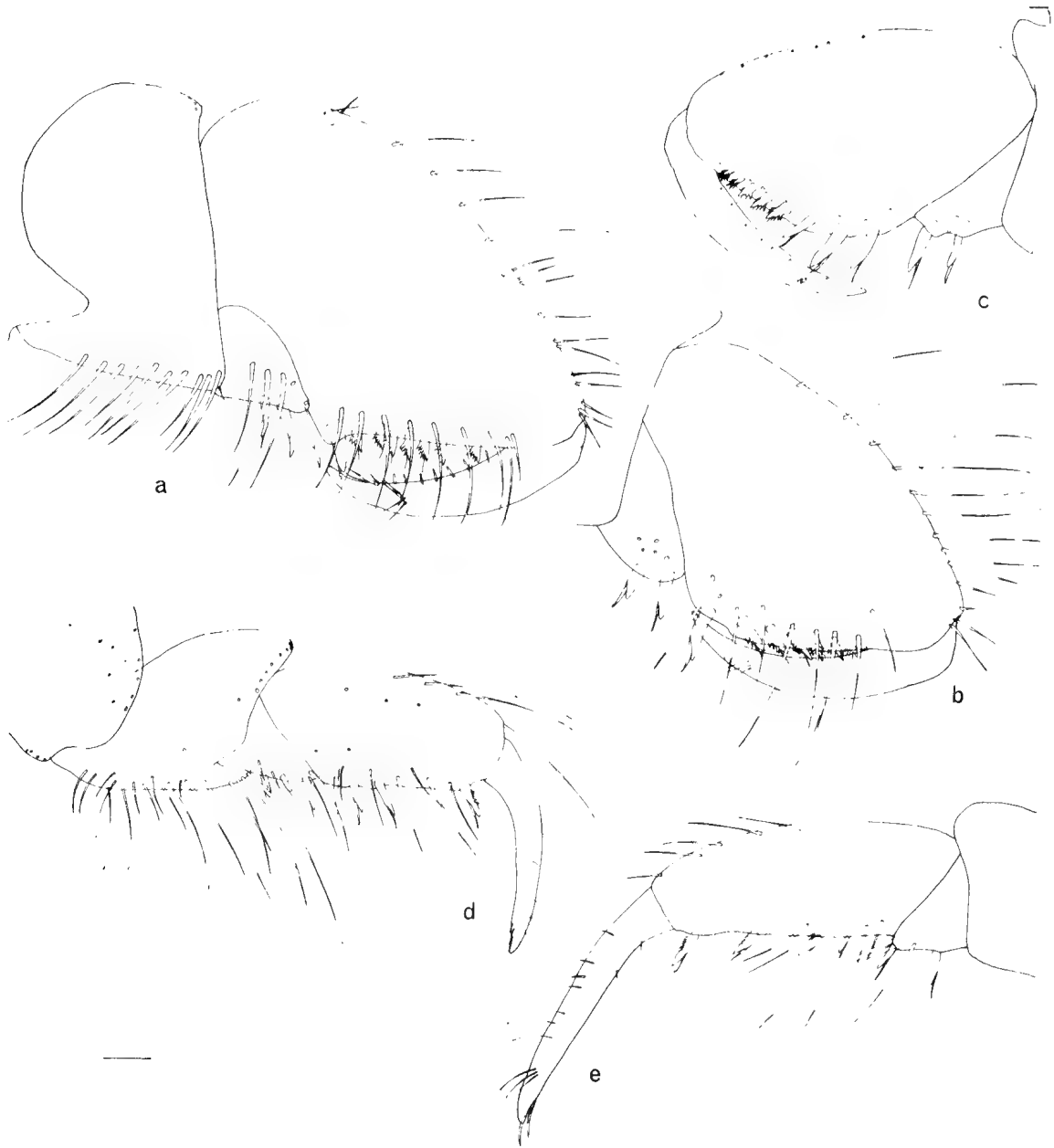


Figure 2—*Leptanthura diemenensis*. Female (NMV J475, PPBES stn 983): a-d, e, pereopods 1-4, 7.

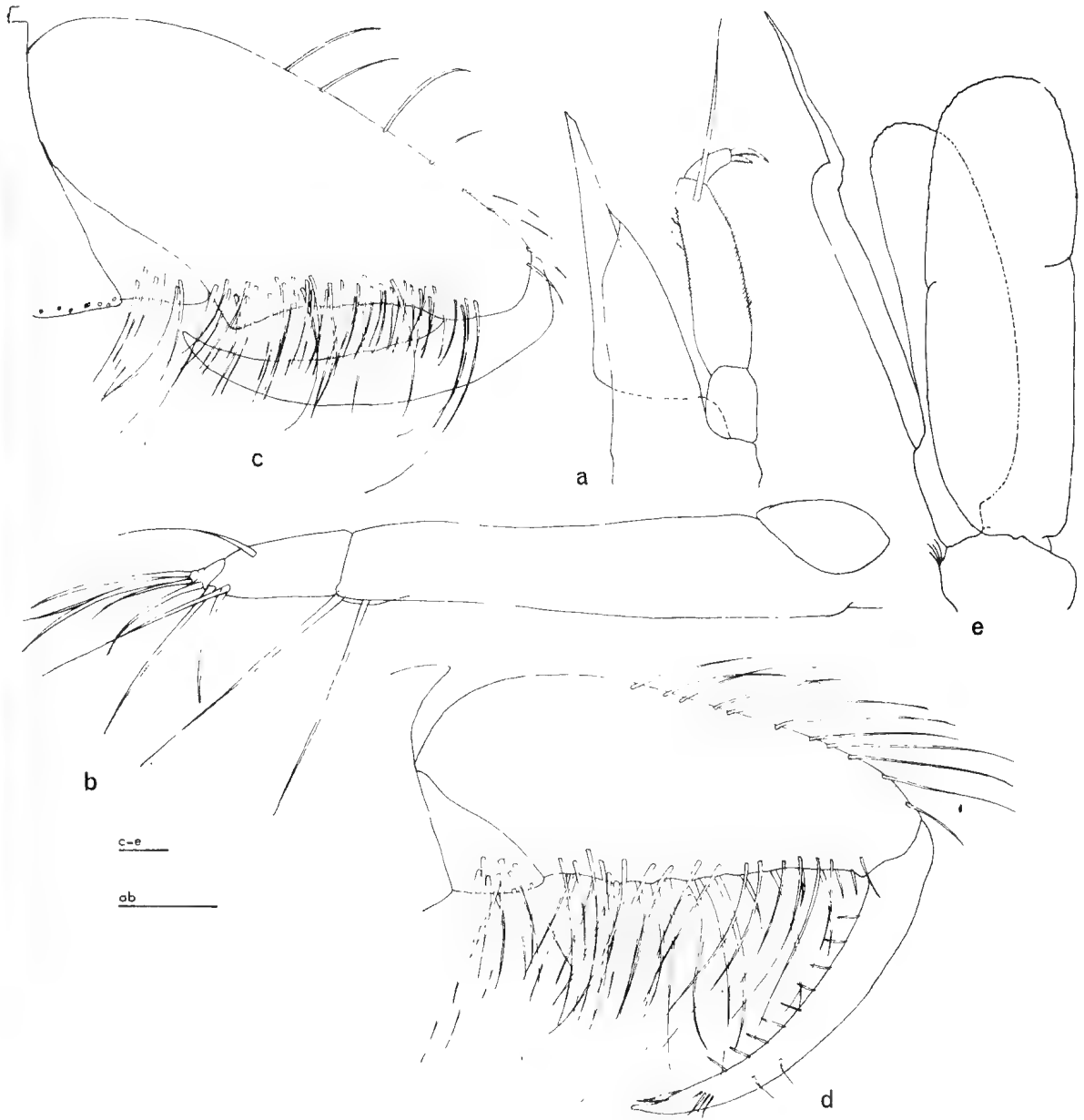


Figure 3—*Leptanthura diemenensis*. Female (NMV J475, PPBES stn 983): a, mandible; b, maxilliped. Male (NMV J475, PPBES stn 961): c, d, pereopods 1, 2 (mesial views); e, pleopod 2.

**Remarks:** *Leptanthura nunana* is distinguished by the long narrow uropodal endopods and the lanceolate exopods. The latter character is shared with *L. agulhasensis* Kensley from South Africa but the two species differ in the

form of the telson and pereopods.

The Australian aboriginal word 'nunana' means 'little' and suggests the small size of this species.



Figure 4—*Leptanthura nunana*. Holotype (NMV J479): a, head; b, pleon and tail fan; c, flagellum of antenna 2; d, mandible; e, maxilliped.

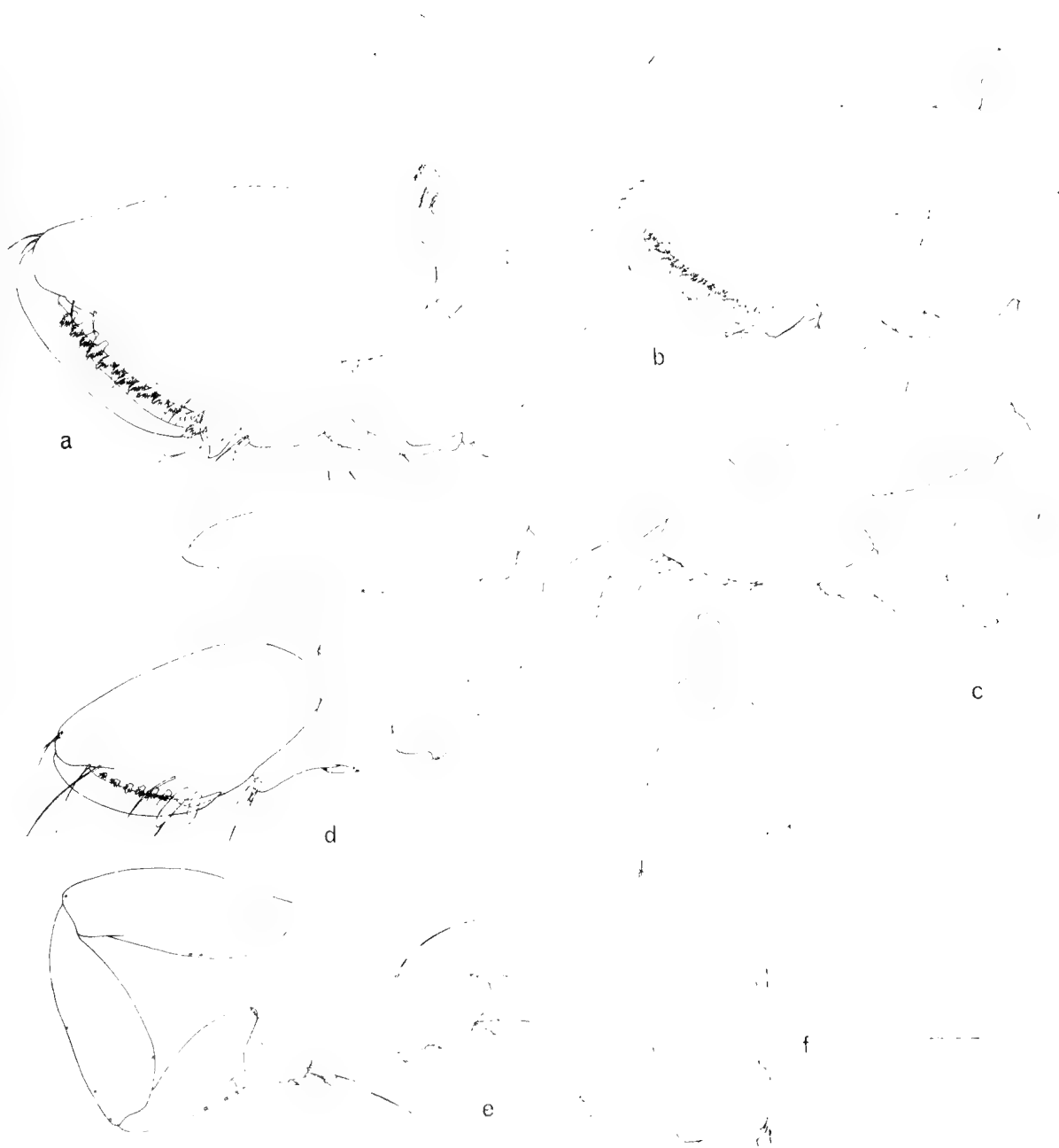


Figure 5—*Leptanthura nunana*. Holotype (NMV J479): a-d, e, pereopods 1-4, 7. Male (NMV J480, PPBES stn 954): f, pleopod 2.

*Leptanthura kapala* sp. nov.

Figures 6, 7

**Description:** Head a little wider than long, about  $\frac{2}{3}$  as long as pereonite 1; rostrum broadly triangular,  $\frac{1}{2}$  length of lateral lobes; eyes absent. Pereonite lengths as follows:  $1 = 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with obsolete dorso-lateral grooves, obsolete dorsal pits on pereonites 4-6. Pleon about as long as pereonite 7, pleonites distinct.

Antenna 1 flagellum of 3-4 articles, shorter than last two articles of peduncle. Antenna 2 flagellum rudimentary, of 3-4 short setose articles, about as long as last article of peduncle.

Mandible with an acute incisor, palp not reaching to end of incisor; palp article 2 almost 3 times as long as first, without setae; palp article 3 small and with 2 stout barbed spines terminally. Maxilla a slender, serrated spine. Maxilliped basis not distinct from head, bearing 1-2 ventral setae distally; maxillipedal palp of 3 articles (but not clearly distinct); article 1 about  $\frac{1}{3}$  length of basis, bearing 1 dorsal and 2 ventral setae distally; articles 2 and 3 minute, together with 4 setae.

Pereopod 1 stout; palm oblique and with a broadly-based thumb proximally. Article 5 of pereopod 1 with 1 spine; palm of article 6 with 11-14 spines laterally, a simple stout seta after the third spine, and several simple setae mesially. Pereopod 2 smaller than first and without a thumb; pereopod 3 much smaller than first, without a thumb but the palm posteriorly lobed. Pereopods 4-7 progressively a little more elongate; article 5 small and triangular, bearing 1 posterior spine and setae; article 6 with 2-3 posterior spines; dactyl longer than palm of article 6.

Uropodal endopod triangular, setose, about  $\frac{2}{3}$  length of peduncle; exopod oval, its dorsal lobe overlying the telson, with setose margins. Telson reaching halfway along endopod, dorsally flat, its lateral margins tapering to an acute apex; statocyst opening to a proximal dorsal pore; 2 long, erect setae dorsally.

**Male:** Differs from description given above in moderately short, setose flagellum of antenna 1 with 8 articles reaching back to end

of head; more elongate pereopods; palm of pereopod 1 with many setae mesially; appendix masculinus with a curved tip reaching to the end of the outer ramus of pleopod 2.

**Material examined:** 4 males, 4 females, 48 juveniles; 7-11 mm.

**Holotype:** AM P25375, juvenile, 9.8 mm.

**Type locality:** N.S.W., E. of Wollongong, 34° 27'S., 151° 27'E., F.R.V. 'Kapala' station K76-23-02, 1200 m, 13 December 1976.

**Paratypes:** N.S.W. Type locality, AM P25376 (12 specimens).

**Other material:** N.S.W. Type locality, AM P25055 (43 specimens).

**Distribution:** New South Wales, bathyal zone, 1200 m.

**Remarks:** *Leptanthura kapala* is the only anthuridean so far described from the bathyal zone around Australia's coast. The species is recognized by the acute telson and broad uropodal exopod. *L. agulhasensis* Kensley from South Africa and *L. tenuis* (Sars) from the North Atlantic share the acute telson but the uropods and pereopods of these species differ.

The species is named for the N.S.W. State Fisheries research vessel, F.R.V. 'Kapala', which collected these specimens and has made some of the first biological collections from deep waters in Australia.

*Bullowanthura* new genus

**Diagnosis:** Paranthuridae without eyes. Pereon with feeble dorsolateral grooves, otherwise smooth; pereonites 4-6 with small dorsal pits. Pleonites distinct. Telson thin, concave dorsally, not indurated; a single statocyst opening by a dorsal pore proximally. Uropod with endopod barely exceeding telson, exopod broad and erect. Antenna 1 flagellum rudimentary, of 3-4 articles. Antenna 2 flagellum rudimentary, of 4-5 articles. Mandible with a palp of a single article bearing one terminal seta. Maxilliped elongate, articles 1 and 2 fused to head; endite obsolete; palp about  $\frac{1}{3}$  length of basis, of 2 articles, the last minute. Pereopod 1 stout, subchelate, palm with a proximal thumb, oblique. Pereopods 2, 3 much less well developed than first, barely subchelate. Pereopods 4-7

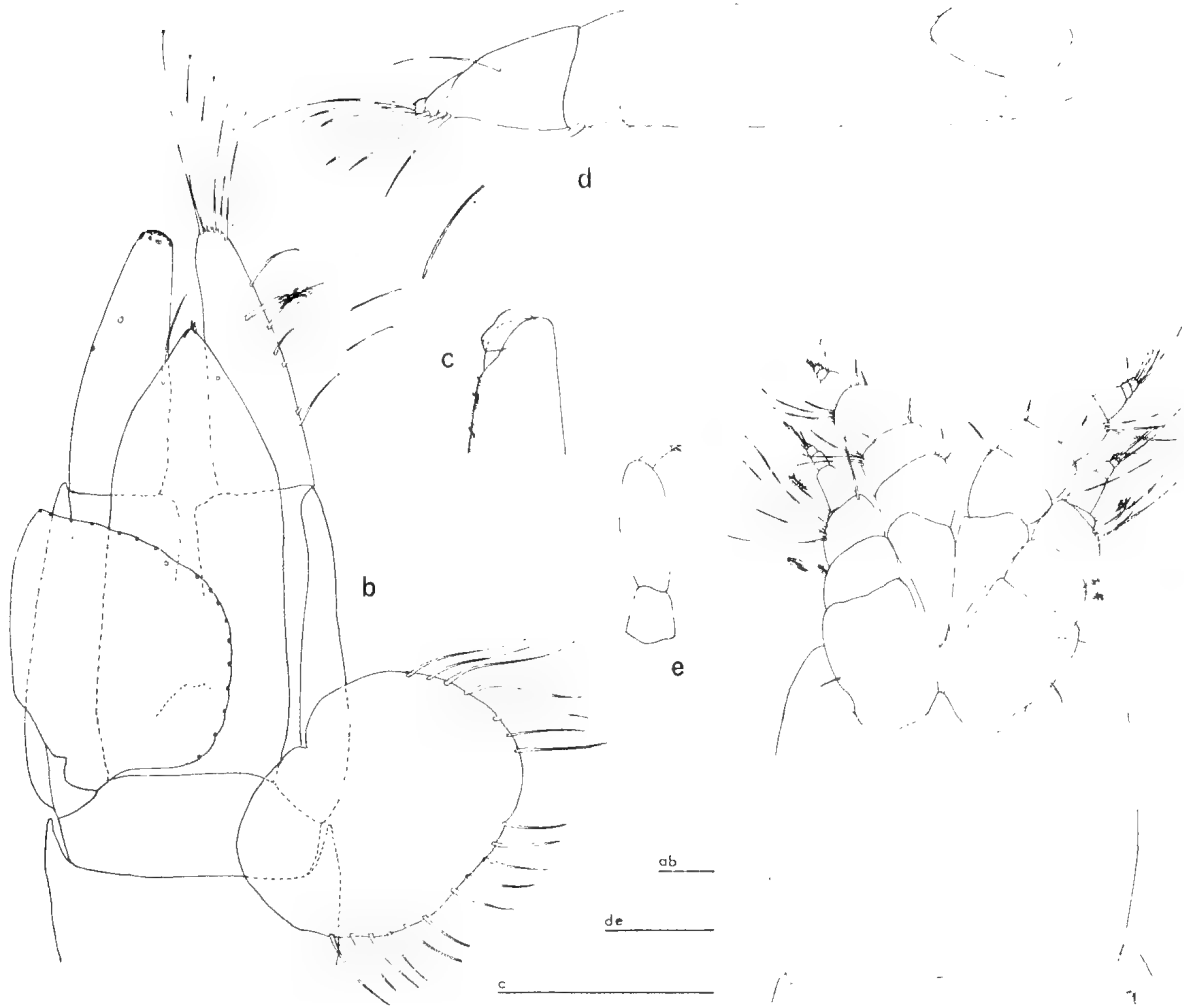


Figure 6—*Leptanthura kapala*. Holotype (AM P25375): a, head; b, tail fan; c, mandibular palp (terminal articles); d, maxilliped. Juvenile (AM P25376): e, mandibular palp.

with article 5 triangular and lacking a free anterior margin. Pleopod 1 operculiform, only moderately indurated. Adult male characterized by more elongate pereopods than juveniles or females and by a multi-articulate, setose flagellum on antenna 1. Females with oostegites on pereonites 2-5.

*Type species: Bullowanthura pambula* new species.

*Remarks: Bullowanthura* is close to *Leptanthura*, differing in having a mandibular palp

of a single article. *Leptanthura* possesses a 3-articulate palp of characteristic form. Both genera are blind, have distinct pleonites, have similar telson and uropods, similar antennae, maxillipeds and pereopods 4-7.

Barnard (1925) recognized the constant form of the mandibular palp in *Leptanthura* but noted variations in other genera. He did not find 'it always possible to use these differences as generic characters'. Nevertheless, three anthurid genera, *Pendantanthura*, *Ptilanthura* and *Xenanthura*, and three paranthurid genera, *Cruregens*, *Colanthura* and possibly *Cruranthura*, lack a mandibular palp so it seems the character may have some value. *Bullowanthura* and the following new genus, *Ula-*



Figure 7—*Leptanthura kapala*. Holotype (AM P25375): a-d, e, pereopods 1-4, 7.

*kanthura*, are the only paranthurids with a palp of a single article.

*Bullovanthura* and *Ulakanthura* differ in the degree of development of pereopods 2 and 3. In *Bullovanthura* pereopods 2 and 3 are poorly developed and approach walking legs in form. In *Ulakanthura* these two limbs are larger than the first pereopod. Pereopods 4-7 are also different in the two genera.

The genus is monotypic.

The prefix 'bullova' used in formation of the generic name is an Australian aboriginal word meaning 'flower' and reflects the mean-

ing of the root 'anthos' used in most generic names in the family.

#### ***Bullovanthura pambula* sp. nov.**

Figures 8, 9

*Description:* Head as wide as long, about  $\frac{1}{2}$  as long as pereonite 1; rostrum broadly triangular,  $\frac{1}{2}$  length of lateral lobes; eyes absent. Pereonite lengths as follows:  $1 = 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with obsolete dorso-lateral grooves, obsolete dorsal pits on pereonites 4-6. Pleon little longer than pereonite 7, pleonites distinct.

Antenna 1 flagellum of 3-4 articles, first the longest, little longer than last article of ped-



uncle. Antenna 2 flagellum rudimentary, of 4-5 short setose articles.

Mandible with an acute incisor, palp a single narrow article with 1 terminal seta. Maxilla slender, serrated spine bearing a minutely hooked keel on its distal inner margin. Maxilliped basis not distinct from head, bearing 2-3 ventral setae distally; maxillipedal palp of 2 articles, first about  $\frac{1}{3}$  length of basis and bearing 1 dorsal seta and 4 ventral setae, second minute and with 3 terminal setae.

Pereopod 1 stout; palm oblique and with a strong proximal thumb. Article 5 of pereopod 1 with 2-4 spines; palm of article 6 with 7-13 spines laterally and in the same row a long simple seta near the base of the thumb and another after the last spine; palm with 8-12 simple setae mesially. Pereopods 2, 3 unlike the first, article 6 barely thickened, palms lacking a thumb and bearing 6 spines. Pereopods 4-7 subequal; article 5 small and triangular, bearing 2 spines; article 6 with 2-4 posterior spines; dactyl about as long as article 6.

Uropodal endopod elongate-triangular, setose, little shorter than peduncle; exopod divided into two parts by a very shallow terminal notch, a smaller ventral lobe with a rounded apex and a larger semicircular dorsal lobe. Telson reaching more than halfway along endopod, dorsally concave, lateral margins curved to a broadly rounded apex; statocyst opening to a proximal dorsal pore; 2 pairs of setae terminally and a few dorsally.

*Male:* Differs from the above description in multi-articulate, setose flagellum of antenna 1 with about 10-12 articles reaching back to end of head; more elongate pereopods; palm of pereopod 1 with a longer and narrower thumb, bearing 11-14 spines laterally and many setae mesially; appendix masculinis a simple rod extending well beyond the outer ramus of pleopod 2.

*Material examined:* 6 males, 3 females, 17 juveniles; 3-11 mm.

*Holotype:* AM P25378, juvenile, 10.3 mm.

*Type locality:* N.S.W., 1.6 km E. of Malabar, Sydney, AMSBS stn III, 33° 58'S., 151° 17'E., dredged from 66 m, 31 July 1973.

*Paratypes:*

N.S.W. E of Malabar, Sydney, 66-69 m, AMSBS stations: stn III, AM P25379 (6 specimens), AM P22814 (2), AM P25380 (3); stn V, AM P25382 (2); stn 4C, AM P22790 (1).

E. of Long Bay, Sydney, 66 m, AMSBS station IV, AM P25381 (3).

VICTORIA. Port Phillip Bay, 8-25 m, PPBES stations: stn 901, NMV J486-J488 (3); stn 906, NMV J489 (1); stn 969, NMV J554 (1); stn 982, NMV J555-J557 (3).

*Distribution:* New South Wales and Victoria, 8-69 m, on sandy sediments.

*Remarks:* The species has been previously confused with *Leptanthura diemenensis* with which it co-occurs. *Bullowanthura pambula* may be separated on its smaller size and more pronounced thumb on pereopod 1 and, more definitely, on the uni-articulate mandibular palp.

The series from Port Phillip Bay differed slightly from those off Sydney in features which could only be attributed to their slightly smaller size. In general, smaller specimens have fewer spines on the cutting edges of articles 6 of the pereopods, the number on pereopod 1, for example, showing quite a wide range.

The Australian aboriginal word 'pambula' means 'two waters' and indicates the distribution of the species.

*Ulakanthura* new genus

*Diagnosis:* Paranthuridae without eyes. Pereon with feeble dorsolateral grooves, otherwise smooth; pereonites 4-6 with small dorsal pits. Pleonites distinct. Telson thin, concave to moderately convex dorsally, not indurated; a single statocyst opening by a dorsal pore proximally. Uropod with endopod exceeding telson by about half its length, exopod usually broad and erect. Antenna 1 flagellum rudimentary, of 3-4 articles. Antenna 2 flagellum rudimentary, of 4-5 articles. Mandible with a palp of a single article without setae. Maxilliped elongate, articles 1 and 2 fused to head; endite obsolete; palp about one-third of length of basis, of 2 or 3 articles, the last minute. Pereopod 1 stout, subchelate, palm with a proximal thumb, oblique-transverse. Pereopods 2 and 3 stout, second at least more well de-

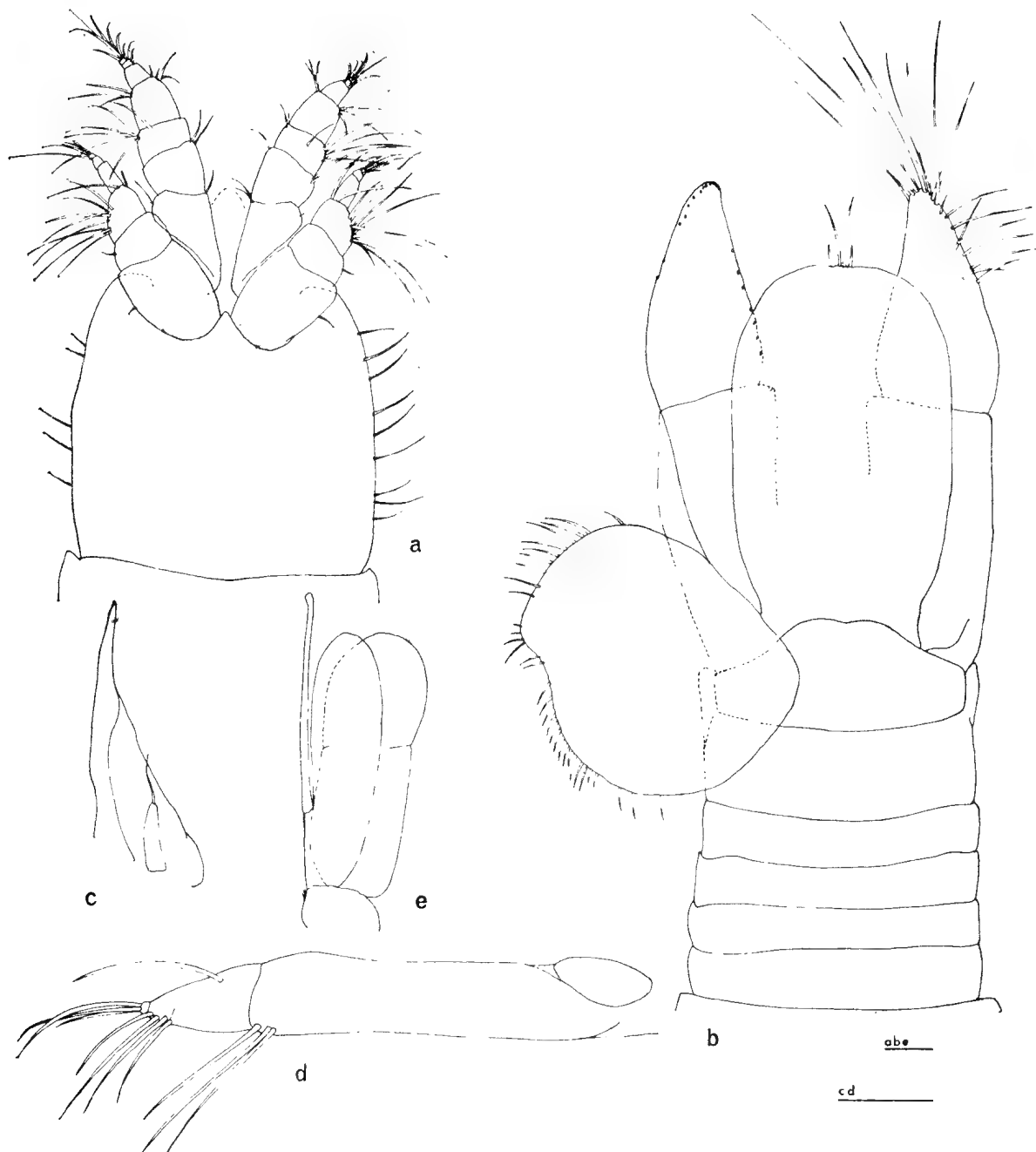


Figure 8—*Bullovanthura pambula*. Holotype (AM P25378): a, head; b, pleon and tail fan; c, mandible; d, maxilliped. Male (AM P25382, AMSBS stn V): e, pleopod 2.

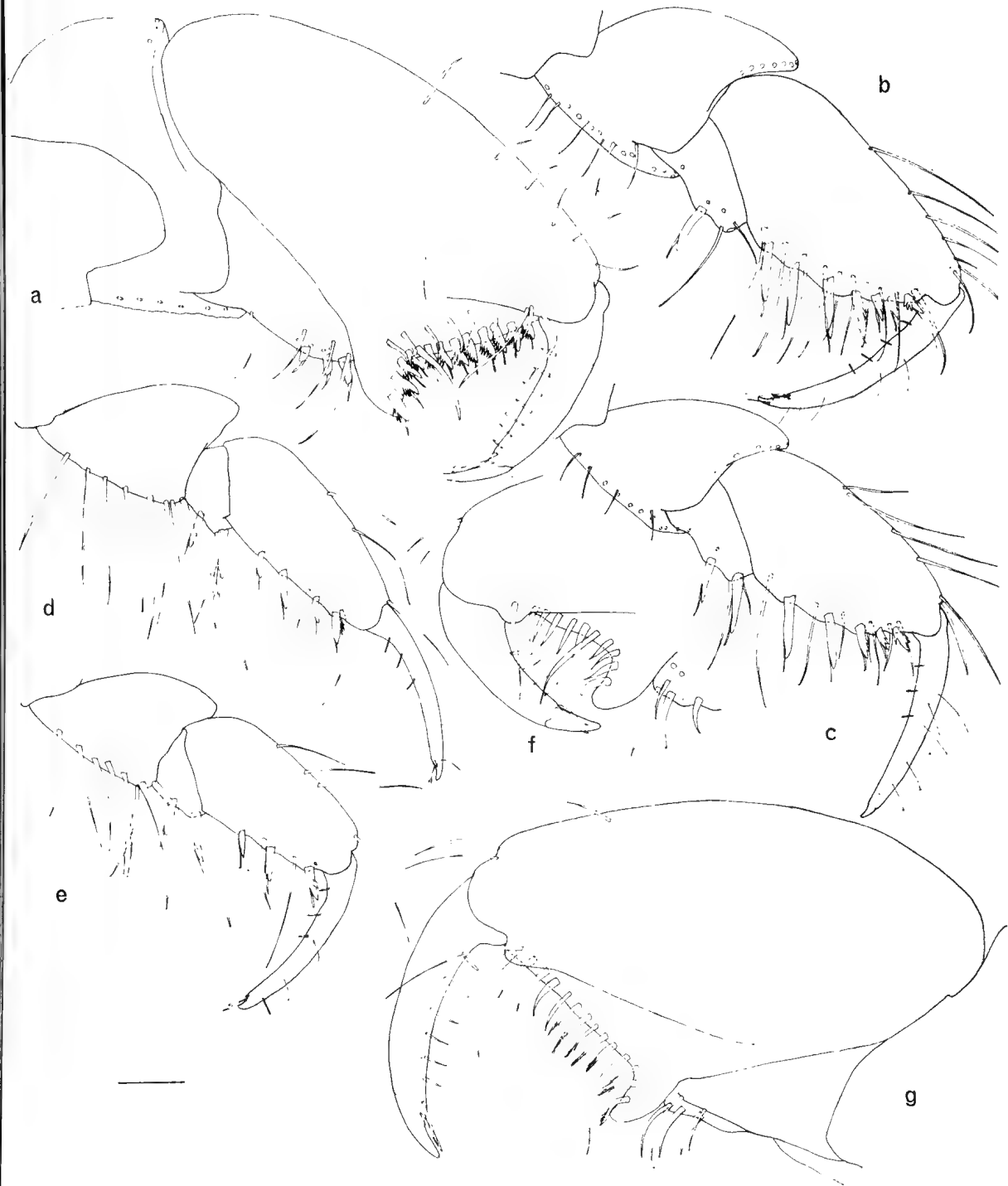


Figure 9—*Bullovanthura pambula*. Holotype (AM P25378): a-d, e, pereopods 1-4, 7. Male (NMV J486, PPBES stn 901): f, pereopod 1 (mesial setae omitted). Male (AM P25382, AMSBS stn V): g, pereopod 1 (mesial setae omitted).

veloped than first; articles 2 and 6 especially broad. Pereopods 4-7 with article 5 lobed posteriorly and extending along posterior margin of more distal articles; article 5 triangular and lacking a free anterior margin; articles 5 and 6 with strong posterior spines and article 7 with terminal articulating spines. Pleopod 1 operculiform, only moderately indurated. Adult male characterized by multi-articulate setose flagellum on antenna 1 and more elongate limbs. Females with oostegites on pereonites 2-5.

*Type species: Paranthura crassicornis* Haswell, 1881.

*Remarks: Ulakanthura* is very close to *Leptanthura* and the preceding new genus, *Bulloanthura*. All three genera are blind, have distinct pleonites and have similar telsons, uropods, antennae and maxillipeds. *Leptanthura* is distinguished by the 3-articulate mandibular palp of constant form. The other two genera share a mandibular palp of a single article, a feature found in few other anthurideans. The terminal seta on the palp of *B. pambula* is not found in species of *Ulakanthura* described here.

*Ulakanthura* is notable for the relative size of pereopods 1-3, the first being the smallest. This relationship is unknown in other paranthurids. The posterior lobe on article 4 and the terminal articulating spines which replace the unguis on article 7 of pereopods 4-7 are also not known in other paranthurid genera.

The genus is found only from eastern Australia where at present six species are known.

The prefix 'ulaka' used in formation of the generic name is an Australian aboriginal word meaning 'flower' and reflects the meaning of the root 'anthos' used in most generic names in the family.

#### KEY TO SPECIES OF *ULAKANTHURA*

- 1 Uropodal exopod apically cleft. . . . . 2  
 — Uropodal exopod not apically cleft. . . . . 4
- 2 Maxillipedal basis with many (>7) ventral and lateral setae. . . . . *U. colac*  
 — Maxillipedal basis with few (<4) ventral and lateral setae. . . . . 3

- 3 Telson broadest terminally, apical lobes squarish; article 4 of pereopod 4 with posterior lobe extending distally almost to end of article 6. . . . . *U. cooma*  
 — Telson widest at midpoint, apical lobes rounded; article 4 of pereopod 4 with posterior lobe extending distally to end of article 5. . . . . *U. crassicornis*
- 4 Telson tapering to two acute terminal lobes; uropodal exopod lanceolate ( $\frac{1}{2}$  as wide as long) . . . . . *U. namoo*  
 — Telson ending in two broadly semicircular lobes; uropodal exopod ovate ( $\frac{2}{3}$  as wide as long) . . . . . 5
- 5 Telson widest at proximal one third; appendix masculinis of male shorter than outer ramus of pleopod 2. . . . . *U. lara*  
 — Telson parallel-sided; appendix masculinis of male longer than outer ramus of pleopod 2. . . . . *U. wanda*

#### *Ulakanthura crassicornis* (Haswell)

Figures 10, 11

- Paranthura* (?) *crassicornis* Haswell, 1881: 478, pl. 18, fig. 5.—Haswell, 1882: 305.  
*Leptanthura crassicornis*.—Barnard, 1925: 151. Nierstrasz, 1941: 232 (part).  
 not *Paranthura crassicornis*.—Haswell, 1884: 1011-2, pl. 53, figs. 8, 9 (= *Paranthura* sp.).  
 not *Calathura*, sp. — Stebbing, 1905: 8 (from Sri Lanka).  
 not *Leptanthura crassicornis* (Haswell). Nierstrasz, 1941: 242 (part from Sri Lanka).

*Description:* Head about as long as greatest width, tapering anteriorly, almost as long as pereonite 1; rostrum broadly triangular, about  $\frac{1}{3}$  as long as lateral lobes; eyes absent. Pereonite lengths as follows  $1 < 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with dorsolateral grooves, dorsal pits and paired rows of setae on dorsum of pereonites 4-6. Pleon as long as pereonite 7, pleonites distinct.

Antenna 1 flagellum of 3-4 articles, shorter than last article of peduncle. Antenna 2 flagellum rudimentary, of 4 setose articles.

Mandible with an acute incisor, palp a single tapering article, not reaching to midpoint

of mandible. Maxilla a slender, serrated spine bearing a minutely-hooked keel on its distal inner margin. Maxilliped basis not distinct from head, bearing 1 ventral seta distally; maxillipedal palp of 2 barely-distinct articles, about  $\frac{1}{3}$  length of basis and bearing 8 ventral-distal setae and 1 dorsal-proximal seta.

Pereopod 1 stout; palm oblique-transverse and with a broad square thumb proximally. Article 5 of pereopod 1 with 3-4 spines; article 6 with 12-15 spines laterally along the cutting edge and a stout seta in the same row after the fourth spine. Pereopods 2, 3 stouter than first, articles 2 and 6 broader than those of first. Article 5 of pereopods 2, 3 without spines; palm of article 6 with a blunt proximal thumb and a row of about 16 spines laterally. Pereopods 4-7 dissimilar to pereopods 1-3, subequal; article 4 of pereopods 4-7 setose, posteriorly lobed, the lobe not reaching end of article 5 on pereopod 4 and about  $\frac{1}{3}$  way along article 5 on pereopod 7; article 5 triangular, bearing 3-4 strong posterior spines; article 6 with 4-5 strong posterior spines; article 7 proximally curved, not tapering, with 1 short and 1 long terminal spine.

Uropodal endopod triangular, setose, about  $\frac{2}{3}$  as long as peduncle; exopod divided by a clear notch into a ventral lobe with an acute apex and a larger erect dorsal lobe, with setose margins. Telson widest at midpoint and reaching halfway along endopod, dorsally flat-concave, divided by a deep wide notch into two semi-circular lobes; statocyst opening to a dorsal pore at the base of the telson; two pairs of setae in the terminal notch.

*Male:* Differs from the above description in possessing an elongate, setose flagellum on antenna 1 with about 14 articles reach back to end of pereonite 1; axial setose palm of pereopod 1; longer dactyls on pereopods 4-7; appendix masculinis on pleopod 2. The only adult male is the 'holotype' which is not in good condition, the remaining males examined lacked setae on the antenna 1 flagellum.

*Material examined:* 5 males, 1 female, 5 juveniles; 10-13 mm.

*Holotype:* AM P3316, male, 12.5 mm.

L

*Type locality:* N.S.W., Port Jackson.

*Other material:*

N.S.W. Belmont Beach, 16 km S. of Hunter R., 22 m, HDWBS samples AM P24021-24025 (6 specimens).

Burwood Beach, 3.5 km S. of Hunter R., 22-28 m, HDWBS samples: AM P24028 (2), AM P24029 (1).

E. of Malabar, Sydney, 31 m, AMSBS stn A1: AM P25383 (1).

*Distribution:* Central New South Wales, 22-31 m, coarse sandy sediments.

*Remarks:* Three paranthurids are catalogued together in the Old Collection of the Australian Museum as P3316 under the name *Paranthura crassicornis*. I have deduced that one of these, a male, is the specimen described by Haswell in 1881 and its large setose antenna 1 suggested the specific name to Haswell. In 1884 Haswell ascribed two more specimens to *P. crassicornis* noting differences in the antennae. The two other specimens stored as P3316 are probably those referred to by Haswell in 1884 but are not the same species as the original.

Haswell (1881) remarked that pereopod 1 was larger than the following ones, a feature common in most anthurids. This is not so in *U. crassicornis* but is not obvious at first glance.

*Ulakanthura crassicornis* is one of three species in this genus in which the uropodal exopod is cleft. The others are *U. cooma* from which it differs in form of the pereopods and telson, and *U. colac* from which it differs in the same characters and in the number of setae on the maxilliped basis. *U. crassicornis* is sympatric only with *U. cooma*.

Stebbing (1905) suggested that two specimens collected in Ceylon (Sri Lanka) may belong to *Paranthura (?) crassicornis* Haswell. Nevertheless, he listed them under the name *Calathura*, sp. and remarked on their dark eyes. This character clearly excludes them from *Ulakanthura crassicornis*.



Figure 10—*Ulakanthura crassicornis*. Juvenile (AM P24021, HDWBS sample): a, head; b, tail fan; c, mandible; d, maxilliped.

***Ulakanthura colac* sp. nov.**

Figures 12, 13

**Description:** Head about as long as greatest width, tapering only anteriorly, about  $\frac{2}{3}$  length

of pereonite 1; rostrum broadly triangular; eyes absent. Pereonite lengths as follows:  $1 < 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with obsolete dorsolateral grooves, dorsal pits and paired rows of few setae on dorsum of pereonites 4-6. Pleon little shorter than pereonite 7, pleonites distinct.

Antenna 1 flagellum of 3-4 articles, little

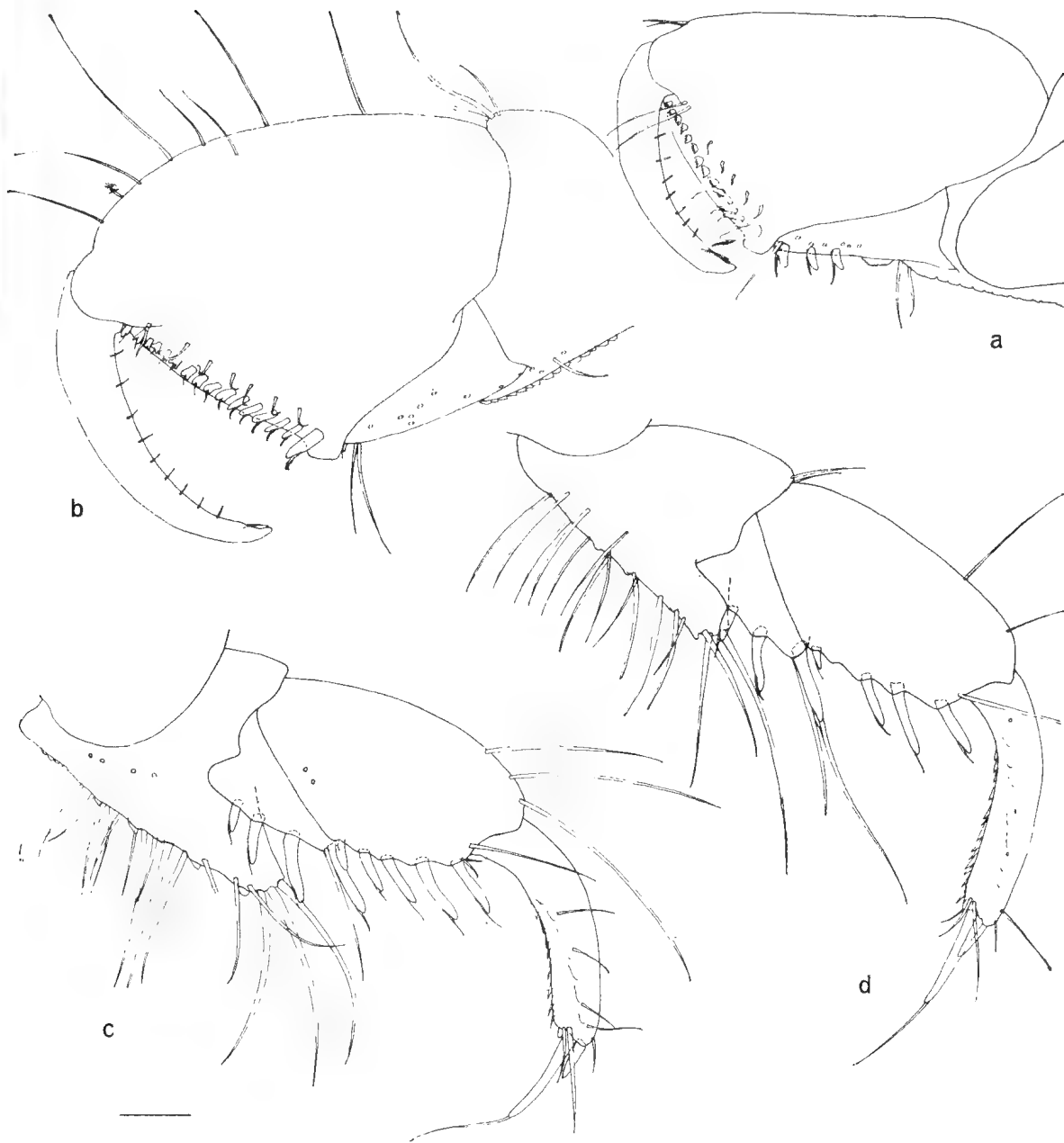


Figure 11—*Ulakanthura crassicornis*. Juvenile (AM P24021, HDWBS sample): a, b, c, d, pereopods 1, 2, 4, 7.

longer than last article of peduncle. Antenna 2 flagellum of 4-5 setose articles.

Mandible with an acute incisor, palp a single article, about  $\frac{1}{3}$  length of incisor. Maxilla a slender, serrated spine bearing a minutely-hooked keel on its distal inner margin. Maxil-

liped basis not distinct from head, bearing 1 distal ventral seta and 7-14 setae laterally; maxillipedal palp with a distinct, minute, terminal article; palp articles together about  $\frac{1}{3}$  length of basis and with 1 dorsal seta and 6 ventral-distal setae.

Pereopod 1 stout; palm axial-oblique and with a broad thumb proximally. Article 5 of pereopod 1 with 3-4 spines; article 6 with 7-10

spines laterally along cutting edge, a stout seta after the third or fourth and after the last spine. Pereopod 2 stouter than pereopod 1, article 2 especially broader than that of first, palm oblique. Article 5 of pereopods 2, 3 with 2-5 spines; palm of article 6 with a proximal thumb and row of 6-9 spines laterally. Pereopods 4-7 dissimilar to pereopods 1-3, subequal. Article 4 of pereopods 4-7 setose, lobed posteriorly, the lobe reaching only a little beyond the distal end of article 5 on pereopod 4 and not reaching this point on pereopod 7; article 5 triangular, with 3-6 strong posterior spines; article 6 with 4-8 stout posterior spines; article 7 barely tapering, with 1 long and 1 short terminal spine.

Uropodal endopod setose, triangular, about twice as long as wide,  $\frac{2}{3}$  as long as peduncle; exopod broad and with a shallow apical notch, folded over telson. Telson reaching halfway along endopod, dorsally concave, more or less parallel-sided, tapering distally to two rounded-triangular lobes separated by a strong apical notch; statocyst opening by a small proximal dorsal pore; one pair of simple setae and one pair of 'brush-setae' in the terminal notch and setae on dorsal surface of the telson.

*Male:* Differs from the above description in more elongate palm on pereopod 1; setose flagellum of antenna 1 with 12 articles reaching back to middle of pereonite 1. Appendix masculinis a simple rod reaching to the end of the outer ramus of pleopod 2.

*Material examined:* 7 males, 3 females, 49 juveniles; 4-12 mm.

*Holotype:* QM W7400, juvenile, 7.8 mm.

*Type locality:* QUEENSLAND. Middle Banks, Moreton Bay, clean sand, 9-10 m, collected by S. Cook and S. Newlands for University of Queensland benthic studies, March 1973.

*Paratypes:*

QUEENSLAND: Middle Banks, Moreton Bay, QUBS samples: QM W7344 (4 specimens), QM W7345 (6), QM W7346 (1).

*Other material:*

N.S.W. Burwood Beach, 3.5 km S. of Hunter R., 14-22 m, HDWBS samples: AM P24026 (1 specimen), AM P25384 (1).

Botany Bay, SPCC stations: stn 18, AM P25360 (1); stn 65, AM P25366 (1); stn 83, AM P25367 (1); stn 85, AM P25368 (1).

VICTORIA: Port Phillip Bay, 5-10 m, PPBES stations: stn 960, NMV J490-494 (44); stn 967, NMV J495 (1).

*Distribution:* Southern Queensland, New South Wales and Victoria, well-sorted sandy sediments, 5-22 m.

*Remarks:* *Ulakanthura colac* is a widespread species found in all shallow water coastal surveys from eastern and southeastern Australia. The species is recognized by the combination of cleft uropodal exopod and setose maxilliped basis (see Remarks for *U. crassicornis* and *U. cooma*).

The epithet 'colac' is an aboriginal word for 'sand' and reflects the sandy habitat of this and other species in the genus.

***Ulakanthura cooma* sp. nov.**

Figures 14, 15

*Description:* Head about as long as greatest width, tapering anteriorly, about  $\frac{2}{3}$  as long as pereonite 1; rostrum broadly triangular; eyes absent. Pereonite lengths as follows:  $1 < 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with dorso-lateral grooves, dorsal pits and paired rows of setae on dorsum of pereonites 4-6. Pleon little shorter than pereonite 7, pleonites distinct.

Antenna 1 flagellum of 4 articles, about as long as last article of peduncle. Antenna 2 flagellum of 4 setose articles.

Mandible with an acute incisor, palp a single article, about  $\frac{1}{3}$  as long as incisor. Maxilla a slender, serrated spine bearing a minutely-hooked keel on its distal inner margin. Maxilliped basis not distinct from head, bearing 1 distal and 1-2 subdistal setae; maxillipedal palp with a barely-distinct second article and a distinct terminal article; palp articles together with 1 dorsal seta and 7 ventral-distal setae.

Pereopod 1 stout; palm axial and with a broad thumb proximally. Article 5 of pereopod 1 with 5 spines; article 6 with 10-11 spines laterally along cutting edge, a stout seta after the fourth or fifth spine and another after the last spine. Pereopods 2, 3 stouter than pereopod 1.



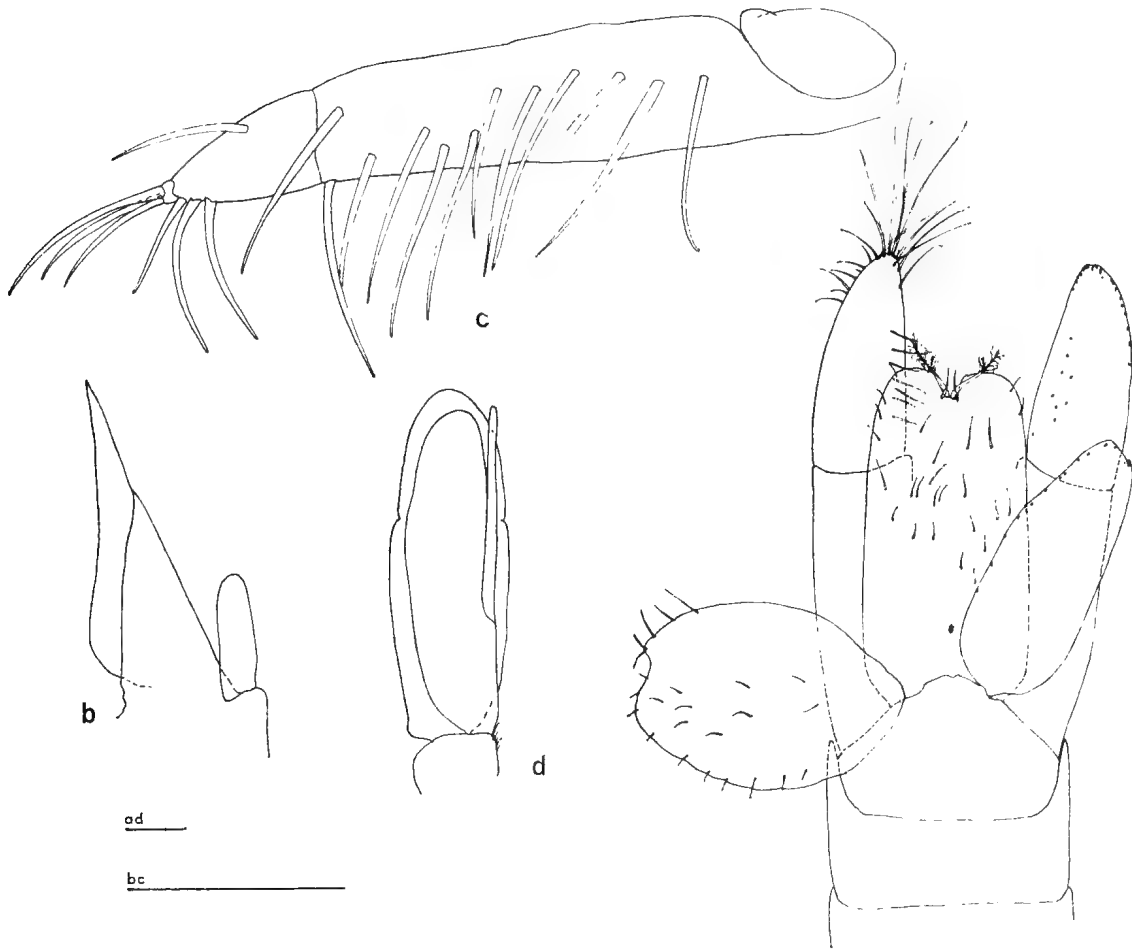


Figure 12—*Ulakanthura colac*. Holotype (QM W7400): a, tail fan; b, mandible; c, maxilliped. Male (QM W7344, QUBS sample): d, pleopod 2.

pod 1, articles 2 and 6 broader than those of first, palm oblique. Article 5 of pereopods 2, 3 with 1-3 spines; palm of article 6 with a proximal thumb and a row of 12-14 spines laterally. Pereopods 4-7 dissimilar to pereopods 1-3, subequal. Article 4 of pereopods 4-7 setose, strongly lobed posteriorly, the lobe reaching almost to the distal end of article 6 on pereopod 4 and halfway along article 6 on pereopod 7; article 5 triangular, with 6-8 strong posterior spines; article 6 with 8-10 stout posterior spines; article 7 barely tapering, with 1 long and 1 short terminal spine.

Uropodal endopod setose, linear-triangular, about 3 times as long as wide, almost as long as peduncle; exopod broad and apically notched, folded over telson. Telson reaching little beyond the end of the peduncle, dorsally concave, widest distally, two almost truncate terminal lobes separated by a strong apical notch; statocyst opening by a proximal dorsal pore; 1 pair of simple setae and 1 pair of 'brush-setae' in terminal notch, telson setose dorsally.

*Male*: Differs from above description in more elongate pleon; more elongate and more setose palm on pereopod 1; setose flagellum on antenna 1 with 12 articles reaching back to middle of pereonite 1. Appendix masculinis a simple rod exceeding the inner ramus of pleopod 2 by about  $\frac{1}{4}$  its length.

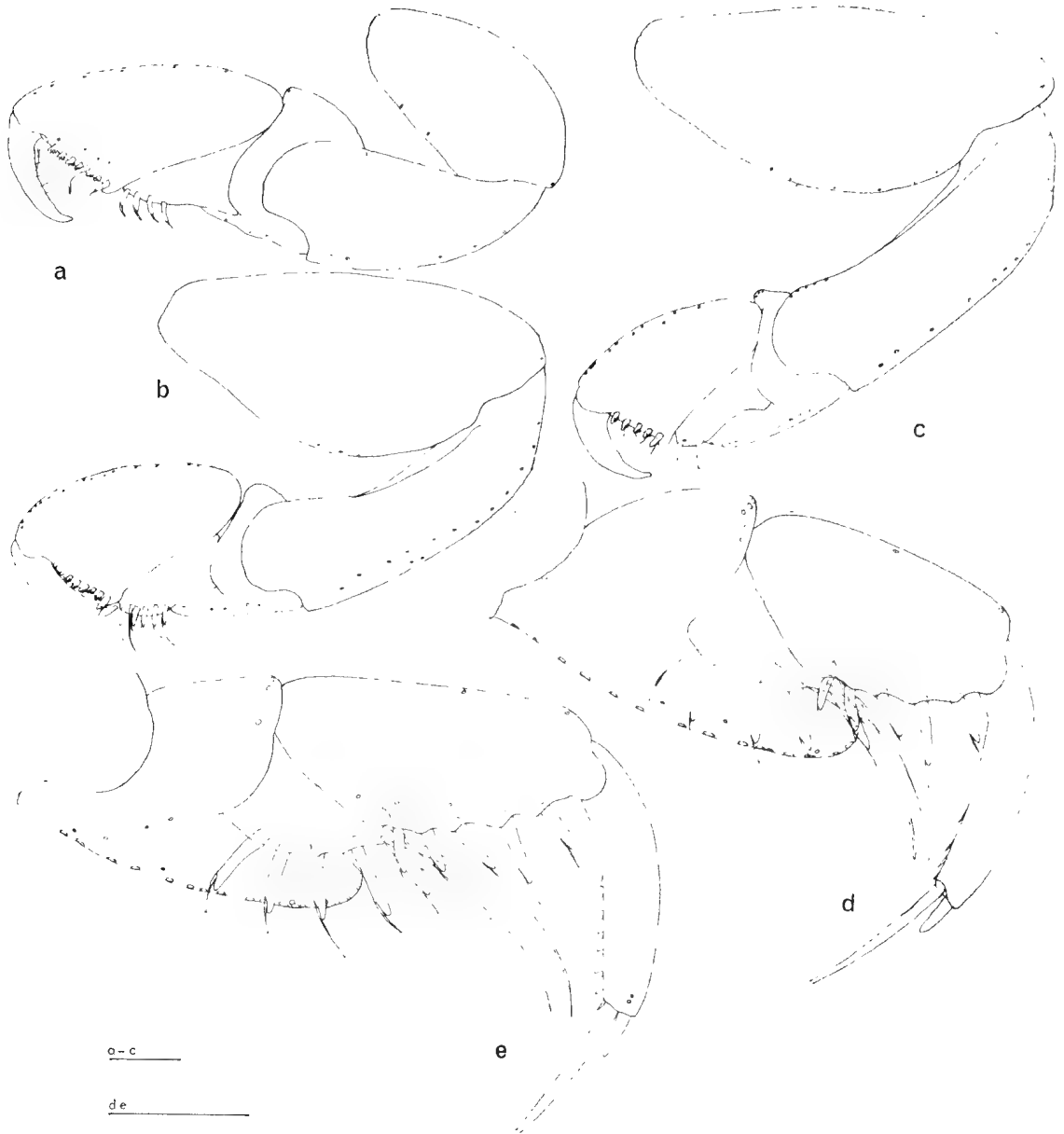


Figure 13—*Ulakanthura colac*. Holotype (QM W7400): a-d, e, pereopods 1-4, 7.

*Material examined*: 5 males, 13 females, 60 juveniles; 7-18 mm.

*Holotype*: QM W7347, juvenile, 14.2 mm.

*Type locality*: QUEENSLAND. Middle Banks, Moreton Bay, clean sand, 9-10 m, collected by S. Cook and S. Newlands for the University of Queensland benthic studies, September 1973.

*Paratypes*:

QUEENSLAND. Middle Banks, Moreton Bay, QUBS samples: QM W6132 (14 specimens), QM W6133 (19).

*Other material*:

QUEENSLAND. Middle Banks, Moreton Bay, QUBS samples: QM W6125 (1 specimen), QM W6130 (9), QM W6131 (16), NMV J496 (4), AM P25385 (14).

*Distribution:* Southern Queensland, clean sand, 9-10 m.

*Remarks:* *Ulakanthura cooma* is a species of restricted distribution distinguished from others in the genus with a cleft uropodal exopod by the splayed, almost truncate telson and the particularly long lobes on articles 4 of pereopods 4-7.

The aboriginal word 'cooma' means a 'sand bank' and indicates the environment from which this species has been taken.

### *Ulakanthura lara* sp. nov.

Figures 16-18

*Description:* Head about as long as greatest width, strongly tapering anteriorly, about  $\frac{3}{4}$  length of pereonite 1; rostrum broadly triangular, about  $\frac{1}{2}$  length of lateral lobes; eyes absent. Pereonite lengths as follows:  $1 < 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with dorsolateral grooves, dorsal pits and paired rows of setae on dorsum of pereonites 4-6. Pleon as long as pereonite 7, pleonites distinct.

Antenna 1 flagellum of 4 articles, about as long as last article of peduncle. Antenna 2 flagellum of 4 setose articles.

Mandible with an acute incisor, palp a single article about  $\frac{1}{2}$  as long as incisor. Maxilla a slender, serrated spine bearing a minutely-hooked keel on its distal inner margin. Maxilliped basis not distinct from head, bearing 6-14 lateral setae (most on larger specimens), 2 ventral setae and 1 dorsal seta distally; maxillipedal palp with a barely-distinct second article, palp about  $\frac{1}{2}$  length of basis, bearing 7 ventral-distal setae and 1 dorsal seta.

Pereopod 1 stout; palm axial-oblique and with a short, broad thumb proximally. Article 5 of pereopod 1 with 4 ventral spines; article 6 with 10 spines laterally along the cutting edge, a stout seta after the fourth spine and another after the last spine. Pereopods 2, 3 stouter than pereopod 1, articles 2 and 6 broader than those of pereopod 1, palm oblique. Article 5 of pereopods 2, 3 with 1 posterior spine; palm of article 6 with a squarish proximal thumb and a row of about 13 spines laterally. Pereopods 4-7 dissimilar to pereopods 1-3, subequal;

posterior spines; article 6 with 6 stout posterior spines; article 7 proximally curved, not tapering, with 1 short and 1 long terminal spine.

Uropodal endopod triangular, setose, about  $\frac{2}{3}$  length of peduncle; exopod broadly lanceolate, without an apical notch. Telson reaching halfway along endopod, dorsally flat-concave, broadest at proximal third and tapering to two short, rounded lobes separated by an apical notch; statocyst opening to a dorsal pore at the base of the telson; 1 pair of simple setae and 1 pair of 'brush-setae' in the terminal notch and many setae dorsally on the telson.

*Male:* Differs from the above description in more elongate pleon; more setose palm of pereopod 1; setose flagellum of antenna 1 with 8 articles reaching back to end of head. Appendix masculinis a simple rod reaching almost to end of outer ramus of pleopod 2.

*Material examined:* 5 males, 22 females, 91 juveniles; 8-16 mm.

*Holotype:* NMV J497, juvenile, 16.0 mm.

*Type locality:* VICTORIA. 3.5 km NE of Point King, South Channel, Port Phillip Bay, PPBES stn 980, sandy sediment, 31 m, 12 October 1971.

#### *Paratypes:*

VICTORIA: Port Phillip Bay, 2-31 m, PPBES stations; stn 967, NMV J498 (3 specimens); stn 973, AM P25386 (2); stn 974, NMV J499, J500 (4); stn 975, AM P25387 (1); stn 980, AM P25388 (1); stn 981, AM P25389 (6); stn 984, NMC J501-J503 (12); stn 986, NMV J504, J505 (10).

Western Port, 9-16 m, 1965 CPBS stations: stn 24N, NMV J447 (3); stn 31E, AM P25377 (1); stn 40E, NMV J448 (2).

#### *Other material:*

VICTORIA: Port Phillip Bay, 4-31 m, PPBES stations, NMV J508: stn 921 (5 specimens); stn 967 (7); stn 973 (10); stn 974 (4); stn 975 (4); stn 979 (2); stn 980 (1); stn 981 (9); stn 984 (4); stn 985 (1); stn 986 (9); stn 1244 (1); stn 1264 (1).

Western Port, 10-14 m, 1964 CPBS stations, NMV J509: stn A6 (2); stn B2 (1); stn B6 (4); stn C5 (1).



Figure 14—*Ulakanthura cooma*. Holotype (QM W7347): a, tail fan; b, c, d, e, pereopods 1, 2, 4, 7.

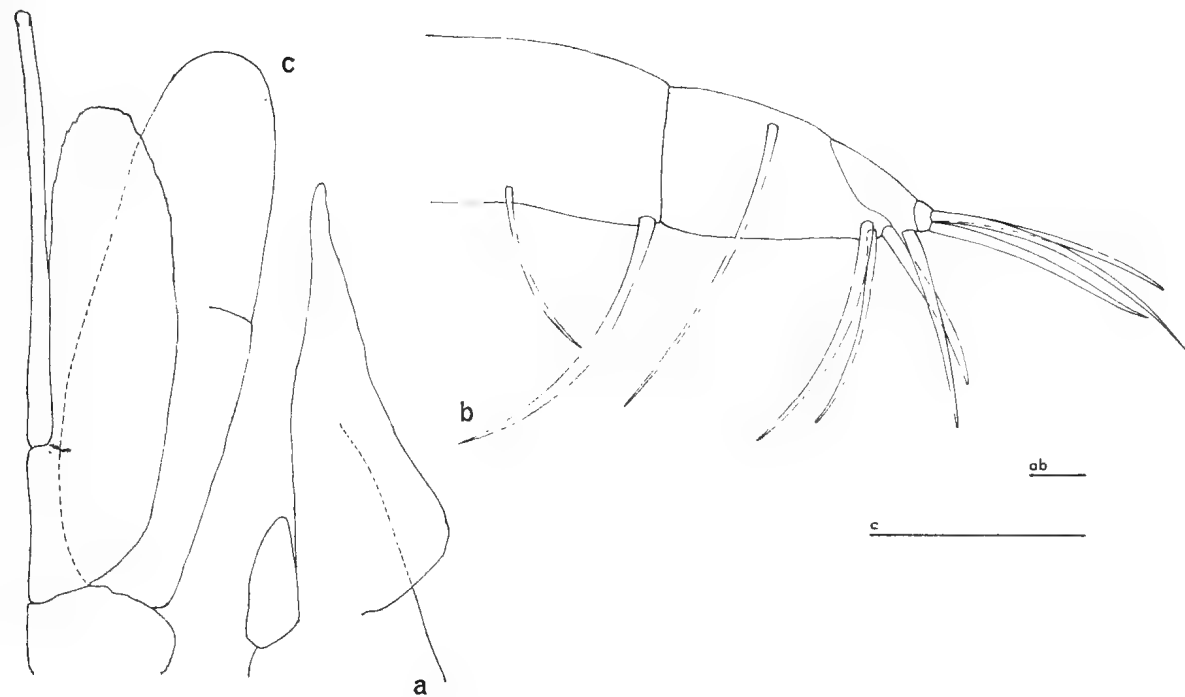


Figure 15—*Ulakanthura cooma*. Holotype (QM W7347): a, mandible; b, maxilliped. Male (QM W6135, MBBS sample): c, pleopod 2.

***Ulakanthura namoo* sp. nov.**

Figures 19, 20

*Description:* Head a little longer than greatest width, tapering slightly anteriorly, about  $\frac{3}{4}$  length of pereonite 1; rostrum triangular; eyes absent. Pereonite lengths as follows:  $1 < 2 = 3 < 4 = 5 = 6 > 7$ . Pereon with obsolete dorsolateral grooves, dorsal pits and paired rows of setae on dorsum of pereonites 4-6. Pleon about as long as pereonite 7, pleonites distinct.

Antenna 1 flagellum of 5 articles, about as long as last 3-4 articles of peduncle. Antenna 2 flagellum of 3 setose articles.

Mandible with an acute incisor, palp a single article about  $\frac{1}{4}$  as long as incisor. Maxilla a slender, serrated spine bearing a minutely-hooked keel on its distal inner margin. Maxilliped basis fused on to head, bearing 2 ventral setae and 5-8 lateral setae; maxillipedal palp with a barely distinct terminal article; palp articles together with 1 dorsal seta and 7 ventral-distal setae.

Pereopod 1 stout; palm axial-oblique and with a broad thumb proximally. Article 5 of

article 4 setose, strongly lobed posteriorly, the lobe reaching to the distal corner of article 5 on pereopod 4 and not quite to this point on pereopod 7; article 5 triangular, bearing 5 stout  
1965 CPBS stations, NMV J510: stn 24S (1); stn 35N (1); stn 36N (1); stn 41N (1); stn 42N (1).

1966-70 CPBS station, NMV J511: stn 32N (1).

*Distribution:* Victoria, well-sorted coarse sandy sediments often with shell, 2-31 m.

*Remarks:* *Ulakanthura lara* is the only species dealt with in this paper endemic to Victoria. The species is very close to *U. wanda* from Moreton Bay but differs in the more oval form of the telson and the length of the appendix masculinis of the male.

The epithet 'lara' is an aboriginal place name from near Port Phillip Bay.

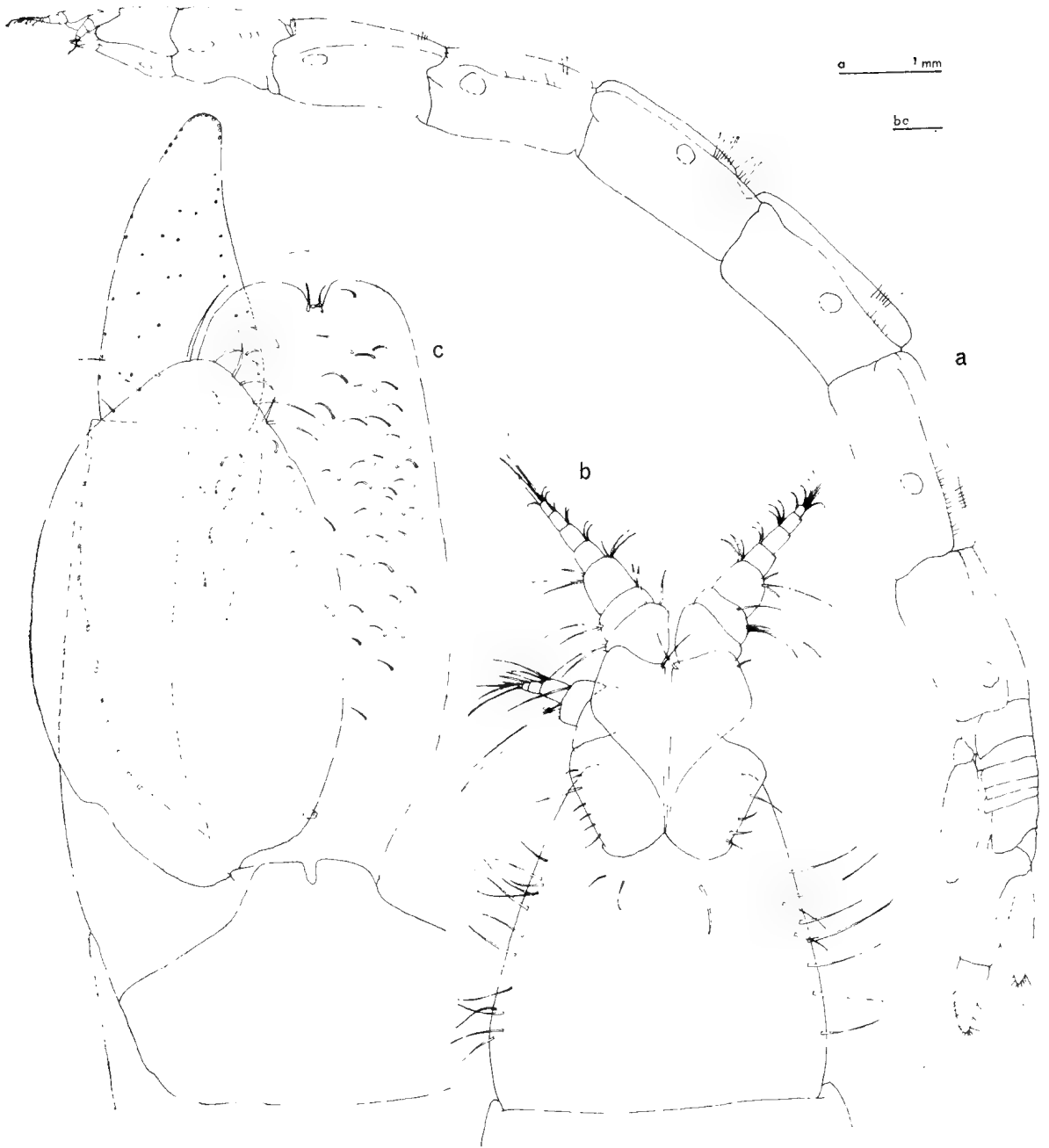


Figure 16—*Ulakanthura lara*. Holotype (NMV J497): a, lateral (limbs omitted); b, head; c, tail fan.

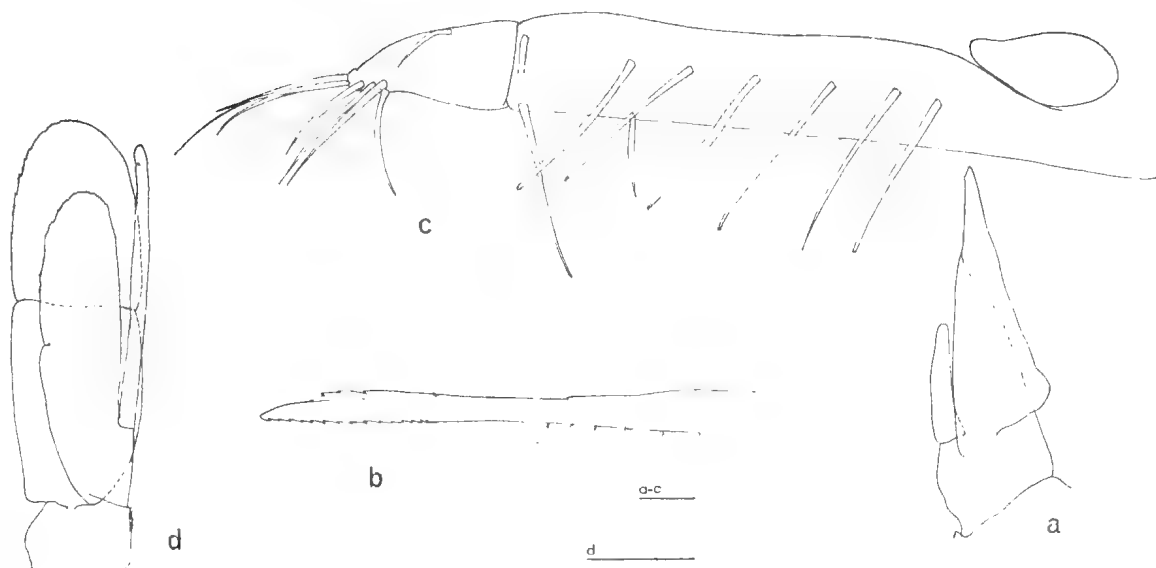


Figure 17—*Ulakanthura lara*. Holotype (NMV J497): a, mandible; b, maxilla; c, maxilliped. Male (NMV J449, PPBES stn 974): d, pleopod 2.

pereopod 1 with 3-5 spines; article 6 with 6-7 spines laterally along the cutting edge, a stout seta after the third or fourth spine and another after the last spine. Pereopods 2, 3 stouter than pereopod 1, article 2 particularly broader than that of pereopod 1, palm oblique. Article 5 of pereopods 2, 3 with 1 posterior spine; palm of article 6 with a proximal thumb and a row of 5-7 spines laterally. Pereopods 4-7 dissimilar to pereopods 1-3, subequal. Article 4 of pereopods 4-7 marginally setose, strongly lobed posteriorly, the lobe reaching distally midway along the posterior margin of article 6 on pereopod 4 and about  $\frac{1}{3}$  along article 6 on pereopod 7; article 5 triangular and with 4-5 strong posterior spines; article 6 with 5-6 stout posterior spines; article 7 barely tapering, with 1 short and 1 long terminal spine.

Uropodal endopod setose, triangular, about twice as long as wide, about  $\frac{2}{3}$  as long as peduncle; exopod lanceolate,  $\frac{1}{2}$  as wide as long, not apically notched, folded over telson. Telson reaching halfway along endopod, dorsally convex, slightly tapering proximally but tip narrowing strongly to two acute lobes separated by a strong apical notch; statocyst opening

by a proximal dorsal pore; 1 pair of simple setae and 1 pair of 'brush-setae' in the terminal notch and several setae dorsally on the telson.

*Male*: Differs from the above description in slightly more elongate pleon; more setose and elongate palm on pereopod 1; setose flagellum on antenna 1 with 12 articles reaching back just beyond the posterior margin of the head. Appendix masculinis a simple rod just exceeding the inner ramus of pleopod 2.

*Material examined*: 17 males, 16 females, 103 juveniles; 7-10 mm.

*Holotype*: QM W7348, juvenile, 9.6 mm.

*Type locality*: QUEENSLAND. Middle Banks, Moreton Bay, clean sand, 9-10 m, collected by S. Cook and S. Newlands for the University of Queensland benthic studies, June 1973.

*Paratypes*:

QUEENSLAND: Middle Banks, Moreton Bay, 9-10 m, QUBS samples: QM W6138 (19 specimens), QM W6140 (20).

*Other material*:

QUEENSLAND: Middle Banks, Moreton Bay, 9-10 m, QUBS samples: QM W6136 (14 specimens), QM W6137 (8), QM W6141 (16), QM W6143 (22), NMV J512 (17), AM P25457 (7).

N.S.W.: Burwood Beach, 3.5 km S. of Hunter

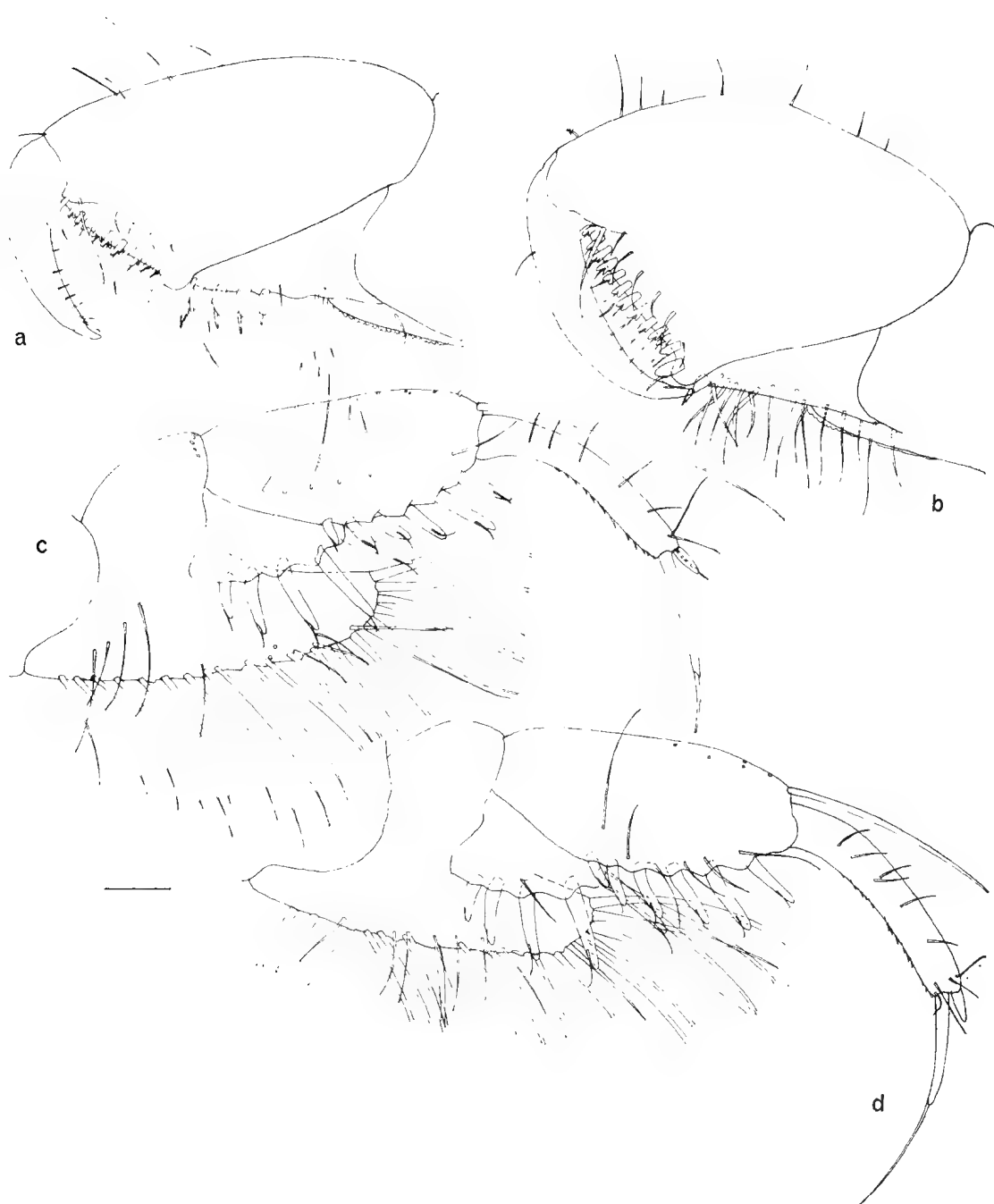


Figure 18—*Ulakanthura lara*. Holotype (NMVJ497): a, b, c, d, pereopods 1, 2, 4, 7.



R., 14-16 m, HDWBS samples: AM P24030-24032 (3 specimens).

Dudley Beach, 4-8 km S. of Hunter R., 10 m, HDWBS sample: AM P24039 (1).

Belmont Beach, 16 km S. of Hunter R., 12-23 m, HDWBS samples: AM P24033-24038 (8).

*Distribution:* Southern Queensland to central New South Wales; clean coarse sand; 9-23 m.

*Remarks:* *Ulakanthura namoo* is a clearly distinguished species recognized by its lanceolate uropodal exopod and by the narrow acute apical lobes on the telson. *U. wanda* and *U. lara* share with *U. namoo* a non-cleft exopod and also have a setose maxilliped basis but differ in the broader exopod and form of the telson.

The aboriginal word 'namoo' means 'sand' and indicates the environment from which this species is taken.

### *Ulakanthura wanda* sp. nov.

Figures 21, 22

*Description:* Head little longer than greatest width, tapering anteriorly, about as long as pereonite 1; rostrum broadly triangular; eyes absent. Pereonite lengths as follows:  $1 < 2 = 3 = 4 < 5 = 6 > 7$ . Pereon with dorso-lateral grooves, dorsal pits and paired rows of setae on dorsum of pereonites 4-6. Pleon about as long as pereonite 7, pleonites distinct.

Antenna 1 flagellum of 3-4 articles, little longer than last article of peduncle. Antenna 2 flagellum of 4 setose articles.

Mandible with an acute incisor, palp a single article, almost  $\frac{1}{2}$  as long as incisor. Maxilla a slender, serrated spine bearing a minutely-hooked keel on its distal inner margin. Maxilliped basis not distinct from head, bearing 2 ventral and 8-10 lateral setae; maxillipedal palp with a barely-distinct terminal article; palp articles together with 1 dorsal seta, 1 lateral seta and 7 ventral-distal setae.

Pereopod 1 stout; palm axial and with a broad thumb proximally. Article 5 of pereopod 1 with 4-5 spines; article 6 with 10-11 spines laterally along the cutting edge, a stout seta after the fourth spine and another after the last spine. Pereopods 2, 3 stouter than pereopod

1, articles 2 and 6 especially broader than those of pereopod 1; palm oblique. Article 5 of pereopods 2, 3 with 1 posterior spine; palm of article 6 with a proximal thumb and row of 12 spines laterally. Pereopods 4-7 dissimilar to pereopods 1-3, subequal. Article 4 of pereopods 4-7 setose, strongly lobed posteriorly, the lobe reaching about  $\frac{1}{3}$  way along the posterior margin of article 6 on pereopod 4 and just beyond end of article 5 on pereopod 7; article 5 triangular, with 4-5 strong posterior spines; article 6 with 6-7 stout posterior spines, article 7 barely tapering, with 1 short and 1 long spine terminally.

Uropodal endopod setose, triangular, almost 3 times as long as wide, about  $\frac{2}{3}$  as long as peduncle; exopod broad (about  $\frac{2}{3}$  as wide as long), not apically notched, folded over telson. Telson reaching almost halfway along endopod, dorsally concave, more or less parallel-sided, terminally two rounded lobes separated by a strong apical notch; statocyst opening by a proximal dorsal pore; 1 pair of simple setae and 1 pair of 'brush-setae' in the terminal notch and many setae on the dorsal surface of telson.

*Male:* Differs from the above description in more elongate pleon; more setose and more elongate palm on pereopod 1; setose flagellum of antenna 1 with 11-14 articles reaching back to middle of pereonite 1; appendix masculinis a simple rod exceeding the inner ramus of pleopod 2 by about  $\frac{1}{3}$  its length and exceeding the outer ramus.

*Material examined:* 4 males, 3 females, 12 juveniles; 7-11 mm.

*Holotype:* QM W6124, juvenile, 10.7 mm.

*Type locality:* QUEENSLAND. Middle Banks, Moreton Bay, clean sand, 9-10 m, collected by S. Cook and S. Newlands for the University of Queensland Moreton Bay benthic studies, December 1973.

*Paratypes:*

QUEENSLAND: Middle Banks, Moreton Bay, 9-10 m, QUBS samples: QM W6135 (1 specimen), QM W6139 (1), QM W7349 (5).

*Other material:*

QUEENSLAND: Middle Banks, Moreton Bay,

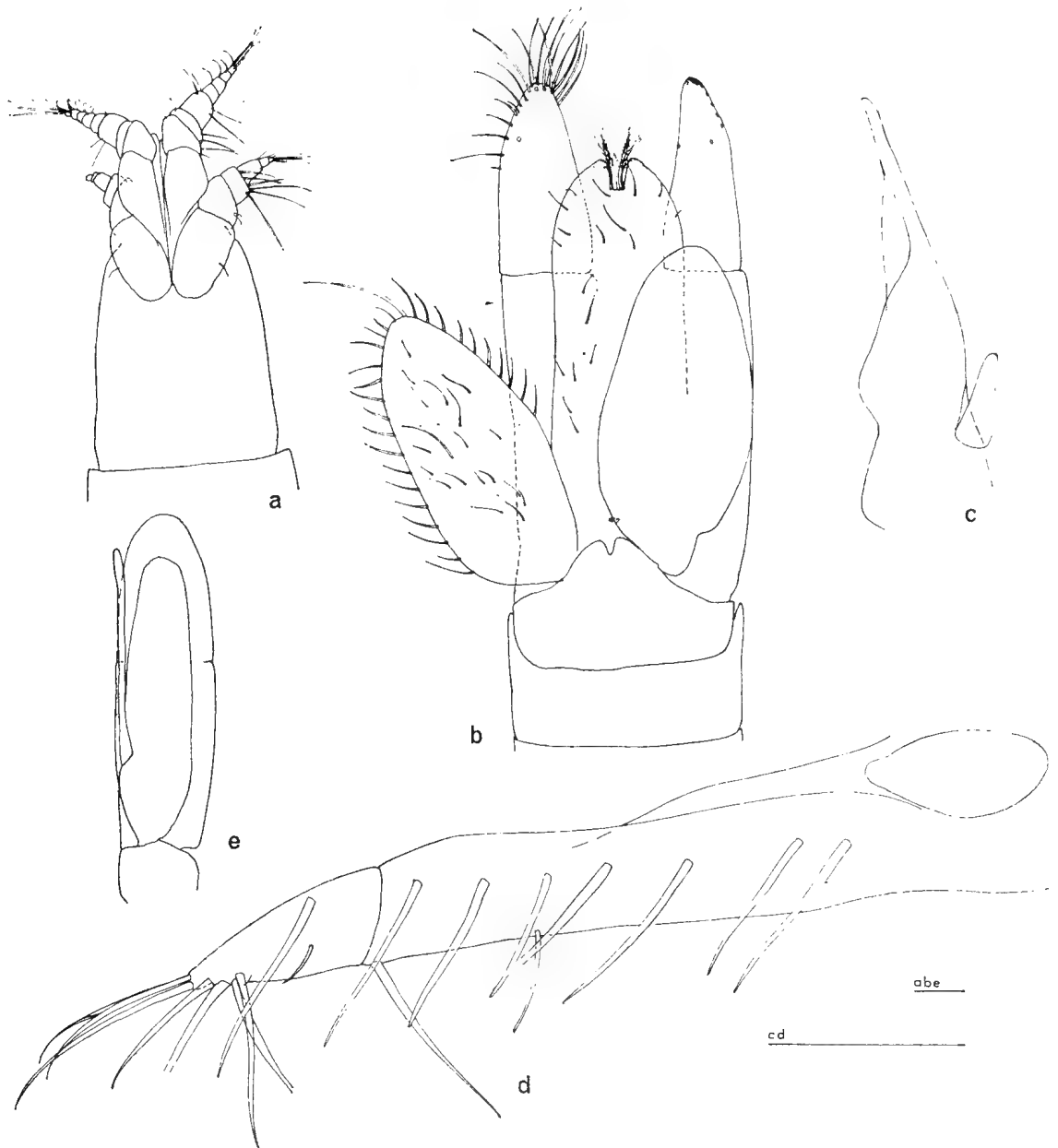


Figure 19—*Ulakanthura namoo*. Holotype (QM W7348): a, head; b, tail fan; c, mandible; d, maxilliped. Male (QM W6140, QUBS sample): e, pleopod 2.

9-10 m, QUBS samples: QM W7351 (3 specimens), AM P25458 (4 specimens), NMV J513 (4).

*Distribution:* Southern Queensland, clean sand, 9-10 m.

*Remarks:* This species is closest to *U. lara* from Victoria differing in the form of the telson and length of the appendix masculinis of the male.

The aboriginal word 'wanda' means 'sand hills'.

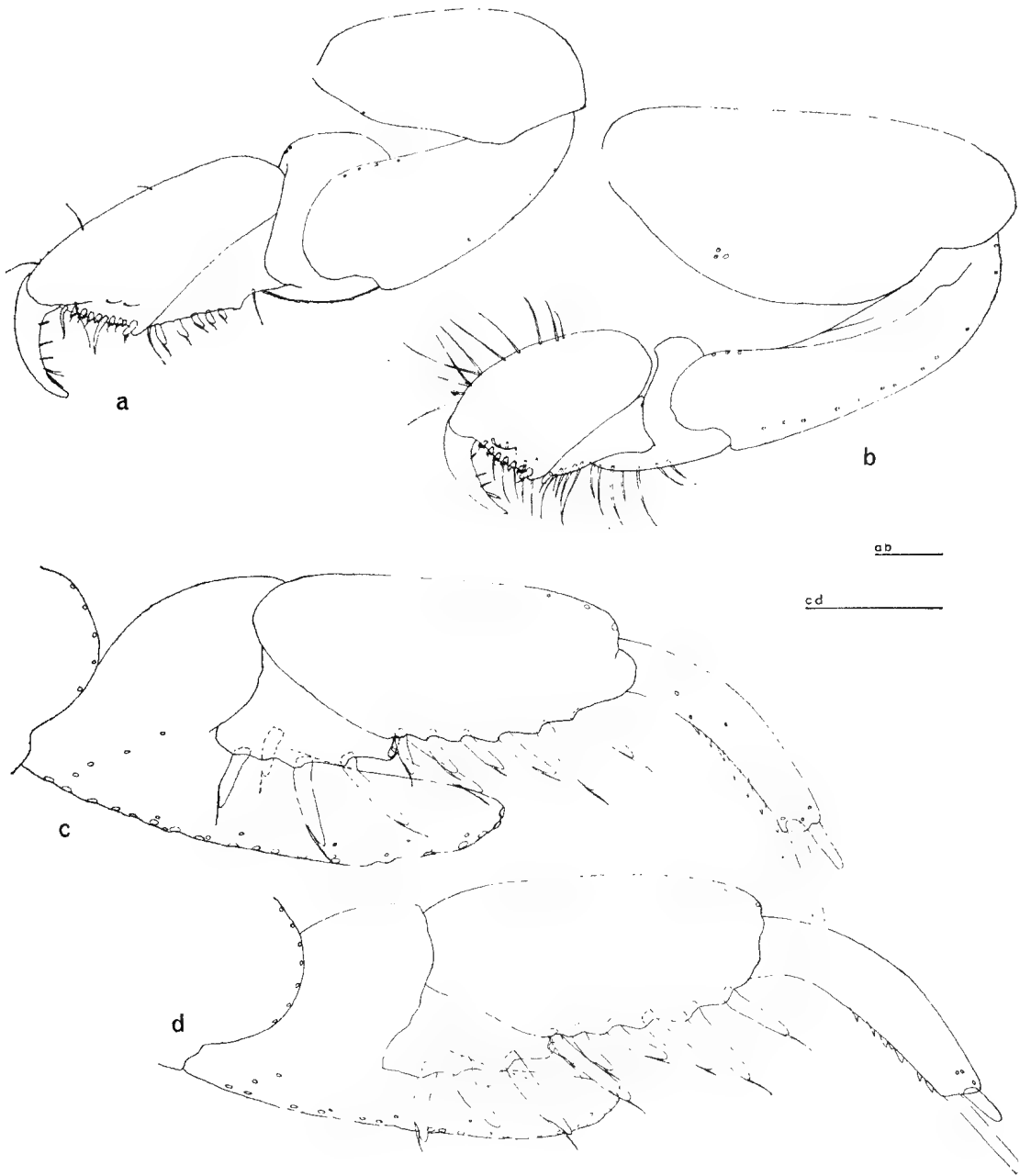


Figure 20—*Ulakanthura namoo*. Holotype (QM W7348): a, b, c, d, pereopods 1, 2, 4, 7.



Figure 21—*Ulakanthura wanda*. Holotype (QM W6124): a, tail fan; b, mandible; c, pereopod 1. Male (QM W6135, QUBS sample): d, maxilliped; e, pleopod 2.

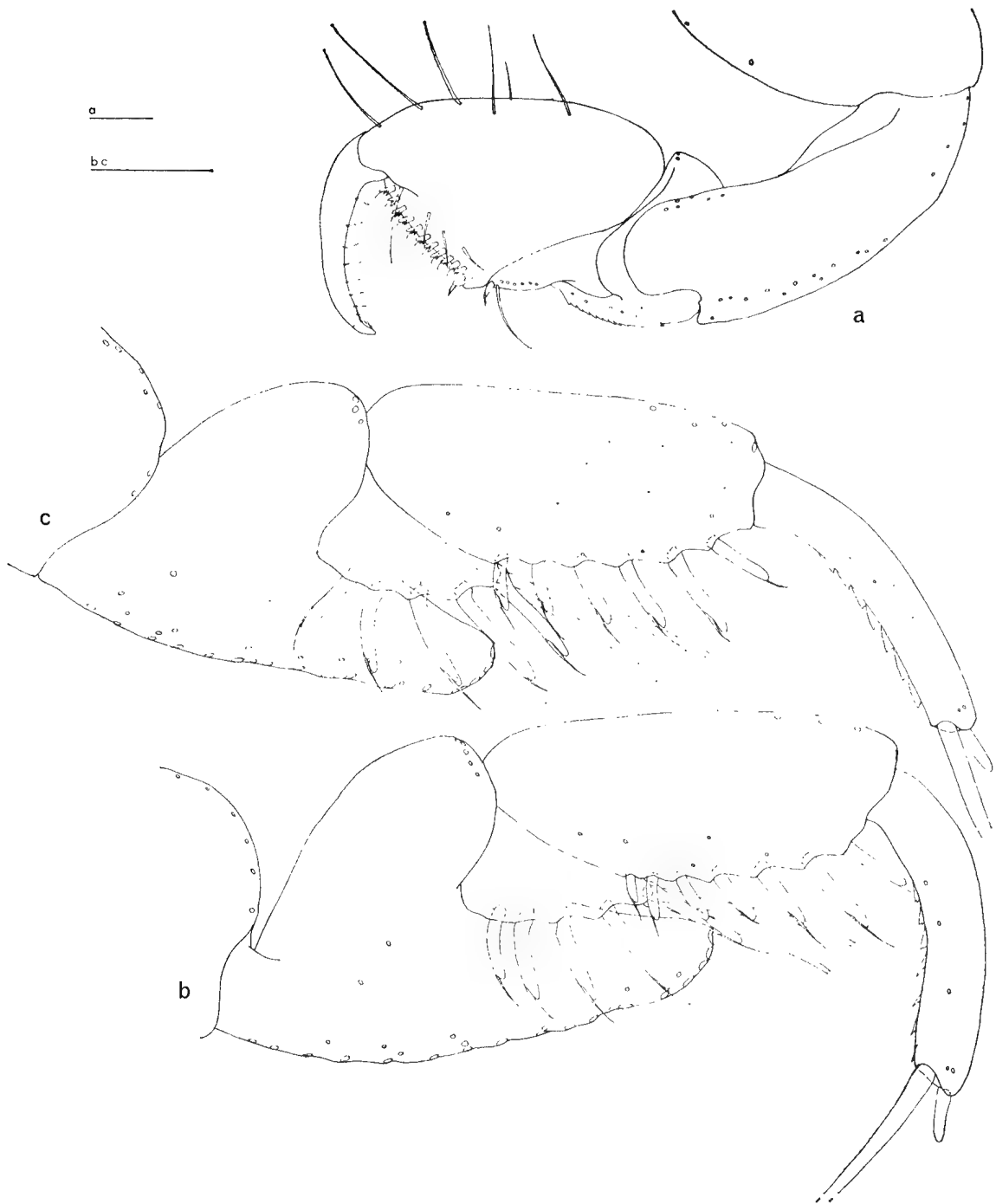


Figure 22—*Ulakanthura wanda*. Holotype (QM W6124): a, b, c, pereopods 2, 4, 7.

## NOMEN DUBIUM

*Paranthura australis* Haswell

*Paranthura australis* Haswell 1881: 477-8, pl. 18, fig. 4.—Haswell, 1882: 304-5.

*Leptanthura australis*. — Barnard, 1925: 151. —Nierstrasz, 1941: 242 (part).

not *Paranthura australis*. Miers, 1884: 311. Haswell, 1884: 1012 (= *Apanthura cop-pingeri* Barnard, 1925).

*Remarks:* Haswell (1881) described and illustrated an anthuridean from Port Jackson in very general terms. None of the characters described by Haswell is sufficiently diagnostic to allow the name to be applied to any presently known species. Moreover, two specimens (AM P3315) in the Old Collection of the Australian Museum labelled '*Paranthura australis*, Hasw Variety 524 Port Jackson' cannot be reconciled with Haswell's description and figures. Both are males, probably of the genus *Paranthura*. Haswell did not designate types (Barnard, 1974) although many of the specimens examined by him remain in the Australian Museum collections. It appears that AM P3315 was allocated to *P. australis* (Number 524 in Haswell's (1882) catalogue) in error at a later date.

The name *Paranthura australis* Haswell is therefore nomen dubium, not certainly applicable to any known taxon.

## Discussion

*Leptanthura*, *Bullowanthura*, *Ulakanthura*, and possibly the monotypic genus *Neoanthura*, are separated from the remaining paranthurids by possessing a triangular article 5 on pereopods 4-7. They also share loss of eyes, some reduction of the mandibular palp, and consistent form of the maxilliped. A review of paranthurid genera in preparation by me shows that the group forms one of the major divisions of the family.

It is noteworthy that southeastern Australia is a centre of distribution for this group of genera. *Leptanthura* now includes about 19 species mostly from bathyal regions. Three species are recorded here from Australia, two from sublittoral environments (less than 200 m). The monotypic genus *Bullowanthura* is

endemic to the region as are all species of *Ulakanthura*. The latter genus is particularly significant in illustrating once again the high degree of speciation found in marine peracarids from southern Australia. Previously I have described ten species of *Haliophasma* (Anthuridae) from southern Queensland, New South Wales and Victoria (Poore, 1975) and Barnard (1972) has discussed at length adaptive radiation in Australian gammaridean amphipods.

The total endemicity of this fauna at the species level and endemicity of two of the three genera makes discussion of its biogeographical relationships difficult. The closest relatives of Australian species of *Leptanthura* seem to be South African species which is unusual for the southeastern Australian fauna. Better appreciation of the origins of these species may be obtained by greater knowledge of the deep-sea isopods of the region.

## Acknowledgements

I wish to thank the following individuals and institutions for the loan of the material on which this study was based: Diane Brown, Helen Fisher and Jim Lowry from the Australian Museum, Sydney; Ronald Monroe from the Queensland Museum, Brisbane; Stephen Cook from the Department of Zoology, University of Queensland; and Margaret Drummond from the Marine Studies Group, Victoria.

I gratefully acknowledge the valuable comments of Brian Kensley from the South African Museum on the first draft of this paper.

This paper is number 167 in the Ministry for Conservation, Victoria, Environmental Studies Series.

## References

- BARNARD, J. L., 1972. Gammaridean Amphipoda of Australia, Part I. *Smithson. Contr. Zool.* 103: 1-333.
- , 1974. Gammaridean Amphipoda of Australia, Part II. *Smithson. Contr. Zool.* 139: 1-148.
- BARNARD, K. H., 1925. A revision of the family Anthuridae (Crustacea Isopoda), with remarks on certain morphological peculiarities. *J. Linn. Soc.* 36: 109-160.

- BIRSTEIN, Y. A., 1963. 'Deepsea Isopods from the North-western Pacific.' [In Russian], p. 214. Akademii Nauk, USSR: Moscow.
- HASWELL, W. A., 1881. On some new Australian marine Isopoda. Part I. *Proc. Linn. Soc. N.S.W.* 5: 471-481.
- , 1882. 'Catalogue of the Australian Stalk- and Sessile-eyed Crustacea.' p. xxiv, 326. Australian Museum: Sydney.
- , 1884. A revision of the Australian Isopoda. *Proc. Linn. Soc. N.S.W.* 9: 1001-1014.
- KENSLEY, B., 1975. Marine Isopoda from the continental shelf of South Africa. *Ann. S. Afr. Mus.* 67: 35-89.
- MENZIES, R. J., 1962. The isopods of abyssal depths in the Atlantic Ocean. *Vema Res. Ser.* 1: 79-206.
- MIERS, E. J., 1884. Crustacea. p. 178-322 in 'Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. 'Alert', 1881-2.' Brit. Mus. (Nat. Hist.): London.
- NIERSTRASZ, H. F., 1941. Die Isopoden der Siboga-Expedition. IV. Isopoda Genuina. III. Gnathii-  
dea, Anthuridea, Valvifera, Asellota, Phreati-  
coidea. *Siboga Exped.* 32d: 235-308.
- POORE, G. C. B., 1975. Australian species of *Haliophasma* (Crustacea: Isopoda: Anthuridae). *Rec. Aus. Mus.* 29: 503-533.
- SARS, G. O., 1899. 'An Account of the Crustacea of Norway. Vol. II. Isopoda.' p. x, 270. Bergen Museum: Bergen.
- STEBBING, T. R. R., 1905. On the Isopoda. *Rept Govt Ceylon Pearl Oyster Fisheries Gulf Manaar, Part 4, Suppl. Rept* 23: 1-64.
- WOLFF, T., 1956. Isopoda from depths exceeding 6000 metres. *Galathea Rep.* 2: 85-159.





# THE SPIONIDAE (POLYCHAETA) FROM SOUTHEASTERN AUSTRALIA AND ADJACENT AREAS WITH A REVISION OF THE GENERA<sup>1</sup>

By JAMES A. BLAKE

Pacific Marine Station, University of the Pacific, Dillon Beach, California, USA 94929.

and JERRY D. KUDENOV

Ministry for Conservation, Marine Studies Group  
605 Flinders Street Extension, Melbourne, Victoria, Australia 3000.

## Abstract

The Spionidae of southeastern Australia are described. Intertidal and subtidal collections come mostly from Victoria, New South Wales and southern Queensland. A few records from West Australia, South Australia, Tasmania and the Great Barrier Reef (Queensland) are also included.

A total of 68 species in 19 genera have been identified. These include 4 new genera and 43 new species, with new synonyms and generic emendations also proposed.

The genera with pointed prostomia include *Scolecopsis* (9 species, 8 being new), *Aonides* (1 species) and *Dispio* (1 new species). *Australospio trifida* gen. et. sp. nov. is a unique spionid with both a distally pointed prostomium and lateral prostomial horns. The genera with frontal or lateral prostomial horns include *Malacoceros* (3 species, 2 being new), *Rhynchospio* (2 new species) and *Scolecopides* (1 new species). The definition of *Rhynchospio* is expanded to include those species with branchiae free from dorsal lamellae. *Laonice* includes 3 new species, with 1 being a simultaneous hermaphrodite. *Spiophanes* includes 3 species, *Spio* with 3 species (2 being new) and *Microspio* with 1 new species.

The genera of the *Prionospio*-complex are reviewed and revised to include: *Paraprionospio* (1 species), *Orthoprionospio* gen. nov. (1 new species), *Streblospio* (not represented) and *Prionospio* (9 species, 5 being new).

A generic revision of the *Polydora*-complex is presented with 6 genera recognized: *Boccardia* (3 species), *Carazziella* gen. nov. (4 new species), *Polydora* (15 species, 8 being new), *Boccardiella* gen. nov. (2 species, 1 being new), *Tripolydora* (not represented) and *Pseudopolydora* (5 species, 2 being new). *Polydorella* is synonymized with *Pseudopolydora*.

Approximately  $\frac{2}{3}$  of the species reported herein are endemic to Australia; the remainder are species with more cosmopolitan distributions.

## Introduction

The Spionidae is one of the largest and most common of the polychaete families encountered in intertidal and shallow subtidal habitats throughout the world. Species are typically marine bottom deposit feeders which occur in all types of substrata, from soft muds to hard calcareous structures. Important systematic treatments of the family or of certain genera are by Mesnil (1896), Söderström (1920), Fauvel (1927), Hartman (1941), Pettibone (1962; 1963), Woodwick (1964), Day (1967), Foster (1971), Blake (1971), Blake and Woodwick (1971-72), Rainer (1973), Read (1975) and Light (1977; 1978).

<sup>1</sup>Contribution No. 178 from the Ministry for Conservation, Melbourne, Victoria.

Despite the voluminous global literature on spionids and the large number of species known to occur along some coastlines, there is very little information on Australian spionids. A review of the literature reveals only 4 species which were originally described from Australia. These are *Polydorella prolifera* Augener, 1914 and *Spio mesnili* Augener, 1914 from West Australia, *Polydora polybranchia* Haswell, 1885 (now *Boccardia*) from New South Wales and *Boccardia limnicola* Blake and Woodwick, 1976 from Victoria. In the southeastern region of Australia few species have been identified below the generic level. Haswell (1885) reported *Polydora ciliata* from commercial oysters in New South Wales, Augener (1927) reported *Spiophanes kroeyeri* from Victoria and Monro (1931) reported *Sco-*

*lelepis* (= *Malacoceros*) *indicus* from Queensland. Several genera have been recorded by Hutchings and Recher (1974) from New South Wales and by Poore, *et al.* (1975) from Victoria, but species names were generally not assigned. There are no published records at all from Tasmania or South Australia.

The purpose of the present paper is to describe a new and highly endemic spionid fauna from southeastern Australia. As defined herein, southeastern Australia includes southern Queensland from Moreton Bay and Brisbane, all of New South Wales and Victoria, eastern South Australia and Tasmania.

### Materials and Methods

Specimens have been accumulated from several sources. Extensive Victorian material comes from the Port Phillip Bay and Westernport Bay Environmental Surveys (PPBES, WPBES) performed by the Marine Studies Group (MSG) of the Ministry for Conservation. Location of MSG stations plus additional data are given by Poore, *et al.* (1975), Poore and Kudenov (1978 a-b) and Coleman, *et al.* (1978). Additional specimens from the Fisheries and Wildlife Crib Point Benthic Survey (CPBS) in Westernport were also examined. These materials are deposited in the National Museum of Victoria (NMV). Other Victorian materials include NMV collections obtained through Dr Brian Smith, Westernport epifauna collected by Mr Dave Staples and specimens from various localities along the Victorian coast collected by us. Spionidae in the Australian Museum, Sydney (AM) were loaned by Dr P. A. Hutchings. Queensland benthic spionids from Moreton Bay were loaned by Dr W. Stephenson. Some of these specimens are deposited in the Queensland Museum (QM). Spionids from the New South Wales State Fisheries (NSWSF) were provided by Ms M. Skeel from shellfish surveys and through Dr Leon Collett from benthic surveys of Botany Bay. Mr C. Pregonzer (University of New South Wales) loaned specimens he had collected from shellfish. Mr R. Buttermore and M. Skeel provided specimens from Tasmania, which are now lodged in the Tasmanian Museum (TM). Mr W. Zeidler, South Australian Museum (SAM), kindly allowed the second

author access to their collections during August 1977. Dr G. Hartmann-Schröder provided Augener type materials from the Zoological Museum of Hamburg (ZMH). Dr Marian H. Pettibone loaned comparative specimens from the collections of the National Museum of Natural History, Washington, D.C. (USNM).

Since the materials examined in the present study were obtained from various sources, there is little uniformity in mode of collection and preservation. Specimens collected by us or in collections of the MSG were fixed in 10% formalin or Bouin's fluid and preserved in 70% ETOH to which glycerine had been added. Type material has been deposited in the NMV, AM and QM.

We are grateful to the administration of the Marine Pollution Studies Group (Ministry for Conservation) for providing facilities and space to the first author during his stay in Melbourne in 1977. We are also grateful to MSG for financial support for this paper. The first author was supported by a sabbatical leave from University of the Pacific and by 2 grants from the National Science Foundation [NSF Grant Int76-11756 from the US-Australia Co-operative Science Programme and NSF Grant GA-30900 from the Biological Oceanography Section]. To these agencies, and to people who loaned or obtained materials on which this study is based, we extend our gratitude. A special debt of gratitude is extended to William J. Light, Oakland Museum, for critically reviewing the manuscript, sharing his thoughts on many aspects of this study with the first author and by generously allowing us to use some of his unpublished observations.

### Family Spionidae Grube, 1850

*Diagnosis:* Prostomium variable: anteriorly rounded or incised, anteriorly expanded to acutely pointed, with or without frontal horns. Occipital tentacle sometimes present on prostomial caruncle. A pair of long prehensile peristomial palps arising on either side of caruncle near junction of peristomium and setiger 1. Setiger 1 reduced to well-developed, often fused with peristomium. Parapodia biramous, with parapodial lobes conical, cirriform or foliose; posterior neuropodia often form low

ridges. Setae simple, including capillaries, acicular spines, modified setae (major spines of polydorids) and unidentate to multidentate hooded or non-hooded hooks. Branchiae present or absent over a variable number of segments. Pygidium reduced to well-developed, with or without cirri, or expanded into disc-like structure or forming several lobes.

The following genera and species are covered in this report.

1. *Scolecopsis lamellicincta* sp. nov.
2. *S. carunculata* sp. nov.
3. *S. phyllobranchia* sp. nov.
4. *S. occipitalis* sp. nov.
5. *S. towra* sp. nov.
6. *S. precirriseta* sp. nov.
7. *S.* sp.
8. *S. viridis* sp. nov.
9. *S. victoriensis* sp. nov.
10. *Aonides oxycephala* (Sars, 1862)
11. *Dispio glabrilamellata* sp. nov.
12. *Australospio trifida* gen. et. sp. nov.
13. *Malacoceros indicus* (Fauvel, 1928)
14. *M. tripartitus* sp. nov.
15. *M. reductus* sp. nov.
16. *Rhynchospio glycera* sp. nov.
17. *R. australiana* sp. nov.
18. *Scolecopides aciculatus* sp. nov.
19. *Laonice quadridentata* sp. nov.
20. *L. hermaphroditica* sp. nov.
21. *L. bassensis* sp. nov.
22. *Paraprionospio pinnata* (Ehlers, 1901)
23. *Orthoprionospio cirriformia* gen. et sp. nov.
24. *Prionospio steenstrupi* Malmgren, 1867
25. *P. australiensis* sp. nov.
26. *P. queenslandica* sp. nov.
27. *P. ehlersi* Fauvel, 1928.
28. *P. paucipinnulata* sp. nov.
29. *P. tridentata* sp. nov.
30. *P. multipinnulata* sp. nov.
31. *P. aucklandica* Augener, 1923
32. *P. cirrifera* Wirén, 1883
33. *Spiophanes bombyx* (Claparède, 1870)
34. *S.* cf. *Kroeyeri* Grube, 1860
35. *S. wigleyi* Pettibone, 1962
36. *Spio mesnili* Augener, 1914
37. *S. pacifica* sp. nov.
38. *S. singularis* sp. nov.
39. *Microspio granulata* sp. nov.

40. *Boccardia polybranchia* (Haswell, 1885)
41. *B. proboscidea* Hartman, 1940
42. *B. chilensis* Blake and Woodwick, 1971
43. *Carazziella victoriensis* gen. et. sp. nov.
44. *C. phillipensis* sp. nov.
45. *C. hymenobranchiata* sp. nov.
46. *C. hirsutiseta* sp. nov.
47. *Polydora flava* Claparède, 1870
48. *P. socialis* (Schmarda, 1861)
49. *P. protuberata* sp. nov.
50. *P. tentaculata* sp. nov.
51. *P. giardi* Mesnil, 1896
52. *P. aciculata* sp. nov.
53. *P. notialis* sp. nov.
54. *P. pilocollaris* sp. nov.
55. *P. armata* Langerhans, 1880
56. *P. ligni* Webster, 1879
57. *P. websteri* Hartman, 1943
58. *P. haswelli* sp. nov.
59. *P. latispinosa* sp. nov.
60. *P. woodwicki* sp. nov.
61. *P. hoplura* Claparède, 1870
62. *Boccardiella bihamata* gen. et. sp. nov.
63. *B. limnicola* (Blake and Woodwick, 1976) comb. nov.
64. *Pseudopolydora paucibranchiata* (Okuda, 1937)
65. *P. kempfi* (Southern, 1921)
66. *P. glandulosa* sp. nov.
67. *P. stolonifera* sp. nov.
68. *P. prolifera* (Augener, 1914) comb. nov.

## KEY TO GENERA OF SPIONIDAE

(\* denotes genera not yet found in Australia)

- 1a. Branchiae absent; setiger 1 with 1-2 large curved neuropodial spines in addition to normal capillaries . . . . . *Spiophanes* (p. 224)
- b. Branchiae present; setiger 1 without large neuropodial spines . . . . . 2
- 2a. Setiger 5 modified, with specialized setae . . . . . 18
- b. Setiger 5 not modified, without specialized setae . . . . . 3
- 3a. Prostomium distally pointed (may appear conical with rounded apex in extremely contracted specimens), with or without subdistal lateral horns . . . . . 4

- b. Prostomium not distally pointed, with distal lateral or frontal horns, broadly rounded or incised on anterior margin . . . . . 7
- 4a. Branchiae beginning on setiger 1 . . . . . 5
- b. Branchiae beginning on setiger 2 . . . . . 6
- 5a. Prostomium with extra subdistal lateral horns in addition to apical point, appearing 3-parted; setigers 6-9 with dense setal fascicles; notosetae of setiger 1 similar in length to those of succeeding setigers; accessory branchiae absent . . . . . *Australospio* (p. 193)
- b. Prostomium without extra lateral horns; setigers 6-9 without dense setal fascicles; notosetae of setiger 1 long, thin; accessory branchiae present . . . . . *Dispio* (p. 191)
- 6a. Branchiae fused to dorsal lamellae at least basally, continuing to end of body . . . . . *Scolecopsis* (p. 175)
- b. Branchiae completely free from dorsal lamellae, present on variable number of anterior setigers, absent posteriorly . . . . . *Aonides* (p. 189)
- 7a. Prostomium with lateral or frontal horns . . . . . 8
- b. Prostomium without lateral or frontal horns . . . . . 10
- 8a. Branchiae beginning on setiger 1 . . . . . 9
- b. Branchiae beginning on setiger 2 . . . . . *Rhynchospio* (p. 198)
- 9a. Hooded hooks in both noto- and neuropodia of posterior segments . . . . . *Scolecopides* (p. 202)
- b. Hooded hooks only in neuropodia of posterior segments . . . . . *Malacoceros* (p. 195)
- 10a. Branchiae limited to middle and posterior setigers except for a single pair on setiger 2 in males . . . . . *\*Pygospio*
- b. Branchiae beginning on setiger 1 or 2 and continuing for a variable number of setigers . . . . . 11
- 11a. Branchiae concentrated in 1-22 anterior setigers, absent posteriorly . . . . . 12
- b. Branchiae present over most of body length . . . . . 15
- 12a. Branchiae beginning on setiger 1 . . . . . 13
- b. Branchiae beginning on setiger 2 . . . . . *Prionospio* (p. 211)
- 13a. One pair of cirriform branchiae; with dorsal collar across setiger 2 . . . . . *\*Streblospio*
- b. Three or more pairs of branchiae; no dorsal collar on setiger 2 . . . . . 14
- 14a. Three pairs of pinnate branchiae; with dorsal ridge across setiger 1 . . . . . *Paraprionospio* (p. 209)
- b. Eighteen to 22 pairs of cirriform branchiae; no dorsal ridge on setiger 1 . . . . . *Orthoprionospio* (p. 210)
- 15a. Branchiae beginning on setiger 1 . . . . . 16
- b. Branchiae beginning on setiger 2 . . . . . 17
- 16a. Hooks in both noto- and neuropodia . . . . . *\*Marenzelleria*
- b. Hooded hooks only in neuropodia . . . . . *Spio* (p. 226)
- 17a. Prostomium broad, bluntly rounded or squared on anterior margin; branchiae free from dorsal lamellae . . . . . *Laonice* (p. 204)
- b. Prostomium narrow, entire or incised on anterior margin; branchiae fused to dorsal lamellae . . . . . *Microspio* (p. 232)
- 18a. Branchiae beginning on setiger 2 . . . . . 19
- b. Branchiae beginning on setigers 6-12 . 21
- 19a. Setiger 5 only slightly modified, with prominent parapodia, major spines of 1 type; hooded hooks tridentate, with secondary teeth closely applied to main fang . . . . . *\*Tripolydora*
- b. Setiger 5 greatly modified, with reduced parapodia and major spines of 2 types or 1 type with companion setae; hooded hooks bidentate with prominent angle between teeth . . . . . 20<sup>1</sup>
- <sup>1</sup> *Polydora guillei* Laubier and Ramos, 1974 bears unidentate unhooded neuropodial hooks and does not agree with any known polydorid genus. See Remarks p. 234.
- 20a. Major spines of setiger 5 of 1 type, these simple, falcate, with smaller companion setae . . . . . *Boccardiella* (p. 264)

b. Major spines of setiger 5 of 2 types, first with expanded ends bearing cusps or bristles, second simple, falcate. . . . . *Boccardia* (p. 235)

21a. Setiger 5 slightly to moderately modified, usually with prominent parapodia; major spines of 2 types, first simple, acicular or falcate, second pennoned with both types usually arranged in U- or J-shaped row; hooded hooks with secondary tooth closely applied to main fang . . . . . *Pseudopolydora*<sup>2</sup> (p. 267)

<sup>2</sup> *Pseudopolydora gibbsi* Light, 1974 and *P. stolonifera* (this study) deviate somewhat from the generic definition in having more modification to setiger 5 than usually seen in more typical *Pseudopolydora* species. The hooded hooks are typical.

b. Setiger 5 greatly modified, with reduced parapodia; major spines of 1 or 2 types in curved row, not J- or U-shaped; hooded hooks with prominent angle between teeth. . . . . 22

22a. Setiger 5 spines of 1 type, variously shaped, with or without companion setae. . . . . *Polydora* (p. 245)

b. Setiger 5 spines of 2 types, first type with expanded end, second type falcate, 1 or both types usually with bristles. . . . . *Carazziella* (p. 240)

### Genus *Scolecopsis* Blainville, 1828

*Scolecopsis* Blainville, 1828. *Type-species*: *Lumbricus squamatus* Müller, 1806, by monotypy.

*Aonis* Audouin and Milne-Edwards, 1833. *Type-species*: *Aonis foliosa* Audouin and Milne-Edwards, 1833, by monotypy.

*Nerine* Johnston, 1838. *Type-species*: *N. coniocephala* Johnston, 1838, selected by Quatrefages 1843 (= *Oonis foliosa*).

*Pseudomalacoceros* Czerniavsky, 1881. *Type-species*: *Malacoceros longirostris* Quatrefages, 1843 (= *Lumbricus squamatus*), by monotypy.

*Nerinides* Mesnil, 1896. *Type-species*: *Nerine longirostris* Saint-Joseph, 1894 (= *Nerinides cantabra* Rioja, 1918), by original designation.

*Scolecopsis* Michaelsen, 1897. Erroneous spelling of *Scolecopsis* Blainville, 1828. [Not Malmgren, 1867].

*Pseudonerine* Augener, 1926. *Type-species*: *P. antipoda* Augener, 1926, by monotypy.

[Synonymy *vide* Pettibone, 1963, p. 91].<sup>1</sup>

<sup>1</sup> Fauchald (1977a) has erroneously cited *Nerinides cantabra* Rioja, 1918, as the type-species of *Pseudo-*

*malacoceros* Czerniavsky, 1881, and has replaced *Nerinides* with *Pseudomalacoceros*. Pettibone's synonymy (see above) is the correct one and *Pseudomalacoceros* is a synonym of *Scolecopsis* (*sensu stricto*).

**Diagnosis:** Prostomium pointed on anterior margin, extending posteriorly as narrow caruncle. Occipital tentacle present or absent. Caruncle posteriorly detached or attached to dorsal body wall. Peristomium well-developed, with or without lateral wings. Branchiae beginning on setiger 2, continuing to near posterior end of body; in anterior setigers, branchiae completely fused to dorsal lamellae or with distal portion free. Capillary noto- and neurosetae of anterior setigers usually arranged in 2 tiers; notosetal capillaries of posterior setigers in a single tier. Most capillary setae with prominent sheaths imparting a uni- or bilimbate appearance. Neuropodial hooded hooks present. Notopodial hooded hooks present or absent. Hooks uni-, bi-, tri- or multi-dentate. Pygidium with oval disc or multi-lobed appendages.

**Remarks:** *Scolecopsis* as defined above is slightly different from that proposed by Pettibone (1963) in that no provision is made for subgenera. The species are normally grouped into those having a distinct notch in the ventral lamellae (subgenus *Scolecopsis*) and those having entire ventral lamellae (subgenus *Nerinides*). Furthermore, Day (1967) pointed out that *Scolecopsis* normally has both notopodial and neuropodial hooded hooks, whereas *Nerinides* has only neuropodial hooded hooks. One or 2 species alternate in these characteristics, but in general they have held up. Light (1977), however, has determined that *S. squamata* in San Francisco Bay shows a continuous distribution in the presence or absence of the neuropodial cleft. He also notes that some specimens have notopodial hooks, whereas others do not (Light, 1978). Moreover, one of our species, *S. viridis* (see below) has neuropodial hooded hooks and unhooded notopodial acicular spines. It is not clear whether such unhooded spines, which are clearly of a different type than the hooded ones, have the same taxonomic importance as the notopodial hooks of other species.

We consider it to be increasingly difficult to maintain 2 subgeneric or generic (see Fau-chald, 1977a) categories based on such tenuous and variable characteristics. Although we regret lumping such a large group of species under one genus, we believe it to be the better course, pending a re-evaluation of the taxonomic characteristics of *Scoelelepis*. A similar position was adopted by Light (1977).

The reader is referred to Pettibone (1963) and Foster (1971) for historical and revisionary clarification of the genus *Scoelelepis*, and for lists and keys to the species. Eighteen species are listed as valid by Pettibone (1963). Wu and Chen (1964), Hartmann-Schröder (1965), Foster (1971), Bellan and Lagardere (1971), Gibbs (1971); (1972), and Day (1973) have described additional species. In our study, we have identified 9 species belonging to *Scoelelepis*, of which 8 are new to science.

#### KEY TO SPECIES OF *SCOLELEPIS* FROM SOUTHEASTERN AUSTRALIA

- |  |                          |
|--|--------------------------|
| 1a. Notosetae present on setiger 1 . . . . .   | 2                        |
| b. Notosetae absent from setiger 1 . . . . .   | 5                        |
| 2a. Caruncle posteriorly free from dorsum . . . . .  | 3                        |
| b. Caruncle attached to dorsum . . . . .   | 4                        |
| 3a. Setiger 1 with notopodial lamella in presetal position (Fig. 6a-b); hooded hooks multidentate, beginning in neuropodia of setiger 15-20 (Fig. 6 g-f) . . . . .   | <i>S. precirriseta</i>   |
| b. Setiger 1 with notopodial lamella in postsetal position (Fig. 2a); hooded hooks bi- or tridentate, beginning in neuropodia of setiger 24-25 (Fig. 2 h-k) . . . . .  | <i>S. carunculata</i>    |
| 4a. Hooded hooks unidentate, aperture of hood smooth (Fig. 1i); occipital tentacle absent, but caruncle posteriorly formed into conical mount (Fig. 1a) . . . . .  | <i>S. lamellicincta</i>  |
| b. Hooded hooks with 5 apical teeth, aperture of hood serrated (Fig. 6i-j); occipital tentacle present . . . . .   | <i>S. sp.</i>            |
| 5a. Caruncle posteriorly elevated or free from dorsum . . . . .  | 6                        |
| b. Caruncle posteriorly low, attached to dorsum . . . . .  | 8                        |
| 6a. Hooded hooks bidentate (Fig. 3d-e); parapodia and branchiae of middle and posterior setigers vesiculate (Fig. 3c) . . . . .  | <i>S. phyllobranchia</i> |
| b. Hooded hooks multidentate (Fig. 4h; 5e); parapodia and branchiae not vesiculate . . . . .   | 7                        |
| 7a. Caruncle posteriorly elevated into foliose lobe (Fig. 4a-b); superior dorsal capillary setae with smooth shaft and tuberculated sheath (Fig. 4j-l); branchiae free at tips (Fig. 4c-d) . . . . .                     | <i>S. occipitalis</i>    |
| b. Caruncle posteriorly elevated, pointed, not foliose (Fig. 5a-b); superior dorsal capillary setae with striated shaft and minutely spinous sheath (Fig. 5a-b); branchiae completely fused to dorsal lamellae . . . . . | <i>S. towra</i>          |
| 8a. Posterior notopodia with acicular spines (Fig. 8g) in addition to capillary setae; area posterior to caruncle with nuchal papilla and raised rectangular patch (Fig. 7 a-b) . . . . .                                | <i>S. viridis</i>        |
| 8b. Posterior notopodia without acicular spines, with capillary setae only; caruncle with rounded lobe; nuchal papilla located posterior to caruncle (Fig. 9 a-b) . . . . .  | <i>S. victoriensis</i>   |

#### *Scoelelepis lamellicincta* sp. nov. (Figure 1)

*Material examined:* QUEENSLAND. Heron Island, sandy shore, NE of island, mid-low tide levels (1 specimen, AM W13000). VICTORIA. Westernport, Point Leo, coll. Mar. Studies Grp., 18 Jan. 1969, Sta. 57/01, 69/05 (HOLOTYPE, NMV G102; PARATYPE, NMV G2987); Shorham, coll. R. Jenz, Sta V40, 3 Dec. 1965 (PARATYPE, NMV G2988); Somers, coll. R. Jenz, Sta. V77, Jan. 1966 (PARATYPE, NMV G2989); Walkerville, coll. R. Jenz, Sta. V170, Jan. 1966 (PARATYPE, NMV G2990). TASMANIA. Macquarie Island, Buckles Bay, dredged, Dec. 1960 (PARATYPE, NMV G2986). SOUTH AUSTRALIA. Elliston, in sand at base of jetty, coll. I. M. Thomas, 18 Feb. 1975 (14, SAM E1577).

*Description:* Holotype 32 mm long and 2.2 mm wide across parapodia for 100 setigers; paratypes up to 100 mm long and 8 mm wide for 140 setigers. Body widest anteriorly, rectangular in cross section. Salmon coloured in alcohol.

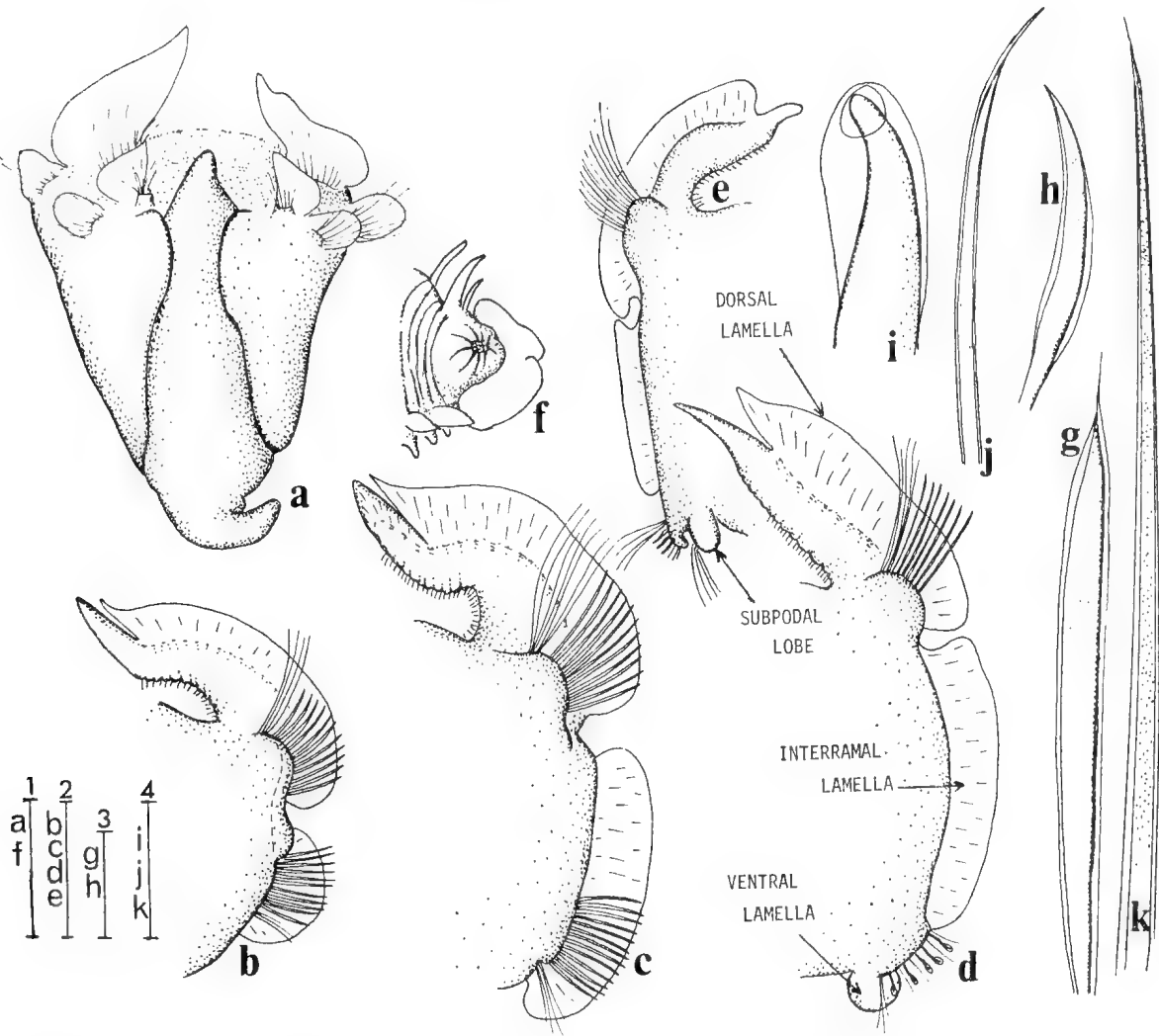


Figure 1—*Scolelepis lamellicincta* sp. nov.—a, anterior end, dorsal view; b, left setiger 11, anterior view; c, left setiger 33, anterior view; d, left setiger 51, anterior view; e, right setiger 120, anterior view; f, pygidium, dorsolateral view; g, capillary seta from posterior tier, setiger 10; h, capillary seta from anterior tier, setiger 10; i, unidentate hooded hook; j, sabre seta; k, superior capillary notoseta. [Scale 1 = 100  $\mu\text{m}$ ; 2 = 200  $\mu\text{m}$ ; 3 = 50  $\mu\text{m}$ ; 4 = 20  $\mu\text{m}$ ]

Prostomium anteriorly projecting, elongate, distally pointed, tapering posteriorly to a blunt and attached, but elevated lobe (Fig. 1a). Two pairs of eyes, arranged trapezoidally, an-

terior pair the larger. Palps extending posteriorly to setiger 10, with basal membrane. Peristomium well-developed, forming lateral wings partially overlapping prostomium.

Setiger 1 reduced, with leaf-like dorsal lamellae and rounded ventral lamellae (Fig. 1a). Dorsal lamellae from setiger 2 distally free from branchiae, flattened, narrow and distally pointed (Fig. 1b-e). Postsetal neuropodial lamellae small and rounded at first, increasing in size and becoming broadly rounded in subsequent anterior segments (Fig. 1b-c); at setigers 19-35, dividing into a long interrampal lamella and a small, rounded ventral lamella (Fig. 1d-e). With slight interrampal presetal

swelling in setigers 2-15 (Fig. 1b); curved subpodal lobe present in far posterior neuropodia (Fig. 1e).

Notosetae arranged in superior and inferior fascicles in anterior setigers and in single fascicles in posterior setigers. All inferior anterior capillary notosetae and neurosetae with granulations (Fig. 1g-h); granulations becoming obscured in posterior notopodial capillaries. Superior fascicle including capillaries with granulated shaft and clear, transparent sheath (Fig. 1k). Anterior capillary neurosetae similar to notosetae. Inferior neuropodial sabre setae from setiger 2-13, numbering 3-6 per fascicle; these distally pointed with finely granulated shaft and prolonged sheaths (Fig. 1j). Unidentate hooded hooks in neuropodia from setiger 25-38, and in notopodia from setiger 75-80, numbering 5-6 per ramus. Hooks distally falcate, blunt, aperture of hood forming smooth circle (Fig. 1i).

Branchiae fused to notopodial lamellae, but distally free (Fig. 1b-e). Pygidium with incised ventral cushion (Fig. 1f). Anus dorsal, surrounded by crenulate margin.

*Remarks:* *Scoelepis lamellicincta* is most closely related to *S. bonneri* (Mesnil) from France and to *S. foliosa* (Audouin Milne-Edwards) of cosmopolitan distribution; it differs from those species and all others by the structure of the parapodia, especially by the long interramal lamella of the middle and posterior segments. The conical caruncle is also unique.

*Distribution:* Queensland; Victoria; Tasmania, Macquarie Island; South Australia.

### *Scoelepis carunculata* sp. nov.

(Figure 2)

*Material examined:* QUEENSLAND. Moreton Bay, Jackson Creek, mangroves and sand flats, coll. P. Hutchings and C. Wallace, 12 July 1973 (1, AM W6057). NEW SOUTH WALES. Belmont Beach, HDWBS sample, Jan. 1976 (1, AM W8926). VICTORIA. Port Phillip Bay, Werribee MSG Sta. 1871, coll. G. Poore and J. D. Kudenov, Nov. 1975 (1, NMV G2991); Westernport, Shorham, Sta. V47, coll. R. Jenz, 20 Dec. 1965 (HOLOTYPE, NMV G2992; 5 PARATYPES NMV G2993); Port Fairy, Sta. V51, coll. R. Jenz, 10 Jan. 1966 (1, NMV G2994). Portland, Sta. V62, coll. R. Jenz, 8 Jan. 1966 (1, NMV G2995); Somers, Sta. V77, coll. R. Jenz, Jan. 1966

(2, NMV G2996). WEST AUSTRALIA. Safety Bay, south of Perth, coll. 15 Sept. 1968 (2, NMV G2997). *Description:* A large species, measuring up to 48 mm long and 3 mm wide for 110 setigers. Body widest anteriorly, tapering gradually posteriorly; elliptical in cross section. Colour in alcohol: opaque white to dusky brown.

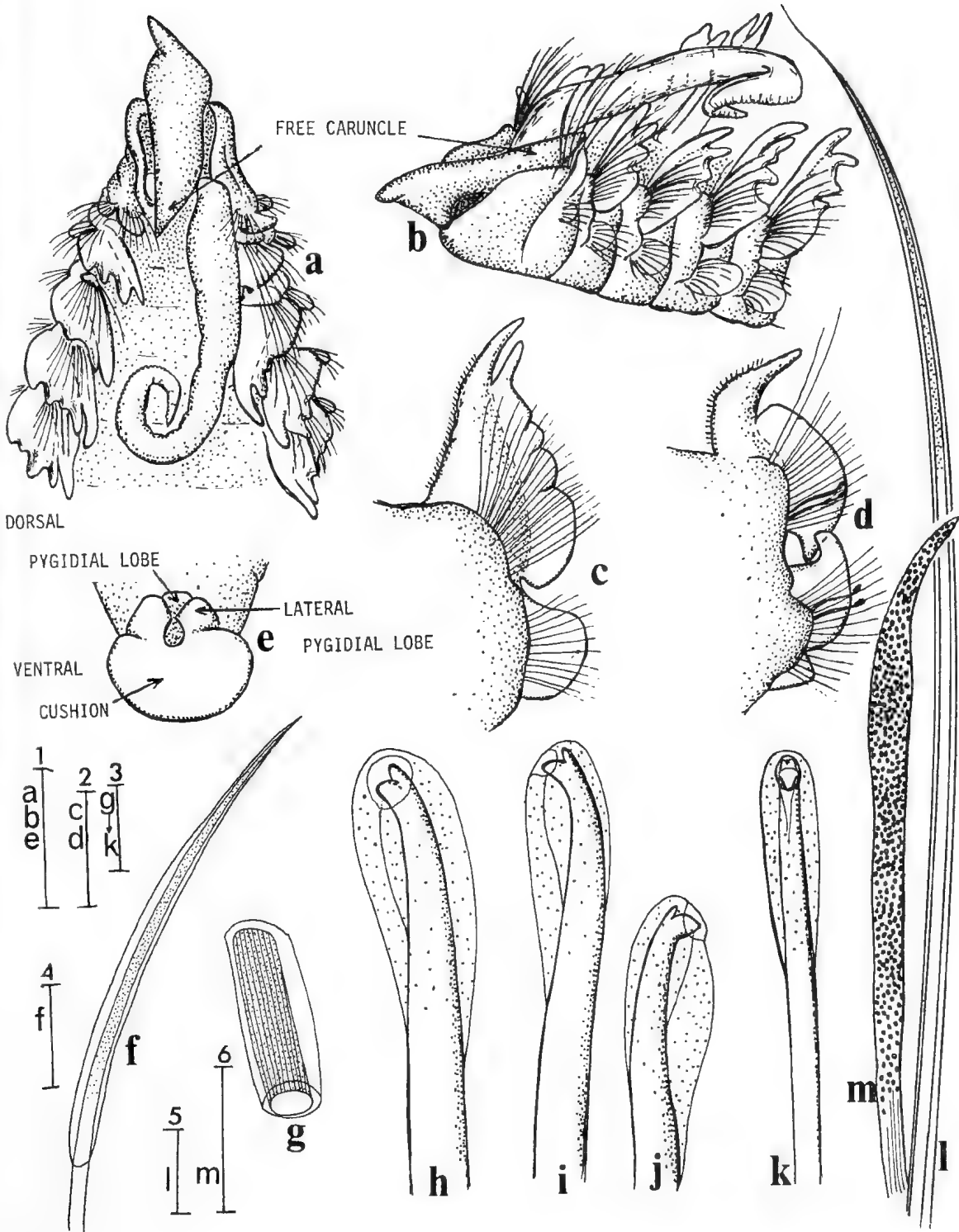
Prostomium slightly fusiform, pointed anteriorly and posteriorly, posterior lobe free unattached, extending to anterior margin of setiger 2 (Fig. 2a-b). Two pairs of eyes, arranged trapezoidally, the anterior pair slightly larger. Palps extending posteriorly to setiger 8-9. Peristomium well-developed, forming lateral wings, but not overlapping prostomium.

Setiger 1 reduced (Fig. 2a), with elliptical postsetal lamellae, dorsal lobes larger than ventral ones. Notopodial lamellae distally free from branchiae, entire, but greatly folded (Fig. 2c). Neuropodial lamellae in anterior setigers elliptical (Fig. 2c), becoming bilobed by setiger 30-35 (Fig. 2d). Parapodial lamellae of posterior setigers overlapping interramally (Fig. 2d).

Anterior setal tiers bear granulated capillaries with transparent sheaths (Fig. 2f-g); superior capillaries of posterior notopodial tiers and inferior capillaries of posterior neuropodial tiers with smooth shafts and sheaths bearing large vesicles, appearing golden in reflected light (Fig. 2m); remaining capillaries of posterior tiers non-granulated; superior dorsal capillaries distally granulated, with thin, prolonged distal process (Fig. 2l). Two to 3 inferior sabre setae in neuropodia from setiger 3. Hooded hooks beginning in setiger 24-45 in neuropodia and in setiger 70-80 in notopodia.

Figure 2—*Scoelepis carunculata* sp. nov.—a, anterior end, dorsal view; b, anterior end, lateral view; c, right setiger 10, anterior view; d, right setiger 30, anterior view; e, pygidium; f, anterior capillary seta; g, detail of shaft of f; h, neuropodial bidentate hooded hook, frontal view; i, same, lateral view; j, notopodial tridentate hooded hook, lateral view; k, notopodial tridentate hooded hook, frontal view; l, inferior capillary neuroseta; m, superior capillary notoseta. [Scale 1 = 500  $\mu$ m; 2 = 500  $\mu$ m; 3 = 20  $\mu$ m; 4 = 50  $\mu$ m; 5 = 20  $\mu$ m; 6 = 20  $\mu$ m]





Hooks bidentate in neuropodia (Fig. 2h-i) and bi- and tridentate in notopodia (Fig. 2j-k); hooks with primary and secondary hoods, primary hood bearing minute granules and secondary hood clear.

Branchiae stout, triangular, partially fused to dorsal lamellae. Pygidium with large ventral, entire cushion; anus surrounded by paired lateral and single dorsal lobes (Fig. 2e).

*Remarks:* *Scoelepis carunculata* is most closely related to *S. squamata* (Müller) in having notosetae on setiger 1 and in exhibiting bidentate hooded hooks. *S. carunculata* differs in the gills being fused to the dorsal lamellae for most of their length, the posterior notopodia are not incised, the dorsal and ventral lamellae of posterior setigers overlapping interramally and in the pygidium having dorsal and lateral lobes in addition to the ventral cushion. *S. carunculata* further differs from all previously described species of the genus in having hooded hooks with a secondary hood.

*Distribution:* Queensland; New South Wales; Victoria; West Australia.

#### *Scoelepis phyllobranchia* sp. nov.

(Figure 3)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 4B coll. W. Stephenson, Jan. 1976 (HOLOTYPE, NMV G2983; PARATYPE, NMV G2984); Sta. 48, Dec. 1972 (PARATYPE, NMV G2985); Sta. 4C, March 1976 (PARATYPE, QM G11586); Sta. 53, Sept. 1973 (PARATYPE, QM G11587).

*Description:* All specimens are incomplete. Holotype the largest specimen, measuring 15 mm long and 5 mm wide for 27 setigers. Anterior end dorsoventrally flattened, wide, rectangular in cross section. Colour in alcohol: opaque white.

Prostomium anteriorly elongate, distally pointed, continuing posteriorly as elevated mound with small apical nuchal papilla (Fig. 3a). Two pairs of subequal eyes, arranged rectangularly. Palps missing. Peristomium moderately developed, forming low lateral wings, partially encompassing prostomium.

Setiger 1 reduced, bearing small rounded notopodial lamellae, lacking notosetae; subquadrate neuropodial lamellae (Fig. 3a). Noto-

podial lamellae totally fused to branchiae from setiger 2 to about 18, thereafter notopodial lamellae from about setiger 20-25 displaced distally on elongated stalk (Fig. 3c), diverging to form 2 leaf-shaped, vesiculate processes: a dorsal lamella and separate branchia. Anterior neuropodial lamellae rounded (Fig. 3b), becoming bilobed from about setiger 25, with vesiculate petaloid interramal lamella (Fig. 3c).

Capillaries of anterior setal tiers mostly granulated, those of posterior row, and anterior superior fascicle of 4-5 capillaries, non-granulated, sheathed, with sheath being distally prolonged in superior capillaries (Fig. 3f-g). Inferior sabre setae absent. Bidentate hooded hooks in neuropodia from setiger 23 (Fig. 3d-e); notopodial hooks lacking in fragmentary material.

Nature of pygidium unknown.

*Remarks:* *Scoelepis phyllobranchia* is unique among spionids in having a stalk or trunk on posterior segments from which branch separate notopodial lamellae and gill processes. These parts as well as the neuropodial interramal lamellae are vesiculated and resemble the dorsal cirri of phyllodocids. The fragmentary nature of the types precludes an assessment of the presence of notopodial hooks.

*Distribution:* Queensland, Moreton Bay.

#### *Scoelepis occipitalis* sp. nov.

(Figure 4)

*Material examined:* NEW SOUTH WALES. Burwood Beach, HDWBS samples, June 1975 (HOLOTYPE, AM W8910 plus 8 PARATYPES from 8 stations, April, May, July, Sept. 1975, AM W8909, 8911-8917); Belmont Beach, HDWBS samples, 9 stations, June, July, Sept., Nov., Dec. 1975 and Feb. 1976 (9 PARATYPES, AM W8918-8925, 8928).

*Description:* A moderate-sized species, up to 16 mm long and 3.0 mm wide for 68 setigers. Body widest anteriorly, rectangular in cross section. Colour in alcohol: opaque white.

Prostomium anteriorly inflated with a distal conical protuberance (Fig. 4a); posteriorly produced into a flattened, irregularly-shaped, partly branched occipital process (Fig. 4a-b). Eyes absent. Palps missing. Peristomium mod-

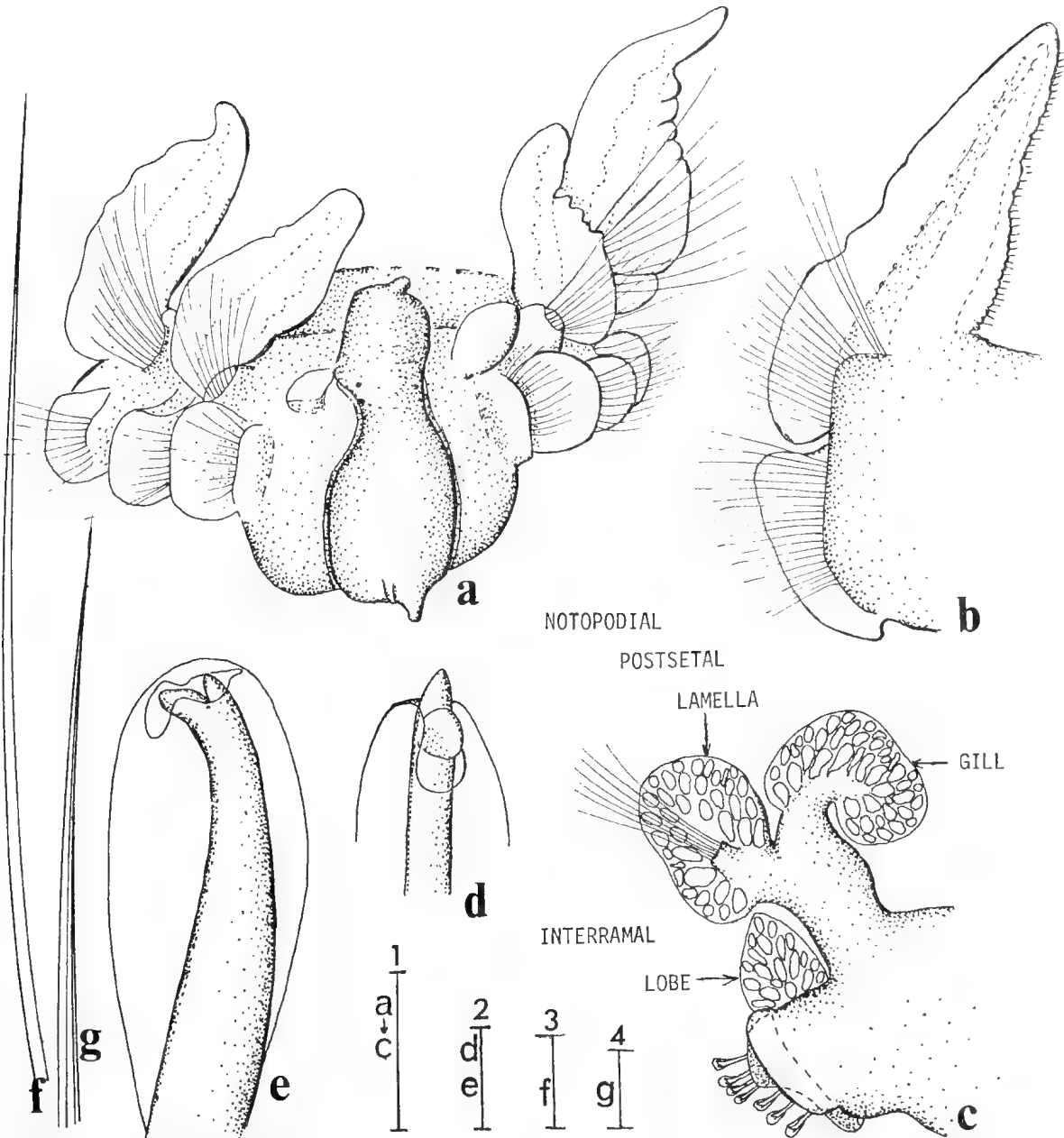


Figure 3—*Scolelepis phyllobranchia* sp. nov.—a, anterior end, anterodorsal view; b, right setiger 10, anterior view; c, right setiger 25, anterior view; d, bidentate hooded hook, frontal view; e, bidentate hooded hook, lateral view; f, superior capillary notoseta; g, detail of same. [Scale 1 = 100 μm; 2 = 20 μm; 3 = 100 μm; 4 = 10 μm]

erately developed, with small lateral wings (Fig. 4a).

Setiger 1 reduced, with small digitiform ase-tigerous notopodial lobes; neuropodial lamellae rounded, bearing capillary setae (Fig. 4 a-b). Anterior notopodial lamellae partly fused with branchiae from setiger 2, but distally free; lamellae elongate with rounded tips in anterior segments (Fig. 4c), becoming wing-shaped and distally pointed in posterior segments (Fig. 4d-e). Branchiae robust, wide and short at first,

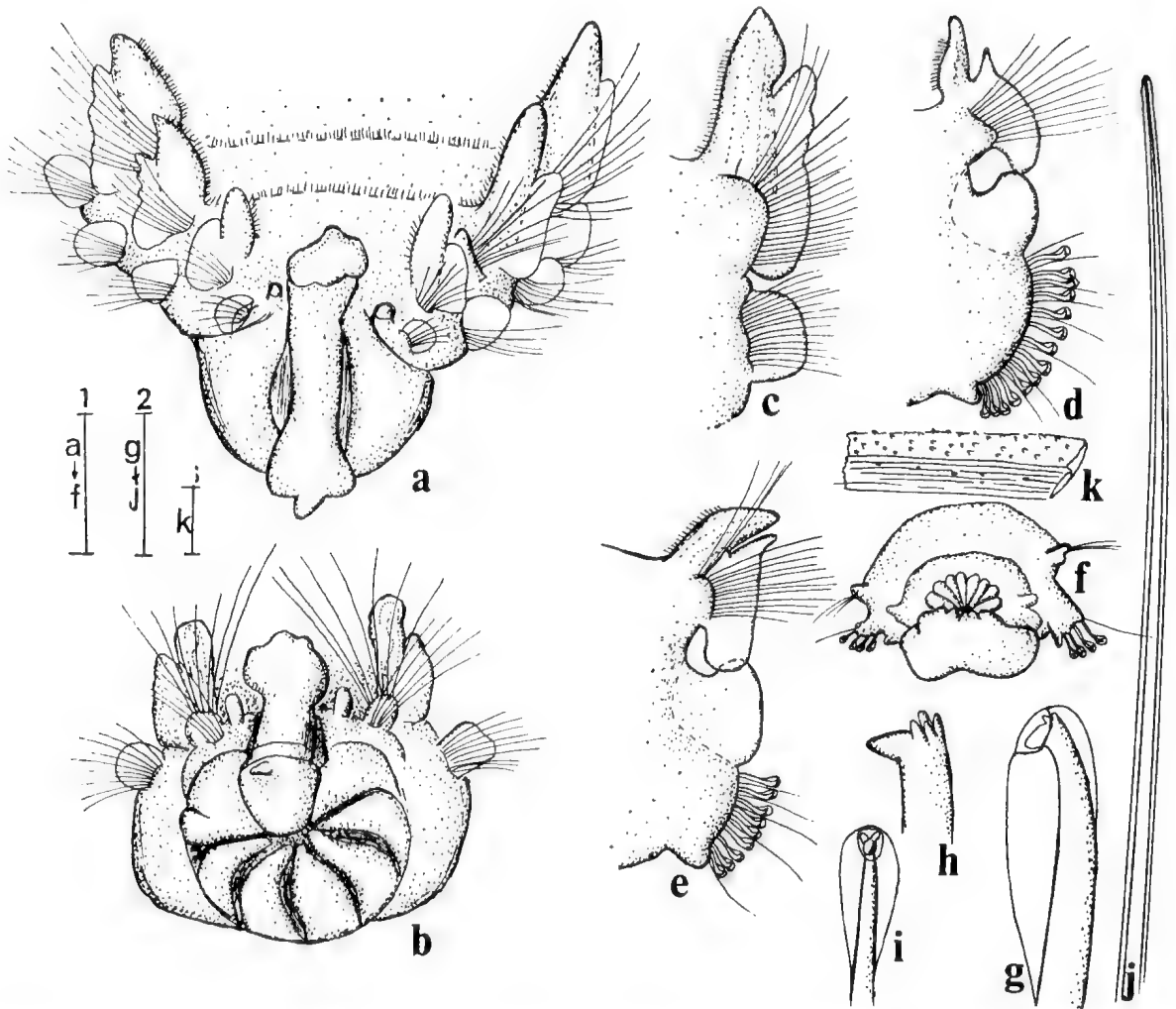


Figure 4—*Scolelepis occipitalis* sp. nov.—a, anterior end, frontal view; b, anterior end, dorsal view; c, right setiger 11, anterior view; d, right setiger 35, anterior view; e, right setiger 58, anterior view; f, pygidium, terminal view; g, quinquedentate hooded hook, lateral view; h, detail of quinquedentate hooded hook, hood omitted [not to scale]; i, quinquedentate hooded hook, frontal view; j, superior capillary notoseta; k, detail of shaft of same. [Scale 1 = 100  $\mu$ m; 2 = 20  $\mu$ m; 3 = 10  $\mu$ m]

increasing in size over anterior region, decreasing in length posteriorly. Anterior neuropodial lamellae entire and rounded; lamellae divided in middle and posterior segments, forming a small ventral lobe and large interramal lamella

(Fig. 4c-e). Dorsal and interramal lamellae of middle and posterior segments overlapping (Fig. 4d-e). Inferior presetal neuropodial lobe from setiger 19-20 (Fig. 4d-e).

Capillary setae granulated in anterior tier, smooth in posterior tier; superior group of 2-5 capillaries with smooth shaft and tuberculated sheath (Fig. 4j-k). Neuropodial quinquedentate hooded hooks from setiger 24-25 (Fig. 4g-i), notopodial hooks beginning about setiger 52. Hooks bearing 4 small apical teeth in 2 rows with a V-shaped medial gap surmounting large main fang (Fig. 4h-i); quinquedentate hooks appearing tridentate in certain views (Fig. 4g-i); inferior sabre setae absent.

Pygidium with ventral cushion, with 1 achae-

tous preanal segment. Anus with deeply scalloped margin (Fig. 4f).

*Remarks:* *Scolelepis occipitalis* is readily recognized by the flattened, partly branched occipital lobe and the configuration of the hooded hooks, which more closely resemble those seen in the genus *Prionospio* than in other species of *Scolelepis*.

*Distribution:* New South Wales.

***Scolelepis towra* sp. nov.**

(Figure 5)

*Material examined:* NEW SOUTH WALES. Botany Bay, Towra Beach, NSWFS Sta. 226, associated with *Posidonia* (HOLOTYPE, NMV G2982).

*Description:* Holotype an incomplete anterior fragment, measuring 7 mm long and 0.8 mm wide for 28 setigers. Specimen a gravid female with hard membraned primary oocytes.

Prostomium distally pointed, widest subterminally, with caruncle tapering posteriorly to form erect conical lobe extending to anterior margin of setiger 3, with slight constriction at level of eyes. Two pairs of eyes arranged trapezoidally, anterior pair the larger (Fig. 5a-b). Palps missing. Peristomium moderately enlarged, without lateral wings.

Notopodial lobe of setiger 1 reduced, lacking notosetae; neuropodium rounded, with capillary setae. Notopodial lamellae completely fused with branchiae from setiger 2, rounded at first (Fig. 5c) then becoming triangular (Fig. 5d) in subsequent segments. Neuropodial lamellae auricular and continuous with notopodial lamellae in anterior setigers (Fig. 5c), decreasing in size posteriorly and shifting dorsally to interramal position, becoming asymmetrical and overlapping notopodial lamellae (Fig. 5d). Low rounded presetal neuropodial lobe from setiger 15-18 (Fig. 5d).

Anterior capillary notosetae and superior group of 3-5 longer capillaries with striated shaft and minutely spinous sheath (Fig. 5g-h), distally prolonged as fine tip. Smooth sabre setae in neuropodia only in setigers 10-14. Multidentate hooded hooks begin setiger 14-15, secondary teeth arranged in 2 pairs, closely applied to elongated main fang (Fig. 5e-f). Notopodial hooks unknown. Nature of pygidium unknown.

*Remarks:* *Scolelepis towra* is closely related to *S. texana* Foster, 1971, from the Gulf of Mexico and *S. occipitalis* (this study), all of which have multidentate hooded hooks. The hooks of *S. occipitalis* differ from those of *S. towra* in exhibiting a large, medial, V-shaped gap between the pairs of apical teeth; no such gap occurs in the hooks of *S. towra*. *S. towra* and *S. texana* have quite similar hooks, but the 2 species can be separated as follows: in *S. towra*, the branchiae are totally fused to the dorsal lamellae and there is no occipital cirrus (although the posterior edge of the caruncle forms an erect lobe); in *S. texana* branchiae are only fused basally, and an erect occipital antenna is present. In addition, the anterior dorsal capillaries of *S. towra* bear striated shafts with finely spinous sheaths; those of *S. texana* exhibit punctate shafts with clear, entire, hyaline sheaths, similar to those seen in *S. squamata* (W. J. Light, personal communication).

*Distribution:* New South Wales, Botany Bay, Towra Beach.

***Scolelepis precirriseta* sp. nov.**

(Figure 6a-h)

*Material examined:* QUEENSLAND. Deception Bay, Burpengary Creek (1, AM W7129); Brisbane, Fine Station, Feb. 1972 (9, AM W7483); 14-25 m, May 1974 (HOLOTYPE, AM W13052; 2 PARATYPES, AM W13047). NEW SOUTH WALES. Wallis Lake, *Zostera* beds, coll. Dixon and O'Gower, Dec. 1970 (2, AM W5007).

*Description:* A moderate-sized species, up to 17 mm long and 1.5 mm wide for 39 setigers. Body dorsoventrally flattened anteriorly, setigers 1-18 elliptical in cross section, subquadrate posteriorly. Collection includes males with sperm and females with hard membraned oocytes. Colour in alcohol: opaque white.

Prostomium anteriorly pointed or blunt, depending on amount of contraction during preservation. Posterior aspect of prostomium produced into elevated free lobe extending posteriorly to setiger 2 (Fig. 6a). Constriction present at level of eyes. Two pairs of eyes, trapezoidally arranged, anterior pair the larger. Peristomium moderately developed, but without lateral wings. Regenerating palps inserted posterolaterally to prostomium in holotype

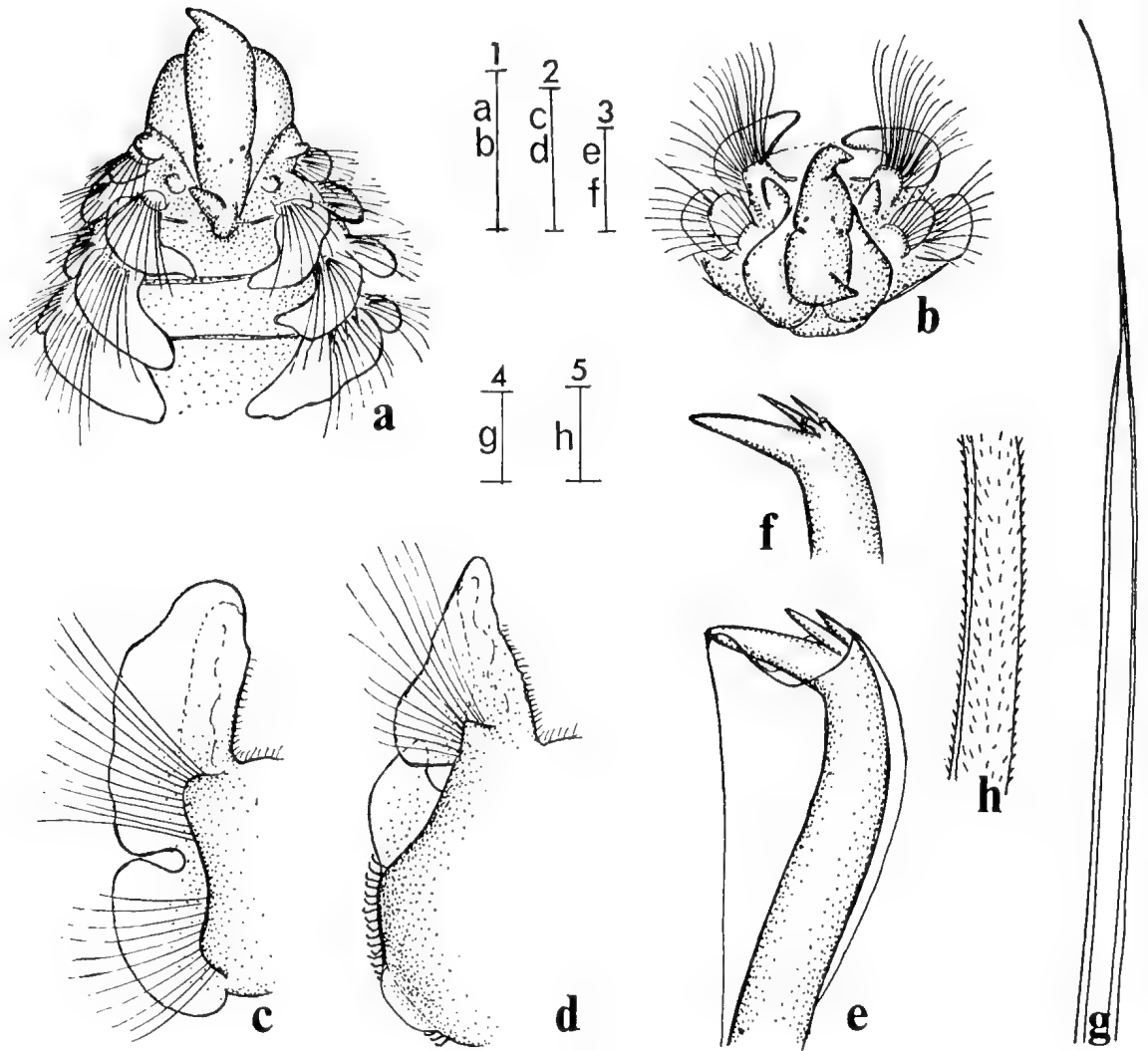


Figure 5—*Scolelepis towra* sp. nov.—a, anterior end, dorsal view; b, anterior end, frontal view; c, right setiger 10, anterior view; d, right setiger 20, anterior view; e, quinquedentate hooded hook, lateral view; f, quinquedentate hooded hook, without hood showing 2 broken teeth and 2 entire teeth behind, lateral view; g, superior capillary notoseta; h, detail of sheath of same. [Scale 1 = 100  $\mu$ m; 2 = 500  $\mu$ m; 3 = 10  $\mu$ m; 4 = 20  $\mu$ m; 5 = 10  $\mu$ m]

(Fig. 6a). Setiger 1 reduced, but with notosetae; notopodial lamellae fingerlike and presetal instead of postsetal in location; neuropodial lamellae rounded and postsetal (Fig. 6a-b).

Dorsal lamellae basally fused with branchiae in anterior setigers, becoming free posteriorly. Lamellae of anterior setigers distally pointed (Fig. 6c), becoming hatchet-shaped in posterior setigers (Fig. 6d-e). Neuropodial lamellae continuous with notopodial lamellae in anterior setigers, the 2 being separated by a shallow notch (Fig. 6c); neuropodia becoming broadly rounded at about setiger 29, then moving to interramal position (Fig. 6d-e).

Anterior dorsal capillaries non-granulated or granulated; 4-5 superior dorsal capillaries with non-granulated shaft and tubercles on sheath (Fig. 6h). Hooded hooks first present

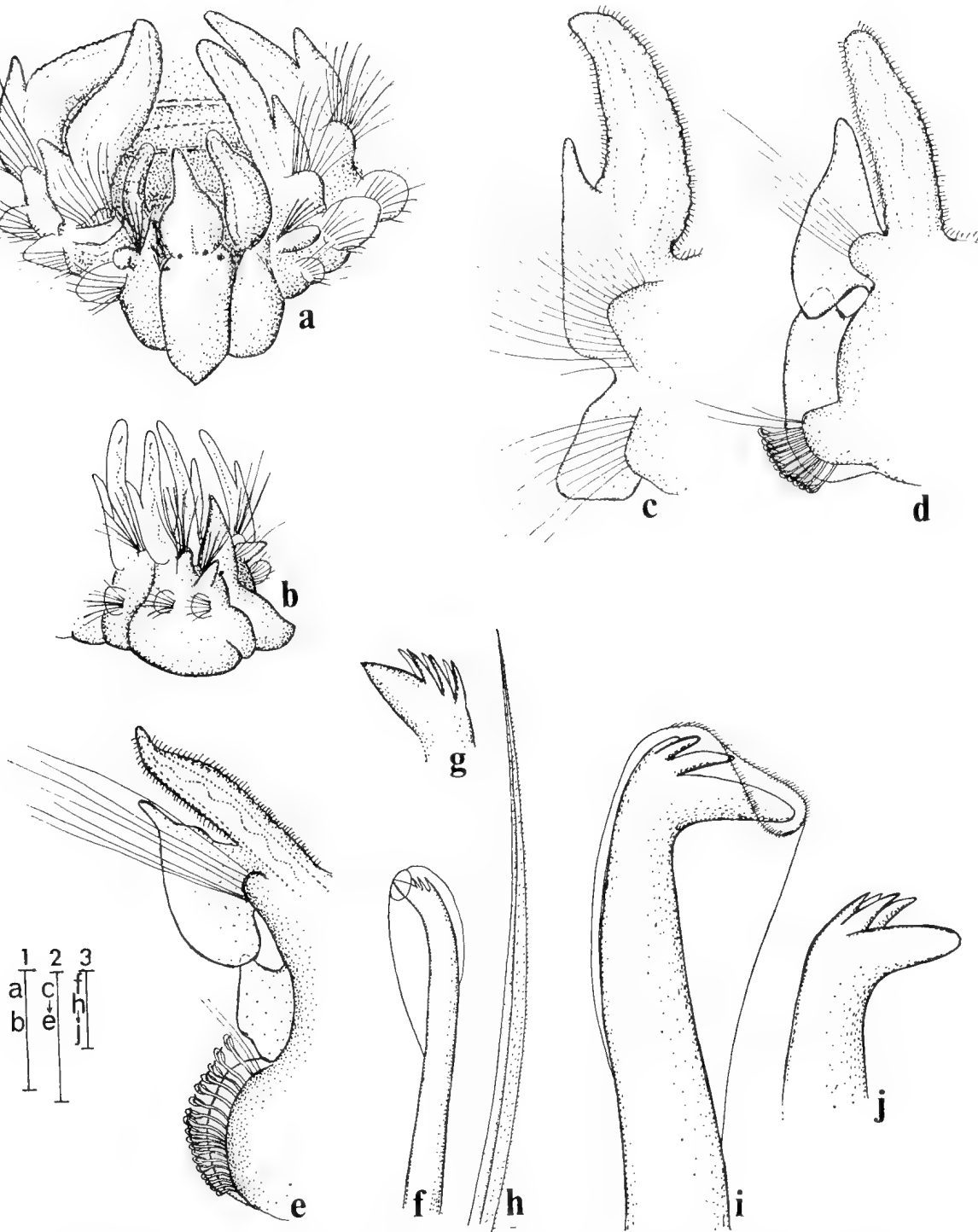


Figure 6—*Scolelepis precirriseta* sp. nov.—a, anterior end, dorsal view; b, anterior end, lateral view; c, right setiger 10, anterior view; d, right setiger 29, anterior view; e, right setiger 39, anterior view; f, multidentate hooded hook, lateral view; g, same, enlarged, hood omitted [not to scale]; h, superior capillary notoseta—*Scolelepis* sp.—i, hexadentate hooded hook, lateral view; j, hexadentate hooded hook, without hood showing arrangement of teeth, frontolateral view. [Scale 1 = 100  $\mu\text{m}$ ; 2 = 300  $\mu\text{m}$ ; 3 = 20  $\mu\text{m}$ ]

in neuropodia from setiger 15-20, mostly replacing capillaries. Hooks with relatively small primary fang and 3 pairs of small apical teeth (Fig. 6f-g), suggestive of a *Prionospio* setal type, appearing quadridentate in lateral view. Notopodial hooks unknown. Sabre setae unknown. Nature of pygidium unknown.

*Remarks:* *Scolecopsis precirriseta* differs from all known species of the genus in having the dorsal lamella of setiger 1 in the presetal instead of postsetal position. The outer superior dorsal capillaries have minute tubercles on the sheath.

*Distribution:* Queensland; New South Wales.

### *Scolecopsis* sp.

(Figure 6i-j)

*Material examined:* VICTORIA. Westernport, Crib Point, CPBS Sta. 32N (1, NMV G2894; 1, NMV G2895).

*Remarks:* The specimens are incomplete and measure up to 25 mm long and 2.5 mm wide for 44 setigers. They are poorly preserved. An occipital tentacle is present. There are no eyes. Setiger 1 bears notosetae. The branchiae are completely fused to the dorsal lamellae in at least in anterior segments. The dorsal lamellae appear highly glandular in anterior segments and are reddish in colour. Anterior fascicles have non-granulated capillary setae with sheaths. Multidentate hooded hooks begin on setiger 11. The margin of the hood aperture is serrated (Fig. 6i). Apical teeth are arranged in 2 pairs above the main fang, and underlie a small unpaired tooth (Fig. 6i-j). Sperm were observed in one specimen (NMV G-2894) and proved to be of the primitive type (Franzén, 1956). Specific identification cannot be made from the present, badly preserved specimens.

*Distribution:* Victoria, Westernport Bay, in muddy sand.

### *Scolecopsis viridis* sp. nov.

(Figures 7-8)

*Material examined:* QUEENSLAND. Great Barrier Reef, Opal Reef, coll. 9 Nov. 1976, subtidal, 2 m in coral sand under boulder on reef flats, coll. J. H. Dorsey (HOLOTYPE, NMV G2914).

*Description:* Holotype complete, measuring 200 mm long and 9 mm wide for about 200

setigers. Body widest anteriorly, gradually tapering posteriorly, generally rectangular in cross section. Posterior segments each with raised glandular ridges surrounding body. Specimen a gravid female with flattened, hard membraned oocytes. Colour in life: bright green; in alcohol: dark grey.

Prostomium distally pointed, widest subterminally, gradually tapering posteriorly (Fig. 7a-b). Flattened nuchal papilla present posterior to and separated from caruncle. A raised rectangular area occurring just posterior to papilla, on setiger 3 (Fig. 7a-b). Palps missing. Two pairs of eyes in trapezoidal arrangement. Peristomium well-developed, forming lateral thickening about prostomium.

Setiger 1 reduced, but with small rounded notopodial lamellae, lacking notosetae; neuro-podial lamella auricular, much larger than notopodial lamella (Fig. 7a). From setiger 2 notopodial lamellae marginally rounded, completely fused with branchiae, both elements forming strap-like structure (Fig. 8a-b); lamellae highly reduced in middle and posterior body region, where branchiae become separated and smaller (Fig. 8c-d), with notopodia elongating into cirriform lobes, barely fused basally to branchiae. Branchiae reduced to ciliated mounds in far posterior setigers (Fig. 8e). Anterior neuropodial lamellae entire (Fig. 8a); with inferior notch in middle setigers (Fig. 8b), becoming narrowly rounded (Fig. 8c-e) in posterior setigers, with small presetal lobe (Fig. 8d-e).

Setal fascicles arranged as 5 tiers of capillary setae per ramus in anterior setigers, decreasing to 2 tiers by setiger 40. From about setiger 50, notopodia each with superior and inferior tuft of capillaries (Fig. 8c). Anterior capillary notosetae of 2 types: (1) those of tiers 1-2 with granulated shaft and clear sheath (Fig. 7c-d); (2) those of tiers 3-5 and superior fascicles with non-granulated shaft and prominently bristled sheath (Fig. 7e-f). With simple, heavy acicular spines in notopodia of middle and posterior setigers (Fig. 8g) from setiger 50. Neurosetae including sheathed granulated and non-granulated capillaries in addition to bidentate hooded hooks. Two inferior sabre setae from setiger 2, number of sabre setae increasing to 20 per fascicle in middle segments;



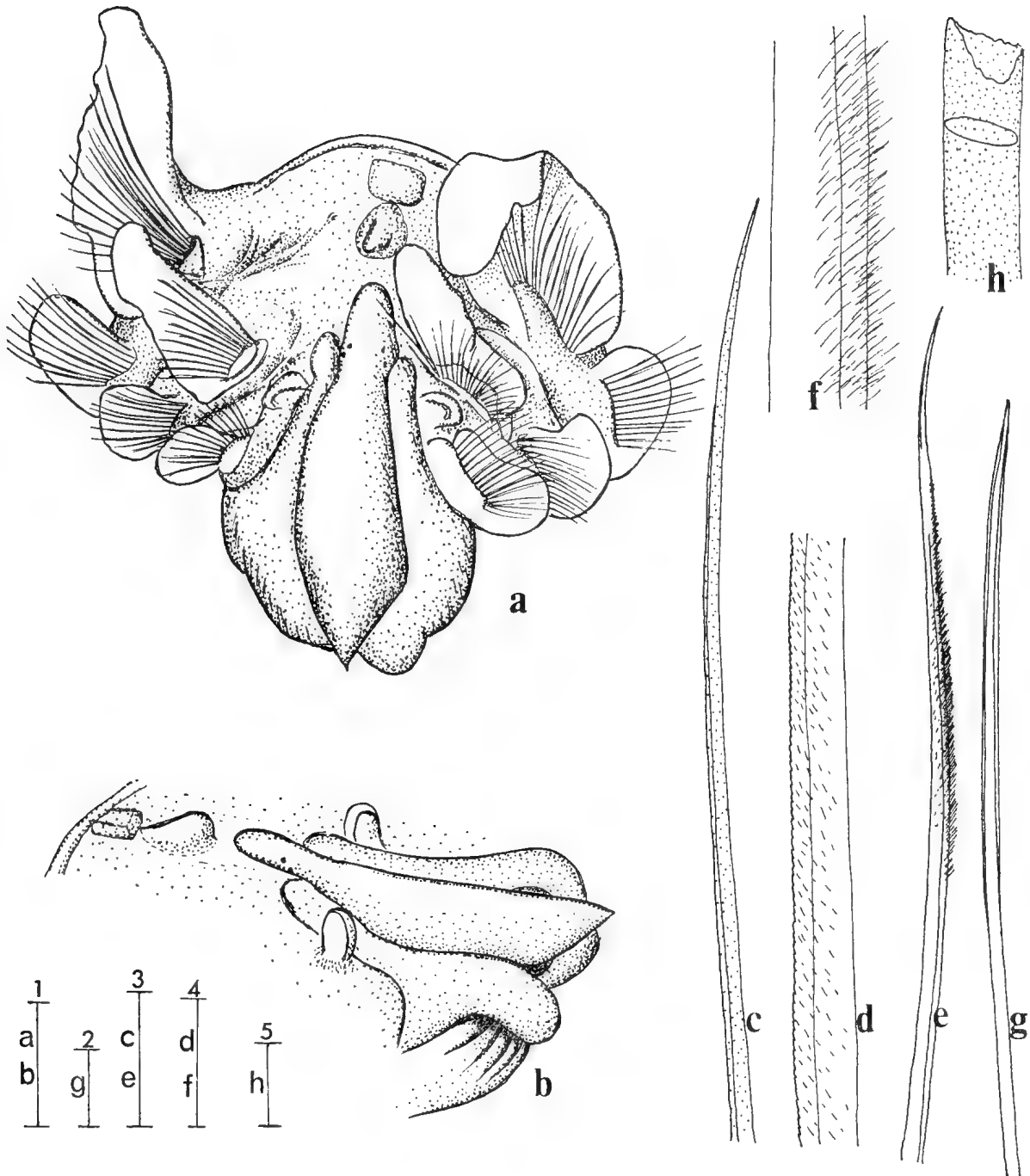


Figure 7—*Scolelepis viridis* sp. nov.—a, anterior end, dorsal view; b, prostomium and peristomium, lateral view; c, superior capillary notoseta; d, detail of same; e, capillary notoseta from tier 3; f, detail of same; g, inferior neuropodial sabre seta; h, detail of same. [Scale 1 = 200  $\mu$ m; 2 = 100  $\mu$ m; 3 = 100  $\mu$ m; 4 = 20  $\mu$ m; 5 = 20  $\mu$ m]

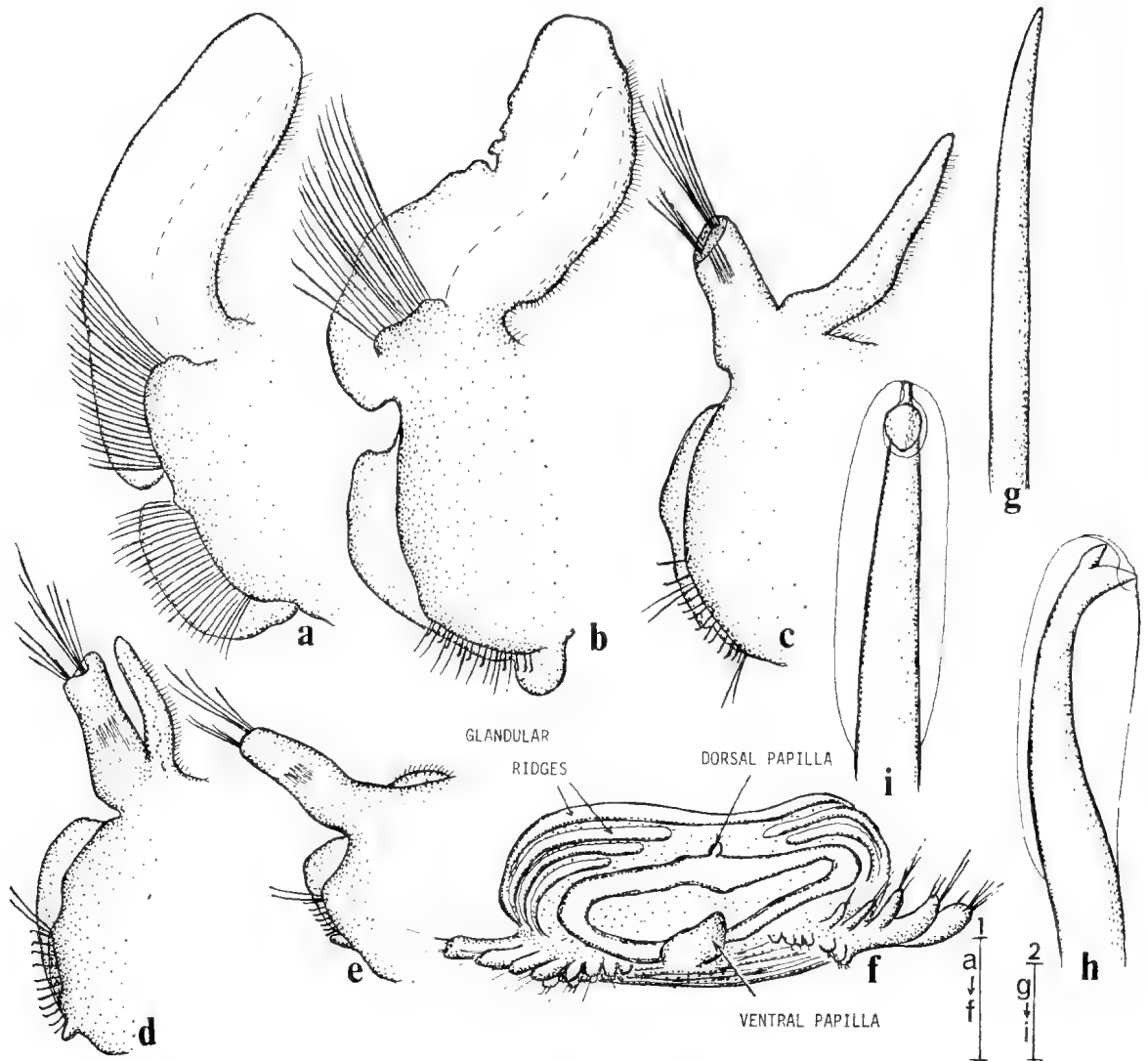


Figure 8—*Scolelepis viridis* sp. nov.—a, right setiger 10, anterior view; b, right setiger 38, anterior view; c, right setiger 100, anterior view; d, right setiger 150, anterior view; e, right setiger 190, anterior view; f, pygidium, terminal view; g, notosetal spine; h, bidentate hooded hook, lateral view; i, same, frontal view. [Scale 1 = 200  $\mu$ m; 2 = 50  $\mu$ m]

these with non-granulated shafts and minute bristles on sheath (Fig. 7g-h). Bidentate hooded hooks from setiger 28-29 in neuropodia, secondary tooth forming angle of about  $60^\circ$  with main fang (Fig. 8h-i).

Pygidium with 2 papillae: the first small,

dorsomedial, the second ventromedial, conical and larger. Pygidium surrounded by thick glandular rings (Fig. 8f).

*Remarks:* *Scolelepis viridis* is a unique species, characterized by having a nuchal papilla and peculiar raised nuchal area posterior to the caruncle; glandular ridges on posterior body segments; reduction of dorsal lamellae and corresponding elongation of the notopodia in middle and posterior segments; the presence of unhooded acicular spines in notopodia; bidentate neuropodial hooded hooks; 5 tiers of anterior capillary setae; and a peculiar pygidial structure with dorsal and ventral papillae.

*Distribution:* Queensland, Great Barrier Reef, with coral.

***Scolelepis victoriensis* sp. nov.**

(Figure 9)

*Material examined:* VICTORIA. Westernport, WPBES Stations 1718-1 (PARATYPE, NMV G2906); 1723-2 (PARATYPE, NMV G2907); 1734-2 (PARATYPE, NMV G2908); 1736-1 (PARATYPE, NMV G2909); 1737-1 (PARATYPE, NMV G2910); 1738-3 (PARATYPE, NMV G2911); 1740-1 (HOLOTYPE, NMV G2912); Crib Point, CPBS Station 300, Dec. 1970 (PARATYPE, NMV G2913).

*Description:* All specimens incomplete anterior fragments measuring up to 15 mm long and 4 mm wide for 31 setigers. Body widest anteriorly, elliptical in cross section. Colour in alcohol; opaque white.

Prostomium distally pointed; posteriorly with rounded lobe just behind and above the 2 pairs of eyes. Anterior pair of eyes the larger. With nuchal papilla posterior to caruncle on setiger 2 (Fig. 9a). Palps missing. Peristomium well-developed, with lateral wings. Proboscis an eversible sac.

Setiger 1 reduced with small, petaloid notopodial lamellae, lacking notosetae; neuropodial about as long as notopodial lamellae (Fig. 9 a-b). Notopodial lamellae marginally rounded and straplike on all anterior setigers, entirely fused to branchiae. Neuropodial lamellae subquadrate in anterior setigers (Fig. 9c), low and broadly rounded in middle body segments (Fig. 9d). Anterior notopodia with well-developed presetal lobes (Fig. 9c-d).

All notopodia bearing capillaries with granulations on shaft and broadly sheathed with minute hair-like fimbriations (Fig. 9e); sheath more closely applied in superiormost capillaries, with fine bristles only apparent under oil immersion (Fig. 9g-h). Neuropodial capillaries similar to those of notopodia. Inferior sabre setae beginning on setiger 2-3 with 2-3 per tuft at first, subsequently increasing to 4-5. Bidentate neuropodial hooded hooks from setiger 25, these hooks bearing a single distally pointed, rather long apical tooth closely applied to main fang (Fig. 9f). Margin of hood aperture not serrated. Dorsal hooks lacking.

*Remarks:* *Scolelepis victoriensis* is a unique species in the nature of the overlapping apical

tooth of the hooded hooks. The presence of a prostomial swelling and separate nuchal papilla are also unusual.

*Distribution:* Victoria, Westernport.

**Genus *Aonides* Claparède, 1864**

*Aonides* Claparède, 1864. *Type-species:* *A. auricularis* Claparède, 1864 [= *A. oxycephala* (Sars, 1862)], by monotypy.

*Paranerine* Czerniavsky, 1881. *Type-species:* *Nerine oxycephala* Sars, 1862, by monotypy.

*Diagnosis:* Prostomium conical, tapered both anteriorly and posteriorly. Peristomium poorly developed. Branchiae cirriform, separated from dorsal lamellae, beginning on setiger 2 and present on a variable number of anterior setigers; absent posteriorly. Bi- or tridentate hooded hooks present in both notopodia and neuropodia. Pygidium with anal cirri.

*Remarks:* A small genus, represented in our collections by only 1 species, *A. oxycephala*, an apparently cosmopolitan species (see Ramos, 1976).

***Aonides oxycephala* (Sars, 1962)**

*Nerine oxycephala* Sars, 1862, p. 64.

*Aonides oxycephala:* Ramos, 1976, p. 11 (Synonymy).

*Aonides californiensis* Rioja, 1947, p. 205. *Fide* Ramos, 1976.

*Aonides mayaguezensis* Foster, 1969, p. 393; 1971, p. 66. *Fide* Ramos, 1976.

*Material examined:* NEW SOUTH WALES. Merimbula, Sta. MER 287N, Spencer Park Transect, sand, 5 Oct. 1975, coll. J. H. Day, *et al.* (1, AM W11735); Sta. MER 289V, channel core N, side central sand bank, *Halophila*, 4 Dec. 1975 (1, AM W11746); Sta. MER 297W, channel core opposite Spencer Park (1, AM W11747). VICTORIA. Port Phillip Bay, PPBES Station 985/2 (1, NMV G2915).

*Remarks:* These specimens agree well with the description by Ramos (1976). There are at least 20 pairs of branchiae, and bidentate hooded hooks begin in the notopodia from about setiger 29 and in the neuropodia from about setiger 40. The usefulness of branchial distributions in the delineation of *Aonides* species needs careful consideration, particularly when dealing with what may be a widespread species. Similarly, the first occurrence of noto- and neuropodial hooks may not be taxonomically important in this genus. An evaluation of this feature requires a more thorough understanding of the larval development (see Hannerz, 1956, pp. 26-32).

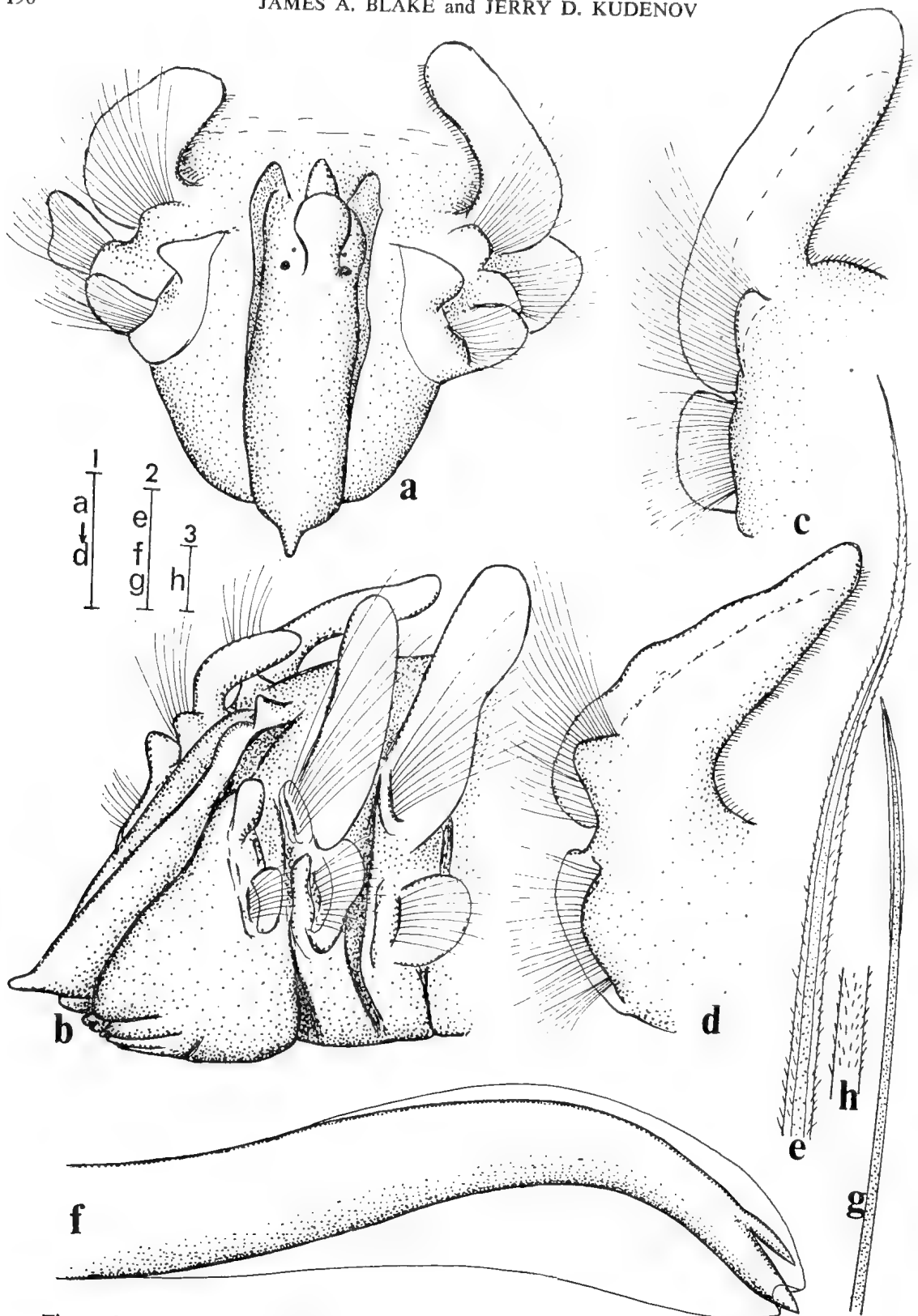


Figure 9—*Scolelepis victoriensis* sp. nov.—a, anterior end, lateral view; b, anterior end, dorsal view; c, right setiger 8, anterior view; d, right setiger 21, anterior view; e, normal capillary notoseta, distal process; f, bidentate hooded hook, lateral view; g, superior capillary notoseta; h, shaft, detail of same. [Scale 1 = 100 μm; 2 = 30 μm; 3 = 10 μm]

*Distribution:* New South Wales, Merimbula, associated with sandy channel sediments and *Posidonia*; Victoria, Port Phillip Bay, 9 m in sandy sediments.

### Genus *Dispio* Hartman, 1951

*Type-species:* *D. uncinata* Hartman, 1951, by monotypy.

*Diagnosis:* Prostomium fusiform, anteriorly pointed, with narrow caruncle extending posteriorly. Eyes present or absent. Peristomium moderately developed, forming low lateral wings. Anterior parapodial lamellae lobed or entire. Presetal notopodial and neuropodial lobes present or absent. Branchiae present from setiger 1, fused to notopodial lamellae for half or more of their length. With accessory branchiae on posterior face of notopodia in middle and posterior segments. With capillary notosetae only. Neurosetae include capillaries, hooded hooks and sabre setae. Pygidium with midventral flap and prominent anal cirri.

### *Dispio glabrilamellata* sp. nov.

(Figure 10)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 3, Dec. 1973 (1, QM G11588); 6D, March 1976 (QM G11589), coll. W. Stephenson. NEW SOUTH WALES. Sydney, S. end Manly Beach, 7.2-8.7 m, coll. 30 June 1971 coll. P. A. Hutchings (1, AM W13001); Burwood Beach, HDWBS Stations, March, May, July, Nov. 1975 (4 PARATYPES, AM W8890-8893); McMasters Beach, HDWBS Stations, July, Nov. 1975 (8 PARATYPES, AM W8894-8896, 8946; HOLOTYPE AM W13048); Belmont Beach, HDWBS Station, Jan. 1976 (2 PARATYPES, AM W8897, 8833); Dudley Beach, HDWBS Station, July 1975 (PARATYPE, AM W8898). VICTORIA. West-ernport, West Head, Flinders Rock Platform, coll. R. Jensz, 16 Jan. 1968 (2 PARATYPES, NMV G2952).

*Description:* All specimens incomplete. Largest fragments up to 20 mm long and 3 mm wide for 110 setigers. Body widest anteriorly, tapering gradually posteriorly; trapezoidal to rectangular in cross section. Colour in alcohol: opaque white.

Prostomium elongate, sharply pointed anteriorly (Fig. 10a). Caruncle short, narrow, reaching only to posterior margin of setiger 1. Occipital tentacle absent, but prominent boss present behind eyes (Fig. 10b). Two pairs of subdermal eyes, often obscured, arranged tra-

pezoidally. Palps missing. Peristomium well-developed, forming distinct lateral wings partially encompassing prostomium (Fig. 10a-b).

Setiger 1 slightly reduced with notopodium shifted dorsally and bearing 4-5 long notosetae; neurosetae much shorter than notosetae. Notopodial lamellae of setiger 2 and succeeding setigers entire, long and narrow, fused with branchiae; lamellae distally free with pointed tips and entire margins (Fig. 10c-e). Neuropodial lamellae rounded to subrectangular in anterior setigers (Fig. 10c), with pointed superior and inferior processes in posterior setigers (Fig. 10d-e). Presetal notopodial lobes from about setiger 30 as thickened margins (Fig. 10d), becoming quite elongate, subulate and maximally developed from around setiger 80 (Fig. 10e), decreasing in size thereafter. Presetal neuropodial lobes from about setiger 60, becoming broadly triangular from around setiger 80 (Fig. 10e).

Setal fascicles arranged in 2 tiers in each ramus. Notosetae sheathed and with or without transverse partitions in the shaft (Fig. 10f). Anterior setigers with 30-35 capillaries and 3-4 longer superior setae in each notopodium, these gradually reduced to about 10 normal and 3 longer superior setae in posterior setigers. Capillaries of setiger 1, superior notosetae and those in posterior tiers of both rami without transverse partitions; anterior tiers in each notopodium with transversely barred capillaries, these partitions tending to disappear in posterior setigers. Neurosetal capillaries similar to notosetal. Neuropodial sabre setae present from setiger 9-11, these lacking partitions initially, but becoming thicker and transversely barred from around setiger 25. Sabre setae numbering 2-5 per fascicle. With unidentate hooded hooks in neuropodia from setiger 22-26 (Fig. 10g); 1 juvenile specimen (AM W8891) with bidentate and unidentate hooded hooks intergrading in the same fascicle (Fig. 10h).

Branchiae from setiger 1, smooth, not serrated, fused with dorsal lamellae. Accessory branchiae on posterior face of notopodia from about setiger 23, continuing to end of body; each with up to 4-6 digitate processes (Fig. 10d-e). Nature of pygidium unknown.

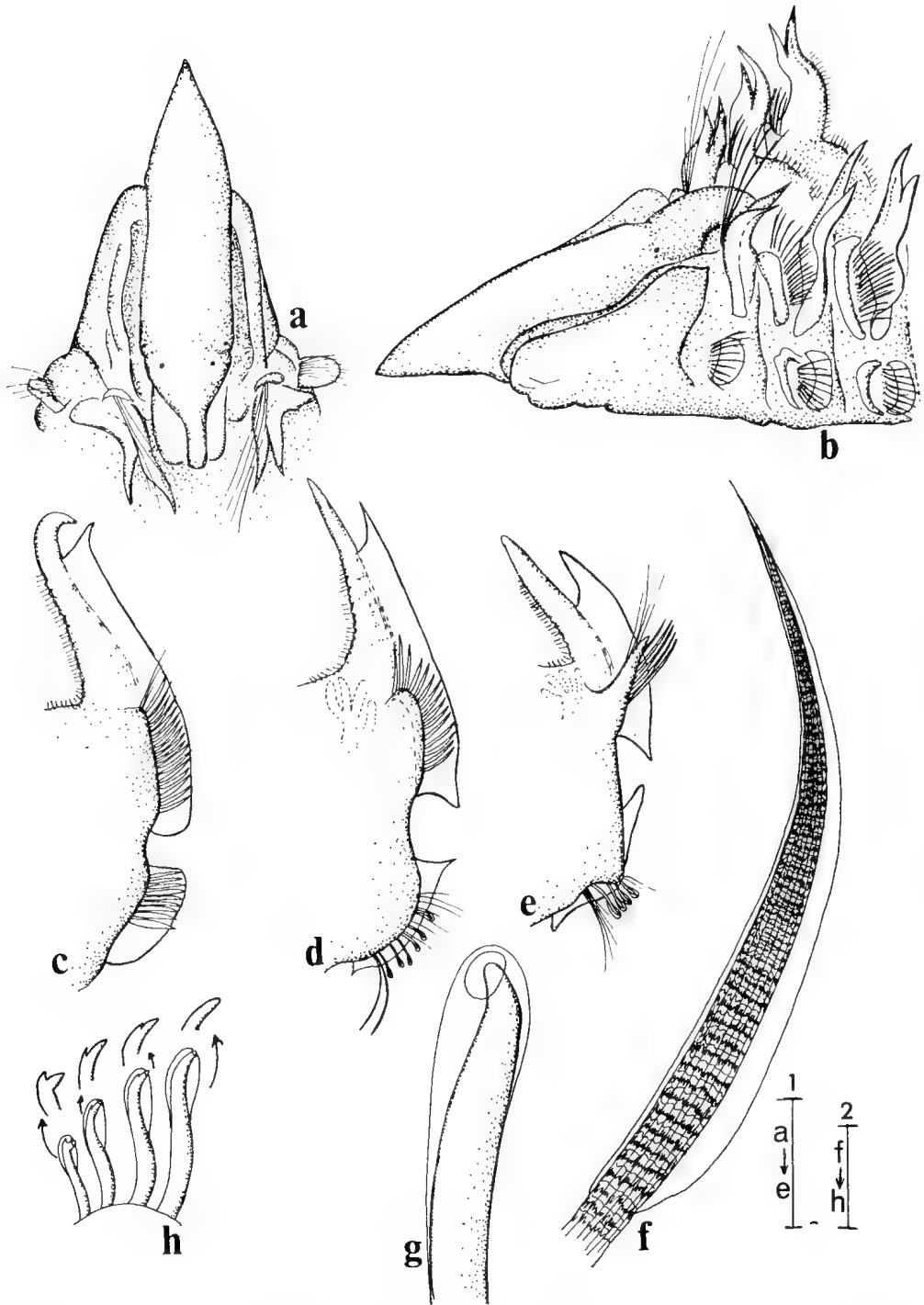


Figure 10—*Dispio glabrilamellata* sp. nov.—a, anterior end, dorsal view; b, anterior end, lateral view; c, left setiger 9, anterior view; d, left setiger 35, anterior view [broken lines indicate location of accessory branchiae on posterior side]; e, left setiger 80, anterior view [same with accessory branchiae]; f, anterior capillary notoseta; g, unidentate hooded hook; h, neuropodial fascicle of hooded hooks from juvenile showing bidentate (unworn) grading into unidentate (worn) hooded hooks [insets amplify details, not to scale]. [Scale 1 = 100  $\mu$ m; 2 = 50  $\mu$ m]

**Remarks:** *Dispio* was reviewed by Pettibone (1963) and Foster (1971). Four species were known at that time: *D. uncinata* Hartman, 1951 from the Gulf of Mexico; *D. magna* (Day, 1955) from South Africa; *D. schusteriae* Friedrich, 1956 from Central America; and *D. re-manei* Friedrich, 1956 from Central America. The two latter species were noted by Foster (1971) to be incompletely described. She noted a wide range of variability in the number and distribution of serrations of the parapodial lamellae in specimens of *D. uncinata* from North America, the Caribbean Sea and Chile. Since these characters were ones which Friedrich (1956) had used to justify his 2 species, Foster strongly suggested that they were probably conspecific with *D. uncinata*, but did not formally place them into synonymy. We concur with Foster's implied synonymy of Friedrich's 2 species with *D. uncinata*, but prefer to delay a formal referral until the type material can be located and examined. Foster considered *D. magna* to be a distinct species because it completely lacks parapodial serrations and its accessory branchiae are reduced to short nodules. *Dispio maroroi* Gibbs, 1971 from the Solomon Islands also falls within the limits of variability for *D. uncinata* (see Light, 1977; 1978) and should probably be referred to synonymy. Like *D. magna*, *D. glabrilamellata* lacks parapodial serrations, but like *D. uncinata* has digitiform accessory branchiae.

The transversely barred capillary setae of *D. glabrilamellata* would at first glance appear Light (1978), however, has found similar setae in *D. uncinata* from California.

The occurrence of bidentate hooded hooks in juveniles of *D. uncinata* was reported by Foster (1971) and have been observed in larval stages of the same species (Blake, unpublished data). We have also found such hooks in juvenile *D. glabrilamellata*; in a single fascicle there is a gradation of wear from the bidentate to unidentate condition, suggesting that unidentate hooks can result from worn bidentate hooks (however, see Foster, 1971, p. 78).

**Distribution:** Queensland; New South Wales; Victoria.

### Genus *Australospio* gen. nov.

**Type-species:** *Australospio trifida* sp. nov. Gender, feminine.

**Diagnosis:** Prostomium with both anterior pointed projection and sub-distal lateral horns. No occipital cirrus. Peristomium reduced, with poorly-developed lateral wings. Proboscis eversible, sac-like. Branchiae from setiger 1, continuing almost to posterior end, basally fused with notopodial lamellae in anterior setigers, becoming nearly free posteriorly. Notopodial lamellae well-developed, entire; neuropodial lamellae well-developed, tending towards bilobate condition in middle setigers. Notosetae all capillaries. Neuropodial setae including capillaries, hooded hooks and inferior sabre-like setae. Nature of pygidium unknown.

**Remarks:** *Australospio* is closely allied to *Scolecopsis* Blainville, *Aonides* Claparède and *Dispio* Hartman in having gills and a pointed prostomium. *Australospio* differs in also bearing lateral horns on the prostomium, a characteristic typical of *Malacoceros* Quatrefages, *Rhynchospio* Hartman and *Scolecopides* Ehlers; however, in the last 3 genera, the prostomium is not anteriorly pointed. The branchiae begin on setiger 1 in both *Australospio* and *Dispio* and on setiger 2 in *Aonides* and *Scolecopsis*. The notopodial lamellae are at least basally fused to the branchiae in *Dispio*, *Australospio* and *Scolecopsis*, whereas they are completely free in *Aonides*. The hooded hooks are bidentate in *Australospio*, bidentate to tridentate in *Aonides*, unidentate in adult *Dispio* species and range from unidentate to multidentate in species of *Scolecopsis*. Only a single species, *Australospio trifida* sp. nov. is known.

### *Australospio trifida* sp. nov.

(Figure 11)

*Scolecopsis* sp. Hutchings, 1974, p. 182.

**Material examined:** NEW SOUTH WALES. Botany Bay, Towra Beach, NSWFS Stations 286 (3 PARATYPES, NMV G2902); 298 (6 PARATYPES, AM W13002); 300 (1, AM W13003); 303 (2, AM W13004); 307 (3, AM W13005); 310 (HOLOTYPE, NMV G2901; 5 PARATYPES, NMV G2903); Towra Point, NSWFS Stations 287 (6, AM W13006); 292 (3, AM W13007); 297 (2, AM W13008); Wallis Lake, *Zostera* bed, Dec. 1970, coll. Dixon and O'Gower (PARATYPE, AM W5006). VICTORIA. Western-

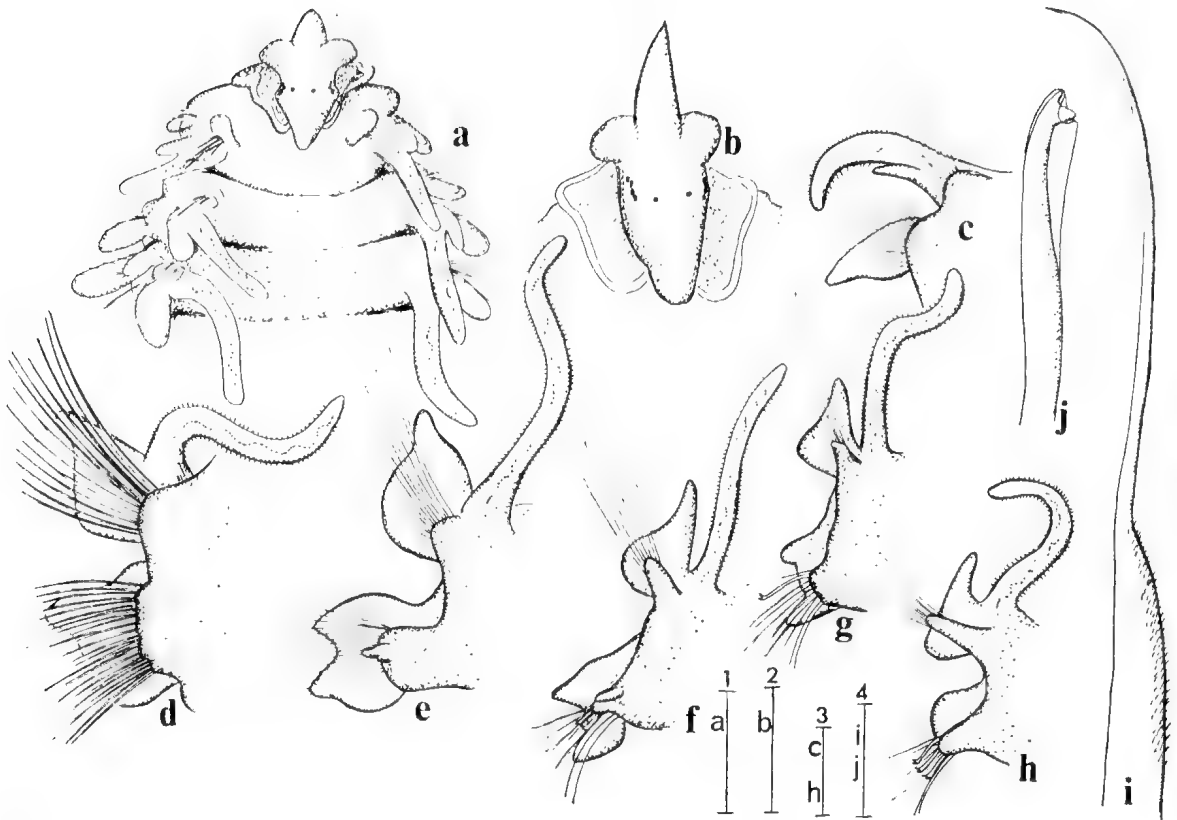


Figure 11—*Australospio trifida* gen et sp. nov.—a, anterior end, dorsal view; b, prostomium, dorsal view; c, right setiger 1, anterior view; d, right setiger 7, anterior view; e, right setiger 15, anterior view; f, right setiger 22, anterior view; g, right setiger 40, anterior view; h, right setiger 50, anterior view; i, neuroseta from setiger 7; j, bidentate hooded hook. [Scale 1 = 100  $\mu$ m; 2 = 50  $\mu$ m; 3 = 200  $\mu$ m; 4 = 30  $\mu$ m]

port, WPBES Stations 1713-2 (PARATYPE, NMV G2904); 1716-3 (PARATYPE, NMV G2905); Port Phillip Bay, Hobsons Bay, 14 April 1977, coll. J. E. Watson (3, NMV G2998).

**Description.** Only incomplete specimens available. A moderate-sized species, up to 12 mm long and 3 mm wide for 55 setigers. Holotype a 50 setiger fragment, 12 mm long and 1.8 mm wide. Body widest anteriorly and dorsoventrally flattened, tapering posteriorly, becoming oval in cross section. Body opaque white in alcohol, but with paired mid-ventral black pigment spots on setigers 2-10.

Prostomium anteriorly pointed, with 2 la-

terally projecting horns (Fig. 11a-b); caruncle reduced, extending posteriorly just into setiger 1. Three to 5 pairs of red, circular eyes. Peristomium reduced ventrally, enveloping prostomium laterally as indistinct wings, palps basally thickened, extending posteriorly for 11-12 segments.

Branchiae from setiger 1, basally fused to dorsal lamellae in anterior and middle setigers, free in posterior setigers; branchiae long and thin throughout with cilia on both inner and outer margins.

Dorsal lamellae short and cirriform on setigers 1-3 (Fig. 11c), becoming broad and leaf-like through setiger 7 (Fig. 11d-e), smaller in middle and posterior setigers (Fig. 11f-h); posterior setigers with prolonged finger-like notopodial lobe (Fig. 11f-h); ventral lamellae leaf-like, entire in anterior setigers, narrow at first (Fig. 11c), becoming broader (Fig. 11d) by setiger 7; lamellae bilobed in middle and posterior setigers (Fig. 11e-g), again becoming entire in far posterior setigers (Fig. 11h).



Setal fascicles arranged in 2 dorsoventral tiers on setigers 1-3, increasing to 4 tiers over setigers 4-11, subsequently diminishing to 2 tiers by setiger 14, with a single tier by setiger 15. Setigers 6-9 conspicuous, appearing modified with heavy thickened capillaries (Fig. 11d) numbering up to 140 in both noto- and neuropodia. Notozetes all capillaries throughout; heavy notosetal capillaries of setigers 6-9 including both granulated and non-granulated types with sheaths only in the latter. Neuropodial capillaries of setigers 6-9 including granulated and unusual geniculate setae bearing fine bristles (Fig. 11i). Bidentate neuropodial hooded hooks (Fig. 11j) from setiger 15-22, numbering 2-3 per neuropodium and accompanied by capillaries and 3-4 granulated inferior sabre setae.

Nature of pygidium unknown.

*Remarks:* *Australospio trifida* is a unique spionid in having both a distally pointed prostomium and subdistal lateral prostomial horns. The species is also unusual in having an anterior modified region with thickened capillaries. Some of those capillaries are of a peculiar hirsuted geniculate type, heretofore unknown in the Spionidae and reminiscent of similar setae reported from species of the family Heterospionidae.

*Distribution:* New South Wales; Victoria. In mud, *Zostera* and *Posidonia* beds.

#### Genus *Malacoceros* Quatrefages, 1843

*Malacoceros* Quatrefages, 1843. *Type-species:* *Spio vulgaris* Johnston, 1827, designated by Pettibone, 1963.

*Colobranthus* Schmarda, 1861. *Type-species:* *C. tetracerus* Schmarda, 1861, by monotypy.

*Uncinia* Quatrefages, 1865. *Type-species:* *Colobranthus ciliatus* Keferstein, 1862 (= *C. tetracerus* Schmarda, 1861), by monotypy.

*Scolecopsis* Malmgren, 1867. *Type-species:* *Spio vulgaris* Johnston, 1827, by original designation.

*Diagnosis:* Prostomium with frontal horns; eyes present or absent; branchiae from setiger 1, partly fused with notopodial lamellae, extending for most of body length. With only capillary notosetae. Neurosetae include capillaries, hooded hooks and sabre setae. Pygidium with anal cirri.

*Remarks:* The present definition of *Malacoceros* conforms closely to that of Pettibone (1963) except that we prefer to elevate *Rhynchospio* to a full genus, thus separating out those species with branchiae from setiger 2.

Three species of *Malacoceros* have been identified in our collections, of which 2 are newly described.

#### KEY TO SPECIES OF *MALACOCEROS* FROM AUSTRALIA

- 1a. Neuropodial lamellae of middle and posterior segments with nipple-like projections. . . . . *M. indicus*
- b. Neuropodial lamellae of middle and posterior segments rounded, without projections (Fig. 12c) . . . . . 2
- 2a. Setiger 1 markedly reduced, with short branchiae (Fig. 13a); body without pigment. . . . . *M. reductus*
- b. Setiger 1 well-developed, with long branchiae (Fig. 12a); body with dark brown pigment. . . . . *M. tripartitus*

#### *Malacoceros indicus* (Fauvel, 1928)

*Scolecopsis indica* Fauvel, 1928a, p. 93; 1930, p. 35; 1953, p. 313; Monro, 1931, p. 25.

*Malacoceros indicus:* Pettibone, 1963, p. 99; Day, 1967, p. 477; Foster, 1971, p. 50.

*Material examined:* QUEENSLAND. Great Barrier Reef Expedition, 1929 (1, AM W2953).

*Remarks:* The single specimen agrees well with the description given by Foster (1971); it is probably one of the specimens studied by Monro (1931). The prostomium is T-shaped, and the caruncle extends posteriorly to setiger 2. There are no eyes. The branchiae are basally fused to the notopodial lamellae and begin on setiger 1. Notozetes are found on setiger 1 and tri- and quadridentate neuropodial hooded hooks are present from setiger 50. The middle and posterior neuropodial lamellae have nipple-like projections. Inferior tufts of neurosetal capillaries are present, each with about 20 setae per bundle. The pygidium was missing.

*Distribution:* Queensland, Great Barrier Reef; circumtropical.

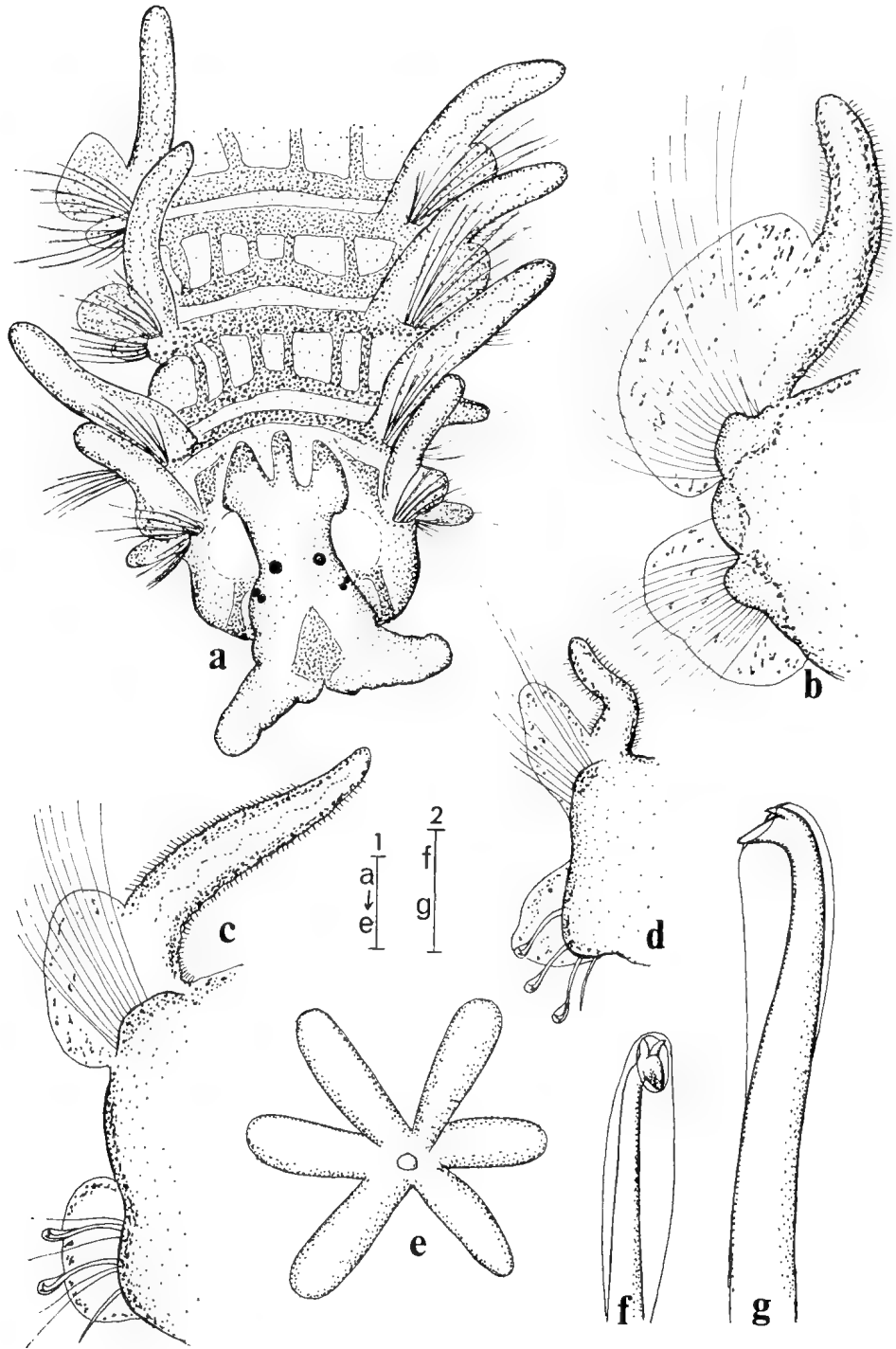


Figure 12—*Malacoceros tripartitus* sp. nov.—a, anterior end, dorsal view; b, right setiger 8, anterior view; c, right setiger 40, anterior view; d, right setiger 65, anterior view; e, pygidium, terminal view; f, tridentate hooded hook, frontal view; g, tridentate hooded hook, lateral view [Scale 1 = 200  $\mu$ m; 2 = 30  $\mu$ m]

**Malacoceros tripartitus** sp. nov.

(Figure 12)

*Material examined:* VICTORIA. Port Phillip Bay, Werribee, Little River, Station 6, MSG Monitoring Program (P609), coll. J. D. Kudenov, 11 Jan. 1977 (HOLOTYPE, NMV G2916; 9 PARATYPES, NMV G2917, 2919-2923); 14 April 1977 (2 PARATYPES, NMV G2918); Yarra River, MSG Benthic Survey, 10 Oct. 1975, coll. G. Poore and J. D. Kudenov, black mud, 7 m, Sta. 128/1 (42, NMV G2924); 128/4 (76, NMV G2925); 128/5 (341, NMV G2926).

*Description:* A moderately-sized species, up to 17 mm long and 1.1 mm wide for 85 setigers. Body widest anteriorly, gradually tapering posteriorly. Colour in alcohol dark brown, with dusky brown pigment granules distributed throughout epidermis in distinct banding patterns over dorsum, ventrum and all along body (Fig. 12a).

Prostomium T-shaped, with distinct lateral horns, continuing posteriorly as a peculiar trilobed caruncle to anterior margin setiger 2 (Fig. 12a). Three pairs of round eyes, trapezoidally arranged, posterior pair the larger; anterior pair formed of 2 partially fused spots (Fig. 12a). Palps inserted posterior to level of eyes, extending posteriorly to setigers 9-10. Peristomium reduced, lacking lateral wings.

Setiger 1 well-developed, with notosetae. Dorsal lamellae elliptical in anterior and middle body setigers (Fig. 12b-c), becoming elongate, and narrow in posterior setigers (Fig. 12d). Anterior neuropodial lamellae subquadrate (Fig. 12b), becoming elliptical in middle setigers (Fig. 12c), and subtriangular in posterior setigers (Fig. 12d). Anteriormost segments with thickened presetal noto- and neuropodial lobes (Fig. 12b).

Notosetae forming spreading fascicles of sheathed, non-granulated capillaries. Neurosetae including non-granulated capillaries, tridentate hooded hooks from setiger 31 and inferior sabre setae from setiger 25 (Fig. 12c-d); hooded hooks distinctly tridentate in frontal view (Fig. 12f), but appearing bidentate in lateral aspect (Fig. 12g).

Branchiae elongate, strap-like, fused to notopodial lamellae. Those on setiger 1 not as well-developed as on succeeding segments. All

branchiae marginally pigmented with brown granules.

Pygidium terminal with 6 anal cirri (Fig. 12e).

*Remarks:* *Malacoceros tripartitus* most closely resembles *M. tetracerus* (Schmarda) from Europe in having a similarly shaped prostomium. *M. tripartitus* has tridentate hooded hooks, a trilobed caruncle and a heavily pigmented body. *M. tetracerus* has bidentate hooded hooks, an entire caruncle and lacks body pigmentation. Foster (1971) pointed out that the hooded hooks of *Malacoceros* need to be examined under oil immersion in order to elucidate their structure; a re-examination of species such as *M. tetracerus* is necessary in order to improve our understanding of the systematics of the genus.

*Distribution:* Victoria, Port Phillip Bay, in mud.

**Malacoceros reductus** sp. nov.

(Figure 13)

*Material examined:* NEW SOUTH WALES. Burwood Beach, HDWBS Stations, Sept., Oct., Nov. 1975 (HOLOTYPE, AM W8906; 13 PARATYPES, AM W8882, 8904, 8905, 8907, 8908).

*Description:* A moderately-sized species, up to 16 mm long and 0.8 mm wide for 75 setigers. Body widest anteriorly, evenly tapering posteriorly; subrectangular in cross section. Colour in alcohol: whitish-brown.

Prostomium with anterior medial incision and very pronounced lateral horns; posteriorly a faint medial protuberance present between lateral nuchal processes that encompass palps (Fig. 13a). Two pairs of eyes, anterior pair the larger, each consisting of 2 fused ocelli; posterior pair round and small. Peristomium moderately developed, forming lateral wings. Palps extending posteriorly to setiger 6-7.

Setiger 1 reduced, but with notosetae. Anterior notopodia fused with branchiae (Fig. 13b-c); both rami of posterior parapodia emerging from raised basal mounds (Fig. 13d).

Notosetae with superior group of capillaries overlying main fascicle, the latter arranged in 2 tiers bearing sheathed, granulated capillaries (Fig. 13f), as well as non-granulated ones. Anterior setigers with about 20 setae per fascicle,

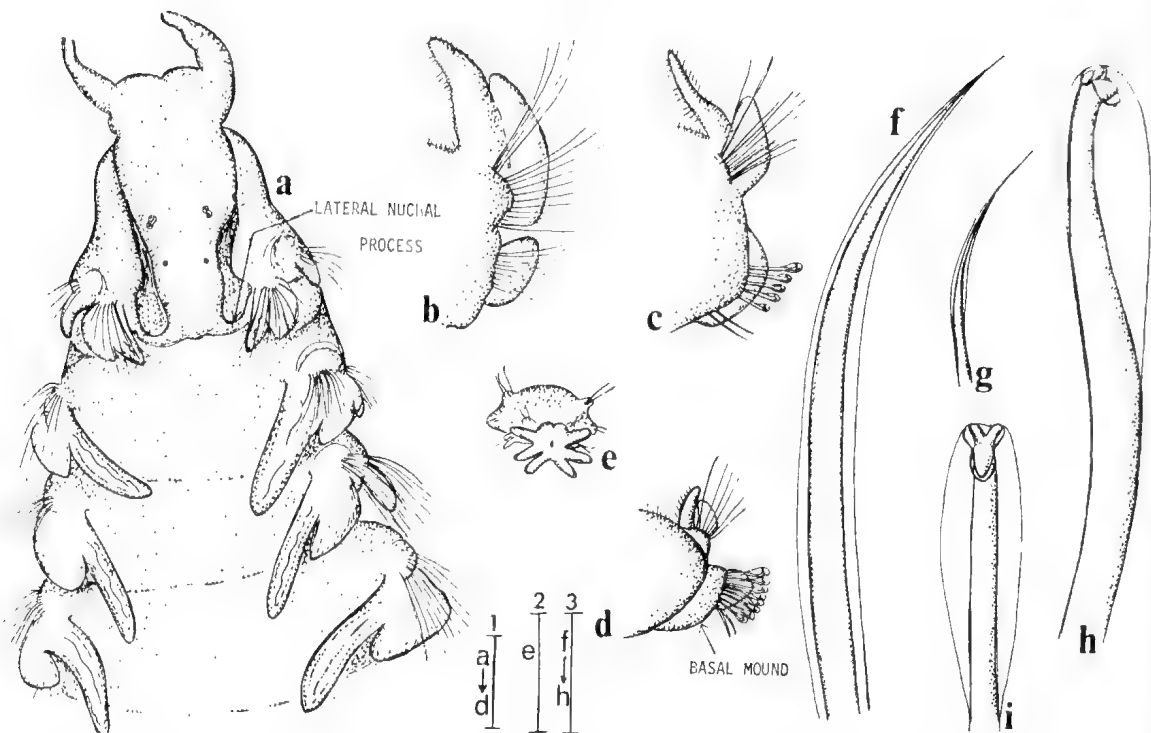


Figure 13—*Malacoceros reductus* sp. nov.—a, anterior end, dorsal view; b, left setiger 11, anterior view; c, left setiger 38, anterior view; d, left setiger 65, anterior view; e, pygidium; f, capillary notoseta; g, sabre seta; h, tridentate hooded hook, lateral view; i, tridentate hooded hook, frontal view. [Scale 1 = 200  $\mu$ m; 2 = 100  $\mu$ m; 3 = 20  $\mu$ m]

and about 5 in superior tuft; fewer setae per fascicle in middle and posterior setigers. Neurosetae include both granulated and non-granulated capillaries of which some are faintly spinous; with tridentate hooded hooks from setiger 20, replacing capillaries, and a single inferior sabre seta from setiger 20. Sabre setae with sheaths forming long distal processes (Fig. 13g). Hooded hooks with distinct, readily visible apical teeth (Fig. 13h-i).

Branchiae of setiger 1 very short, inconspicuous (Fig. 13a), those of setiger 2 more elongate, strap-like and fused to dorsal lamellae; branchiae becoming reduced in length by setiger 35; absent from last 10-12 setigers.

Pygidium terminal, small, with 3 pairs of

short, digitiform anal cirri and a pair of dorsal swellings (Fig. 13e).

**Remarks:** *Malacoceros reductus* most closely resembles *M. fuliginosa* (Claparède) in having a similarly shaped prostomium. In *M. reductus*, setiger 1 is distinctly reduced, tridentate hooded hooks are present from setiger 20-21 and pigmentation is lacking. In *M. fuliginosa*, the parapodia of setiger 1 are only slightly reduced, bidentate hooded hooks occur from setiger 30-40 and the body is heavily pigmented.

**Distribution:** New South Wales in beaches.

**Genus *Rhynchospio* Hartman, 1936 emended**

**Type-species:** *R. arenicola* Hartman, 1936, by monotypy.

**Diagnosis:** Prostomium with frontal horns, caruncle variously developed. Occipital tentacle absent. Eyes present. Branchiae from setiger 2, free from dorsal lamellae or only fused basally. With only capillary notosetae. Neurosetae including capillaries, hooded hooks and sabre setae. Pygidium with cirri or lobes.

**Remarks:** *Rhynchospio* Hartman has been considered both as a full genus (Hartman, 1959;

Day, 1967; Fauchald, 1977a) and as a subgenus of *Malacoceros* (Pettibone, 1963; Foster, 1971). However, we consider the first appearance of the branchiae to be an important taxonomic characteristic for the family Spionidae. We therefore prefer to treat *Malacoceros* and *Rhynchospio* as full genera.

Foster (1971) and others have included the fusion of branchiae and lamellae in their definition of *Rhynchospio*. However, a basal fusion of these 2 elements is barely evident in the 2 valid species discussed by Foster (1971). In this study, we have found 2 previously undescribed species in which the branchiae and lamellae are entirely free from one another. The definition of *Rhynchospio* is accordingly amended herein. According to Hartman (1966) and Fauchald (1977a), spionids having branchiae and lamellae free from each other should be referred to the genus *Mesospio* Gravier, 1911. Such a conclusion is unacceptable, however, since Gravier (1911) clearly states in his discussion that *M. moorei* Gravier, 1911, the type-species, lacks frontal horns. His figures depict a spionid with an incised prostomium. *Mesospio* was referred to the genus *Microspio* Mesnil, 1896 by Foster (1971). We agree with that synonymy since Gravier's species, *Mesospio moorei*, agrees well with the generic definition of *Microspio*.

Foster (1971) reduced the number of valid species of *Rhynchospio* to 2. We are presently re-examining some of her proposed synonyms as part of another study, but for the time being are following her revision.

The following species are assigned to *Rhynchospio*<sup>1</sup>:

<sup>1</sup> *Rhynchospio microcera* Dorsey, 1977 is herein referred to the genus *Microspio*.

1. *R. glutaea*, Ehlers, 1897), p. 83. Straits of Magellan.  
*Scolecopsis cornifera* Ehlers, 1913, p. 509. *Fide* Pettibone, 1963.  
*Rhynchospio arenicola* Hartman, 1936, p. 51. *Fide* Foster, 1971.  
*Rhynchospio arenicola asiaticus* Khlebovitsch, 1959. *Fide* Foster, 1971.
2. *R. inflatus* Foster, 1971, p. 57. Bahamas.

3. *R. glycera* sp. nov. (see below). New South Wales.
4. *R. australiana* sp. nov. (see below). West Australia.

### *Rhynchospio glycera* sp. nov.

(Figure 14)

*Material examined*: NEW SOUTH WALES. Burwood Beach, HDWBS Station, Dec. 1975 (HOLOTYPE, AM W8903).

*Description*: Holotype incomplete, coiled, measuring approximately 8 mm long and 0.5 mm wide for 47 setigers. Body widest anteriorly, elliptical in cross section. Colour in alcohol: opaque white.

Prostomium well-developed, forming large, conical anterior projection bearing a pair of apical horns (Fig. 14a); with raised medially-incised ridge about half-way between anterior and posterior ends, bearing 2 pairs of trapezoidally arranged eyes. Caruncle posteriorly merging with a prominent occipital lobe bearing 2 pairs of digitiform nuchal organs arising from a common base (Fig. 14a). Palps missing. Peristomium greatly reduced, not visible in dorsal view. Muscular pharynx visible through body wall.

Setiger 1 reduced, with bluntly conical notopodial and quadrate neuropodial lamellae; both notosetae and neurosetae present (Fig. 14a). Notopodial lamellae free from branchiae, anterior ones quadrate, those of posterior region subclavate (Fig. 14b-c). Anterior neuropodial lamellae quadrate, posterior ones triangular (Fig. 14b-c).

Setal fascicles arranged in 2 parallel tiers. Notosetae all sheathed, non-granulated capillaries, with somewhat opaque, lightly bristled sheaths (Fig. 14d-e). Anterior notopodia with about 20 short and stout and 3 longer superior capillaries per fascicle (Fig. 14b); posterior notopodia with about 15 narrow capillaries and no superior ones (Fig. 14c). Capillaries of anterior setigers increase in length ventrally. Neurosetae sheathed, non-granulated, opaque, lightly bristled capillaries. No evidence of sabre setae. Anterior neuropodia with about 15 short and stout and 3 longer inferior capillaries (Fig. 14b). Posterior neuropodia with narrow capillaries and hooded hooks (Fig.

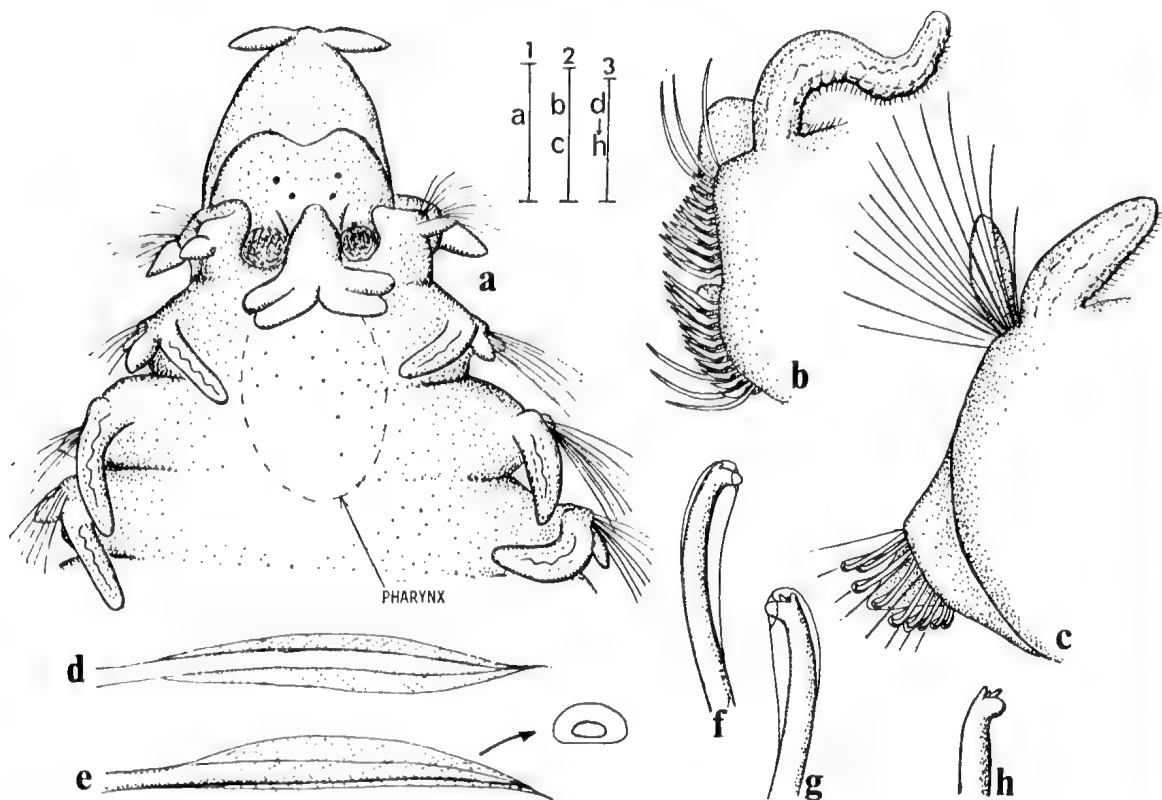


Figure 14—*Rhynchospio glycera* sp. nov.—a, anterior end, dorsal view; b, right setiger 8, anterior view; c, right setiger 45, anterior view; d-e, anterior capillary setae [inset, cross section of same]; f, quadridentate hooded hook, lateral view; g, same, anterolateral view; h, same without hood. [Scale 1 = 200  $\mu$ m; 2 = 200  $\mu$ m; 3 = 20  $\mu$ m]

14c); quadridentate hooded hooks from setiger 27, these appearing bidentate in lateral view, with inconspicuous, medial quaternary tooth inserted between 2 longer intermediate-length apical teeth (Fig. 14f-h), all 3 in 1 plane overlying enlarged main fang.

Branchiae on setiger 2, slightly shorter than subsequent ones, not fused to dorsal lamellae, and continuing to end of specimen. Inner margins ciliated; no evidence of transverse ciliated dorsal ridges. Nature of pygidium not known. *Remarks:* *Rhynchospio glycera* differs from other species of the genus in having a conical prostomium with apically-mounted frontal horns resembling the prostomial antennae seen

in the errant family Glyceridae, in having 4 nuchal organs arising from the caruncle and in the highly unusual arrangement of anterior notopodial capillaries, where they increase in length from the superior to inferior the position.

*Distribution:* New South Wales.

#### *Rhynchospio australiana* sp. nov.

(Figure 15)

*Material examined:* WEST AUSTRALIA. Perth, Cottesloe Beach, in calcareous algae and *Idanthrysus* tubes 3-66 m, coll. H. Paxton, 14 Feb. 1970 (HOLOTYPE, AM W4362).

*Description:* Holotype complete, measuring 5 mm long and 0.3 mm wide for 31 setigers. Body widest anteriorly, tapering gradually posteriorly, trapezoidal in cross section. Pigmentation in patterns of single red chromatophores dorsomedially on setigers 6-13; colour in alcohol: light brown.

Prostomium anteriorly prolonged, blunt bearing 2 broad lateral horns (right one miss-

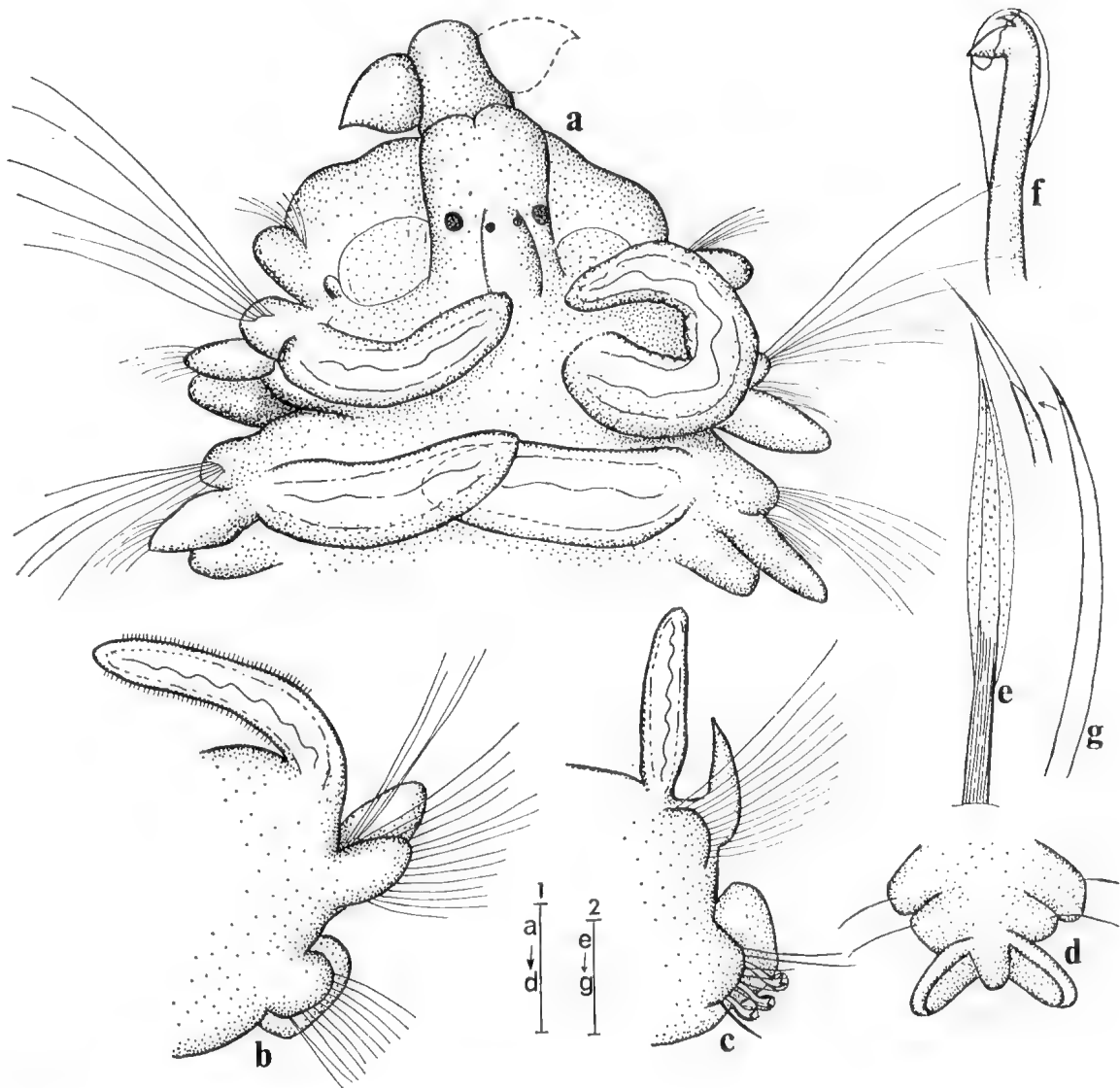


Figure 15—*Rhynchospio australiana* sp. nov.—a, anterior end, dorsal view; b, left setiger 5, anterior view; c, left setiger 23, anterior view; d, pygidium, dorsal view; e, superior capillary notoseta, setiger 5; f, tridentate hooded hook, lateral view; g, inferior sabre seta [inset, detail of same, not to scale]. [Scale 1 = 200  $\mu$ m; 2 = 20  $\mu$ m]

ing from the type), inflated, slightly incised where it overlies anterior margin of peristomium; with raised boss posteriorly (Fig. 15a). Two pairs of eyes, arranged in shallow cres-

cent, distal pair the larger. No occipital cirrus; palp scars on either side of prostomium behind eyes. Peristomium greatly reduced; lateral wings absent.

Setiger 1 with short notopodial lobes, lacking notosetae (Fig. 15a). Neuropodia laterally reduced, with inflated lamellae and capillary neurosetae. Both pre- and postsetal lobes of both rami inflated (Fig. 15b) in anterior setigers; the presetal lobes becoming reduced in posterior setigers (Fig. 15c); notopodial lamellae cylindrical, distally blunt, conical in setigers 2-13; thereafter digitate. Neuropodial

lamellae inflated, elliptical to irregularly rounded.

Notosetal capillaries distally sheathed, sublanceolate, granulated, arranged in 2 tiers per fascicle. Anterior tiers with 15-16 capillaries and 4-5 slightly isolated superior ones; middle setigers with 10 such capillaries, no superior tufts. Superior notopodial capillaries of setigers 2-6 with sheaths bearing large vesicles (Fig. 15e), inferior capillaries lacking such vesicles in sheaths; capillaries from posterior tiers with lightly bristled sheaths. Neurosetae arranged in 2 tiers; anterior tiers bearing 6-7 sheathed granulated capillaries per tier; posterior setigers with 2 superior capillaries, 3 hooded tridentate hooks and inferior sabre seta. Anterior capillaries similar to those of notopodia. Hooded hooks and sabre setae from setiger 8; the hooks with an inconspicuous tooth inserted above the more prominent apical tooth; margin of hood uneven, not serrated (Fig. 15f); sabre setae granulated, distally tapering with prolonged sheath (Fig. 15g).

Branchiae of setiger 2 slightly smaller than those of succeeding setigers; not fused to dorsal lamellae. Branchiae overlapping middorsally, continuing to within last 10 body segments; inner and outer margins ciliated, no transverse ciliary ridges.

Pygidium terminal, trilobate (Fig. 15d). Lateral lobes flattened, plate-like, subequal, the single middorsal lobe a small knob.

*Remarks:* *Rhynchospio australiana* differs from other species of the genus by the shape of the prostomium, which has a subterminal inflated, incised area and 2 broad lateral horns on the terminal portion, by lacking notosetae on setiger 1, the form of the vesiculated sheaths of the anterior capillary setae and the unique structure of the pygidium.

*Distribution:* West Australia.

#### Genus *Scolecopides* Ehlers, 1907

*Type-species:* *Scolecopides benhami* Ehlers, 1907, by monotypy.

*Diagnosis:* Prostomium with frontal or lateral horns. Branchiae present from setiger 1, limited to anterior setigers or continuing throughout body. Anterior setae mostly capillary, with ventral acicular spines present. Bidentate

hooded hooks present in both neuropodia and notopodia. Pygidium with cirri surrounding anus.

*Remarks:* The following species of *Scolecopides* are herein recognized:

1. *S. benhami* Ehlers, 1907, p. 14. New Zealand.
2. *S. viridis* (Verrill, 1873), p. 600 [as *Scolecopis*]. New Jersey.  
*S. arctius* Chamberlin, 1920, p. 17. *Fide* Foster, 1971.
3. *S. aciculatus* sp. nov. (see below). Victoria.

#### *Scolecopides aciculatus* sp. nov.

(Figure 16)

*Material examined:* VICTORIA. Westernport, Flinders, in sand on rock platform, 15 Dec. 1974, coll. J. D. Kudenov (HOLOTYPE, NMV G2891; 100+ PARATYPES, NMV G2892); Port Phillip Bay, Werribee, MSG Monitoring Programme (P609), coll. J. D. Kudenov, 11 Jan. 1977, Stations 16 (24, NMV G2999); 18 (81, NMV G3000-3001); 20 (39, NMV G3002-3003).

*Description:* A large species, measuring up to 37 mm long and 1.5 mm wide for 140 setigers. Body dorsoventrally flattened anteriorly, becoming cylindrical and narrower posteriorly. Colour in alcohol: tan to brown.

Prostomium broadly rounded on anterior margin, bearing 2 lateral horns (Fig. 16a). Posteriorly, prostomium tapering as blunt caruncle terminating at posterior margin of setiger 1; eyes absent; palps short, thick, extending posteriorly to setiger 8.

Setigers 1 and 2 well-developed, but notopodial lamellae and branchiae shorter than on succeeding setigers. Anterior notopodial lamellae elongate, foliaceous, fused basally with branchiae (Fig. 16c); posterior notopodial lamellae shorter, similarly fused to branchiae (Fig. 16d). Neuropodial lamellae much smaller, less foliaceous than those of notopodia.

Capillary notosetae lacking granulations or sheaths. Capillary neurosetae with minute granulations near tips in setigers 1-6, mostly replaced in setigers 6-8 with 2 dorsoventral tiers of acicula, but with a few inferior capillaries remaining (Fig. 16c); acicula sharply pointed or distally blunt (Fig. 16e), blunted acicula thicker and darker than pointed ones; acicula becoming partially replaced by capillary setae



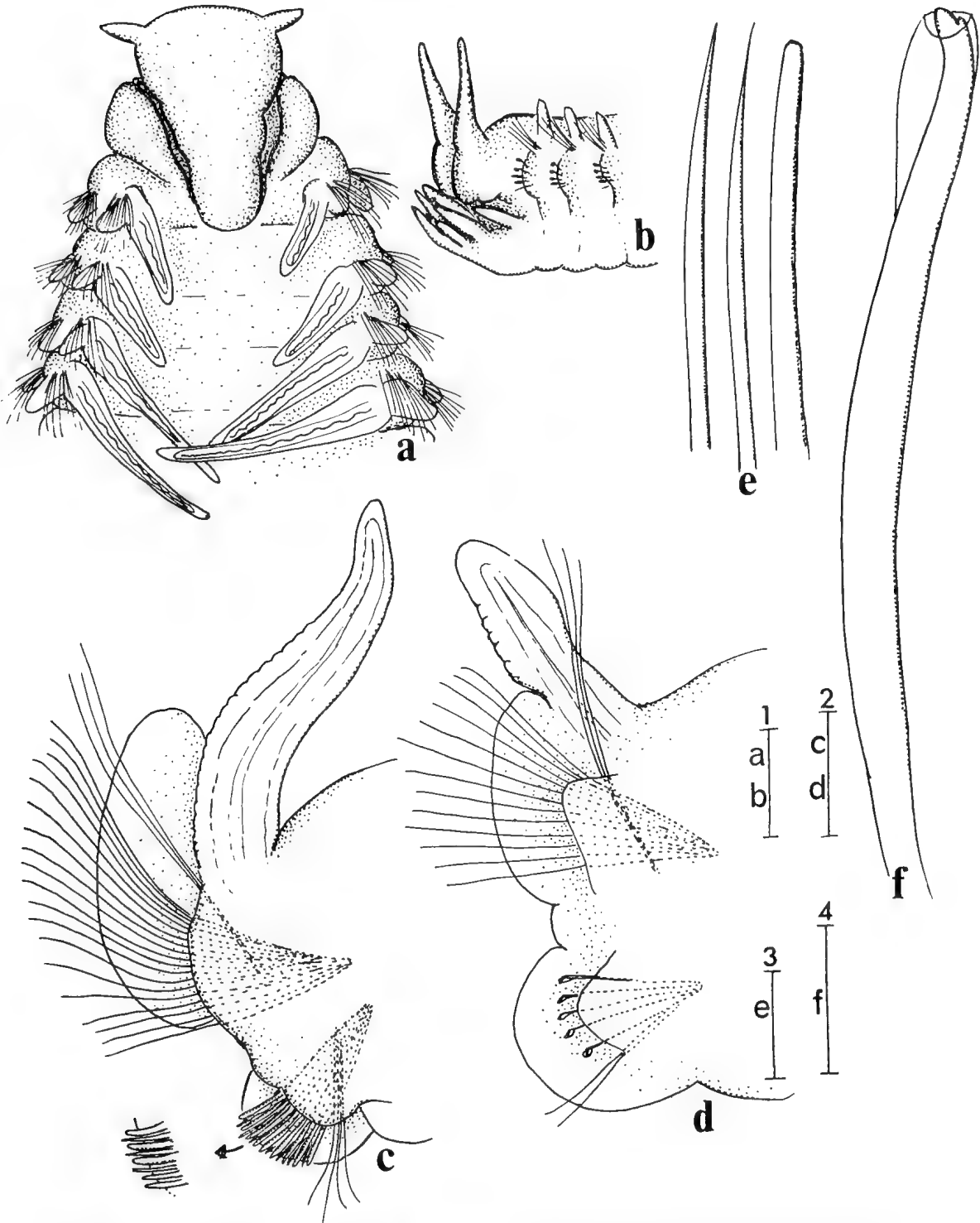


Figure 16—*Scolecolepides aciculatus* sp. nov.—a, anterior end, dorsal view; b, posterior end, lateral view; c, right setiger 13, anterior view; d, right setiger 60, anterior view; e, acicular neurosetae from anterior setigers showing different forms; f, hooded hook. [Scale 1 = 200  $\mu$ m; 2 = 200  $\mu$ m; 3 = 20  $\mu$ m; 4 = 20  $\mu$ m]

before first bidentate hooded hooks on setiger 39-55; hooded hooks with a greatly reduced inconspicuous secondary tooth (Fig. 16f). Notopodial hooded hooks beginning on setigers 80-85.

Branchiae begin setiger 1, long, basally fused to postsetal lobes, continuing to near posterior of body. Pygidium with 2 long superior cirri and up to 6 smaller ones surrounding terminal anus (Fig. 16b).

*Remarks:* *Scolecopides aciculatus* and *S. benhami* closely resemble each other in bearing lateral horns on the prostomium; they differ in this respect from *S. viridis*, which has short frontal horns. *S. aciculatus* has 20 or more neuroacicula of 2 types (pointed and blunt) from setiger 6-8, whereas *S. benhami* has only 4-5 pointed acicula beginning on setiger 9. The pygidium of *S. aciculatus* has 2 long superior cirri and 6 smaller ventral cirri, while *S. benhami* has numerous short cirri. Species of *Scolecopides* appear to be limited to waters of reduced salinity (George, 1966; Estcourt, 1967). *S. aciculatus* has been taken near sewage outfalls and may also tolerate low salinities.

*Distribution:* Victoria, Westernport Bay, Port Phillip Bay.

#### Genus *Laonice* Malmgren, 1867

*Laonice* Malmgren, 1867. *Type-species:* *Nerine cirrata* M. Sars, 1851, designated by Malmgren, 1867. *Spionides* Webster and Benedict, 1887. *Type-species:* *S. cirrata* Webster and Benedict, 1887 [Homonym, = *L. cirrata* (Sars)], by monotypy.

*Aricideopsis* Johnson, 1901. *Type-species:* *A. megalops* Johnson, 1901, monotypy.

*Diagnosis:* Prostomium anteriorly rounded to slightly incised, lacking frontal horns; caruncle extending posteriorly for variable number of setigers; occipital tentacle present. Peristomium reduced, generally without lateral wings. Branchiae from setiger 2, separated from dorsal lamellae, continuing for at least  $\frac{1}{2}$  of body. Notopodia with capillaries only; neurosetae including capillaries, hooded hooks and sabre setae. Interparapodial genital pouches present. Pygidium with anal cirri.

*Remarks:* A considerable degree of confusion persists regarding this genus because of 2 different approaches to species identification: Sö-

derström (1920) emphasized the distribution of genital pouches and recognized that a close relationship exists between their first appearance and the end of the atokous region. This approach was followed by Banse and Hobson (1968) who indicate that although the brood pouches of their newly described species, *L. pugettensis*, first appear from setiger 2-7, oocytes could be seen through the body wall at or just behind setiger 25 (Banse and Hobson, 1968, pp. 26-27); they recognized 5 species of *Laonice* in their paper. A second approach (Fauvel, 1927; Foster, 1971) questions the reliability of this relationship and points out that the distribution of genital pouches is highly variable. Foster (1971) considers *Laonice cirrata* (Sars, 1851) as the only valid species.

It is essential, however, to determine the role of genital pouches in reproduction in order to understand the taxonomic significance of their distribution on the body. At present there is little information available on reproduction in *Laonice*. Morphology of the genital pouches before and after spawning has been described by Söderström (1920) and Orrhage (1964). Hannerz (1956) cultured and described larvae isolated from plankton and determined that the eggs and sperm were spawned into sea water with development being entirely planktonic. No mention was made of the role genital pouches might play in reproduction. We are herein describing a species with an anterior region bearing eggs and genital pouches and a posterior region bearing sperm. The occurrence of anterior brood pouches may reflect the type of reproduction. In our simultaneous hermaphrodite, the genital pouches are more anteriorly located than in most forms. Forms with brood pouches beginning more posteriorly may have separate sexes or possibly represent stages in sequential hermaphroditism.

We prefer to re-examine the *Laonice*-complex utilizing the distribution of genital pouches, together with the configuration of the caruncle, capillary setae, hooded hooks and parapodia. In the present survey we have found 3 distinct forms of *Laonice*, all of which differ from the description of *L. cirrata* as given by Foster (1971). Although a thorough

study of *Laonice* from worldwide areas is needed, we feel justified in describing each form as a distinct species. Each is compared to *L. cirrata* as defined by Foster (1971); other known species of *Laonice* are insufficiently described.

KEY TO SPECIES OF *LAONICE* FROM  
SOUTHEASTERN AUSTRALIA

- 1a. Genital pouches from between setigers 1-2 or 2-3; hooded hooks bi- or quadridentate ..... 2  
 b. Genital pouches from between setigers 6-7; hooded hooks quadridentate (Fig. 17f) ..... *L. quadridentata*  
 2a. Hooded hooks bidentate, hood margins smooth (Fig. 18g); nuchal organs paired, extending to setiger 7; genital pouches beginning between setigers 2-3 ..... *L. bassensis*  
 b. Hooded hooks quadridentate (Fig. 17i), hood margin serrated (Fig. 17j); nuchal organ single, extending to setigers 50-55; genital pouches beginning between setiger 1-2 ..... *L. hermaphroditica*

*Laonice quadridentata* sp. nov.

(Figure 17a-g)

*Material examined:* VICTORIA. Port Phillip Bay, PPBES Stations 930/1 (HOLOTYPE, NMV G2954) and 37 PARATYPES as follows: 908/5 (1, NMV G2960); 909/2 (1, NMV G2976); 910/5 (1, NMV G2966); 925/5 (1, NMV G2961); 926/1 (2, NMV G2971); 926/2 (1, NMV G2957); 930/4 (1, NMV G2977); 931/3 (1, NMV G2964); 931/4 (1, NMV G2981); 932/2 (2, NMV G2973); 932/3 (1, NMV G2963); 932/4 (1, NMV G2967); 932/5 (3, NMV G2970); 933/4 (2, NMV G2959); 933/5 (1, NMV G2980); 936/1 (5, NMV G2958); 944/4 (1, NMV G2974); 946/1 (1, NMV G2962); 954/3 (1, NMV G2969); 957/2 (1, NMV G2972); 957/5 (1, NMV G2953); 965/4 (1, NMV G2979); 972/4 (1, NMV G2978); 982/4 (1, NMV G2955); 983/1 (1, NMV G2975); 983/2 (1, NMV G2956); 983/5 (1, NMV G2968); 985/5 (1, NMV G2965).

*Description:* A large species, up to 50 mm long and 3 mm wide for 136 setigers. Colour in alcohol: pink with faint grey pigment on lamellae.

Prostomium bluntly rounded, 2 pairs of eyes, all fused together into transverse patch; caruncle extending to setiger 18 (Fig. 17a);

with long cirriform occipital tentacle; peristomium forming slight lateral wings emphasizing grooves next to prostomium, with thick palps extending posteriorly for 6 setigers. Setiger 1 about  $\frac{1}{2}$  as large as setiger 2, with subrectangular to rounded parapodial lamellae, containing prominent setal fascicles. Notopodial lamellae from setiger 2 distally pointed, becoming elliptical (Fig. 17b); anterior neuropodial lamellae elliptical, distally blunt, subsequently becoming subtriangular and distally pointed (Fig. 17b).

Notosetae and neurosetae including sheathed, granulated capillaries. Quadridentate hooded hooks bearing 3 small, obscure apical teeth surmounting larger main fang (Fig. 17c-d) from neuropodium of about setiger 40, best seen in lateral view; inferior sabre setae from setiger 16, these heavily granulated, sheathed, distally prolonged (Fig. 17e).

Branchiae reduced at first, smaller than and free from notopodial lamellae, these gradually increasing in length in succeeding setigers, becoming longer than dorsal lamellae. Genital pouches first present between setigers 6-7 (Fig. 17f). Pygidium with 11-12 anal cirri (Fig. 17g). *Remarks:* *Laonice quadridentata* differs from *L. cirrata* in having quadridentate, rather than bidentate, hooded hooks and heavily granulated inferior sabre setae.

*Distribution:* Victoria, Port Phillip Bay.

*Laonice hermaphroditica* sp. nov.

(Figure 17h-k)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 29, Sept. 1972 (HOLOTYPE, NMV G2893); Sta. 35, Sept. 1972 (PARATYPE, QM G11591), Dec. 1972 (2 PARATYPES, QM G11592); Sta. 57, Dec. 1973 (PARATYPE, QM G11593), coll. W. Stephenson.

*Description:* A moderate-sized species, up to 24 mm long and 0.8 mm wide for 80 setigers. Body widest anteriorly, somewhat flattened, elliptical in cross section, becoming cylindrical posteriorly. Colour in alcohol: opaque white with diffuse grey on dorsal lamellae.

Prostomium bluntly rounded on anterior margin (Fig. 17h); caruncle extending posteriorly to setiger 50, present between dorsal transverse segmental lamellae; occipital ten-

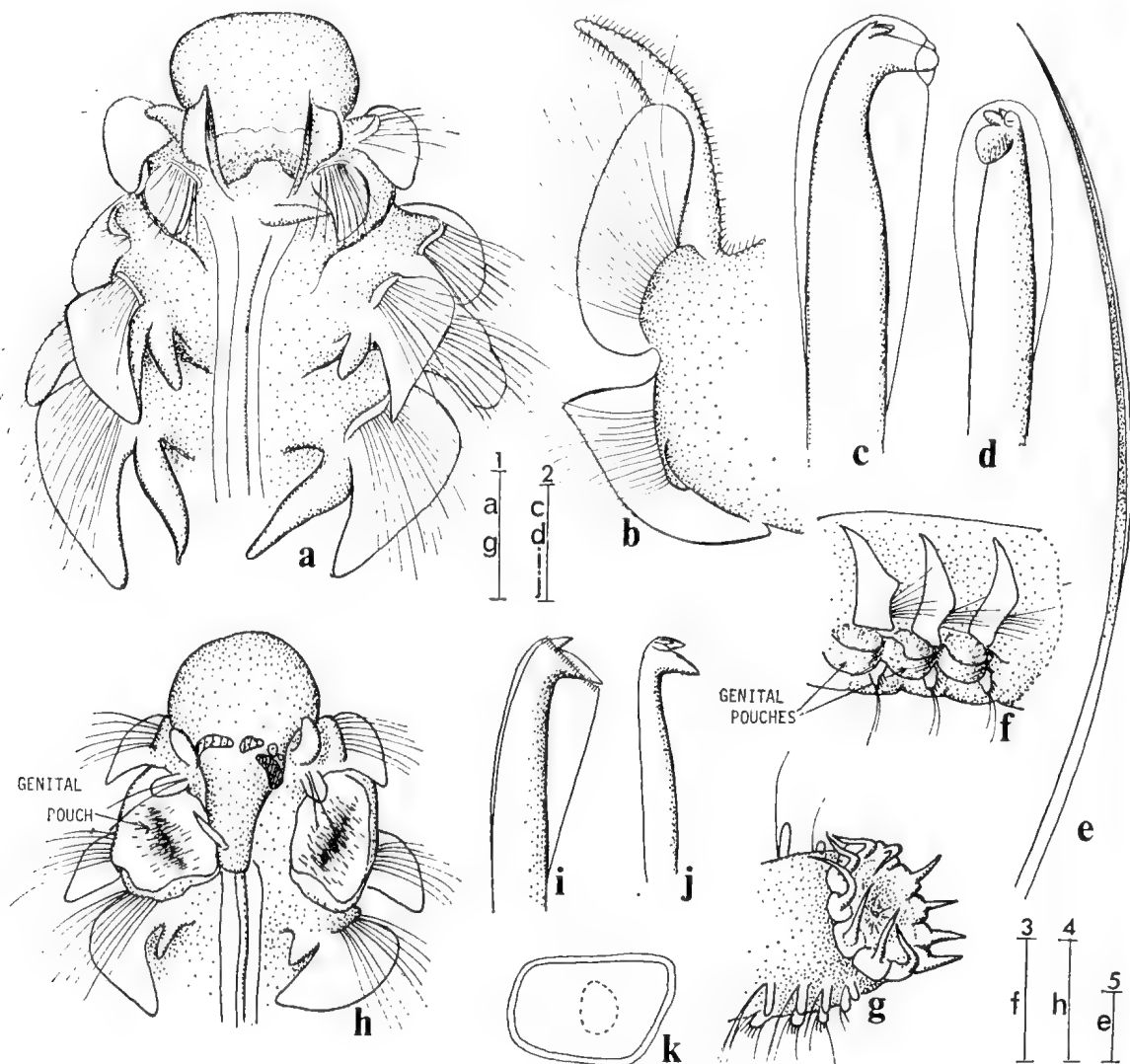


Figure 17—*Laonice quadridentata* sp. nov.—a, anterior end, dorsal view; b, right setiger 10, anterior view; c, quadridentate hooded hook, lateral view; d, quadridentate hooded hook, frontal view; e, sabre seta; f, lateral view showing brood pouches and dorsal lamellae; g, pygidium, dorsolateral view—*Laonice hermaphroditica* sp. nov.—h, anterior end, dorsal view; i, quadridentate hooded hook, lateral view; j, same, without hood, anterolateral view; k, oocyte [250  $\mu$ m]. [Scale 1 = 100  $\mu$ m; 2 = 20  $\mu$ m; 3 = 200  $\mu$ m; 4 = 50  $\mu$ m; 5 = 100  $\mu$ m].

tacle short, thin; 2 pairs of eyes, posterior pair with 1 member often missing, darker in colour, irregularly shaped and placed; anterior pair lighter in colour. Peristomium poorly-developed; palps missing.

Setiger 1 reduced with short, narrow notopodial lamellae bearing only 2-3 capillary setae (Fig. 17h); subsequent notopodial lamellae broad, bluntly rounded. Anterior neuropodial lamellae foliaceous, distally pointed, subsequently becoming reduced and rudimentary.

Notopodia with sheathed capillaries; quadridentate hooded hooks in neuropodia from setigers 24-25, often appearing bidentate in lateral view (Fig. 17i-j); aperture of hood distinctly serrated (Fig. 17i).

Nature of pygidium unknown. Genital pouches first present between setigers 1-2, these large, delicate and easily detached. Large primary oocytes, up to 300  $\mu\text{m}$  in diameter present in anterior 54-55 setigers (Fig. 17k). Short headed sperm present in coelomic cavity from about setiger 56.

*Remarks:* *Laonice hermaphroditica* differs from *L. cirrata* in having quadridentate, rather than bidentate hooded hooks, the caruncle is prolonged over 50 setigers instead of 12-30 and genital pouches first occur from setiger 1 rather than from setiger 4 or thereafter. *L. hermaphroditica* differs from *L. cirrata* and *L. quadridentata* in its apparent simultaneous hermaphroditism and in having hooded hooks with serrated apertures.

*Distribution:* Queensland, Moreton Bay.

#### *Laonice bassensis* sp. nov.

(Figure 18)

*Material examined:* VICTORIA. Bass Strait, ESSO-GIPPS Sta. 8, 106 m, dredged sandy clay bottom, 148° 43' 50"E. 38° 50' 8"S, May 1969 (HOLOTYPE, AM W13009); Sta. 9, 144 m, May 1969 (PARATYPE, AM W13010).

*Description:* Largest specimen, the holotype, measuring 13 mm long and 1.2 mm wide for 42 setigers. Body widest anteriorly, elliptical in cross section, becoming cylindrical posteriorly. Colour in alcohol: opaque white.

Prostomium medially incised on anterior margin (Fig. 18a-b); caruncle continuing to setiger 2, surrounded laterally by 2 nuchal organs extending posteriorly to setiger 7; with small digitiform occipital tentacle; no eyes. Peristomium reduced, with grooves separating prostomium from peristomium; palps missing.

Setiger 1 reduced, dorsally displaced, abutting against prostomium (Fig. 18a-b); anterior notopodial and neuropodial lamellae foliose (Fig. 18c), with rounded apices; posterior dorsal lamellae triangular, elliptical, with pointed inferior processes (Fig. 18d).

All setae arranged in 2 tiers. Capillaries sheathed, shafts with or without granulations distributed along striae (Fig. 18f); anterior notopodia with about 50 capillaries; posterior setigers with about 35 per ramus; neuropodial capillaries similar to those of notopodia, but fewer in numbers. Bidentate hooded hooks from setigers 22-23 (Fig. 18g). Inferior sabre setae from setigers 9-10.

Branchiae shorter than dorsal lamellae for first 4-5 segments, thereafter larger, not fused with lamellae. Genital pouches commencing between setigers 2-3 (Fig. 18e). Nature of pygidium unknown.

*Remarks:* *Laonice bassensis* differs from *L. cirrata* in having an incised, rather than an entire prostomium, paired rather than single nuchal organs, ventrally directed rather than triangular dorsal lamellae in posterior setigers and genital pouches beginning from setiger 2 rather than from setiger 4-50. *L. bassensis* differs from *L. hermaphroditica* and *L. quadridentata* in having bidentate rather than quadridentate hooded hooks.

*Distribution:* Victoria, Bass Strait.

#### General Remarks on the *Prionospio*-complex

Foster (1969; 1971) reorganized *Prionospio* Malmgren into 5 genera: *Prionospio*, *Paraprionospio* Caullery, *Apoprionospio* Foster, *Aquilaspio* Foster and *Minuspio* Foster. With exception of *Paraprionospio*, which has pinnate branchiae beginning on setiger 1, the other 4 genera have branchiae from setiger 2 and are separated on the basis of branchial form. Thus, variation in a single characteristic has been used to set aside 4 genera. Perhaps anticipating objections to the scheme, Foster (1971, p. 80) suggested that 5 subgenera of *Prionospio* might be more acceptable. Day (1973), however, disagreed with the need for *Apoprionospio* and Light (1977) preferred to use subgenera, but synonymized *Aquilaspio* with *Paraprionospio*. Other authors have used all 5 as full genera or as subgenera.

In the present study, we have found 2 heretofore undescribed Australian species which cause considerable confusion to Foster's arrangement. One represents a new genus: it has a well-developed peristomium, setiger 1 is

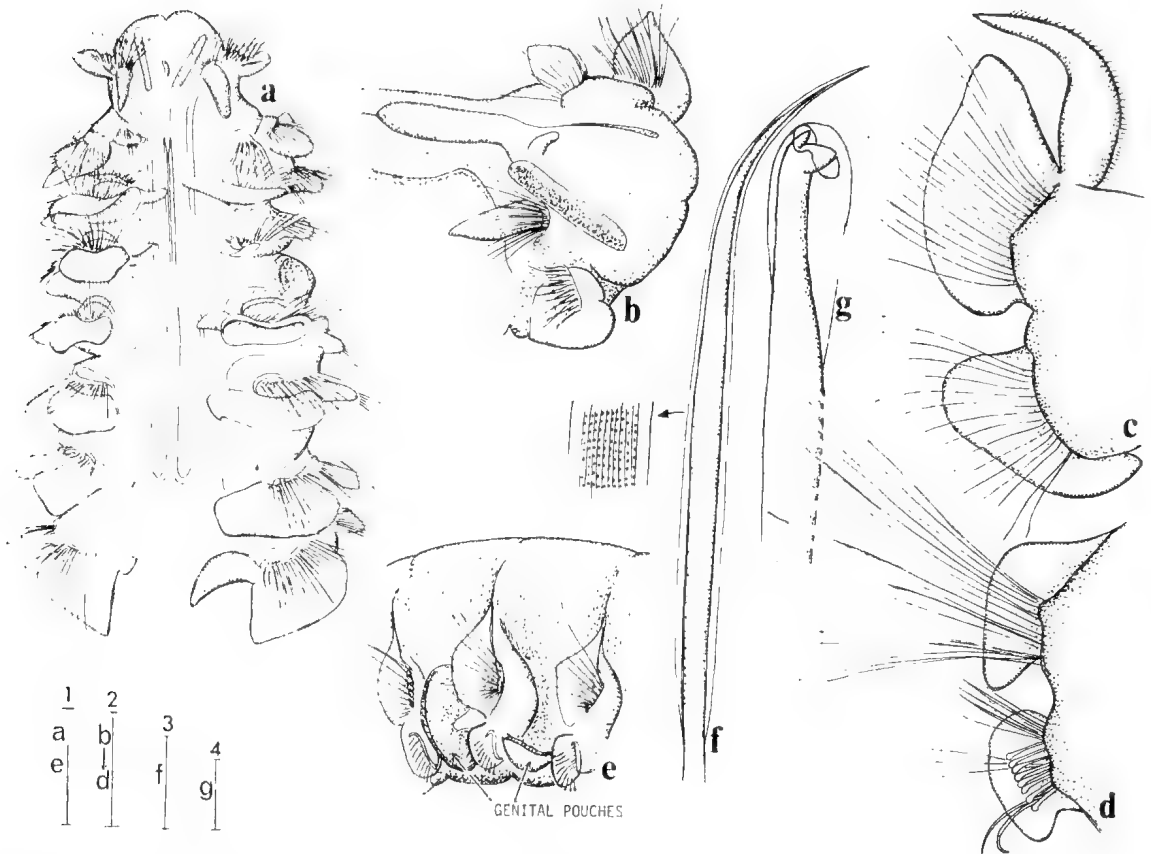


Figure 18—*Laonice bassensis* sp. nov.—a, anterior end, dorsal view; b, prostomium, anterolateral view; c, right setiger 8, anterior view; d, right setiger 41, anterior view; e, genital pouches from about setiger 50, lateral view; f, anterior capillary seta [inset, detail of shaft, not to scale]; g, bidentate hooded hook. [Scale 1 = 200  $\mu\text{m}$ ; 2 = 50  $\mu\text{m}$ ; 3 = 50  $\mu\text{m}$ ; 4 = 20  $\mu\text{m}$ ]

distinct and lacks a dorsal ridge between the parapodial bases, bears 18-22 pairs of branchiae from setiger 1 and has an unusual pygidium and lacks anal cirri. The second species belongs to the genus *Prionospio*, the first and third pairs of branchiae are pinnate and the second and fourth pairs cirriform. The pinnate branchiae have very few pinnules, however so few, in fact that some specimens are missing pinnules on one or both members of a gill-pair. Individual specimens might be thus classified with either *Prionospio* (*sensu*

*stricto*) or a modified version of *Apoprionospio*, based upon Foster's generic definitions.

We consider that the form of branchiae is not an adequate justification for separating genera when used as the sole criterion. We include a suite of what appear to be more conservative characteristics in arranging the *Prionospio*-complex. The position of the branchiae, degree of development of the peristomium, the distinctness and degree of development of setiger 1, structure of the hooded hooks and the form of the pygidium are considered the major generically important characteristics. Branchial form is considered to be of secondary importance. Any discussion of this complex must include the genus *Streblospio* Webster (see also Foster, 1971; Light, 1977). The following genera and subgenera are recognized in the *Prionospio*-complex:

1. *Paraprionospio* Caullery, 1914

2. *Orthoprionospio* gen. nov.
3. *Streblospio* Webster, 1879a
4. *Prionospio* Malmgren, 1867 (*sensu lato*)
  - a. Subgenus *Aquilaspio* Foster, 1971
  - b. Subgenus *Minuspio* Foster, 1971
  - c. Subgenus *Prionospio* (*sensu stricto*)  
[includes *Apoprionospio* Foster, 1971]

Characteristics separating these genera may be seen in Table 1.

The first 3 genera have branchiae beginning on setiger 1 and well-developed peristomia with lateral wings developed to various degrees (see Table 1). In *Paraprionospio* and *Orthoprionospio* setiger 1 is well-developed and distinct from the peristomium, while in *Streblospio* setiger 1 is reduced and fused with the peristomium. *Streblospio* and *Paraprionospio* share peculiarities of hooded hook structure and development of anterior ridges and collars, while *Orthoprionospio* has hooded hooks approaching the condition seen in *Prionospio* and lacks anterior dorsal ridges. *Paraprionospio*, *Orthoprionospio* and *Streblospio* all have different pygidial structures. In *Prionospio*, the branchiae begin on setiger 2, with the peristomium and setiger 1 both reduced and fused. The hooded hooks have inconspicuous secondary hoods. Various kinds of dorsal ridges or crests may be present or absent, but normally only on the postbranchial setigers. The pygidium in *Prionospio* is similar to that of *Paraprionospio*; it includes a medial and 2 ventrolateral cirri. About 30 species of *Prionospio* are currently recognized (Foster, 1971; Fauchald, 1972; this study). We follow Foster (1971) in recognizing groups of species according to whether the branchiae are all pinnate (subgenus *Aquilaspio*), all cirriform (subgenus *Minuspio*) or a combination of cirriform and pinnate (subgenus *Prionospio*). We do not consider these taxa as full genera since their separation is presently based on only a single character. However, we do consider that they are useful categories to separate species groups. *Apoprionospio* cannot be justified as even a subgenus because it is based on a particular ordered arrangement of pinnate and cirriform branchiae. We consider such a character to be important only at the species

level. In this regard we agree with Day (1973). We cannot agree with Light (1977) that *Aquilaspio* is a synonym of *Paraprionospio* because all of the major generic characters of *Prionospio* (Table 1) apply equally to species assigned to *Aquilaspio* and are very different from the generic characters of *Paraprionospio*.

*Streblospio* has not been encountered in our studies. *Paraprionospio pinnata*, *Orthoprionospio cirriformia* gen. et. sp. nov. and 9 species of *Prionospio*, including 5 new species, are described below.

#### Genus *Paraprionospio* Caullery, 1914

*Type-species*: *P. pinnata* (Ehlers, 1901), designated by Caullery (1914).

*Diagnosis*: Prostomium wedge-shaped, slightly curved on anterior margin, without posterior caruncle; peristomium well-developed forming erect lateral wings often completely overlapping prostomium. Setiger 1 well-developed, distinct from peristomium. Notopodial lamellae of setigers 1-5 enlarged, thereafter becoming smaller, rounded. Distinct transverse dorsal ridge present between branchial bases of setiger 1; 3 pairs of branchiae from setiger 1, all pinnate. Anterior setae all capillaries in both rami; posterior noto- and neuropodia with multidentate hooded hooks; hooded hooks with secondary teeth closely applied to main fang; with prominent secondary hood. Ventral sabre setae present. Pygidium with 1 long medial cirrus and 2 shorter ventrolateral cirri.

#### *Paraprionospio pinnata* (Ehlers, 1901)

*Prionospio pinnata* Ehlers, 1901, p. 163; 1908, p. 110; Augener, 1927, p. 351; Okuda, 1937, p. 247; Fauvel, 1953, p. 323; Hartman, 1960, p. 114; Imajima and Hartman, 1964, p. 286; Hartmann-Schröder, 1965, p. 211; Day, 1967, p. 488.

*Paraprionospio pinnata*: Foster, 1971, p. 102 (Synonymy).

*Material examined*: NEW SOUTH WALES. Stockton Bight, dredge, 5.9-9 m, coll. N. Ruello, July 1970 (2, AM W4410); Sydney, Malabar, 28 m, AMSBS Station CA+5 March 1974 (4, AM W6501); B3 S1 (1, AM W6502).

*Description*: Prostomium curved on anterior margin; spindle-shaped, no caruncle; 0-4 eyes. Segment 1 achaetous, together with peristomium forming lateral wings overlapping pro-

TABLE 1  
Taxonomic Criteria Separating Genera of the *Prionospio*-complex

Genus	Peristomium	Setiger 1	Branchiae a. Begin b. Structure	Dorsal ridges or collars	Hooded hooks	Pygidium
<i>Paraprionospio</i>	Enlarged with prominent wings	Well-devel., free from peristomium	a. Setiger 1 b. 3 pairs, all pinnate	Prominent ridge across setiger 1	Large apical teeth, closely applied to main fang; secondary hood prominent	With 1 long dorsomedial cirrus and 2 short ventromedial cirri
<i>Orthoprionospio</i>	Enlarged with moderate wings	Well-devel., free from peristomium	a. Setiger 1 b. 18-22 pairs all cirriform	Absent	Small apical teeth not closely applied to main fang; secondary hood not apparent	With 1 ventral lobe and 4 small lateral papillae
<i>Streblospio</i>	Enlarged with low wings	Reduced, fused to peristomium	a. Setiger 1 b. 1 pair, cirriform	Inconspicuous ridge across setiger 1; prominent hood or collar across dorsum of setiger 2	Large apical teeth not closely applied to main fang; secondary hood prominent	Simple, with 2 rounded lobes; appendages absent
<i>Prionospio</i>	Reduced, with or without lateral wings	Reduced, fused to peristomium	a. Setiger 2 b. 3-40 pairs, all pinnate, cirriform, or combination of both types	Absent. Some species with membranous crests across dorsum on post-branchial segments	Small secondary teeth not closely applied to main fang; secondary hood inconspicuous	With 1 long dorsomedial and 2 short ventrolateral cirri

stomium; palps long with conspicuous membranous basal sheath. Setiger 1 well-developed with prominent parapodial lobes and a conspicuous transverse dorsal ridge connecting bases of first pairs of branchiae. Anterior parapodial lamellae of setigers 1-5 foliose, those of neuropodia less foliaceous and smaller than in preceding segments; notopodia becoming progressively longer and thinner in posterior segments.

Anterior setae in both rami all capillaries. Notosetae anteriorly arranged in 3 tiers; capillaries appearing bilimbate, with prominent sheaths bearing granulations. Multidentate hooded hooks and sabre setae in neuropodia from setiger 9, accompanied by several capillaries; notopodial hooded hooks commencing

posterior to setiger 20, these hooks with 8 secondary teeth in 2 rows above main fang, with a clear primary hood and striated internal secondary hood, the latter tightly applied to shaft.

Pinnules of branchiae numerous, subject to various configurations depending upon stage of growth and or regeneration (*vide* Foster, 1971).

Pygidium bearing 1 long medial cirrus and 2 short lateral cirri, similar to those seen in the genus *Prionospio*.

*Distribution*: New South Wales; cosmopolitan.

Genus ***Orthoprionospio*** gen. nov.

*Type-species*: *Orthoprionospio cirriformia* sp. nov.

Gender, feminine.

*Diagnosis*: Prostomium rounded on anterior



margin; caruncle absent. Peristomium well-developed, forming prominent lateral wings alongside prostomium. Setiger 1 well-developed, distinctly separate from peristomium, parapodia indistinguishable from those of succeeding setigers; notopodial lamellae of all anterior setigers foliose, becoming reduced in posterior segments; dorsal ridges lacking. Branchiae beginning on setiger 1, 18-22 pairs, all cirriform. Anterior setae all capillary; multidentate hooded hooks in both neuropodia and notopodia of posterior segments; hooks with apical teeth not closely overlapping main fang; without secondary hood; inferior sabre setae present in middle and posterior segments. Pygidium with 1 reduced, conical ventral lobe and 4 very small lateral papillae.

*Remarks:* See Table 1 and foregoing discussion. A single species, *O. cirriformia* is known.

#### ***Orthoprionospio cirriformia* sp. nov.**

(Figure 19)

*Material examined:* NEW SOUTH WALES. Botany Bay, Georges River, Picnic Point, coll. NSWSP, 5 July 1972 (7, AM W13011). VICTORIA. Yarra River, MSG Benthic Survey, 10 Oct. 1975, coll. G. Poore and J. D. Kudenov, black mud, 7 m, Stations 128/1 (HOLOTYPE, NMV G2846; 12 PARATYPES, NMV G2847); 128/2 (3, NMV G3004); 128/4 (7, NMV G3005); 128/5 (7 PARATYPES, NMV G2848). TASMANIA. Derwent Estuary, 5 Jan. 1977, coll. R. Buttermore (TM K842).

*Description:* A moderate-sized species, up to 22 mm long for 100 segments. Body light tan to brown in alcohol with black pigment present on palps and between some anterior parapodia.

Prostomium broadly rounded on anterior margin, bell-shaped (Fig. 19b), without caruncle. Three pairs of eyes, anteriormost pair cup-shaped followed by more rounded pairs, all arranged in straight rows. Peristomium with raised lateral peristomial wings (Fig. 19a-b).

Setiger 1 well-developed with enlarged dorsal lamellae; those of all anterior setigers enlarged, subtriangular in shape (Fig. 19f); posterior notopodial lamellae reduced to short lobes; neuropodial lamellae smaller, more rounded. Notosetae including fascicles of delicate capillaries lacking granulations; neuro-

setae similar to notosetae but fewer in number; 2-3 granulated inferior sabre setae per neuropodium, and beginning setiger 18-22 (Fig. 19e); multidentate hooded hooks in neuropodia from setiger 29-34, and in notopodia from setiger 62-68; neuropodial hooks numbering 4-6 per fascicle accompanied by capillaries; hooks bearing 8 apical teeth in 2 rows above main fang (Fig. 19c-d); notopodial hooks in far posterior setigers long, projecting prominently from body and accompanied by long capillaries (Fig. 19g).

Branchiae long, cirriform, beginning setiger 1, continuing for 18-22 segments (Fig. 19a, f). Pygidium as described for genus (Fig. 19g-h).

*Ecology:* The species is common in areas of reduced salinity and according to R. Buttermore is '... the most numerous species in the Derwent Estuary [Tasmania]' (personal communication). The species is also common in the Yarra River (Poore and Kudenov, 1978 b).

*Distribution:* New South Wales; Victoria; Tasmania.

#### **Genus *Prionospio* Malmgren, 1867**

*Prionospio* Malmgren, 1867. *Type-species:* *P. steenstrupi* Malmgren, 1867, by monotypy.

*Ctenospio* M. Sars, 1867. *Type-species:* *C. plumosus* M. Sars, 1867, by monotypy.

*Apoprionospio* Foster, 1969. *Type-species:* *A. dayi* Foster, 1969, by monotypy.

*Diagnosis:* Prostomium more or less straight, medially incised or rounded on anterior margin, without frontal horns; caruncle variously elongated. Peristomium fused in varying degrees with setiger 1, often forming low lateral wings. Parapodia of setiger 1 reduced, notopodia on branchial bearing segments enlarged; postbranchial notopodia becoming smaller, inconspicuous; dorsal folds or crests present or absent on postbranchial segments, rarely on branchial segments. Branchiae all pinnate (subgenus *Aquilaspio* Foster, 1971), all cirriform (subgenus *Minuspio* Foster, 1971) or both pinnate and cirriform (subgenus *Prionospio* [*sensu stricto*]), branchiae always limited to anterior setigers. Anterior setae all capillaries; hooded hooks in posterior noto- and neuropodia; hooks bi-, tri- or multidentate; inferior sabre setae present. Pygidium with 1 long medial

- 3a. Three pairs of pinnate branchiae; low dorsal crest on setiger 7  
 ..... *P. aucklandica*
- b. Four pairs of pinnate branchiae; dorsal crests absent ..... *P. multipinnulata*
- 4a. First pair of branchiae long, pinnate, second and third pairs shorter, cirri-form, fourth pair long, thin, cirri-form (Fig. 20m); with genital pouches on anterior setigers ..... *P. ehlersi*
- b. Branchiae otherwise; genital pouches absent ..... 5
- 5a. First and third pairs of branchiae pinnate (pinnules sparse), second and fourth pairs cirriform (Fig. 22a); caruncle long, reaching to setiger 5  
 ..... *P. paucipinnulata*
- b. Branchiae otherwise; caruncle reaching to setiger 2 ..... 6
- 6a. First and fourth pairs branchiae pinnate, second and third pairs cirriform (Fig. 20a-b); hooded hooks multi-dentate (Fig. 21h) ..... 7
- b. First 3 pairs of branchiae cirriform, fourth pair pinnate (Fig. 23a); hooded hooks tridentate (Fig. 23d)  
 ..... *P. tridentata*
- 7a. Peristomium forming lateral peristomial wings (Fig. 20a) ..... *P. steenstrupi*
- b. Peristomium not forming lateral wings ..... 8
- 8a. Prostomium smoothly rounded on anterior margin (Fig. 20b); prominent dorsal crests on setigers 11-18 (Fig. 20d); first 3 pairs of branchiae short, fourth pair long (Fig. 20b)  
 ..... *P. australiensis*
- b. Prostomium broad or slightly incised on anterior margin (Fig. 21a); dorsal fold on setiger 5 and low dorsal crests on variable number of setigers from setiger 9 (Fig. 21c); first and fourth pairs of branchiae longest, second and third pairs short (Fig. 21a)  
 ..... *P. queenslandica*

***Prionospio (Prionospio) steenstrupi***

Malmgren, 1867

(Figure 20a)

*Prionospio steenstrupi* Malmgren, 1867, p. 202; Mes-

nil, 1897, p. 90; Söderström, 1920, p. 232; Fauvel, 1927, p. 60; Day, 1963, p. 418; 1967, p. 489; Hartman, 1965b, p. 152; Hartmann-Schröder, 1971, p. 325; Foster, 1971, p. 84 (Synonymy); Light, 1977, p. 80.

*Spiophanes tenuis* Verrill, 1879, p. 176; 1881, p. 320. *Fide* Pettibone, 1954, p. 282.

*Prionospio tenuis* Verrill, 1881, p. 370. *Fide* Foster, 1971, p. 84.

*Prionospio steenstrupi malayensis* Caullery, 1914, p. 355. *Fide* Foster, 1971, p. 84. [But see Fauchald, 1972, p. 196].

*Prionospio bocki* Söderström, 1920, p. 234. *Fide* Foster, 1971, p. 84 (Synonymy). [But see Fauchald, 1972, p. 197].

*Prionospio malmgreni* var. *dubia* Day, 1961, p. 489. *Fide* Foster, 1971, p. 84.

*Prionospio malmgreni*: of authors [*partim*]. [Not Claparède, 1870]. *Fide* Fauchald, 1972, p. 197; Light, 1977, p. 80.

*Material examined*: NEW SOUTH WALES—Wallis Lake, Forster, boatsheds, 0.3 m, *Zostera* beds, 24 May 1968, coll. H. Paxton (1, AM W4242; 2, AM W4254); Wallis Lake, weed bed mixed, Dec. 1970, coll. Dixon and O'Gower (1, AM W5018; 2, AM W5020); Charlotte Bay, thick weed, mud-clay, coll. Dixon and O'Gower, Dec. 1970 (1, AM W5021); Sydney, North Head, AMSBS Station, 32 m, May 1972 (AM W6505). VICTORIA. 113 km south Lakes Entrance, 93.6 m, 148° 24' 50"E-39° 00' 00"S, sand, coll. C. Phipps (1, AM W13012).

*Description*: A small species, up to 15 mm long for 170 setigers. Prostomium wedge-shaped, broadly rounded anteriorly, caruncle to posterior margin of setiger 1 (Fig. 20a); 2-3 pairs of eyes. Peristomium reduced, fused dorsally to setiger 1. Parapodia of setiger 1 well-developed with notopodial lamellae forming erect peristomial wings; notopodial lamellae thereafter more rounded, forming low transverse dorsal crests on some specimens. Anterior setae all capillaries; neuropodial sabre setae beginning on setiger 12; multidentate hooded hooks from setiger 15-18 ventrally and from setiger 30-40 dorsally; these hooks multidentate with 10-12 apical teeth arranged in 2 vertical rows above main fang. Four pairs of branchiae with first and fourth pinnate, second and third cirriform. Pygidium with 1 long and 2 short cirri.

*Remarks*: See comments below for *P. queenslandica*.

*Distribution*: New South Wales; Victoria; cosmopolitan.

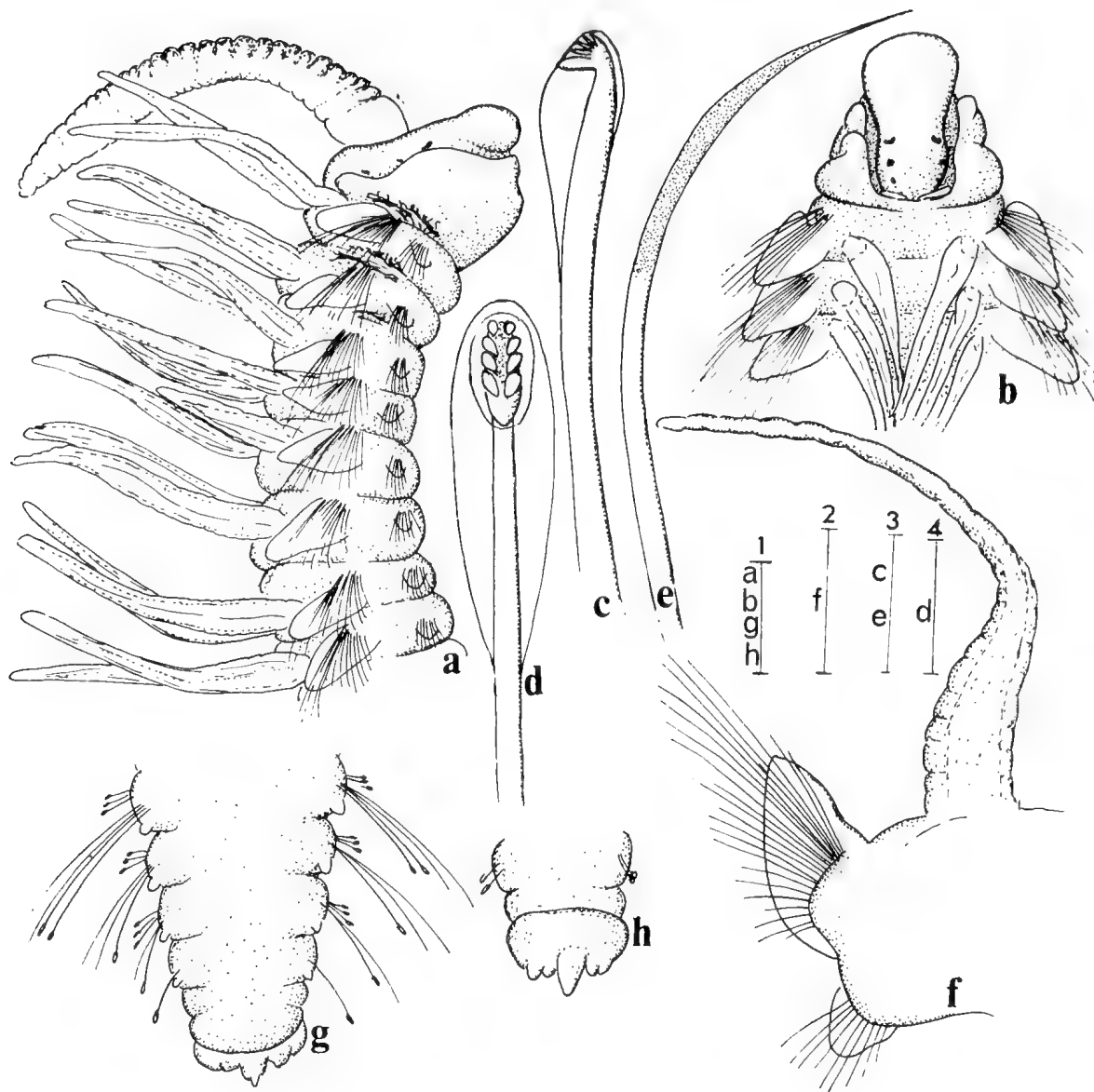


Figure 19—*Orthoprionospio cirriformia* gen. et sp. nov. —a, anterior end, lateral view; b, anterior end, dorsal view; c, hooded hook, lateral view; d, hooded hook, frontodorsal view; e, sabre seta; f, right setiger 8 in anterior view; g, posterior end, dorsal view; h, posterior end, ventral view. [Scale 1 = 200 μm; 2 = 200 μm; 3 = 20 μm; 4 = 10 μm]

cirrus and 2 short ventrolateral cirri or thickened lobes.

KEY TO SPECIES OF *PRIONOSPIO* FROM SOUTHEASTERN AUSTRALIA

- 1a. Branchiae all cirriform (Fig. 25a) ..... *P. cirrifera*
- b. Branchiae all pinnate or pinnate and cirriform ..... 2
- 2a. Branchiae all pinnate (Fig. 24a; 25b) ..... 3
- b. Branchiae both pinnate and cirriform (Fig. 20a-b) ..... 4

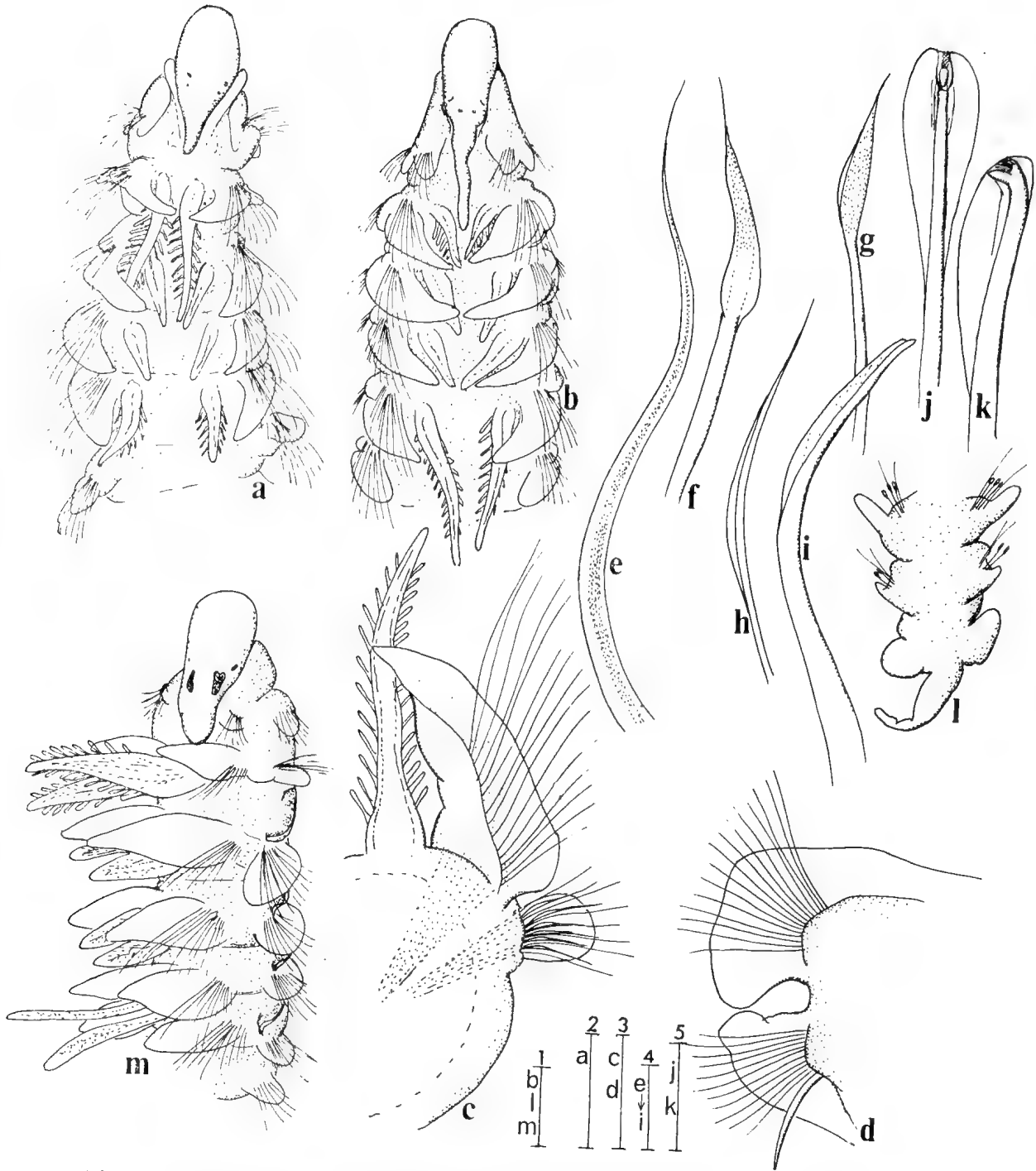


Figure 20—*Prionospio steenstrupi* Malmgren—a, anterior end, dorsal view—*Prionospio australiensis* nov. sp.—b, anterior end, dorsal view; c, left setiger 4, anterior view; d, right setiger 13, anterior view; e, capillary notoseta, setiger 4 from posterior tier; f, capillary notoseta, setiger 4 from anterior tier; g, sheathed neuroseta, setiger 4; h, capillary neuroseta, setiger 13; i, sabre seta; j-k, multidentate hooded hooks; l, posterior end, dorsal view—*Prionospio ehlersi* Fauvel—m, anterior end, dorsolateral view. [Scale 1 = 200  $\mu$ m; 2 = 200  $\mu$ m; 3 = 50  $\mu$ m; 4 = 20  $\mu$ m]

**Prionospio (Prionospio) australiensis** sp. nov.

(Figure 20b-1)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 8, Sept. 1976 (HOLOTYPE, NMV G2842; 14 PARATYPES, NMV G2843), coll. W. Stephenson.

*Description:* A moderately-sized species, up to 34 mm long and 0.75 mm wide for 50 segments. Colour in alcohol: opaque white.

Prostomium bluntly rounded on anterior margin, continuing posteriorly as narrow caruncle to middle setiger 2 (Fig. 20b). Two pairs of eyes, anterior pair cup-shaped, posterior pair irregularly shaped, both pairs about equal in size. Peristomium fused with setiger 1, not forming peristomial wings.

Setiger 1 well-developed with enlarged notopodia and notosetae, but smaller than succeeding setigers; setigers 2-5 with enlarged notopodial lamellae (Fig. 20c), thereafter lamellae rounded, extending across dorsum as prominent dorsal crests on setigers 11-18 (Fig. 20d); dorsal lamellae pronounced on remaining segments; neuropodia of anterior setigers small, rounded at first (Fig. 20c), gradually becoming wider. Capillary notosetae of setigers 1-11 arranged in 3 tiers, with first tier containing shorter lanceolate setae with prominent distal granulations and sheaths (Fig. 20f) and second and third tier containing longer setae with granulations throughout length of shafts and indistinct sheaths (Fig. 20e); thereafter dorsal capillaries delicate, arranged in 2 poorly differentiated tiers. Capillary neurosetae small, unilimbate (Fig. 20g-h). Inferior neuropodial sabre seta from setiger 11 (Fig. 20i); multidentate hooded hooks from neuropodia setiger 17 and from notopodia from about setiger 45; neuropodia with about 8 hooks accompanied by capillaries; these hooks with 8-12 apical teeth arranged in 2 rows above main fang (Fig. 20j-k).

Four pairs of branchiae with the first and fourth pairs pinnate, the second and third pairs cirriform (Fig. 20b). First 3 pairs short, the fourth long; pinnules numerous on posterior face of pinnate branchiae.

Pygidium with 1 long medial cirrus and 2 rounded lateral lobes (Fig. 20l).

*Remarks:* See comments below following *P. queenslandica*.

*Distribution:* Queensland, Moreton Bay.

**Prionospio (Prionospio) queenslandica** sp. nov.

(Figure 21)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 4, Sept. 1976 (HOLOTYPE, NMV G2839; 27 PARATYPES, NMV G2840), coll. W. Stephenson.

*Description:* A moderately-sized species, up to 23 mm long for 65 setigers. Body generally opaque white in alcohol.

Prostomium broad, with 4 small peaks on anterior margin, appearing slightly incised in some specimens (Fig. 21a); caruncle continuing posteriorly to posterior border of setiger 2; 2 pairs of eyes, anterior pair cup-shaped, posterior pair irregular, consisting of several individual ocelli fused together. Peristomium fused with setiger 1, lacking peristomial wings.

Setiger 1 well-developed, with notosetae but with smaller parapodial lobes than succeeding setigers. Setigers 2-5 with enlarged foliose notopodial lamellae (Fig. 21b), with well-developed transverse dorsal fold on setiger 5; subsequent dorsal lamellae low, merging with dorsum in setigers 6-8, but extending across dorsum on setigers 9-13 forming low dorsal crests (Fig. 21c), these low crests indistinct, but continuing on setigers posterior to 14 (Fig. 21d); neuropodia smaller, rounded in anterior setigers, becoming more elongated from about setiger 10. Notosetae and neurosetae of anterior setigers include spreading fascicles of stout, lanceolate granulated capillary setae (Fig. 21g) and delicate smooth capillary setae (Fig. 21f). One inferior neuropodial sabre seta per fascicle from setiger 10 (Fig. 21e), sabre setae bearing a prominent granular sheath; multidentate hooded hooks in neuropodia from setiger 14 and in notopodia from setiger 35-40, hooks numbering 7-8 in neuropodia, accompanied by capillaries; these hooks with 10-12 apical teeth arranged in 2 rows above main fang (Fig. 21h-i).

Four pairs of branchiae, first and fourth pairs long and pinnate, second and third pairs short, cirriform (Fig. 21a); with pinnules paired along axis of branchia, but absent from tip.

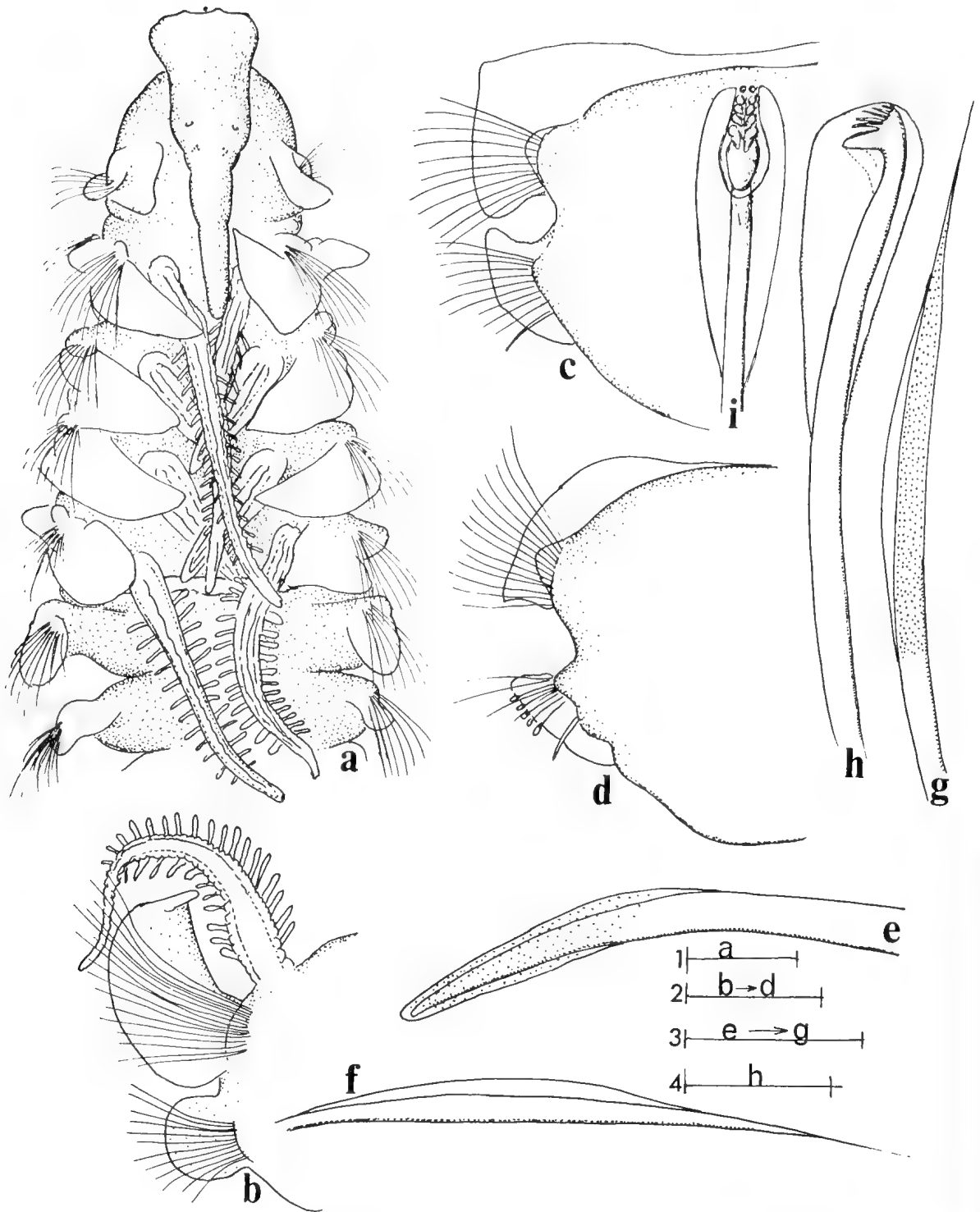


Figure 21—*Prionospio queenslandica* sp. nov.—a, anterior end, dorsal view; b, right setiger 5, anterior view; c, right setiger 12, anterior view; d, right setiger 20, anterior view; e, sabre seta; f, smooth capillary notoseta from setiger 5; g, granulated capillary notoseta from setiger 5; h, hooded hook, lateral view; i, same, frontal view. [Scale 1 = 200  $\mu$ m; 2 = 300  $\mu$ m; 3 = 50  $\mu$ m; 4 = 20  $\mu$ m; 5 = 10  $\mu$ m]

Pygidium with a single long medial cirrus and 2 lateral bulges.

**Remarks:** Foster (1971) redescribed *P. steenstrupi* and compared it with *P. fallax* Söderström, 1920. She noted that *P. fallax* possesses a high dorsal crest on setiger 7, which *P. steenstrupi* presumably lacks. *P. steenstrupi*, however, may possess or lack low or high dorsal crests on some postbranchial setigers (Foster, 1971; Light, 1977). Light (1977) found that specimens which he referred to *P. steenstrupi* from Canada, San Francisco Bay and southern California possess moderate to well-developed dorsal folds on a variable number of segments from setiger 7. He also suggested that *P. cristata* Foster, 1971 might be a juvenile of *P. steenstrupi*, since it has dorsal crests on setigers 7 and 9 and overlaps characteristics on *P. steenstrupi* from the northeastern Pacific.

None the less, after a study of Australian materials it is apparent to us that several closely related species forming a suite of siblings may eventually need to be sorted from populations currently lumped by Foster (1971) and others under the name *P. steenstrupi*.

There is no question that at least 3 species in the *steenstrupi* group occur in Australia. What we call *P. steenstrupi* has a reduced peristomium, which forms peristomial wings in conjunction with notopodia of setiger 1. *P. australiensis* and *P. queenslandica* on the other hand, have well-developed peristomia, but lack any development of lateral peristomial wings. *P. australiensis* is distinguished from *P. queenslandica* in having the prostomium smoothly rounded on the anterior margin instead of broad or slightly incised, by having prominent dorsal crests on setigers 11-18 instead of low crests from setiger 9, in lacking instead of having a dorsal fold on setiger 5 and in having a short pinnate gill on setiger 2, instead of a long one.

**Distribution:** Queensland, Moreton Bay.

***Prionospio (Prionospio) ehlersi* Fauvel, 1928**

(Figure 20m)

*Prionospio ehlersi* Fauvel, 1928b, p. 10; 1936, p. 61; Day, 1967, p. 490; Hartman, 1965a, p. 151; Hartman and Fauchald, 1971, p. 105; Gibbs, 1971, p. 170.

*Prionospio krusadensis*: Lee, 1976, p. 65. [Not Fauvel, 1929 = *P. aucklandica* Augener].

**Material examined:** QUEENSLAND. Moreton Bay, Middle Banks, Sta. 9, Sept. 1976 (2, NMV G2841), coll. W. Stephenson.

**Description:** A small species, up to 8 mm long and 0.8 mm wide for about 35 setigers. Colour in alcohol: opaque white.

Prostomium broadly rounded on anterior margin, caruncle short, terminating at posterior margin of setiger 1 (Fig. 20m). Two pairs of eyes, anterior pair small, inconspicuous, consisting of several small individual spots, posterior pair enlarged, irregularly shaped. Peristomium reduced, fused with setiger 1, without lateral wings.

Setiger 1 reduced, notosetae present with small noto- and neuropodia. Setigers 2-6 with enlarged subtriangular notopodial lamellae, these largest on setigers 2-4; following notopodia low, occasionally forming low ridges across dorsum, but prominent dorsal crests lacking; neuropodia small rounded throughout. With genital pouches between successive neuropodia of anterior segments beginning between setigers 2-3.

Anterior segments with dense fascicles of granular unilimbated capillary notosetae arranged in 3 tiers; neurosetae fewer, less dense; neuropodia with a stout inferior sabre seta and multidentate hooded hooks from setiger 20; 5-6 neuropodial hooks accompanied by capillaries; hooks with 6-8 apical teeth in 2 rows above main fang and a conspicuous secondary hood.

Four pairs of branchiae on setigers 2-5. First pair long, pinnate, second and third pairs short, cirriform with fourth pair long, thin, cirriform. Pygidium typical for genus.

**Remarks:** Specimens from Queensland agree well with descriptions from other areas. *P. ehlersi* is the only *Prionospio* observed in Australia to date with genital pouches. The branchial arrangement is unique.

**Distribution:** Queensland; Morocco; South Africa; eastern North America; South America; Solomon Islands; Korea.

***Prionospio (Prionospio) paucipinnulata* sp. nov.**

(Figure 22)

**Material examined:** VICTORIA. Port Phillip Bay,

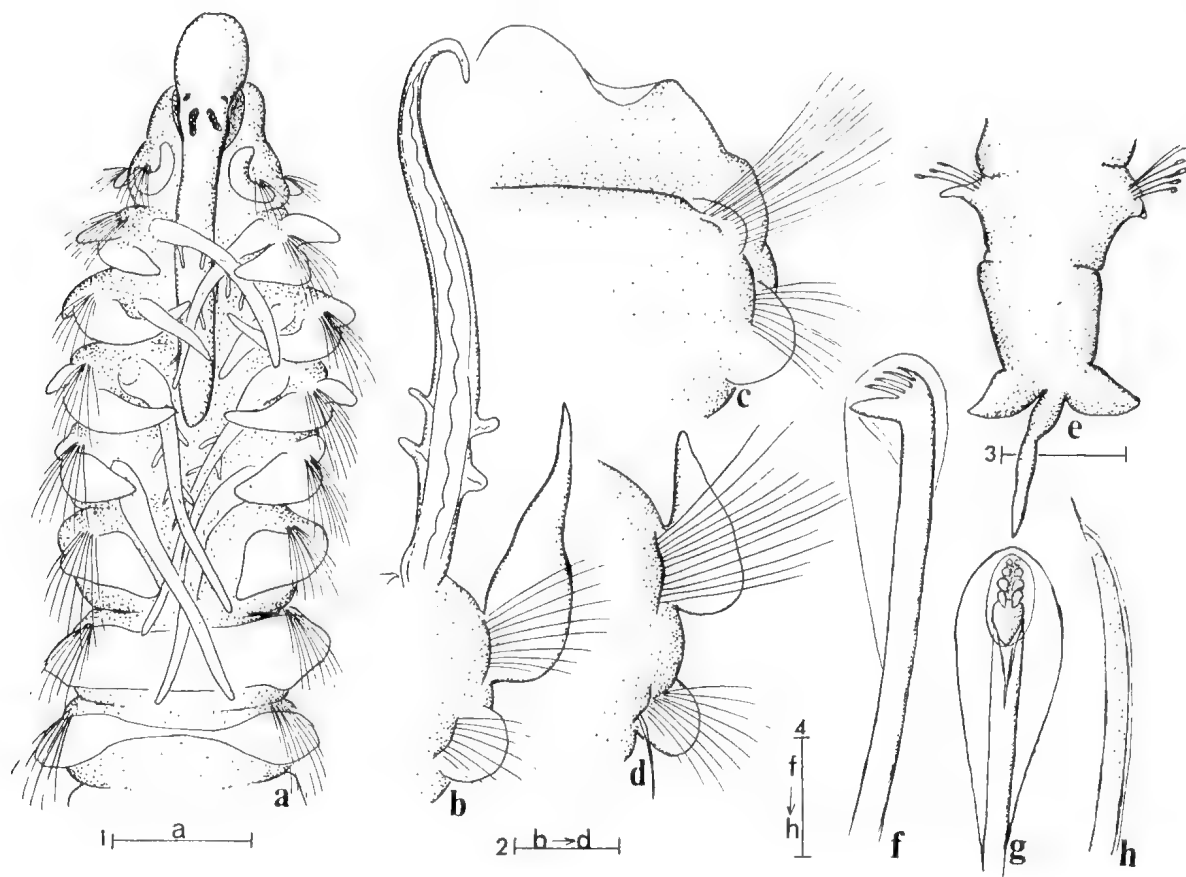


Figure 22—*Prionospio pausipinnulata* sp. nov.—a, anterior end, dorsal view; b, left setiger 4, anterior view; c, left setiger 20, anterior view; d, left setiger 10, anterior view; e, posterior end, dorsal view; f, hooded hook, lateral view; g, same, frontal view; h, sabre seta. [Scale 1 = 200  $\mu$ m; 2 = 200  $\mu$ m; 3 = 300  $\mu$ m; 4 = 20  $\mu$ m]

PPBES Stations 985 (HOLOTYPE, NMV G2837; 21 PARATYPES, NMV G2838; 80, NMV G3006); 907 (2, NMV G3007); 918 (1, NMV G3008); 944 (4, NMV G3009); 945 (6, NMV G3010).

**Description:** A small species, up to 7 mm long and 0.4 mm wide for 53 setigers. Colour in alcohol: opaque white.

Prostomium rounded on anterior margin, continuing posteriorly as long caruncle to posterior setiger 4 (Fig. 22a); 2 pairs of eyes; anterior pair smaller, cup-shaped; and a larger, irregularly shaped posterior pair. Peristomium broad with short lateral wings.

Setiger 1 well-developed, smaller than setiger 2; setigers 2-5 with well-developed subtriangular notopodial lamellae (Fig. 22b); notopodia of setiger 7 fused, forming large dorsal crest (Fig. 22c); similar crest also present on setiger 8 but less-developed; notopodia thereafter smaller, appearing subtriangular (Fig. 22d); neuropodia small, rounded throughout. Notosetae of first and subsequent setigers including fascicles of granulated capillaries, those on setiger 1 being thinner; neurosetae of setigers 1-9 in fascicles of granular capillaries; a single inferior sabre seta in each neuropodium from setiger 10 (Fig. 22h). Multidentate hooded hooks from neuropodia of setiger 13 with 1-3 hooks at first, thereafter increasing to 6-7 in middle body segments, those hooks with 6-8 apical teeth arranged in 2 rows above main fang (Fig. 22f-g); similar hooks in notopodia from setiger 34-35.



Four pairs of branchiae in setigers 2-5; first and third pairs pinnate, second and fourth pairs cirriform; short second pair (Fig. 22a); branchial pinnules sparse, usually no more than 4-7 on a single branchia; in some cases, pinnules reduced to 1-3 per gill or may even be lacking from 1 or both members of a branchial pair.

Pygidium with 1 long medial cirrus and 2 lateral lappets (Fig. 22e).

*Remarks:* *Prionospio paucipinnulata* is unique in the arrangement of pinnate (first and third) and cirriform (second and fourth) branchiae and the reduced number of pinnules on the pinnate branchiae. The long caruncle is also unusual among species of *Prionospio*.

*Distribution:* Victoria.

***Prionospio (Prionospio) tridentata* sp. nov.**

(Figure 23)

*Material examined:* NEW SOUTH WALES. Botany Bay, Towra Point, coll. NSWFS, April 1973 (2, NMV G2844; 1, NMV G2845); Newcastle, Burwood Beach, HDWBS Station, March 1975 (HOLOTYPE, AM W8829), April, 1975 (PARATYPE, AM W8900).

*Description:* A small species, up to 10 mm long and 0.5 mm wide for 60 segments. Colour in alcohol: light tan.

Prostomium trapezoidal, anteriorly broad to narrow with medial incision, tapering posteriorly to narrow caruncle terminating midway onto setiger 2 (Fig. 23a); 2 pairs of eyes, anterior pair widely spaced, cup-shaped, posterior pair rounded, close together. Peristomium reduced, without lateral wings.

Setiger 1 well-developed, with notosetae, parapodial lamellae smaller than those of following setigers; notopodia of setigers 2-6 with enlarged triangular lamellae, those of setiger 7 merging across dorsum as a dorsal crest; dorsal lamellae of succeeding setigers low, merging with dorsum, not forming crests; neuropodial lamellae rounded throughout. Setigers 2-5 with dense fascicles of bilimbate granulated capillaries (Fig. 23b). Neuropodia bearing an inferior sabre seta with partial distal sheath from setiger 11 (Fig. 23c); tridentate hooded hooks having 2 secondary teeth in line above main fang (Fig. 23d), in neuropodia from seti-

ger 19 and in notopodia from setiger 28; neuropodial hooks number 4-5 with capillaries.

Four pairs of branchiae on setigers 2-5, first pair narrow, thin, cirriform, second and third pairs thick, cirriform, fourth pair thick, long, pinnate (Fig. 23a) with numerous pinnules on posterior face.

Pygidium with short medial cirrus and 2 lateral bulges.

*Remarks:* Six species of *Prionospio* have been previously described as having the first 3 pair of branchiae cirriform and the fourth pinnate (Fauchald, 1972). Five of those species and *P. tridentata* are compared in Table 2. *P. nova* Annenkova, 1938 is poorly known and based upon incomplete specimens. Since there is no type material, or any specimens, for that matter, of *P. nova* available (Light, personal communication), the species is here considered a *nomen dubium*. *P. tridentata* is most closely related to *P. caspersi* (Table 2). *P. tridentata* differs by having tridentate, instead of bidentate, hooded hooks, and the prostomium is distinctly bilobed to incised instead of entire.

Foster (1969) removed this entire species group from *Prionospio* to her newly erected genus *Apoprionospio*. We do not consider that the ordered arrangement of cirriform and pinnate branchiae is a character of sufficient weight to warrant generic or subgeneric rank and have included *Apoprionospio* in the synonymy of *Prionospio* (see foregoing discussion above, p. 209).

*Distribution:* New South Wales.

***Prionospio (Aquilaspio) multipinnulata* sp. nov.**

(Figure 24)

*Material examined:* NEW SOUTH WALES. Merimbula, Sta. MER 404L-S, core sample, *Posidonia*, opposite Spencer Park, 18 March 1976, coll. J. H. Day, et al. (1, AM W11736); MER 278M, netting over weed beds, 3 Dec. 1975 (1, AM W11737). VICTORIA. Port Phillip Bay, PPBES Station 953 (HOLOTYPE, NMV G2836; 5 PARATYPES, NMV G2833-2835).

*Description:* Only incomplete specimens available. A moderately-sized species, up to 36 mm long for 85 setigers. Colour in alcohol: opaque white.

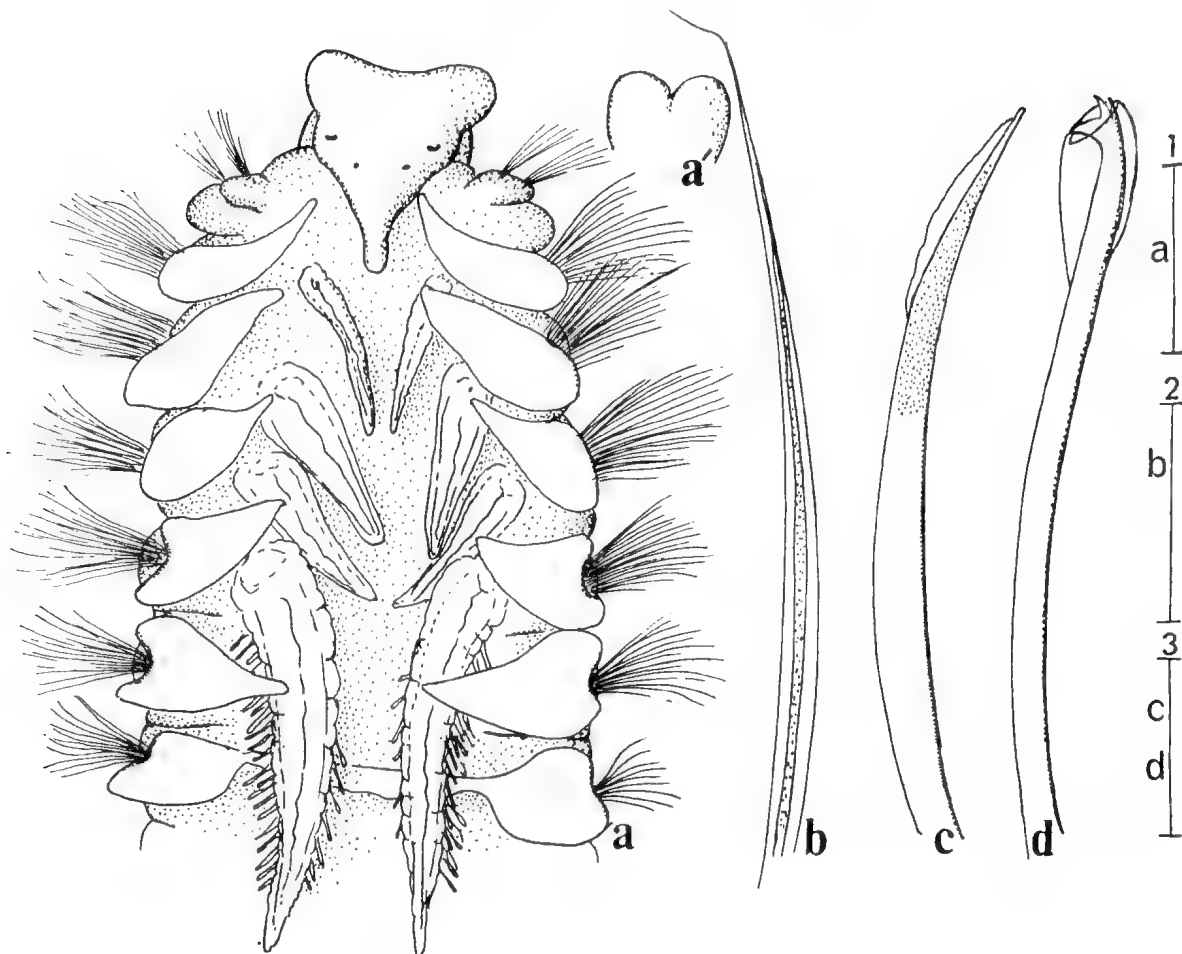


Figure 23—*Prionospio tridentata* sp. nov.—a, anterior end, dorsal view; a', prostomium from holotype; b, anterior capillary notoseta; c, sabre seta; d, hooded hook. [Scale 1 = 200  $\mu$ m; 2 = 200  $\mu$ m; 3 = 20  $\mu$ m]

Prostomium broadly rounded on anterior margin, tapering posteriorly as short caruncle to anterior margin of setiger 2 (Fig. 24a); 4-6 pairs of eyes, anterior pair largest, posterior pair often divided. Peristomium with short lateral wings.

Setiger 1 well-developed, notosetae present, notopodial lobe enlarged, neuropodium small, rounded; setigers 2-5 with enlarged notopodia (Fig. 24d), thereafter notopodia smaller, of low profile, merging with dorsum but not forming dorsal crests (Fig. 24e-f); neuropodia smaller, rounded throughout body. Anterior capillary

notosetae and neurosetae granulated; neuropodia with an inferior sabre seta lacking a sheath from setiger 10; multidentate hooded hooks accompanied by capillaries in neuropodia from setiger 18; 5-6 such hooks and capillaries in notopodia from setiger 30; hooded hooks with 6-8 apical teeth arranged in 2 rows above main fang (Fig. 24b-c), surmounted by a single apical tooth (Fig. 24c).

Four pairs of pinnate branchiae on setigers 2-5, first pair the largest (Fig. 24a). Numerous pinnules irregularly arranged on posterior side. Nature of pygidium unknown.

*Remarks:* *Prionospio multipinnulata* is closely related to *P. peruana* Hartmann-Schröder, 1962 from Peru and to *P. tetelensis* Gibbs, 1971 from the Solomon Islands in having 4 pairs of pinnate branchiae. *P. multipinnulata*

TABLE 2

Some Taxonomic Characteristics of Species of the *Prionospio pygmaea* Group

Species	Anterior margin of prostomium	Peristomium	Sabre setae begin	Hooded hooks: number of apical teeth	Distribution of branchial pinnules	Occurrence of dorsal crests	References
<i>dayi</i> Foster	Broad with small distal peak	With low lateral wings	Setiger 11	2-3	2 rows	Setiger 7 only	Foster, 1969; 1971
<i>caspersi</i> Laubier	Broad to weakly concave	Reduced; no lateral wings	Setiger 11	1	Irregular	Setiger 7 only	Laubier, 1962
<i>pygmaea</i> Hartman	Broad with small distal peak	With low lateral wings	Setiger 11	6-8	2 rows	Setiger 7 & subsequent segments*	Hartman, 1961; Foster, 1971; Light, 1978
<i>saldanha</i> Day	Rounded	Well-developed; with low lateral wings	Setiger 12	1	Irregular	Setiger 19 to end of body	Day, 1961; 1967
<i>vermilliensis</i> Fauchald	Broad	Well-developed with low lateral wings	?	?	2 rows	?	Fauchald, 1972
<i>tridentata</i> n. sp.	Concave to deeply incised	Reduced; no lateral wings	Setiger 11	2	Irregular	Setiger 7	This study

\* The presence of very thin dorsal membraneous crest have only recently been discovered in *P. pygmaea* (see Light, 1978).

differs from both species in lacking dorsal crests on postbranchial setigers; from *P. tetelen-sis* in having a shorter caruncle and lacking notosetae on setiger 1; and from *P. peruana* in having the prostomium broadly rounded on the anterior margin, rather than straight across with an apical peak, and further differs in having instead of lacking short peristomial wings.

*Distribution:* New South Wales; Victoria.

### *Prionospio (Aquilaspio) aucklandica*

Augener, 1923

(Figure 25b-g)

*Prionospio aucklandica* Augener, 1923, p. 69.

*Prionospio krusadensis* Fauvel, 1929, p. 182; 1930, p. 38; 1953, p. 236. *Fide* Foster, 1971.

*Material examined:* NEW SOUTH WALES. Wallis Lake, sandy mud, Dec. 1970, coll. Dixon and O'Gower (1, AM W5017); Merimbula, Sta. MER

197A, transect on S. bank of estuary 200 m seaward of bridge, coll. J. H. Day *et al.* 6 Oct. 1975 (1, AM W11739; 2, AM W11740); Botany Bay, Towra Point, Towra Beach, NSWFS Stations 317 (4); 207 (2); 321 (6); 325 (5); 329 (1); 331 (6); 332 (6); 333 (1); 335 (7); 344 (2) (NMV G3135-3144). VICTORIA. Port Phillip Bay, PPBES Stations 919 (3); 929 (7); 932 (1); 940 (1); 941 (1); 944 (87); 953 (41); 971 (1) (NMV G3092-3099); Werribee; MPSG Sta. 1833, coll. G. Poore and J. D. Kudenov, Nov. 1975 (1, NMV G3091); Westernport, WPBES Stations 1701 (2); 1703 (5); 1705 (13); 1706 (6); 1708 (3); 1709 (1); 1710 (4); 1715 (1); 1716 (9); 1718 (4); 1720 (1); 1721 (12); 1724 (1); 1735 (2); 1736 (6); 1737 (16); 1738 (16); 1740 (22); 1741 (15) (NMV G3072-3090).

*Description:* A moderately-sized species, up to 23 mm for 110 segments. Colour in alcohol: opaque white.

Prostomium rounded on anterior margin with 3 small prominences, these obscured if

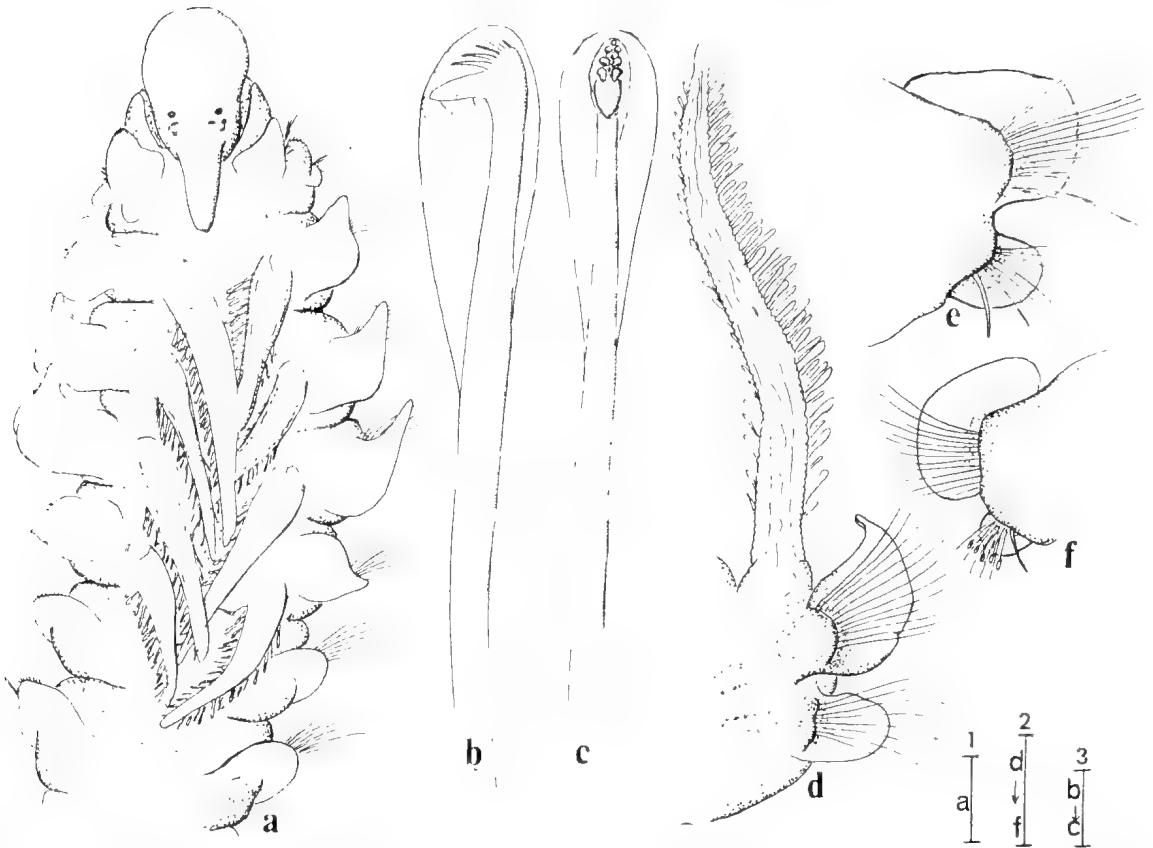


Figure 24—*Prionospio multipinnulata* sp. nov.—a, anterior end, dorsal view; b-c, hooded hooks; d, left setiger 4, anterior view; e, left setiger 10, anterior view; f, right setiger 20, anterior view. [Scale 1 = 200  $\mu$ m; 2 = 200  $\mu$ m; 3 = 20  $\mu$ m]

poorly preserved (Fig. 25b); caruncle thick, continuing to posterior end of setiger 1; 2 pairs of eyes, the anterior pair somewhat further apart, oval, posterior pair more closely spaced, cup-shaped. Peristomium narrow, without lateral hood; palps thick, extending posteriorly for 6-7 segments.

Setiger 1 well-developed, notosetae present; dorsal lamellae of setigers 2-5 enlarged, membranous, thereafter notopodia reduced; setiger 7 with low dorsal crest; neuropodia smaller, more rounded throughout body. Noto- and neuropodia of setigers 1-9 with heavy bilimbate capillaries exhibiting prominent granulations (Fig. 25g). Capillaries thereafter smaller; inferior sabre setae in setiger 10 (Fig. 25f); multidentate hooded hooks appearing in neuro-

podia from setiger 17-18 and in notopodia from setiger 27-30; hooks bearing 5 tiers of apical teeth arranged in multiple rows above main fang; lower tier with 3-4 teeth, second and third tiers with 2-4 teeth each, fourth tier with 2 teeth and fifth with a single apical tooth (Fig. 25c-e); primary hood long and inflated; secondary hood present, but inconspicuous.

Three pairs of branchiae on setigers 2-4, all pinnate, first pair the largest (Fig. 25b). Pygidium with 1 long cirrus and 2 short lobes.

*Remarks:* The large number of teeth on the hooded hooks reported for this species appears to be unique for the genus *Prionospio*. It is the only member of the genus known to bear 3 pairs of pinnate gills.

*Distribution:* New South Wales; Victoria; India; Auckland Islands.

***Prionospio (Minuspio) cirrifera* Wirén, 1883**

(Figure 25a)

*Prionospio cirrifera* Wirén, 1883, p. 409; Fauvel,

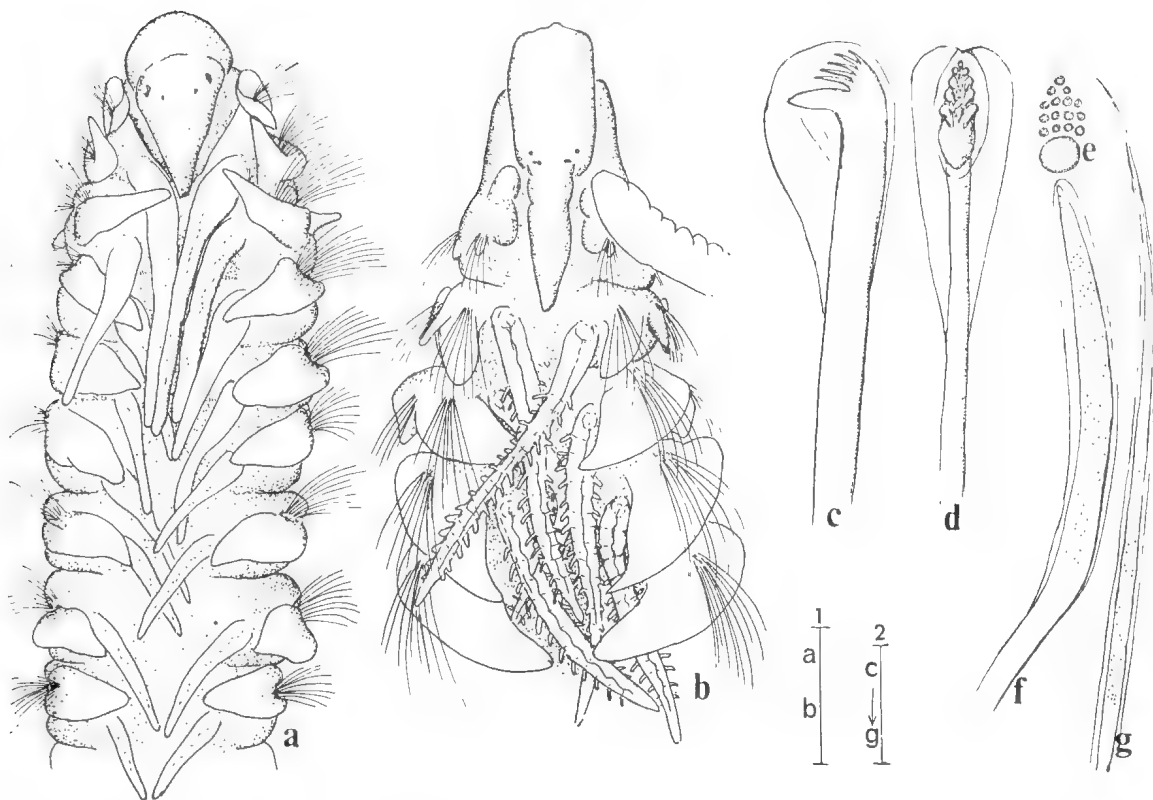


Figure 25—*Prionospio cirrifera* Wirén—a, anterior end, dorsal view—*Prionospio aucklandica* Augener—b, anterior end, dorsal view; c, hooded hook, lateral view; d, same frontal view; e, diagram of hooded hook tooth pattern at maximal development of secondary teeth; f, sabre seta; g, anterior capillary notoseta. [Scale 1 = 200  $\mu$ m; 2 = 20  $\mu$ m]

1927, p. 62; 1953, p. 324; Söderström, 1920, p. 237; Day, 1967, p. 486; Hartmann-Schröder, 1971, p. 324.

*Prionospio multibranchiata* Berkeley, 1927, p. 414; Pettibone, 1967, p. 12. HOMONYM [not Fauvel, 1928a].

*Prionospio delta* Hartman, 1965a, p. 11, 46, 147. *Fide* Foster, 1971, p. 108.

*Minuspio cirrifera*: Foster, 1971, p. 108 (Synonymy).

*Prionospio (minuspio) cirrifera*: Light, 1977, p. 82.

**Material Examined:** QUEENSLAND. Deception Bay, Burpengary Creek, Jan. 1975 (50+, AM W7127-7128, 7130-7131). NEW SOUTH WALES. Newcastle, Hunter River region, April, June 1971, coll. P. A. Hutchings and N. Ruello (20+, AM W13013-13015); Tuncurry Creek, Site 25-3, Aust. Littoral Soc., Jan. 1973 (1, AM W5673); Merimbula, Sta. MER 120G, Oyster lease transect, Oct. 1975, coll. J. H.

Day *et al.* (3, AM W11723); MER 117F Oct. 1975 (3, AM W11724); MER 148W, Spencer Park transect, *Zostera*, muddy sand, Oct. 1975 (1, AM W11728); MER 278M, netting over weed beds, Dec. 1975 (1 AM W11727); MER 366N-Z, grab sample from channel, March 1976 (1, AM W11726). VICTORIA. Port Phillip Bay, PPBES Stations 901 (93); 913 (2); 921 (11); 932 (2); 945 (54); 952 (215); 962 (1); 978 (2); 983 (5) (NMV G3146-3154); Hobsons Bay-Yarra River, MSG Stations, Feb.-Nov. 1975, coll. G. Poore and J. D. Kudenov, 128 (1554, NMV G3155); 131 (165, NMV G3156); 134 (109, NMV G3157); Paynesville, Gippsland Lakes, from jetty, 2 m, sand, coll. J. D. Kudenov (20, NMV G3145).

**Description:** Prostomium anteriorly rounded, with caruncle extending to posterior end of setiger 2 (Fig. 25a). Peristomium with low lateral wings partially enclosing prostomium. Six to 12 pairs of cirriform branchiae from setiger 2; these varying in length. Low dorsal crests present on a variable number of post-branchial setigers. Anterior setae all capillaries; multidentate hooded hooks in neuropodia from setiger 12-19 and in notopodia from setiger 15-40; these hooks with 8-10 apical teeth ar-

ranged in 2 rows over main fang. Pygidium with long medial cirrus and 2 lateral cirri.

*Remarks:* The variability seen in different populations of *P. cirrifera* suggest that a detailed global analysis of the morphology of this species is needed. We have not observed genital pouches on any of our specimens, nor did Light (1977) in his San Francisco Bay study. Foster (1971), however, indicated that they did occur in some of her material.

*Distribution:* Queensland; New South Wales; Victoria; cosmopolitan.

#### Genus *Spiophanes* Grube, 1860

*Type-species:* *Spiophanes kroeyeri* Grube, 1860, by monotypy.

*Diagnosis:* Prostomium anteriorly broad, rounded or bell-shaped with frontal horns developed to varying degrees; eyes present or absent; with or without occipital tentacle. Branchiae entirely lacking. Setigers 1-4 shifted dorsally with well-developed dorsal and ventral lamellae; setigers 5-14 generally with interramal thread glands forming supernumerary bacillary setae. Neuropodia of setiger 5 and subsequent segments poorly-developed, with reduced neuropodia; notopodia also reduced, more laterally placed. Anterior notosetae all capillaries, hooks or crochets only in neuropodia, generally from about setiger 15, these hooks bi-, tri-, or quadridentate, with or without hood; 1-2 large curved spines in neuropodia of setiger 1, inferior sabre setae generally occurring in middle and posterior neuropodia. Pygidium with 2 or more anal cirri, with or without other processes or papillae.

#### KEY TO SPECIES OF *SPIOPHANES* FROM SOUTHEASTERN AUSTRALIA

- 1a. Occipital tentacle present; prostomium bell-shaped, broad anteriorly, without frontal horns; nuchal organs single (Fig. 27a) . . . . . *S. kroeyeri*
- b. Occipital tentacle absent; prostomium rounded anteriorly or with distinct frontal horns; nuchal organs paired . . . . . 2
- 2a. Prostomium rounded anteriorly; nuchal organs extend posteriorly to setiger 4 then curve back anteriorly toward prostomium (Fig. 26a) . . . *S. wigleyi*

- b. Prostomium straight across anteriorly, with prominent frontal horns; nuchal organs extend posteriorly and terminate about setiger 4 . . . . . *S. bombyx*

#### *Spiophanes bombyx* (Claparède, 1870)

*Spio bombyx* Claparède, 1870, p. 485.

*Spio crenaticornis:* Giard, 1881, p. 600. *Not* Montagu, 1813. *Fide* Mesnil, 1896, p. 249; Foster, 1971, p. 41.

*Spiophanes verrilli* Webster and Benedict, 1884, p. 728. *Fide* Pettibone, 1962, p. 85; Foster, 1971, p. 41.

*Spiophanes bombyx:* Mesnil, 1896, p. 249; Fauvel, 1927, p. 41; Söderström, 1920, p. 243; Okuda, 1937, p. 222; Day, 1967, p. 474; Foster, 1971, p. 41 (Synonymy); Light, 1977, p. 80.

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 5A, Jan. 1976, coll. W. Stephenson (2, QM G11594). VICTORIA. Gippsland, McGaurans Beach, 9-18 m, sandy with shell fragments and silt, June, Aug. 1977, coll. J. E. Watson (2, NMV G3050).

*Description:* Prostomium with 2 prominent frontal horns, lacking occipital cirrus. Neuropodia of setiger 1 with 1-2 large curved spines. Hooded hooks tridentate, beginning on setiger 15-16. Setiger 5-15 with parapodial thread glands, from which supernumerary setae extend through an interramal opening. Pygidium with 2 anal cirri.

*Remarks:* *Spiophanes bombyx* is the best known species of the genus, occurring throughout the world in sand substrata. Our specimens agree well with the recent description by Foster (1971). Day (1967) described *S. bombyx* from South Africa as having an occipital tentacle, but subsequently reported this to be in error (Day, 1973).

*Distribution:* Queensland; Victoria; cosmopolitan.

#### *Spiophanes wigleyi* Pettibone, 1962

(Figure 26)

*Spiophanes wigleyi* Pettibone, 1962, p. 83; Hartman, 1965a, p. 147; Foster, 1971, p. 43.

*Material examined:* VICTORIA. Bass Strait, ESSO-GIPPS Sta. 9, sand, 148° 35'S-38° 8'E. (1, AM W13016); Sta. 17, 419 m, sand, 148° 34'S-38° 59'E (3, AM W13017); Sta. 20, 93.6 m, sand, 148° 24' 50"S-39° 00' 02"E (1, AM W13018).

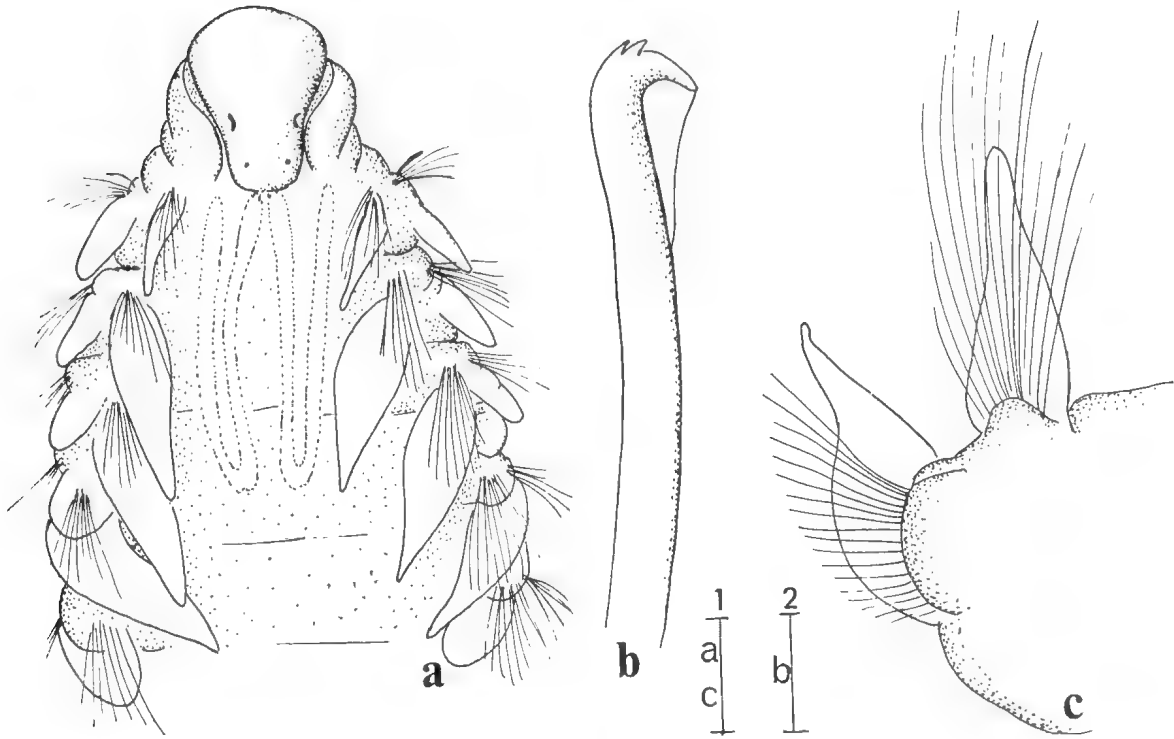


Figure 26—*Spiophanes wigleyi* Pettibone—a, anterior end, dorsal view; b, hooded hook; c, right setiger 3, anterior view. [Scale 1 = 200  $\mu$ m; 2 = 20  $\mu$ m]

**Description:** A small species up to 10 mm long for about 40 segments. Prostomium rounded anteriorly, lacking frontal horns and occipital tentacle (Fig. 26a). Caruncle absent; usually 2 pairs of eyes, the anterior pair cup-shaped, posterior pair oval; a pair of recurved dorsal sense organs extending to setiger 4, then turning forward and returning to setiger 1 forming W-shaped pattern (Fig. 26a). Setiger 1 well-developed but with shorter dorsal cirri than 2-4; notopodia of setigers 1-4 basally broad, tapering distally (Fig. 26c), neuropodia broadly triangular, longest on setigers 2-3; parapodia reduced from setiger 5, neuropodia pad-like; notopodia shorter.

Anterior noto- and neurosetae capillaries with granulations arranged in 2 tiers, neurosetae reduced to 1 tier by setiger 9; tridentate neuropodial hooks with reduced hood (Fig. 26b) from setiger 15-16.

Dorsal segmental ridges or crests present

from setiger 15, these prominent on setigers 18-30 thereafter inconspicuous. Setiger 5-14 with parapodial thread glands bearing bacillary setae. Genital pouches absent.

Pygidium with 4-6 anal cirri.

**Remarks:** Specimens agree well with the original description of *S. wigleyi*. The apparent disjunct range of this species is probably a reflection of the lack of samples along continental shelf margins.

**Distribution:** Victoria; North America, New England [Type locality] to Gulf of Mexico.

#### *Spiophanes* cf. *kroeyeri* Grube, 1860

(Figure 27)

*Spiophanes kroeyeri* Grube, 1860, p. 88; Pettibone, 1962, p. 85 (Synonymy).

*Spiophanes kroeyeri*: Fauchald, 1972, p. 29; Light, 1977, p. 79 (Synonymy).

**Material examined:** QUEENSLAND. Moreton Bay, Middle Banks, Sta. 4, Sept. 1976, coll. W. Stephenson (11, NMV G2849-2850). NEW SOUTH WALES. Sydney, Malabar, AMSBS Sta. B3 S1 (12, AM W6499); Same, Sta. CA + 5 (AM W6500); Newcastle, Burwood Beach, HDWBS Station, April 1975 (1, AM W8947). VICTORIA. Bass Strait, ESSO-GIPPS Stations 11, 738 m, 148° 39'S-38° 18' 20'E (1, AM

W13019); Sta. 13, 1440 m, ooze, 148° 40' 10"S-38° 26' 26"E (I, AM W13020); Sta. 20, 93-6 m, sand, 148° 24' 50"S-39° 00' 02"E (AM W13021).

**Description:** A moderate-sized species up to 22 mm long and 2 mm wide for 47 segments. Body generally opaque white in alcohol with dark brown parapodial glands on setigers 6-12. Body flattened, thereafter narrower, cylindrical.

Prostomium bell-shaped, with occipital tentacle, caruncle extending to setiger 1-2. Eyes variable, usually 2 pairs, anterior pair rounded, posterior pair with several distinct ocelli (Fig. 27a). Peristomium well-developed, but not enclosing prostomium. Narrow nuchal ciliary tracts extending posteriorly along dorsum behind caruncle.

Setiger 1 with finger-like, pointed neuropodial lamella (Fig. 27b); ventral lamellae of setigers 2-4 rounded, elongate; neuropodia thereafter reduced to low ridge (Fig. 27e); notopodia of setigers 1-4 cirriform, thereafter reduced, with broad base and narrow finely tapered cirrus (Fig. 27c-e).

Setiger 1 with large, curved non-granulated spine (Fig. 27b). Granulated inferior sabre seta appearing on setiger 4, 1 per fascicle, continuing throughout body (Fig. 27g); notosetae of setigers 1-4 in 3 tiers, setae of first tier with granulations, rest non-granulated, all unilimbate; notosetae of setiger 5 and subsequent setigers fewer, shorter; capillary neurosetae of setigers 1-4 smooth, these replaced over following setigers by broadly sheathed pointed setae with granulated shafts (Fig. 27f), numbering up to 12-15 per fascicle by setiger 9 (Fig. 27c); all capillaries replaced by setiger 15 with 6-7 quadridentate hooks (Fig. 27d) without hoods (Fig. 27h); hooks increasing to 11-12 per ramus in posterior neuropodia.

Dark glands present between noto- and neuropodia on setigers 6-12, each gland with a cleft (Fig. 27c); no bacillary setae (see *Remarks*). Genital pouches from setiger 15 occurring between successive parapodia for variable number of segments; dorsal crests with cilia from setiger 18 (Fig. 27e).

Pygidium cylindrical, surrounded by 8 thin cirri.

**Remarks:** The present specimens are closely related to *S. kroeyeri* Grube, 1860 known from

cosmopolitan cold water areas (Light, 1977). They differ somewhat in having a bell-shaped instead of subtriangular prostomium, and by lacking, instead of having, bacillary setae emerging from parapodial thread glands. Although bacillary setae are often difficult to observe, we did examine each specimen carefully, and in no case were the supernumerary setae detected. Several segments were removed and squashed under coverslips, but in no case were threads or bacillary setae observed. The glandular material appeared as clumps of globular cells suggestive of mucous glands rather than thread glands. We tentatively refer our material to *S. kroeyeri*.

#### General Remarks on the Genera *Spio* and *Microspio*

The separation of the genera *Spio* and *Microspio* has been vague in the previous literature. *Microspio* is currently considered a subgenus of *Spio* (see Foster, 1971). The branchiae begin on setiger 1 in *Spio* and on setiger 2 in *Microspio*. However, some species of *Spio*, have very reduced branchiae on setiger 1 and have been considered by some authors as species of *Microspio* (see Foster, 1971 for review). We consider that the first occurrence of the branchiae is absolute, regardless of size, and concur with Foster (1971), but prefer to raise both taxa to full generic rank.

Species of both *Spio* and *Microspio* are numerous and in need of review (Holmquist, 1967; Foster, 1971). Our studies have confirmed that the dorsal sense organs of the Australian species are important to species concepts, provided that specimens are well-preserved. Such an approach was previously utilized by Söderström (1920). Any revision of *Spio* and *Microspio* should thus consider dorsal sense organs at the species level.

#### Genus *Spio* Fabricius, 1785

*Spio* Fabricius, 1785. *Type-species: Nereis flicicornis* Müller, 1776, designated by Söderström, 1920.

*Paraspio* Czerniavsky, 1881. *Type-species: Spio decoratus* Bobretzky, 1870, by monotypy.

**Diagnosis:** Prostomium anteriorly rounded or incised, without frontal horns (although may be anteriorly inflated); eyes present or absent.



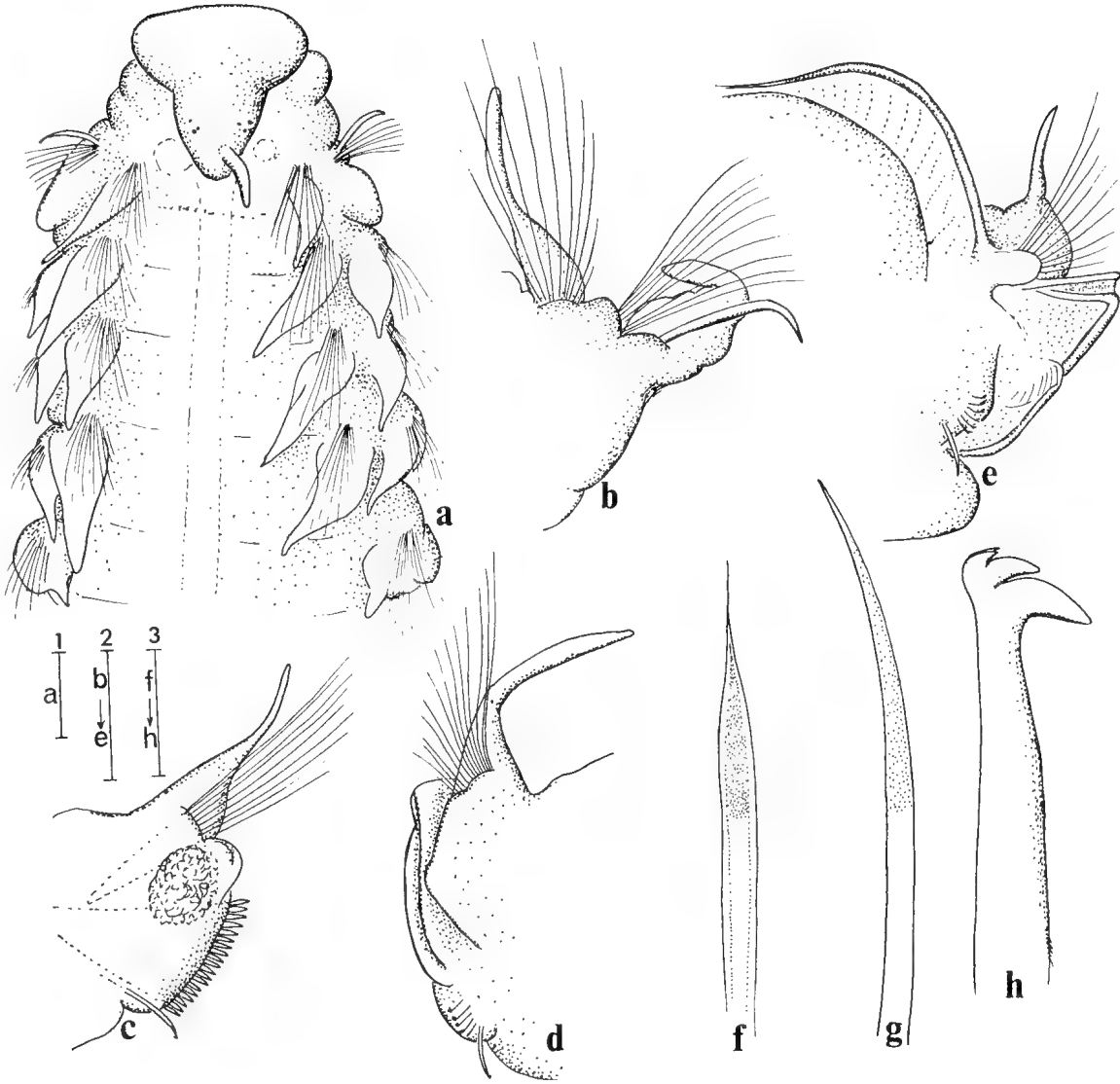


Figure 27—*Spiophanes* cf. *kroeyeri* Grube—a, anterior end, dorsal view; b, left setiger 1, anterior view; c, left setiger 9, anterior view; d, right setiger 15, anterior view; e, left setiger 21, anterior view; f, broad sheathed neuroseta from setiger 9; g, sabre seta, setiger 15; h, quadridentate hook. [Scale 1 = 200  $\mu$ m; 2 = 200  $\mu$ m; 3 = 20  $\mu$ m]

Branchiae from setiger 1, continuing throughout body, fully developed or greatly reduced at first, increasing in length thereafter, often partially fused to dorsal lamellae in anterior, and free in posterior setigers. Notosetae capil-

laries only; neurosetae including capillaries, hooded hooks and sabre setae. Pygidium with anal cirri.

#### KEY TO SPECIES OF *SPIO* FROM AUSTRALIA

- 1a. Prostomium incised on anterior margin . . . . . *S. mesnili*
- b. Prostomium entire on anterior margin . . . . . 2
- 2a. Branchiae reduced on setiger 1, fully developed by setiger 2 (Fig. 29a); hooded hooks multidentate (Fig. 29g) from setiger 15-20 . . . . . *S. singularis*

- b. Branchiae fully developed on setiger 1 (Fig. 28a); hooded hooks tridentate (Fig. 28i) from setiger 9-11  
 .....*S. pacifica*

***Spio mesnili* Augener, 1914**

(Figure 28l)

*Spio mesnili* Augener, 1914, p. 10.

*Material examined:* WEST AUSTRALIA. Sharks Bay, Surf Point, outer bar, 16 June 1905, S.W. Australia Exped. 1905, Sta. 25 (1, TYPE, ZMH V-8222).

*Description of Holotype:* The type specimen is a poorly preserved anterior fragment approximately 4 mm long and 1.1 mm wide for 17 setigers. Body elliptical in cross section. Colour in alcohol; opaque white.

Prostomium anteriorly incised; no eyes; occipital tentacle lacking; nuchal organs obscured by poor preservation; peristomium poorly-developed; proboscis a flattened funnel.

Setiger 1 reduced dorsally, with notosetae; notopodial lamellae fused with branchiae; neuropodial lamellae small, elliptical; parapodia of setiger 2 slightly displaced dorsally, intermediately between those of setigers 1 and 3, subsequent segments similar to setiger 3.

Anterior setae sheathed capillaries, arranged in 2 tiers in both rami, first tier with short, granulated capillaries in all parapodia, second tier with non-granulated capillaries in all notopodia and in neuropodia of setigers 1-10; tridentate hooded hooks with secondary hoods first appearing in neuropodia of setiger 11, these hooks bearing main fang overlain by elongate secondary tooth and a third small apical tooth, poorly-defined (Fig. 28l). Setal distribution as follows: notopodia of setigers 4-14 with 9-10 capillaries in first tier and 10-12 in second tier; neurosetae of setiger 4 as in notopodia; neurosetae from setiger 14 with 7-8 granulated capillaries in first tier and 6 hooded hooks in second tier, plus 3 inferiorly located granulated capillaries. Branchiae from setiger 1 reduced,  $\frac{1}{2}$  as long as on setiger 2, branchiae arching dorsally, reaching midline at about setiger 10-15, bases connected by transverse dorsal ciliated ridge continuous with ciliated inner gill margin.

Pygidium absent on type, but according to

Augener (1914) it consists of 2-4 anal cirri.

*Remarks:* The new description of the type as presented above, generally agrees with the original description by Augener (1914, pp. 10-12). He notes, however, that 2 pairs of eyes were present and arranged in a square. The absence of those eyes on the type today, probably represents fading after 60 years in alcohol.

The type specimen of *S. mesnili* is from station 25 (S.W. Australian Expedition of 1905) and was noted by Augener (1914) to differ from other specimens from stations 1 and 3. The latter specimens were said to bear branchiae on setiger 1 which were as long as those on setiger 2, they apparently lacked granulated notosetae, and the tridentate hooded hooks began on setiger 14 and numbered only 3-4 per fascicle. In contrast, the type specimen has branchiae on setiger 1 which are only  $\frac{1}{2}$  as long as on setiger 2, the anterior notosetae are granulated and hooded hooks begin on setiger 11 and number up to 7-8 per fascicle. The specimens from stations 1 and 3 possibly represent a separate species, but final confirmation and possible identification must await either the location of those specimens or the collection of new materials from Sharks Bay.

*Spio mesnili* bears some similarity to *S. pacifica* (see below), but differs in having an incised prostomium and hooded hooks with secondary hoods and in lacking granulated sheaths in anterior capillaries. The presence or absence of inferior sabre setae in *S. mesnili* is not known.

*Distribution:* West Australia, Sharks Bay.

***Spio pacifica* sp. nov.**

(Figure 28a-k)

*Material examined:* QUEENSLAND, Moreton Bay, Middle Banks, Sta. 6E, May 1976, coll. W. Stephenson (1, QM G11590). NEW SOUTH WALES, Botany Bay, Towra Point, coll. NSW SF, April 1973, Sta. 211 (HOLOTYPE, NMV G2939 and 27 PARATYPES, NMV G2940); 107 PARATYPES from Botany Bay as follows: Sta. 213 (3); 332 (11); 337 (16); 340 (11) (NMV G2941-2944); 203 (3); 207 (2); 215 (4); 218 (6); 320 (5); 324 (4); 325 (10); 329 (13); 331 (11); 344 (8) (AM W13022-13031); Stockton Beach, HDWBS Station, Nov. 1975, (1, AM W8899). VIC-

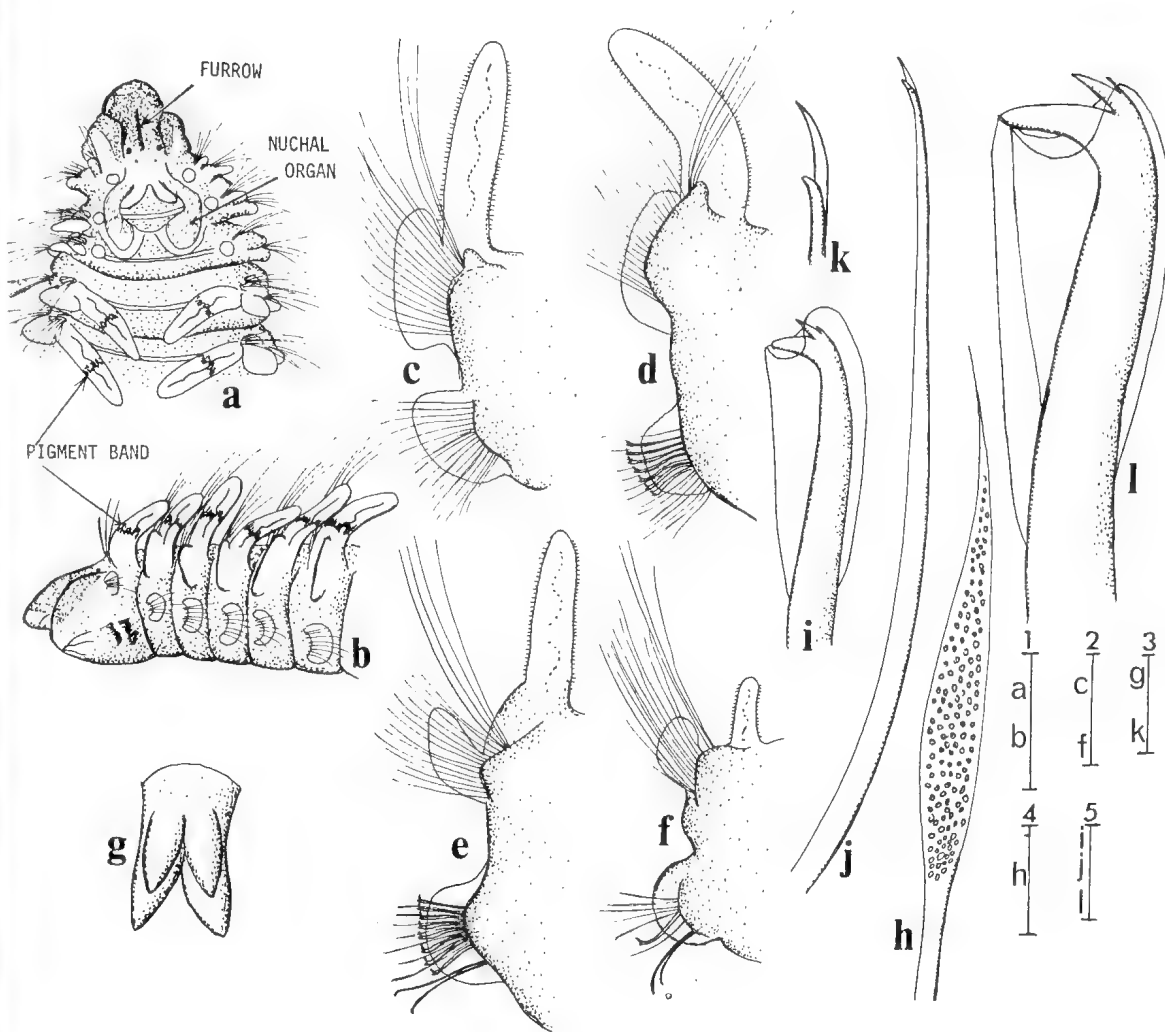


Figure 28—*Spio pacifica* sp. nov.—a, anterior end, dorsal view; b, anterior end, lateral view; c, right setiger 4, anterior view; d, right setiger 11, anterior view; e, right setiger 22, anterior view; f, right setiger 36, anterior view; g, pygidium, dorsal view; h, anterior capillary seta; i, tridentate hooded hook; j, inferior sabre seta; k, detail of j [not to scale]—*Spio mesnili* Augener—1, hooded hook. [Scale 1 = 100  $\mu$ m; 2 = 200  $\mu$ m; 3 = 20  $\mu$ m; 4 = 50  $\mu$ m; 5 = 20  $\mu$ m]

920/5 (1, NMV G2934); 945 (2, NMV G2932-2933); 967 (5, NMV G2935-2937).

**Description:** A small species, up to 10 mm long and 1 mm wide for 50 setigers. Body widest anteriorly, tapering gradually posteriorly. Specimens heavily pigmented anteriorly with brown pigment on prostomium, peristomium, dorsum, ventrum and intersegmental regions (Fig. 28 a-b); brown transverse band mid-way along gill filaments (Fig. 28b) and paired mid-ventral spots on setigers 2-10; no pigment in middle and posterior setigers.

Prostomium rounded on anterior margin, with a median furrow (Fig. 28a). Caruncle divides into 2 lobes surrounded laterally by

TORIA, Westernport, Crib Point, CPBS Station 32S Dec. 1969 (1, NMV G2896); Westernport, WPBES Stations 1722 (2, NMV G2929-2930); 1724 (4, NMV G2927-2928); 1732 (1, NMV G2931). Port Phillip Bay, PPBES Stations 123/3 (1, NMV G2938);

paired, curved ciliated nuchal organs extending to middle of setiger 3. Eyes 2 pair; anterior pair largest. Palps extend posteriorly to setiger 8-10. Peristomium moderately developed to form lateral wings.

Setiger 1 reduced, notopodial lamellae small, elliptical, dorsolaterally positioned; neuropodial lamellae 2-3 times larger, subquadrate (Fig. 28a-b); notopodial lamellae of anterior setigers elliptical to subquadrate (Fig. 28c-d); those of middle and posterior setigers elongate, rounded (Fig. 28e-f); neuropodial lamellae rounded (Fig. 28c-f), with presetal notopodial lobes in setigers 1-17 (Fig. 28c-d).

Anterior notosetae and neurosetae sheathed capillaries, granulated and non-granulated, arranged in 2 tiers, notopodia with additional 3 long smooth superior capillaries; capillaries of anterior tier golden with large granules in setigers 1-6 (Fig. 28h); granulations becoming small, and setae appearing light brown by setiger 11; granulations only distal from about setiger 22 and completely gone by setiger 36; anterior neurosetae include sheathed granulated and non-granulated capillaries arranged in 2 tiers; inferior sabre setae from setigers 11-33, these sabre setae unique, granulated, distally falcate with partial hood formed by extension of sheath (Fig. 28j-k); neuropodial tridentate hooded hooks first present from setiger 9-11, with third tooth inconspicuous, then becoming more pronounced in posterior setigers (Fig. 28i). Margin of hood aperture smooth.

Branchiae beginning setiger 1, continuing to end of body; well-developed, fused with dorsal lamellae in anterior segments, free in middle and posterior segments, ciliated on both inner and outer margins, connected by transverse ciliated bands across dorsum; ciliated band of setiger 2 interrupted by paired nuchal organs (Fig. 28a).

Pygidium terminal, with 2 pairs of thick anal cirri (Fig. 28g), ventral pair  $1\frac{1}{2}$  times longer and wider than dorsal pair; pygidium equal in length to last 5-6 setigers.

*Remarks:* *Spio pacifica* and *Spio pettiboneae* Foster, 1971 have rounded prostomia, large branchiae on setiger 1 and tridentate hooded hooks. *S. pacifica* differs in having presetal

notopodial lobes in the anterior segments, an inconspicuous third tooth on the hooded hooks instead of a prominent one, acicular and falcate sabre setae with distal partial hoods and a different pygidial structure.

*Distribution:* Queensland; New South Wales; Victoria.

### *Spio singularis* sp. nov.

(Figure 29)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 57, Dec. 1972, coll. W. Stephenson (HOLOTYPE, NMV G2884); Sta. 51, Dec. 1973 (PARATYPE, NMV G2945); Sta. 48, Dec. 1972 (PARATYPE, NMV G2946); Sta. 29, Sept. 1972 (3 PARATYPES, QM G11595); Sta. 28, Dec. 1973 (PARATYPE, QM G11596).

*Description:* Only incomplete specimens available. A small species, up to 10 mm long and 2 mm wide for 30 setigers. Anterior body very wide, subrectangular in cross section. Body brownish red with brown pigment patches on prostomium, and brown interramal spots (Fig. 29 a-b).

Prostomium bluntly rounded, with raised inflated boss at level of setiger 1 (Fig. 29a); caruncle extending posteriorly in 1 or 2 descending steps to middle of setiger 2; no eyes; peristomium reduced, forming slight lateral wings; nuchal organs paired, extending to anterior margin setiger 3.

Setiger 1 reduced, with notosetae, notopodia shifted dorsally, notopodial lamellae elliptical, becoming subtriangular in middle segments (Fig. 29c-e); neuropodial lamellae elliptical to broadly rounded (Fig. 29c-e). Notosetae sheathed capillaries, arranged in 2 tiers, those of anterior setigers granulated, becoming non-granulated posteriorly; neurosetae similarly arranged in 2 tiers; sabre setae first present from about setiger 13; hooded hooks from setiger 15, numbering up to 6 per neuropodium, appearing tridentate in lateral view (Fig. 29f); but with 4-5 secondary teeth when seen in frontal view (Fig. 29g).

Branchiae short on setiger 1, reaching full-size by setiger 2, but gills narrower than those of setiger 3, branchial ciliation present on inner gill margin, continuous with dorsal transverse ciliary bands on body wall (Fig. 29a). Pygidium unknown.

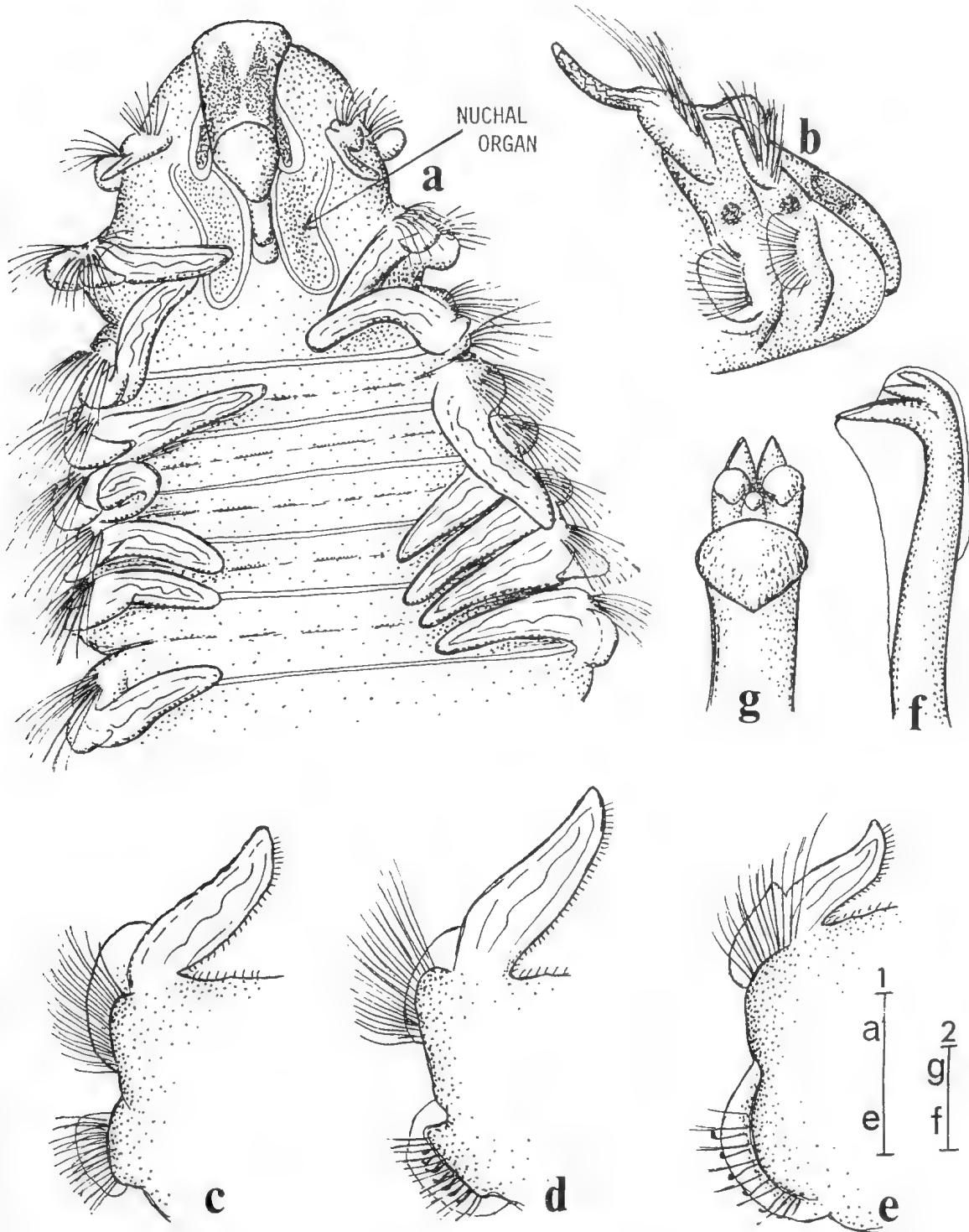


Figure 29—*Spio singularis* sp. nov.—a, anterior end, dorsal view; b, anterior end, lateral view; c, right setiger 6, anterior view; d, right setiger 13, anterior view; e, right setiger 27, anterior view; f, quinquedental hooded hook, lateral view; g, hexadentate hooded hook, hood omitted [not to scale]. [Scale 1 = 100  $\mu$ m; 2 = 20  $\mu$ m]

*Remarks:* The presence of hooded hooks bearing 4 and 5 apical teeth is unique for the genus *Spio*.

*Distribution:* Queensland, Moreton Bay.

#### Genus *Microspio* Mesnil, 1896

*Microspio* Mesnil, 1896. *Type-species:* *Spio mecznikowianus* Claparède, 1869, designated by Söderström, 1920.

*Mesospio* Gravier, 1911. *Type-species:* *Mesospio moorei* Gravier, 1911, by monotypy. *Fide* Foster, 1971.

*Diagnosis:* Prostomium rounded to bilobed on anterior margin, without frontal horns; eyes present or absent. Occipital cirrus present or absent. Branchiae beginning on setiger 2. Capillary notosetae only; neurosetae including capillaries, hooded hooks and sabre setae. Pygidium with anal cirri.

#### *Microspio granulata* sp. nov.

(Figures 30-31)

*Material examined:* NEW SOUTH WALES. Botany Bay, Towra Point, NSWFS Stations 329, April 1973 (HOLOTYPE, NMV G2947), 6 PARATYPES as follows: Sta. 211 (1, NMV G2950); Sta. 311 (1, NMV G2951); Sta. 325 (1, NMV G2948); Sta. 338 (1, AM W13049); Sta. 342 (1, AM W13050); Sta. 335 (1, AM W13032).

*Description:* Holotype and paratypes incomplete, up to 10 mm long and 1.5 mm wide for 31 setigers. Body very wide anteriorly, elliptical in cross section; intensely pigmented with brown patches on prostomium, peristomium and branchiae, brown paired rectangular patches on dorsum continuous laterally and ventrally (Fig. 30a-b); a dorsomedial strip lacking pigment in anterior 6-7 segments (Fig. 30a); from setiger 8, segmentally paired medial pigment areas, occurring on each side of transverse ciliary band.

Prostomium bilobed, deeply incised on anterior margin with medial furrow continuing on frontal lobe, caruncle bluntly terminating at middle of setiger 2, posteriorly rounded, with prominent occipital papilla (Fig. 30a-b); 2 pairs of eyes, arranged trapezoidally, anterior pair the larger. With transverse hood reminiscent of dorsal collar seen in genus *Streblospio* present posterior to prostomium, surrounded laterally and posteriorly by curved nuchal

grooves. Peristomium weakly developed. Palps extend posteriorly 6-7 setigers. Proboscis an eversible sac.

Setiger 1 reduced, with small digitiform notopodial lamellae shifted dorsally, lacking notosetae; postsetal neuropodial lamellae reduced, inserted ventrolaterally (Fig. 30a-b); anterior notopodial lamellae broadly to narrowly rounded, partially fused to branchiae (Fig. 30c-e); anterior neuropodial lamellae broadly rounded, reaching maximum size at about setiger 20.

Notosetae include sheathed capillaries arranged in 2 tiers; notopodia with 20-30 capillaries in main fascicles plus 2-3 long superior capillaries; anterior tiers of setigers 2-5 with granulated capillaries, these granulations lost in subsequent setigers, only non-granulated capillaries remaining in posterior setigers; posterior tiers with distally granulated capillaries throughout body; sheaths of setae on setigers 2-6 strongly granulated (Fig. 31a). Neurosetae of anterior setigers with about 10-11 capillaries in each of 2 tiers, plus 2 long, tapered, inferior capillaries; capillaries of anterior tiers of setigers 1-4 granulated throughout their lengths, remaining setae of both neurosetal tiers granulated only on distal half. Capillary sheaths of posterior tiers distally bristled (Fig. 31b); tridentate hooded hooks beginning from setiger 9, 8-9 hooks per fascicle (Fig. 31c-d); sabre setae first appearing in setigers 15-17, these distally mucronate, heavy and spinous (Fig. 31e).

Branchiae fully developed from setiger 2, continuing to end of body; with inner ciliated gill margins connected by transverse ciliated ridges on dorsum from setiger 3. Pygidium unknown.

Genital pouches present from setiger 12, decreasing in size to setiger 29 (Fig. 30d-e).

*Remarks:* *Microspio granulata* is similar to *M. mecznikowianus* (Claparède) in lacking notosetae on setiger 1 and in bearing tridentate hooded hooks. *M. granulata* differs in having an occipital cirrus and a transverse hood across setiger 2; such a hood is otherwise known only in the genus *Streblospio*.

*Distribution:* New South Wales, Botany Bay.

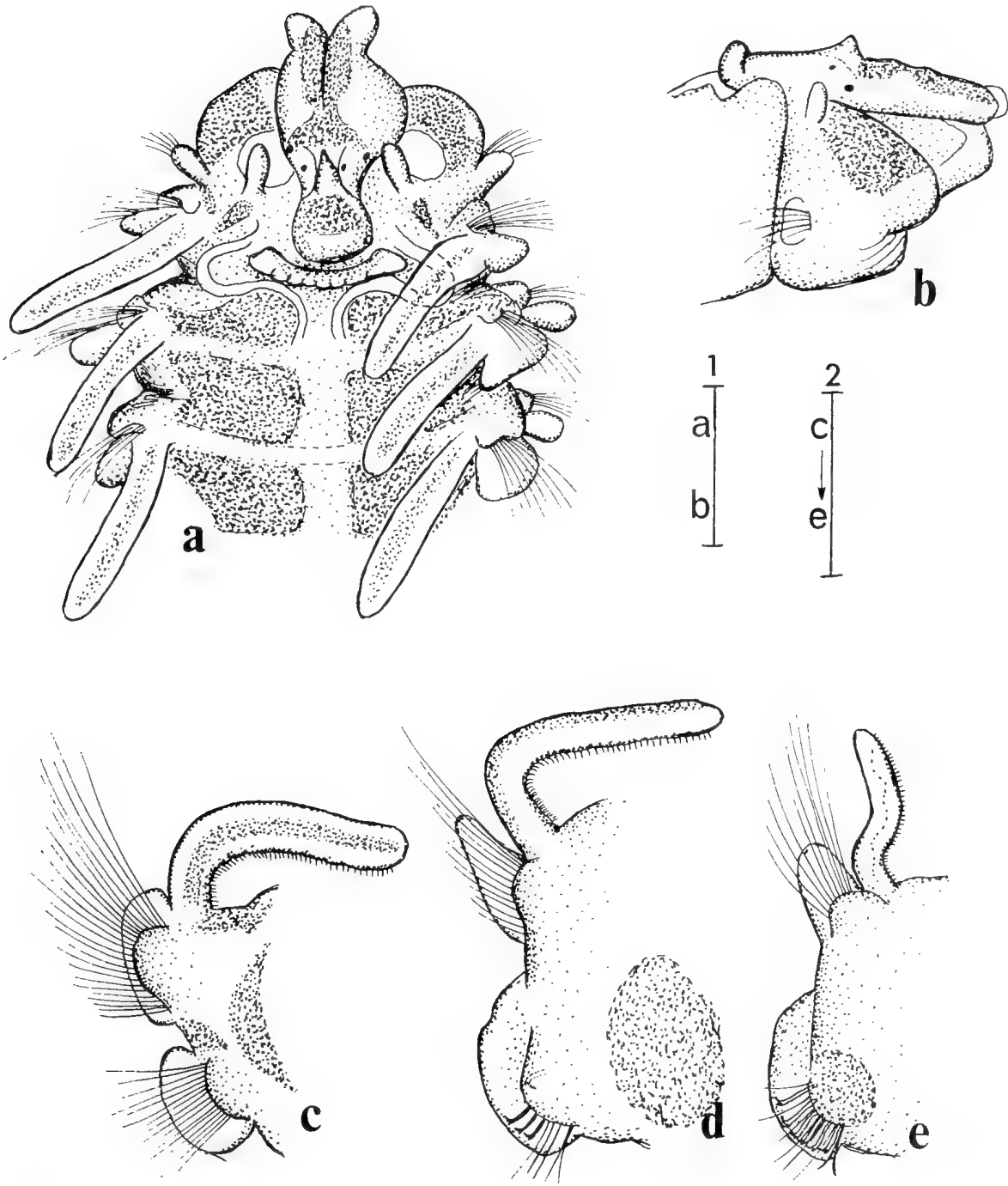


Figure 30—*Microspio granulata* sp. nov.—a, anterior end, dorsal view; b, anterior end, lateral view; c, right setiger 4, lateral view; d, right setiger 12, anterior view; e, right setiger 29, anterior view. [Scale 1 = 100  $\mu\text{m}$ ; 2 = 200  $\mu\text{m}$ ]

#### General Remarks on the *Polydora*-complex

The generic arrangement of the numerous species of the *Polydora*-complex has usually been based upon the first appearance of hooded hooks and the presence of branchiae

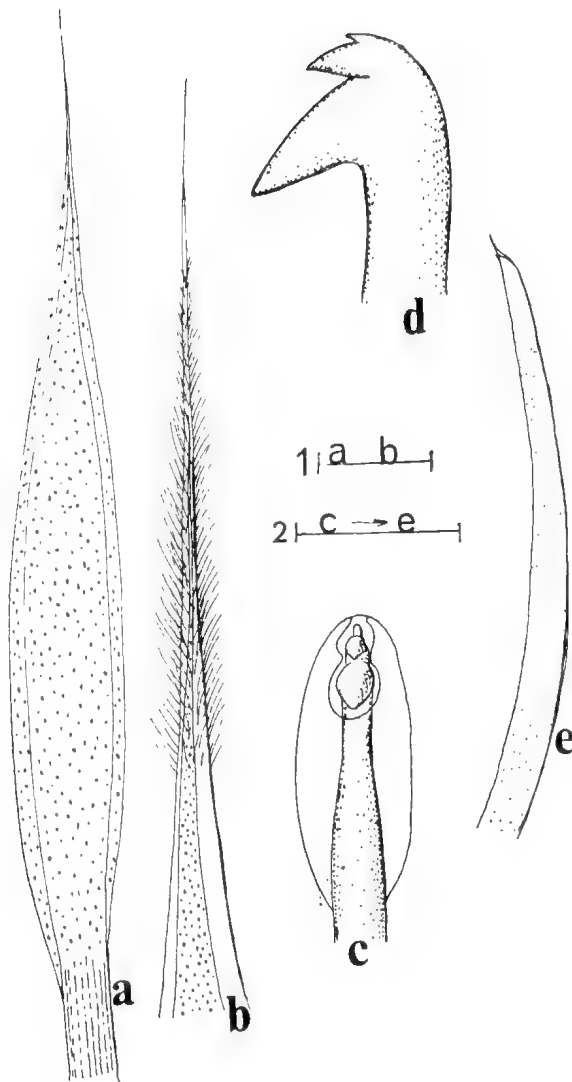


Figure 31—*Microspio granulata* sp. nov.—a, superior capillary notoseta; b, anterior capillary neuroseta, distal tip; c, tridentate hooded hook, frontal view; d, tridentate hooded hook, lacking hood, lateral view; e, inferior sabre seta. [Scale 1 = 20  $\mu$ m; 2 = 20  $\mu$ m]

anterior or posterior to setiger 5. Five genera are normally recognized: *Polydora* Bosc, *Boccardia* Carazzi, *Pseudopolydora* Czerniavsky, *Tripolydora* Woodwick and *Polydorella* Augener. A sixth genus, *Paraboccardia* Rainer has lately been regarded as a subgenus of *Boccardia* (Read, 1975). Many species, how-

ever, demonstrate characteristics of one or more of these genera and the system has remained unstable (Woodwick, 1964; Foster, 1971; Read, 1975) with little agreement between workers on which genera (or subgenera) are valid.

In the present study we introduce a new generic format based on the degree of modification of setiger 5, structure of modified spines in setiger 5, first appearance of branchiae and to a lesser degree, structure and first appearance of hooded hooks.

The polydorids are herein arranged into 6 full genera: *Pseudopolydora*, *Polydora*, *Carazziella* nov. gen., *Tripolydora*, *Boccardiella* nov. gen. and *Boccardia*. *Paraboccardia* is a new synonym of *Boccardia* and *Polydorella* is a new synonym of *Pseudopolydora*. Details for each of these genera and reasons for the synonymies are discussed under each genus in the text. Table 3 is a summary of characteristics of each of the 6 genera. As seen in this arrangement, 3 genera have branchiae beginning on setiger 2 and 3 have branchiae beginning posterior to setiger 5. In each of these groups there is a genus bearing a close relationship to one in the other group. For example, *Pseudopolydora* and *Tripolydora* are similar, but the first has branchiae posterior to setiger 5 while the second has branchiae from setiger 2. Both have relatively undeveloped fifth setigers and similar hooded hook structures, but a different arrangement and structure of major spines of setiger 5. In a similar manner, *Polydora* and *Boccardiella* show close relationships as do *Carazziella* and *Boccardia*. *Polydora* remains the most heterogeneous of the genera and it contains the greatest number of species. *Polydora guillei* Laubier and Ramos, 1974 from the Mediterranean, described from fragmentary specimens, differs from all 6 polydorid genera and all known spionids in having unhooded unidentate neuropodial hooks from setiger 15. The species probably represents a separate genus.

In the present study only the genus *Tripolydora* was not encountered. Species making up the newly proposed genera *Carazziella* and *Boccardiella* are, in part, removed from other pre-existing genera, but, several new



TABLE 3  
Some Taxonomic Characteristics of the Genera of the *Polydora*-complex

Genus	Setiger 1	Setiger 5 modification	Setiger 5 major spines	Branchiae begin	Hooded hooks beginning; no. teeth	Hooded hooks Structure
<i>Pseudopolydora</i>	Normal to achaetous	Slight to moderate	2 types, usually in J- or U-shaped double rows	Posterior to setiger 5	Setiger 8; bidentate	Secondary tooth closely applied main fang; with constriction on shaft
<i>Polydora</i>	With or without notosetae	Great	1 type, with or without companion setae	Posterior to setiger 5	Setigers 7-17; bidentate	With prominent angle between teeth; with or without constric- tion on shaft
<i>Carazziella</i>	With or without notosetae	Great	2 types in 2 rows, 1 or both may bear bristles	Posterior to setiger 5	Setigers 7-14; bidentate	With prominent angle between teeth; without constriction on shaft
<i>Tripolydora</i> *	Without notopodia and notosetae	Slight	1 type, with companion setae	Setiger 2, present on setiger 5	Setiger 9; tridentate	Secondary teeth closely applied to main fang; no constriction on shaft
<i>Boccardiella</i>	With or without notosetae	Great	1 type, with companion setae	Setiger 2, present or absent on setiger 5	Setiger 7; bidentate	With prominent angle between teeth; without constriction on shaft
<i>Boccardia</i>	With or without notopodia and <sup>†</sup> notosetae	Great	2 types in 2 rows, 1 may be bristle- topped	Setiger 2, absent on setiger 5	Setigers 7-8; bidentate	With prominent angle between teeth; without constriction on shaft

\* Holotype of *Tripolydora spinosa* Woodwick, 1964 [Type-species] from Eniwetok was examined (USNM 254881).

species are also described. Fifteen new polydorid species are described below from southeastern Australia. Further reviews and descriptions of additional new species from world-wide areas will be published in a subsequent paper (Blake, in preparation).

#### Genus *Boccardia* Carazzi, 1893 emended

*Boccardia* Carazzi, 1893. *Type-species: Polydora (Leucodora) polybranchia* Haswell, 1885, by monotypy.

*Paraboccardia* Rainer, 1973. *Type-species: Paraboccardia syrtis* Rainer, 1973, by original designation.

**Diagnosis:** Prostomium rounded or incised, extending posteriorly as caruncle. Setiger 1 with

or without notosetae. Setiger 5 modified with 2 types of major spines, few capillary notosetae, or these absent. Bidentate hooded hooks with conspicuous angle between teeth, without constriction or manubrium on shaft; first appearing on setiger 7-8. Posterior notopodial spines present or absent. Branchiae beginning on setiger 2, absent from setiger 5, present thereafter and continuing for variable number of segments. Pygidium disc-like with or without separate lobes or reduced to small lobes or cuffs.

**Remarks:** The genus *Boccardia* is herein restricted to those species having 2 types of ma-

major spines on setiger 5. Species formerly assigned to *Boccardia* on the basis of gills being present anterior to setiger 5, but having a single type of major spine on setiger 5 are herein transferred to *Boccardiella* (see below).

*Paraboccardia* was erected by Rainer (1973) for a group of New Zealand species, in which the hooded hooks were first present on setiger 8 instead of 7; Read (1975) treated *Paraboccardia* as a subgenus of *Boccardia*. The distribution of hooded hooks has been found to be of marginal importance in defining spionid genera, and for that reason *Paraboccardia* is here considered a synonym of *Boccardia*.

*Boccardia* is left with 16 species, 3 of which occur in Australia.

KEY TO SPECIES OF *BOCCARDIA* FROM  
SOUTHEASTERN AUSTRALIA

- 1a. One of the 2 types of major spines on setiger 5 densely bristle-topped without distal cavity (Fig. 32d); occipital tentacle absent . . . . . 2
- b. One of the 2 types of major spines on setiger 5 with distal concavity and central cone, bristles few, only around rim (Fig. 33d); occipital tentacle present . . . . . *B. chilensis*
- 2a. Prostomium deeply incised (Fig. 33a); notosetae absent from setiger 1 . . . . . *B. polybranchia*
- b. Prostomium rounded or weakly incised; short notosetae on setiger 1 . . . . . *B. proboscidea*

***Boccardia polybranchia* (Haswell, 1885)  
emended  
(Figure 32)**

*Polydora polybranchia* Haswell, 1885, p. 275; Söderström, 1920, p. 256.

*Boccardia polybranchia*: Carazzi, 1893, p. 16; Mesnil, 1896, p. 221; Fauvel, 1927, p. 58; Hartman, 1948, p. 63; Berkeley and Berkeley, 1952, p. 16; Imajima and Hartman, 1964, p. 279; Hartman, 1966, p. 15; Day, 1967, p. 463. [Major references only].

*Polydora euryhalina* Hartmann-Schröder, 1960, p. 33. Fide Hartman, 1965b.

*Material examined*: NEW SOUTH WALES. Coffs Harbour, amongst *Galeolaria* tubes and coralline algae, on rocks, in pools, 28 Feb. 1971, coll. P. Hutchings (2, AM W13033). VICTORIA. Kilcunda, amongst algae in tide pools, 13 Feb. 1977, coll. J. A.

Blake and J. D. Kudenov (1, NMV G3011). Tasmania, Macquarie Island (5, AM W4742-4743).

*Description*: A moderate-sized species up to 15 mm long for 80 segments. Specimens light tan in alcohol, with dark pigment along sides of prostomium and on palps.

Prostomium anteriorly bifid, continuing posteriorly as caruncle to posterior margin of setiger 3 (Fig. 32a); no occipital tentacle; 2 pairs of eyes, anterior pair more widely separated than posterior pair. Palps thick extending posteriorly for 9-10 setigers.

Setiger 1 reduced, with small notopodial lobe, without notosetae. Capillary neurosetae short; setigers 2, 3, 4, -, 6 and succeeding segments with prominent fascicles of sheathed, unilimbate capillary notosetae arranged in 3 tiers: first tier with short, thick setae, the second gradually elongating, setae of third tier longest and thinnest. Number of capillary setae gradually reduced along body, with only a few long pointed setae remaining, in posterior segments; without posterior notopodial spines. Neuropodia of setigers 2, 3, 4, - and 6 bearing fascicles of unilimbate capillary setae. Bidentate hooded hooks beginning setiger 7; hooks numbering 7-8 at first with 3-4 capillaries, increasing to 12-13 in middle body segments, the capillaries dropping out; hooks exhibiting wide angle between teeth; hood bearing striae and serrations at hood opening (Fig. 32b).

Setiger 5 with ventral fascicle of unilimbate capillary setae; major spines of 2 types: (1) simple falcate with weak subdistal concavity along one edge (Fig. 32c); (2) bristle-topped, with tip laterally produced into smooth boss (Fig. 32d-e).

Branchiae on setigers 2, 3, 4, -, 6 and succeeding segments, but absent from posterior  $\frac{1}{4}$  of body; branchiae longest from setigers 8-9, rarely overlapping at midline.

Pygidium with 4 equal lobes (Fig. 32f). *Remarks*: The original description of *B. polybranchia* by Haswell (1885) (as *Polydora*) was brief and lacked figures. There have been no reports of the species from Australia since the original description. The type locality has changed drastically since 1885 and oyster growing centres, once so numerous along the Hunter River are essentially gone due to industrial

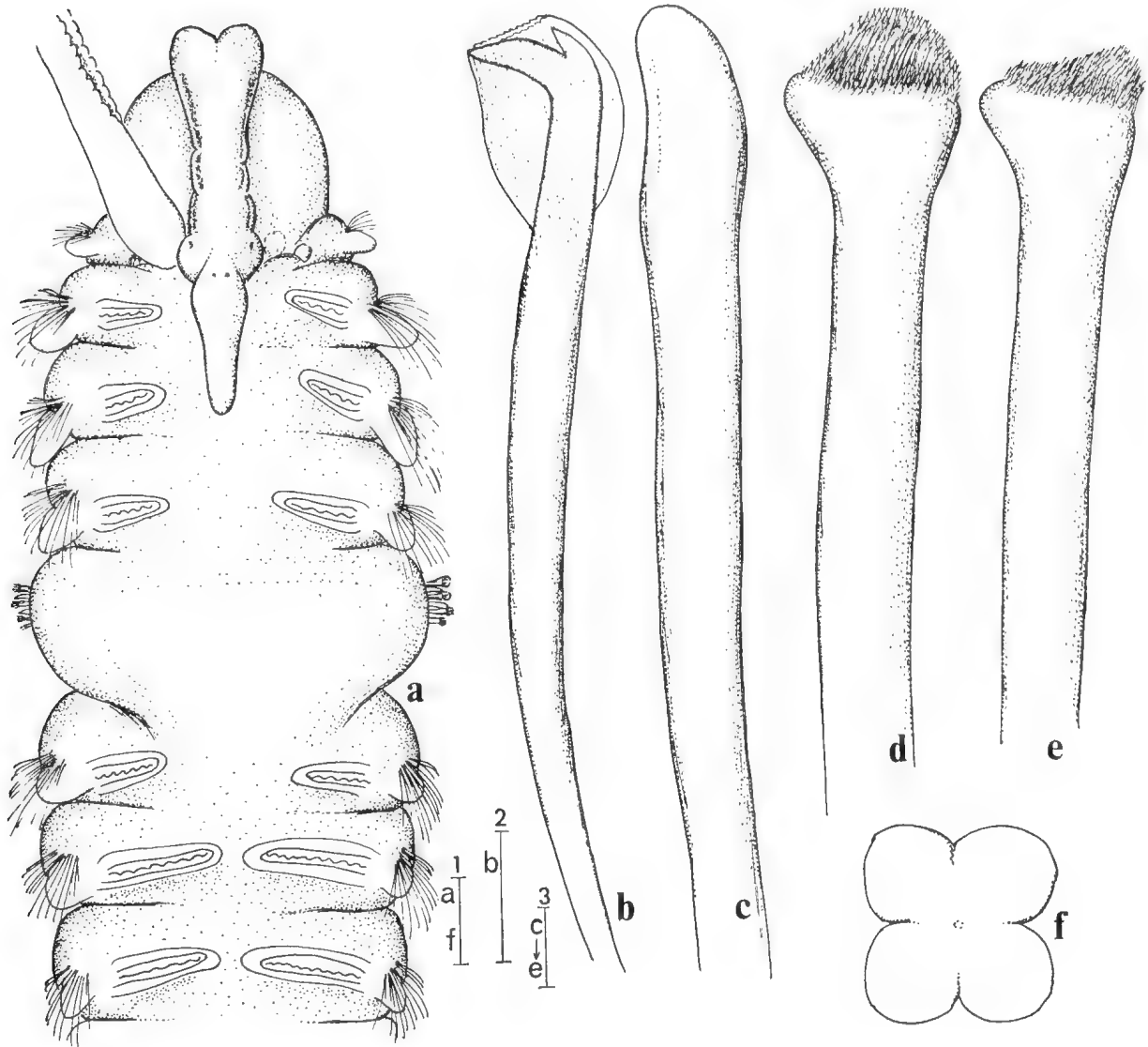


Figure 32—*Boccardia polybranchia* (Haswell)—a, anterior end, dorsal view; b, hooded hook; c, simple spine from setiger 5; d-e, bristle-topped spines from setiger 5; f, pygidium. [Scale 1 = 200  $\mu$ m; 2 = 20  $\mu$ m; 3 = 20  $\mu$ m]

development and pollution. Carazzi (1893) re-described the species based on materials from Naples. Subsequent authors have adapted Carazzi's definition of *B. polybranchia* and the species as such has been reported from many regions of the world.

New collections have been acquired in the benthos in the Hunter River area from the one

remaining oyster farm, as well as from adjacent areas. In no case was a specimen taken which agreed with the current definition of *B. polybranchia*. *Boccardia chilensis* (see below), however, was abundant and proved to be the only species of *Boccardia*. Collections from Coff's Harbour, 325 km north of the Hunter River entrance, contained 2 specimens which fit *B. polybranchia*. Another specimen from Kilcunda, Victoria also proved to be *B. polybranchia*. Because these specimens agree so well with the more cosmopolitan concept of *B. polybranchia*, they are here accepted as

representing that species, even though not found at the type locality. It is possible that *B. chilensis* may actually be what Haswell originally described, but because of inadequate descriptions, the lack of type material and alteration of the type locality, that can probably never be definitely ascertained.

The synonyms listed above represent a few of the many citations of *B. polybranchia* in the literature. A more complete review of this literature and a comparison of the Coff's Harbour material with *B. polybranchia* from South America and elsewhere is the subject of another paper (Blake, in preparation).

*Distribution*: New South Wales; Victoria; Tasmania, Macquarie Island; cosmopolitan.

### ***Boccardia proboscidea* Hartman, 1940**

(Figure 33a-c)

*Polydora californica* Treadwell, 1914, p. 203. HOMO-NYM.

*Boccardia proboscidea* Hartman, 1940, p. 382; 1941, p. 299; 1944, p. 259; 1961, p. 28; 1969, p. 95; Hartman and Reish, 1950, p. 27; Berkeley and Berkeley, 1950, p. 51; 1952, p. 17; Woodwick, 1963, p. 132; 1977, p. 347; Imajima and Hartman, 1964, p. 279; Fauchald, 1977b, p. 47; [Not Carrasco, 1974, p. 186; 1976, p. 8 = *B. tricuspa* (Hartman)].

*Material examined*: VICTORIA, Port Phillip Bay, Werribee, MSG Monitoring Program (P609), coll. J. D. Kudenov, 11 Jan. 1977, Station 9 (919, NMV G3012-3016), numerous additional specimens with egg capsules, used for live study, many not preserved, coll. J. A. Blake and J. D. Kudenov, 17 Feb., 3 Mar. 1977 (NMV G2851, 2854).

*Description*: Prostomium rounded to weakly incised on anterior margin; caruncle to end of setiger 3; 4 eyes. Notosetae present on setiger 1. Spines of setiger 5 of 2 types: (1) falcate, simple (Fig. 33b); (2) bristle-topped (Fig. 33a). Bidentate hooded hooks beginning setiger 7 (Fig. 33c). Branchiae occurring on setigers 2, 3, 4, -, 6 and succeeding segments, absent from posterior  $\frac{1}{3}$  of body. Pygidium with 4 lobes, dorsal pair smaller than ventral.

*Remarks*: Some specimens tend to show a faint incision on the prostomium, but the species agrees in all other respects with *B. proboscidea* from California. The colouration in life is a pale green on the body with 2 long black lines along the sides of the prostomium,

exactly the same as those we have observed on live specimens from California.

The presence of *B. proboscidea* in Port Phillip Bay is the first record from the southern hemisphere. Carrasco (1974; 1976) reported it from Chile, but his descriptions match those of *B. tricuspa* (Hartman), and his specimens should probably be referred to the latter species.

*Ecology*: At the sewage outfall drains at Werribee, *B. proboscidea* is the numerically dominant polychaete at some stations (Kudenov, unpublished). Johnson (1970) determined that *B. proboscidea* was opportunistic on sand flats in Tomales Bay, California, where it often dominates.

*Distribution*: Victoria, North America, California, Oregon; Panama; Japan.

### ***Boccardia chilensis* Blake and Woodwick, 1971**

(Figure 33d-e)

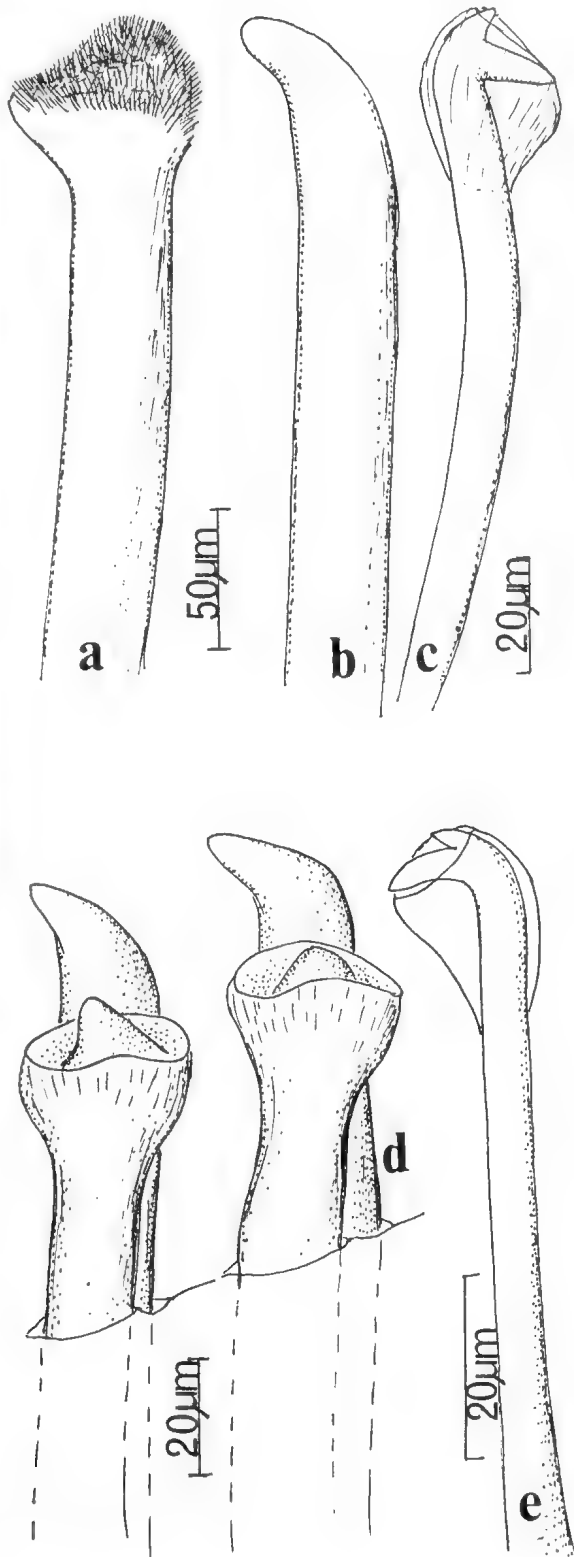
*Polydora polybranchia*: Fauvel, 1916, p. 441. [Not Haswell, 1885].

*Boccardia* sp. Hartman, 1948, p. 109.

*Boccardia chilensis*. Blake and Woodwick, 1971, p. 36; Read, 1975, p. 398; Carrasco, 1976, p. 11.

*Boccardia jubata* Rainer, 1973, p. 547. *Fide* Read, 1975.

*Material examined*: NEW SOUTH WALES. Hunter River, Fullerton Creek, dredged, shell bottom, 16 Feb. 1977, coll. M. Skeel (65+, NMV G3017); Camden Haven, Evans Oyster lease, bottom sample, 20 April 1977, coll. M. Skeel (1, NMV G3018); Same, Kennedy-Googley's lease, on oysters, 20 April 1977, coll. M. Skeel (6, NMV G3019); Nambucca, Diemars Lease, in, on oysters, 26 April 1977, coll. M. Skeel (3, NMV G3020); MacLeary River, Stewarts Point, Sheppards Lease, from oysters, 5 May 1977, coll. M. Skeel (10, NMV G3021); Port Stephens, North Bay arm, Phillips Lease, mud, 5 May 1977, coll. M. Skeel (4, NMV G3022); Port Phillips, Swan Bay, oysters, 28 April 1977, coll. M. Skeel (4, NMV G3023); Port Stephens, Tilligery Creek, 28 April 1977, coll. M. Skeel (10, NMV G3024); Sydney, Vault Point, Drumoyne, inside terminal spire whorls of *Velacumantes australis*, 7 May 1975, coll. J. Walker (1, AM W7133); Paramatta River, Road Point, rock pool covered with Ulva, 27 Jan. 1971, coll. R. McCloskie (3, AM W4523); Minnie Waters, offshore reef, under boulders in gravel, crevices, sandy-silt, 25 Feb. 1971, J. Holloway and P. Hutchings (2, AM W13034). VICTORIA. Port Phillip Bay, St. Kilda Marina, amongst *Galcolaria* tubes, 6 April 1977, coll. J. A. Blake and J. D. Kudenov (18, NMV G2853); Werribee, Station 14, MPSG Monitoring



Program (P609), coll. J. D. Kudenov, 14 Feb. 1977 (38, NMV G3025-3027), numerous additional specimens with egg capsules, used for live study, not preserved, coll. J. A. Blake and J. D. Kudenov, 17 Feb., 3 Mar. 1977. TASMANIA. Macquarie Island, among coralline algae, Green Gorge, in rock pool, Jan. 1964 (7, NMV G2851; several in coralline algae, NMV G3028).

**Description:** Prostomium deeply incised on anterior margin; occipital tentacle present; caruncle to posterior end of setiger 2 with additional mid-dorsal swelling on setigers 5-8. Setiger 1 with long notosetae. Setiger 5 with about 4 simple falcate spines and 4 spines with distal concavity and central cone (Fig. 33d); bidentate hooded hooks beginning on setiger 7 (Fig. 33e). Branchiae occurring on setigers 2, 3, 4, -, 6 and succeeding setigers. Pygidium a fleshy pad, weakly divided.

**Remarks:** Australian specimens agree well with descriptions from Chile (Blake and Woodwick, 1971) and New Zealand (Rainer, 1973 as *B. jubata*; Read, 1975). Minor differences between Chilean specimens and those from New Zealand were pointed out by Read (1975), but are taxonomically insignificant. We note, however, that both New Zealand and Australian specimens have long capillary notosetae in setiger 1 whereas the Chilean specimens were not observed to have such long setae. Length of the notosetae on some specimens is reminiscent of *B. columbiana* from the Pacific coast of North America. The lack of such setae in the Chilean material may be actual or merely reflect the treatment and age of material examined by Blake and Woodwick (1971) which was part of the Lund University Chile Expedition of 1948. Larvae of *B. chilensis* recently described by Carrasco (1976) from Chile are nearly identical to larvae we have cultured from Port Phillip Bay (Blake and Kudenov, unpublished).

In Australia, *B. chilensis* is readily differentiated from related species by the form of the bristle-topped spines of setiger 5 (see key).

Figure 33—*Boccardia proboscidea* Hartman—a, bristle-topped spine from setiger 5; b, simple spine from setiger 5; c, hooded hook—*Boccardia chilensis* Blake and Woodwick—d, group of simple and cusp-topped spines from setiger 5; e, hooded hook.

*Distribution:* New South Wales; Victoria; Chile; New Zealand; Falkland Islands; Macquarie Island.

Genus **Carazziella** gen. nov.

*Type-species:* *Polydora citrona* Hartman, 1941. Gender, feminine.

*Diagnosis:* Prostomium rounded or incised, extending posteriorly as a caruncle; eyes present. Setiger 1 with or without notosetae. Setiger 5 modified with 2 types of heavy spines arranged in a double curved row: (1) first type with an expanded tip bearing cusps or bristles; (2) second type simple, falcate; both types usually bristle-topped; superior dorsal notosetae present or absent; neurosetae of setiger 5 forming a well-developed fascicle of capillaries. Bidentate neuropodial hooded hooks beginning on setiger 7-14, with conspicuous angle between teeth, without constriction on shaft. Branchiae beginning posterior to setiger 5. Pygidium with 2-4 lobes or 4 finger-like cirri.

*Remarks:* Species having 2 types of major spines in 2 rows in setiger 5 as adults and previously referred to the genus *Polydora* are herein assigned to *Carazziella*. The species of *Carazziella* form a link between the genera *Boccardia* and *Pseudopolydora*. Since both types of major spines in most species of *Carazziella* bear bristled tips, they are among the most modified in the entire *Polydora*-complex. They are most closely related to *Boccardia* species in setal morphology, but unlike the latter genus, all lack branchiae anterior to setiger 5.

Seven species are herein assigned to *Carazziella*. These are *Polydora citrona* Hartman, 1941 from California designated the type-species, *Pseudopolydora reishi* Woodwick, 1964 from Eniwetok, *Polydora quadricirrata* Rainer, 1973 from New Zealand and 4 newly described species below. Five additional new species, three from North America and two from South America, will be described in a subsequent paper (Blake, in preparation).

Some juvenile and post-larval *Polydora* are known to have 2 types of spines in setiger 5. This is considered a larval and not an adult characteristic (see *Remarks* under *Polydora*).

The genus *Carazziella* is named in honour of Carazzi, an early Italian student of the family Spionidae.

KEY TO SPECIES OF *CARAZZIELLA* FROM SOUTHEASTERN AUSTRALIA

- 1a. Hooded hooks beginning on setigers 7-8; branchiae and notopodia separate . . . . . 2
- b. Hooded hooks beginning on setigers 11-14; branchiae and notopodia fused . . . . . *C. hymenobranchiata*
- 2a. Hooded hooks beginning on setiger 7; superior dorsal fascicle with distinctive fimbriated setae (Fig. 37c) . . . . . *C. hirsutiseta*
- b. Hooded hooks beginning on setiger 8; superior dorsal fascicle with simple, unilimbate setae (Fig. 34d) or such setae absent . . . . . 3
- 3a. Setiger 1 without notosetae, notopodium short, same length as neuropodium; prostomium rounded (Fig. 34a-b) . . . . . *C. victoriensis*
- b. Setiger 1 with notosetae, notopodium longer than neuropodium; prostomium bifid (Fig. 35a) . . . . . *C. phillipensis*

***Carazziella victoriensis* sp. nov.**

(Figure 34)

*Material examined:* VICTORIA. Port Phillip Bay, PPBES Stations 901/1 (3, NMV G3103); 901/3 (4, NMV G3104); 901/4 (25, NMV G3105); 904/1 (1, NMV G3106); 914/4 (3, NMV G3107); 924/3 (1, NMV G3108); 930/2 (8, NMV G3109); 930/3 (HOLOTYPE, NMV G2855; 2 PARATYPES, NMV G2857); 940/2 (8, NMV G3110); 940/3 (14, NMV G3111); 941/1 (9, NMV G3112); 941/3 (2, NMV G3113); 943/3 (10 PARATYPES, NMV G2856); 943/5 (7, NMV G3114); Westernport, WPBES Stations 1701 (8); 1703 (1); 1711 (4); 1712 (5); 1713 (7) (NMV G3115-3119); Paynesville, Gippsland Lakes, jetty, sand, 2 m, 7 August 1975, coll. J. D. Kudenov (350+, NMV G3120).

*Description:* A small species, up to 5 mm long and 0.5 mm wide for 38 setigerous segments. Body generally opaque white, except for brown flecks around eyes.

Prostomium flattened or rounded on anterior margin (Fig. 34a-b); caruncle unique, extending to posterior margin of setiger 1 where it terminates, followed by a second ridge

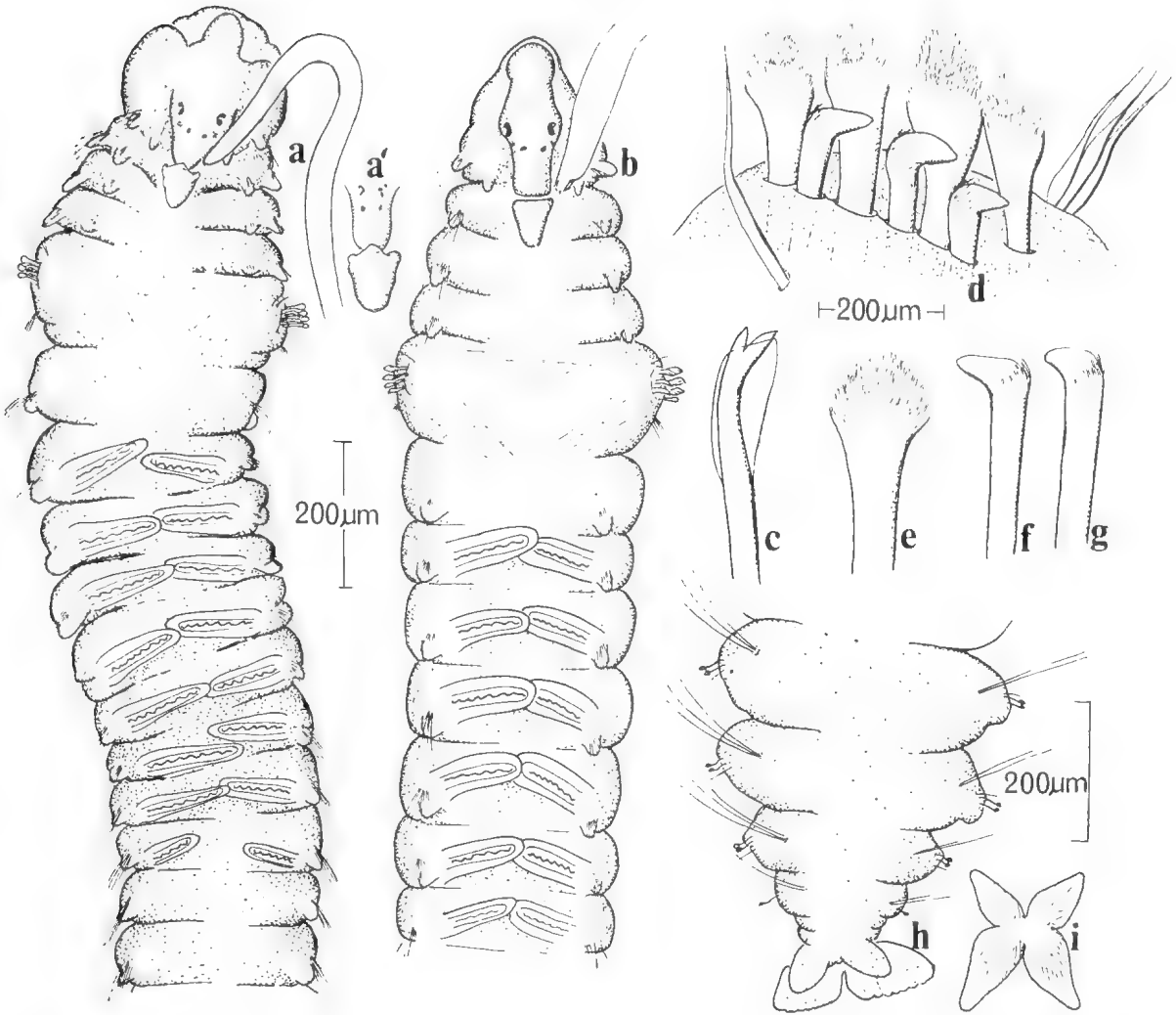


Figure 34—*Carazziella victoriensis* gen. et sp. nov.—  
 a, anterior end, dorsal view in contracted state; a', detail of caruncle [not to scale];  
 b, anterior end, dorsal view in relaxed state; c, hooded hook; d, setae of setiger 5,  
 single superior dorsal seta on left, bristle-topped spines in centre, ventral fascicle  
 to right; e, bristle-topped spine from setiger 5; f-g, falcate spines from setiger 5;  
 h, posterior end in dorsal view; i, pygidium.

on setiger 2 (Fig. 34a-b); anterior margin of ridge elevated, sometimes overlapping terminal end of caruncle (Fig. 34a'); no occipital tentacle, although anterior edge of ridge may approximate tentacle; 2 pairs of eyes: anterior pair cup-shaped; posterior pair oval. Peristo-

mium inflated extending anteriorly beyond prostomium; palps long, extending posteriorly 12-15 setigers.

Setiger 1 with well-developed noto- and neuropodial lobes, but lacking notosetae; neurosetae including simple fascicle of capillary setae. Setigers 2-4 with fascicles of capillary noto- and neurosetae. Parapodial lobes short, conical. Setiger 6 and succeeding segments with fascicles of long capillary notosetae. Neuropodia of setigers 6-7 with capillary setae; bidentate hooded hooks from setiger 8 (Fig. 34c), these number 2-6 per fascicle and accompanied by 2-3 inferior capillary setae for most of body length.

Setiger 5 distinctly modified, with heavy dor-

sal musculature and prominent heavy modified spines, these spines of 2 types, both with bristle-tops and arranged in a double curved row: (1) ventral row of spines large, distally expanded and bristle-topped (Fig. 34d-e); (2) dorsal row smaller, falcate, with short bristles enveloping fang distally (Fig. 34d, f-g); 1 or 2 small, unilimbate superior dorsal capillaries present above anteriormost spine (Fig. 34d), occasionally absent; with prominent fascicle of sheathed, bilimbate capillaries ventral to major spine series (Fig. 34d).

Branchiae from setiger 7, continuing for only 7-10 setigers.

Pygidium with 4 lobes, ventral pair larger than dorsal pair (Fig. 35h-i).

*Remarks:* See comments for *C. phillipensis*.

*Distribution:* Victoria.

#### ***Carazziella phillipensis* sp. nov.**

(Figure 35)

*Material examined:* VICTORIA. Port Phillip Bay, PPBES Stations 901/1 (2 PARATYPES, NMV G2861); 901/3 (14, NMV G3122); 901/4 (5, NMV G3123); 901/5 (PARATYPE, NMV G2859); 901/5 (2, NMV G3124); 904/2 (1, NMV G3125); 915/3 (1, NMV G3126); 926/2 (1, NMV G3127); 933/3 (2, NMV G3129); 936/5 (1, NMV G3130); 943/3 (1, NMV G3131); 972/1 (HOLOTYPE, NMV G2858); Hobsons Bay-Yarra River, MSG Station 134/4, 10 Feb. 1975, coll. G. Poore and J. D. Kudenov (3 PARATYPES, NMV G2860).

*Description:* Similar to *C. victoriensis*. Body small, up to 5 mm long and 0.5 mm wide for 36 setigerous segments. Generally opaque white in alcohol with dusky brown on prostomium and near eyes.

Prostomium anteriorly weakly incised, appearing nearly round on contracted specimens (Fig. 35a); caruncle generally as in *C. victoriensis*, without occipital tentacle; 4 pairs of eyes; anterior pair distinctly cup-shaped; posterior pair oval to irregular in shape. Peristomium inflated as in *C. victoriensis*; palps extending posteriorly for 8-9 setigers.

Setiger 1 with well-developed fascicles of capillary noto- and neurosetae (Fig. 35a); notopodial lobe unusually long, much longer than neuropodial lobe. Setigers 2-4 with fascicles of capillary notosetae and neurosetae; notopodial

lobes broad and short, neuropodial lobes short and finger-like. Setiger 6 and succeeding segments with spreading fascicles of capillary notosetae; neuropodia of setigers 6-7 with capillary setae. Bidentate hooded hooks from setiger 8 (Fig. 35b); these hooks numbering 5-7 per neuropodium throughout, accompanied by several capillary setae at each end of row of hooded hooks, although in some cases only inferior group of capillaries present.

Setiger 5 large (Fig. 35c), with 2-3 superior dorsal capillaries anterior and dorsal to major spines; spines of 2 types: (1) ventral row of large, bristle-topped spines with distal cavity (Fig. 35c); (2) dorsal spines smaller, falcate, with bristles forming prominent tuft on convex surface (ventral) of spine (Fig. 35c); setiger 5 with well-developed ventral fascicle of capillary setae.

Branchiae from setiger 7, occurring for only 5-6 setigers; branchiae broad, meeting at midline.

Pygidium with 4 subequal lobes (Fig. 35d).

*Remarks:* *Carazziella victoriensis* and *C. phillipensis* are closely related. *C. phillipensis* bears notosetae on setiger 1, the prostomium is anteriorly incised and the ventral row of major spines on setiger 5 exhibits a prominent distal concavity. In contrast, *C. victoriensis* lacks notosetae on setiger 1, the prostomium is anteriorly entire and the ventral row of major spines on setiger 1 are distally conical and domed, showing only a faint notch or none at all.

*Distribution:* Victoria, Port Phillip Bay.

#### ***Carazziella hymenobranchiata* sp. nov.**

(Figure 36)

*Material examined:* VICTORIA. Port Phillip Bay, PPBES Stations 904 (1, NMV G3049); 906/1 (PARATYPE, NMV G2862); 921/3 (5 PARATYPES, NMV G2863); 944/4 (4 PARATYPES, NMV G2864); 126/6 (HOLOTYPE, NMV G2865).

*Description:* Most specimens incomplete anterior fragments; holotype measuring 5 mm long for 20 setigers. A paratype measures 10 mm long and 1.0 mm wide for approximately 48 segments. Body light tan, no other body pigment.



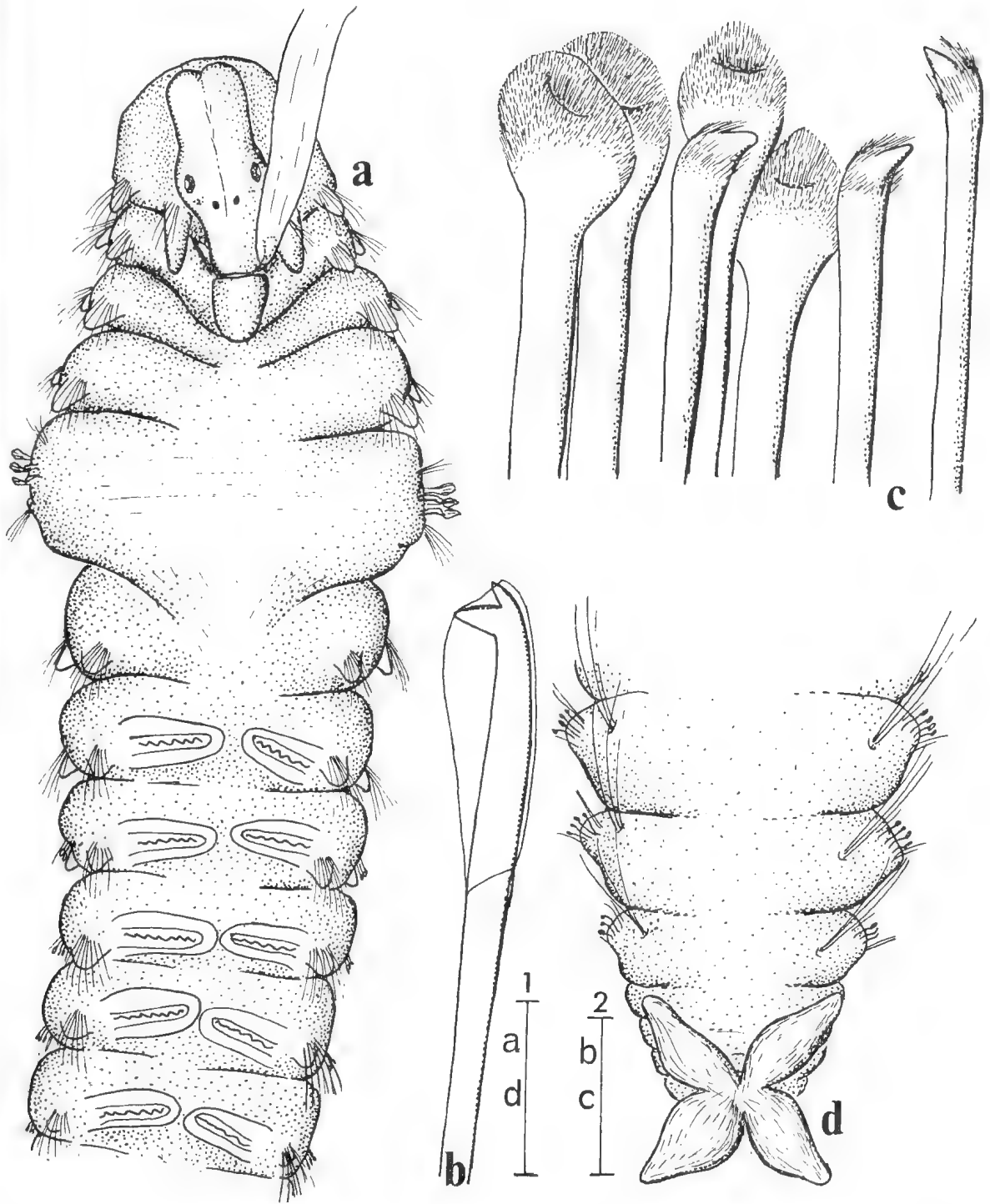


Figure 35—*Carazziella phillipensis* sp. nov.—a, anterior end in dorsal view; b, hooded hook; c, group of spines from setiger 5; d, posterior end in dorsal view. [Scale 1 = 200  $\mu\text{m}$ ; 2 = 20  $\mu\text{m}$ ]

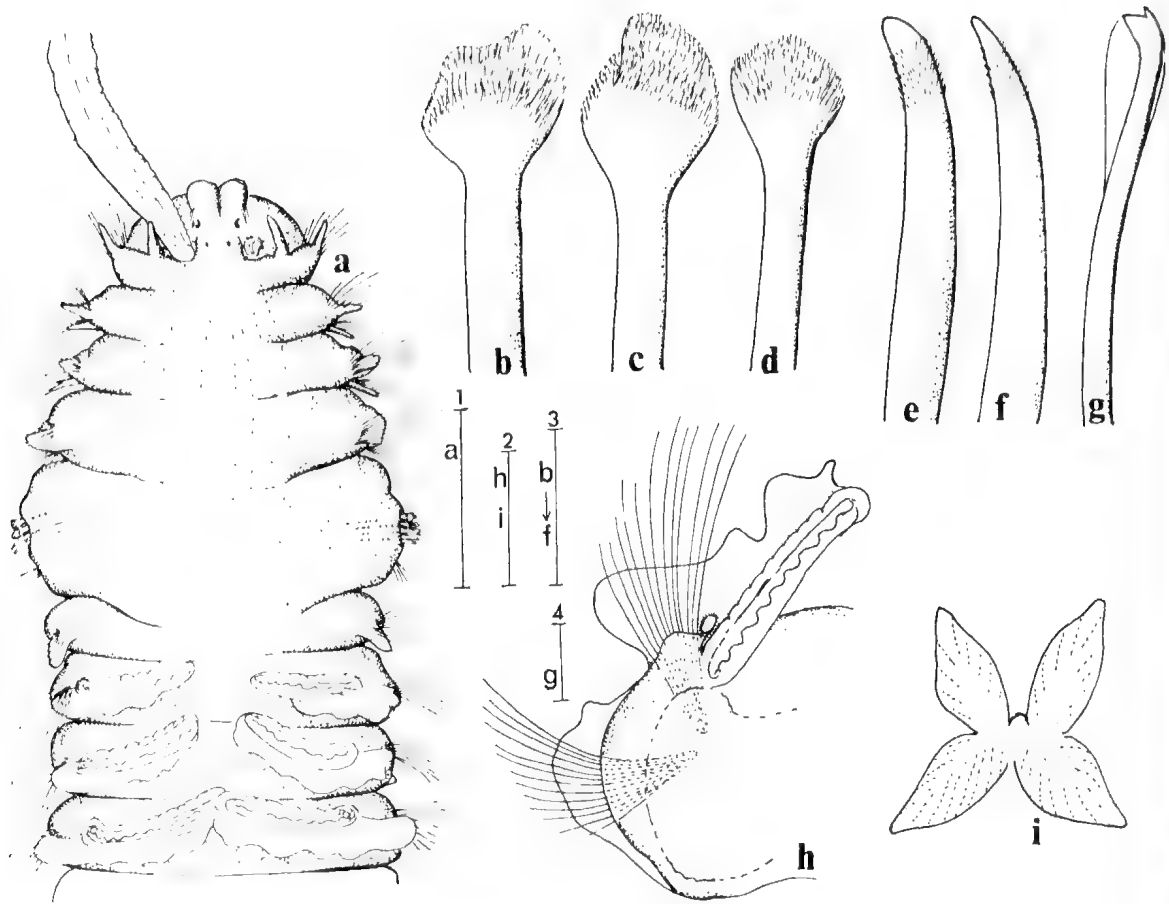


Figure 36—*Carazziella hymenobranchiata* sp. nov.—a, anterior end, dorsal view; b-d, large bristle-topped spines from setiger 5; e-f, curved spines from setiger 5; g, hooded hook; h, right parapodium, setiger 10, anterior view; i, pygidium. [Scale 1 = 500  $\mu$ m; 2 = 200  $\mu$ m; 3 = 50  $\mu$ m; 4 = 20  $\mu$ m]

Prostomium distinctly bifid on anterior margin; caruncle not apparent, nuchal ridge merging with setiger 1 immediately posterior to eyes (Fig. 36a); 2 pairs of eyes: first pair cup-shaped and widely spaced; posterior pair rounded and closely spaced. Peristomium slightly enlarged, but not inflated; palps reaching posteriorly 8-9 segments.

Setiger 1 with long noto- and neuropodial lobes, but lacking notosetae (Fig. 36a); neurosetae including spreading fascicles of capillary setae. Setigers 2-4 with spreading fascicles of unilimbate capillary noto- and neurosetae; digi-

tiform notopodial lobes of setigers 2, 3, 4, - and 6 become expanded leaf-like lamellae on setiger 7; these extending ventrally down the segment and fusing dorsally with branchiae, forming membranous wings (Fig. 36a, h); condition persisting through gill bearing middle body region, thereafter notopodial lobes reduced to simple protuberances. Notoetae unilimbate capillaries from setiger 6, posterior capillaries lacking sheaths. Neuropodia of setigers 2, 3, 4, - and 6 at first digitiform, becoming progressively flattened blade-like lobes; neuropodial lobe a thin lamella throughout branchial region. Neurosetae in setigers 6-10 unilimbate capillaries. First appearance of hooded hooks variable from setiger 11-14; hooks with reduced secondary tooth (Fig. 36g), numbering 5-6 initially, increasing to 7-8 per neuropodium in mid-body region, reduced to 5-6 in posterior region; hooks accompanied by

equal number of interspersed slender capillary setae.

Modified spines of setiger 5 arranged in semi-circle, with 7-8 large brush-like spines enclosing 3-4 falcate spines; bristle-topped spines with tall peak, seen in certain angles (Fig. 36b-d); falcate spines with fine bristles on subdistal curved portion of shaft (Fig. 36e-f); without superior dorsal setae, but with spreading fascicles of ventral unilimbate capillaries.

Branchiae from setiger 7, continuing through middle body segments, these fused with flattened notopodial lobes, as noted above (Fig. 36h).

Pygidium with 4 subequal lobes (Fig. 36i).

*Remarks:* The fusion of branchiae and notopodial lobes in *C. hymenobranchiata* are unique for this genus, as is the lack of a posteriorly prolonged caruncle, and the relative lack of peristomial inflation.

*Distribution:* Victoria, Port Phillip Bay.

#### *Carazziella hirsutiseta* sp. nov.

(Figure 37)

*Material examined:* NEW SOUTH WALES. Botany Bay, Towra Point, NSWFS Stations, 17 April 1973 (HOLOTYPE, NMV G2866; 6 PARATYPES, NMV G2867-2969).

*Description:* A small species measuring 3.2 mm long and 0.5 mm wide for 34 setigerous segments. Body widest at setiger 5, tapering abruptly anteriorly and in posterior segments. Generally opaque white in alcohol with some brown pigment near eyes.

Prostomium rounded on anterior margin, appearing bulbous, continuing posteriorly as caruncle to posterior border of setiger 2 (Fig. 37a); 2-3 pairs of eyes: anterior pair cup-shaped, further apart and occasionally divided into 2 pairs; posterior pair oval, closer together; no occipital tentacle.

Setiger 1 with long notopodial and neuro-podial lobes, but lacking notosetae (Fig. 37a); neurosetae slender, unilimbate capillaries. Setigers 2, 3, 4, -, 6 and succeeding segments with thickened notopodia and fascicles of unilimbate capillaries arranged in 2 tiers: first tier with shorter, thicker setae, those of second tier being longer; notosetae of posterior segments reduced to a few long slender capillaries.

Neurosetae of setigers 2, 3, 4, - and 6 similar to notosetae, arranged in spreading 2-tiered fascicle. Bidentate hooded hooks with reduced angle between teeth (Fig. 37b) from setiger 7, with 3 hooks and 5 capillaries at first, thereafter 7-9 hooks and 3-4 capillaries in middle segments, with 3 hooks and no capillaries in posterior segments.

Setiger 5 setae include a dorsal group of 3-4 peculiar truncated, distally fimbriated setae (Fig. 37c), 2 types of bristle-topped spines and a ventral inferior fascicle of unilimbate capillary neurosetae. Bristle-topped spines of 2 types: (1) a ventral row of spines distally expanded into 3 very pronounced bluntly rounded knobs enclosing a deep central concavity (Fig. 37f-g), 1 of these knobs greatly exceeding the other 2 in length; (2) 4-5 falcate spines in a dorsal row (Fig. 37d-e) bearing bristled tips (Fig. 37d-e).

Branchiae from setiger 7, occurring only over 5-6 segments or setigers 12-13. Branchiae short, thickened, barely reaching to mid-line.

Pygidium with 4 thin subequal lobes or cirri (Fig. 37h).

*Remarks:* *Carazziella hirsutiseta* is the only species of the genus with hooded hooks beginning on setiger 7. The large tricuspid bristle-topped spines of setiger 5 are unusually pronounced at their apex and bear a large terminal notch or cavity. The dorsal superior fascicle also bears highly distinctive fimbriated setae which appear to be transitional between normal capillaries and bristle-topped major spines.

*Distribution:* New South Wales, Botany Bay.

#### Genus *Polydora* Bosc, 1802 emended

*Polydora* Bosc, 1802. *Type-species:* *Polydora cornuta* Bosc, 1802.

*Diplothis* Montagu, 1813. *Type-species:* *Diplothis hyalina* Montagu, 1813.

*Leucodore* Johnston, 1838. *Type-species:* *Leucodore ciliatus* Johnston, 1838.

*Leipoceras* Mobius, 1874. *Type-species:* *Leipoceras uviferum* Mobius, 1874.

*Dipolydora* Verrill, 1881. *Type-species:* *Polydora concharum* Verrill, 1881.

*Protopolydora* Czerniavsky, 1881. *Type-species:* *Polydora hamata* Langerhans, 1880. (HOMONYM of *Polydora hamata* Webster, 1879b) = [*Polydora posthamata* Jones, 1962].

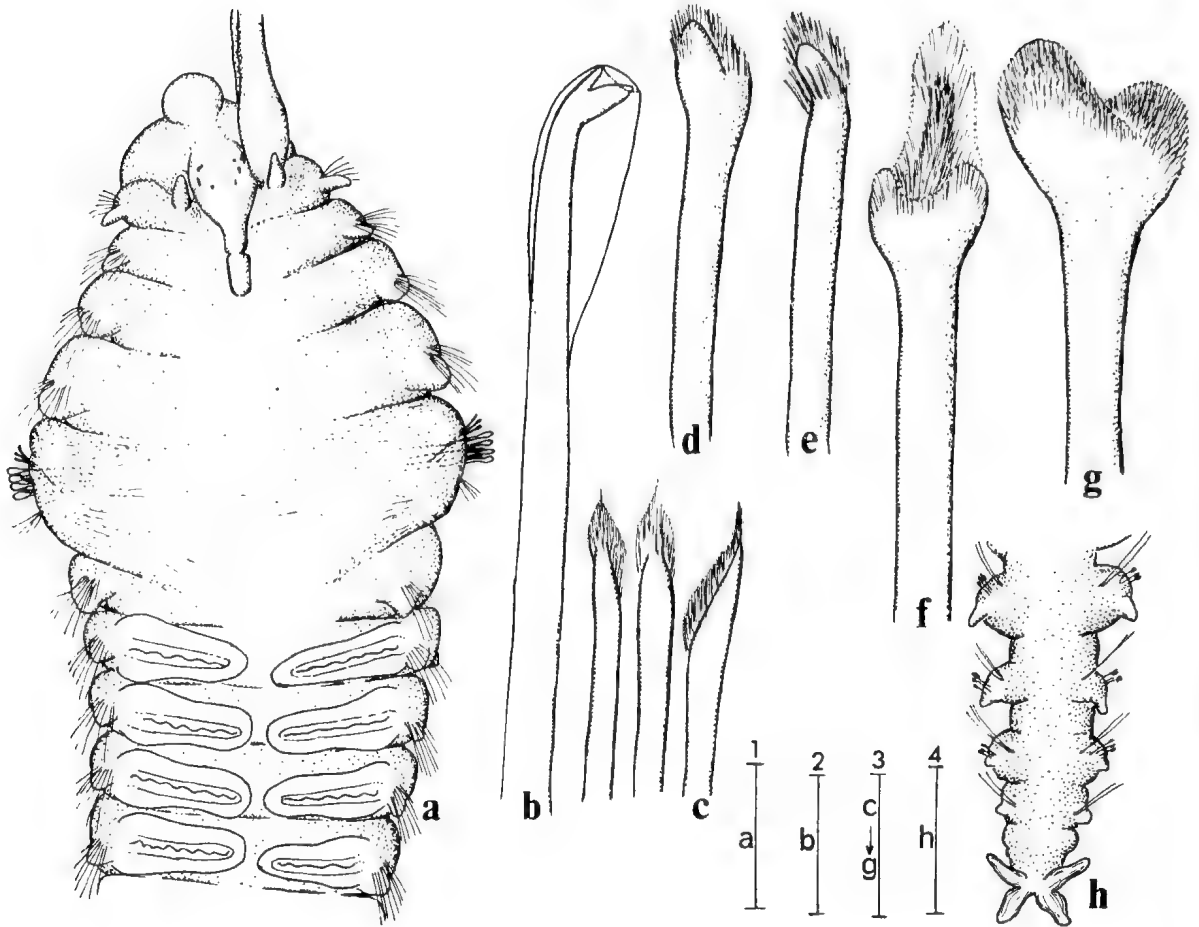


Figure 37—*Carazziella hirsutiseta* sp. nov.—a, anterior end, dorsal view; b, hooded hook; c, superior dorsal setae, setiger 5; d-e, falcate bristle-topped spines, setiger 5; f-g, large bristle-topped spines, setiger 5; h, posterior end, dorsal view. [Scale 1 = 200  $\mu\text{m}$ ; 2 = 100  $\mu\text{m}$ ; 3 = 20  $\mu\text{m}$ ; 4 = 100  $\mu\text{m}$ ]

*Pseudoleucodore* Czerniavsky, 1881. *Type-species*: *Leucodorum caecum* Oersted, 1843.

**Diagnosis:** Prostomium anteriorly entire or incised, extending posteriorly as caruncle; eyes present or absent. Setiger 1 with or without notosetae. Setiger 5 greatly modified, with major spines of one type, usually accompanied by slender companion setae; spines arranged in single curved row. Posterior notopodial spines present or absent. Neuropodial hooded hooks bidentate with conspicuous angle be-

tween teeth, with or without constriction on shaft and beginning on setigers 7-17. Branchiae beginning posterior to setiger 5. Pygidium reduced or enlarged, cuff-like, saucer-like or divided into lobes.

**Remarks:** With the erection of the genus *Carazziella*, species with 2 types of major spines in setiger 5 as adults are removed from *Polydora*. This includes *P. citrona* Hartman, which was noted by Woodwick (1964) as one of the species not exactly conforming to the definition of *Polydora*. Restricting the genus *Polydora* to include only those species with 1 type of major spine on setiger 5 stabilizes the genus, although there remain a few problems with species described as juveniles. Blake (1969) pointed out that some species of larval or post-larval *Polydora* have an initial simple falcate

spine among the main series of spines which develop on setiger 5. This spine eventually drops out and is replaced by the setae typical for that particular species. At least 3 species have been described from juveniles having such a setal configuration: *P. heterochaeta* Rioja, 1939; *P. laticephala* Hartmann-Schröder, 1959 and *P. punctata* Hartmann-Schröder, 1959. This type of setal arrangement is considered to be a larval and not an adult characteristic (Blake, 1969); the validity of any species described from larval or post-larval forms should be seriously questioned.

*Polydora cornuta* Bosc, 1802 is the indeterminate type-species of the genus (Blake, 1971; Foster, 1971). Comments concerning the identification of *P. cornuta* will be included in a forthcoming paper (Blake, in preparation).

KEY TO SPECIES OF *POLYDORA* FROM  
SOUTHEASTERN AUSTRALIA

- |  |                        |
|--|------------------------|
| 1a. Hooded hooks with constriction on shaft (Fig. 43j) . . . . .   | 10                     |
| b. Hooded hooks without constriction on shaft (Fig. 38b) . . . . .   | 2                      |
| 2a. Major spines of setiger 5 bearing accessory structures as teeth, flanges, or bristles, or with distal cavity . . . . .   | 6                      |
| b. Major spines of setiger 5 simple, falcate, without accessory structures, but may have subterminal enlargement (Fig. 38a, d, e) . . . . .  | 3                      |
| 3a. Occipital tentacle present (Fig. 39a) . . . . .  | <i>P. tentaculata</i>  |
| b. Occipital tentacle absent . . . . .   | 4                      |
| 4a. Posterior notopodial spines or needles present; gizzard absent, or if present, seen only upon dissection . . . . .   | 5                      |
| b. Posterior notopodial spines absent; gizzard present internally in setigers 18-19, prominently seen externally as swelling . . . . .   | <i>P. socialis</i>     |
| 5a. Posterior notopodial spines present as individual acicula among capillaries (Fig. 38h); major spines of setiger 5 with large subterminal protuberance (Fig. 38f) . . . . .       | <i>P. protuberata</i>  |
| b. Posterior notopodial spines present as dense expanded packets of needles (Fig. 38c); major spines of setiger 5 with weak subterminal swelling (Fig. 38a) . . . . .                | <i>P. flava</i>        |
| 6a. Major spines of setiger 5 with crest of bristles on convex side and with accessory flange, collar or cavity . . . . .  | 8                      |
| b. Major spines of setiger 5 without crest of bristles, with 1 or 2 accessory teeth, with or without cawling or hood connecting teeth . . . . .                                      | 7                      |
| 7a. Major spines of setiger 5 with large accessory tooth (Fig. 38i); posterior notopodial spines absent; branchiae from setiger 9 . . . . .  | <i>P. giardi</i>       |
| b. Major spines of setiger 5 bifid with hood or cawling connecting 2 teeth (Fig. 43a-c); posterior notopodial acicular spines present (Fig. 43g); branchiae from setiger 7 . . . . . | <i>P. armata</i>       |
| 8a. Branchiae from setiger 9; major spines of setiger 5 with lateral accessory flange (Fig. 40g-h); posterior notopodial spines present . . . . .                                    | <i>P. aciculata</i>    |
| b. Branchiae from setiger 7; major spines setiger 5 with subterminal concavity or collar; posterior notopodial spines absent . . . . .   | 9                      |
| 9a. Prostomium entire, major spines of setiger 5 with subterminal concavity and crest of bristles on convex side (Fig. 41b) . . . . .  | <i>P. notialis</i>     |
| b. Prostomium incised; major spines of setiger 5 with collar on convex side from which bristles emerge (Fig. 42b-c) . . . . .  | <i>P. pilocollaris</i> |
| 10a. Posterior notopodia with needle packets or large spines . . . . .   | 11                     |
| b. Without posterior notopodial spines . . . . .   | 12                     |
| 11a. Packets of posterior notopodial needles (Fig. 45j-k); major spines of setiger 5 with small lateral flange (Fig. 45c-f) . . . . .  | <i>P. latispinosa</i>  |
| b. Posterior notopodial spines individual, large, not needle-like, curved in towards mid-line (Fig. 47e); major spines of setiger 5 with large flange (Fig. 47b-c) . . . . .         | <i>P. hoplura</i>      |

- 12a. Occipital tentacle present; companion setae of setiger 5, delicate, feathery in appearance (Fig. 43h) ..... *P. ligni*
- b. Occipital tentacle absent; companion setae of setiger 5, bilimbate, not feathery (Fig. 46g) ..... 13
- 13a. Prostomium entire; caruncle short, globular (Fig. 46g); pygidium smaller than posterior segments, cuff-shaped (Fig. 46k) ..... *P. woodwicki*
- b. Prostomium incised; caruncle long, narrow (Fig. 44a); pygidium, larger than posterior segments, saucer-like (Fig. 44g) ..... 14
- 14a. Major spines of setiger 5 with 1 accessory flange (Fig. 43k, m) ..... *P. websteri*
- b. Major spines of setiger 5 with 1 accessory flange located just ahead of an accessory tooth (Fig. 44c-e) ..... *P. haswelli*

***Polydora flava* Claparède, 1870**

(Figure 38a-c)

*Polydora flava* Claparède, 1870, p. 487; Fauvel, 1927, p. 52; Day, 1967, p. 468; Hartmann-Schröder, 1971, p. 305. [major references only]

*Polydora pusilla* Saint-Joseph, 1894, p. 65.

*Polydora dorsomaculata* Rainer, 1973, p. 558. *New synonymy*.

*Material examined*: NEW SOUTH WALES. North Heads, Sydney, AMSBS, May 1972 (1, AM W6941); Botany Bay, Towra Beach, NSWFS Station, April 1973 (1, AM W13035). VICTORIA. Port Phillip Bay, PPBES Stations 907 (55), 913 (1), 915 (1), 919 (56), 929 (318), 930 (4), 932 (4), 944 (2), 985 (1) (NMV G3029-3037); Westernport, Crib Point, CPBS Station 32A, April 1970 (5, NMV G3048).

*Description*: A moderate-sized species averaging about 8 mm long and 0.5 mm wide for 80 setigerous segments.

Prostomium strongly bifid on anterior margin, caruncle extending to setiger 3; no occipital tentacle; no eyes. Setiger 1 with both noto- and neuropodial setal fascicles; neuropodial lobes of setiger 1 long. Setigers 2, 3, 4, - and 6 with well-developed fascicles of sheathed, unilimbated capillaries in both rami. Bidentate neuropodial hooded hooks completely replacing capillaries from setiger 7,

hooks numbering 3-4 per ramus, and normally with wide angle between teeth (Fig. 38b); one specimen from Towra Beach, N.S.W. bearing a reduced secondary tooth in posterior setigers. With capillary notosetae in posterior setigers accompanied by packets of fine needles (Fig. 38c).

Setiger 5 modified, bearing curved row of simple falcate spines, each with subterminal swelling (Fig. 38a); with bilimbate companion setae and 5-6 superior dorsal pointed setae; ventral fascicle of sheathed unilimbated capillaries present.

Branchiae from setiger 8. Pygidium a 3-lobed disc, with 2 small dorsal lobes and a larger ventral lobe.

*Remarks*: This species agrees well with descriptions from other seas. The posterior needles are arranged in a tight, flattened group as in *P. convexa* Blake and Woodwick (1972) and *P. latispinosa* (see below).

*Distribution*: New South Wales; Victoria; Europe; Ceylon; Sumatra; Japan.

***Polydora socialis* (Schmarda, 1861)**

(Figure 38d-e)

*Polydora socialis*: Blake, 1971, p. 20 (Synonymy); Light, 1977, p. 71.

*Polydora plena*: Foster, 1971, p. 24. *Fide* Light, 1977, p. 71.

*Material examined*: NEW SOUTH WALES. Sydney, Wy-ar-gine Point, Middle Harbour, in *Galeolaria* associations, 14 Dec. 1968 (1, AM W13036); Malabar, Sydney, AMSBS Stations (1, AM W6496; 5, AM W6497); Sydney Harbour, S.E. Chinamens Beach, Malacological club survey, 8 May 1971 (1, AM W13037); Botany Bay, Towra Beach, NSWFS Station, 12 April 1973 (1, AM W13038). VICTORIA. Port Phillip Bay, PPBES Stations 907 (56); 919 (144); 929 (318); 932 (4); 944 (2); 953 (7); 965 (4); 978 (9); 982 (3) (widespread in PPB) (NMV G3158-3166).

*Description*: A moderate-sized species, up to 9 mm long and 0.75 mm wide for 66 setigers. Prostomium strongly incised on anterior margin, caruncle extending to setiger 4-5; no occipital tentacle; 2 pairs of eyes. Setiger 1 with notosetae. Major spines of setiger 5 with subterminal boss (Fig. 38d). Companion setae bilimbate (Fig. 38d). No posterior neuropodial spines. Bidentate hooded hooks from setiger 7 (Fig. 38e) accompanied by capillary setae. Branchiae from setiger 8. Pygidium disc-like.

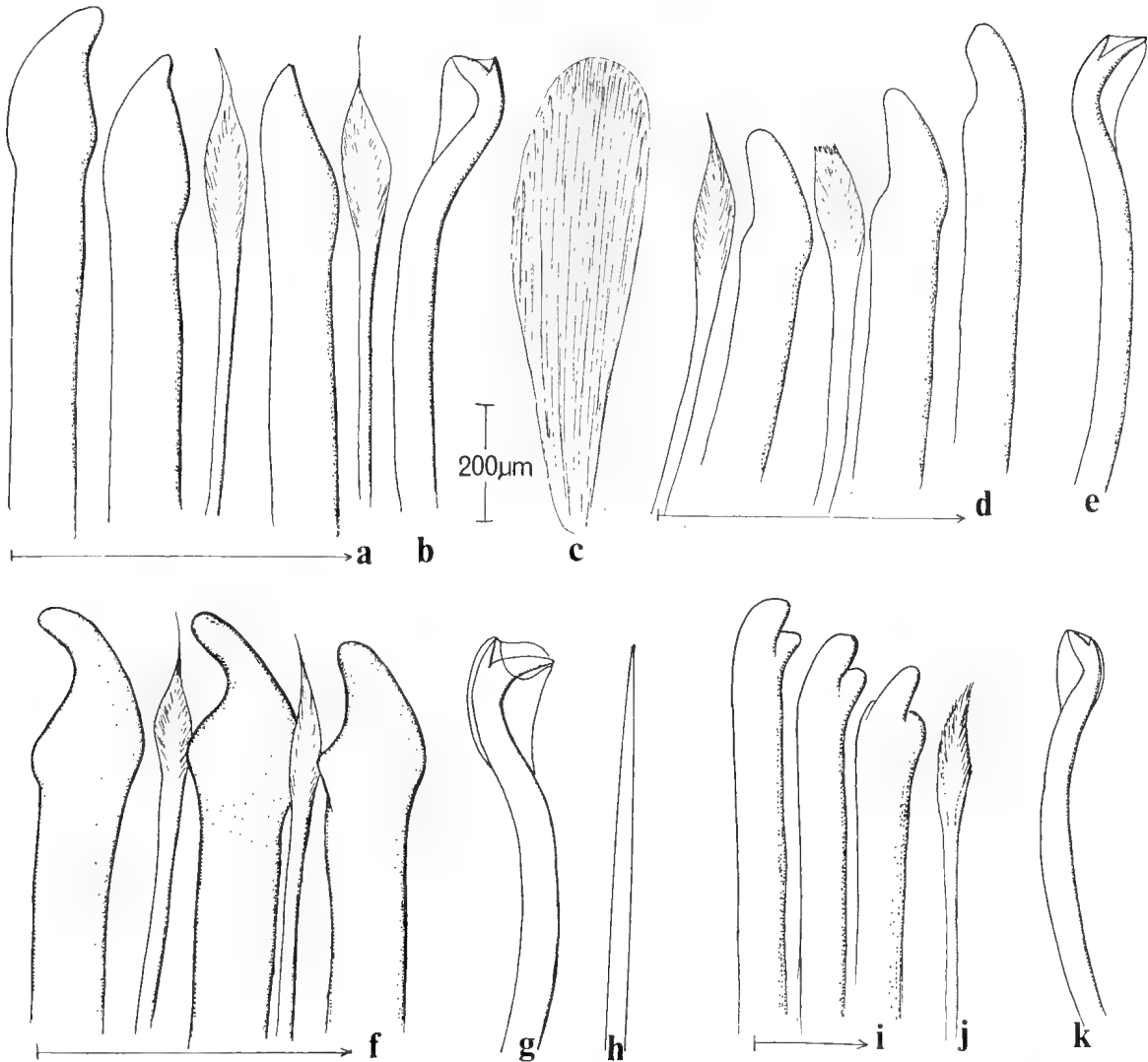


Figure 38—*Polydora flava* Claparède—a, 3 major spines and 2 companion setae, setiger 5; b, hooded hook; c, posterior notopodial needles—*Polydora socialis* (Schmarda)—d, 4 major spines and 2 companion setae, setiger 5; e, hooded hook—*Polydora protuberata* nov. sp.—f, 3 major spines and 2 companion setae, setiger 5; g, hooded hook; h, posterior notopodial spine—*Polydora giardi* Mesnil—i, 3 major spines, setiger 5; j, companion seta, setiger 5; k, hooded hook.

seem generally smaller. Reduction of the secondary tooth in posterior hooded hooks was observed by Blake (1971), for specimens from New England; this feature was not found in the present collections. Variation in that character has been observed in other populations from North America and will be discussed in a subsequent paper (Blake, in preparation). Some specimens exhibit dorsal pigment flecks, which are believed to be remnants of larval pigment (Blake, 1971). The gizzard is a highly diagnostic feature of *P. socialis*. Located internally at about setigers 18-19, it appears as a conspicuous external bulge. A simi-

Gizzard present internally in setigers 18-19.

*Remarks:* Specimens agree well with collections from other geographic areas, although they

lar structure is also present in *P. protuberata* and *P. tentaculata* (see below), but is not as conspicuous as in *P. socialis* and best seen upon dissection. As shown by Blake (1971), *P. socialis plena* Berkeley and Berkeley, 1936 is an invalid subspecies because the character on which it is based, namely the presence of notosetae on setiger 1, occurs on all specimens of *P. socialis (sensu lato)*. Hence, elevation of *P. plena* to full species rank by Foster (1971) is not supported (see also Light, 1977).

*Distribution:* New South Wales; Victoria; New Zealand; North America; South America.

***Polydora protuberata* sp. nov.**

(Figure 38f-h)

*Material examined:* VICTORIA. Port Phillip Bay, PPBES Stations 904 (1, NMV G3049) 907 (20 PARATYPES, NMV G2871); 908 (2, NMV G3050); 913 (1, NMV G3051); 922 (2, NMV G3052); 928 (3, NMV G3053); 930 (1, NMV G3054); 946 (HOLOTYPE, NMV G2870).

*Description:* Holotype the largest specimen, broken in 2 parts, measuring 16 mm long and 1 mm wide for 115 segments. Body colourless.

Prostomium distinctly incised on anterior margin, caruncle extending to setigers 3-5, no occipital tentacle or eyes.

Setiger 1 with capillary notosetae. Setigers 2, 3, 4, -, 6 and succeeding segments with unilimbate capillary notosetae in 3 tiers; posterior notopodia with several short acicular spines in addition to long capillaries (Fig. 38h). Neurosetae of setigers 2, 3, 4, - and 6 with unilimbate capillaries in 2 tiers. Four to 5 bidentate neuropodial hooded hooks from setiger 7, accompanied by capillary setae for only a few segments; hooks with wide angle between teeth; main fang forming oblique angle with shaft; constriction lacking on shaft (Fig. 38g).

Setiger 5 modified, with superior dorsal fascicle of geniculate setae lacking sheaths, a curved row of major spines and sheathed bilimbate companion setae and a ventral fascicle of unilimbate capillaries; major spines simple, falcate, with a large subterminal protuberance (Fig. 38f), this much more pronounced than in *P. socialis* (Fig. 38d).

Branchiae from setiger 8, continuing to near posterior end. Pygidium disc-like, with dorsal

notch. Weakly-developed gizzard, best seen in dissection, observed on some specimens at about setigers 17-18.

*Remarks:* *Polydora protuberata* is very similar to *P. caeca* (Oersted, 1843) from Europe (Fauvel, 1927; Hartmann-Schröder, 1971) and South Africa (Day, 1967). The 2 species differ in the structure of the major spines of setiger 5. In *P. caeca*, the spines have a slight swelling whereas *P. protuberata* has a large expanded protuberance. The 2 species also differ in habitat. *P. caeca* is a borer in calcareous habitats (Fauvel, 1927) while *P. protuberata* lives in sediment.

*Distribution:* Victoria, Port Phillip Bay.

***Polydora tentaculata* sp. nov.**

(Figure 39)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Sta. 34, March 1974, coll. W. Stephenson (2 PARATYPES, QM G11597); Sta. 56, June 1974 (PARATYPE, QM G11600). NEW SOUTH WALES. Botany Bay, Towra Beach, NSW Station, April 1973 (HOLOTYPE, NMV G2885; 1 PARATYPE, NMV G2886).

*Description:* A moderate-sized species up to 15 mm long and 1.0 mm wide for 88 setigerous segments. Body generally opaque white with some anterior brown pigment bars located dorsally on anterior setigers.

Prostomium deeply bifurcate on anterior margin, forming 2 divergent lobes (Fig. 39a). Caruncle extending to middle of setiger 5; with triangular shaped occipital tentacle present at level of setiger 1; eyes 0-2.

Setiger 1 with notosetae and long notopodial lobes (Fig. 39a). Setigers 2, 3, 4, -, 6 and succeeding setigers with fascicles of notosetae arranged in 2 tiers; posterior notosetae including long slender capillaries (Fig. 39b) and a stouter spine (Fig. 39c). Neurosetae of setigers 2, 3, 4, - and 6 with capillaries. Bidentate hooded hooks from setiger 7, hooks numbering 5-8 throughout; without constriction on shaft; angle between teeth variable within a single fascicle, being widest in superiormost position (Fig. 39d) and less in more inferior position (Fig. 39e); hooks accompanied by inferior capillaries in first few segments.

Setiger 5 modified, larger than setigers 4 or



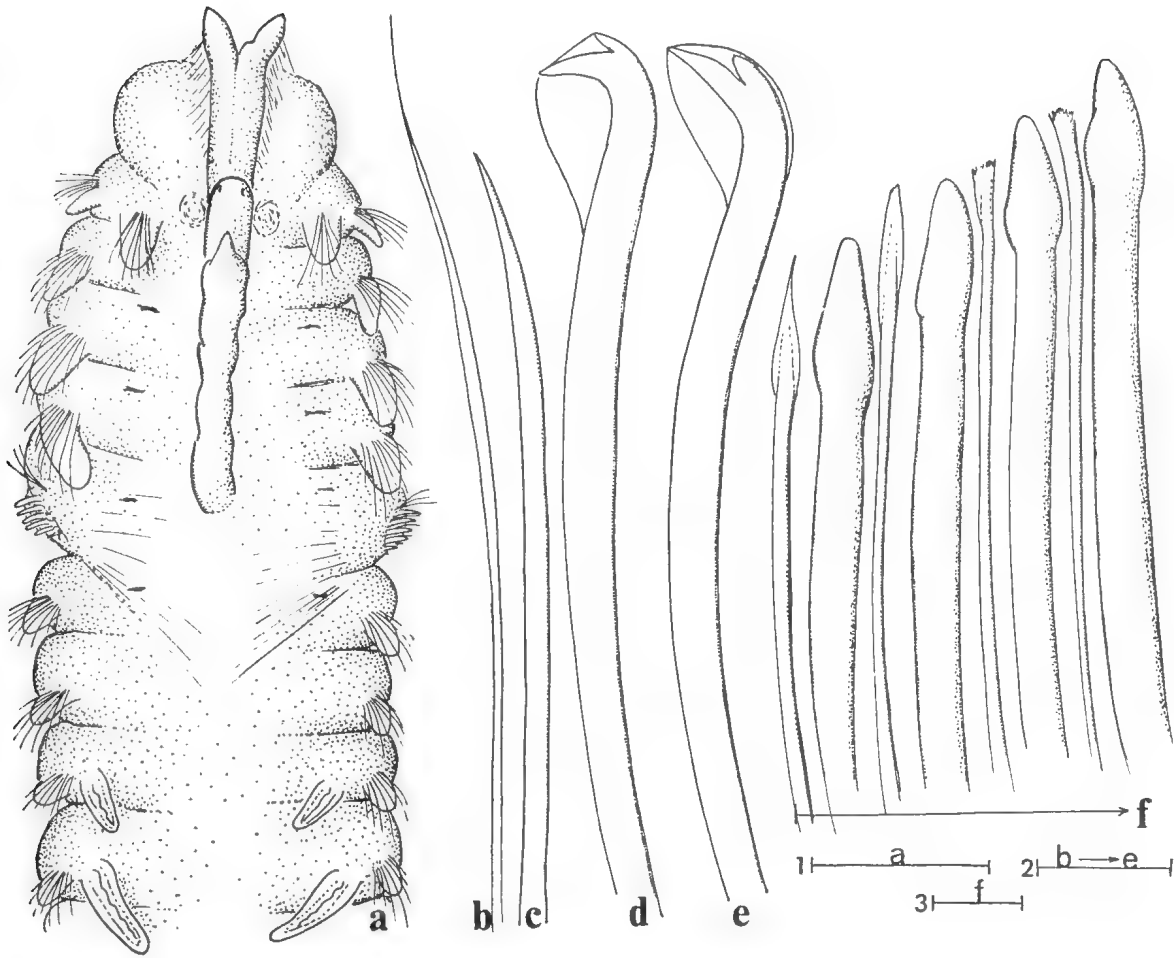


Figure 39—*Polydora tentaculata* sp. nov.—a, anterior end, dorsal view; b, long posterior capillary notoseta; c, short acicular-like posterior notoseta; d, hooded hook from superior neuropodial position; e, hooded hook from inferior neuropodial position; f, group of 4 major spines and 4 companion setae, setiger 5. [Scale 1 = 500  $\mu$ m; 2 = 200  $\mu$ m; 3 = 20  $\mu$ m]

6; setae including a superior dorsal fascicle of geniculate setae lacking sheaths, a curved row of major spines accompanied by simple bilimbate companion setae (Fig. 39f) and a ventral fascicle of unilimbate capillaries. Major spines simple, falcate, lacking accessory structures (Fig. 39f).

Branchiae from setiger 8, small at first, reaching full-size by setiger 10, present over most of body.

Pygidium unknown.

Gizzard observed at level of setigers 19-20 as bulge in dorsum; appears as muscular enlargement of intestine upon dissection; not as well-developed as in *P. socialis*.

*Remarks:* *Polydora tentaculata* is most closely related to *P. socialis*, *P. flava*, *P. protuberata* and *P. caeca*. It differs from all of these in possessing an occipital tentacle and in bearing hooded hooks in which the angle changes within individual fascicles from the superior to inferior position. In the combined feature of bearing an occipital tentacle and simple major spines on setiger 5, *P. tentaculata* also resembles *P. nuchalis* Woodwick (1953) from California. The latter species, however, exhibits a constriction on the shafts of the hooded hooks, and belongs to a group of spe-

cies related to *P. ligni* Webster (see below).

*Distribution:* Queensland; New South Wales.

***Polydora giardi* Mesnil, 1896**

(Figure 38i-k)

*Polydora giardi* Mesnil, 1896, p. 195; Fauvel, 1927, p. 50; Hartman, 1941, p. 309; 1969, p. 135; Rainer, 1973, p. 560; Read, 1975, p. 413.

*Material examined:* NEW SOUTH WALES. Sydney, Wy-ar-gine Point, Middle Harbour, from *Galeolaria* association, 19 Dec. 1968 (10+, AM W13039). VICTORIA. Kilcunda, Bourne Creek, in shell (*Haliotus ruber*, 11 April 1977, coll. J. A. Blake and J. D. Kudenov (6, NMV G2949); Bass Strait, 20 m, 38° 28'S-144° 48'E, dredged, from bryozoans, coralline algae on sandstone reef, coll. J. A. Blake and J. D. Kudenov, May 1977 (2, NMV G3055).

*Description:* A small species measuring up to 7 mm long and 0.3 mm wide for 75 setigerous segments, but reported larger in other areas (Rainer, 1973). Prostomium incised, caruncle extending to anterior margin of setiger 3; no occipital tentacle or eyes. Setiger 1 with both noto- and neurosetae, and well-developed parapodial lobes. Notopodia of setigers 2, 3, 4, -, 6 and succeeding segments with fascicles of unilimbate capillaries; with long capillaries in posterior setigers, but spines lacking. Neurosetae of setigers 2, 3, 4, - and 6 with unilimbate capillaries. Bidentate hooded hooks from setiger 7, 3-4 hooks at first accompanied by 1-2 capillaries; hooks with acute angle between secondary tooth and main fang and wide angle between main fang and shaft (Fig. 38k), no constriction on shaft.

Setiger 5 modified with dorsal fascicle of prominent geniculate setae, lacking sheaths, a curved row of heavy spines and bilimbate companion setae (Fig. 38j) and a ventral fascicle of winged capillary neurosetae; major spines falcate with large accessory tooth (Fig. 38i), some specimens appearing to have an additional small spur on convex side of shaft.

Branchiae from setiger 9, absent from posterior  $\frac{1}{3}$  of body. Pygidium a small disc.

*Distribution:* New South Wales; Victoria; Europe; California; New Zealand.

***Polydora aciculata* sp. nov.**

(Figure 40)

*Material examined:* VICTORIA. Kilcunda, Bourne Creek, in shell *Haliotus ruber*, 11 April 1977, coll.

J. A. Blake and J. D. Kudenov (HOLOTYPE, NMV G2872, 8 PARATYPES, NMV G2873).

*Description:* A moderate-sized species up to 10 mm long and 0.3 mm wide for 85 setigers. Body generally opaque white in alcohol, with faint brown lines along margin of caruncle.

Prostomium entire and narrow on anterior margin (Fig. 40a), caruncle continuing as low ridge to posterior margin of setiger 3; no occipital tentacle or eyes. Peristomium and prostomium depressed and lower in lateral view than first setiger and succeeding segments.

Setiger 1 with capillary setae in both rami (Fig. 40a). Setigers 2, 3, 4, -, 6 and succeeding setigers containing spreading fascicles of unilimbate capillary notosetae arranged in 2 tiers, first tier with shorter setae and longer setae in second; in mid-body region, shorter capillary setae replaced by 2-3 stout acicular spines (Fig. 40b-c) accompanied by 3-4 long, thin capillary setae. Notosetae maintaining this arrangement to end of body (Fig. 40k-l). Three to 4 bidentate hooded hooks per neuropodium from setiger 7 accompanied by a single capillary for a few segments; without constriction on shaft (Fig. 40d); hooks with wide angle between secondary tooth and main fang; this angle gradually diminishing along body, secondary tooth and hood gradually becoming smaller and more closely pressed to main fang (Fig. 40e), both eventually disappearing in far posterior segments (Fig. 40f), leaving neuropodia with acicular spines.

Setiger 5 modified, overlapping setiger 6 (Fig. 40a); setae including 5-6 superior dorsal geniculate setae (Fig. 40j) lying anterior to a semi-circular row of heavy spines alternating with smaller hastate companion setae (Fig. 40i) and small fascicle of unilimbate capillary neurosetae located ventral to major spines; major spines falcate, with distinct lateral flange and crest of fine bristles on convex side of curved end (Fig. 40g-h).

Branchiae from setiger 9, at first short reaching full-size on setigers 11-12, present only over first  $\frac{1}{3}$  of body, absent thereafter.

Pygidium with 4 lobes, the dorsal pair smaller than ventral pair (Fig. 40k).

*Remarks:* *Polydora aciculata* has several unique characteristics: the modified spines of

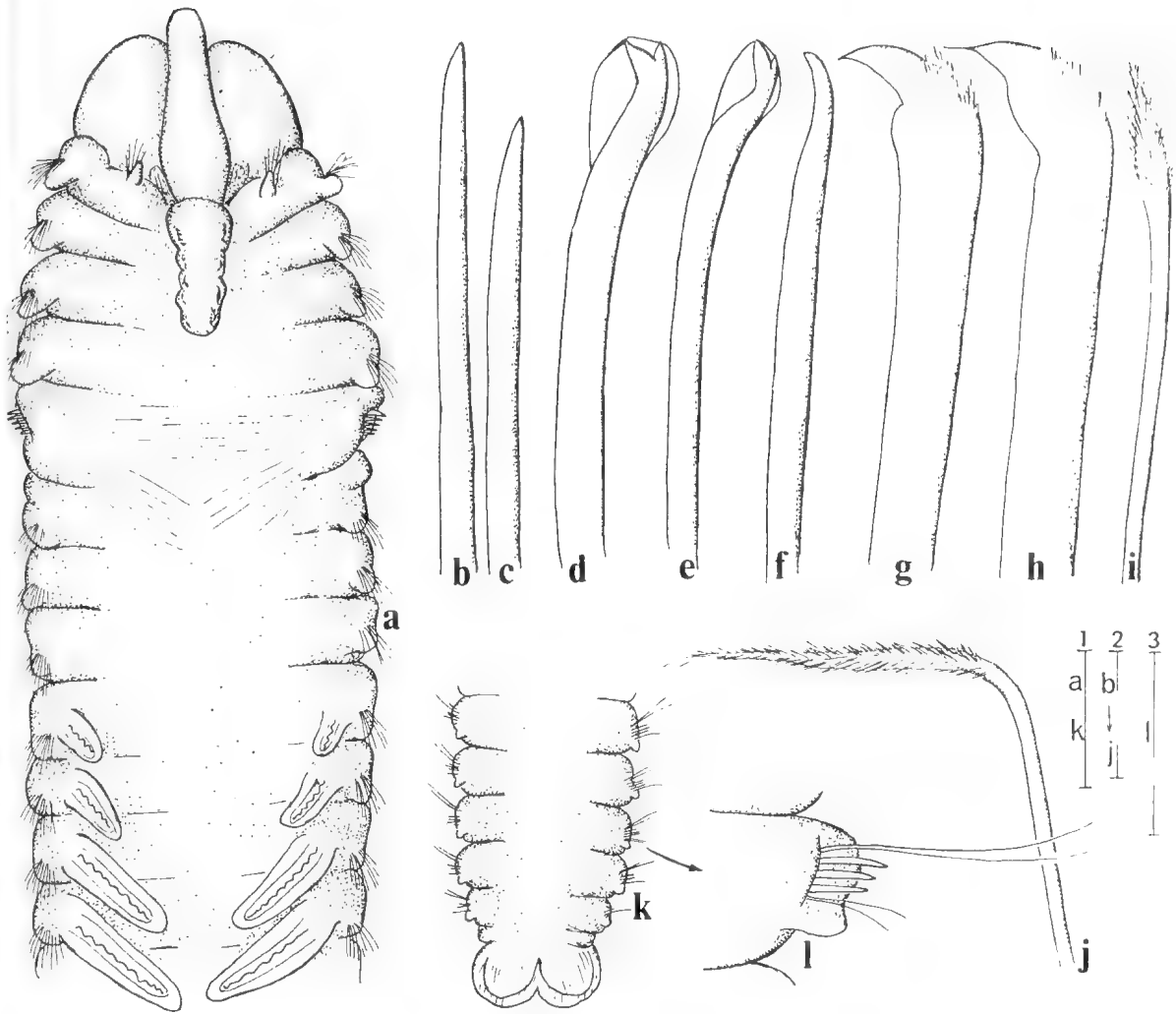


Figure 40—*Polydora aciculata* sp. nov.—a, anterior end, dorsal view; b-c, posterior notopodial spines; d, hooded hook from anterior setiger; e, hooded hook from medial body setiger; f, posterior neuropodial spine; g-h, major spines from setiger 5; i, hastate companion seta, setiger 5; j, superior dorsal seta from setiger 5; k, posterior end, dorsal view; l, posterior segment, dorsal view. [Scale 1 = 200  $\mu$ m; 2 = 20  $\mu$ m; 3 = 20  $\mu$ m]

setiger 5 are similar to those of *P. caulleryi* Mesnil and *P. notialis* sp. nov. (see below). Those of *P. caulleryi* are sharply falcate, with a crest of bristles, but no accessory structures, those of *P. notialis* bear a crest of bristles and a

subterminal concavity. *P. aciculata* has a crest and a pronounced lateral flange.

The presence of posterior acicular spines in both notopodia and neuropodia is rare in polydorids. *P. convexa* Blake and Woodwick (1972) has a similar arrangement with unidentate hooded hooks and specialized posterior notosetae. The notosetae, however, are not acicula, but packets of fine needles. *Boccardia basilaria* Hartman (1961) has posterior noto- and neuropodial acicular spines. This situation was not noted by Hartman (1961) and was only determined during a recent examination of the types (Blake, unpublished).

*Ecology*: Occupies twisting galleries in shells

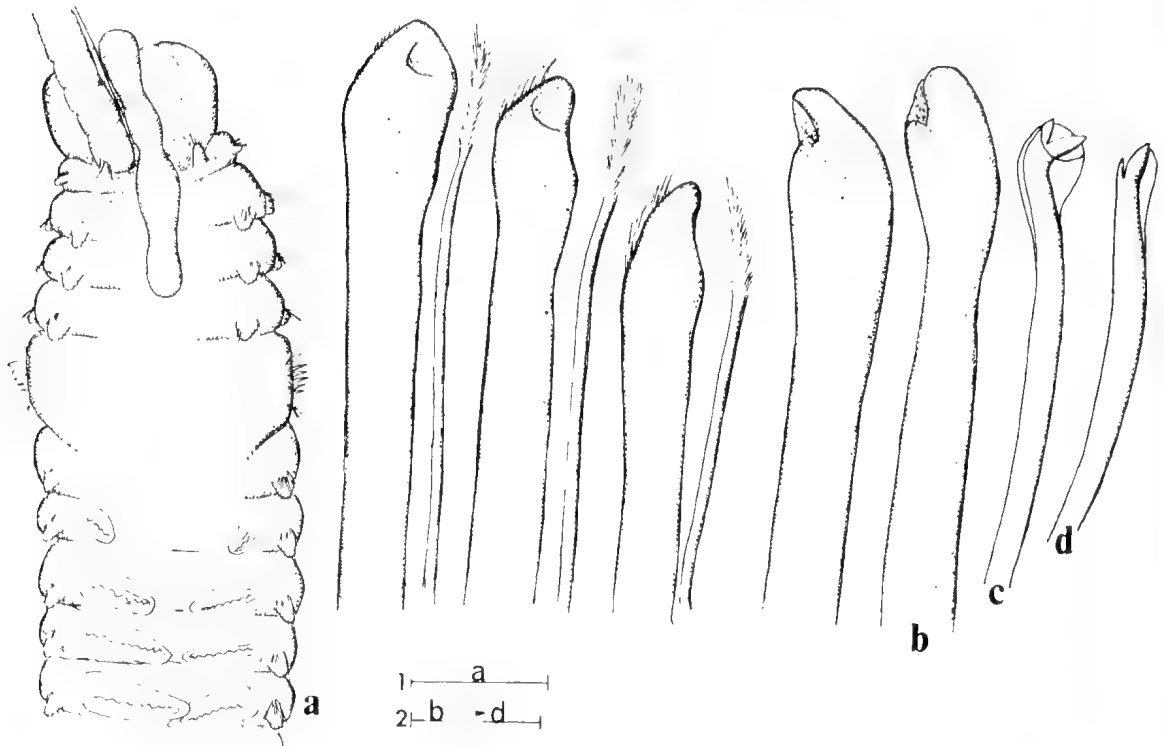


Figure 41—*Polydora notialis* sp. nov.—a, anterior end, dorsal view; b, major spines and companion setae, setiger 5 showing different angles and degrees of wear; c, hooded hook, setiger 8; d, hooded hook, setiger 35. [Scale 1 = 200  $\mu$ m; 2 = 20  $\mu$ m]

of *Haliotis ruber* Leach, 1814. Associated with *Polydora giardi* Mesnil in the shells.

*Distribution:* Victoria.

***Polydora notialis* sp. nov.**

(Figure 41)

*Material examined:* SOUTH AUSTRALIA. Tipara, from shell of *Haliotis roei*, 7 April 1971, coll. S. Shepherd (HOLOTYPE, NMV G2877).

*Description:* A single, posteriorly incomplete specimen measures 3.5 mm long and 0.4 mm wide for 38 setigerous segments. Body generally opaque white in alcohol, with lateral intersegmental brown pigment on setigers 1-3 and along margins of prostomium.

Prostomium rounded on anterior margin, caruncle extending to posterior margin of setiger 3 (Fig. 41a); no occipital tentacle. Two

pairs of subcutaneous eyes. Palps short, extending posteriorly for 6 setigers.

Setiger 1 with capillary notosetae in both noto- and neuropodia (Fig. 41a). Setigers 2, 3, 4, -, 6 and succeeding segments with 2 tiers of unilimbate capillary notosetae; first tier with shorter setae; number of capillary notosetae gradually diminishing in posterior segments; nature of posterior end unknown. Neurosetae of setigers 2, 3, 4, - and 6 as spreading fascicles of winged capillaries. Bidentate hooded hooks beginning on setiger 7, with 3 hooks in anterior setigers, accompanied by capillary setae for a few segments, number of hooks reduced to 2 per neuropodium posteriorly; angle between main fang and secondary tooth acute, wider in anterior and becoming much reduced in posterior setigers (Fig. 41c-d); without constriction on shaft.

Setiger 5 modified, with heavy dorsal musculature, overlapping setiger 6; setae include dorsal fascicle of geniculate setae, curved row of 4-5 heavy spines, thin hastate companion setae (Fig. 41b) and ventral fascicle of unilimbate capillary neurosetae; 4-5 major spines

with expanded, slightly curved end, with subterminal cavity (Fig. 41b), convex side of inflated end bearing bristled crest.

Branchiae from setiger 7, reaching full-size by setiger 10, continuing for  $\frac{1}{2}$  body length. Pygidium unknown.

*Remarks:* *Polydora notialis* bears similarities to 2 groups of species. With a subdistal concavity on the major spines of setiger 5, *P. notialis* is similar to *P. hornelli* Willey (1905) from India, *P. cavitensis* Pillai (1965) from the Philippines, *P. allopuris* Light (1970a) from California and *P. wobberi* Light (1970b) from the Gulf of California. *P. notialis* differs from each of the foregoing species in possessing a crest of fine bristles on the convex surface of those same spines and in the lack of a constriction on the shaft of the hooded hooks. *P. notialis* also resembles those species having a crest on the major spines: *P. caulleryi* Mesnil and *P. aciculata* (see remarks for preceding species).

*Distribution:* South Australia.

#### *Polydora pilocollaris* sp. nov.

(Figure 42)

*Material examined:* VICTORIA. Port Phillip Bay, PPBES Station 907 (HOLOTYPE, NMV G2878; 6 PARATYPES, NMV G2879-2880).

*Description:* A small species, measuring up to 6.5 mm long and 0.5 mm wide for 70 setigerous segments. Holotype 3.5 mm long and 0.3 mm wide for 55 setigers. Opaque white in alcohol.

Prostomium distinctly incised anteriorly with 2 rounded lobes; caruncle thickened, extending to posterior margin of setiger 2-3 (Fig. 42a); no occipital tentacle; eyes present as only 1 subcuticular pair, or absent.

Setiger 1 with long finger-like notopodial lobe, notosetae lacking, with capillary neurosetae. Setigers 2, 3, 4, -, 6 and succeeding setigers with fascicles of unilimbate capillary notosetae arranged in 2 tiers, setae of first tier the shorter and thicker; shorter setae gradually lost in posterior setigers. No specialized posterior notosetae, but with short pointed capillaries accompanying longer ones.

Neuropodia of setigers 2, 3, 4, - and 6 with spreading fascicles of unilimbate capillaries.

Three to 5 bidentate hooded hooks from setiger 7, accompanied by a single capillary for first few setigers; hooks with relatively narrow angle between secondary tooth and main fang (Fig. 42d); no constriction on shaft.

Setiger 5 modified, overlapping setiger 6; with dorsal fascicle of heavy geniculate setae, curved row of major spines, hastate companion setae (Fig. 42b) and a ventral fascicle of unilimbate capillaries; major spines falcate, with collar on convex side bearing prominent tuft of bristles (Fig. 42c); unworn spines sometimes with a thin distal mucron.

Branchiae from setiger 7, at first small, reaching full-size on setiger 10-11; absent from posterior  $\frac{1}{2}$  of body.

Pygidium with 4 lobes, dorsal pair slightly smaller than ventral pair (Fig. 42e).

*Remarks:* *Polydora pilocollaris* resembles *P. convexa* Blake and Woodwick (1972) from California in having a collar on the convex side of the major spines of setiger 5. *P. convexa*, however, lacks the tuft of bristles associated with the collar, has a posterior armature which *P. pilocollaris* lacks and has unidentate hooded hooks in posterior segments, rather than bidentate ones, as in *P. pilocollaris*.

*Distribution:* Victoria, Port Phillip Bay.

#### *Polydora armata* Langerhans, 1880

(Figure 43a-g)

*Polydora armata* Langerhans, 1880, p. 93; Fauvel, 1927, p. 55; Hartman, 1941, p. 306; 1969, p. 127; Woodwick, 1964, p. 14; Day, 1967, p. 466; Rainer, 1973, p. 58; Read, 1975, p. 412.

*Polydora monilaris* Ehlers, 1905, p. 43. *Fide* Day, 1954.

*Material examined:* VICTORIA. Port Phillip Bay, Point Gellibrand, Williamstown, in shell of *Haliotus ruber*, 5 April 1977, coll. J. A. Blake and J. D. Kudenov (70+, NMV G2881). SOUTH AUSTRALIA. Ti-para, shell of *Haliotus roei*, 19 May 1971, coll. S. Shepherd (4, NMV G3056).

*Description:* A small species, up to 3-4 mm long and 0.5 mm wide for 30 segments. Prostomium bilobed anteriorly; caruncle extending to posterior margin of setiger 2; no occipital tentacle or eyes. Setiger 1 with 2-3 capillary notosetae; neurosetae more numerous. Setigers 2, 3, 4, -, 6 and succeeding setigers with unilimbate capillary notosetae; posterior setigers with

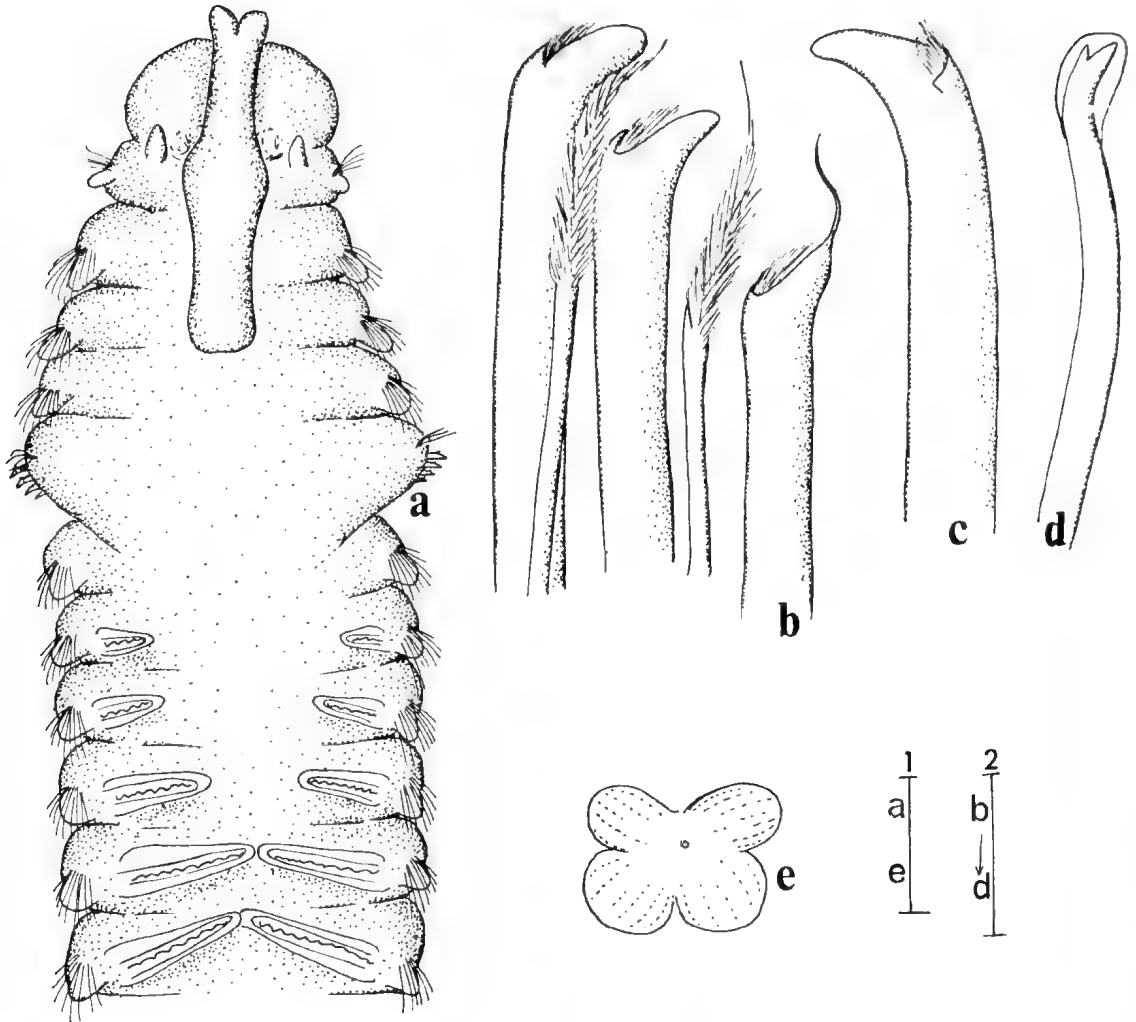


Figure 42—*Polydora pilocollaris* sp. nov.—a, anterior end, dorsal view; b, fascicle of 3 major spines and 2 companion setae, setiger 5; c, individual major spine, setiger 5; d, hooded hook; e, pygidium. [Scale 1 = 300  $\mu$ m; 2 = 20  $\mu$ m]

cone-shaped bundles of acicular spines (Fig. 43g), these usually not emergent in small specimens. Neurosetae of setigers 2, 3, 4, - and 6 unilimbate capillaries. Bidentate hooded hooks beginning on setiger 7 (Fig. 43f), without constriction on shaft, with acute, but fairly wide angle (about  $50^\circ$ ) between main fang and secondary tooth.

Setiger 5 highly modified, with dorsal fas-

cicle of 2-3 geniculate setae, a row of heavy spines and ventral fascicle of unilimbate capillary neurosetae; major spines bidentate, teeth connected by lateral hood or cowling on one side (Fig. 43a-c) and thin shelf on opposite side (Fig. 43d-e). Cowling bears fine bristles seen only under oil immersion on new or unworn spines. No companion setae of any sort.

Branchiae from setiger 7, reaching full-size by setiger 8, continuing to setigers 11-12. Pygidium small, cuff-shaped, with dorsal and ventral gaps.

*Remarks:* We have found *P. armata* to have bidentate spines on setiger 5 as Langerhans (1880) originally reported. The pres-

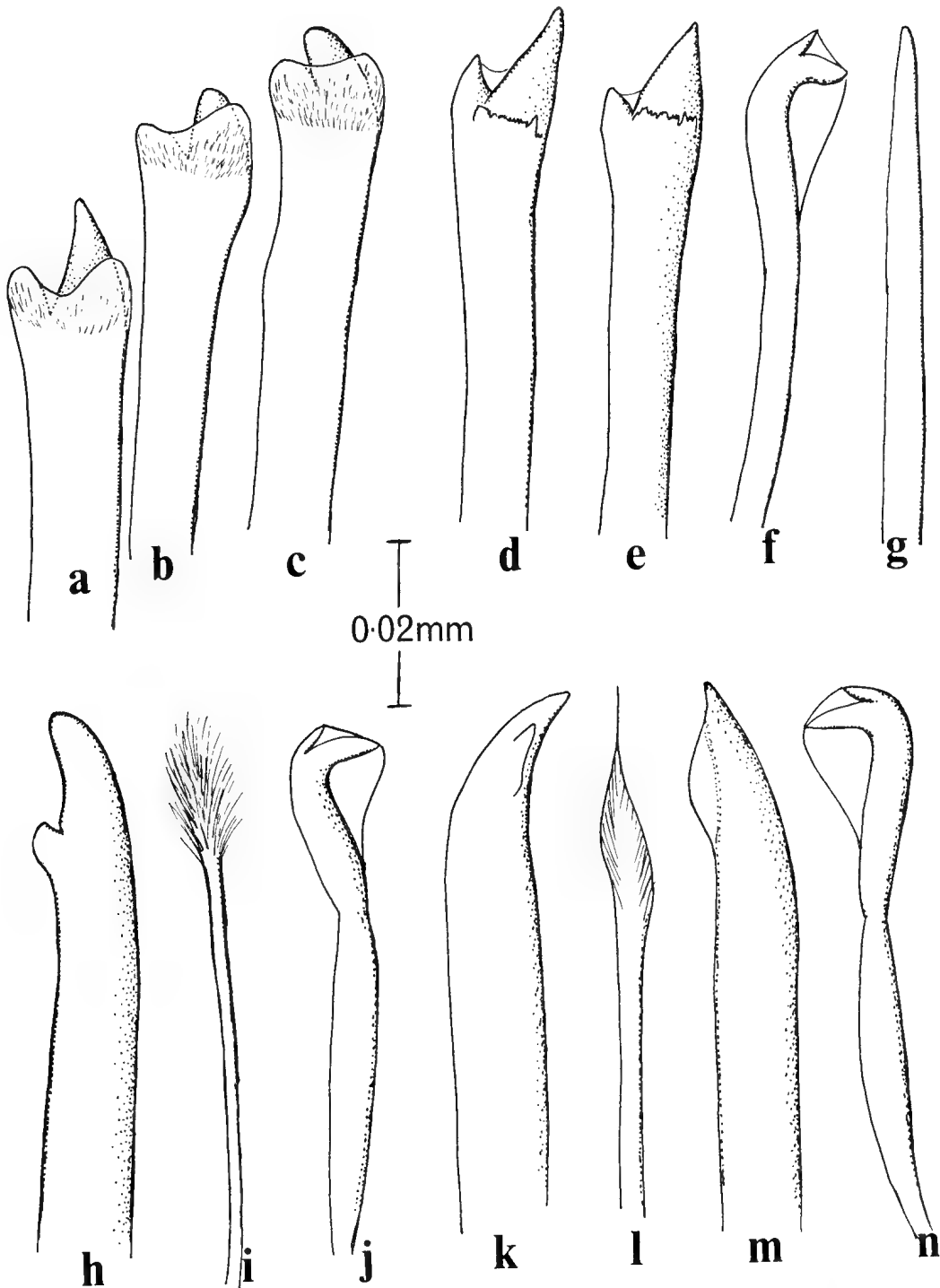


Figure 43—*Polydora armata* Langerhans—a-e, spines, setiger 5; f, hooded hook; g, posterior notopodial spine—*Polydora ligni* Webster—h, major spine, setiger 5; i, companion seta, setiger 5; j, hooded hook—*Polydora websteri* Hartman—k, major spine, setiger 5; l, companion seta, setiger 5; m, major spine, setiger 5; n, hooded hook.

ence of minute bristles on the hood or cowl-ing is a new finding, although Figure 2(2) of Woodwick (1964) suggests that similar bristles are present in his Eniwetok specimens.

*P. armata*, *P. caulleryi* Mesnil, *P. quadrilobata* Jacobi, 1883 and *P. aciculata* belong to a group of species having acicular spines in the posterior notopodia, hooded hooks lacking a constriction on the shaft and some similarity in design of the major spines of setiger 5. The major spines in *P. armata* are unique, but have been interpreted in various ways by different authors, apparently because the spines look different in different views. Woodwick (1964) reviewed the literature on *P. armata* spines and presented illustrations based on Eniwetok specimens which compared favourably with the various past interpretations of other authors. In this manner he was able to support the synonymy of *P. monilaris* Ehlers, 1905 with *P. armata*, first proposed by Day (1954). Rainer (1973) did not disagree with this synonymy, but suggested that the types of *P. monilaris* should be examined. We support the synonymy of *P. monilaris* and *P. armata*, but also feel that type material should be located and examined.

**Distribution:** Victoria; South Australia; Japan; South Africa; Europe; New Zealand; North Eastern Pacific.

#### ***Polydora ligni* Webster, 1879**

(Figure 43h-j)

*Polydora ligni* Webster, 1879b, p. 119; Blake, 1971, p. 5 (Synonymy); Foster, 1971, p. 22 (Synonymy); Light, 1977, p. 70.

**Material examined:** VICTORIA. Port Phillip Bay, Hobsons Bay-Yarra River, MSG Stations, Feb.-Aug. 1975, coll. G. Poore and J. D. Kudenov, Sta. 128 (1144); 130 (58); 133 (7); 136 (28); 138 (1) (NMV G2882, 3167-3171); Werribee, MSG Monitoring Programme (P609), coll. J. D. Kudenov, Stations 10-11, 11 Jan. 1977 (3, NMV G3172-3174).

**Description:** A medium to large species, often measuring up to 32 mm long for 80 setigerous segments (Blake, 1971), Australian specimens generally smaller. Colour in alcohol: opaque white.

Prostomium incised with 2 widely separated lobes; caruncle to setiger 2-3. Two pairs of

eyes, widely spaced, forming a square; occipital tentacle on caruncle behind eyes.

No notosetae on setiger 1, but with well-developed finger-like notopodial lobe; neurosetae with fascicle of delicate capillaries. Setigers 2, 3, 4, - and 6 with typical fascicles of unilimbate capillary noto- and neurosetae. No posterior spines. Bidentate neuropodial hooded hooks from setiger 7 (Fig. 43j), main fang forming approximately right angles with shaft; shaft with constriction.

Setiger 5 with curved row of modified spines and closely adhering feather-like companion setae (Fig. 43i), spines weakly falcate with small secondary tooth (Fig. 43h); with ventral fascicle of unilimbate capillaries.

Branchiae from setiger 7, continuing to posterior end. Pygidium a large flaring disc.

**Distribution:** Victoria; North America; northern Europe.

#### ***Polydora websteri* Hartman, 1943**

(Figure 43k-n)

*Polydora ciliata*: Haswell, 1885, p. 272 [Not Johnston, 1838].

*Polydora websteri* Hartman, 1943, p. 70; Blake, 1971, p. 6 (Synonymy); Foster, 1971, p. 26 (Synonymy).

**Material examined:** NEW SOUTH WALES. Newcastle, ca. 1885 (3, AM G11390); Tuross Lake, from *Crassostrea commercialis*, April 1977, coll. M. Skeel (4, NMV G3057).

**Description:** A moderately-sized species measuring up to 10 mm long and 0.5 mm wide for 100 setigerous segments.

Prostomium weakly bifid on anterior margin, caruncle extending to middle setiger 3; 4 eyes; no occipital tentacle.

Setiger 1 lacking notosetae. Setigers 2, 3, 4, -, 6 and succeeding setigers with unilimbate capillary notosetae; posterior notopodial spines absent. Setigers 2, 3, 4, - and 6 with unilimbate capillary neurosetae. Six to 7 bidentate hooded hooks per neuropodium from setiger 7 having a wide angle between teeth (Fig. 43n); main fang forming right angle with shaft; with constriction.

Setiger 5 with dorsal and ventral fascicles of unilimbate capillaries and a row of major spines and bilimbate companion setae (Fig. 43i), major spines falcate with lateral flange (Fig. 43k, m).



Branchiae from setiger 7, absent from posterior  $\frac{1}{3}$  of body. Pygidium disc-like with dorsal notch.

**Remarks:** Specimens agree well with *P. websteri* from North American waters. The species may be widespread in oyster growing centres where it forms mud-blisters in shells. Specimens of *P. ciliata* reported by Haswell (1885) most certainly should be referred to *P. websteri*, since specimens in the Australian Museum appear to be from Haswell's collection (E. Pope, communication to K. H. Woodwick, 1964). *P. websteri* is related to *P. ciliata* (Johnston, 1838) and has probably been mistaken for it on numerous occasions (see Hartman, 1943; Blake, 1971). Such references can only be verified by direct examination of the specimens in question. This uncertainty applies to the reports of *P. ciliata* in oysters from New South Wales by Whitelegge (1890) and Roughley (1922). Their specimens were possibly *P. websteri*, but in the absence of specimens, such suspicions cannot be verified.

The presence in Australia of another closely related and newly described species, *P. haswelli* (see below), adds to the confusion. *P. websteri* and *P. haswelli* are separated with difficulty (see key) and since both occur with oysters, careful attention to detail is required to separate reliably.

**Ecology:** Drills into oyster shells, forming mud-blisters (for review, see Blake and Evans, 1973).

**Distribution:** New South Wales; North America.

### *Polydora haswelli* sp. nov.

(Figure 44)

**Material examined:** NEW SOUTH WALES. Sydney, Wy-ar-gine Point, Middle Harbour, *Galeolaria* association, 19 Dec. 1968 (5, AM W13040); Scraping from hull of BEN SHORTRIDGE, tug from Newcastle, coll. Sydney Harbour, 29 Feb. 1972 where tug was cleaned, *P. Hutchings* (1, AM W13041); Sydney Harbour, 8-10 m, near N. Chinamens Beach, sand, 8 May 1971, coll. *P. Hutchings* (HOLOTYPE, AM W 7283; 12 PARATYPES, AM W13042; 5 PARATYPES, NMV G2883); Botany Bay, Towra Beach, NSWFS Station, April 1973 (1, AM W13043); Camden Haven, Kennedy oyster lease, in mud blisters, 20 April 1977, coll. M. Skeel (3, NMV G3058).

**Description:** A moderate-sized species, up to

13 mm long and 0.75 mm wide for 72 segments. Body light tan with considerable black pigment, including a line along each side of prostomium, an area on peristomium anterior to palps and paired dorsolateral spots located on setigers 1-3; additional pigment on palps.

Prostomium distinctly incised on anterior margin, caruncle extending posteriorly to middle of setiger 3 (Fig. 44a); occipital tentacle; 4 small, oval-shaped, subcuticular eyes, or eyes absent.

Setiger 1 with short conical notopodial lobes lacking notosetae; neuropodial lobes finger-like, with fascicle of thin capillaries. Setigers 2, 3, 4, -, 6 and succeeding segments with spreading fascicles of unilimbate capillary notosetae; posterior notosetae gradually reduced to few long slender erect capillaries; no posterior spines. Neurosetae of setigers 2, 3, 4, - and 6 unilimbate capillaries. Six to 8 bidentate hooded hooks in neuropodia from setiger 7; these with strong angle between secondary tooth and main fang, main fang forming right angle with shaft; with prominent constriction on shaft (Fig. 44f); not accompanied by capillaries.

Setiger 5 strongly modified, musculature overlapping setiger 6; setae including dorsal fascicle of bilimbate setae, curved row of heavy spines (Fig. 44c-e) alternating with bilimbate companion setae (Fig. 44b) and a ventral inferior fascicle of capillaries; heavy spines slightly falcate with 2 accessory structures (Fig. 44c-e); one a prominent accessory tooth; the second a low flange located just distal to tooth.

Branchiae from setiger 7, small at first, reaching full-size by setiger 9 and overlapping at mid-line; branchiae absent from posterior  $\frac{1}{4}$  of body. Pygidium a flaring disc with narrow dorsal notch (Fig. 44g).

**Remarks:** *Polydora haswelli* resembles *P. websteri* in having a flange on the major spines of setiger 5; it also resembles *P. ciliata* in having a sharp accessory tooth on those same spines. It differs from both species in bearing both a flange and an accessory tooth. The species is named for Professor W. F. Haswell, a pioneering Australian polychaete taxonomist who

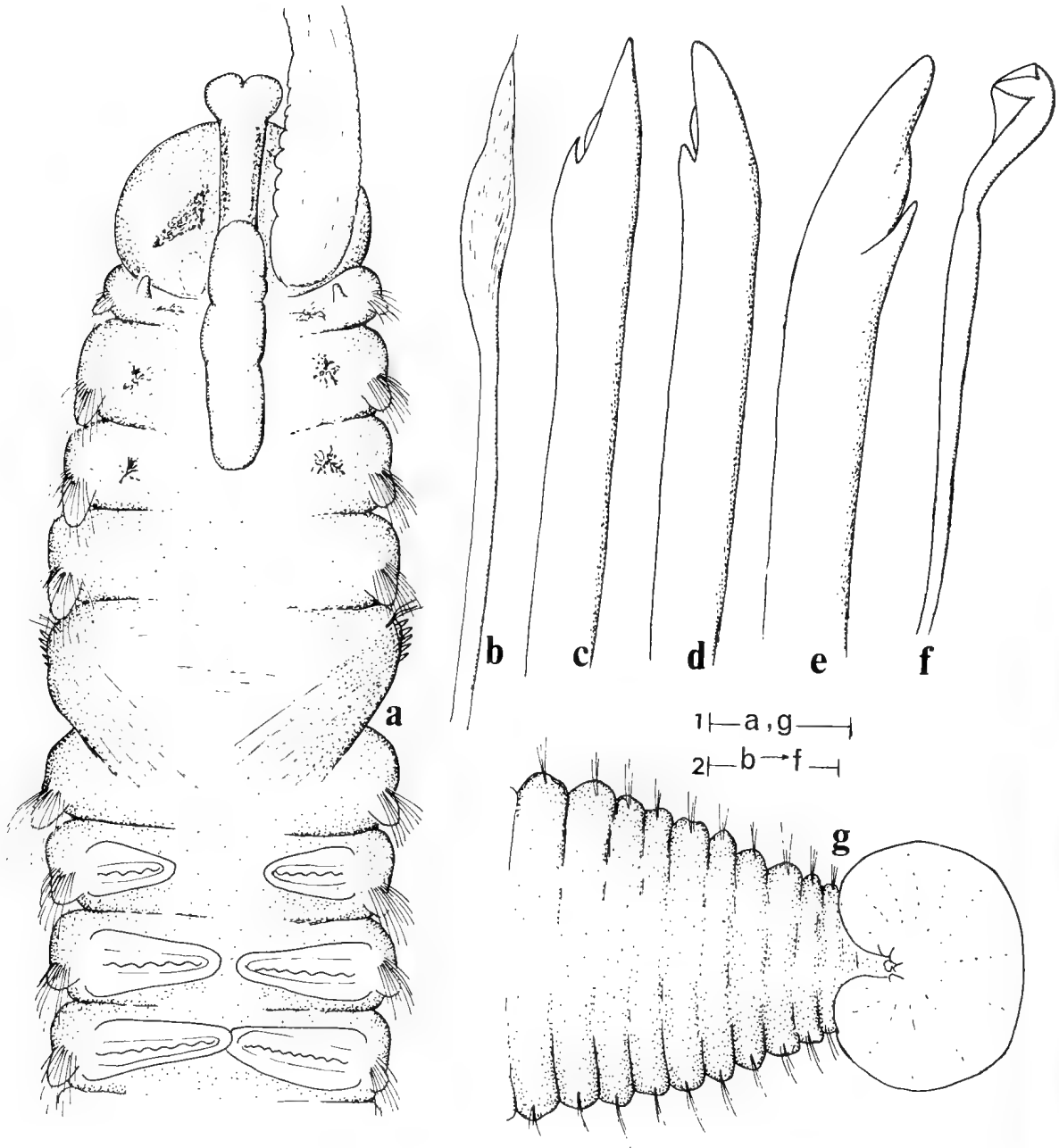


Figure 44—*Polydora haswelli* sp. nov.—a, anterior end, dorsal view; b, companion seta, setiger 5; c-e, major spines, setiger 5; f, hooded hook; g, posterior end, dorsal view. [Scale 1 = 200  $\mu\text{m}$ ; 2 = 20  $\mu\text{m}$ ]

published an early paper on *Polydora* in Australia (Haswell, 1885).

*Distribution*: New South Wales.

***Polydora latispinosa* sp. nov.**

(Figure 45)

*Material examined*: VICTORIA. Port Phillip Bay, Point Cook, dredged, oysters and scallops (*Pecten alba*) shells, 14 April 1977, coll. J. A. Blake and J. D.

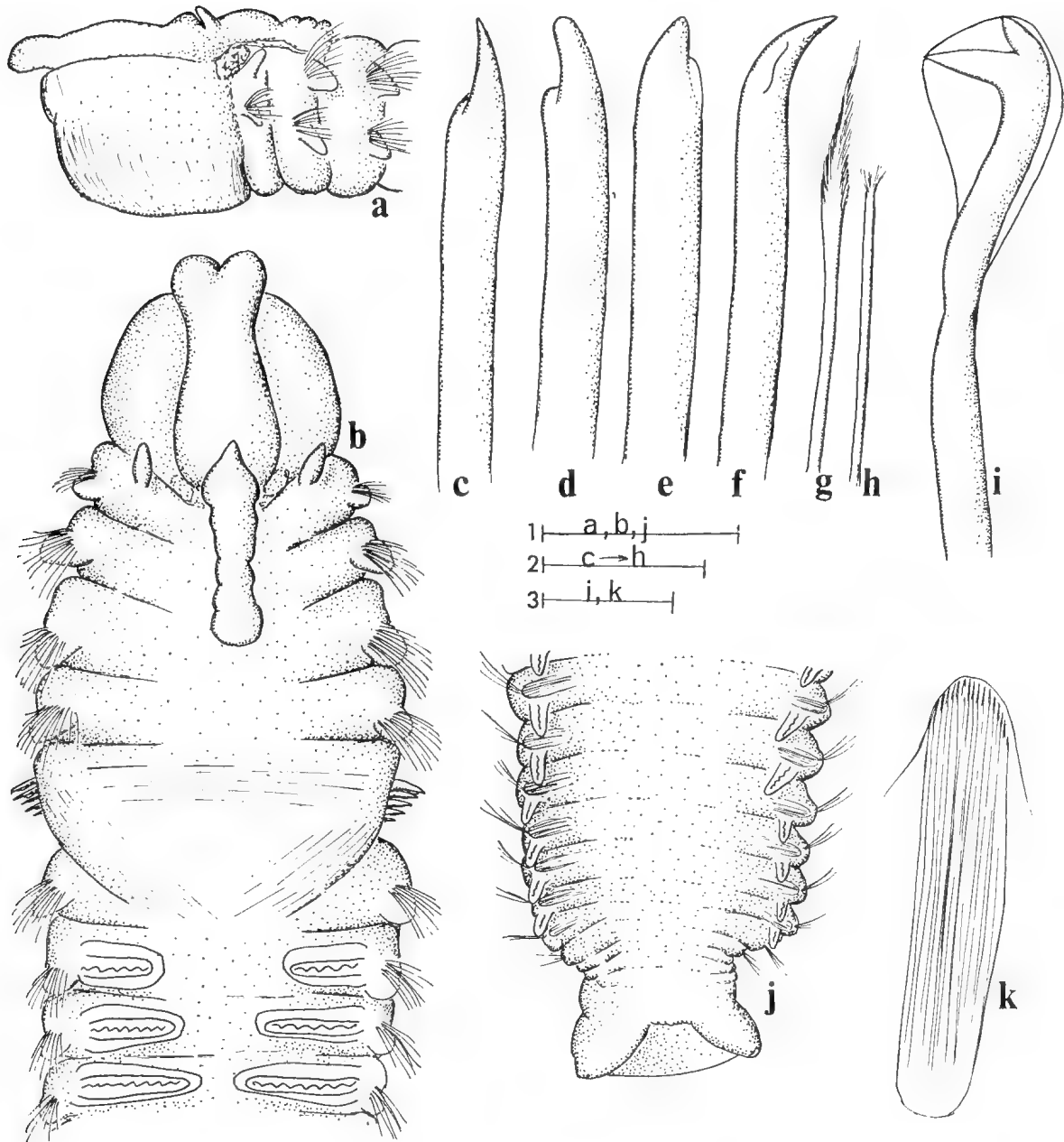


Figure 45—*Polydora latispinosa* sp. nov.—a, anterior end, lateral view; b, anterior end, dorsal view; c-f, major spines, setiger 5, various views; g-h, companion setae, setiger 5 (worn and unworn); i, hooded hook; j, posterior end, dorsal view; k, posterior bundle of needles. [Scale 1 = 500  $\mu$ m; 2 = 50  $\mu$ m; 3 = 20  $\mu$ m]

Kudenov (HOLOTYPE, NMV G2874; 50+ PARATYPES, NMV G2875-2876).

*Description*: A large species, measuring up to 33 mm long and 1.2 mm wide for 210 setigerous segments. Body light tan in life with bright red blood vessels and branchiae; some dark ventral patterns caused by capillary blood

vessels; brown pigment along edges of caruncle.

Prostomium distinctly bilobed anteriorly (Fig. 45a); caruncle extending posteriorly to end of setiger 2; with short triangular occipital tentacle formed by fold in caruncle at anterior margin of setiger 1 (Fig. 45b); 1-2 pairs of obscure, subcutaneous eyes present or eyes absent. Palps short, thick, extending posteriorly only 5-6 setigers.

Setiger 1 with well-developed finger-like notopodia, lacking notosetae; with fascicle of delicate capillary neurosetae. Setigers 2, 3, 4, -, 6 and succeeding segments with capillary notosetae arranged in 2 tiers, first tier with shorter thicker setae; posterior notopodia with fewer, pointed thinner capillaries and flattened packets of fine needles, these sometimes projecting through cuticle (Fig. 45j-k). Neurosetae of setigers 2, 3, 4, - and 6 unilimbate capillaries, not as prominent as notosetae. Bidentate hooded hooks from setiger 7, about 6 hooks per neuropodium at first, completely replacing capillary setae, increasing to 11-12 per neuropodium in middle body segments and diminishing, to 5-6 per ramus, posteriorly; hooks with strong angle between teeth throughout, main fang forming right angle with shaft; with distinct constriction on shaft (Fig. 45i).

Setiger 5 large, overlapping 6 with heavy dorsal musculature; no dorsal fascicle; with a row of major spines alternating with narrow hastate setae (Fig. 45g-h), and ventral fascicle of unilimbate capillary setae; major spines falcate with lateral sheath or flange (Fig. 45c-f).

Branchiae from setiger 7, at first small, reaching full-size on setigers 9-10, continuing to posterior end of body.

Pygidium a large flaring disc, with wide dorsal gap (Fig. 45j).

*Remarks:* *Polydora latispinosa* belongs to the *P. ciliata-websteri* group; it is most closely related to *P. vulgaris* Mohammad (1972) in having an occipital tentacle and posterior notopodial spines and in lacking superior notosetae on setiger 5. However, in *P. latispinosa* the posterior spines are packets of fine needles, while *P. vulgaris* bears individual notopodial spines.

*Ecology:* *Polydora latispinosa* forms complex burrows and mud-blisters in shells of scallops and oysters in Port Phillip Bay.

*Distribution:* Victoria, Port Phillip Bay.

***Polydora woodwicki* sp. nov.**

(Figure 46)

*Material examined:* VICTORIA. Port Phillip Bay, Point Gellibrand, Williamstown, shell of *Haliotis ruber*, 5 April 1977, coll. J. A. Blake and J. D. Kudenov (HOLOTYPE, NMV G2873).

*Description:* A moderate-sized species. The holotype is in 3 parts, measuring in total 15 mm long and 0.75 mm wide for 105 segments. Colour light tan with red-brown intersegmental pigment in posterior segments.

Prostomium anteriorly entire; caruncle short, thick and bulbous, extending posteriorly to end of setiger 2 (Fig. 46a); no occipital tentacle; 2 pairs of oval eyes; palps regenerating on holotype (Fig. 46a) and normal length or form unknown.

Setiger 1 with rounded notopodial lobes, lacking notosetae; neuropodial lobe ill-defined, but with spreading fascicle of delicate capillaries. Setigers 2, 3, 4, -, 6 and succeeding setigers with short, thick notopodial lobes bearing unilimbate capillary notosetae arranged in 2 tiers: first tier with short setae, long, thin setae in second tier. In posterior setigers notopodia reduced, setae fewer, more delicate. Posterior notosetae including both long and short stiff, erect capillary setae, imparting spinous appearance to posterior end (Fig. 46k). Neurosetae of setigers 2, 3, 4, - and 6 in spreading fascicles of unilimbate capillaries. Five to 6 bidentate hooded hooks in anterior segments from setiger 7, completely replacing capillary setae, with hooks increasing to 8 per ramus in middle segments; hooks with wide angle between teeth, main fang forming right angles or less with shaft; with prominent constriction on shaft (Fig. 46b).

Setiger 5 modified, somewhat contracted and larger than setigers 4 and 6; with superior dorsal fascicle of geniculate setae (Fig. 46j), a group of major spines alternating with bilimbate companion setae (Fig. 46e, g) and a ventral inferior fascicle of unilimbated setae (Fig. 46i). Major spines slightly falcate with prom-

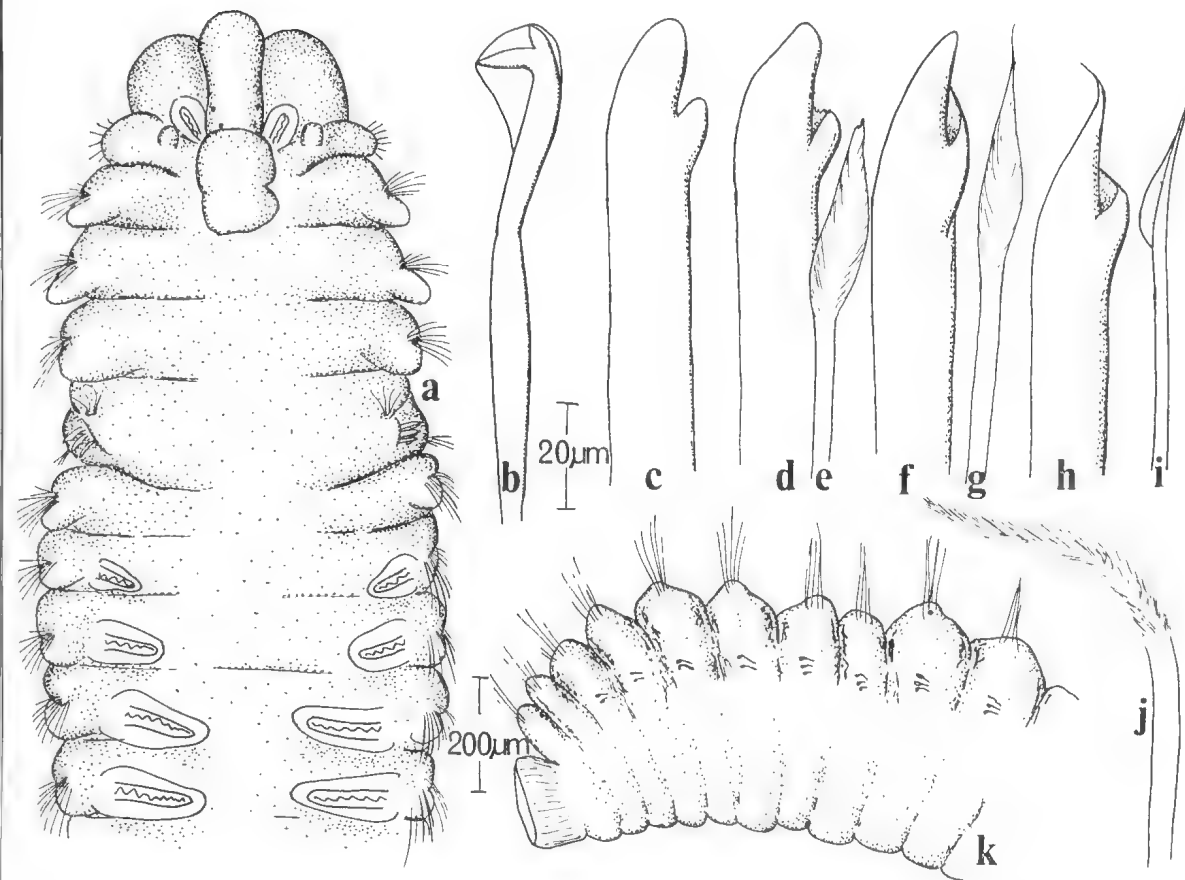


Figure 46—*Polydora woodwicki* sp. nov.—a, anterior end of holotype in dorsal view; b, hooded hook; c-h, 4 major spines and 2 companion setae, setiger 5; i, neuroseta, setiger 5; j, superior dorsal notoseta, setiger 5; k, posterior end, lateral view.

inent accessory flange (Fig. 46c-d, f, h); unworn spines with terminal mucron (Fig. 46h).

Short branchiae from setiger 7, never extending more than  $\frac{1}{3}$  of distance across dorsum (Fig. 46a), continuing for only 21-23 segments, absent from posterior  $\frac{2}{3}$  of body.

Pygidium a small cuff-shaped disc, with mid-dorsal gap, somewhat telescoped into terminal segments (Fig. 46k).

**Remarks:** *Polydora woodwicki* belongs to the *P. websteri-ciliata* group in having an accessory flange on the major spines of setiger 5. The species is most closely related to *P. spondylana* Mohammad (1973) in having a rounded pro-

stomium. *P. spondylana* differs in having an enlarged, oval prostomium, a long narrow caruncle reaching to setiger 5, no eyes and a large disc-like pygidium, while *P. woodwicki* has a typical narrow Prostomium, short bulbous caruncle reaching only to setiger 3, 4 eyes and a smaller cuff-shaped pygidium. *P. woodwicki* also resembles *P. rickettsi* Woodward (1961) from Mexico in having a rounded prostomium. *P. rickettsi*, however, has a long caruncle reaching to setiger 5, the major spines of setiger 5 bear a distinct accessory tooth rather than a flange and the pygidium is large and disc-like, being larger than prepygidial segments. This species is named in honour of Dr. Keith H. Woodward, in recognition of his many studies on spionid polychaetes.

**Ecology:** Bores into abalone shells. At Point Gellibrand it was associated with *P. armata*.

**Distribution:** Victoria, Port Phillip Bay.

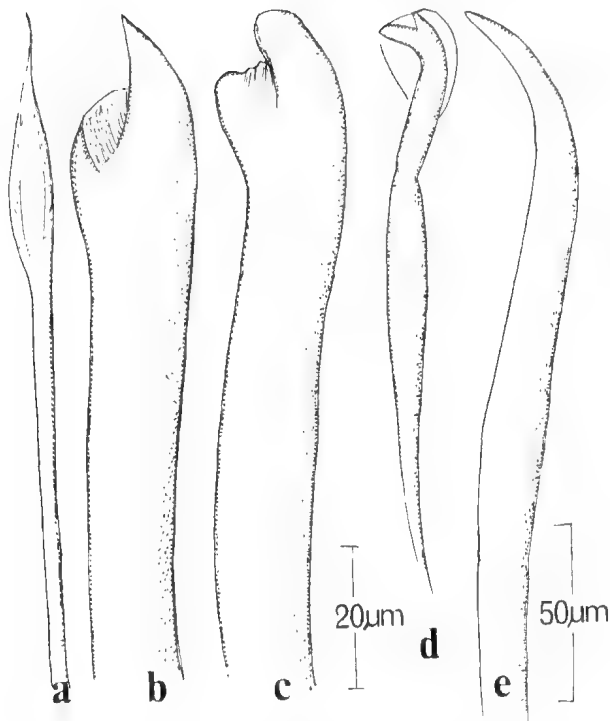


Figure 47—*Polydora hoplura* Claparède—a, companion seta, setiger 5; b-c, major spines, setiger 5; d, hooded hook; e, posterior notopodial spine.

***Polydora hoplura* Claparède, 1870**

(Figure 47)

*Polydora hoplura* Claparède, 1870, p. 58; Carazzi, 1893, p. 20; Fauvel, 1927, p. 50; Day, 1967, p. 468; Read, 1975, p. 411.

*Material examined:* NEW SOUTH WALES. Point Henry Pier, in oysters, 22 March 1975, coll. C. Pregezer (1, NMV G3059). TASMANIA. Simmons Beach, shells *Crassostrea gigas*, 17 June 1977, shipment specimens arranged M. Skeel (10+, NMV G3060).

*Description:* A large species measuring up to 40 mm long and 2 mm wide for over 160 segments. Body colourless.

Prostomium weakly incised, caruncle extending to end of setiger 3; with low occipital tentacle. Notosetae lacking on setiger 1, neurosetal capillaries present. Setigers 2, 3, 4, -, 6 and succeeding segments with fascicles of unilimbate capillary notosetae; posterior segments with 1-2 large, medially directed falcate spines in each fascicle (Fig. 47e). Neurosetae of setigers 2, 3, 4, - and 6, short, unilimbate capil-

laries; 8-10 bidentate hooded hooks from setiger 7, exhibiting wide angle between teeth; main fang and shaft forming oblique angle; with constriction on shaft (Fig. 47d).

Major spines of setiger 5 falcate, with large subterminal flange, appearing tooth-like in certain views and depending upon wear (Fig. 47b-c); companion setae bilimbate (Fig. 47a); with dorsal and ventral fascicles of unilimbate capillary setae.

Branchiae from setiger 7 along most of body, terminating just anterior to appearance of posterior spines.

Pygidium a large disc with wide dorsal notch. *Remarks:* Australian specimens agree with descriptions of specimens from New Zealand by Read (1975); the occipital tentacle and long caruncle, seen in these examples has not been reported in earlier accounts from Europe.

*Ecology:* Forms mud-blisters in oysters.

*Distribution:* New South Wales; Tasmania; Europe; South Africa; New Zealand.

**Genus *Boccardiella* gen. nov.**

*Type-species:* *Polydora hamata* Webster, 1879a. Gender feminine.

*Diagnosis:* Prostomium anteriorly entire or incised, extending posteriorly as caruncle. Setiger 1 with or without notosetae. Setiger 5 strongly modified with only 1 type of major spine in a single row, with smaller companion setae; capillary notosetae present. Bidentate hooded hooks from setiger 7, main fang and shaft forming oblique angle with reduced (acute) angle between main fang and secondary tooth; main fang and secondary tooth more or less subequal without constriction on shaft; posterior notopodial spines or 'boat hooks' present or absent. Branchiae from setiger 2, present or absent on setiger 5, continuing for variable number of segments. Pygidium disc-like or reduced to small lobes or lappets, with or without small cirri or papillae.

*Remarks:* Species with branchiae anterior to setiger 5 and with only 1 type of major spine on setiger 5 are herein removed from *Boccardia* to *Boccardiella*, which contains the following species:

1. *B. bihamata* sp. nov. (see below)

2. *B. hamata* (Webster, 1879a) n. comb.  
*Boccardia uncata* Berkeley, 1927. *Fide* Blake (1966).
3. *B. ligerica* (Ferronière, 1898) comb. nov.  
*Polydora redeki* Horst, 1920. *Fide* Blake and Woodwick (1971).  
*Polydora uncatiformis* Monro, 1938.  
*New synonymy.*
4. *B. limnicola* (Blake and Woodwick, 1976) comb. nov.
5. *B. magniovata* (Read, 1975) comb. nov.
6. *B. truncata* (Hartman, 1936) comb. nov.

*Boccardiella* species are a distinct group of polydorids, sharing setal characteristics of setiger 5 with *Polydora* on the one hand, and branchial characteristics with *Boccardia* on the other. Distinctions between this species group and other *Boccardia* species were observed by Blake and Woodwick (1971). The synonymy of *Polydora uncatiformis* Monro, 1938 with *Boccardia hamata* (now *Boccardiella*) proposed by Blake (1966) was in error. Monro's species should instead be referred to synonymy with *Boccardiella ligerica*. Further comments on that situation will be published elsewhere (Blake, in preparation). For further information on the *Boccardiella* species see Blake and Woodwick (1971; 1976) and Read (1975). See Table 3 for generic relationships of *Boccardiella* to the other polydorid genera and remarks elsewhere.

#### *Boccardiella bihamata* sp. nov.

(Figure 48)

*Material examined:* NEW SOUTH WALES. Botany Bay, Towra Beach, NSWFS Stations, 12-17 April 1973 (HOLOTYPE, NMV G2887; 4 PARATYPES NMV G2888-2889; 5 PARATYPES, AM W13044).

*Description:* A moderate-sized species measuring up to 12 mm long and 0.75 mm wide for 75 setigers. Specimens mostly opaque white in alcohol; colour on some specimens indeterminate due to staining by Rose Bengal.

Prostomium distinctly bifid on anterior margin, forming 2 rounded lobes (Fig. 48a), caruncle extending posteriorly to near posterior border setiger 3; without occipital tentacle; 2 pairs of eyes, or eyes absent; when present anterior pair widely spaced and oval, posterior

pair widely spaced and cup-shaped. Palps long, extending posteriorly for 20-22 setigers.

Setiger 1 with well-developed noto- and neuropodia, but lacking notosetae (Fig. 48a); neurosetae including a small fascicle of capillaries. Setigers 2, 3, 4, -, 6 and succeeding segments with spreading fascicles of unilimbate capillary notosetae arranged in 2 tiers, the more anterior setae shortest and thickest; number of capillary setae gradually reduced through middle body segments. Posterior end highly modified, with 2 types of acicular notopodial spines; each notopodium with (1) a large, stout recurved hook (Fig. 48k), (2) accompanied by 3-4 smaller straight acicular spines (Fig. 48l-n), and 2-3 long capillary setae (Fig. 48n); parapodia elevated on each side, forming middorsal channel into which acicular spines project (Fig. 48m-n). Neuropodia of setigers 2, 3, 4, - and 6 with fascicles of unilimbate capillaries. Bidentate hooded hooks from setiger 7, numbering 6-8 through middle segments accompanied by 2-3 inferior capillary setae, reduced to 3-4 in posterior segments, with capillaries becoming lost; structure of hooks changing from anterior to posterior setigers: hooks initially bidentate with an obtuse angle between nearly subequal teeth (Fig. 48g-h), secondary tooth becoming lost in posterior setigers, resulting in unidentate hooded hooks (Fig. 48i), with superior hooks usually losing hood (Fig. 48j), with broken hood occasionally seen hanging from shaft.

Setiger 5 with dorsal superior fascicle of 5-6 stout geniculate unilimbate setae (Fig. 48f), row of major spines (Fig. 48c-d) alternating with bilimbate companion setae (Fig. 48b) and a ventral inferior fascicle of 10-12 unilimbate capillaries (Fig. 48e); major spines simple, weakly falcate, without accessory structures (Fig. 48c-d).

Branchiae occurring setigers 2, 3, -, -, 6 and subsequent segments for about  $\frac{2}{3}$  of body length.

Pygidium a flattened plate from which 2 short lateral cirri arise (Fig. 48m), closely resembling that of *B. hamata*. The anus opens dorsally.

*Remarks:* *Boccardiella bihamata* is closely related to *B. hamata* and *B. ligerica* in the struc-

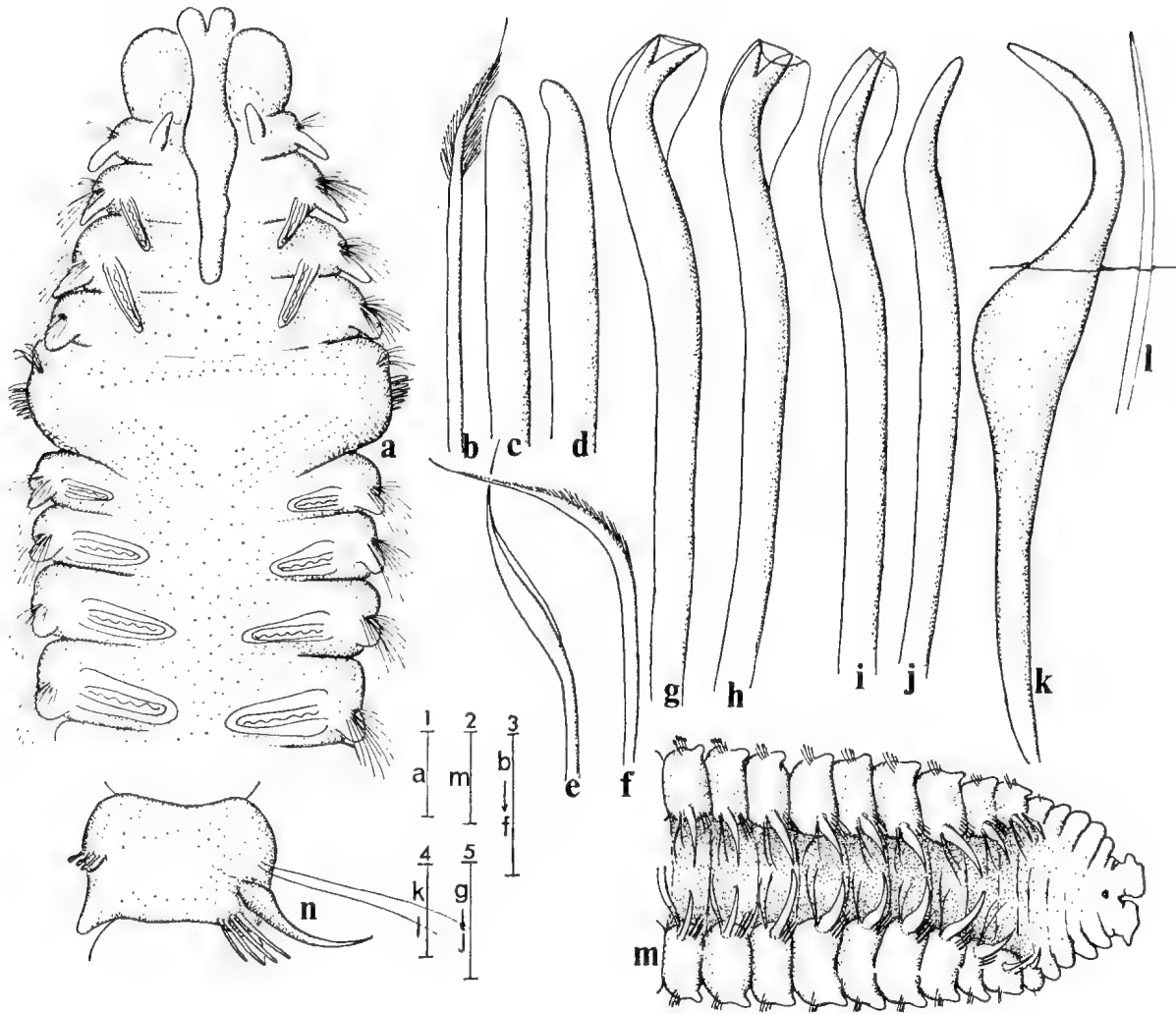


Figure 48—*Boccardiella bihamata* gen. et sp. nov.—a, anterior end, dorsal view; b, companion seta, setiger 5; c-d, major spines, setiger 5; e, neuroseta, setiger 5; f, superior dorsal seta, setiger 5; g-j, progression of hooded hook structure from anterior (g), medial (h) and posterior (i, j) setigers; k-l, large hook and small spine from posterior notopodium; m, posterior end, dorsal view; n, posterior segment, dorsal view. [Scale 1 = 200  $\mu\text{m}$ ; 2 = 200  $\mu\text{m}$ ; 3 = 50  $\mu\text{m}$ ; 4 = 50  $\mu\text{m}$ ; 5 = 20  $\mu\text{m}$ ]

ture of the posterior end and in bearing large recurved posterior notopodial hooks. It differs significantly from both in the possession of an additional type of acicular notopodial spine in posterior segments and in the presence of unidentate neuropodial hooks in the same region.

See Blake and Woodwick (1971; 1976) for further information on related species.

*Distribution*: New South Wales, Botany Bay.

***Boccardiella limnicola* (Blake and Woodwick, 1976) comb. nov.**

*Boccardia limnicola* Blake and Woodwick, 1976, p. 123.

*Material examined*: QUEENSLAND. Brisbane, Centenary Bridge, Feb. 1972 (10+, AM W7491); Deception Bay, Burpengary Creek, Jan. 1975, coll. J. Davie (70+, AM W7126). VICTORIA. Port Phillip Bay, Werribee, MSG Monitoring Programme (P609), coll. J. D. Kudenov, Station 10, 11 Jan. 1977 (16, NMV G3061-3063); Lake Bong Bong, 17 Nov. 1970, coll. B. V. Timms (HOLOTYPE AM W7033; 19 PARATYPES AM W7034); Glenelg River, July 1975, coll. J. D. Kudenov and P. A. Hutchings (48,



NMV G3064-3065); Fitzroy River, July 1975, coll. J. D. Kudenov and P. Hutchings (20, NMV G3066); Port Fairy, July 1975, coll. J. D. Kudenov and P. Hutchings (50+, NMV G3068); Warrnambool, Merri River, July 1975, coll. J. D. Kudenov and P. Hutchings (21, NMV G3067); Paynesville, Gippsland Lakes, jetty, 2 m, sand, Aug. 1975, coll. J. D. Kudenov (9, NMV G3069-3070).

**Remarks:** The reader is referred to Blake and Woodwick (1976) for a description of the species. We note in the new material, that the length of the branchiae on setiger 5 is highly variable, being rudimentary on some specimens to as long as those on setigers 4 and 6 in others.

*Boccardiella limnicola* is similar to *B. magniovata* (Read, 1975) from New Zealand. The latter species differs significantly, however, in lacking branchiae on setiger 5 and form of the pygidium. The two species are very closely related, however, and share a common ancestry.

**Ecology:** *B. limnicola* was described from freshwater Victorian lakes. Although favouring areas of reduced salinities, we have now found the species to occur in more saline environments such as tidal rivers and near sewage outfalls. One record of a freshwater spionid overlooked by Blake and Woodwick (1976) was that of *Marenzelleria wireni* reported by Holmquist (1967) from Alaska.

**Distribution:** Queensland; Victoria.

#### Genus *Pseudopolydora* Czerniavsky, 1881 emended

*Pseudopolydora* Czerniavsky, 1881. *Type-species:* *P. antennata* (Claparède, 1870), by monotypy.

*Carazzia* Mesnil, 1896. *Type-species:* *C. antennata* (Claparède, 1870), by monotypy.

*Polydorella* Augener, 1914. *Type-species:* *P. prolifera* Augener, 1914, by monotypy. *New synonymy.*

**Diagnosis:** Prostomium entire or incised, extending posteriorly as a caruncle; occipital tentacle present or absent; eyes present or absent. Setiger 1 generally reduced, with or without notosetae (and in some species without neurosetae if animals are reproducing asexually and regenerating). Setiger 5 generally not distinctly enlarged, with noto- and neuropodia often well-developed with postsetal lobes and bearing spreading fascicles of capillaries; with curved row of heavy spines of 2 types, or single type with companion setae; modified

setae often forming J- or U-shaped setal group. Posterior notopodial spines or 'boat hooks' present or absent. Neuropodial hooded hooks from setiger 8, these hooks bidentate, with secondary tooth closely applied to main fang, with constriction on shaft; accompanying capillaries present or absent. Branchiae first appearing posterior to setiger 5. Pygidium enlarged or reduced, collar-like or divided into lobes or small lappets.

**Remarks:** Species of the genus *Pseudopolydora* are among the least modified of the *Polydora*-complex. Read (1975) pointed out that the low degree of modification to setiger 5 and the structure of the hooded hooks are more characteristic of *Pseudopolydora* than the first appearance of hooded hooks on setiger 8. One species, *P. reishi* Woodwick (1964) was noted by Read (1975) to be doubtfully placed in *Pseudopolydora*. We agree, and herein transfer it to *Carazziella*.

*Polydorella*, with modified spines on setiger 4, rather than 5, was noted by Read (1975) to be closely related to *Pseudopolydora*. In this study, we have been able to examine the type series of *Polydorella prolifera*, the type-species of the genus, and to demonstrate that setae may be present on the generally achaetous segment 1 on some specimens. This is a function of the state of regeneration, since the species is capable of asexual reproduction by paratomy. The discovery of a closely related and previously undescribed species, has confirmed this point of view. We therefore place *Polydorella* into synonymy with *Pseudopolydora*. The status of *Polydorella novaegeorgiae* Gibbs, 1971 remains uncertain, until type material is examined. Its overall morphology is, however, very similar to species of *Pseudopolydora*.

*Pseudopolydora* is herein defined to include species in which setiger 1 is completely reduced to an achaetous condition.

#### KEY TO SPECIES OF *PSEUDOPOLYDORA* FROM AUSTRALIA

- 1a. Maximal number of segments 15-16; small, up to 3 mm long . . . . . 2
- b. More than 20 segments; large, over 6 mm long . . . . . 3
- 2a. Pennoned spines of setiger 5 with fe-

- nestrated edge surrounding cavity, and long bristled apex (Fig. 50n); prostomium entire . . . . . *P. prolifera*
- b. Pennoned spines of setiger 5 with expanded bristle-topped ends (Fig. 50 f-h); prostomium incised . . . *P. stolonifera*
- 3a. Prostomium entire . . . *P. paucibranchiata*
- b. Prostomium incised . . . . . 4
- 4a. Prostomium with 2 widely flaring anterior lobes; occipital tentacle just behind eyes; caruncle continuing posteriorly to setigers 3-4; branchiae without glands . . . . . *P. kempfi*
- b. Prostomium with 2 rounded anterior lobes (Fig. 49a); nuchal tentacle at posterior end of caruncle on setiger 2; branchiae with glands (Fig. 49a) . . . . . *P. glandulosa*

***Pseudopolydora paucibranchiata* (Okuda, 1937)**

*Polydora (Carazzia) paucibranchiata* Okuda, 1937, p. 231.

*Pseudopolydora paucibranchiata*: Imajima and Hartman, 1964, p. 288; Blake, 1975, p. 215; Blake and Woodwick, 1975, p. 110; Read, 1975, p. 414; Light, 1977, p. 71 (Synonymy).

*Material examined*: NEW SOUTH WALES. Botany Bay, Towra Beach, NSWFS Stations, 12 April 1973 (1, AM W13045); Jervis Bay, Currubene Creek, 23 Jan. 1977 (1, AM W5223). VICTORIA. Port Phillip Bay, PPBES Stations 904 (2); 919 (15); 924 (2); 926 (10); 939 (4); 942 (47); 953 (36); 984 (2) (NMV G3175-3182); Hobsons Bay-Yarra River, MSG Stations, Feb., May 1975, coll. G. Poore and J. D. Kudenov, 128 (637); 130 (3); 131 (4); 132 (15); 138 (21) (NMV G2890, 3183-3187); Westernport, WPBES Stations 1702 (27, NMV G3133); 1716 (64, NMV G3134).

*Description*: Prostomium entire on anterior margin, caruncle extending to posterior margin of setiger 3; occipital tentacle present. Palps long, extending  $\frac{1}{2}$  length of worm. Setiger 1 without notosetae. Major spines of setiger 5 arranged in a U-shaped line, consisting of 12-14 pennoned, curved spines and an equal number of simple falcate spines; setiger 5 relatively unmodified, same size as setigers 4 and 6. Hooded hooks from setiger 8, completely replacing neuropodial capillaries. Branchiae from setiger 7, continuing to about setiger 35. Pygidium with small, ventral, collar-like disc with large dorsal gap.

*Remarks*: Specimens agree well with others observed by us in California. *P. paucibranchiata* is widely distributed in bays throughout the Pacific and is possibly introduced into Australia. It is similar in some respects to *P. kempfi*, but differs in having an entire, rounded, rather than incised prostomium, and a ventral collar-like rather than a dorsally flaring pygidium. *Distribution*: New South Wales; Victoria; Japan; California; New Zealand.

***Pseudopolydora kempfi* (Southern, 1921)**

*Polydora (Carazzia) kempfi* Southern, 1921, p. 636; Okuda, 1937, p. 233.

*Neopygospio laminiifera* Berkeley and Berkeley, 1954, p. 462. *Fide* Banse 1972, p. 219.

*Pseudopolydora kempfi japonica* Imajima and Hartman, 1964, p. 287.

*Pseudopolydora kempfi californica* Light, 1969, p. 542.

*Pseudopolydora kempfi*: Hartman, 1969, p. 167; Blake, 1975, p. 215; Blake and Woodwick, 1975, p. 126; Light, 1977, p. 71.

*Polydora (Pseudopolydora) kempfi japonica*: Banse, 1972, p. 219.

*Material examined*: QUEENSLAND. Moreton Bay, Jackson Creek, 12 July 1973, coll. C. Wallace and P. Hutchings (1, AM W6042); Same, Serpentine Creek, sand bank, coll. C. Wallace (1, AM W6043); Brisbane River, Quarantine Station May 1972 (6, AM W7474). NEW SOUTH WALES. Merimbula, Sta. 197H, 200J, 6 Oct. 1975, sand, coll. by J. H. Day, et al. (1, AM W11703, 1, AM W11704).

*Description*: A moderately large species, up to 25 mm long for 45 setigers in some areas, generally smaller in Australia. Body opaque white, otherwise colourless, but with black anterior intersegmental pigment in other localities (Light, 1969).

Anterior end expanded. Prostomium with 2 widely flared lobes, continuing posteriorly as a caruncle to setiger 3-4. Occipital tentacle present, just posterior to eyes; 2 pairs of eyes.

Setiger 1 without notosetae, postsetal lobes erect, short. Setigers 2 and succeeding with well-developed notopodial fascicles of unilimbate setae arranged in 3 tiers: shortest thickest setae in first tier; becoming progressively longer and thinner in tiers 2 and 3; setigers 4 and 6 with anterior tier developed ventrally, curving posteriorly and approaching the condition found in modified setae of setiger 5 (see Southern, 1921, p. 636, pl. 28, fig. 30; Okuda,

1937, p. 235, fig. 13b). Neurosetae setigers 2-7 with well-developed fascicles of unilimbate capillary setae; 25-30 bidentate hooded hooks from setiger 8.

Setiger 5 with about 23-25 pairs of each of 2 types of specialized spines arranged in a J-shaped row; outer row consisting of short pennoned setae, inner row consisting of simple spines, slightly curved apically.

Branchiae from setiger 7, continuing posteriorly for about  $\frac{1}{2}$  body length. Pygidium missing in Australian specimens, but elsewhere reported disc-like, dorsally notched and bearing 2 erect processes on each dorsolateral side (Okuda, 1937; Blake, 1975; Blake and Woodwick, 1975).

*Remarks:* *Pseudopolydora kempfi* is one of the least modified members of the genus or the *Polydora*-complex for that matter. In overall view, it is difficult to see the modification of setiger 5. Specimens reported here agree well with descriptions from other areas. Lack of pigmentation may be actual or be an artifact of preservation.

*Distribution:* Queensland; New South Wales; Japan; India; British Columbia, California.

***Pseudopolydora glandulosa* sp. nov.**

(Figure 49)

*Material examined:* QUEENSLAND. Moreton Bay, Middle Banks, Stas. 43, 54, Sept. 1972, coll. W. Stephenson (2, QM G11598-11599). NEW SOUTH WALES. Botany Bay, Towra Beach, NSWFS Stations, April 1973, (2, AM W13046). VICTORIA. Westernport, Crib Point, CPBS Station 300 (HOLOTYPE, NMV G2899; 5 PARATYPES, NMV G2900).

*Description:* A small species, measuring up to 11 mm long and 1.1 mm wide for 37 setigerous segments on an incomplete specimen. Animals heavily pigmented, with brown pigment on prostomium, peristomium and anterior margins of setigers 1-6; brown pigment on posterior margins of most segments ventrally.

Anterior end broad, head and first 2 setigers small and contracted relative to setiger 3 and following segments. Prostomium distinctly incised on anterior margin (Fig. 49a), but not formed into flaring lobes; caruncle terminating at middle to end of setiger 2; occipital tentacle inserted at posterior end of caruncle (Fig. 49a).

Peristomium well-developed, folded into 2 lobes; palps missing.

Setiger 1 with short notopodial lobes, lacking notosetae; neuropodia well-developed with delicate capillary setae (Fig. 49a). Setiger 2 and succeeding setigers with rounded notopodial lobes and long, thin capillary notosetae, arranged in 2 tiers, with shorter, thicker setae in first tier and longer, thinner setae in second; posterior spines absent; neurosetae of setigers 2-7 with dense fascicles of broad bilimbate capillary setae having fine granulations on the shaft (Fig. 49d). Bidentate hooded hooks numbering 18-21 per fascicle without accompanying capillary setae beginning in setiger 8; hooks with reduced angle between teeth, a striated hood with serrated hood opening and distinct constriction on shaft (Fig. 49e).

Setiger 5 only slightly modified, not much different from 4 and 6, with J-shaped row of modified spines located between the noto- and neuropodial fascicles. Outer setae pennoned (Fig. 49c), inner setae as simple spines with inflated slightly curved apex (Fig. 49b).

Branchiae from setiger 7, continuing for only about 11 setigers. Branchiae glandular, with additional line of glands extending across dorsum between each gill. Pygidium unknown.

*Remarks:* *Pseudopolydora glandulosa* has a relatively unmodified fifth setiger and approaches *P. kempfi* (Southern) in certain respects. The 2 species differ strikingly in overall appearance, especially the larger more erect notopodial lobes and wider flaring prostomium of *P. kempfi*. The pigmentation of *P. glandulosa* contrasts with that of *P. kempfi* in Australia, where it is generally lacking. In California, however, *P. kempfi* is heavily pigmented in the intersegmental regions of the anterior setigers (Light, 1969, fig. 9), *P. glandulosa* on the other hand, has prominent dorsal and ventral pigmentation. The striated hood of the hooded hooks of *P. glandulosa* is unique for the genus. *Distribution:* Queensland; New South Wales; Victoria.

***Pseudopolydora stolonifera* sp. nov.**

(Figure 50a-j)

*Material examined:* VICTORIA. Westernport, Crawfish Rock, 5 m, associated with various sponge

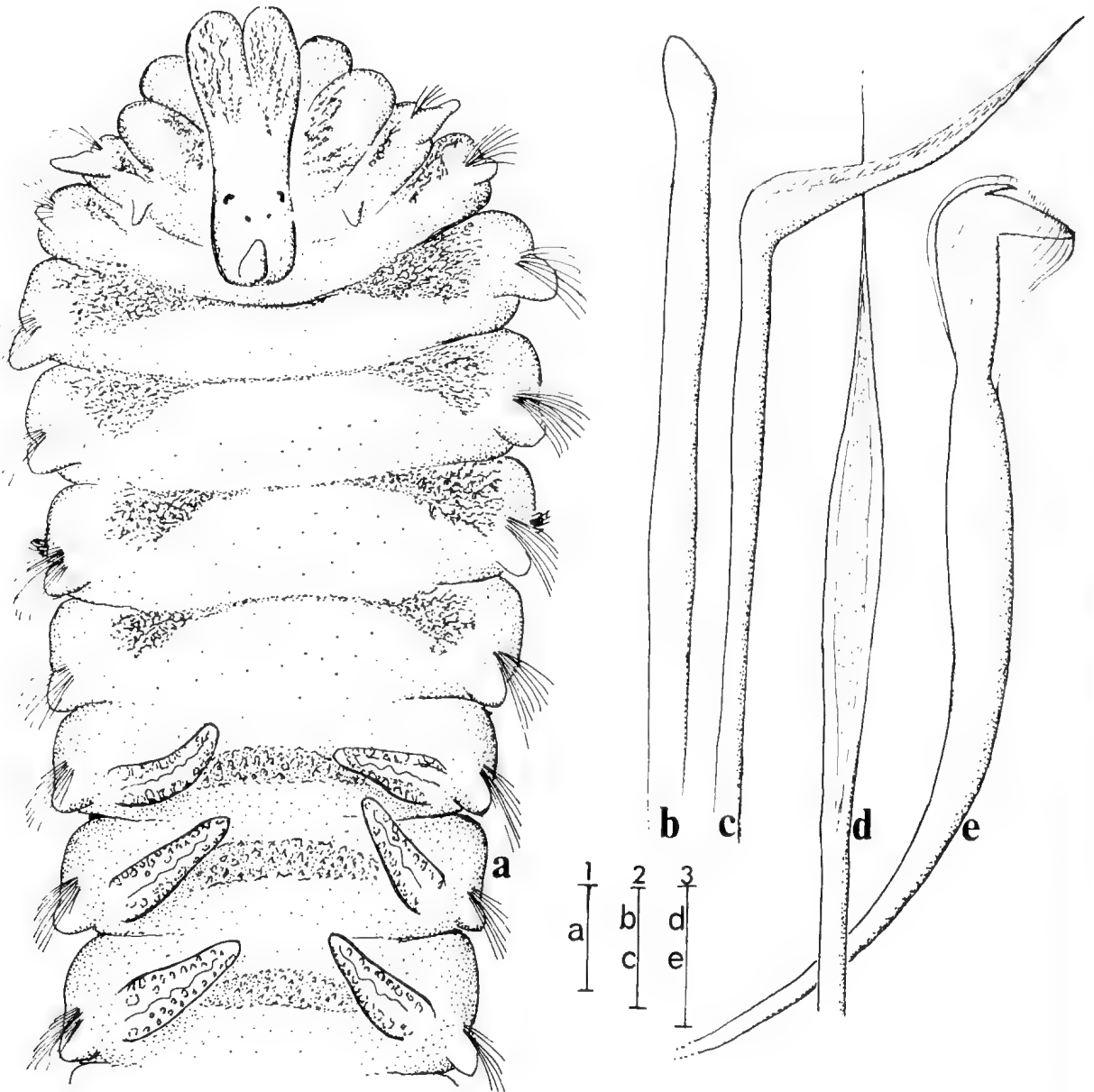


Figure 49—*Pseudopolydora glandulosa* sp. nov.—a, anterior end, dorsal view; b, simple spine, setiger 5; c, pennoned spine, setiger 5; d, neuroseta, setiger 5; e, hooded hook. [Scale 1 = 200  $\mu\text{m}$ ; 2 = 30  $\mu\text{m}$ ; 3 = 20  $\mu\text{m}$ ]

species, and pycnogonid *Nymphon mulleri*, 3 Jan. and 13 May 1977, coll. D. Staples (HOLOTYPE, NMV G2897; 60+ PARATYPES, NMV G2898; 50+, NMV, G3071).

**Description:** A small species measuring 2.8 mm long and 0.4 mm wide for a maximum of

16 setigerous segments. First 8 setigers narrow, last 8 greatly enlarged. Body with reticulated brown pigment on gills, peristomium and laterally on anterior body segments; reflective white pigment on prostomium observed in living animals. Some specimens undergoing active asexual reproduction with regeneration of a new head beginning between setigers 10-11. Following description refers to entire animals only, not regenerating ones.

Prostomium incised on anterior margin (Fig.

50a-b), caruncle terminating at posterior edge of setiger 2, occipital tentacle and eyes absent.

Setiger 1 reduced, without notopodium or notosetae; neuropodium ventrally displaced, with fascicles of winged capillaries (Fig. 50b-c). Setigers 2, 3, 4, -, 6 and succeeding setigers with fascicles of unilimbate capillary notosetae, these becoming longer and fewer in posterior setigers. Neurosetae of setigers 2, 3, 4, -, 6 and 7 with unilimbate capillaries. Bidentate hooded hooks beginning on setiger 8, numbering 6-8 throughout, lacking accompanying capillaries; hood with serrated opening (Fig. 50d).

Setiger 5 modified, with both types of major spines arranged in a slightly curved line (Fig. 50b, e); major spines numbering 3-5 of each type, including: (1) pennoned, densely bristled spines with expanded ends (Fig. 50f-h) in ventral row, and (2) simple acicular spines (Fig. 50e, i) in dorsal row; no superior dorsal fascicle; with inferior ventral fascicle of 3-5 bilimbate setae (Fig. 50j).

Two pairs of branchiae on setigers 7-8. Pygidium with 3 small cirri developed above smooth terminal ending (Fig. 50b).

**Asexual Reproduction:** The collection includes animals in various stages of regeneration and budding. A new anterior end develops in a growth zone between setigers 10-11. Small palp buds appear with morphology of the head developing prior to budding. This type of asexual reproduction where development precedes budding is called *paratomy* (Schroeder and Hermans, 1975). Different stages of regeneration are seen in the collections. Some late stages of regeneration appear complete, but setiger 1 lacks notosetae, a situation similar to that seen in *P. prolifera* (see below).

**Remarks:** *Pseudopolydora stolonifera* shows more modification to setiger 5 than most species of the genus, in having poorly developed parapodia and in lacking notosetae. The structure of the spines on setiger 5 and hooded hooks, however, clearly ally this species to *Pseudopolydora* and not *Carazziella*. The species is most closely related to *P. prolifera*, but differs in having a bilobed instead of an entire prostomium, having serrated openings on the hooded hooks, lacking superior dorsal notosetae on setiger 5 and by having the pennoned

major spines of setiger 5 with expanded densely bristled tips instead of a fenestrated spine with apical cavity.

**Distribution:** Victoria, Westernport Bay, on sponges.

***Pseudopolydora prolifera* (Augener, 1914)**  
comb. nov.

(Figure 50k-n)

*Polydorella prolifera* Augener, 1914, p. 16. [Not Fauvel, 1930, p. 36; 1953, p. 322].

**Material examined:** WEST AUSTRALIA. Sharks Bay, South Passage, 9 m, 16 April 1905, S.W. Australia Exped. 1905 (2 SYNTYPES, ZMH V10106).

**Description:** A small species, capable of asexual reproduction by paratomy. Both syntypes with 16 setigers measuring up to 2.8 mm long and 0.6 mm wide. Both specimens slightly damaged, showing evidence of deterioration.

Prostomium entire on anterior margin, no apparent caruncle or occipital tentacle; eyes absent. Setiger 1 reduced, without notopodium or notosetae; neuropodial lobe small, dorsally elevated with 3-4 very fine capillaries on one specimen and absent on second leaving an entirely achaetous segment. Setigers 2, 3, 4, -, 6 and succeeding setigers with fascicles of unilimbate capillary notosetae; neurosetae fewer in number. Neuropodial hooded hooks from setiger 8 (Fig. 50k), 4-5 hooks at first increasing to 6 in middle body segments, reduced to 2-3 in posterior segments, without accompanying capillaries.

Setiger 5 only slightly modified, with well-developed dorsal and ventral fascicles of unilimbate capillary setae (Fig. 50l) and 2 types of major spines: (1) 1 type distally enlarged, with one edge fenestrated and surrounding cavity and other bearing elongated bristle-topped projection (Fig. 50n); (2) second type a simple acicular spine (Fig. 50m).

Branchiae missing on types, but according to Augener (1914), a single pair occur on what would be setiger 7. With a dark-brown achaetous segment bearing 2 palp buds lying between setigers 10 and 11, denoting area where a new anterior end is regenerating. Pygidium consisting of 2 thickened lateral lobes, with wide medial gap (Augener, 1914).

**Remarks:** *Polydorella* was described as having

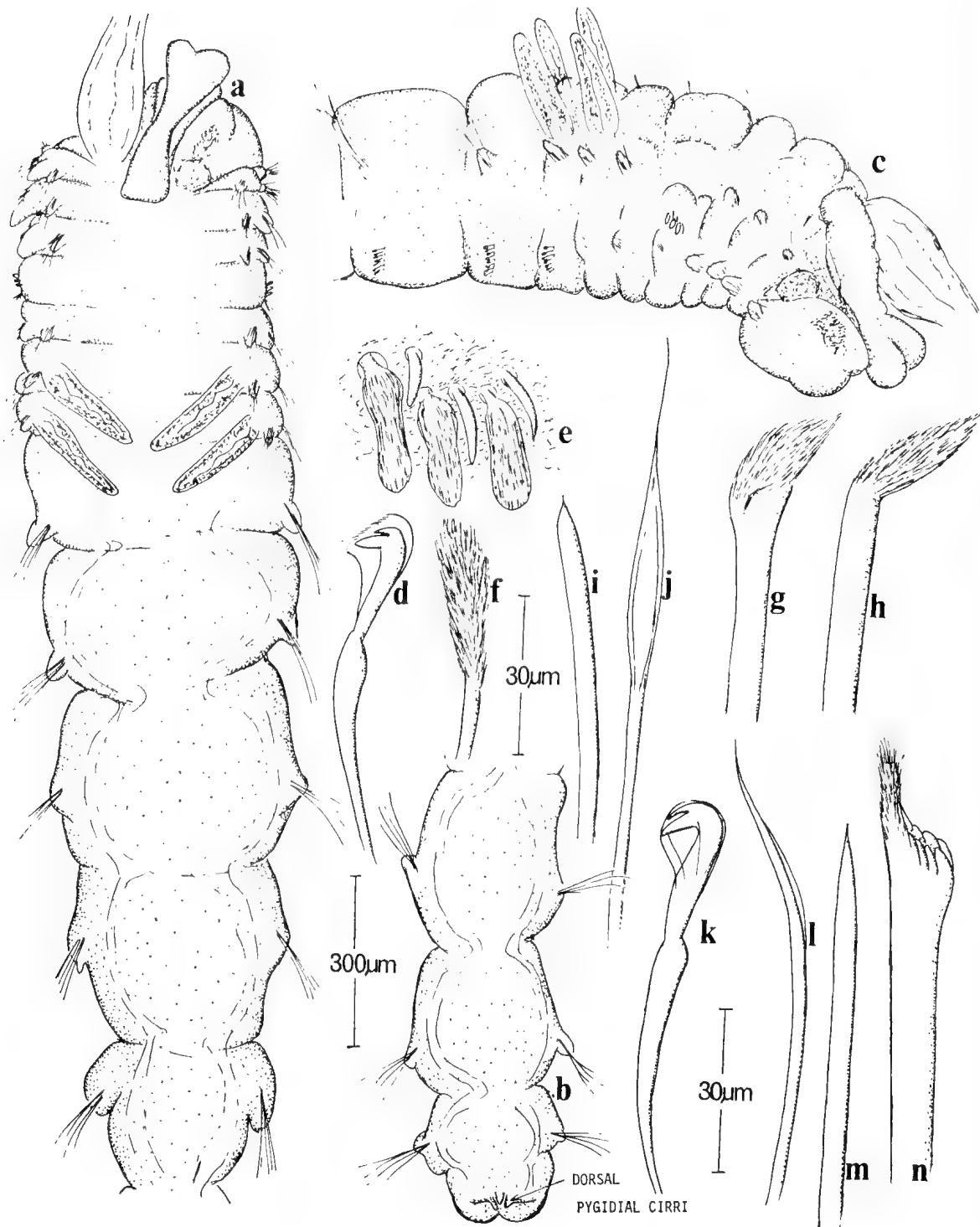


Figure 50—*Pseudopolydora stolonifera* sp. nov.—a-b, entire animal in dorsal view, drawn in 2 parts (a, is the first 13 setigers; b, the last 3 setigers); c, anterior end, lateral view; d, hooded hook; e, group of spines, setiger 5, lateral view; f-h, pennoned spines, setiger 5; i, simple spine, setiger 5; j, neuroseta, setiger 5—*Pseudopolydora prolifera* (Augener)—k, hooded hook; l, superior notoseta, setiger 5; m, simple spine, setiger 5; n, pennoned-type spine, setiger 5.

the fourth setigerous segment modified instead of the fifth. An examination of the 2 syntypes has shown that one bears an achaetous first segment with a conspicuous neuropodial lobe, 3 normal setigers and then the modified segment. The second specimen has 3-4 very fine capillary setae associated with the neuropodial lobe on the first segment. Thus Augener's species should be referred to *Pseudopolydora* since 4 setigers precede the modified one, instead of 3. Since 1 of the 2 specimens did actually lack setae on the first segment, the presence and absence of setae in setiger 1 in different specimens of the species emphasize the tendency for reduction in setiger 1 among species of *Pseudopolydora*. In *P. prolifera*, however, the reduction of setiger 1 is in part explained by its mode of asexual reproduction. Specimens undergoing anterior regeneration would probably demonstrate various stages of setal development. If the regenerating region involves a specific characteristic such as an already reduced first setiger, then the total absence of setae on setiger 1 would not be unexpected. We have this very situation in another, closely related species, *P. stolonifera* (see above).

Since the type-species of the genus *Polydorella* is now known to lie well within the definition of the genus *Pseudopolydora*, the former genus must be sunk into synonymy in its entirety.

Still another species may exist with a reduced first setiger and asexual reproduction. Fauvel (1930; 1953) and Gravely (1927) reported a species from India which Fauvel called *Polydorella prolifera* and Gravely referred to as 'post-larval chaetopterid'. This species, however, clearly has a different type of acicular spine on the modified segment. Gravely (1927) indicated it lived on the surface of sponges, as does *Pseudopolydora stolonifera* (see above).

*Distribution:* West Australia, Sharks Bay.

### Discussion

*Genera of the Spionidae:* Apart from disagreements relating to the status of particular taxa at subgeneric or generic levels, the spionid genera have been relatively well understood

due to recent efforts by Hartmann (1941; 1959), Pettibone (1963), Day (1967) and Foster (1971).

Australian spionids, however, have presented so many new taxa that a re-examination of the status of certain genera and generic groups must be undertaken. Throughout this paper we have reviewed certain genera or generic complexes where appropriate, and either expanded their definitions to accommodate new species or have named new genera to accommodate taxa otherwise too far removed from existing taxa. We have also taken the opportunity to partly alter the generic arrangement of the *Polydora*-complex because of the new species groups in our collections.

At least 3 genera: *Polybranchia* Potts, 1928; *Anaspio* Chamberlin, 1920; and *Morants* Chamberlin, 1919 are not included, although Fauchald (1977a) diagnosed all 3 in his book on polychaete families and genera. We consider that the former may be validly placed among genera with frontal horns, but prefer to wait, pending a re-examination of the type-species. The 2 latter genera are highly doubtful. Both were possibly described from damaged material and neither has been reported since the original description. Type material is apparently lost. Both *Anaspio* and *Morants* are best considered *nomina dubia*.

*Generic Characteristics:* Different taxonomic characters are important at the generic level in different generic groups. This is expected since different groups of species have specialized along their own lines following an early dichotomy from ancestral spionids. Spionids possibly date from Devonian time (Cameron, 1967; 1969), and one should not expect to use the same characteristics with equal weight in genera such as *Scolecopsis*, *Prionospio* and *Polydora*. Species of these genera and others have different ecological requirements and modes of life. Structures important in the adaptive radiation of polydorids are certainly not the same as those in genera such as *Scolecopsis* or *Prionospio*. Each genus has evolved independently and its species may not necessarily utilize the same structures as species belonging to other genera. With spionids, then, we cannot organize a simple system of uniform

characters to diagnose genera as is possible for certain other families (Kudenov and Blake, 1978). Instead, we must consider a wide range of features inherent in a given generic group; it is to be expected that the reasons for separating genera with frontal horns are not necessarily the same as those distinguishing groups with pointed prostomia.

Some characteristics do remain conservative throughout the family: these include the shape of the prostomium and first appearance of branchiae. These characters have been and are still important in establishing the current generic system for spionids. For example, *Scoelelepis-Dispio*; *Malacoceros-Rhynchospio*; *Polydora-Boccardia*; *Spio-Microspio*; *Paraprionospio-Prionospio* are some examples of generic groups where the first appearance of branchiae are important. Other characters important to some genera are the degree of fusion of branchiae and dorsal lamellae, the presence or absence of notopodial hooded hooks, the structure of the hooded hooks and their initial occurrence in some genera (in other genera, the occurrence of hooded hooks is age dependent [Hannerz, 1956] and is not always reliable).

Some genera have their own peculiar morphology: *Dispio* has accessory branchiae on the postsetal notopodial lobes, the polydorids have various degrees of modifications to setiger 5, and species of the *Prionospio*-complex have various peristomial and branchial modifications not found in other groups.

*Zoogeographic Considerations:* Three species included in this report are only known from West Australia. Of the 63 species reported herein for the Southeast and 2 from the Great Barrier Reef (Queensland), 44 are endemic to Australia. The other species generally have more cosmopolitan distributions. Such species include: *Aonides oxycephala*, *Malacoceros indicus*, *Paraprionospio pinnata*, *Prionospio steenstrupi*, *P. ehlersi*, *P. cirrifera*, *Spiophanes bombyx*, *S. kroeyeri*, *Polydora flava*, *P. socialis*, *P. giardi*, *P. armata*, *P. ligni*, *P. websteri*, *P. hoplura* and *Boccardia polybranchia*. Two species, *Pseudopolydora kempfi* and *P. Paucibranchiata* have wide distributions in the Pacific basin, while *Boccardia chilensis*, and *Priono-*

*spio aucklandica* are limited to the Southern Hemisphere. *Boccardia proboscidea* is known from Western North America and Japan and has apparently been introduced to Port Phillip Bay. *Spiophanes wigleyi* is known from continental shelf margins of eastern North America and the Gulf of Mexico. However, this apparent disjunct range may represent inadequate sampling on continental shelf margins.

Several bays have been found to harbour large numbers of endemic species. For example, Port Phillip Bay is the only known locality for 10 species. Westernport Bay has 2 endemic species and 1 species occurs in both bays. It is likely that several of these species will be found to be more widely distributed in Victoria once careful investigation of the Gippsland Lakes is completed.

Two other areas containing large numbers of endemic forms are Botany Bay in New South Wales and Moreton Bay in Queensland; four new taxa come from the former and 5 from the latter location. Other areas in New South Wales and Queensland contain still other endemic species. While many endemic species occur in several localities, the high percentage of species known from just a single locality is surprising. We suspect that some of these isolated records may reflect lack of adequate collecting, but it does appear that certain bodies of water, such as Port Phillip Bay, Victoria are important areas for adaptive radiation.

We anticipate the discovery of still more species of Spionidae from this region. Our lack of material from South Australia and Tasmania is painfully apparent. Moreover, the shell boring habitat has scarcely been explored for the polydorids. Microhabitats, such as sponges and corals, have not been investigated.

## References

- AUDOUIN, J. V. and H. MILNE EDWARDS, 1833. Classification des annélides et description de celles qui habitent les côtes de la France. *Ann. Sci. Nat. Paris* 30: 411-425.
- AUGENER, H., 1914. Polychaeta II, Sedentaria. *Fauna Südwest-Australiens* 5(1): 1-170, 1 pl.
- , 1923. Polychaeten von den Auckland und Campbell-Inseln. *Vidensk. Medd. naturhist. Foren. København* 75: 1-115.



- , 1926. Polychaeten von Neuseeland, II. Sedentaria. *Vidensk. Medd. Naturh. Foren. København* 81: 157-294.
- , 1927. Polychaeten von Südost- und Süd-Australien (Papers from Dr. Th. Mortensen's Pacific Expedition 1914-16). *Vidensk. Medd. nat. Foren. København* 83: 71-275.
- ANNENKOVA, N., 1938. Polychaeta of the North Japan Sea and their horizontal and vertical distribution. *Hydrobiol. Exped. U.S.S.R. in 1934 to the Japanese Sea*. (In Russian). Trudy D.-V. Filial Akad. Nauk, pp. 81-230.
- BANSE, K., 1972. On some species of Phyllodocidae, Syllidae, Nephthyidae, Goniadidae, Apistobranchidae, and Spionidae (Polychaeta) from the Northeast Pacific Ocean. *Pacific Sci.* 26: 191-222.
- and HOBSON, K. D., 1968. Benthic polychaetes from Puget Sound, Washington with remarks on four other species. *Proc. U.S. Nat. Mus.* 125: 1-53.
- BELLAN, G. and F. LAGARDERE, 1971. *Nerine mesnili*, n. sp., spionidien méconnu des plages sableuses de la province lusitanienne. *Bull. Soc. Zool. France* 96: 571-579.
- BERKELEY, E., 1927. Polychaetous annelids from the Nanaimo district. 3. Leodicidae to Spionidae. *Contribs. Canad. Biol. Ottawa*, n.s. 3: 405-422.
- and BERKELEY, C. 1936. Notes on Polychaeta from the coast of western Canada. 1. Spionidae. *Ann. Mag. Nat. Hist. London*, ser. 10, vol. 18: 468-476.
- and ———, 1950. Notes on Polychaeta from the coast of western Canada. Polychaeta Sedentaria. *Ann. Mag. Nat. Hist. London*, ser. 12, vol. 3: 50-69.
- and ———, 1952. Annelida. Polychaeta Sedentaria. *Canadian Pacific Fauna, Fish. Res. Bd. Canada* 9b (2): 1-139.
- and ———, 1954. Additions to the polychaete fauna of Canada, with comments on some older records. *Jour. Fish. Res. Bd. Canada* 11: 454-471.
- BLAINVILLE, H. DE, 1828. *Dictionnaire des Sciences Naturelles* 47: 368-501.
- BLAKE, J. A., 1966. On *Boccardia hamata* (Webster), new combination (Polychaeta, Spionidae). *Bull. So. Calif. Acad. Sci.*, 65: 176-184.
- , 1969. Reproduction and larval development of *Polydora* from northern New England (Polychaeta: Spionidae). *Ophelia* 7: 1-63.
- , 1971. Revision of the Genus *Polydora* from the east coast of North America (Polychaeta: Spionidae). *Smiths. Contribs. Zool.* 75: 1-32.
- , 1975. Phylum Annelida: Class Polychaeta. In R. I. Smith and J. T. Carlton (Eds), *Light's Manual Intertidal Invertebrates of the Central California Coast*. Univ. Calif. Press, Berkeley: 151-243.
- and J. W. EVANS, 1973. *Polydora* and related genera as borers in mollusk shells and other calcareous substrates. *The Veliger* 15: 235-249.
- and K. H. WOODWICK, 1971. A review of the genus *Boccardia* Carazzi (Polychaeta: Spionidae) with descriptions of two new species. *Bull. So. Calif. Acad. Sci.* 70: 31-42.
- and ———, 1972. New species of *Polydora* (Polychaeta: Spionidae) from the coast of California. *Bull. So. Calif. Acad. Sci.* 70: 72-79.
- and ———, 1975. Reproduction and larval development of *Pseudopolydora paucibranchiata* (Okuda) and *Pseudopolydora kempfi* (Southern) (Polychaeta Spionidae). *Biol. Bull.* 149: 109-127.
- and ———, 1976. A new species of *Boccardia* (Polychaeta: Spionidae) from two freshwater lakes in southeastern Australia. *Rec. Aust. Mus.* 30(7): 123-128.
- BOBRETZKY, N., 1870. On the Fauna of the Black Sea [In Russian]. *Kiev. obshchestvo estest. Zapiski* 1: 1-26.
- BOSC, L. A. G., 1802. *Histoire naturelle des vers, contenant leur description et leurs moeurs; avec figures dessinées d'après nature*. vol. 1, pp. 1-324.
- CAMERON, B., 1967. Fossilization of an ancient (Devonian) soft-bodied worm. *Science* 155: 1246-1248.
- , 1969. Paleozoic shell-boring annelids and their trace fossils. *Amer. Zool.* 9: 689-703.
- CARRASCO, F. D., 1974. Spionidae (Polychaeta) provenientes de la Bahía de Concepcion y lugares adyacentes. *Bol. Soc. Biol. de Concepcion* 48: 185-201.
- , 1976. Larvas de la familia Spionidae (Polychaeta) en el plancton de la Bahía de Concepcion, Chile. *Gayana Inst. Biol. Zoología* 38: 1-63.
- CARAZZI, D., 1893. Revisione del genere *Polydora* Bosc, e cenni su due specie che vivono sulle ostriche. *Mitt. Zool. Stat. Neapel* 11: 4-45, pl. 2.
- CAULLERY, M., 1914. Sur les polychètes du genre *Prionospio* Mgn. *Bull. Soc. Zool. Paris* 39: 355-361.
- CHAMBERLIN, R. V., 1919. New polychaetous annelids from Laguna Beach, California. *Jour. Entom. Zool. Pomona* 11: 1-23.
- , 1920. *Report of the Canadian Arctic Expedition 1913-18*. Volume 9B, *Polychaeta*. Ottawa, pp. 1-41B, 6 pls.
- CLAPARÈDE, E., 1864. Glanures zootomiques parmi les Annélides de Port-Vendres (Pyrenées Orientales). *Mem. Soc. Phys. Genève* 17: 463-600, 8 pls.
- , 1869. Recherches sur les Annélides Chétopodes présentant deux formes sexuées distinctes. *Arch. Sci. Bibliogr. Univ. Genève* 36: 129-165.
- , 1870. Les Annélides Chétopodes du Golfe

- de Naples. *Mém. Soc. Phys. Genève* 20(2): 365-542, 14 pls.
- COLEMAN, N., W. CUFF, M. DRUMMOND and J. D. KUDENOV, 1978. A quantitative survey of the macrobenthos of Westernport, Victoria, Australia. *Aust. Jour. Mar. & Freshwat. Res.*
- CZERNIAVSKY, V., 1881. Materialia ad zoographicum Ponticam comparatam. 3 Vermes. *Bull. Soc. Imp. Nat. Moscow* 56: 338-420.
- DAY, J. H., 1954. The Polychaeta of Tristan da Cunha. *Res. Norweg. Sci. Exped. Tristan da Cunha 1937-38*, 29: 1-35.
- , 1955. The Polychaeta of South Africa. Part 3: Sedentary species from Cape shores and estuaries. *Jour. Linn. Soc. Zool.* 42: 407-452.
- , 1961. The polychaete fauna of South Africa. Part 6: Sedentary species dredged off Cape coasts with a few new records from the shore. *Jour. Linn. Soc. Zool.* 44: 463-560.
- , 1963. The polychaete fauna of South Africa. Part 7: Species from depths between 1,000 and 3,300 metres west of Cape Town. *Ann. So. African Mus.* 46: 353-371.
- , 1967. *A Monograph on the Polychaeta of Southern Africa. Part 2. Sedentaria*. British Mus. Nat. Hist. London, Publ. No. 656: 459-878.
- , 1973. New Polychaeta from Beaufort, with a key to all species recorded from North Carolina. *NOAA Tech. Rep. NMFS Circ.* 375: 1-140.
- DORSEY, J. H., 1977. A new species of *Rhynchospio* (Polychaeta: Spionidae) from San Clemente Island, California. *Bull. So. Calif. Acad. Sci.* 76: 1-4.
- EHLERS, E., 1897. Polychaeten. *Hamburger Magalhaensischen Sammelreise*. Hamburg, Friedrichsen & Co. 148 pp., 9 pls.
- , 1901. Die Polychaeten des magellanischen und chilenischen Strandes. Ein faunistischer Versuch. Festschrift zur Feier des Hundertfünfzigjährigen Bestehens der königlichen Gesellschaft der Wissenschaften zu Göttingen. (Abh. Math.-Phys.) Berlin, Wiedmannsche Buchhandlung, pp. 1-232, pls. 1-25.
- , 1905. Neuseeländische Anneliden. K. *Ges. Wiss. Göttingen, Math-Phys. Kl., Abh. neue Folge* 3(1): 1-494.
- , 1907. Neuseeländische Anneliden. II. K. *Ges. Wiss. Göttingen, Math-Phys. Kl., Abh., neue Folge* 5(4): 1-31.
- , 1908. Wissenschaftliche Ergebnisse der deutschen Tiefsee-Expedition auf dem Dampfer *Valdivia* 1898-1899. Im Auftrage des Reichsamtes des Innern, herausgegeben von Carl Chun, Professor der Zoologie in Leipzig, Leiter der Expedition, vol. 16, Lief. 1. Die Bodensässigen Anneliden aus den Sammlungen der deutschen Tiefsee-Expedition. Jena, Gustav Fischer, pp. 1-168, 23 pls.
- , 1913. Die Polychaeten-Sammlungen der deutschen Südpolar-Expedition 1901-1903. *Deutsche Südpolar-Exped.* 13(4): 397-598, pls. 26-46.
- ESTCOURT, I. N., 1967. Burrowing polychaete worms from a New Zealand estuary. *Trans. Roy. Soc. N.Z.* 9(7): 65-78.
- FABRICIUS, O., 1785. Von dem *Spio*-Geschlechte, *Nereis seticornis* und *Nereis filicornis*. *Schr. Ges. Naturf. Freunde Berlin* 6: 256-270.
- FAUCHALD, K., 1972. Benthic polychaete annelids from deep water off western Mexico and adjacent areas in the eastern Pacific Ocean. *Allan Hancock Monogr. Mar. Biol.* 7: 1-575.
- , 1977a. *The Polychaete Worms. Definitions and Keys to Orders, Families and Genera*. Los Angeles County Museum of Natural History, Science Series 28: 1-190.
- , 1977b. Polychaetes from intertidal areas in Panama, with a review of previous shallow-water records. *Smiths. Contribs. Zool.*, 221: 1-81.
- FAUVEL, P., 1916. Annélides polychètes des Iles Falkland recueillie par M. Rubert Vallentin Esqre (1902-1910). *Arch. Zool. exp. gen. Paris* 55: 417-482, pls. 8-9.
- , 1927. Polychètes sédentaires. Addenda aux Errantes, Archiannelides, Myzostomaires. *Faune de France* 16: 1-494.
- , 1928a. Annélides polychètes nouvelles de l'Indie. *Bull. Mus. Nat. Hist. Paris* 34: 90-96.
- , 1928b. Annélides polychètes nouvelles du Maroc. *Bull. Soc. Zool. Paris* 53: 9-13.
- , 1929. Polychètes nouvelles du golfe de Manaar, Inde. *Bull. Soc. Zool. Paris* 54: 180-186.
- , 1930. Annelida Polychaeta of the Madras Government Museum. *Bull. Madras Govt. Mus.*, n. s. Nat. Hist. Sec., vol. 1(2): 1-72.
- , 1936. Contribution a la faune des Annélides polychètes du Maroc. *Mem. Soc. Sci. nat. Maroc* 43: 1-143.
- , 1953. Annelida Polychaeta. In, *The Fauna of India including Pakistan, Ceylon, Burma and Malaya*. 507 pp. Allahabad.
- FERRONNIÈRE, G., 1898. Contribution a l'étude de la faune de la Loire-inférieure (Polygordiens, Spionidiens, Nemertien). *Bull. Soc. Sci. Nat. l'Ouest France* 8: 101-115.
- FOSTER, N., 1969. New species of spionids (Polychaeta) from the Gulf of Mexico and Caribbean Sea, with a partial revision of the genus *Prionospio*. *Proc. Biol. Soc. Wash.* 82: 381-400.
- , 1971. Spionidae (Polychaeta) of the Gulf of Mexico and the Caribbean Sea. *Studies on the Fauna of Curacao and other Caribbean Islands*. 36: 1-183.
- FRANZÉN, A., 1956. On spermiogenesis, morphology of spermatozoon, and biology of fertilization among invertebrates. *Zool. Bidrag Uppsala* 31: 355-482.
- FRIEDRICH, H., 1956. Mitteilungen über neue und

- wenig bekannte Polychaeten aus Mittel- und Sud-Amerika. *Senckenbergiana biol.* 37: 57-68.
- GEORGE, J. D., 1966. Reproduction and early development of the spionid polychaete *Scolecopides viridis* (Verrill). *Biol. Bull.*, 130: 76-93.
- GIARD, A., 1881. Sur un curieux phénomène de pré-fécondation observé sur un Spionide. *CR Acad. Sci. Paris* 93: 600-602.
- GIBBS, P. E., 1971. The polychaete fauna of the Solomon Islands. *Bull. Brit. Mus. Nat. Hist.* 21: 101-211.
- , 1972. Polychaete annelids from the Cook Islands. *Jour. Zool. London* 168: 199-220.
- GRAVELY, F. H., 1927. The littoral fauna of Krusadai Island in the Gulf of Manaar. Chaetopoda. *Bull. Madras Govt. Mus., n.s. Nat. Hist.*, vol. 1: 55-86, pls. 9-10.
- GRAVIER, C., 1911. Annélides polychètes recueillies par la seconde expédition antarctique française (1908-1910). *Deuxième expédition antarctique française* 1: 1-165, 12 pls.
- GRUBE, A.-E., 1850. Die Familien der Anneliden. *Arch. Naturg.* 16: 249-364.
- , 1860. Beschreibung neuer oder wenig bekannter Anneliden. *Arch. Naturg.* 26: 71-118.
- HANNERZ, L., 1956. Larval development of the polychaete families Spionidae Sars, Disomidae Mesnil and Poecilochaetidae n. fam. in the Gullmar Fjord (Sweden). *Zool. Bidrag Uppsala* 31: 1-204.
- HARTMAN, O., 1936. New species of Spionidae (Annelida Polychaeta) from the coast of California. *Univ. Calif. Publ. Zool.* 41: 45-52.
- , 1940. *Boccardia proboscidea*, a new species of spionid worm from California. *Jour. Wash. Acad. Sci.* 30: 382-387.
- , 1941. Some contributions to the biology and life history of Spionidae from California. *Allan Hancock Pac. Expeds.* 7(4): 289-324, 3 pls.
- , 1943. *Polydora websteri* Hartman. In V. L. Loosanoff and J. Engle, *Polydora* in oysters suspended in the water. *Biol. Bull.* 85: 69-78.
- , 1944. Polychaetous annelids from California, including the description of two new genera and nine new species. *Allan Hancock Pac. Expeds.* 10(2): 239-310, 7 pls.
- , 1948. The marine annelids erected by Kinberg with notes on some other types in the Swedish State Museum. *Ark. Zool., Stockholm* 42A: 1-137, 18 pls.
- , 1951. The littoral marine annelids of the Gulf of Mexico. *Publ. Inst. Mar. Sci. Univ. Texas* 2: 7-124, 27 pls.
- , 1959. Catalogue of the polychaetous annelids of the world. *Allan Hancock Found. Occas. Pap.* No. 23: 1-628.
- , 1960. Systematic account of some marine invertebrate animals from the deep basins off southern California. In *The benthic fauna of the deep basins off southern California. Pt. 2, Allan Hancock Pac. Expeds.* 22(2): 69-215, 19 pls.
- , 1961. Polychaetous annelids from California. *Allan Hancock Pac. Expeds.* 25: 1-226, 34 pls.
- , 1965a. Deep water benthic polychaetous annelids off New England to Bermuda and other North Atlantic areas. *Allan Hancock Found. Occas. Pap.* No. 28: 1-378, 52 pls.
- , 1965b. Catalogue of the polychaetous annelids of the world. Supplement and index (1960-1965). *Allan Hancock Found. Occas. Pap.* No. 23: 1-197.
- , 1966. Polychaeta Myzostomidae and Sedentaria of Antarctica. Amer. Geophysical Union (Publ. No. 1414). *Antarctic Res. Ser.* 7: 1-158, 46 pls.
- , 1969. *Atlas of the Sedentariate Polychaetous Annelids from California*. Allan Hancock Foundation, Los Angeles. 828 pp.
- and K. FAUCHALD, 1971. Deep water benthic polychaetous annelids off New England to Bermuda and other North Atlantic areas. Pt. II. *Allan Hancock Monogr. Mar. Biol.* No. 6: 1-327, 34 pls.
- and D. J. REISH, 1950. The marine annelids of Oregon. *Oregon State Coll., Monogr. Series*, pp. 1-64.
- HARIMANN-SCHRÖDER, G., 1959. Zur Ökologie der Polychaeten des Mangrove-Estero-Gebietes von El Salvador. *Beitr. z. Neotropisch. Fauna* 1(2): 69-183.
- , 1960. Zur Polychaetenfauna von Peru. Teil I. *Beitr. z. Neotropisch. Fauna* 2(1): 1-44.
- , 1962. Zweiter Beitrag zur Polychaetenfauna von Peru. *Kieler Meeresforschungen* 18: 109-147.
- , 1965. Die Polychaeten des Sublitorals. In *Zur Hartmann-Schröder, G. und G. Hartmann. Zur Kenntnis des Sublitorals der chilenischen Küste unter besonderer Berücksichtigung der Polychaeten und Ostracoden. Mitt. Hamburg. Zool. Mus. und Inst.* 62 Supplement: 59-305.
- , 1971. Annelida, Borstenwürmer, Polychaeta. *Die Tierwelt Deutschlands* 58: 1-594.
- HASWELL, W. F., 1885. On a destructive parasite of the rock oyster. *Proc. Linn. Soc. N. So. Wales* 10: 273-275.
- HOLMQUIST, C. VON, 1967. *Marenzellaria wireni* Augener—a polychaete found in fresh waters of northern Alaska—with taxonomical considerations on some related spionid worms. *Zeitschr. Zool. Syst. Evols.* 5(3): 298-313.
- HORST, R., 1920. Polychaete anneliden uit het Alkmaarder Meer door Dr. R. Horst. *Zool. Mededeelingen, Leiden* 5: 110-111.
- HUTCHINGS, P. A., 1974. Polychaeta of Wallis Lake, New South Wales. *Proc. Linn. Soc. N.S.W.* 98: 175-195.
- and H. F. RECHER, 1974. The fauna of

- Careel Bay with comments on the ecology of Mangrove and sea-grass communities. *Aust. Zool. J.* 18: 99-128.
- JACOBI, R., 1883. *Anatomisch-histologische Untersuchung der Polydoren der Kieler Buch*. Inaugural Dissertation, Kiel: 1-35, 2 pls.
- IMAJIMA, M. and O. HARTMAN, 1964. The polychaetous annelids of Japan, I-II. *Allan Hancock Found. Occ. Pap.* No. 26: 1-452.
- JOHNSON, H. P., 1901. The Polychaeta of the Puget Sound region. *Proc. Boston Soc. Nat. Hist.* 29: 381-437.
- JOHNSON, R. G., 1970. Variations in diversity within benthic marine communities. *Amer. Nat.*, 104: 285-300.
- JOHNSTON, G., 1827. Contributions to the British fauna. *Zool. Jour. London* 3: 321-336.
- , 1838. *Miscellanea Zoologica*. Aricadae. *Mag. Zool. Bot. Edinburg* 2: 62-73.
- JONES, M. L., 1962. On some polychaetous annelids from Jamaica, the West Indies. *Bull. Amer. Mus. Nat. Hist.* 124: 173-212.
- KEFERSTEIN, W., 1862. Untersuchungen über niedere Seethiere. *Zeitschr. wiss. Zool.* 12: 1-147. [Annelida p. 93-129].
- KHLEBOVITSCH, V. V., 1959. Species of polychaete worms from the Kurile Islands which are new or recorded for the first time in the U.S.S.R. *Zool. Zhurnal* 28: 167-181. [In Russian].
- KUDENOV, J. D. and J. A. BLAKE, 1978. A revision of the genera and species of the family Scalibregmidae (Polychaeta) with descriptions of one new genus and three new species from Australia. *Jour. Nat. Hist. London*. 12: In Press.
- LANGERHANS, P., 1880. Die Würmfauuna von Madeira. *Zeitschr. wiss. Zool.* 34: 87-143.
- LAUBIER, L., 1962. Quelques annélides polychètes de la lagune de Venise. Description de *Prionospio caspersi* n. sp. *Vie et Milieu* 13: 123-159.
- and J. RAMOS, 1974. *Polydora guillei* sp. nov. nouvelle espèce de Polychète spionidien en Méditerranée occidentale. *Vie et Milieu* 24(3A): 479-486.
- LEE, J. H., 1976. A study on the benthic fauna along the Busan coast. *Publ. Inst. Mar. Sci. Nat. Fish. Univ. Busan* 9: 49-70. [Descriptions of polychaete species new to benthic fauna of Korea, pp. 61-67].
- LIGHT, W. J., 1969. *Polydora narica*, new species, and *Pseudopolydora kempi californica*, new subspecies, two new spionids (Annelida: Polychaeta) from central California. *Proc. Calif. Acad. Sci.* 36: 531-550.
- , 1970a. *Polydora alloporis*, new species, a commensal spionid (Annelida, Polychaeta) from a hydrocoral off central California. *Proc. Calif. Acad. Sci.* 37(14): 459-472.
- , 1970b. A new spionid (Annelida, Polychaeta) from the Gulf of California. *Bull. So. Calif. Acad. Sci.* 69: 74-79.
- , 1974. A new species of *Pseudopolydora* (Polychaeta, Spionidae) from the Solomon Islands. *Proc. Biol. Soc. Wash.* 87: 389-394.
- , 1977. Spionidae (Annelida: Polychaeta) from San Francisco Bay, California: a revised list of nomenclatural changes, new records, and comments on related species from the north-eastern Pacific Ocean. *Proc. Biol. Soc. Wash.* 90: 66-88.
- , 1978. *Invertebrates of the San Francisco Bay Estuary System*. Family Spionidae (Annelida, Polychaeta). The Boxwood Press, Pacific Grove, California. In press.
- MALMGREN, A. J., 1867. *Annelata Polychaeta Spetsbergiae, Groenlandiae, Islandiae et Scandinaviae hactenus cognita*. *Öfv. K. Vetensk. Akad. Forh.* 24: 127-235.
- MESNIL, F., 1896. Études de morphologie externe chez les annélides. I. Les spionidiens des côtes de la Marche. *Bull. Sci. France Belg.* 29: 110-287, pls. 7-15.
- , 1897. Études de morphologie externe chez les annélides. II. Remarques complémentaires sur les spionidiens, la famille nouvelle des disomidiens. La place des *Aonides* (sensu Tauber, Levinsen). *Bull. Sci. France Belg.* 30: 83-100, 1 pl.
- MICHAELSEN, W., 1897. Die Polychaetenfauna der deutschen Meer, einschliesslich der benachbarten und verbindenden Gebiete. *Wiss. Meeresunters. deutsch. Meere, Kiel u. Leipzig*, n. Folge, vol. 2(1): 1-216, 1 pl.
- MOBIUS, K., 1874. Mollusca, Vermes and Coelenterata of the Second German North-Polar Voyage. *Ann. Mag. Nat. Hist. London*, ser. 4, vol. 13: 196-204, pl. 11, figs. 4-14. [Translation].
- MOHAMMAD, M.-B.M., 1972. Infestation of the Pearl oyster *Pinctada margaritifera* (Linné) by a new species of *Polydora* in Kuwait, Arabian Gulf. *Hydrobiologia*, 39: 463-477.
- , 1973. New species and records of polychaete annelids from Kuwait, Arabian Gulf. *Zool. Jour. Linn. Soc.*, 52: 23-44.
- MONRO, C. C. A., 1931. Polychaeta, Oligochaeta, Echiuroidea and Sipunculoidea. Great Barrier Reef (Queensland) Exp. 1928-29. *Sci. Rep. Brit. Mus. (Nat. Hist.)* 4(1): 1-37.
- , 1938. On a small collection of Polychaeta from Uruguay. *Ann. Mag. Nat. Hist.* ser. 11, vol. 2: 311-314.
- MONTAGU, G., 1813. An account of some new and rare marine British shells and animals. *Trans. Linn. Soc. London* 11: 179-204.
- MÜLLER, O. F., 1776. *Zoologica Danicae Prodrum seu Animalium Daniae et Norvegiae indigenarum characteres, nomine et synonyma imprimis popularium*. Havniae. xxxii and 274 pp. Plates published 1777.
- , 1806. *Zoologica Danica seu Animalium Daniae et Norvegiae rariorum ac minus notorum*,

- Descriptiones et Historia*. Havnicae, pp. 1-160 [Atlas].
- OERSTED, A. S., 1843. *Annulatorum danicorum conspectus, Fasc. 1. Maricolae*. pp. 1-52, 7 pls.
- OKUDA, S., 1937. Spioniform polychaetes from Japan. *Jour. Fac. Sci. Hokkaido Imp. Univ.* 5: 217-254.
- ORRHAGE, L., 1964. Anatomische und morphologische Studien über die Polychaeten-familien Spionidae, Disomidae und Poecilochaetidae. *Zool. Bidrag Uppsala* 36: 335-405.
- PETTIBONE, M. H., 1954. Marine polychaete worms from Pt. Barrow, Alaska with additional records from the North Atlantic and North Pacific. *Proc. U.S. Nat. Mus.* 103: 203-356.
- , 1962. New species of polychaete worms (Spionidae: *Spiophanes*) from the east and west coast of North America. *Proc. Biol. Soc. Wash.* 75: 77-88.
- , 1963. Revision of some genera of polychaete worms of the family Spionidae, including the description of a new species of *Scolelepis*. *Proc. Biol. Soc. Wash.* 76: 89-104.
- , 1967. Type-specimens of polychaetes described by Edith and Cyril Berkeley (1923-1964). *Proc. U.S. Nat. Mus.* 119(3553): 1-23.
- PILLAI, T. G., 1965. Annelida Polychaeta from the Philippines and Indonesia. *Ceylon Jour. Sci. (Biol. Sci.)* 5: 110-177.
- POORE, G. C. B. and J. D. KUDENOV, 1978 a. Benthos around an outfall of the Werribee sewage-treatment farm, Port Phillip Bay, Victoria. *Aust. Jour. Mar. & Freshwat. Res.* 29 (2): In press.
- and ———, 1978 b. Benthos of the Port of Melbourne: the Yarra River and Hobsons Bay, Victoria. *Aust. Jour. Mar. & Freshwat. Res.* 29 (2): In press.
- , S. RAINER, R. B. SPIES and E. WARD, 1975. The zoobenthos program in Port Phillip Bay, 1969-73. *Fish. & Wildlife Pap. Vic.* No. 7: 1-78.
- POTTS, F. A., 1928. Report on the annelids (sedentary polychaetes). Zoological results of the Cambridge expedition to the Suez Canal. *Trans. Zool. Soc. London* 22: 693-705, figs. 210-213.
- QUATREFAGES, A. de, 1843. Description de quelques espèces nouvelles d'Annélides errantes recueillies sur les côtes de la Manche. *Mag. Zool. Paris*, ser. 2, vol. 5: 1-16, pls. 1-3.
- , 1865. *Histoire naturelle des Annéles marina et d'eau douce. Annélides et Gephyriens*. Paris Libr. Encycl. de Roret, vol. 1: 1-588.
- RAMOS, J. M., 1976. *Aonides oxycephala* (Sars, 1862) remarques taxinomiques. *Vie et Milieu* 26 (1A): 11-20.
- RAINER, S., 1973. *Polydora* and related genera (Polychaeta: Spionidae) from Otago waters. *Jour. Roy. Soc. N.Z.* 3: 545-564.
- READ, G. B., 1975. Systematics and biology of polydoridae species (Polychaeta: Spionidae) from Wellington Harbour. *Jour. Roy. Soc. N.Z.* 5: 395-419.
- RIOJA, E., 1918. Adiciones a la fauna de anelidos del Cantabrico, Madrid. *Rev. Acad. Cien. Madrid* 17: 54-79.
- , 1939. Estudios anelidológicos I. Observaciones acerca de varias formas larvianas y postlarvianas pelagicas de Spionidae, precedentes de Acapulco, con descripcion de una especie neuva del genero *Polydora*. *Ann. Inst. Biol. Mexico* 10: 297-311.
- , 1947. Estudios anelidológicos XVII. Contribución al conocimiento de los anélidos poliquetos de Baja California y Mar de Cortés. *Ann. Inst. Biol. Mexico* 18: 197-224.
- ROUGHLEY, T. C., 1922. Oyster culture on the George's River, New South Wales. *Tech. Mus. Sydney, Tech. Educ. Ser.*, 25: 1-69.
- SAINT-JOSEPH, B. A. DE, 1894. Les Annélides polychètes des côtes de Dinard. *Ann. Sci. Nat. Paris*, pt. 3, ser. 7, vol. 17: 1-395, pls. 1-13.
- SARS, M., 1851. Beretning om en i Sommeren 1849 foretagen zoologisk reise i Lofoten og Finmarken. *Nyt Mag. Naturvid. Oslo* 6: 121-211.
- , 1862. On annelidslægten *Nerine* og dans norske arter. *Forh. Vidensk. Selsk. Christiana* 1861: 59-67.
- , 1867. Beskrivelse og afbildninger of folgende norske annelider. *Forh. Vidensk. Selsk. Christiana* 1866: 29.
- SCHMARDA, L. K., 1861. *Neue wirbellose Thiere beobachtet und gesammelt auf einer Reise um die Erde 1853 bis 1857. Leipzig, Vol. 1. Turbellarien, Rotorien und Anneliden*. Pt. 2: 1-164, 22 pls.
- SCHROEDER, P. C. and C. O. HERMANS, 1975. Annelida: Polychaeta. In Geise, A. and Pearce, J. (Eds.) *Reproduction of Marine Invertebrates, vol. III Annelids and Echiurians*. Academic Press. pp. 1-211.
- SÖDERSTRÖM, A., 1920. *Studien über die Polychaetenfamilie Spionidae*. Diss. Uppsala, pp. 1-286.
- SOUTHERN, R., 1921. Fauna of Chilka Lake. Polychaeta of the Chilka Lake and also of fresh and brackish waters in other parts of India. *Mem. Indian Mus.* 5: 563-659.
- TREADWELL, A. L., 1914. Polychaetous annelids of the Pacific coast in the collection of the Zoological Museum of the University of California. *Univ. Calif. Publ. Zool.* 13: 175-234.
- VERRILL, A. E., 1873. Report upon the invertebrate animals of Vineyard Sound and the adjacent waters, with an account of the physical characters of the region. *Rep. U.S. Fish. Comm. Wash.* 1871-1872: 295-778.
- , 1879. Notice of recent additions to the marine Invertebrata, of the north-eastern coast of America, with descriptions of new genera and species and critical remarks on others. Pt. 1. Annelida, Gephyrea, Nemertina, Nematoda, Polyzoa, Tunicata, Mollusca, Anthozoa, Echinodermata, Porifera. *Proc. U.S. Nat. Mus.* 2: 165-205.

- , 1881. New England Annelida. Pt. 1. Historical sketch, with annotated list of the species hitherto recorded. *Trans. Conn. Acad. Arts Sci.* 4: 285-324.
- WEBSTER, H. E., 1879a. Annelida Chaetopoda of the Virginian coast. *Trans. Albany Inst. N.Y.* 9: 202-269, 11 pls.
- , 1879b. The Annelida Chaetopoda of New Jersey. *Ann. Rep. N.Y. State Mus. Nat. Hist.* 32: 101-128. [Plates cited were not published until 1886].
- and J. E. BENEDICT, 1884. The Annelida Chaetopoda from Provincetown and Wellfleet, Mass. *Rep. U.S. Comm. Fish. Wash.*, vol. for 1881, pp. 699-747, 8 pls.
- and ———, 1887. The Annelida Chaetopoda from Eastport, Maine. *Rep. U.S. Comm. Fish. Wash.*, vol. for 1885, pp. 707-755, 8 pls.
- WHITELEGGE, T., 1890. Report on the worm disease affecting the oysters on the coast of New South Wales. *Rec. Aust. Mus.* 1: 41-53.
- WILLEY, A., 1905. Report on the Polychaeta collected by Professor Herdman, at Ceylon in 1902. *Suppl. Rep. Ceylon Pearl Oyster Fish.*, pt. 4: 243-324, pls. 1-8.
- WIREŃ, A., 1883. Chaetopoder fran Sibiriska Ishafvet och Berings Haf insamlade under Vega-Expeditionen 1878-79. *Vega-Exped.-Vetenskapliga Iakttagelser* 2: 383-428, pls. 27-32.
- WOODWICK, K. H., 1953. *Polydora nuchalis*, a new species of polychaetous annelid from California. *Jour. Wash. Acad. Sci.* 43: 281-283.
- , 1961. *Polydora rickettsi*, a new species of spionid polychaete from lower California. *Pacific Sci.* 15: 78-81.
- , 1963. Comparison of *Boccardia columbiana* Berkeley and *Boccardia proboscidea* Hartman (Annelida Polychaeta). *Bull. So. Calif. Acad. Sci.* 62: 132-139.
- , 1964. *Polydora* and related genera (Annelida, Polychaeta) from Eniwetok, Majuro and Bikini Atolls, Marshall Islands. *Pacific Sci.* 18: 146-159.
- , 1977. Lecithotrophic larval development in *Boccardia proboscidea* Hartman. In *Essays on Polychaetous Annelids in Memory of Dr. Olga Hartman*, Edited by Reish, D. J. and Fauchald, K., Allan Hancock Found. Univ. South. Calif. Press, Los Angeles, pp. 347-371.
- WU, B. L. and M. CHEN, 1964. A new species of polychaete worm of the family Spionidae from Chushan Archipelago, East China Sea. *Acta Zootaxonomica Sinica* 1(1): 195-198 [In Chinese and English].

# SURVEY OF THE VERTEBRATE FAUNA IN THE GRAMPIANS-EDENHOPE AREA OF SOUTHWESTERN VICTORIA

W. B. EMISON, J. W. PORTER, K. C. NORRIS and G. J. APPS

Fisheries and Wildlife Division, Ministry for Conservation,  
Arthur Rylah Institute for Environmental Research  
123 Brown Street, Heidelberg, Victoria 3084

## Abstract

The Grampians-Edenhope Area of southwestern Victoria, Australia, contains four major land forms: woodland on sedimentary plains and sand dunes; heath, woodland and forest on sandstone ranges; woodland on plains and low hills of gravel and metamorphic rock; and woodland and forest on basaltic plains. On the plains much of the land has been cleared for crops and pasture but the remnants of native vegetation support valuable wildlife communities and are especially important for nomadic birds. The Grampians ranges were least affected by settlement and are the most important areas for wildlife in western Victoria. More than 50 plant communities and aquatic habitats are described and are used to discuss the distribution of 233 bird species, 54 mammal species, 40 reptile species, 14 amphibian species and 26 fish species. Most of these species are discussed individually: the birds in terms of abundance, distribution, habitat preference, breeding, feeding and conservation aspects; and the mammals and reptiles in terms of abundance, distribution, habitat preference, breeding and morphology.

## Introduction

The Fisheries and Wildlife Division, Victoria, conducted wildlife surveys in the Grampians-Edenhope Area of southwestern Victoria (Fig. 1) between August 1974 and April 1975. Data collected during these surveys formed the basis of the fauna chapter in the Land Conservation Council's (LCC) report on their Southwest 2 Study Area (in prep.). Because the report by the LCC simply documents the existing fauna and is necessarily general, we publish this paper to provide a permanent record of: (1) our assessments of areas important for fauna conservation; (2) data collected during the surveys on animal habitats and on individual vertebrate species; and (3) detailed faunal information generously contributed by naturalists residing in the survey area (see Acknowledgements).

The following two sections of this paper describe the survey area, methods used and results obtained during the survey. Our assessments of areas important for fauna conservation (by region) appear in the main text and are followed by appendices which contain the detailed information on flora and fauna.

## Survey Area

*Landform.* The surveys were conducted over an area of approximately 16,000 km<sup>2</sup> (Fig. 1), of which about 20 per cent is still in public ownership. The survey area has been divided into four main regions based on Sibley's (1967) geomorphological descriptions: (1) the Edenhope Region where plains of fluvial and estuarine sediments are covered in many places by aeolian dunes and sheets of siliceous sands; (2) the Grampians Region (including the Black Range and Dundas Range) which consists of sandstone ranges uplifted into a cuesta formation and rising to 800 m; (3) the Ararat Region consisting mainly of undulating plains and low hills of slates and sandstones; and (4) the Hamilton Region where the plains and stony rises at Mt. Eccles and Mt. Napier have been formed by basalt lavas.

*Climate.* The climate of the Grampians-Edenhope Region is characterized by warm temperatures, winter rains, summer droughts and prevailing northwesterly summer winds (Walter 1971).

The average annual rainfall over the plains (i.e. Edenhope, Ararat and Hamilton Regions)

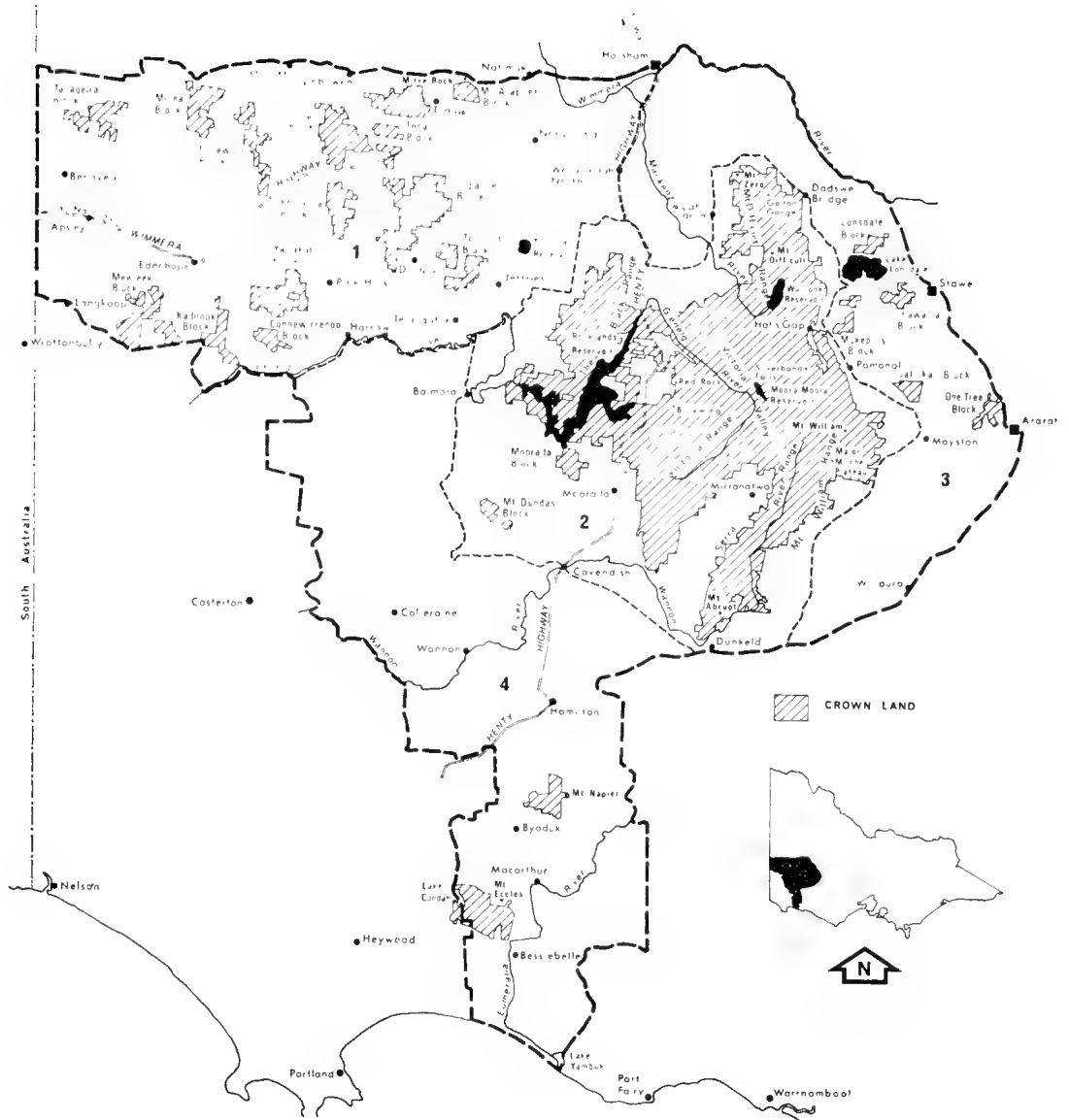


Figure 1—Place names and major blocks of Crown Land in the Grampians-Edenhope Area. The survey area is divided into four regions: 1 = Edenhope Region; 2 = Grampians Region; 3 = Ararat Region; and 4 = Hamilton Region.



ranges between 450 and 700 mm, whereas that at Halls Gap in the mountains of the Grampians Region is more than 900 mm. The wettest months (June, July and August) have a monthly average rainfall of 50-80 mm on the plains and more than 100 mm in the mountains. In summer monthly averages are 20-30 mm on the plains and 35 mm in the mountains. Large, irregular fluctuations in annual rainfall occurred between 1940 and 1965 (Gibbs and Maher 1967). During this period droughts occurred over much of the survey area in 10 of the 25 years, with one drought lasting for three years (1943-1945). At the other extreme, wet years occurred during 8 of the 25 years. The winter during which our fauna surveys were conducted (1974) was relatively wet.

Temperatures in towns on the plains average 25-30°C (maxima) to 11-13°C (minima) during January and 11-13°C (maxima) to 3-5°C (minima) during July. The mountainous area of the Grampians Region has lower average temperatures than those of the plains.

### Methods and Results

**Wildlife Habitats.** The survey of the terrestrial wildlife habitats in the Grampians-Edenhope Area consisted of one or more visits to 180 different sites to gather information on physical habitat, structure of the vegetation, relative numbers of each tree species, cover abundance and growth-form of most shrub species, and listing of common herbaceous plants. Data collected at each site are presented as an annotated list (Appendix 1) and a table showing structure (Appendix 2) of 50 plant communities. A classification of terrestrial habitats (Table 1) was based on plant formations defined by Specht *et al.* (1974), and a simplified distribution of the major plant formations in the survey area is shown in Fig. 2. Nomenclature of plant species follows that of Willis (1962, 1972) and Appendix 3 lists scientific and common names of most plants collected during the survey and now held by the Fisheries and Wildlife Division, Victoria. Twenty-two species of *Eucalyptus* occur in large numbers in the survey area, and are the main plant species used in defining the plant communities in Table 1 and Appendix 1. Re-

lationships between each pair of *Eucalyptus* species (whether in association or not in association but in contact or not in contact) and also the relationship of each species or association to each of the major regions of the survey area are shown in Appendix 4.

The survey of the aquatic habitats was more opportunistic than that of the terrestrial habitats and was mainly concerned with recording the flow, seasonality, depth and occurrence of wetland types in each survey region (Table 2) at the same time as surveying the vertebrate animals (usually birds) utilizing them. The land in the Grampians-Edenhope Area has been described by Blackburn and Gibbons (1956), Gibbons and Downes (1964) and Sibley (1967), in terms of land systems and land units. Salinities of some of the lakes in the survey area are given in Williams (1967) and in Chessman and Williams (1974). By combining these data and our survey data a simplified wetlands distribution map has been drawn up for the survey area (Fig. 3).

The following brief discussion of wildlife habitats in the Grampians-Edenhope Area is mainly based on the detailed survey information presented in the various figures, tables and appendices referred to above.

The most prevalent plant formations in the Edenhope Region are shrublands and woodlands. The shrublands are dominated by Brown Stringybark, heaths, (e.g. *Leptospermum*, *Banksia*) and sedges. These shrublands occur on the sandsheets and many hectares remain on Crown Land. Woodlands of Yellow Gum and River Red Gum once occurred continuously across the plains, and surrounded the patches of shrubland. Today most of these woodlands have been cleared for pasture and only scattered trees remain. Intrusions of mallee, typical of northwestern Victoria, occur near Mt. Arapiles and east of Noradjuha but are small in area and do not constitute a major habitat in the Edenhope Region. Wetlands occur throughout the plains in the Edenhope Region except in those areas covered by sandsheets. These wetlands range from temporarily inundated, shallow depressions, such as occur on the gilgaied soils north of Apsley, though country containing shallow swamps with sedge, reed

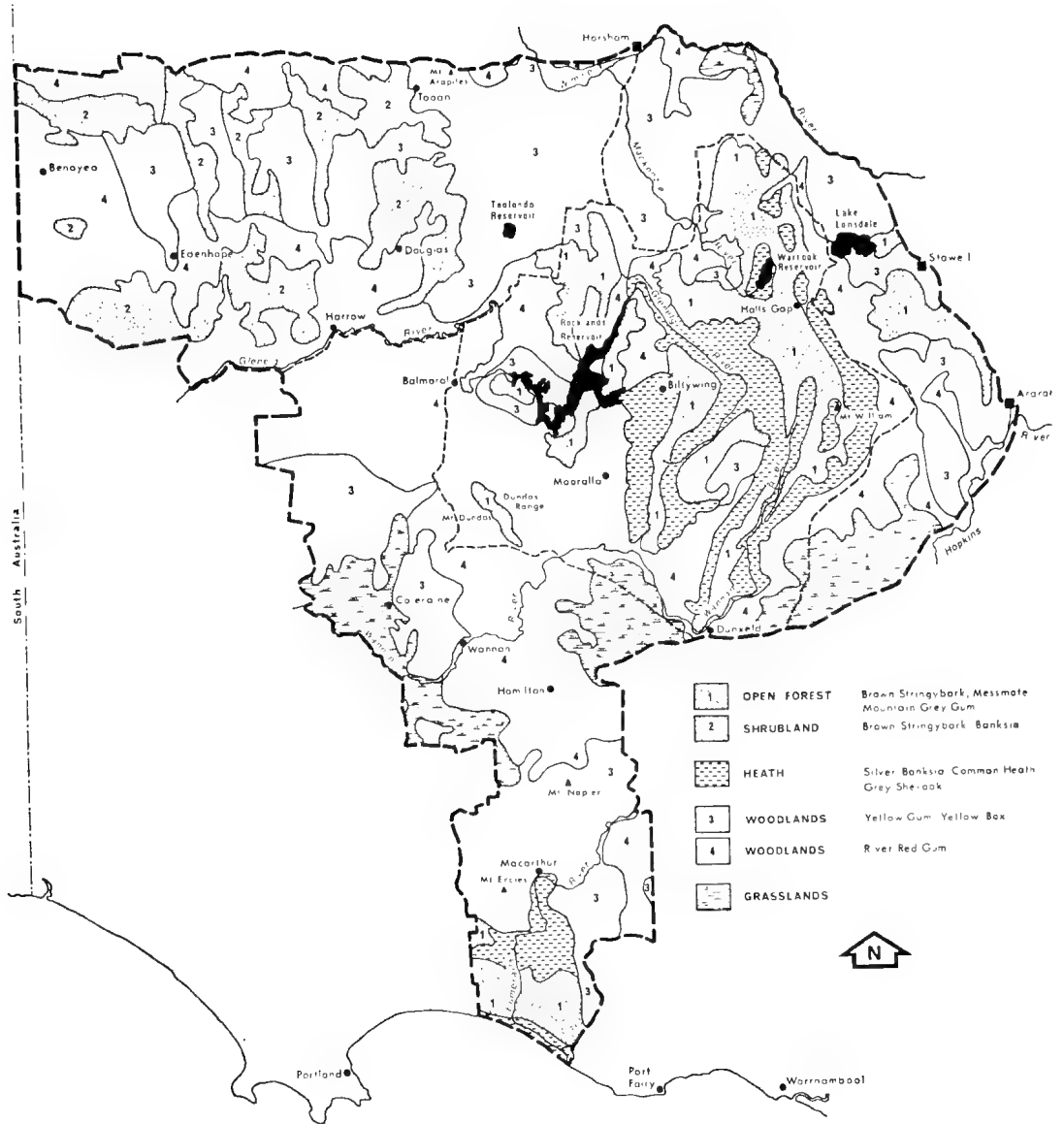


Figure 2—Major vegetation formations in the Grampians-Edenhope Area.

TABLE 1

## Vegetation formations in the Grampians-Edenhope Area

<i>Formation/ Structurally dominant species</i>	<i>Community numbers in Appendix 1</i>			
	<i>Edenhope</i>	<i>Grampians</i>	<i>Ararat</i>	<i>Hamilton</i>
<b>Tall open forest</b>				
Messmate		7, 11		
Mountain Grey Gum		11, 12		
<b>Open forest</b>				
Messmate		5, 8, 10		28
Mountain Grey Gum		8, 9, 10		
Brown Stringybark		6, 8, 9, 10, 13		
Manna Gum		23		22
Swamp Gum		30, 31		30, 31
Candlebark		39		
Red Stringybark			40	
<b>Low open forest</b>				
Messmate		14		
Brown Stringybark		15, 16		
Long-leaf Box		15, 21	21	
<b>Woodland</b>				
River Red Gum	33, 34, 36, 37	33, 34, 36, 37	37	37
Yellow Box	42	42	41	
Yellow Gum	42, 43, 44, 45	42, 43		
Grey Box	46			
Black Box	47			
Manna Gum	25	24	24	
Slender Cypress Pine	49			
<b>Shrubland</b>				
Brown Stringybark	17, 18, 19, 20			
Mallee eucalypts	48			
Salt Paper-bark	50			
<b>Heath</b>				
White Sallee		1		
Grampians Gum		2, 3, 4		
Scent-bark		26		
Shining Peppermint		29		
Scented Paper-bark		32		
Cross-leaf Honey-myrtle		35		
Common Heath		27		
<b>Grassland</b>				
Native Grasses				37, 38
Pastures, Crops	Present	Present	Present	Present

TABLE 2  
Occurrence of wetlands in the Grampians-Edenhope Area

<i>Flow/Salinity</i>	<i>Seasonality/Depth</i>	<i>Edenhope</i>	<i>Grampians</i>	<i>Ararat</i>	<i>Hamilton</i>
Standing Fresh Water	Temporarily Inundated Depressions	X		X	
	Seasonal Swamps	X	X	X	X
	Permanent Swamps and Shallow (<2 m) Lakes	X	X	X	
	Permanent Deep (>2 m) Lakes	X	X	X	
Flowing Fresh Water	Temporarily Inundated River Plains		X	X	
	Permanent Slow-Flowing Rivers	X	X	X	X
	Permanent Fast-Flowing Streams		X		
Standing Saline Water	Temporarily Inundated Depressions	X			X
	Seasonal Swamps and Saltpans				X
	Permanent Deep (>2 m) Lakes	X			X

X = Present in substantial numbers or area or both.

and River Red Gum margins, into country containing deep lakes, mostly of a lunette formation. A chain of large saline lakes extends north from White Lake past Mt. Arapiles. Fig. 4 shows the important wetlands in the Edenhope Region and Table 3 lists some of the more notable wildlife inhabitants and uses dependent on the wildlife resources.

The major plant formations in the Grampians Region are open forest, low open forest, heath and woodland. The open forests occur primarily on the ranges and surrounding slopes and are dominated by trees of Brown Stringybark, Messmate and Mountain Grey Gum. Beneath the trees in these forests heaths may cover large areas. Other shrubs in the open forests include small communities of mesomorphic shrubs along watercourses which are often fringed by dry sclerophyll shrubs. The most common herbs throughout the open forests are mid-height sedges which form a sparse to mid-dense layer. Tall dense sedges

and fern layers occur only along wet gullies. Heath communities are found on shallow infertile soils in both sub-alpine situations and valleys. In the valleys, heaths merge into Scentbark forests on dry margins and into Swamp Gum forests on wet margins. Woodland communities composed of Yellow Gum, Yellow Box, and River Red Gum are extensive in the Black Range and intrude along valleys into the Grampian Ranges. Another common formation in the Black Range is low open forest dominated by Brown Stringybark, Messmate, Long-leaf Box and a tall, mid-dense growth of heaths (e.g. Oyster Bay Pine, Dwarf Sheoak and Silver Banksia). The major wetlands of the Grampians Region are permanent fast-flowing streams and canals and four deep freshwater reservoirs (viz. Rocklands, Wartook, Moora Moora and Bellfield). Seasonally flooded deposition plains occur along the Glenelg River and Tea-tree, Dwyer, Fyans and Mt. William Creeks, the banks of which are usu-

TABLE 3

Important uses or inhabitants of some wetlands in the Edenhope Region (see Fig. 4).

<i>Wetland</i>	<i>Use or inhabitant</i>
Boikerbert Swamp	Hunting
Booroopki Swamp	Potential Murray Cod holding site
Boundary Swamp	Hunting
Bringalbert (Lake)	Limited hunting; Redfin fishing
Carchap (Lake)	Waterfowl sanctuary
Carpolac (Lake)	Redfin fishing
Centre Lake	Wading birds
Charlegrark (Lake)	Murray Cod hatchery
Clarke (Lake)	Hunting
Clear Lake	Limited hunting; Redfin and Yabbie fishing
Collins Lake	Redfin fishing
Connagorach Swamp	Limited hunting; Yabbie fishing
Darragan Swamp	Limited hunting
Dollanoke (Lake)	Hunting; Redfin fishing; few Brolgas
Donald Swamp	Limited hunting
Dumbopportunity Swamp	Limited hunting; Redfin fishing
Gymbowen Lake	Yabbie fishing
Jaka Lake	Important for waterfowl; limited hunting
Jarracteer (Lake)	Hunting; Redfin fishing; few Brolgas
Kanagulk (Lake)	Important for waterfowl; hunting
Karnak (Lake)	Hunting; Yabbie fishing
Koynock (Lake)	Hunting; Yabbie fishing
Kingcourt Swamp	Limited hunting
Leak Swamp	Redfin fishing
Miga Lake	Limited hunting; Redfin fishing
Mill Swamp	Yabbie fishing
Mockinya Swamp	Limited hunting
Mullancoree (Lake)	Hunting; Redfin fishing; few Brolgas
Murranbool Swamp	Yabbie fishing
North Lake	Wading birds
No-where-else Swamp	Potential Murray Cod holding site
Ratzcastle (Lake)	Redfin fishing
St. Marys Lake	Limited hunting; Redfin fishing

Toolondo Reservoir	Redfin and trout fishing
Wallace (Lake)	Important for waterfowl;
	Redfin and trout fishing
White Lake	Wading birds

ally covered by dense communities of tea-tree and River Red Gum.

The Ararat Region contains two floristic intrusions which do not occur elsewhere in the survey area. One intrusion consists of species belonging to the Long-leaf Box and Red Stringybark open forests occurring mainly near Ararat; the other, which occurs near Horsham, is woodland of Grey Box from the Northern Plains. The Ararat Region contains relatively few wetlands, although there are a few impoundments (e.g. Lakes Fyans, Lonsdale, Taylor and Pine) and slow-flowing rivers. A few Black Box and lignum swamps and gilgaied depressions occur east of Horsham but most are now under cultivation.

The Hamilton Region contains mainly agricultural land and remnants of the original vegetation of the volcanic plains. Our survey in this region was concentrated on the Stones State Faunal Reserve near Mt. Eccles. The reserve is covered by Manna Gum open forest and is atypical in relation to the rest of the volcanic plains which were once covered by River Red Gum grassy open woodlands and grasslands. This region contains a few large saline lakes (e.g. Lake Condah) which are now mostly drained and some areas of slightly saline depressions occurring on the basalt plains.

*Birds.* Terrestrial field work consisted primarily of surveying birds in as many of the 180 vegetation survey sites (Appendix 1) as possible. Some surveys were not standardized because the time, duration and effort of observations varied between different sites and between visits to the same sites. However, during all surveys we recorded actual or relative numbers of all avian species present and their utilization of particular structures within the habitat. Other surveys consisted of recording birds along lines (transects) 0.5 km long established in a number of vegetation survey

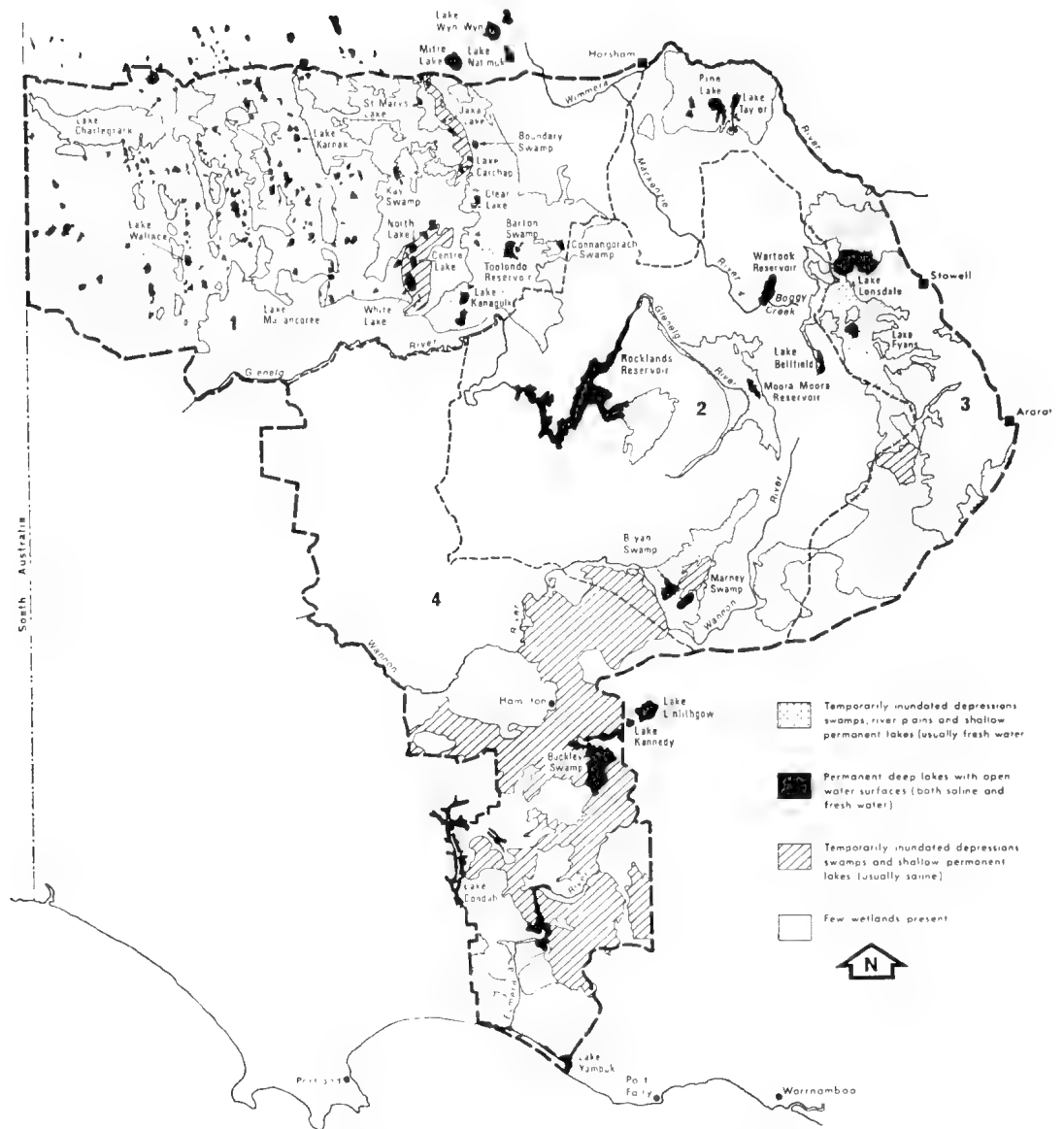


Figure 3—Distribution of wetlands in the Grampians-Edenhope Area.

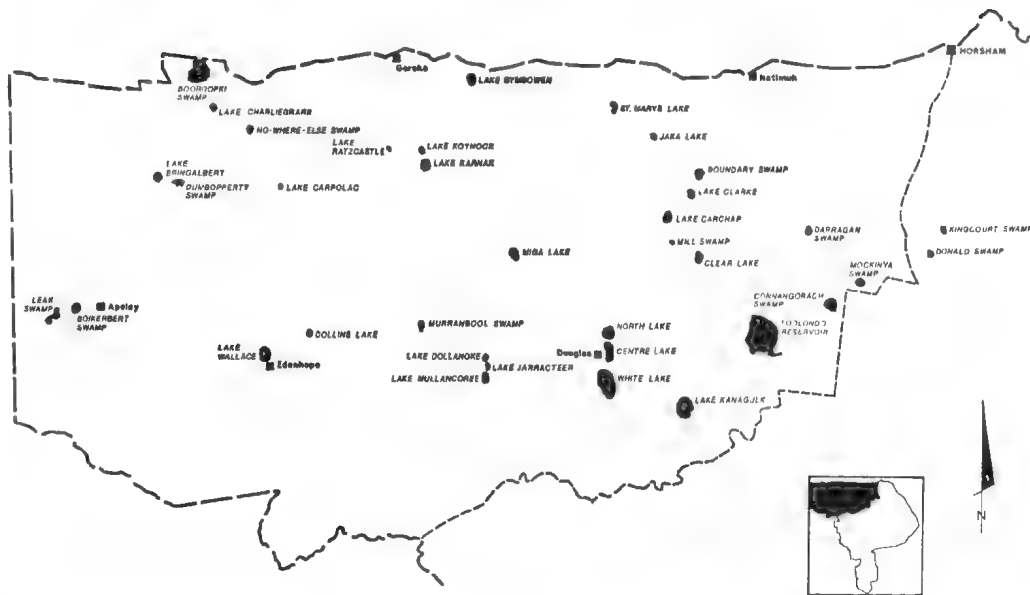


Figure 4—Major lakes, swamps and reservoirs in the Edenhope Region.

sites. Birds were recorded along most of these transects during spring, summer and autumn. Spotlighting from vehicles (usually in conjunction with the mammal survey) was used for surveying nocturnal species such as owls and frogmouths. The wetland birds were recorded whenever they were encountered during field activities. However, in the Edenhope, Grampians and Ararat Regions we conducted periodic censuses (spring and autumn, occasionally also summer) of waterbirds on selected swamps, lakes and rivers. Another large portion of our information came from the literature and previous work done by staff of the Fisheries and Wildlife Division, Victoria, and other interested individuals (see Acknowledgements). Records held by the National Museum of Victoria, and by the Royal Australasian Ornithological Union were also important sources of information.

From the above sources we have documented the occurrence of 233 avian species in the Grampians-Edenhope Area. This number excludes seabirds that occur along the southern boundary of the survey area. One hundred and twelve species of birds occur in the forest, woodland, shrubland and heath for-

mations (Table 4); 52 avian species are inhabitants of the semi-cleared pasture, grassland and suburban areas (Table 5); and 69 species occur in aquatic habitats (Table 6). Detailed information, including distribution, abundance, habitat preference, feeding and breeding, for each species appears in an annotated list (Appendix 5). Nomenclature follows Condon (1975) for the non-passerines and Schodde (1975) for the passerines.

**Mammals.** The published information available on the mammal fauna of the Grampians-Edenhope Area is meagre and consists mainly of old imprecise popular accounts and a more recent general discussion by Wakefield (1974). Some specific and up-to-date information has been derived from specimens in the collections of both the National Museum of Victoria, and the Fisheries and Wildlife Division, Victoria, and field data have recently been available from two mammal survey groups operating in the State. However, most of the information presented here is derived from the field work (about 140 man-days) of two members of the survey team. Mammal trapping was conducted in 31 of the 180 vegetation survey sites (Appendix 1), usually when the vegetation was being analysed. One hundred wire mesh cage traps (360 x 200 x 165 mm), baited with a

mixture of peanut butter, honey and rolled oats, were set at each locality for two nights and the intervening day. Traps were checked on the first morning and captured animals were either retained or marked and released. All traps were reset and checked again on the second morning, after which they were removed

TABLE 4

Checklist of avian species occurring in forest, woodland, shrubland and heath areas in the Grampians-Edenhope Area. See Appendix 5 for scientific names

Brown Goshawk	Willie Wagtail
Collared Sparrowhawk	Spotted Quail-thrush
Painted Button-quail	Grey-crowned Babbler
Bush Stone-curlew	White-browed Babbler
Japanese Snipe	Rufous Songlark
Peaceful Dove	Superb Blue Wren
Diamond Dove	Variegated Wren
Common Bronzewing	Southern Emu-wren
Brush Bronzewing	White-browed Scrubwren
Red-tailed Black Cockatoo	Chestnut-rumped Hylacola
Yellow-tailed Black Cockatoo	Fieldwren
Gang-gang Cockatoo	Speckled Warbler
Rainbow Lorikeet	Weebill
Musk Lorikeet	White-throated Warbler
Purple-crowned Lorikeet	Brown Thornbill
Little Lorikeet	Chestnut-rumped Thornbill
Cockatiel	Buff-rumped Thornbill
Budgerigah	Yellow Thornbill
Swift Parrot	Striated Thornbill
Crimson Rosella	Varied Sittella
Blue-winged Parrot	White-throated Treecreeper
Elegant Parrot	Brown Treecreeper
Pallid Cuckoo	Red Wattlebird
Fan-tailed Cuckoo	Little Wattlebird
Black-eared Cuckoo	Spiny-cheeked Honey-eater
Rufous-tailed Bronze-cuckoo	Regent Honeyeater
Shining Bronze-cuckoo	Blue-faced Honeyeater
Powerful Owl	Yellow-faced Honeyeater
Spotted Owl	Singing Honeyeater
Barking Owl	White-eared Honeyeater
Masked Owl	Yellow-tufted Honeyeater
Tawny Frogmouth	Fuscous Honeyeater
Owlet-nightjar	White-plumed Honeyeater
	Black-chinned Honeyeater

Spotted Nightjar	Brown-headed Honeyeater
Sacred Kingfisher	White-naped Honeyeater
Rainbow Bee-eater	Painted Honeyeater
White-bellied Cuckoo-shrike	Crescent Honeyeater
White-winged Triller	New Holland Honeyeater
Scaly Thrush	White-fronted Honeyeater
Southern Scrub-robin	Tawny-crowned Honey-eater
Rose Robin	Eastern Spinebill
Pink Robin	Mistletoebird
Flame Robin	Spotted Pardalote
Scarlet Robin	Striated Pardalote
Red-capped Robin	Silvereve
Hooded Robin	Red-browed Firetail
Eastern Yellow Robin	Diamond Firetail
Crested Shrike-tit	Olive-backed Oriole
Gilbert's Whistler	White-winged Chough
Golden Whistler	Masked Woodswallow
Rufous Whistler	White-browed Wood-swallow
Grey Shrike-thrush	Dusky Woodswallow
Satin Flycatcher	Grey Butcherbird
Restless Flycatcher	Pied Currawong
Rufous Fantail	Grey Currawong
Grey Fantail	

TABLE 5

Checklist of avian species occurring in grasslands, semi-cleared pastures and suburban areas in the Grampians-Edenhope Area. See Appendix 5 for scientific names

Emu	Fork-tailed Swift†
Black-shouldered Kite	Kookaburra
Black Kite	Singing Bushlark*
Whistling Kite	Common Skylark*
Wedge-tailed Eagle	Welcome Swallow
Little Eagle	Tree Martin
Spotted Harrier	Fairy Martin
Swamp Harrier	Richard's Pipit
Black Falcon	Black-faced Cuckoo-shrike
Peregrine Falcon	Common Blackbird*
Little Falcon	Jacky Winter
Brown Falcon	Brown Songlark
Nankeen Kestrel	Yellow-rumped Thornbill
Stubble Quail	Southern Whiteface
Brown Quail	Noisy Miner
Little Button-quail	White-fronted Chat
Plains-wanderer	European Goldfinch*
Domestic Pigeon*	European Greenfinch*
Crested Pigeon	House Sparrow*



Galah	Eurasian Tree Sparrow*
Long-billed Corella	Common Starling*
Sulphur-crested Cockatoo	Australian Magpie Lark
Eastern Rosella	Little Woodswallow
Red-rumped Parrot	Australian Magpie
Barn Owl	Australian Raven
Spine-tailed Swift†	Little Raven

\* Introduced

† Aerial

Musk Duck	Golden-headed Cisticola
White-breasted Sea-eagle	

\* Recorded breeding in the Edenhope Region during 1974.

TABLE 6

Checklist of avian species occurring in aquatic habitats in the Grampians-Edenhope Area. See Appendix 5 for scientific names

Great Crested Grebe	Land Rail
Hoary-headed Grebe*	Water Rail
Little Grebe*	Marsh Crake
Australian Pelican	Spotted Crake
Darter	Spotless Crake
Pied Cormorant	Black-tailed Native-hen*
Little Pied Cormorant*	Dusky Moorhen*
Black Cormorant	Swamphen
Little Black Cormorant	Coot
White-necked Heron*	Brolga
White-faced Heron	Painted Snipe
Cattle Egret	Pied Oystercatcher
Large Egret	Masked Plover*
Nankeen Night-heron	Banded Plover
Brown Bittern	Red-kneed Dotterel
Glossy Ibis	Hooded Dotterel
White Ibis	Double-banded Dotterel
Straw-necked Ibis	Red-capped Dotterel*
Royal Spoonbill	Black-fronted Dotterel*
Yellow-billed Spoonbill	Pied Stilt
Plumed Tree-duck	Banded Stilt
Black Swan*	Red-necked Avocet
Freckled Duck	Greenshank
Cape Barren Goose	Sharp-tailed Sandpiper
Mountain Duck*	Red-necked Stint
Black Duck*	Curlew Sandpiper
Grey Teal*	Sanderling
Chestnut Teal	Silver Gull
Shoveller	Whiskered Tern
Pink-eared Duck*	Gull-billed Tern
White-eyed Duck	Azure Kingfisher
Wood Duck*	Clamorous Reed-warbler
Blue-billed Duck	Little Grassbird

from the site and set in another locality later in the day. In Appendix 6, reference is made to a trapping rate which is a measure of trapping susceptibility rather than abundance; nevertheless it gives some indication of relative numbers of small ground-dwelling mammals. The rate is simply the percentage of traps occupied by individuals of a particular species where the unit duration of a trapping period is one night. Spotlighting from vehicles at night allowed long distances to be covered and was particularly useful for recording large macropod species and many of the possums. Hand-held spotlights were used while walking through small areas of bush and allowed quiet observations to be made on the relatively small arboreal mammals which can be overlooked while spotlighting from vehicles. Daylight observations were restricted mainly to large species such as kangaroos and deer. Other information came from finding dead animals, skeletal remains, tracks and identifiable faecal deposits. Anecdotal and often valuable information was supplied by interested local naturalists and farmers.

During the survey we documented the occurrence of 54 mammal species in the Grampians-Edenhope Area (Table 7); about 20% were introduced species. It appears that the mammal fauna of the plains in western Victoria has been altered by some species of rodents, dasyurids, bandicoots and macropods disappearing either directly or indirectly as a result of European settlement (Wakefield 1974). Some species still extant in western Victoria are presently in danger of extinction; these will be considered in more detail later in the discussion. Detailed information on abundance, distribution, habitat preference, breeding and recent records for each mammal species in the survey area appears in an annotated list (Appendix 6). Scientific nomenclature for the native mammals follows Ride (1970) except for *Potorous apicalis* which is replaced here by *P. tridactylus* following Johnston (1973).

TABLE 7

Checklist of mammals in the  
Grampians-Edenhope Area.  
See Appendix 6 for scientific names

Echidna	Bush Rat
Platypus	Black Rat*
Tiger Cat	Swamp Rat
Tuan	Sewer Rat*
Yellow-footed Antechinus	Silky Desert Mouse
Brown Antechinus	Smokey Mouse
Swainson's Antechinus	Heath Rat
Mouse Dunnart	House Mouse*
Fat-tailed Dunnart	Eastern Water Rat
Short-nosed Bandicoot	Fox*
Gunn's Bandicoot	Cat (feral)*
Koala	Pig (feral)*
Brush-tailed Possum	Red Deer*
Ring-tailed Possum	Goat (feral)*
Sugar Glider	Sheep (feral)*
Squirrel Glider	Greater Long-eared Bat
Yellow-bellied Glider	Lesser Long-eared Bat
Feather-tailed Glider	Bent-winged Bat
Eastern Pigmy Possum	Gould's Wattle Bat
Western Pigmy Possum	Chocolate Bat
Potoroo	Little Bat
Eastern Grey Kangaroo	Tasmanian Pipistrelle
Western Grey Kangaroo	Large-footed Bat
Red-necked Wallaby	Little Broad-nosed Bat
Brush-tailed Rock Wallaby	White-striped Bat
Hare*	Little Flat Bat
Rabbit*	Yellow-bellied Bat

\* Introduced

*Reptiles and amphibians.* Field work on these groups was usually confined to opportunistic collecting while we were surveying either birds or mammals. The annotated list of reptiles (Appendix 7) and the checklist (Table 8) are based primarily on specimens in the National Museum of Victoria. However, a few days during the survey period were devoted to searching for reptiles in suitable habitats and a representative collection of species was lodged with the National Museum of Victoria. Specimens were collected by searching in hollow logs, around rocky out-crops, under logs and in litter. The distributions of the 40 spe-

cies of reptiles occurring in the survey area are consistent with the assessment by Rawlinson (1971) that the reptile fauna is composed of three groups which correspond to the three major zoogeographic zones (Eyrean, Warm Temperate Bassian and Cool Temperate Bassian) in the survey area. Nomenclature for the reptiles follows Cogger (1975) except for *Anotis maccoyi*, *Lampropholis delicata* and *L. guichenoti* which follow Greer (1974) and the addition of *Leiolopisma coventryi* following Rawlinson (1975).

The distributions in the survey area of the 14 species of amphibians known to occur there (Table 9) are based on recently published data (Brook 1975) and are shown in Appendix 8. Nomenclature for the amphibians follows Cogger (1975) except for the genus *Crinia* which is replaced here by *Ranidella* following Blake (1973).

*Fishes.* During the present survey our involvement with terrestrial vertebrates precluded the gathering of much information on fishes.

However, detailed studies and surveys are presently being conducted on selected lakes and streams in the Grampians-Edenhope Area by the Freshwater Fisheries Section of the Fisheries and Wildlife Division, Victoria, and their results will be presented elsewhere. A list of fishes occurring in the survey area appears in Table 10. The list does not include all estuarine and marine fishes which may occur along the southern boundary of the study area. Nomenclature follows Barnham (in prep.).

TABLE 8

Checklist of reptiles in the  
Grampians-Edenhope Area

Chelidae (Side-necked Tortoise)	<i>Chelodina longicollis</i> (Long-necked Tortoise)
Agamidae (Dragon Lizards)	<i>Amphibolurus barbatus</i> (Bearded Dragon)
	<i>Amphibolurus diemensis</i> (Mountain Dragon)
	<i>Amphibolurus muricatus</i> (Jacky Lizard)
	<i>Amphibolurus pictus</i> (Painted Dragon)
Gekkonidae (Geckos)	<i>Diplodactylus tessellatus</i> (Tessellated Gecko)
	<i>Phyllodactylus marmoratus</i> (Marbled Gecko)
Pygopodidae (Snake-lizards)	<i>Delma inornata</i>
	<i>Delma impar</i>

## Scincidae (Skinks)

*Anotis maccoyi*  
*Cryptoblepharus boutonii*  
*Ctenotus robustus*  
*Egernia luctuosa* (Mourning Skink)  
*Egernia saxatilis* (Black Rock Skink)  
*Egernia whitii* (White's Skink)  
*Hemiergis decresiensis*  
*Hemiergis peronii*  
*Lampropholis delicata*  
*Lampropholis guichenoti*  
*Leiolopisma entrecasteauxii*  
*Leiolopisma trilineata*  
*Leiolopisma coventryi* (Coventry's Skink)  
*Lerista bougainvillii*  
*Morethia adelaidensis*  
*Morethia boulengeri*  
*Morethia obscura* (Ocellated Skink)  
*Sphenomorphus tympanum*  
*Sphenomorphus* sp.  
*Tiliqua nigrolutea* (Blotched Blue-tongued Lizard)  
*Tiliqua scincoides* (Eastern Blue-tongued Lizard)  
*Trachydosaurus rugosus* (Shingle-back)

## Varanidae (Monitor Lizards)

*Varanus gouldii* (Sand Monitor)  
*Varanus varius* (Lace Monitor)

## Elapidae (Elapid Snakes)

*Austrelaps superba* (Lowlands Copperhead)  
*Drysdalia coronoides* (White-lipped Snake)  
*Notechis scutatus* (Eastern Tiger Snake)  
*Pseudechis porphyriacus* (Red-bellied Black Snake)  
*Pseudonaja textilis* (Eastern Brown Snake)  
*Uroechis flagellum* (Little Whip Snake)

## Typhlopidae (Blind Snakes)

*Typhlina proxima*

TABLE 9

## Checklist of amphibians in the Grampians-Edenhope Area

## Hylidae (Tree Frogs)

*Litoria ewingii* (Brown Tree Frog)  
*Litoria lesueurii* (Lesueur's Frog)  
*Litoria raniformis*

## Leptodactylidae (Southern Frogs)

*Geocrinia laevis*  
*Geocrinia victoriana*  
*Limnodynastes dumerillii* (Eastern Banjo Frog)  
*Limnodynastes peronii* (Brown-striped Frog)  
*Limnodynastes tasmaniensis* (Spotted Grass Frog)  
*Neobatrachus centralis* (Trilling Frog)  
*Neobatrachus pictus* (Meeowing Frog)  
*Pseudophryne bibronii* (Brown Toadlet)

*Pseudophryne semimarmorata* (Southern Toadlet)  
*Ranidella parinsignifera*  
*Ranidella signifera* (Common Eastern Froglet)

TABLE 10

## Checklist (incomplete) of fishes in the Grampians-Edenhope Area

## Mordaciidae

*Geotria australis* (Pouched Lamprey)

## Retropinnidae

*Retropinna semoni* (Australian Smelt)

## Anguillidae

*Anguilla australis* (Short-finned Eel)

## Mugilidae

*Aldrichetta forsteri* (Yellow-eyed Mullet)

## Eleotridae

*Philypnodon grandiceps* (Big-headed Gudgeon)  
*Hypseleotris compressus* (Carp Gudgeon)  
*Hypseleotris klunzingeri* (Western Carp Gudgeon)

## Gadopsidae

*Gadopsis marmoratus* (Blackfish)

## Plotosidae

*Tandanus tandanus* (Catfish)

## Bovichthyidae

*Pseudaphritis urvilli* (Tupong)

## Nannopercaidae

*Nannoperca australis* (Pigmy Perch)

## Plectroplitidae

*Plectroplites ambiguus* (Golden Perch)

## Maccullochellidae

*Maccullochella peeli* (Murray Cod)

## Macquariidae

*Percalates colonorum* (Estuary Perch)  
*Macquaria australasica* (Macquarie Perch)

## Sparidae

*Acanthopagrus butcheri* (Black Bream)

## Galaxiidae

*Galaxias maculatus* (Common Galaxiid)  
*Galaxias olidus* (Ornate Mountain Galaxiid)  
*Galaxiella pusillus* (Dwarf Galaxiid)

## Percidae

*Perca fluviatilis* (English Perch or Redfin)\*

## Poeciliidae

*Gambusia affinis* (Mosquito Fish)\*

## Salmonidae

*Salmo gairdneri* (Rainbow Trout)\*  
*Salmo trutta* (Brown Trout)\*

## Cyprinidae

*Carassius auratus* (Goldfish)\*

*Carassius carassius* (Crucian Carp)\*

*Tinca tinca* (Tench)\*

\* Introduced

### Discussion

The first European to explore the Grampians-Edenhope Area was Major Thomas Mitchell, who climbed Mt. William in the Grampians in July 1836 (Mitchell 1839). His party then traversed the northern portions of the Ararat and Edenhope Regions before striking southwest past White Lake to the Glenelg River and down the river to the ocean, which they reached on 20 August 1836. Later that year they passed through the Hamilton Region, climbing both Mt. Napier and Mt. Abrupt (Grampians Region) before striking northeast towards Sydney. Mitchell extolled the beauty and the richness of the soil of the plains country, and his descriptions of the physical surroundings suggest that much of the plains was covered by relatively open, grassy woodlands. Today most of the areas through which Mitchell travelled are crop or pasture lands with few of the woodland trees and native grasses remaining. The mountainous areas of the Grampians Region have been less affected by European settlement, and the species of birds inhabiting the Grampians Region in 1891 (Anon. 1892) were essentially the same as those recorded there during the present survey.

Modification of wildlife habitats on the plains has undoubtedly benefited some animals, particularly domestic mammals (cattle, sheep, horses) some introduced bird species (starling, pigeon, sparrow, goldfinch) and some native bird species (quail, some cockatoos, pipit, magpie). However, the loss of such habitat is also detrimental to many species of native wildlife, and should most of the remaining native trees, shrubs and grasses be cleared, a large portion of the original complement of wildlife species would disappear.

Most standing surface water in the survey area is in the Edenhope Region, although a few large freshwater and saline lakes and impoundments occur in the other regions. The Grampians Region supports most of the fast-flowing streams in the survey area with a few

slow-flowing rivers occurring in the other regions. Many of these bodies of water have been modified by draining, clearing of native vegetation from the catchments, stream or lake modifications, diversions, building of dams, irrigation and dumping of waste. However, many of the wetlands still support large assemblages of vertebrates but the continued modification of such waters will probably result in a decrease in the diversity of species inhabiting them.

Despite extensive habitat modification throughout the survey area the terrestrial and aquatic areas of Crown Land support valuable vertebrate communities. The wildlife values of the four survey regions (Fig. 1) of the Grampians-Edenhope Area are discussed below.

*Wildlife values of the Edenhope Region.* Remnants of the original vegetation indicate that most of the alienated land in the Edenhope Region (unshaded in Fig. 1) originally supported woodlands of River Red Gum, Yellow Gum, Yellow Box and, possibly, Grey Box. Because these woodlands occurred on the deeper more fertile soils, they were cleared for pasture and crops. Consequently, most of these woodlands have now gone, and only roadside remnants and a few plantations of small River Red Gums (along the margins of some blocks of Crown Land) remain of what was once the major terrestrial habitat in the region. It is impossible to determine the number of animal species which were common in these woodlands before European settlement, but there are indications that, at least, some mammal species have recently disappeared (Wakefield 1974). The results of our survey indicate that at present about 100 terrestrial vertebrate species occur in the woodland remnants of the Edenhope Region. These species include only those which are either common throughout the year or rely on the woodlands during some periods of the year (e.g. for feeding or nesting). Bird species make up about 60 per cent of the total number of common species in the woodlands, mammals about 25 per cent and reptiles and amphibians the remaining 15 per cent. Approximately 5 per cent are species alien to Australia which, in general, exert a disproportionate influence on the

vegetation and on the well-being of many of the native animal species. The populations of many of the native animals will decrease and some will disappear if the woodland remnants continue to be modified or destroyed. We suggest that at least 15 per cent of the total number of species are either already, or will soon be, experiencing difficulties in maintaining their population numbers in the Edenhope Region (see annotated lists for details). These include 13 species of birds (Bush Stone-curlew, Rainbow Lorikeet, Musk Lorikeet, Little Lorikeet, Purple-crowned Lorikeet, Swift Parrot, Long-billed Corella, Barking Owl, Grey-crowned Babbler, Blue-faced Honeyeater, Painted Honeyeater, Regent Honeyeater and Grey Butcherbird), one mammal species (Tuan) and one reptile species (Lace Monitor).

Most species whose populations may be in difficulties, as well as many of the other native woodland animals, fall into one or more of the following categories: (1) birds such as lorikeets and honeyeaters which move to the woodlands seasonally to feed on pollen, nectar and insects when the River Red Gums, Yellow Gums and Grey Box are flowering; (2) animals such as corella, cockatoos, owls, possums, tuans and Lace Monitor which require hollows in the trunks or limbs of large trees for breeding or sheltering; and (3) birds such as curlews and babblers which forage on the ground and appear to depend on woodland with relatively unchanged native undergrowth.

Maintenance of woodland habitats in the Edenhope Region will require the cooperation of government agencies and private land holders. As a first step, a detailed botanical study of the woodlands of the entire Grampians-Edenhope Area should be conducted to ascertain: (1) where the various woodland communities occurred originally; (2) the species composition in each community at present; and (3) the best means of ensuring that adequate mature trees and associated plants are present and that regeneration is occurring. Those woodland remnants still on Crown Lands (e.g. margins of the larger Crown Land blocks, roadside reserves, etc.) should be carefully managed to ensure that enough large trees remain to support populations of nectar-feeding

animals, that enough over-mature trees remain to provide holes for nests and shelter and, if possible, that the understoreys of some woodlands be restored to their original composition. Ways of encouraging private landholders to plant appropriate woodland species when landscaping, creating shelter belts or even specifically planting areas for native wildlife should also be explored.

The vegetation on most of the large Crown Land blocks (shaded in Fig. 1) in the Edenhope Region is mainly Brown Stringybark shrubland. These shrublands were not alienated during early settlement because the soils were too poor to support crops or pasture. Consequently, these Crown Land blocks now support a relatively unmodified habitat, although grazing and fires have probably somewhat altered the ground-cover. The species composition of the vertebrate wildlife is different from that occurring in the adjacent pasture/woodland areas and consists of about 65 commonly occurring species (50 per cent birds, 30 per cent mammals and 20 per cent reptiles/amphibians). The relatively dense undergrowth on some of the blocks appears to be an important structural feature influencing the distribution of some of the wildlife species, particularly some thornbills, honeyeaters and the Western Pigmy Possum. The Red-tailed Black Cockatoo occurs in these blocks and we saw large numbers in the Jilpanger Block. The range of this cockatoo in Victoria has decreased since European settlement, and the large Crown Land blocks in the Edenhope Region appear to be one of the last strongholds of this species in the State. Also the Little Wattlebird sometimes occurs in large numbers in dense stands of banksias, which provide an important food source.

Occurring together within some of the Crown Land blocks in the Edenhope Region are typical inland (Eyrean) species of reptiles (Painted Dragon and Ocellated Skink) and temperate (Bassian) species of reptiles (Black Rock Skink). The shrublands are generally rich in reptiles which attain maximum diversity in blocks such as Mt. Arapiles where rocky outcrops adjoin woodland, shrubland and low open forest. The Silky Desert Mouse occurs

along the high sand ridges in areas which have not suffered heavy grazing or burning. Mouse Dunnarts are probably widespread in the shrublands but their numbers are difficult to assess because they are not usually captured in conventional traps. Other native mammals occurring in this habitat include the Echidna, Yellow-footed Antechinus, Western Grey Kangaroo and Red-necked Wallaby.

To ensure perpetuation of the assemblage of wildlife species now present in these shrublands in the Edenhope Region we suggest that as many as possible of the large Crown Land blocks be retained intact and in public ownership. A more detailed study of the fauna of these areas is required to ascertain the importance of each Crown Land block, particularly in relation to similar vegetation further south. Several of the blocks have fringes of woodland which, if at all possible, should be retained to provide wildlife habitat.

The intrusions of mallee vegetation into the Mt. Arapiles, Noradjuha and Wonwondah North areas are small but constitute some of the southern-most extensions of this habitat into western Victoria. Species of birds such as the Southern Scrub-robin, Variegated Wren, Gilbert's Whistler, White-fronted Honeyeater and Spiny-cheeked Honeyeater are at the southern limit of their range in western Victoria in these small intrusions of mallee. These wildlife species are more common further north but the Mt. Arapiles block, in particular, contains not only these animals, which have adapted to a mallee habitat, but also wildlife adapted to living in woodlands, low open forests, or on exposed rocky outcrops because of the diversity of habitats in this one block.

The pastures and croplands in the Edenhope Region support populations of most of the avian species listed in Table 5. The open terrain is suitable for hunting over by such predatory birds as eagles, kites, harriers and falcons. Some members of the parrot and cockatoo family (particularly Long-billed Corella, Galah and Sulphur-crested Cockatoo) forage in the pastures for roots and bulbs. Other wildlife species particularly well-adapted to survival in this open habitat include bird species (such as some quails and larks,

Richard's Pipit, Yellow-rumped Thornbill, White-fronted Chat, Jacky Winter, House Sparrow, goldfinch, starling, magpie and raven), mammal species (such as Fat-tailed Dunnart, Rabbit, House Mouse, Fox and Cat) and reptile species (such as Eastern Blue-tongued Lizard, Shingle-back, and Eastern Brown Snake).

During periods of high rainfall many of the pastures are covered either entirely or partially by standing water. These temporary wetlands are favoured foraging areas for some of the large waders (e.g. Large Egret, White-necked and White-faced Herons), the small grebes and some of the ducks (e.g. Black Duck and Grey Teal). The Brolga is also a conspicuous species along the margins of the open pasture and aquatic areas in the Edenhope Region. This species still breeds in the region, but its long-term survival in the area is not certain. A detailed study of the habitat requirements of the Brolga in western Victoria would be a first step towards a management plan needed to ensure their survival.

The importance of the Edenhope Region in providing a large proportion of the aquatic habitat in western Victoria is apparent in Fig. 2. Although some avian species utilize impoundments and temporarily flooded agricultural land, their main habitats are the large areas of natural fresh and saline wetlands, most of which are unprotected and unmanaged in the Edenhope Region. Our survey only touched on some of these important wetlands and a more detailed study is required to determine priorities for conservation and management. Requirements for breeding, feeding and shelter of a particular avian species may be fulfilled only by a wide range of aquatic conditions. Therefore, a regional management plan must aim at preserving maximum diversity of wetland habitats.

Hundreds of saline and freshwater lakes, swamps and depressions which hold water temporarily occur throughout the western two-thirds of the Edenhope Region. The spring and early summer of 1974 were unusually wet, and standing water was widespread throughout the region. Waterbirds took advantage of these conditions and nests and broods of 15 different

species were documented in the region (Table 6). However, the area of nesting habitat has been considerably reduced by the clearing of land down to the margins of some lakes and by the draining of many of the swamps and seasonal depressions. Many of these lakes and swamps provide public duck hunting areas and a few of the more important ones are listed in Table 3 and shown in Fig. 4.

The permanent water bodies are probably important refuges for waterfowl during periods of low rainfall and after most temporary bodies of water have dried up, as occurred in 1972 (Mitchell 1973). During the non-breeding season the mud flats of some of these waters also provide foraging areas for six species of inter-continental migrants, of which two breed in the Arctic (Red-necked Stint and Curlew Sandpiper), three breed in Eurasia (Japanese Snipe, Greenshank and Sharp-tailed Sandpiper) and one breeds in New Zealand (Double-banded Dotterel). The narrow strip of land containing saline lakes and swamps, which extends from Mitre Lake on the northern boundary of the Edenhope Region through White Lake near the southern boundary (Fig. 2), may be important to such wader species as Pied and Banded Stilts and Red-necked Avocets. Very large flocks of these waders, as well as Black Swans and various species of ducks, have been reported from some of these lakes (particularly North, Centre and White Lakes near Douglas). We suggest that detailed and regular observations be made on the waders especially. The wide range of aquatic habitats is, in part, also responsible for the widespread occurrence in the Edenhope Region of at least five species of amphibians (and four other less widely distributed amphibians) as well as supporting other vertebrate species such as the Eastern Water Rat and the Long-necked Tortoise.

Some of the permanent lakes in the Edenhope Region (Table 3 and Fig. 4) support an important amateur freshwater fishery based mainly on Redfin (a few lakes also support trout populations). Amateur fishing for yabbies is popular, but at present they are not being commercially exploited in the region although the potential for such an industry exists. The Freshwater Fisheries Section of the Fisher-

ies and Wildlife Division, Victoria, has recently established a Murray Cod hatchery on Lake Charlegrark. Two nearby bodies of permanent water, Booropki Swamp and Nowhere-else Swamp (Morea Block), may be important for use as alternate Murray Cod holding sites as the project develops.

*Wildlife values of the Grampians Region.* The area of Crown Land remaining in this region exceeds 200,000 ha, most of it being continuous through the Grampians Ranges (e.g. Victoria, Serra and Mt. Difficult Ranges) and the Black Range (Fig. 1). The diverse habitats contained within this large Crown Land area support a correspondingly large and diverse assemblage of native vertebrate species. To maintain this diversity it is important that the continuous area of public land be managed as a single functional unit rather than arbitrarily dividing it into a series of small discrete units and managing each as an entity. Management of this Crown Land area as a single unit will enhance the chances of survival of those species of wildlife whose life cycles require the utilization of two or more distinct habitats as well as those species which attain their highest densities in ecotones.

The Crown Land west of the Victoria Range probably contains what is now the largest remaining area of woodland (River Red Gum, Yellow Gum and Yellow Box) in southwestern Victoria (Plate 19, Fig. 1). Although this plant formation was one of the major habitats in the survey area before European settlement, it has now nearly gone and the woodland area west of the Victoria Range covers only slightly more than 20,000 ha. These woodlands are the remains of a vast area of woodland which originally also covered most of the Edenhope Region to the west. Consequently, remarks made previously on the fauna of the woodlands in the Edenhope Region apply equally to the fauna of woodlands in the Grampians Region. However the woodlands in the Grampians region represent the most important area of this habitat remaining in southwestern Victoria and one major aim of their management should be to provide food, breeding sites and shelter for the large assemblage of vertebrate animals (some 100 species) which inhabit them. We

strongly suggest that an assessment of some of the structural features known to be important to vertebrate species (e.g. mature trees with large hollows, dense undergrowth, decaying logs) be made to ascertain how these woodlands can be managed to provide a more suitable environment (i.e. similar to pre-European woodlands) for many of the native species of wildlife.

Heath communities, widespread throughout the Crown Lands in the Grampians Region (Fig. 2), are inhabited by about 80 species of commonly occurring vertebrate animals (55 per cent birds, 30 per cent mammals and 15 per cent reptiles/amphibians). Lowland heaths, including the ecotone of heath under open forest, and sub-alpine heaths are the most extensive heath types occurring in the Grampians.

The lowland heaths (particularly those in the Victoria Valley) appear to be the northern extremity in Victoria of a predominantly coastal heath type which extends inland along the Glenelg River to the Grampians (Plate 19, Fig. 2). In these heaths such species as the Southern Emu Wren and the Heath Rat reach the northern limits of their distributions in Victoria. Similarly, the most northerly populations of the Short-nosed Bandicoot and the Potoroo in Victoria occur in heaths in the Grampians Region, but these heaths are usually under large trees and generally adjacent to thick gully vegetation. The importance to native mammals of this ecotonal zone in the Grampians has been discussed by Seebeck (1976). A single specimen of the Mourning Skink, a rare species whose centre of distribution appears to be coastal Victoria, has been collected from a heathy swamp in the Victoria Range. Large numbers of three species of honeyeaters (New Holland, Tawny-crowned and Eastern Spinebill) move into the lowland heaths in the spring to feed on the nectar from the flowers of the Common Heath. The fauna of the heath communities in the Victoria Valley is of special interest to biologists because of its similarities to the vertebrate fauna in the heaths occurring along the coast of Victoria. The perpetuation of these plant communities (and their associated fauna) in

the Grampians should be a major aim in the management of this region. The management of these heaths may require periodic burning to maintain numbers and diversity of the vertebrate species inhabiting them (Cockburn 1975). However, this should be the subject of careful study and experimentation before wildlife management based mainly on controlled burning is introduced.

The number of the Victorian endemic Smokey Mouse recorded during our 1974-75 survey of the sub-alpine heaths in the Grampians Region exceeded the total number recorded in Victoria prior to that time and illustrates the likely importance of the Grampians area for this species' conservation. Most of the bird species which occur in the lowland heath and five species of reptiles also inhabit the sub-alpine heaths. The heaths are one of the nesting areas of the Flame Robin in western Victoria. Crescent Honeyeaters were common in the heaths near the summit of Major Mitchell Plateau in August 1974.

The open and low open forests, including the vegetation mapped as scrub by the Forests Commission of Victoria (undated), form the most extensive vegetation formation occurring in the Grampians Region (Fig. 1). At least 100 species of wildlife (55 per cent birds, 25 per cent mammals and 20 per cent reptiles/amphibians) commonly occur in these formations. Most of these species occur in other formations in the survey area, but the open forests are particularly important because of the relatively large area they cover. The chances of maintaining viable populations of many of the vertebrate species now occurring in southwestern Victoria will be enhanced if the areas of low open and open forest in the Grampians remain large. Uncommon species, such as Powerful and Barking Owls, have recently been recorded in the open forests of the Grampians. The forests also support the largest western Victorian populations of such species as Gang-gang Cockatoo and Koala and the low open forests contain large numbers of Scaly Thrushes and New Holland Honeyeaters.

At present this region is a popular recreation and tourist area which will probably become even more important in the future.



Recreation and tourism presently is compatible with flora and fauna conservation. However, as the number of people involved in such activities increases, conflicts between recreation and conservation will appear, particularly in local areas where concentrations of people occur because of easy access, scenic qualities, picnic facilities and presence of wildlife. We also suggest that the formulation of wildlife management policies for this Crown Land should take into account the importance of mature or overmature trees for those species requiring nest hollows and dens. Their precise requirements should be the subject of more detailed studies.

The Grampians Region contains the most extensive and scenic sandstone mountain ranges, including numerous cliffs and caves, in western Victoria. Thousands of tourists visit the Grampians each year partly because of the spectacular scenery and panoramic views provided by these mountain ranges. However, these ranges are also the habitat of the only known Brush-tailed Rock Wallaby colony remaining in western Victoria and they support a large breeding population of Peregrine Falcons. Both these species have been proposed for proclamation as Notable Species under the Wildlife Act 1976; the wallaby because of its serious decline in this State since 1900 and the falcon because of its decline in the northern hemisphere and fears that the local population may suffer a similar decline. Management authorities should avoid constructing roads, carparks, camp sites, picnic areas, nature walks etc. in areas which are important to these two species. Other species which occur in these rock communities include Nankeen Kestrel, Welcome Swallow, Eastern Pigmy Possum, some bats, Marbled Gecko and Black Rock Skink.

The few small scattered areas of tall open forest in the Grampians Region are important as the western limit of this habitat type in Victoria. The largest area of tall open forest in the Grampians Region occurs along Dairy Creek near Silverband Falls. Although we recorded only about 30 species of wildlife occurring in this habitat, it is important in supporting either migrants or relatively large populations of at least five of these species (Rufous Fantail, Satin

Flycatcher, Crescent Honeyeater, Smokey Mouse and Coventry's Skink).

Two pine plantations (east of Wartook Reservoir and at Billywing) have been established in the Grampians Region by the Forests Commission of Victoria. Our survey did not include a census of vertebrate animals in these plantations, so we cannot compare their density or diversity with those of the adjacent native forests. However, a recent survey of birds in pine and native forests in New South Wales showed 'that the loss of diversity of species and actual numbers of individuals is very great when native forest is removed for pines' (Disney and Stokes 1976). We strongly recommend that careful consideration be given to the effects on native fauna before further expansion of existing pine plantations or establishing new plantations in the Grampians Region.

The main aquatic habitats in the Grampians Region are man-made reservoirs (e.g. Rocklands Reservoir, Moora Moora Reservoir, Wartook Reservoir, Lake Bellfield) and permanent fast-flowing streams and canals. There are also a few permanent swamps in the plains adjacent to the Grampians Ranges (e.g. Bryans, Marneys, Bradys) as well as some short portions of slow-flowing creeks and rivers (e.g. Green Creek and the upper reaches of the Wannon and Glenelg Rivers) (Plate 20, Fig. 3).

The reservoirs and slow-flowing rivers provide a large area of habitat for fishes. During our recent surveys seven Dwarf Galaxiids were found in Green Creek, a slow-flowing stream with a silt or mud bottom at an altitude of about 200 m. The only other records of this species from eastern Australia come from a few other areas in southwestern Victoria (Frankenberg 1969; Chessman and Williams 1974) and from restricted localities around Western Port. Therefore, Green Creek presents an excellent opportunity for preservation of a population of this little known species. Also another native species, the Pigmy Perch, is common in slow-flowing streams around the Grampians. Other fish species include Redfin, Brown and Rainbow Trout, Tench and Carp. The importance of these reservoirs and slow-flowing streams to the avifauna is not well known, but they prob-

ably provide refuge for many waterbirds during droughts. Aquatic mammals, such as the Platypus and Eastern Water Rat, and reptiles, such as the Long-necked Tortoise, also occur in some of these waters.

The permanent fast-flowing streams and canals in the Grampians Ranges support a fish fauna which is, as yet, relatively undisturbed. At present Blackfish and the Ornate Mountain Galaxiid inhabit some of these streams, but the effects of habitat alteration or competition with introduced species on populations of these two native species should be examined. Many species of mammals, birds, reptiles and amphibians depend on these permanent streams for water when other temporary sources have dried up. Therefore any water management plans for this part of Victoria should take into account the need to maintain adequate stream flows and standing water suitable for wildlife throughout the year.

Bryans Swamp, a shallow but relatively persistent body of water, is a State Faunal Reserve in the Grampians Region. It was surveyed on three occasions during 1974 and 1975, and 19 species of birds were recorded. Changes in the species composition of the avifauna appeared to be related to seasonal variations in water level. The avifauna on this swamp also appears to be highly variable between years, and as many as 500 White-necked Herons and 1000 White-faced Herons as well as Royal Spoonbills, Glossy Ibis, and Whiskered Terns have been reported (Mitchell 1973).

*Wildlife values of the Ararat Region.* Most of the land in this region has been cleared and is in private ownership. The few small remaining areas of Crown Land are either woodland (Plate 20, Fig. 4) or open forest. All these areas are valuable because, as Parsons *et al.* (1972) point out, 'very little is known of the ecology of the Grampians Plains and the destruction of the last remnants of native vegetation would make future study impossible'.

The Crown Land blocks around Lake Lonsdale (e.g. Illawarra, Mokepilly and Lonsdale Blocks in Fig. 1) are predominantly woodlands and are inhabited by a vertebrate fauna which once occurred throughout the plains surrounding the Grampians but which is now restricted

to a few isolated Crown Land areas. These woodlands contain many of the 100 (approximately) vertebrate species that occur in similar woodland remnants in the Edenhope and Grampians Regions. Additionally, the Mokepilly Block contains a mixture of open forest and woodland vegetation and consequently has a more diverse fauna than either the woodland areas to the east or the open forest areas to the west. The woodlands of Yellow and Long-leaf Box and Red Stringybark in the Jallukar Block also contain some avian species (e.g. Speckled Warbler, Fuscous Honeyeater, Yellow-tufted Honeyeater, etc.) which attain their largest Victorian populations in the box-ironbark vegetation further east. However, their populations in the Jallukar Block are large relative to the other Crown Land blocks in the Grampians-Edenhope survey area.

The woodlands in the Ararat Region originally supported populations of the Squirrel Glider (Plate 21, Fig. 5), a species uncommon in Victoria. Two records exist for the Ararat Region: 5 km northwest of Stawell in 1970; and at Dadswell Bridge in 1968. This species may still be extant in the Ararat Region, but will require research to determine its status and to enable recommendations to be made on appropriate actions needed to maintain populations of this species in the survey area. The Lace Monitor has also been recorded from the woodlands of the Illawarra Block.

The open forest of Red Stringybark and Long-leaf Box which originally extended into the eastern portion of the survey area is now mainly confined to One Tree Block near Ararat. Most wildlife species which commonly occur in this block are found in the open forests on other blocks of Crown Land in the survey area. However, the floristics of this area differ from those of most other blocks in the survey area and a more detailed fauna survey might reveal subtle differences in species composition of the wildlife.

We endorse the recommendations implicit in the statement by Parsons *et al.* (1972) that 'it is necessary to reserve as many of the surviving remnants of the plains vegetation as possible, to ensure adequate preservation of the unique vegetation of the whole Grampians area'. We

point out that because the vegetation on these areas of Crown Land is different from that in the Grampians Ranges, the vertebrate fauna is also markedly different and further supports the suggestion that these woodland and open forest areas be preserved.

Pastures in the Ararat Region support most of the bird species listed in Table 5. Introduced vertebrate species such as House Sparrow, European Goldfinch, Common Starling, Domestic Pigeon, Rabbit, House Mouse, Fox and Cat, compete with or prey upon many of the native vertebrate species and are undoubtedly responsible for reductions of some populations. The impact that these introduced species have on native vertebrate populations is little known and a study on the interactions between some of these species is required.

In the Ararat Region, the lakes and reservoirs containing permanent or relatively persistent standing water include Alexandra Lake, Dock Lake, Lake Fyans, Green Lake, Lake Lonsdale, Norval Dam, Pine Lake and Taylor Lake. These waters support populations of Blackfish, Redfin, Carp, Tench, Brown and Rainbow Trout and, rarely, Murray Cod (Tunbridge and Rogan 1976). Golden Perch have recently been introduced into Green Lake (Barnham, Fisheries and Wildlife Division, pers. comm.). The few permanent streams (e.g. Fyans Creek, MacKenzie River and Mt William Creek) in this region support a similar fish fauna but probably have few Tench or Murray Cod.

The permanent waters of the reservoirs, streams and some swamps (e.g. Mt. William Swamp) probably provide refuge for many of the species of birds listed in Table 6. Some of the reservoirs still have many dead trees standing around their margins. These trees are important roosting and nesting structures for some parrots and cockatoos (e.g. Musk Lorikeet, Sulphur-crested Cockatoo, Long-billed Corella, Galah, Eastern Rosella, Red-rumped Parrot) and some birds of prey. However, once the trees decay and fall they will not be replaced. Platypus, Eastern Water Rat, Long-necked Tortoise and several species of amphibians are present in some of the permanent waters in the region.

*Wildlife values of the Hamilton Region.* Because most of this region is now in private ownership, the few remaining areas of Crown Land supporting native vegetation are very important. Before European settlement this region was covered by two main plant formations: woodlands of large trees with grassy undergrowth; and treeless grasslands of the volcanic plains (Fig. 2). The Stones and Mt. Napier Blocks (Fig. 1) were originally relatively small rocky areas of volcanic craters and associated lava flows which supported Manna Gum open forest; these areas were surrounded by deeper soils on which the woodlands grew. The woodlands were replaced by exotic grasses and other crops soon after settlement, and the land was alienated, leaving only the relatively infertile areas (Stones and Mt Napier) in public ownership. Today, although modified by fires and grazing, the vegetation on these two Crown Land areas is still composed of many of the original plant species.

The Stones Block includes both the Stones State Faunal Reserve (5241 ha) and Mt. Eccles National Park (395 ha). The wildlife reserve supports a large assemblage of bird species, most of which occur commonly in other open forest habitats. However, the mammalian fauna is distinctive and few areas, if any, support a ground fauna composed of the Tiger Cat, Brown Antechinus, Swainson's Antechinus, Eastern Grey Kangaroo, and Bush Rat, and an arboreal fauna which probably includes the Koala, Yellow-bellied Glider, Brush-tailed Possum, Sugar Glider and Feather-tailed Glider. The wildlife reserve also supports a large reptile population, and large numbers of Eastern Tiger Snakes have been reported by local residents. The Stones State Wildlife Reserve provides one of the best opportunities to protect and study species such as the Tiger Cat, the Yellow-bellied Glider, and the Eastern Tiger Snake within a small well-defined area of Victoria. Lake Surprise, in the adjacent national park, provides a permanent source of water for the vertebrate animals inhabiting the block, and the cliffs around the lake also provide habitat for some cliff-nesting birds. The Stones Block is important both for fauna conservation and for public recrea-

tion. However, the recreation consists primarily of sight-seeing and picnicking around Lake Surprise and it is doubtful whether the Manna Gum forests would support intensive recreational use without disturbance to some of the more important vertebrate populations. Around the Stones Block there are a few small isolated blocks of Crown Land which should be managed in conjunction with that block. The small blocks contain habitats (e.g. grasslands, marshes) which are not well represented in the present wildlife reserve/national park complex in the Hamilton Region. The vegetation in the Mt. Napier Block appears to have been modified to a greater extent than that in the Stones Block and may not support all the species known from the Stones.

The woodlands, grasslands and heaths which originally covered most of the Hamilton Region have been cleared mainly for pasture and crops. We are uncertain what the vertebrate species compositions of these areas were before settlement by Europeans, but a number of animal populations have probably declined as a result of habitat modification. A detailed historical study of the flora and fauna of this region would be useful in determining future land-use priorities in relation to wildlife populations. At least eight species of animals may be having difficulties in maintaining population numbers in the Hamilton Region; these include four avian species (Brolga, Plains-wanderer (Plate 21, Fig. 6), Long-billed Corella and Grey Butcherbird) and four mammal species (Gunn's Bandicoot, Tuan, Eastern Grey Kangaroo and Red-necked Wallaby). Habitat alteration (e.g. clearing of woodland trees or undergrowth, draining of swamps, grazing and other alterations to the grasslands, clearing of heathlands) is probably responsible for the declining populations of most of these species. Detailed biological and distributional studies, particularly on the Brolga, Plains-wanderer, Gunn's Bandicoot and Tuan, are required to effectively protect the remaining small populations of these species in western Victoria.

The grasslands along the Wannon River and northeast of Hamilton (Fig. 2) were the western limits of an extensive grassland which originally extended eastward almost to Melbourne. In

Victoria these grasslands represent the plant formation most drastically reduced as a result of European settlement.

Conservation of the remnants of native woodlands which occur in roadside reserves, on margins of the few larger Crown Land blocks and on freehold land should be encouraged. These small areas should be carefully managed to ensure that enough large trees remain to support populations of nectar-feeding animals, to produce seeds for natural regeneration and to provide holes for nests and shelter.

The narrow strip of heath along the coast was not the subject of a detailed survey. However, the coastal heaths east of the survey area support species such as the Rufous Bristle Bird, Tawny-crowned Honeyeater, Beautiful Firetail, Swamp Antechinus and several species of skinks (Emison *et al.* 1975) and some of these species are probably present along the coastline of the Hamilton Region. We suggest that a specific effort be made to document the vertebrate fauna in this particular habitat.

Many swamps and depressions in the Hamilton Region have been drained. A few of the larger water bodies (e.g. Lake Condah, Buckley Swamp) may occasionally fill to nearly their original capacity, but usually they are either dry or a series of drains and channels. Brolgas and waterfowl still nest in the region, but their wetland habitat has been reduced to relatively small areas. Any Crown Lands with potential for supporting wetland habitat in the region should be retained and managed to perpetuate the presence of surface waters and associated vegetation.

The Eumeralla River flows through pasture land and has both a mud and a gravel bottom. Its upper reaches have been modified into a steep-sided, deep channel by river improvement works. It contains Brown Trout, eels, Tench, Crucian Carp, Tupong and Blackfish. The Shaw River carries a small population of Brown Trout. Lake Yambuk, which is formed by the joining of the Eumeralla and Shaw Rivers, is surrounded by sand dunes and has a sand and mud bottom. Species of fish commonly caught include bream, mullet, salmon and Estuary Perch. Brown Trout which enter

the lake from the Eumeralla and Shaw Rivers are sometimes taken (Tunbridge and Rogan 1976).

### Acknowledgements

We are indebted to the following residents in or near the survey area who generously provided fauna data which they had collected over many years of observations: C.N. Austin of Coleraine (now residing at New Gisborne); A. C. Isles of Warrnambool; I. R. McCann of Stawell; A. M. McGarvie of Cavendish (now living on King Island, Tasmania); J. McQueen of Natimuk; W. G. D. Middleton of Wail; J. H. Morris of Hamilton (Fisheries and Wildlife Officer); and O. J. Thomas of Horsham (Fisheries and Wildlife Officer).

The support of this survey by the following organizations and personnel is gratefully acknowledged. National Museum of Victoria: J. M. Dixon for comments on mammals; A. R. McEvey for comments on birds; A. J. Coventry for comments on reptiles; and P. W. Menkhorst for references on the birds. La Trobe University: P. A. Rawlinson for comments on the reptiles. Monash University: H. Parnaby for comments on the bats. Fisheries and Wildlife Division: J. C. F. Wharton (Director), S. J. Cowling (Assistant Director, Wildlife) and J. K. Dempster (Officer-in-charge, Wildlife Research) for administrative and financial support; W. M. Bren, D. B. Hespe and J. M. Marcus for field and laboratory support; A. McShane for draughting support; and J. B. Cooper for providing the photographs for all plates. Royal Australasian Ornithologists Union: various individuals who contributed nest record cards on birds in the survey area; and H. B. Young for her assistance in providing the nest record cards to us.

### References

- Anonymous, 1892. Field Naturalist Club's excursion to the Grampians, 21st November to 5th December, 1891. *Victorian Nat.* 8: 181-196.
- ASHBY, E., 1927. The Grampians Range of Victoria and its bird life. *Emu* 26: 285-292.
- ATTIWILL, A. R., 1960. Red-tailed Black Cockatoo in south-east of South Australia. *South Aust. Orn.* 23: 37-38.
- AUDAS, J. W., 1920. Through the Murra Murra country (western Grampians). *Victorian Nat.* 37: 59-65.
- , 1925. *One of nature's wonderlands. The Victorian Grampians.* Ramsey, Melbourne.
- AUSTIN, C. N., 1951. Birds of the southern end of Victoria-South Australian border. *South Aust. Orn.* 20: 14-15.
- , 1953a. The Black Falcon and some other raptors in south-west Victoria. *Emu* 53: 77-80.
- , 1953b. Swift Parrot in south-west Victoria. *Emu* 53: 260-261.
- , 1954. White-throated Warbler in western Victoria. *Emu* 54: 28.
- , 1962a. Cattle Egret in south-west Victoria. *Emu* 62: 183.
- , 1962b. Stilts and Avocets. *Bird Obs.* 372: 3.
- , 1962c. Powerful Owl in the Grampians. *Bird Obs.* 367: 3.
- , 1963a. Rose Robin at Coleraine, Victoria. *Bird Obs.* 375: 5.
- , 1963b. *In Along the by-ways with the editor.* *Victorian Nat.* 80: 192-193.
- , 1969. Little Wood-swallows in western Victoria. *Bird Obs.* 450: 4.
- , 1972. Wood-swallows in western Victoria. *Aust. Bird W.* 7: 220-222.
- BALD, A. M., 1957a. Banded Stilts near Harrow, Vic. *Bird Obs.* 312.
- , 1957b. Southern Scrub-robin and Purple-backed Wren. Extension in range. *Emu* 57: 68-69.
- BARNHAM, C. A., In preparation. *A guide to Freshwater Fish of Victoria.* Fisheries and Wildlife Division, Victoria.
- BINNS, G., 1957. Emu nest in Grampians foothills. *Bird Obs.* 310.
- BLACKBURN, G. and F. R. GIBBONS, 1956. A reconnaissance survey of the soils of the Shire of Kowree, Victoria. CSIRO Aust. Div. Soils, Soils and Land-use Series No. 17.
- BLAKE, A. J. D., 1973. Taxonomy and relationships of myobatrachine frogs (Leptodactylidae): a numerical approach. *Aust. J. Zool.* 21: 119-149.
- BROOK, A. J., 1975. The distribution of anuran amphibians in Victoria. *Victorian Nat.* 92: 104-120.
- CAMPBELL, A. G., 1906. Some Victorian winter notes. *Emu* 6: 60-65.
- , 1910a. New egg for Victoria. *Emu* 9: 164.
- , 1910b. New nesting locality for Flame-breasted Robin. *Emu* 9: 249-250.
- CHESSMAN, B. C. and W. D. WILLIAMS, 1974. Distribution of fish in inland saline waters in Victoria, Australia. *Aust. J. Mar. and Freshwat. Res.* 25: 167-172.
- CHISHOLM, A. H., 1955. Distribution of inland birds. *Emu* 55: 72-74.
- , 1964. *In Along the by-ways with the editor.* *Victorian Nat.* 80: 368-369.

- COCKBURN, A., 1975. The ecology of the genus *Pseudomys* in Victorian heath communities. B.Sc. Honours Thesis, Monash University.
- COGGER, H. G., 1975. *Reptiles and Amphibians of Australia*. A. H. and A. W. Reed, Sydney.
- COHN, M., 1927. Birds of the Grampian Range, Victoria. *Emu* 27: 274-277.
- COLLINS, H., 1942. Little Wood-swallow in Victoria. *Emu* 42: 16.
- CONDON, H. T., 1969. *A handlist of the birds of South Australia*. The South Australian Ornithological Association, Adelaide.
- , 1975. *Checklist of the birds of Australia, I. Non-passerines*. RAOU, Melbourne.
- CONDON, H. T. and A. R. MCGILL, 1974. *Field guide to the waders*. Bird Observers Club, Melbourne.
- CONNOR, D. J., 1966. Vegetation studies in north-west Victoria. II. The Horsham area. *Proc. R. Soc. Vict.* 79: 637-653.
- COOPER, R. P., 1960. The Crescent Honeyeater. *Aust. Bird W.* 1: 70-76.
- DISNEY, H. J. DE S. and A. STOKES, 1976. Birds in pine and native forests. *Emu* 76: 133-138.
- D'OMBRAIN, E. A., 1903. Nest of the Masked Owl. *Emu* 2: 184.
- , 1905a. Field notes on some birds of the Casterton District (Victoria). Part I *Emu* 4: 124-129.
- , 1905b. Field notes on some birds of the Casterton District (Victoria). Part II. *Emu* 4: 161-163.
- , 1926. The vanishing Plain-wanderer. *Emu* 26: 59-63.
- EMISON, W. B., J. W. PORTER, K. C. NORRIS and G. J. APPS, 1975. Ecological distribution of the vertebrate animals of the volcanic plains-Otway Range area of Victoria. *Fish. Wildl. Pap., Vict.* No. 6.
- Forests Commission Victoria, undated. Grampians State Forest vegetation types. Colour map.
- FRANKENBERG, R. S., 1969. Studies on the evolution of galaxiid fishes with particular reference to the Australian fauna. Ph.D. Thesis, University of Melbourne.
- FRITH, H. J., 1969. *Birds in the Australian High Country*. A. H. and A. W. Reed, Melbourne.
- GIBBS, W. J. and J. V. MAHER, 1967. Rainfall deciles as drought indicators. Bulletin 48, Bureau of Met. Aust.
- GIBBONS, F. R. and R. G. DOWNES, 1964. *A study of the land in south-western Victoria*. Soil Conservation Authority, Victoria.
- GLOVER, B., 1954. Bird observations in the south-east and elsewhere. *South Aust. Orn.* 21: 31-32.
- GREER, A. E., 1974. The generic relationships of the scincid lizard genus *Leiopisma* and its relatives. *Aust. J. Zool. Suppl. Ser.* No. 31: 1-67.
- HALL, B. and J. MCKEAN, 1962. Some notes on birds of the Grampians. *Bird Obs.* 365: 5-6.
- HICKEY, J. J., 1968. *Peregrine falcon populations: their biology and decline*. University of Wisconsin Press, Milwaukee.
- HILL, G. F., 1907a. Birds of Ararat District. Part I. *Emu* 6: 176-179.
- , 1907b. Birds of Ararat District. Part II. *Emu* 7: 18-23.
- HINDWOOD, K. A., 1935. The Painted Honeyeater. *Emu* 34: 149-157.
- JOHNSTON, P. G., 1973. Variation in island and mainland populations of *Potorous tridactylus* and *Macropus rufogriseus* (Marsupialia). Ph.D. Thesis, University of New South Wales.
- KIRSCH, J. A. W. and W. E. POOLE, 1972. Taxonomy and distribution of the grey kangaroos, *Macropus giganteus* Shaw and *Macropus fuliginosus* (Desmarest), and their subspecies (Marsupialia: Macropodidae). *Aust. J. Zool.* 20: 315-339.
- LANG, C. L., 1929. The Fuscous Honeyeater. *Emu* 28: 315.
- , 1932. White-browed Babbler. *Emu* 32: 70.
- LEARMONTH, N. F., 1951. A trip to Mt. Eccles (Vic.). *Victorian Nat.* 68: 133.
- , 1965. Rufous Fantail in western Victoria. *Bird Obs.* 400: 4.
- , 1966. *Birds of Portland (Victoria) district*. Portland Field Naturalist Club.
- MACDONALD, J. D., 1973. *Birds of Australia*. A. H. and A. W. Reed, Sydney.
- MCCANN, I. R., 1957. Regent Honeyeaters. *Victorian Nat.* 74: 73.
- , 1961. Major Mitchell Plateau, in the Victorian Grampians. *Victorian Nat.* 78: 4-7.
- , 1963. In Along the by-ways with the editor. *Victorian Nat.* 80: 161.
- , 1964. In Along the by-ways with the editor. *Victorian Nat.* 80: 369.
- MCCULLOCH, E. M., 1973. Birds breeding at Balmoral, Victoria. *Aust. Bird W.* 5: 97-99.
- MCEVEY, A., 1958. Some notes on the Yellow-tufted Honeyeater. *South Aust. Orn.* 22: 59.
- MITCHELL, A., 1973. Christmas camp at Balmoral. *Bird Obs.* 495.
- MITCHELL, T. L., 1839. *Three expeditions into the interior of eastern Australia; with descriptions of the recently explored region of Australia Felix, and of the present colony of New South Wales*. Vol. II. 2nd ed. carefully revised. T. and W. Boone, London.
- PARSONS, R. F., N. H. SCARLETT and N. J. ROSENGREN, 1972. Ecology of some *Eucalyptus* woodlands near Halls Gap, Victoria. *Victorian Nat.* 89: 41-49.
- POOLE, W. E., 1973. A study of breeding in grey kangaroos, *Macropus giganteus* Shaw and *M. fuliginosus* (Desmarest), in Central New South Wales. *Aust. J. Zool.* 21: 183-212.
- RAWLINS, P. A., 1971. Reptiles. *Victorian Year Book* 85: 11-36.
- , 1975. Two new lizard species from the

- genus *Leiopisma* (Scincidae:Lygosominae) in southeastern Australia and Tasmania. *Mem. Nat. Mus. Vict.* 36: 1-16.
- RIDE, W. D. L., 1970. *A guide to the native mammals of Australia*. Oxford University Press, Melbourne.
- ROWLEY, I., 1970. The genus *Coryvus* (Aves:Corvidae) in Australia. *CSIRO Wildl. Res.* 15: 27-71.
- SCHODDE, R., 1975. *Interim list of Australian song-birds. Passerines*. RAOU, Melbourne.
- SEEBECK, J. H., 1976. Mammals in the Pomonal area, The Grampians. *Victorian Nat.* 93: 138-147.
- SHANKS, D., 1953. Random notes from south-eastern Victoria. *Emu* 53: 276-279.
- SIBLEY, G. T., 1967. *A study of the land in the Grampians area*. Soil Conservation Authority, Victoria.
- SLATER, P., 1970. *A field guide to Australian birds: non-passerines*. Rigby, Adelaide.
- , 1974. *A field guide to Australian birds: passerines*. Rigby, Adelaide.
- SMITH, M. D., 1962. Long-billed Corella. *Aust. Bird W.* 1: 201.
- SPECHT, R. L., E. M. ROE and V. H. BOUGHTON, 1974. Conservation of major plant communities in Australia and Papua New Guinea. *Aust. J. Bot.* Supplement no. 7.
- STORR, G. M., A. H. LENDON and R. W. MCKECHNIE, 1952. Some observations in south-eastern South Australia and adjacent parts of Victoria. *South Aust. Orn.* 20: 70-71.
- SULLIVAN, C., 1928. Notes from the western district, Victoria. *South Aust. Orn.* 9: 241-249.
- , 1929a. Arrivals and departures of birds in south-western Victoria and other bird notes. *Emu* 29: 39-44.
- , 1929b. The Whiskered Tern. *Emu* 29: 77.
- , 1929c. The corella in southern Victoria. *Emu* 29: 75.
- , 1929d. Birds of the western district, Victoria. *South Aust. Orn.* 10: 139-141.
- TUNBRIDGE, B. R. and P. L. ROGAN, 1976. *A guide to the inland angling waters of Victoria*. Fisheries and Wildlife Division, Victoria.
- WAKEFIELD, N. A., 1963a. Mammal remains from the Grampians, Victoria. *Victorian Nat.* 80: 130-133.
- , 1963b. The Australian pigmy-possums. *Victorian Nat.* 80: 99-116.
- , 1971. The Brush-tailed Rock-wallaby (*Petrogale penicillata*) in western Victoria. *Victorian Nat.* 88: 92-102.
- , 1974. Mammals of Western Victoria. In *The natural history of western Victoria*. Australian Institute of Agricultural Science, Hamilton.
- WAKEFIELD, N. A. and R. M. WARNEKE, 1967. Some revision in Antechinus (Marsupialia)—2. *Victorian Nat.* 84: 69-99.
- WALTER, H., 1971. *Ecology of tropical and sub-tropical vegetation*. Oliver and Boyd, Edinburgh.
- WILLIAMS, W. D., 1967. The chemical characteristics of lentic surface waters in Australia: a review. In *Australian inland waters and their fauna: eleven studies*. Australian National University Press, Canberra.
- WILLIS, J. H., 1962. *A handbook to plants in Victoria. Volume I. Ferns, conifers and monocotyledons*. Melbourne University Press, Melbourne.
- , 1972. *A handbook to plants in Victoria. Volume II. Dicotyledons*. Melbourne University Press, Melbourne.
- WHEELER, J. and T. PESCOFF, 1973. Birds of Rocklands. *Geelong Nat.* 9: 93-96.
- WHEELER, W. R., 1964. Easter camp at Edenhope, Victoria. *Bird Obs.* 392.
- , 1965. Bird notes, 1964-65. *Bird Obs.* 406: 2-4.
- , 1967a. *A handlist of the birds of Victoria*. Melbourne University Press, Melbourne.
- , 1967b. Easter, 1967. *Bird Obs.* 427: 4-6.
- WHITE, C. M., 1968. Is there a genetic continuity concerned in eyrie maintenance? In *Peregrine Falcon populations: their biology and decline*. University of Wisconsin Press, Milwaukee.

#### Abbreviations used in the following appendices

AR	Ararat Region
d.b.h.	diameter at breast height
E	east or eastern
ER	Edenhope Region
FWD	Fisheries and Wildlife Division, Victoria
GR	Grampians Region
Herb	herb layer (Appendix 1)
HR	Hamilton Region
km	kilometre
m	metre
mm	millimetre
N	north or northern
NMV	National Museum of Victoria
p.c.	plant community
pers. comm.	personal communication
RAOU	Royal Australasian Ornithologists Union
S	south or southern
Shrub	shrub layer (Appendix 1)
Tree	tree layer (Appendix 1)
Unpub. MS	unpublished manuscript
W	west or western

### Appendix 1

Annotated list of plant communities in the Grampians-Edenhope Area of southwestern Victoria. See Appendix 3 for scientific names

1. Heath (White Sallee on sub-alpine sites). Occurrence. Major Mitchell Plateau and Mt. William (rare), GR. Survey Sites. 12/8/74: S side of Major Mitchell Plateau at 1050 m. 20/3/75: SE side of Mt. William at 1120 m. Floristics. Tree: White Sallee. Shrub: Spike Wattle, Coast Banksia, Silver Banksia, Dwarf She-oak, Shiny Tea-tree and Prickly Tea-tree (also see McCann 1961). Herb: tussocks of sedge and grass (mat-rush, Tasman Flax-lily), several Compositae and other forbs. Moss mats are present.
2. Heath (Grampians Gum on moist sub-alpine sites). Occurrence. Mt. William, GR. Survey Sites. 5/11/74 and 22/3/75: summit of Mt. William at 1120 m. Floristics. Tree: Grampians Gum. Shrub: Spike Wattle, Silver Banksia, Coast Banksia, Dwarf She-oak, Prickly Tea-tree, Heath Tea-tree and Shiny Tea-tree. Herb: saw-sedges and many tussocks of short sedges. Moss is present.
3. Heath (Grampians Gum on dry sub-alpine sites). Occurrence. Serra Range, GR. Survey Sites. 21/3/75: W facing slope on Mirranatwa Gap at 460 m. 25/3/75: Serra Range E of Serra Park Homestead. Floristics. Tree: Grampians Gum. Shrub: Silver Banksia, Oyster Bay Pine, Dwarf She-oak, Prickly Tea-tree, Shiny Tea-tree, Common Correa, Common Heath, Pine Heath, Horny Cone-bush, Variable Prickly Grevillea, Flame Grevillea, flat-pea and Leafless Currant-bush. Herb: mainly sedges.
4. Heath. Occurrence. Victoria, Mt. Difficult and Mt. William Ranges, GR. Survey Sites. 12/8/74: W slope of Major Mitchell Plateau at 1080 m. 19/3/75: Mt. Difficult Range at 800 m. 20/3/75: Carters Track, Mt. Difficult Range at 620 m. 22/4/75: Mt. Thackeray and near Castle Rock, Victoria Range at 850 m. Floristics. Tree: Grampians Gum and Brown Stringybark. Shrub: Mountain Hickory Wattle, Spike Wattle, Silver Banksia, Coast Banksia, Veined Beard-heath, Prickly Tea-tree, Grampians Fringe-myrtle, Notched Phebalium, Cross-leaf Honey Myrtle, Wedge-leaf Hop-bush, Rough Coprosma and Hairy Correa. Herb: prostrate sedges, grass tussocks and some low ferns. Moss is present.
5. Open forest (Messmate and Brown Stringybark with a Mountain Hickory Wattle and Veined Beard-heath shrub layer). Occurrence. Uncommon and restricted to high altitudes in the ranges, GR. Survey Sites. 24/4/75: Victoria Range near Mt. Thackeray at 920 m. Floristics. Tree: Messmate and Brown Stringybark. Shrub: Mountain Hickory Wattle, Prickly Tea-tree, Orange Bell-climber, Common Heath, Pine Heath and Veined Beard-heath. Herb: tall tussocks of saw-sedge with a lower layer of grass tussocks, ferns and other forbs.
6. Open forest (Brown Stringybark, Shining Peppermint and heaths). Occurrence. High altitudes in Victoria, Mt. William and Mt. Difficult Ranges, GR. Survey Sites. 14/8/74: Mt. William Range above Stockyard Creek at 600-800 m. 7/9/74: near Wallaby Rocks, head of Sheet of Water Creek, Mt. Difficult Range at 600 m. 9/9/74: head of Hut Creek, Victoria Range at 600 m. Floristics. Tree: Brown Stringybark, Shining Peppermint and Messmate. Shrub: Myrtle Wattle, Mitchell's Wattle, Spike Wattle, Silver Banksia, Coast Banksia, Oyster Bay Pine, Prickly Tea-tree, Heath Tea-tree, Dwarf Hakea, Bushy Needlewood, Furze Hakea, Grampians Fringe-myrtle, Grampians Thryptomene, Common Heath and several other low heath species. Herb: sedge tussocks with an underlayer of moss.
7. Tall open forest (Messmate and Narrow-leaf Wattle). Occurrence. Uncommon and restricted to sheltered areas at high altitudes in the ranges, GR. Survey Sites. 9/9/74: near Hut Creek Junction, Victoria Range at 600 m. 19/3/75: Long Gully, Mt. Difficult Road at 600 m. Floristics. Tree: Messmate. Shrub: Blackwood, Narrow-leaf Wattle, Prickly Moses, Prickly Tea-tree, velvet-bush, Rough Coprosma and a few low heaths. Herb: tussock and prostrate sedges, Austral Bracken, grass and moss.
8. Open forest (Brown Stringybark and stunted Mountain Grey Gum). Occurrence. Sandstone outcrops at high altitudes on Mt. Difficult and Victoria Ranges, GR. Survey Sites. 5/9/74: near Goat Track, Victoria Range at 640 m. 7/9/74: Wallaby Rocks Track, Mt. Difficult Range. Floristics. Tree: Brown Stringybark and Mountain Grey Gum. Shrub: Myrtle Wattle, Spike Wattle, Silver Banksia, Oyster Bay Pine, Prickly Tea-tree, Heath Tea-tree, Grampians Fringe-myrtle, Notched Phebalium, Dwarf Hakea, Furze Hakea, Variable Prickly Grevillea, Pine Heath, Common Heath and several other low heaths. Herb: prostrate sedges, grass tussocks, Austral Bracken and lichens.



9. Open forest (Brown Stringybark and Mountain Grey Gum). Occurrence. High Altitudes in Victoria and Serra Ranges, GR. Survey Sites. 31/10/74: Sawmill Track, Victoria Range at 600 m. Floristics. Tree: Brown Stringybark and Mountain Grey Gum. Shrub: Blackwood, Prickly Moses, Hedge Wattle, spyridium, Hairy Correa, Orange Bell-climber, Golden-tip, Rough Coprosma, Rough Bush-pea, and Love Creeper. Herb: Forest Wire Grass, Austral Bracken and a few other ferns.

10. Open forest (Messmate, Brown Stringybark and Mountain Grey Gum). Occurrence. Uncommon in the ranges, usually on margins of tall open and open forests, GR. Survey Sites. 14/8/74: Stockyard Creek Track, Mt. William Range at 480 m. 9/9/74: head of Hut Creek, Victoria Range at 400 m. Floristics. Tree: Messmate, Brown Stringybark and Mountain Grey Gum. Shrub: Narrow-leaf Wattle, Prickly Moses, Hedge Wattle, Myrtle Wattle, Rough Wattle, Silver Banksia, Dwarf She-oak, Prickly Tea-tree, Yellow Hakea, Dwarf Hakea, Common Correa, Common Heath, Austral Grass-tree, spyridium, Hairy Correa, Rough Bush-pea, Rough Coprosma and Orange Bell-climber. Herb: tussocks of sedges, goodenia and lichens.

11. Tall open forest (Messmate and Mountain Grey Gum). Occurrence. Sheltered gullies in the ranges, GR. Survey Sites. 1/11/74: above Silverband Falls, Serra Range at 450 m. Floristics. Tree: Messmate and Mountain Grey Gum. Shrub: Blackwood, Narrow-leaf Wattle, Hazel Pomaderris, Hairy Correa, Prickly Currant-bush, Rough Coprosma and Victorian Christmas-bush. Herb: saw-sedge tussocks, Austral Bracken, grass, flax-lily, prostrate sedges, moss and several ground ferns.

12. Tall open forest (Mountain Grey Gum). Occurrence. Uncommon and restricted to gullies, GR. Survey Sites. 9/9/74: Happy Track, Victoria Range at 400 m. Floristics. Tree: Mountain Grey Gum. Shrub: Hazel Pomaderris, Blue Howittia, Hairy Correa, Cherry Ballart, spyridium and Rough Coprosma. Herb: saw-sedge tussocks, grass and flax-lily.

13. Open forest (Brown Stringybark). Occurrence. Uncommon and mainly restricted to sheltered scree deposits below Victoria Range, GR. Survey Sites. Happy Track, Victoria Range at 400 m Floristics. Tree: Brown Stringybark. Shrub: Myrtle Wattle, Common Correa, velvet-

bush, Love Creeper, Rough Bush-pea and Slender Dodder-laurel. Herb: goodenia, flax-lily, tussocks of grass and saw-sedge.

14. Low open forest (Brown Stringybark and Messmate). Occurrence. Common and widespread in the ranges, GR. Survey Sites. 3/11/74: near Camp of Emus Foot, Victoria Range at 400 m. 29/10/74: Muirfoot Track, Black Range at 400 m. 19/3/75: 6 km N of Halls Gap on Mt. Zero Road at 400 m. 20/3/75: shores of Lake Wartook at 400 m. 10/9/74: junction of Wallaby Rocks and Roses Creek Roads at 440 m. Floristics. Tree: Brown Stringybark and Messmate. Shrub: Myrtle Wattle, Mitchell's Wattle, Spike Wattle, Sallow Wattle, Silver Banksia, Oyster Bay Pine, Dwarf She-oak, Winged Spyridium, Prickly Tea-tree, Woolly Tea-tree, Heath Tea-tree, Fringe-myrtle, three species of hakea, Common Heath, Variable Prickly Grevillea, bitter-pea and Cherry Ballart. Herb: sedge tussocks, Austral Bracken, prostrate sedges and flax-lily.

15. Low open forest (Brown Stringybark and Long-leaf Box). Occurrence. Common around low rock and scree slopes in the Grampians and Black Ranges, GR. Survey Sites. 6/9/74: N end of Black Range at 300 m. 11/9/74: below Asses Ears, Mt. Difficult Range at 380 m. Floristics. Tree: Brown Stringybark and Long-leaf Box. Shrub: Myrtle Wattle, Spreading Wattle, Var-nish Wattle, Juniper Wattle, Silver Banksia, Oyster Bay Pine, Dwarf She-oak, Winged Spyridium, Heath Tea-tree, grevilleas, Common Correa, Common Heath, hakeas, Grampians Thryptomene, Cross-leaf Honey-myrtle and several bush-peas. Herb: sedge tussocks, mosses and lichens.

16. Low open forest (Brown Stringybark). Occurrence. Common on lower slopes of outwash sand in and around the mountains and ranges, GR and ER. Survey Sites. 10/9/74: Hines Track S of Mt. Difficult Range at 240 m. 2/11/74: below Asses Ears, Mt. Difficult Range at 300 m. 29/10/74: SW of Mt. Zero at 250 m. 19/3/75: Halls Gap on Mt. Zero Road below Mt. Difficult Range at 260 m. 24/3/75: Mt. Zero at 250 m. 26/3/75: below Red Rock, Victoria Range. 17/4/75: Mt. Arapiles at 250 m. Floristics. Tree: Brown Stringybark. Shrub: 30 species recorded in this association and listed in Appendix 3. Herb: prostrate sedges and annual grasses.

17. Shrubland (Brown Stringybark). Occurrence. Uncommon and restricted to ER where it occurs on the crests of a few high sand ridges. Sur-

vey Sites. 16/4/75 and 19/4/75: Jilpanger Block. Floristics. Tree: Brown Stringybark. Shrub: Desert Banksia, Mitchell's Wattle, Oyster Bay Pine, Dwarf She-oak, Heath Tea-tree, Daphne Heath, Spreading Brachyloma, Rosy Baeckea, Fringe-myrtle and Beaked Hakea. Herb: mainly prostrate sedges.

18. Shrubland (Brown Stringybark). Occurrence. Common on sand sheets, ER. Survey Sites. 6/10/74: Yallakar Block at 200 m. 6/12/74: Kadnook Block. 16/4/75 and 19/4/75: Jilpanger Block. Floristics. Tree: Brown Stringybark. Shrub: Desert Banksia, Oyster Bay Pine, Dwarf She-oak, Common Heath, bush-pea, Fringe-myrtle, Austral Grass-tree and Spike Wattle. Herb: mainly prostrate sedges.

19. Shrubland (Brown Stringybark). Occurrence. Common and restricted to sand sheets, ER. Survey Sites. 3/10/74, 4/10/74 and 5/10/74: Toon Block at 160 m. 4/12/74: Tallageira Block at 160 m. 5/12/74: Morea Block at 160 m. 11/12/74: Yallakar Block at 200 m. 19/4/75: Jilpanger Block. Floristics. Tree: Brown Stringybark. Shrub: same as in 18 (above) plus Myrtle Wattle, Spike Wattle, Silver Banksia and Heath Tea-tree. Herb: prostrate sedges, flax-lily, Austral Bracken, clover and mosses.

20. Shrubland (Brown Stringybark). Occurrence. Common and widespread on sand sheets, ER. Survey Sites. 6/10/74: Yallakar Block at 200 m. 8/12/74: Jilpanger Block. Floristics. Tree: Brown Stringybark with Yellow Gum and Manna Gum on some margins. Shrub: Black Wattle, Prickly Tea-tree, Heath Tea-tree, Fringe-myrtle, Silver Banksia, Desert Banksia, beard-heath, bush-pea, Dwarf She-oak and Oyster Bay Pine. Herb: prostrate sedges, Austral Bracken and flax-lily.

21. Low open forest (Long-leaf Box). Occurrence. Uncommon, scattered and restricted to AR and E side of GR except for an isolated occurrence at Mt. Arapiles, ER. Survey Sites. 11/9/74: near Zumsteins below Mt. Difficult Range, GR, at 240 m. 17/4/75: near lookout on Mt. Arapiles, ER, at 300 m. 15/3/75: near Jallukar Block, AR, at 240 m. 15/3/75: One Tree Block, AR, at 400 m. 29/3/75: Black Range S of Stawell, AR, at 400 m. 20/3/75: Pohlner's Track near Mt. Zero, GR. 21/4/75: Chinamans Track below Mt. Difficult Range, GR, at 300 m. Floristics. Tree: Long-leaf Box. Shrub: Black Wattle, Hedge Wattle, Wallowa Wattle, Varnish Wattle, Rough Wattle, Sallow Wattle, Juniper

Wattle, Golden Wattle, Silver Banksia, Austral Grass-tree, Grampians Thryptomene, Beaked Hakea, Variable-Prickly Grevillea and Cherry Ballart. Herb: a mixture of sedges, forbs and grasses.

22. Open forest (Manna Gum). Occurrence. Restricted to stony rises in the Stones and Mt. Napier Blocks, HR. Survey Sites. 18/2/75: near the Natural Bridge, Stones Block at 240 m. 18/2/75: near Vaughan Buffer, Stones Block at 240 m. 22/2/75: Millard Track, Stones Block at 240 m. Floristics. Tree: Manna Gum. Shrub: Blackwood, Black Wattle, Cherry Ballart, Sweet Bursaria, Tree Lucerne and cassinia. Herb: Austral Bracken, grass tussocks, thistles, maiden-hair fern, clover and lichens.

23. Open forest (Manna Gum). Occurrence. Mainly on uncleared private lands near Halls Gap, GR. Survey Sites. 1/11/74: S of golf course, Halls Gap at 260 m. Floristics. Tree: Manna Gum. Shrub: Blackwood, Black Wattle and Prickly Tea-tree. Herb: Austral Bracken, grass tussocks, mosses and orchids.

24. Woodland (Manna Gum). Occurrence. Restricted to small areas in GR and AR. Survey Sites. 19/3/75: Black Range S of Stawell, AR, at 340 m. 21/4/75: Chinamans Track W of Mt. Difficult Range, GR. Floristics. Tree: Manna Gum (may be a hybrid with Scent-bark). Shrub: Black Wattle, Golden Wattle and Silver Banksia. Herb: a scattered cover of annual grasses.

25. Woodland (Manna Gum). Occurrence. Restricted to a narrow zone between Brown Stringybark and River Red Gum or Yellow Gum on sands, ER. Survey Sites. 2/10/74: W of Bartons Swamp, Toolondo Block at 160 m. 6/10/74: Haylocks Road, Yallakar Block at 180 m. 4/12/74: Tallageira Block at 180 m. 8/12/74: Apsley Common, 5/12/74: Dopewora Block. Floristics. Tree: Manna Gum (possibly a hybrid with Scent-bark). Shrub: Blackwood, Black Wattle, Silver Banksia, Prickly Tea-tree, Daphne Heath and Flame Heath. Herb: scattered annual grasses.

26. Heath (Scent-bark). Occurrence. Extensive on outwash sands in GR, particularly in Victoria Valley and Billywing area. Survey Sites. 19/3/75: Mt. Difficult Track at 500 m. 20/3/75: Coppermine Track near Mt. Zero at 300 m. 22/3/75: Halls Gap rubbish dump near Mokepilly, AR, at 200 m and Cassidy Gap, Serra Range at 300 m. 10/9/74: Lodge and Siphon Roads junction, Vic-

toria Valley at 220 m. 2/9/74: Lodge Road, Victoria Valley. Floristics. Tree: Scent-bark (possibly a hybrid with Manna Gum). Shrub: Varnish Wattle, Myrtle Wattle, Wirilda, Hedge Wattle, Sallow Wattle, Rough Wattle, hakeas, Heath Tea-tree, Prickly Tea-tree, Silver Banksia, Flame Heath and Common Heath. Herb: scattered annual grasses and occasionally sedges.

27. Heath (Plate 19, Fig. 2). Occurrence. Common in Victoria Valley and Billywing area, GR. Survey Sites. 3/9/74: Siphon Road, Victoria Valley. 4/9/74: Billywing area. Floristics. Tree: none. Shrub: Silver Banksia, Desert Banksia, Dwarf She-oak, Common Heath, beard-heath, Flame Heath, guinea-flower, Furze Hakea, Common Correa and Broom Spurge. Herb: saw-sedge and rapier-sedge.

28. Open forest (Messmate). Occurrence. SW of Bessiebelle HR. Survey Sites. 20/2/75: SW of Bessiebelle at 100 m. Floristics. Tree: Messmate. Shrub: Blackwood, Black Wattle, Prickly Tea-tree and Sweet Bursaria. Herb: Austral Bracken and grass.

29. Heath (Shining Peppermint). Occurrence. Uncommon, mainly in valleys on SE side of GR. Survey Sites. 12/3/75: near head of Wannan River, GR, at 300-380 m. 22/3/75: rubbish dump E of Halls Gap, AR, at 200 m. Floristics. Tree: Shining Peppermint, Brown Stringybark, Messmate and Scent-bark. Shrub: Varnish Wattle, Silver Banksia, Oyster Bay Pine, Dwarf She-oak, Common Heath, Prickly Tea-tree, Heath Tea-tree, Variable-Prickly Grevillea and Common Correa. Herb: mainly sedges (see Parsons *et al.* 1972).

30. Open forest (Swamp Gum). Occurrence. Widely distributed along margins of gullies in the S portions of GR and HR. Survey Sites. 9/9/74: Hut Gully, Victoria Range, GR. 11/9/74: near Roses Gap below Mt. Difficult Range, GR. 1/11/74: Halls Gap, GR. 20/2/75: S of Bessiebelle, HR. Floristics. Tree: Swamp Gum; this is an ecotonal community which merges into nearly pure Swamp Gum on the wetter margins and into Manna Gum, Brown Stringybark, Scent-bark, Long-leaf Box, Yellow Box, Messmate, Mountain Grey Gum and Shining Peppermint on the drier margins. Shrub: similar to those listed for community 31 (below) with a few additional species from the drier adjacent communities. Herb: Austral Bracken, grass tussocks, mosses and orchids.

31. Open forest (Swamp Gum). Occurrence. Restricted to a few small wet gullies in GR and HR.

Survey Sites. 20/2/75: SW of Bessiebelle, HR. 21/3/75: E side of Lake Wartook, GR. 21/3/75: near Cassidy Gap, Serra Range, GR. Floristics. Tree: Swamp Gum. Shrub: Blackwood, Black Wattle, Varnish Wattle, Wirilda, Prickly Moses, Silver Banksia, Dwarf She-oak, Flame Heath, Prickly Tea-tree, Woolly Tea-tree, Heath Tea-tree, Scented Paper-bark and bauera. Herb: Austral Bracken, saw-sedge, grass, moss, goodenia, lichens, prostrate sedges and rapier-sedge.

32. Heath (Scented Paper-bark). Occurrence. Uncommon and restricted to a few gullies in GR, becoming common SW of the Stones Block, HR. Survey Sites. 5/9/74: near Goat Track, Victoria Range, GR, and E side of Lake Wartook, Mt. Difficult Range, GR. Floristics. Tree: a few Scent-barks or Messmates may be present. Shrub: Scented Paper-bark, Swamp Honey-myrtle, Prickly Moses, Silver Banksia, Dwarf She-oak and Prickly Tea-tree. Herb: saw-sedge, prostrate sedges, mosses and lichens.

33. Woodland (River Red Gum) (Plate 19, Fig. 1). Occurrence. Widespread in ER, GR and AR. Survey Sites. 9/9/74: Moora Moora Reservoir, Victoria Valley, GR. 12/9/74: Lodge Road, Victoria Valley, GR. 1/11/74: Halls Gap rubbish dump. Floristics. Tree: River Red Gum. Shrub: Blackwood, Black Wattle, Prickly Moses, Hedge Wattle, Spike Wattle, Varnish Wattle, Golden Wattle, Prickly Tea-tree, Cross-leaf Honey-myrtle, Cherry Ballart and Silver Banksia. Herb: short sedges, broad-leaved forbs, mosses and grasses.

34. Woodland (River Red Gum and myrtles). Occurrence. Mainly on swamp margins (usually freehold) in ER. Survey Sites. 3/10/74: Kallungar Block, ER. 24/3/75: Sheet of Water Creek, Victoria Valley, GR. Floristics. Tree: River Red Gum. Shrub: Prickly Tea-tree, Cross-leaf Honey-myrtle and Scarlet Bottlebrush. Herb: tall sedges, rushes, water milfoil and spike-rush.

35. Heath (Cross-leaf Honey-myrtle). Occurrence. Areas of winter inundation, GR. Survey Sites. Sheet of Water Creek, Victoria Valley, GR. Floristics. Tree: a few River Red Gum. Shrub: Silver Banksia, Prickly Tea-tree, Manuka, Cross-leaf Honey-myrtle, Dwarf Hakea and Yellow Hakea. Herb: grasses, mosses and moisture tolerant forbs.

36. Woodland (River Red Gum with open grass areas underneath) (Plate 20, Fig. 4). Occurrence. Originally covered large areas on the

- plains in ER and GR; now mainly cleared. Survey Sites. 2/9/74: near Halls Gap, GR. 8/9/74: near Glenisla Crossing, Victoria Valley, GR. 4/12/74: swamp margin N of Apsley, ER. Floristics. Tree: River Red Gum. Herb: mainly grasses, lilies and other forbs.
37. Woodland and pasture (River Red Gum and annual grasses). Occurrence. River Red Gum woodlands were once widespread and common, now mainly cleared to pastures with scattered trees; common throughout the plains of ER, GR and AR. Survey Sites. 4/9/74: Glenisla-Billywing area, GR, and Mokepilly, AR. 6/12/74: Thompson Creek at Benayeo N of Apsley, ER. 5/12/74: Dopewora Block, ER. Floristics. Tree: River Red Gum. Shrub: a few Bull-oaks. Herb: mainly annual grasses except on gilgaied soils where lilies and sedges predominate.
38. Grassland with River Red Gum fringing the rivers. Occurrence. Natural grassland was not originally extensive in the survey area, occurring only in HR and AR. Grasslands have increased since European settlement. Survey Sites. 19/2/75: along Wannon River and in Wannon Valley near Coleraine, HR. Floristics. Tree: River Red Gum along the rivers. Herb: mainly annual grasses; along rivers Cane Grass and tall forbs are present.
39. Open forest (Candlebark). Occurrence. Rare, seen only in GR. Survey Sites. W of Lake Bellfield at 300 m. Floristics. Tree: Candlebark. Shrub: similar to the list for community 41 (below).
40. Open forest (Red Stringybark). Occurrence. Uncommon in E portion of AR. Survey Sites. 15/3/75: One Tree Hill Block at 420 m. Floristics. Tree: Red Stringybark. Shrub: similar to the list for community 41 (below). Herb: tussocks of grass.
41. Woodland (Yellow Box). Occurrence. Uncommon and restricted to GR and AR. Survey Sites. 9/3/75: SW of Stawell, AR, at 400 m. 21/4/75: Chinamans Track, GR, at 320 m. 15/3/75: Jallukar Block, AR, at 240 m and W of Ararat, AR, at 400 m. Floristics. Tree: Yellow Box, Long-leaf Box and Red Stringybark. Shrub: Blackwood, Black Wattle, Narrow-leaf Wattle, Prickly Moses, Hedge Wattle, Sallow Wattle, Lightwood, Silver Banksia, Oyster Bay Pine, Drooping She-oak, Common Heath, Flame Heath, Cranberry Heath, Prickly Tea-tree and Grampians Thryptomene. Herb: grasses, forbs and mosses.
42. Woodland (Yellow Gum and Yellow Box). Occurrence. Widespread in ER, GR and AR where it fringes Crown Land; much has been cleared. Survey Sites. 6/9/74: 10 km E of Halls Gap in a Crown Land road reserve, AR, at 200 m; H.G.H. Corner, Black Range, GR, at 240 m; and Roses Gap, GR. 11/9/74: Mt. Victory and Asses Ears Roads junction, GR, at 240 m. 3/10/73: Toolondo Block, ER, at 200 m. 1/12/74: Mokepilly Block, AR. 15/3/75: Jallukar Block, AR. Floristics. Tree: Yellow Gum and Yellow Box. Shrub: wattles and a few heath-like species. Herb: short sedges or annual grasses, depending on soil moisture.
43. Woodland (Yellow Gum and wattles). Occurrence. Outwash sands at Mt. Arapiles, ER, probably also present in GR. Survey Sites. 16/4/75: NW side of Mt. Arapiles, ER, at 240 m. Floristics. Tree: Yellow Gum and Yellow Box. Shrub: Golden Wattle, Juniper Wattle, Gold-dust Wattle, Wallowa, Pine Heath, Cranberry Heath, guinea-flower and Heath-myrtle. Herb: annual grasses, short sedges and other forbs.
44. Woodland (Yellow Gum and heaths). Occurrence. Widespread in ER, occurring in small stands on winter-wet clay pans in and around sand sheets. Survey Sites. 5/12/74: Morea Block at 160 m. 7/12/74: Tallageira Block. 22/3/75: Yallakar Block. Floristics. Tree: Yellow Gum and Brown Stringybark. Shrub: Silver Banksia, Flame Heath, Cranberry Heath, guinea-flower, Prickly Tea-tree, Broom Baeckea, Fringe-myrtle, Mallee Honey-myrtle, Violet Honey-myrtle, Moonah, Scarlet Bottlebrush, Desert Hakea, Muntries, Yellow Rice-flower, Cherry Ballart and several species of wattles. Herb: not assessed.
45. Woodland (Yellow Gum and Bull-oak). Occurrence. Uncommon in ER and AR, mainly cleared and now only occurring as remnants on freehold land. Survey Sites. 7/12/74: Thompson Creek along Benayeo Road, ER. 22/3/75: near Mokepilly, AR. Floristics. Tree: Yellow Gum. Shrub: Bull-oak. Herb: annual grasses and a few sedges.
46. Woodland (Grey Box). Occurrence. Originally widespread in the plains of ER and AR, now mainly cleared; a few small stands still fringe some Crown Lands. Survey Sites. 30/10/74: roadside near Lah-arum, AR. 7/12/74: Thompson

Creek at Benayeo N of Apsley, ER. 17/4/75: golf course at Mt. Arapiles, ER. 18/4/75: 2 km S of Horsham, ER. 15/4/75: near Wimmera River E of Horsham, AR. Floristics. Tree: Grey Box, Black Box and Bull-oak. Shrub: Bull-oak and a few species of wattles. Herb: see Connor (1966) for a list of both shrub and herb species.

47. Woodland (Black Box and Bull-oak). Occurrence. Uncommon and restricted to flood plains of the Wimmera River, ER and AR. Survey Sites. 8/8/74: NW of Mt. Arapiles, ER. 15/4/75: Wimmera River E of Horsham, AR. Floristics. Tree: Black Box and Bull-oak. Shrub: Bull-oak. Herb: see Connor (1966) for list.

48. Shrubland (mallee eucalypts). Occurrence. A few small areas of mallee occur between Horsham and the Tooan Block, ER. They are outliers of mallee from the Little Desert and it is suggested that 2 or 3 tongues of mallee once extended S across what is now farmland along ironstone ridges into the Natimuk area (Middleton pers. comm.). Survey Sites. 1/10/74: Tooan Block. 6/10/74: SW of Horsham and E of Noradjuha. 16/4/75: NW slopes of Mt. Arapiles. 17/4/75: flora reserve E of Noradjuha. Floristics. Tree:

Kamarooka Mallee, Dumosa Mallee, Yellow Mallee and Peppermint Box. Shrub: Golden Wattle, Gold-dust Wattle, Spiny Wattle, Juniper Wattle, Grey Mulga, Oyster Bay Pine, Flame Heath, Cranberry Heath, hakeas, guinea-flower, Rosy Baeckea, Muntries, Fringe-myrtle, Leafless Bitter-pea, Thorny Bitter-pea, correa, Sweet Bursaria, Cross-leaf Honey-myrtle, Violet Honey-myrtle and Broom Honey-myrtle. Herb: annual grasses, mosses and a few sedges.

49. Woodland (Slender Cypress Pine). Occurrence. Mainly restricted to old lunettes in ER. Survey Sites. 5/10/74: S edge of Crown Land in Kallungar Block. 18/4/75: 4 km S of Horsham. Floristics. Tree: Slender Cypress Pine. Shrub: Flame Heath and Daphne Heath. Herb: annual grasses.

50. Shrubland (Salt Paper-bark). Occurrence. Restricted to the shores of a chain of saline lakes occurring along the E boundaries of the Tooan, Jilpanger and Toolondo Blocks, ER. Survey Sites. 7/10/74: lakeside N of Douglas in Jilpanger Block. Floristics. Tree: Salt Paper-bark. Herb: mainly sedges.

**Appendix 2.**—Structure of plant communities in the Grampians-Edenhope Area  
(a) Shrubland and heath formations

Plant community numbers (see Appendix 1)	1	2	3	4	17	18	19	20	26	27	29	32	35	48	50
Tall shrubs (m)	1.5	—	2	4-10	6-8	4-9	6-8	8-12	6-12	—	3-11	—	—	4-12	8-10
—bole (m)	—	—	—	3	—	1	2	4	4	—	—	—	—	2	0.5
—d.b.h. (m)	0.04	—	—	0.1	0.1	0.1	0.3	0.3	0.9	—	—	—	—	0.1	0.3
—(%)	15	—	35	30	8	15	15	20	25	—	20	—	—	10-40	20
Mid-height shrubs (m)	1	1	1.5	3	1	2	3	1	4	1	4	3	3	4	—
—(%)	30	50	28	30	10	30	30	20	15	55	30	45	60	30	—
Low shrubs (m)	0.3	0.2	—	0.5	0.4	0.4	0.3	0.5	1	0.4	0.4	—	—	0.5	—
—(%)	50	70	—	25	40	35	35	35	8	45	30	—	—	8	—
Herbs (m)	0.4	0.2	—	0.2	0.1	0.1	0.3	0.2	0.3	0.3	0.2	0.2	—	0.2	1
—(%)	50	70	—	25	20	10	36	50	30	20	60	70	—	50	50
Bryophytes (%)	20	20	—	—	—	—	15	80	25	—	—	10	—	80	60
Logs*	—	—	—	—	1	6	16	10	16	—	—	—	—	—	—
Litter depth (mm)	—	2	—	—	4	5	4	5	2	—	—	—	—	—	—
—(%)	—	60	—	—	15	15	15	15	4	—	—	—	—	—	—
Bare ground (%)	20	20	—	—	30	15	15	8	10	5	—	—	—	—	—

(%) = per cent cover

\* = number of fallen logs within a 15 x 200 m area

(b) Tall open, open and low open forest formations

Plant Community numbers (see Appendix 1)	5	6	7	8	9	10	11	12	13	14	15	16	21	22	23	28	30	31	39	40
Tree height (m)	25-30	8-24	26-33	10-24	30	25-30	15	26-33	26-33	8-26	6-12	5-10	6-16	14-26	18	18-25	8-25	24	25	15
—bole (m)	20	9	20	5	20	13	7	18	20	16	5	0.4	—	15	15	8	12	—	—	—
—d.b.h. (m)	1.5	0.8	0.4	0.7	1	1.5	1	1	1	1.2	0.7	0.2	—	0.5	0.5	0.8	1	—	—	—
—hollowst	—	5	—	—	—	—	20	60	—	10	8	10	—	6	5	16	10	—	—	—
—(%)	45	35	50	50	35	50	35	55	55	25	30	25	25	25	30	40	30	35	35	25
Tall shrubs (m)	3	2	4	4	6	3	4	3	—	3	4	5	2	4	5	6	5	3	7	—
—(%)	15	35	20	20	2	45	50	60	—	25	40	10	15	10	5	20	5	35	25	—
Low shrubs (m)	1	1	1	—	1.5	1	1	—	1	1	1	1	0.4	0.4	1.5	—	2	0.5	—	1
—(%)	20	45	40	—	40	25	35	—	60	25	35	15	25	60	10	—	40	100	—	15
Herbs (m)	0.8	0.3	—	—	—	—	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.4	0.4	0.5	0.5	1	0.1	0.2
—(%)	70	30	—	—	—	—	5	70	70	60	15	25	90	70	70	80	60	95	45	100
Bryophytes (%)	—	—	70	—	40	50	95	—	25	—	—	30	—	10	10	—	—	30	—	—

Logs*	—	5	—	16	16	5	16	16	16	16	12	12	12	8	—	—	—
Litter depth (mm)	—	4	—	4	5	1	2	2	1	1	5	5	5	8	5	—	—
—(%)	—	25	—	30	80	40	70	40	40	40	15	15	20	30	30	—	—
Bare ground (%)	—	—	—	—	—	—	5	—	—	—	15	15	15	—	—	—	—

(%) = per cent cover

\* = number of fallen logs within a 15 x 200 m area

† = per cent of trees containing hollows

(c) Woodland formation

Plant community numbers (see Appendix 1)	24	25	33	34	36	37	41	42	43	44	45	46	47	49
Tree height (m)	14	7-18	14-24	12-15	12-26	10-20	10-15	10-14	10-14	10-16	14-19	12-16	11-13	8-12
—bole (m)	—	5	12	—	6	—	—	8	6	—	—	2	—	0-1
—d.b.h. (m)	—	0.5	1.5	—	1.5	1	—	7	0.3	—	—	0.3	—	0.3
—hollows†	—	7	6	—	4	6	—	25	—	—	—	—	—	—
—(%)	20	30	28	15	20	25	18	22	15	25	25	30	9	45
Tall shrubs (m)	4	4	5	2	—	7	4	3	1	2	7	3	10	—
—(%)	6	15	10	70	—	10	—	10	12	50	10	5	30	—
Low shrubs (m)	—	1	1	—	—	—	1	—	0.3	0.2	—	—	—	0.5
—(%)	—	30	8	—	—	—	—	—	10	25	—	—	—	15
Herbs (m)	0.4	0.4	0.2	—	0.3	0.1	0.2	0.2	0.2	—	—	0.3	0.1	—
—(%)	40	40	12	—	50	20	70	65	90	—	—	80	75	—
Bryophytes (%)	—	40	85	—	95	20	—	90	—	—	15	10	—	5
Logs*	—	15	8	—	5	9	—	4	2	—	—	4	—	—
Litter depth (mm)	—	—	5	—	—	—	—	1	—	—	—	—	—	—
—(%)	—	4	25	—	30	—	—	10	—	—	—	15	—	—
Bare ground (%)	—	15	—	—	—	—	—	6	—	—	—	—	—	—

(%) = per cent cover

\* = number of fallen logs within a 15 x 200 m area

† = per cent of trees containing hollows

## Appendix 3.—Plant species list

Common name	Scientific name	Plant community numbers (see Appendix 1)
Annual Veldt Grass	<i>Ehrharta longiflora</i>	
Austral Bracken	<i>Pteridium esculentum</i>	
Austral Grass-tree	<i>Xanthorrhoea australis</i>	4, 6, 7, 10, 14–19, 21, 26
Australian Clematis	<i>Clematis aristata</i>	1, 9, 11, 13
Australian Dusty Miller	<i>Spyridium parvifolium</i>	
Australian Indigo	<i>Indigofera australis</i>	
Beaked Hakea	<i>Hakea rostrata</i>	14–18, 21
Bitter-pea	<i>Daviesia mimosoides</i>	
Black-anther Flax-lily	<i>Dianella revoluta</i>	
Black Box	<i>Eucalyptus largiflorens</i>	47
Black Rapier-sedge	<i>Lepidosperma carphoides</i>	
Black Wattle	<i>Acacia mearnsii</i>	14, 16, 20–26, 28, 30, 31, 33, 39–41
Blackwood	<i>Acacia melanoxylon</i>	7, 9, 11, 22, 23, 25, 28, 30, 33, 39–41
Blue Boronia	<i>Boronia caerulea</i>	
Blue Howittia	<i>Howittia trilocularis</i>	12
Blue Stars	<i>Chamaescilla corymbosa</i>	
Blue Tinsel-lily	<i>Calectasia cyanea</i>	
Boneseed	<i>Chrysanthemoides monilifera</i>	
Broom Baeckea	<i>Baeckea behrii</i>	21, 44, 48
Broom Honey-myrtle	<i>Melaleuca uncinata</i>	48
Broom Spurge	<i>Amperea xiphoclada</i>	1, 21, 27, 29
Brown Stringybark	<i>Eucalyptus baxteri</i>	4–5, 7–10, 13–20
Bull-oak	<i>Casuarina luehmannii</i>	16, 37, 38, 42, 45, 46
Bundled Guinea-flower	<i>Hibbertia fasciculata</i>	14–16, 18–20, 25, 26, 27, 29, 33, 43
Bush Heath	<i>Brachyloma ericoides</i>	15, 18
Bushy Needlewood	<i>Hakea sericea</i>	
Bush-pea	<i>Pultenaea benthamii</i>	3, 11
Bush-pea	<i>Pultenaea costata</i>	5
Bush-pea	<i>Pultenaea d'altonii</i>	3
Bush-pea	<i>Pultenaea hibbertioides</i>	17, 18, 26
Bush-pea	<i>Pultenaea humilis</i>	16
Bush-pea	<i>Pultenaea laxiflora</i>	16, 43
Bush-pea	<i>Pultenaea prolifera</i>	16, 27
Button-grass	<i>Gymnoschoenus sphaerocephalus</i>	
Candlebark	<i>Eucalyptus rubida</i>	39
Cassinia	<i>Cassinia</i> sp.	4
Cherry Ballart	<i>Exocarpos cupressiformis</i>	12, 14, 16, 21, 22, 26, 33, 44
Chocolate Lily	<i>Dichopogon strictus</i>	
Cleland's Beard-heath	<i>Leucopogon clelandii</i>	
Clustered Everlasting	<i>Helichrysum semipapposum</i>	
Coarse Dodder-laurel	<i>Cassytha melantha</i>	
Coarse Twine-rush	<i>Leptocarpus brownii</i>	
Coast Banksia	<i>Banksia integrifolia</i>	1, 2, 6
Coast Saw-sedge	<i>Gahnia trifida</i>	
Coast Swainson-pea	<i>Swainsona lessertiifolia</i>	
Common Beard-heath	<i>Leucopogon virgatus</i>	15–20, 25, 27, 29
Common Billy-buttons	<i>Craspedia glauca</i>	
Common Correa	<i>Correa reflexa</i>	1–3, 6–8, 10, 13–16, 18, 19, 20, 26, 27, 29



Common name	Scientific name	Plant community numbers (see Appendix 1)
Common Heath	<i>Epacris impressa</i>	1-3, 5, 6, 8, 10, 13-16, 18-20, 26, 27, 29, 39-41
Common Hovea	<i>Hovea heterophylla</i>	8, 11, 12, 14-16, 27
Common Rapier-sedge	<i>Lepidosperma filiforme</i>	
Cootamundra Wattle	<i>Acacia baileyana</i>	20
Cranberry Heath	<i>Astroloma humifusum</i>	16, 20-21, 25, 26, 33, 39-41, 43, 44, 48
Cross-leaf Honey-myrtle	<i>Melaleuca decussata</i>	4, 15, 33-35, 48
Dagger Hakea	<i>Hakea teretifolia</i>	
Daisy-bush	<i>Olearia erubescens</i>	
Daphne Heath	<i>Brachyloma daphnoides</i>	14, 16-21, 26
Desert Banksia	<i>Banksia ornata</i>	16-20, 27
Downy Dodder-laurel	<i>Cassytha pubescens</i>	
Desert Hakea	<i>Hakea muellerana</i>	44
Drooping She-oak	<i>Casuarina stricta</i>	21, 39-41
Dumosa Mallee	<i>Eucalyptus dumosa</i>	48
Dwarf Geebung	<i>Persoonia chamaepeuce</i>	
Dwarf Hakea	<i>Hakea rugosa</i>	3, 6, 8, 10, 15, 20, 35, 42
Dwarf She-oak	<i>Casuarina pusilla</i>	1-3, 10, 14-20, 26-27, 29, 31, 32
Early Black Wattle	<i>Acacia decurrens</i>	
Erect Guinea-flower	<i>Hibbertia stricta</i>	
Eutaxia	<i>Eutaxia microphylla</i>	44
Fairy Wax-flower	<i>Eriostemon verrucosus</i>	
Flame Grevillea	<i>Grevillea dimorpha</i>	3
Flame Heath	<i>Astroloma conostephioides</i>	6, 14-21, 25-27, 31, 39-41, 43, 44, 48
Flat Cord-rush	<i>Restio complanatus</i>	
Forest Wire Grass	<i>Tetrarrhena juncea</i>	9
Fringed Everlasting	<i>Helichrysum baxteri</i>	
Fringe-myrtle	<i>Calytrix tetragona</i>	4, 14, 16-21, 44, 48
Furze Hakea	<i>Hakea ulicina</i>	6, 8, 14, 18, 20, 27
Gold-dust Wattle	<i>Acacia acinacea</i>	42, 43, 46, 48
Golden Heath	<i>Styphelia adscendens</i>	6, 8, 17, 18, 25, 26, 27, 31
Golden Pennants	<i>Loudonia behrii</i>	
Golden Spray	<i>Viminaria juncea</i>	
Golden-tip	<i>Goodia lotifolia</i>	
Golden Wattle	<i>Acacia pycnantha</i>	16, 21, 33, 39-41, 44, 48
Gorse Bitter-pea	<i>Daviesia ulicifolia</i>	13, 14, 16, 17, 20
Grampians Fringe-myrtle	<i>Calytrix sullivanii</i>	1, 4, 6
Grampians Grevillea	<i>Grevillea confertifolia</i>	
Grampians Guinea-flower	<i>Hibbertia humifusa</i>	
Grampians Gum	<i>Eucalyptus alpina</i>	2-4
Grampians Parrot-pea	<i>Dillwynia oreodoxa</i>	
Grampians Thryptomene	<i>Thryptomene calycina</i>	6, 15, 16, 21, 26, 39-41
Grey Box	<i>Eucalyptus microcarpa</i>	46
Grey Everlasting	<i>Helichrysum obcordatum</i>	
Grey Mulga	<i>Acacia brachybotrya</i>	44, 48
Guinea-flower	<i>Hibbertia cistiflora</i>	17
Guinea-flower	<i>Hibbertia obtusifolia</i>	48
Guinea-flower	<i>Hibbertia procumbens</i>	
Guinea-flower	<i>Hibbertia virgata</i>	16, 18-20, 25-27, 44
Hairy Boronia	<i>Boronia pilosa</i>	
Hairy Correa	<i>Correa aemula</i>	4, 9-12, 14
Hairy Geebung	<i>Persoonia rigida</i>	14, 15, 17-20

Common name	Scientific name	Plant community numbers (see Appendix 1)
Hairy Mint-bush	<i>Prostanthera hirtula</i>	
Hare's-tail	<i>Lagurus ovatus</i>	
Harlequin-flower	<i>Sparaxis grandiflora</i>	
Hazel Pomaderris	<i>Pomaderris aspera</i>	11, 12
Heath-myrtle	<i>Micromyrtus ciliata</i>	16, 26, 43, 48
Heath Spyridium	<i>Spyridium eriocephalum</i>	11
Heath Tea-tree	<i>Leptospermum myrsinoides</i>	1, 2, 6, 14–20, 26, 29, 31, 32
Hedge Wattle	<i>Acacia armata</i>	9, 10, 21, 26, 33, 39–41, 44
Holly Grevillea	<i>Grevillea ilicifolia</i>	
Hooked Needlewood	<i>Hakea vittata</i>	
Hop Bitter-pea	<i>Daviesia latifolia</i>	
Hop Wattle	<i>Acacia stricta</i>	
Horny Cone-bush	<i>Isopogon ceratophyllus</i>	3, 6, 8, 10, 14–20, 26, 27, 29, 31
Ivy Flat-pea	<i>Platylobium triangulare</i>	3
Juniper Wattle	<i>Acacia ulicifolia</i>	15, 16, 21, 43, 48
Kamarooka Mallee	<i>Eucalyptus froggattii</i>	48
Lance Beard-heath	<i>Leucopogon lanceolatus</i>	
Large-leaf Ray-flower	<i>Anthocercis frondosa</i>	
Lavender Grevillea	<i>Grevillea lavandulacea</i>	15
Leafless Bitter-pea	<i>Daviesia brevifolia</i>	8, 14–18, 26, 48
Leafless Currant-bush	<i>Leptomeria aphylla</i>	3, 8, 14, 15, 17, 18
Lightwood	<i>Acacia implexa</i>	
Long-leaf Box	<i>Eucalyptus goniocalyx</i>	15, 21
Love Creeper	<i>Comesperma volubile</i>	8, 10, 13, 16
Mallee Honey-myrtle	<i>Melaleuca neglecta</i>	
Manna Gum	<i>Eucalyptus viminalis</i>	22–26
Manuka	<i>Leptospermum scoparium</i>	35
Matted Bush-pea	<i>Pultenaea pedunculata</i>	15, 16
Messmate Stringybark	<i>Eucalyptus obliqua</i>	5, 7, 10, 11, 14, 28
Mistletoes	<i>Amyema</i> sp.	
Mitchell's Wattle	<i>Acacia mitchellii</i>	6, 14, 17, 18
Moonah	<i>Melaleuca lanceolata</i>	4, 44
Mountain Correa	<i>Correa lawrenciana</i>	
Mountain Grevillea	<i>Grevillea alpina</i>	
Mountain Grey Gum	<i>Eucalyptus cypellocarpa</i>	8–12
Mountain Hickory Wattle	<i>Acacia obliquinervia</i>	4, 5
Mountain Pepper	<i>Drimys lanceolata</i>	5, 6, 8, 10, 13–16, 18–20
Mountain Tea-tree	<i>Leptospermum grandifolium</i>	
Mt. Byron Bush-pea	<i>Pultenaea patellifolia</i>	15, 16
Muntries	<i>Kunzea pomifera</i>	48
Myrtle Wattle	<i>Acacia myrtifolia</i>	6, 8, 10, 13–16, 19, 28
Narrow-leaf Bitter-pea	<i>Daviesia virgata</i>	15, 20
Narrow-leaf Trymalium	<i>Trymalium d'altonii</i>	
Narrow-leaf Wattle	<i>Acacia mucronata</i>	7, 10, 11, 39–41
Notched Phebalium	<i>Phebalium bilobum</i>	1, 4, 5
Onion-grass	<i>Romulea rosea</i>	
Orange Bell-climber	<i>Marianthus bignoniaceus</i>	5, 9, 10
Oyster Bay Pine	<i>Callitris rhomboidea</i>	2, 4, 6, 8, 14–20, 29, 39–41, 48
Pale-fruit Ballart	<i>Exocarpos strictus</i>	44
Pale Turpentine Bush	<i>Beyeria leschenaultii</i>	16, 21
Pale Rush	<i>Juncus pallidus</i>	
Peach Heath	<i>Lissanthe strigosa</i>	

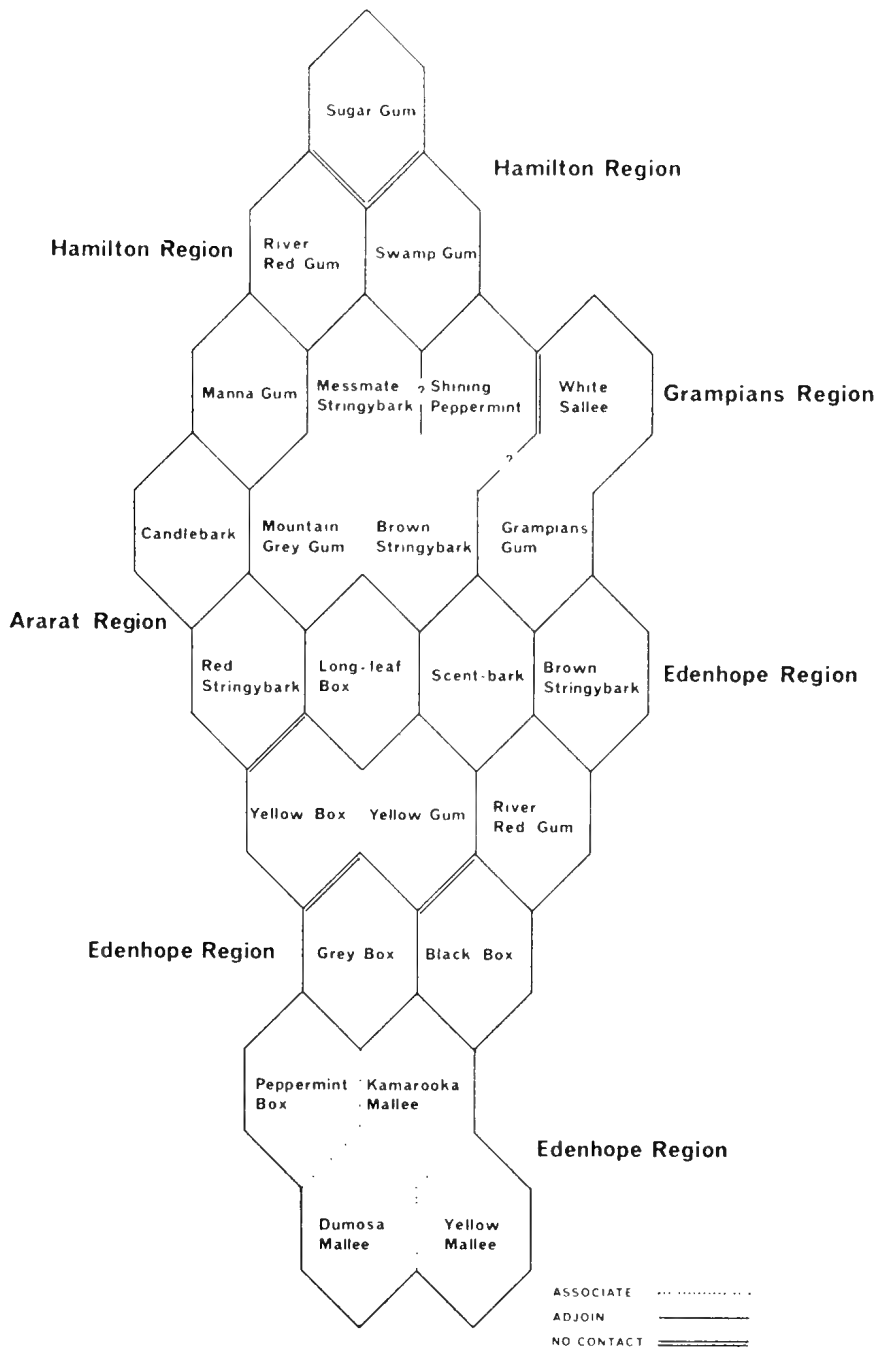
Common name	Scientific name	Plant community numbers (see Appendix 1)
Peppermint Box	<i>Eucalyptus odorata</i>	48
Pine Heath	<i>Astroloma pinifolium</i>	1, 4, 5, 7, 8, 15, 16, 19, 21, 26
Pink Beard-heath	<i>Leucopogon ericoides</i>	10, 16
Pink-bells	<i>Tetralochea ciliata</i>	5, 8, 10, 13-15, 18-20, 26
Pink Swamp-heath	<i>Sprengelia incarnata</i>	1
Ploughshare Wattle	<i>Acacia gunnii</i>	
Prickly Bush-pea	<i>Pultenaea juniperina</i>	
Prickly Cryptandra	<i>Cryptandra tomentosa</i>	27
Prickly Currant-bush	<i>Coprosma quadrifida</i>	11
Prickly Geebung	<i>Persoonia juniperina</i>	8
Prickly Moses	<i>Acacia verticillata</i>	7, 9, 10, 14, 26, 28, 29, 31, 32, 33, 39-41
Prickly Starwort	<i>Stellaria pungens</i>	
Prickly Tea-tree	<i>Leptospermum juniperinum</i>	1-8, 10, 14, 16, 20, 23, 25-26, 28-35, 44
Purple Coral-pea	<i>Hardenbergia violacea</i>	
Purple Eyebright	<i>Euphrasia collina</i>	
Red-fruit Saw-sedge	<i>Gahnia sieberiana</i>	
Red Parrot-pea	<i>Dillwynia hispida</i>	
Red Stringybark	<i>Eucalyptus macrorhyncha</i>	40
River Bottlebrush	<i>Callistemon paludosus</i>	
River Red Gum	<i>Eucalyptus camaldulensis</i>	33-38
River Tea-tree	<i>Leptospermum obovatum</i>	30
Rock Correa	<i>Correa glabra</i>	1, 2
Rosemary Grevillea	<i>Grevillea rosmarinifolia</i>	
Rosy Baeckea	<i>Baeckea ramosissima</i>	17, 18, 48
Rough Bush-pea	<i>Pultenaea scabra</i>	8, 9, 10, 13, 14
Rough Coprosma	<i>Coprosma hirtella</i>	4, 7, 9-12
Rough Mint-bush	<i>Prostanthera denticulata</i>	
Rough Star-hair	<i>Astrotricha asperifolia</i>	
Rough Wattle	<i>Acacia aspera</i>	10, 21, 26
Round-leaf Mint-bush	<i>Prostanthera rotundifolia</i>	
Round Templetonia	<i>Templetonia egena</i>	27, 32
Ruddy Beard-heath	<i>Leucopogon rufus</i>	1, 6, 17, 20
Rust Bush-pea	<i>Pultenaea hispidula</i>	
Rusty-pods	<i>Hovea longifolia</i>	
Sallow Wattle	<i>Acacia longifolia</i>	14, 16, 21, 24, 26, 49-52
Salt Paper-bark	<i>Melaleuca halmaturorum</i>	50
Saw-sedge	<i>Gahnia</i> sp.	
Scarlet Bottlebrush	<i>Callistemon macropunctatus</i>	34, 44
Scarlet Coral-pea	<i>Kennedia prostrata</i>	15, 16, 18-20
Scent-bark	<i>Eucalyptus aromaphloia</i>	24-26, 29
Scented Paper-bark	<i>Melaleuca squarrosa</i>	31, 32
Scrambling Lily	<i>Geitonoplesium cymosum</i>	
Scrubby Velvet-bush	<i>Lasiopetalum dasyphyllum</i>	6, 7
Shrub Violet	<i>Hybanthus floribundus</i>	
Shining Peppermint	<i>Eucalyptus nitida</i>	3, 6, 14, 29
Shiny Tea-tree	<i>Leptospermum nitidum</i>	1-4
Short Purple-flag	<i>Patersonia fragilis</i>	
Showy Bauera	<i>Bauera sessiliflora</i>	11, 31
Showy Parrot-pea	<i>Dillwynia sericea</i>	14
Silky Guinea-flower	<i>Hibbertia sericea</i>	15-21, 25, 48

Common name	Scientific name	Plant community numbers (see Appendix 1)
Silver Banksia	<i>Banksia marginata</i>	1, 4, 6, 8, 10, 14-16, 18-21, 24-27, 29-33, 35, 39-41, 44
Silver Daisy	<i>Celmisia asteliifolia</i>	1
Silver Wattle	<i>Acacia dealbata</i>	
Slender Bog-rush	<i>Schoenus tenuissimus</i>	
Slender Cypress Pine	<i>Callitris preissii</i>	49
Slender Dodder-laurel	<i>Cassytha glabella</i>	4, 6, 13-20, 26
Slender Honey-myrtle	<i>Melaleuca gibbosa</i>	
Slender Hop-bush	<i>Dodonaea angustissima</i>	21
Slender Mint-bush	<i>Prostanthera saxicola</i>	
Slender Rice-flower	<i>Pimelea linifolia</i>	
Slender Saw-sedge	<i>Gahnia microstachya</i>	
Slender Smoke-bush	<i>Conospermum patens</i>	14, 16-19, 26
Slender Twine-rush	<i>Leptocarpus tenax</i>	
Slender Velvet-bush	<i>Lasiopetalum baueri</i>	6, 10, 13, 44, 48
Small-flower Grevillea	<i>Grevillea parviflora</i>	
Small-fruit Hakea	<i>Hakea microcarpa</i>	
Small Grass-tree	<i>Xanthorrhoea minor</i>	20, 25
Small-leaved Clematis	<i>Clematis microphylla</i>	16, 19, 22
Smooth Tea-tree	<i>Leptospermum glabrescens</i>	
Snow Myrtle	<i>Calytrix alpestris</i>	
Spike Wattle	<i>Acacia oxycedrus</i>	1, 2, 4, 6, 8, 13, 14, 19, 26, 31
Spiny Mint-bush	<i>Prostanthera spinosa</i>	
Spiny Wattle	<i>Acacia spinescens</i>	14, 48
Spreading Brachyloma	<i>Brachyloma depressum</i>	14-21, 33
Spreading Wattle	<i>Acacia diffusa</i>	15
Sugar Gum	<i>Eucalyptus cladocalyx</i>	37
Swamp Club-moss	<i>Selaginella uliginosa</i>	
Swamp Gum	<i>Eucalyptus ovata</i>	30, 31
Swamp Honey-myrtle	<i>Melaleuca squamea</i>	44
Sweet Apple-berry	<i>Billardierai cymosa</i>	
Sweet Bursaria	<i>Bursaria spinosa</i>	11, 14, 15, 22, 28, 48
Sweet Quandong	<i>Santalum acuminatum</i>	
Tall Rice-flower	<i>Pimelea ligustrina</i>	
Tall Sword-sedge	<i>Lepidosperma elatius</i>	
Tasman Flax-lily	<i>Dianella tasmanica</i>	
Tassel Cord-rush	<i>Restio tetraphyllus</i>	
Tassel Rope-bush	<i>Hypolaena fastigiata</i>	
Thatch Saw-sedge	<i>Gahnia radula</i>	
Thorny Bitter-pea	<i>Daviesia pectinata</i>	48
Thyme Beard-heath	<i>Leucopogon thymifolius</i>	2, 7, 9, 14, 16
Trailing Ground-berry	<i>Acrotiche prostrata</i>	
Tree Everlasting	<i>Helichrysum dendroideum</i>	
Tree Lucerne	<i>Chamaecytisus proliferus</i>	22, 25
Variable Daisy	<i>Brachycome ciliaris</i>	
Variable Prickly Grevillea	<i>Grevillea aquifolium</i>	1-3, 6, 8, 14-16, 21, 26, 29
Variable Sword-sedge	<i>Lepidosperma laterale</i>	
Varnish Wattle	<i>Acacia verniciflua</i>	15, 16, 21, 26, 33
Veined Beard-heath	<i>Leucopogon neurophyllus</i>	1, 2, 45
Victorian Christmas-bush	<i>Prostanthera lasianthos</i>	11, 31
Victorian Flat-pea	<i>Platylobium alternifolium</i>	
Victorian Smoke-bush	<i>Conospermum mitchellii</i>	1, 2, 8, 16, 27, 29

Common name	Scientific name	Plant community numbers (see Appendix 1)
Violet Honey-myrtle	<i>Melaleuca wilsonii</i>	44, 48
Violet Kunzea	<i>Kunzea parvifolia</i>	44
Wallowa	<i>Acacia calamifolia</i>	16, 21, 30, 43, 44
Wedge-leaf Hop-bush	<i>Dodonaea cuneata</i>	4, 16
Western Golden-tip	<i>Goodia medicaginea</i>	
White Sallee	<i>Eucalyptus pauciflora</i>	1, 2
Winged Spyridium	<i>Spyridium vexilliferum</i>	14, 15
Wirilda	<i>Acacia retinodes</i>	14, 16, 26, 31, 33
Wiry Bauera	<i>Bauera rubioides</i>	1, 6, 30
Wombat Berry	<i>Eustrephus latifolius</i>	
Woolly-style Heath	<i>Epacris lanuginosa</i>	
Woolly Tea-tree	<i>Leptospermum lanigerum</i>	14, 31, 33, 39–41
Yellow Box	<i>Eucalyptus melliodora</i>	41, 42
Yellow Gum	<i>Eucalyptus leucoxylon</i>	42–45
Yellow Hakea	<i>Hakea nodosa</i>	10, 35
Yellow Mallee	<i>Eucalyptus incrassata</i>	48
Yellow Rice-flower	<i>Pimelea flava</i>	44
Zieria	<i>Zieria</i>	

**Appendix 4.**

Relationships between the species of *Eucalyptus* occurring in the Grampians- Edenhope Area



## Appendix 5.

Annotated list of birds from the  
Grampians-Edenhope Area of southwestern  
Victoria

## DROMAIIDAE (EMU)

*Dromaius novaehollandiae*. Emu.

Abundance and distribution. Common and restricted in ER, GR and AR; not seen in HR. Flocks containing 50 birds were seen occasionally; However, most sightings were of family groups. Habitat. Mainly pasture lands bordering woodland and open forest, particularly in GR. Occasional flocks were also in some Crown Land areas covered by woodland, shrubland, open forest and heath. It appears that the mosaic pattern of woodland or open forest surrounded by pasture land which occurs in the N portion of the survey area is conducive to the continued success of this species in the area. Breeding. Between October and December 1974 the total number of young counted in six family groups ranged from 3 to 8 and averaged 4.5 young. On 28 July 1957 a nest with eight eggs was found near Mt. Zero, GR, in an area of Brown Stringybark with heath undergrowth (Binns 1957).

## PODICIPEDIDAE (GREBES)

*Podiceps cristatus*. Great Crested Grebe.

Abundance and distribution. Rare. Recorded in ER near the Mt. Arapiles Block, on Jaka Lake and on Lake Wallace; in GR near Dunkeld; and in AR at Lake Fyans. Habitat. Permanent freshwater lakes and reservoirs with areas of open deep water. Breeding. Eggs were found at Lake Wallace, ER, in late December 1972 (Mitchell 1973; McCulloch 1973).

*Podiceps poliocephalus*. Hoary-headed Grebe.

Abundance and distribution. Uncommon and widespread; usually alone or in small flocks. Habitat. Temporary and permanent freshwater lakes, swamps and flooded pastures; open water areas are favoured. Breeding. A nest containing eggs was in a flooded pasture in ER near the Mt. Arapiles Block in October 1974.

*Tachybaptus novaehollandiae*. Little Grebe.

Abundance and distribution. Common and widespread in ER and AR; uncommon in GR and HR. Habitat. Temporary and permanent freshwater swamps and lakes. Breeding. A floating nest containing seven eggs was found (3 October 1974) on a pond 7 x 15 m and located between

Kallungar and Tooan Blocks in ER. Sedges and River Red Gums were on its margin, but the surrounding area was mainly pasture.

## PELECANIDAE (PELICANS)

*Pelecanus conspicillatus*. Australian Pelican.

Abundance and distribution. Uncommon. Recorded in ER at Toolondo Reservoir; in GR at Rocklands Reservoir, Marney Swamp and Moora Moora Reservoir; and in AR at Lake Lonsdale. Habitat. Large bodies of deep standing fresh water.

## ANHINGIDAE (DARTERS)

*Anhinga melanogaster*. Darter.

Abundance and distribution. Rare. Recorded in GR on Rocklands Reservoir and at Cherrypool. Habitat. Large freshwater lakes and reservoirs. Breeding. A single nest on a horizontal tree branch was found near Rocklands Reservoir in December 1974 (Morris pers. comm.).

## PHALACROCORACTIDAE (CORMORANTS)

*Phalacrocorax varius*. Pied Cormorant.

Abundance and distribution. Rare. Recorded in AR at Lake Lonsdale. Habitat. Large permanent freshwater lakes. Breeding. One pair was nesting at Lake Lonsdale in December 1964 (Wheeler 1965).

*Phalacrocorax melanoleucos*. Little Pied Cormorant.

Abundance and distribution. Common and widespread. Habitat. It was present on large permanent bodies of standing fresh water (e.g. Toolondo and Rocklands Reservoirs, and Lakes Fyans, Lonsdale and Charlegrark), and farm dams in all regions, on temporary freshwater swamps, on flooded pastures and woodlands particularly in ER, on streams and rivers (e.g. Boggy Creek in GR and the Glenelg River) and on estuaries (Lake Yambuk at the mouth of the Eumeralla River). Breeding. On 7 December 1974 a nesting colony consisting of at least eight nests was located in the middle of a flooded woodland on the E margin of the Tallageira Block, ER. The nests were on the branches of River Red Gums and contained well-developed young. Thirty pairs nested in AR on Lake Lonsdale between December 1964 and February 1965 (Wheeler 1965).

*Phalacrocorax carbo*. Black Cormorant.

Abundance and distribution. Uncommon. Re-

corded in GR at Bryan Swamp, Rocklands Reservoir and near Balmoral; in AR at Lake Lonsdale and near Mokepilly; and in HR at Cavendish. Habitat. Large deep bodies of permanent fresh water; occasionally rivers, temporary swamps and other shallow bodies of water. Breeding. Twenty pairs nested in AR at Lake Lonsdale between December 1964 and February 1965 (Wheeler 1965).

*Phalacrocorax sulcirostris*. Little Black Cormorant.

Abundance and distribution. Uncommon. Recorded in ER at Lake Connangorach, over flooded woodland near Apsley and at Lake Wallace; in GR at Rocklands Reservoir and near Balmoral; and in AR at Lake Lonsdale. Habitat. Permanent bodies of flowing and standing fresh water. Breeding. Sixty pairs nested in AR at Lake Lonsdale between December 1964 and February 1965 (Wheeler 1965).

ARDEIDAE (HERONS AND BITTERNS)

*Ardea pacifica*. White-necked Heron.

Abundance and distribution. Uncommon and widespread with local concentrations, particularly in ER and GR. Habitat. Pastures (either flooded or with new plant growth) or shallow margins of swamps and lakes. Breeding. Several nests were in River Red Gums around Barton Swamp, ER, in October 1974. Two nests, each containing at least two well-developed young, were in the Tallageira Block, ER, on 7 December 1974. Both were in the lower branches of River Red Gums standing in the middle of flooded woodlands.

*Ardea novaehollandiae*. White-faced Heron.

Abundance and distribution. Common and widespread. Habitat. Margins of temporary and permanent freshwater swamps and lakes; pastures (both flooded and those with new plant growth) are favoured foraging areas. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

*Ardeola ibis*. Cattle Egret.

Abundance and distribution. Rare; recently established in Australia and recorded in GR near Dunkeld in 1962 (Austin 1962a). Recorded in HR near Nareen in 1972 and 1973 (Austin pers. comm.). Habitat. Swamp margins and pastures.

*Egretta alba*. Large Egret.

Abundance and distribution. Uncommon and widespread with local concentrations during FWD

survey in ER at Lake Charlegrark and S of Mt. Arapiles Block; and in GR at Bryan Swamp and in the Wannon River floodplain at SE end of Serra Range. Habitat. Shallow margins of freshwater lakes and swamps and pastures (either flooded or with new plant growth).

*Nycticorax caledonicus*. Nankeen Night-heron.

Abundance and distribution. Uncommon; recorded in ER at Lake Charlegrark and St. Marys Lake; in GR at Bryan Swamp, Cherrypool and near Balmoral; and in HR near Cavendish. Habitat. Usually in trees on margins of freshwater streams, lakes and swamps.

*Botaurus poiciloptilus*. Brown Bittern.

Abundance and distribution. Rare; not seen during FWD survey. Recorded N of Mt. Dundas Block in GR in 1956-57 (McGarvie pers. comm.); and in HR at Mt. Eccles in September 1951 (Learmonth 1951). Habitat. Confined to thick reed-beds in swamps, lakes and streams (Wheeler 1967a).

PLATALEIDAE (IBISES AND SPOONBILLS)

*Plegadis falcinellus*. Glossy Ibis.

Abundance and distribution. Rare; not seen during FWD survey. Recorded in late December 1972, at Lake Natimuk (just N of the ER boundary) and in GR at Bryan Swamp and near Balmoral. Habitat. Margins of rivers and swamps. Breeding. No nesting recorded in the survey area. However, it breeds at Naracoorte, South Australia (Condon 1969), which is about 20 km W of the western boundary of ER. Movements. Condon (1969) indicates that its occurrence depends on rainfall. It is interesting to note that 1972 (when flocks were in the survey area) was an unusually dry year (McCulloch 1973).

*Threskiornis molucca*. White Ibis.

Abundance and distribution. Uncommon and widespread. Habitat. Margins of freshwater swamps, lakes and rivers (e.g. Bryan Swamp in GR, Lake Lonsdale in AR, the Wannon River in GR, etc.). It forages in pastures. Breeding. Nesting occurred in GR at Bryan Swamp in 1960 and along the Wannon River near Bryan Swamp in 1968; and in HR at Buckley Swamp in 1968 (Cowling unpub. MS). Conservation aspects. The conservation of this species should be encouraged because it feeds upon invertebrate pest species in agricultural areas.



*Threskiornis spinicollis*. Straw-necked Ibis.

Abundance and distribution. Common and widespread. Flocks in excess of 100 birds were noted in ER between the Konnepra and Jilpanger Blocks and SW of the Toolondo Block; and in AR near Mt. Dryden. Habitat. Margins of freshwater swamps, lakes, rivers and farm ponds. It commonly forages in pastures. Breeding. Nesting occurred in GR on Bryan Swamp in 1960 and along the Wannan River near Bryan Swamp in 1968 (Cowling, unpub. MS). A rookery is also reported in GR on Shannon Swamp near Glenisla (Middleton pers. comm.). Conservation aspects. As for White Ibis (above).

*Platalea regia*. Royal Spoonbill.

Abundance and distribution. Rare. Recorded in ER near Edenhope; in GR at Bryan Swamp and near Balmoral; and in AR at Lake Lonsdale. Habitat. Margins of swamps, rivers and lakes.

*Platalea flavipes*. Yellow-billed Spoonbill.

Abundance and distribution. Common and widespread. Habitat. Shallows of freshwater lakes, rivers, swamps and flooded pastures. Breeding. Young were present in GR during late December 1972 (McCulloch 1973). Between 10 and 20 nests were in ER at Boikerbert Swamp (Apsley) in 1972 (Thomas pers. comm.).

## ANATIDAE (GEESE, SWANS, DUCKS)

*Dendrocygna eytoni*. Plumed Tree-duck.

Abundance and distribution. Rare; not observed in FWD survey. Since 1970 we have reports of it in ER at Clear Lake (Middleton pers. comm.) and on Lake Natimuk along the N boundary of the survey area (McQueen pers. comm.). Habitat. Freshwater lakes and swamps. Breeding. Local residents of ER state that it occasionally breeds in the region. However, we were unable to confirm this.

*Cygnus atratus*. Black Swan.

Abundance and distribution. Common and widespread. Habitat. A wide range of aquatic habitats including saline lakes (e.g. White Lake, ER), freshwater lakes (e.g. Lake Lonsdale, AR), estuaries (e.g. Lake Nambuk, HR), flooded mountain streams in GR, large swamps with dense emergent vegetation (e.g. NW margin of Morea Block in ER) and flooded pastures and woodlands throughout the survey area. Breeding. Adults with broods were first recorded on 13 August and some cygnets were still considerably

smaller than the adults in December. Between 13 August and 4 October the young counted in 20 broods averaged 4.9 cygnets per brood (range, 2-8). During late December of the relatively dry year of 1972 young swans were dying of starvation on some of the lakes which were drying up (Mitchell 1973).

*Stictonetta naevosa*. Freckled Duck.

Abundance and distribution. Rare; not seen in FWD survey. A flock of about 30 was recorded in March-April of 1953 near the E boundary of HR (Shanks 1953). There are few other published records of this species in the vicinity of the survey area. Habitat. The flock was on a small saline lake of about 16 ha.

*Cereopsis novaehollandiae*. Cape Barren Goose.

Abundance and distribution. Rare; not seen in FWD survey. General sightings have been recorded from ER and AR subsequent to 1970 (Middleton and Thomas pers. comm.). Specific sightings were recorded (Morris pers. comm.) from Lake Kennedy (E boundary of HR) on 11 February 1967 (a flock of 14) and on 3 August 1967 (a flock of 3). A single bird was seen in HR at Nareen in 1970 (Austin pers. comm.) and another was at Branxholme (near W boundary of HR) in July 1975 (Middleton pers. comm.). Habitat. During February of 1967 Morris (pers. comm.) provided the following comments on Lake Kennedy: open water which is surrounded by pasture; the geese can be seen regularly in the NE corner feeding in the vegetation growing over salty ground; the lake will probably dry up later in the year.

*Tadorna tadornoides*. Mountain Duck.

Abundance and distribution. Common in ER, AR and HR and uncommon in GR; widespread throughout. Large mobile flocks are formed after fledging of young. Habitat. Both open water and margins of fresh to saline lakes and swamps. Pastures with new plant growth or those which are flooded are extensively utilized. Breeding. Broods were seen September through November. Of 18 broods counted in ER, the average number of young in each was 8.9.

*Anas superciliosa*. Black Duck.

Abundance and distribution. Common and widespread. Habitat. Bodies of standing and flowing fresh water, particularly temporary sedge swamps and flooded or unflooded pastures with new plant growth. Breeding. A nest with 8 eggs was found

on 6 September 1974 in AR. It was on the ground in dense Kangaroo Grass (25 cm tall) in a roadside reserve of Yellow Gum woodland. Adults with ducklings were also noted in ER in early October 1951 (Storr *et al.* 1952).

*Anas gibberifrons*. Grey Teal.

Abundance and distribution. The most common duck in the survey area and widespread throughout. Groups in excess of 500 birds have been recently recorded in ER near Douglas and on Lake Carchap; and in GR on Rocklands Reservoir. Habitat. Bodies of water ranging from flooded woodlands through seasonal swamps to large lakes and reservoirs. Also flowing waters but usually the slower moving, vegetated portions of streams or rivers were occupied. Breeding. Many broods were seen in ER between early October and early December. Of 11 broods counted, the average number of young in each was 7.2 (range, 6-8).

*Anas castanea*. Chestnut Teal.

Abundance and distribution. Rare; seen singly or in pairs in ER during FWD survey. Local concentrations are occasionally reported, e.g. Karnak Swamp during early 1974 (Thomas pers. comm.). Habitat. Usually on large bodies of standing water.

*Anas rhynchotis*. Shoveller.

Abundance and distribution. Uncommon and widespread with local concentrations (e.g. near Goroce, ER, early in 1974) (Thomas pers. comm.). Recorded in ER on Connangorach Swamp, near Goroce, S of Barton Swamp, near the Tooan Block and on Lake Mullancoree; in GR near Balmoral; in AR along the Western Highway (N of Mt. Zero); and on Lake Linlithgow (near E boundary of HR). Habitat. Usually on temporary swamps and flooded pastures in spring and congregating on permanent lakes and swamps in autumn. Breeding. A brood of 14 young was seen in AR on 1 October.

*Malacorhynchus membranaceus*. Pink-eared Duck.

Abundance and distribution. Uncommon in ER with local concentrations, such as occurred on Karnak Swamp early in 1974 (Thomas pers. comm.). Mitchell (1973) also recorded 50 on Lake Mullancoree during late December 1972. Populations in Victoria fluctuate and largest numbers occur apparently after wet years in inland Australia (Wright pers. comm.). This appeared to be the case in 1965 when large flocks were reported on Lake Linlithgow (near E boundary of

HR) during late February-early March (Morris pers. comm.) and in ER on Lake Carchap in late May (Thomas pers. comm.). Habitat. Large bodies of standing water. Breeding. A pair of adults with 2 young were seen on a temporary swamp along the Wimmera Highway W of the Kallungur Block, ER, on 4 October 1974.

*Aythya australis*. White-eyed Duck.

Abundance and distribution. Uncommon in ER with local concentrations near Goroce and Edenhope in 1974 and near Douglas early in 1975 (Thomas pers. comm.). More than 500 were on Lake Mullancoree in December 1972 (Mitchell 1973). Habitat. Temporary and permanent swamps and lakes.

*Chenonetta jubata*. Wood Duck.

Abundance and distribution. Common and widespread. Pairs and small flocks, usually of less than 10 birds, were present August through December. After December flocks of more than 100 birds were on bodies of water such as Clear Lake and Toolondo Reservoir in ER; Bryan Swamp and Rocklands Reservoir in GR; Lake Lonsdale, Pine Lake and Lake Taylor in AR; and the Wannan River in HR. Habitat. Flooded pastures and woodlands, seasonal swamps and on farm ponds as well as foraging in unflooded pastures. Large bodies of flowing and standing freshwater were occupied subsequent to nesting. Breeding. Four broods, averaging 7.5 young in each, were seen in ER and AR between October and early December.

*Oxyura australis*. Blue-billed Duck.

Abundance and distribution. Uncommon in ER; not observed elsewhere. Recorded on Jaka Lake and Lake Wallace. Habitat. Both lakes have large areas of open deep water.

*Biziura lobata*. Musk Duck.

Abundance and distribution. Uncommon and widespread with local concentrations noted in ER on St. Marys Lake, White Lake and Lake Charlegrark; and in GR on Bryan Swamp and Moora Moora Reservoir. Habitat. Large, deep bodies of standing fresh water; occasionally on rivers and seasonal sedge swamps.

ACCIPITRIDAE (KITES, HAWKS, EAGLES)

*Elanus notatus*. Black-shouldered Kite.

Abundance and distribution. Uncommon and widespread over the plains of the survey area. In

1952, population numbers were larger than normal in the Coleraine area, HR, and Austin (1953a) indicated that a wide range of habitat was being utilized. Breeding. Nests in trees in pastures of HR (Austin pers. comm.).

*Milvus migrans*. Black Kite.

Abundance and distribution. Rare; not seen in FWD survey. In 1952 a spectacular increase in numbers occurred in Victoria (Wheeler 1967a). Single birds began arriving in HR around Hamilton-Coleraine in February 1952 and by June had joined into flocks of up to 30 birds (Austin 1953a). Two such flocks occurred between Hamilton and Coleraine where they occupied territory and food with Whistling Kites. Austin (1953a) speculated that an outbreak of myxomatosis, and the consequent large numbers of rabbits killed on the roads, may have been responsible for the increased population of this species. Habitat. Open forest and plains country particularly near habitation (Wheeler 1967a). Feeding. The birds in HR during 1952 were feeding mainly on rabbits killed on roads (Austin 1953a).

*Haliastur sphenurus*. Whistling Kite.

Abundance and distribution. Common and widespread; usually as solitary or paired birds soaring overhead. Habitat. Semi-cleared pastures. Feeding. Rabbits are reportedly taken in, or near, the survey area (Hill 1907; Austin 1953a). Breeding. A common nesting bird in the survey area; some breeding details are given by Hill (1907a) for the Ararat District (near AR), by D'Ombra (1905a) for the Casterton District (near the W boundary of HR), and by McCulloch (1973) for GR.

*Accipiter fasciatus*. Brown Goshawk.

Abundance and distribution. Common in GR, uncommon elsewhere; widespread throughout. Habitat. Open forests; occasionally woodlands, shrublands and roadside trees in pastures. Feeding. Usually this goshawk catches and kills its own food, which consists mainly of vertebrates. However, during an outbreak of myxomatosis in 1952, the goshawk was seen feeding on rabbit carcasses in HR near Coleraine (Austin 1953a). Breeding. Adults with young out of the nest were in GR near Balmoral during late December 1972 (McCulloch 1973).

*Accipiter cirrhocephalus*. Collared Sparrowhawk.

Abundance and distribution. Rare; recorded in GR along the Glenelg River at Balmoral and S

of Rocklands Reservoir. Habitat. The bird near Rocklands Reservoir was in a Yellow Gum/Yellow Box woodland. Feeding. The individual in the woodland unsuccessfully chased a New Holland Honeyeater through the tree canopies.

*Haliaeetus leucogaster*. White-breasted Sea-eagle.

Abundance and distribution. Rare; not seen in FWD survey. Recorded in ER at Lake Wallace; in GR at Rocklands and Moora Moora Reservoirs; and in AR at Lakes Lonsdale and Fyans. Habitat. Large freshwater lakes.

*Aquila audax*. Wedge-tailed Eagle.

Abundance and distribution. Common and widespread. The literature indicates that the population of this species in SW Victoria has remained relatively constant during the past 80 years. However, precise information is lacking; this is unfortunate because it would be relatively simple to locate all the nests of this species within a defined area and then to follow the breeding population fluctuations over a long period of time. Habitat. It soars over all habitats, but most commonly over pastures, woodlands and open rock formations. Feeding. Reported feeding on dead rabbits on roads in GR (Mitchell 1973). Breeding. About the turn of this century 10 or 12 pairs were nesting in the Ararat District (just E of AR) (Hill 1907a). Hill indicated that they sometimes nested on dead trees in open, level country, but more often in growing timber on hillsides.

*Hieraaetus morphnoides*. Little Eagle.

Abundance and distribution. Uncommon and widespread; most sightings during FWD survey were in ER. Habitat. Our sightings were of birds over pastures. However, Austin (1953a) saw five over timbered country. Breeding. Young were in nests in GR near Balmoral in late December 1972 (McCulloch 1973).

*Circus assimilis*. Spotted Harrier.

Abundance and distribution. Rare and widespread; not seen in FWD survey. Habitat. Grasslands and croplands (Wheeler 1967a).

*Circus aeruginosus*. Swamp Harrier.

Abundance and distribution. Uncommon and widespread. Habitat. Swamps, lake and river margins, pastures, heathy areas and croplands. Breeding. D'Ombra (1905a) noted that this species often nested in the middle of a crop in the Casterton District (W boundary of HR), and that

breeding commenced in September. Clutches generally contained three and occasionally five eggs.

#### FALCONIDAE (FALCONS)

##### *Falco subniger*. Black Falcon.

Abundance and distribution. Rare; not seen in FWD survey but population increases occasionally occur. Between April 1951 and June 1952, at least 30 sightings of this species were made by Austin (1953a) in SW Victoria. He usually saw it singly, but on one occasion he did record a pair. Occasionally seen in GR near S end of Victoria Range in 1952-53 (McGarvie pers. comm.). Habitat. Austin (1953a) noted that all birds were in areas with little or no timber, and the only trees used as perches were isolated and dead. The observations by McGarvie were also in cleared areas. Feeding. An Australian Magpie Lark and a Common Skylark were taken (Austin 1953a). He also describes this falcon as hunting above and behind a Swamp Harrier as it flew over long grass.

##### *Falco peregrinus*. Peregrine Falcon.

Abundance and distribution. Common in GR and uncommon but with local concentrations elsewhere; widespread throughout. Habitat. Cliff faces which provide protection for nest sites and perching areas. Most cliffs overlooked pastures although a few overlooked open forests and woodlands. Feeding. Skeletal material found in eyries indicates that the introduced Domestic Pigeon is a major food source, but a wide range of other avian species are also taken (e.g. Gang-gang and Sulphur-crested Cockatoos, Crimson Rosellas, Common Starlings, White-faced Herons, cormorants, magpies and Masked Plovers). The location of eyries may influence the types of prey taken. For example, eyries above bodies of water contained remains of more aquatic species than did the eyries overlooking either pastures or open forests. Breeding. Nesting was documented in ER and GR. Copulation was recorded between 3 September and 4 October 1974. We followed the progress of two active eyries through the 1974 nesting season: one eyrie, located in a small recess close to the top of a cliff face, was found on 3 October; it contained three eggs which were being incubated. The nesting platform was level, dirt-covered and about 0.7 x 0.7 m in size. The cliff was near a major road in an area subjected to fairly intensive recreational use; the eyrie was easily accessible by a short

climb up the back of the cliff. On 5 October three eggs and an adult were still present, but by 9 October only two eggs were in the eyrie and on 20 October the nest was empty. The second eyrie, located under an overhanging ledge at the base of a sheer cliff, was found on 12 September; it contained two eggs and one adult was present. To reach the eyrie a large, steep, rounded rock had to be climbed; the top of this rock was relatively level and extended to the base of the cliff where the eyrie was situated. The location of the eyrie was near a minor road in an area which, potentially, could be important for recreation. Fortunately, it has only light usage at the present time. On 30 September both eggs were present and two adults were flying over the eyrie. On 10 October both eggs were fractured and the young birds inside were vocalising; two adults were flying overhead. On 29 October, 2 November and 7 November two downy young and one adult were present; both chicks were banded on the last-mentioned visit. Our final inspection of the eyrie was made on 11 December when we observed one adult and two juveniles flying overhead. Conservation aspects. The abundance of this species in the survey area is of particular importance in view of the nearly world-wide population decline of this species (Hickey 1968). Studies initiated now, while this species is still in substantial numbers in Victoria, could assist in preventing similar, local population declines. Obviously, the data presented on the breeding of this species in the survey area suggest that accessible eyries are vulnerable to human interference. Because of the tendency of this falcon to have traditional nesting sites (White 1968) it is essential that management authorities in areas which are, or will be, predominantly recreation-oriented be informed as to eyrie locations. Such information (which should not be made public) would not only allow a discreet surveillance of these sites (to discourage human interference) but, more importantly, would prevent the management authority from constructing roads, car parks, camp sites, picnic areas, nature walks, etc., near documented eyrie sites.

##### *Falco longipennis*. Little Falcon.

Abundance and distribution. Rare and widespread. Recorded in ER near North Lake; in GR near Balmoral; and in HR near Coleraine and near Wannon. Habitat. The bird near North Lake was over a pasture adjacent to a large block of Brown Stringybark shrubland. Feeding. We observed it pursuing starlings.

*Falco berigora*. Brown Falcon.

Abundance and distribution. One of the most abundant raptors throughout the survey area. Usually seen singly or in pairs and only occasionally in threes or fours (family groups?). Habitat. Semi-cleared pasture and crop lands and occasionally woodlands, heathy areas, over swamps and on margins of open forests. Breeding. D'Ombraïn (1905a) gave the following information on nests in the Casterton District (W boundary of HR): five nests were found during September 1903, all in River Red Gums. The clutch size was three in every case.

*Falco cenchroides*. Nankeen Kestrel.

Abundance and distribution. Uncommon and widespread. Usually seen singly, as pairs or, rarely, in groups of up to six birds. Habitat. Semi-cleared pasture and crop lands, woodlands, open forests, heathy areas, rock cliffs and rocky offshore pinnacles. Breeding. D'Ombraïn (1905a) noted that this species nested in the Casterton District (W boundary of HR) between October and November. He stated that the clutch is generally four, but frequently five, and gave specific information on a nest found in a hole in a River Red Gum on 28 October 1903.

## PHASIANIDAE (QUAILS)

*Coturnix pectoralis*. Stubble Quail.

Abundance and distribution. Common and widespread except in timbered and mountainous areas. During the past 15 years large numbers have sometimes been recorded near Lake Linlithgow (E boundary of HR), in the S portion of AR and in the Natimuk area of ER by Morris and Thomas (pers. comm.). Habitat. Pastures and crop lands, particularly those containing wheat, linseed, hog weed or new growths of grass. Breeding. Reported from various places in the survey area (Morris, Thomas, Austin and McGarvie pers. comm.).

*Coturnix australis*. Brown Quail.

Abundance and distribution. Not seen during FWD survey. Recorded in GR at Marney and Bryan Swamps and at Rocklands Reservoir during late December 1972 (Mitchell 1973). Habitat. Margins of freshwater swamps and reservoirs. Breeding. McCulloch (1973) noted young in GR during late December 1972.

## TURNICIDAE (BUTTON-QUAILS)

*Turnix varia*. Painted Button-quail.

Abundance and distribution. Uncommon and widespread. Habitat. Open forests, woodlands and shrublands, particularly where there is little ground cover.

*Turnix velox*. Little Button-quail.

Abundance and distribution. Not seen during FWD survey. Hill (1907b) recorded it during some summers before 1907 E of Ararat (near E boundary of AR) and Austin (1951) recorded it in 1949-50 near Casterton (just W of HR) and near Edenhope, ER. Habitat. Austin (1951) saw this quail in light bracken in open country. Breeding. The birds near Casterton were reported nesting in 1949-50.

## PEDIONOMIDAE (PLAINS-WANDERER)

*Pedionomus torquatus*. Plains-wanderer

(Plate 21, Fig. 6).

Abundance and distribution. Rare; not seen in FWD survey. A dead bird was found N of Horsham (N boundary of survey area) in May 1973, and was sent to NMV where it is lodged as a specimen (W 9092). D'Ombraïn (1926) noted it in HR near Hamilton in 1922. Habitat. Flat, open, grass-covered plains (Frith 1969). Conservation aspects. Early during European settlement it was common on the plains in Victoria (D'Ombraïn 1926), but a dramatic population decline has occurred throughout its range and today it is seldom seen. Studies to determine its present Victorian status are required.

## RALLIDAE (RAILS, CRAKES, SWAMPHENS)

*Rallus philippensis*. Land Rail.

Abundance and distribution. Not seen in FWD survey; recorded recently in AR at Stawell (McCann pers. comm.) and in HR at Nareen (Austin pers. comm.) but there are few other recent literature records for the survey area. Some old, general records of it occurring in or near the survey area include: Anon. (1892); Hill (1907b); and Sullivan (1929a). Habitat. Swampy conditions, crops and cultivation, and, at times, forested areas (Wheeler 1967a). Breeding. Five eggs were found in a nest at Warrnambool (just E of HR) during late October 1928 (Sullivan 1929a).

*Rallus pectoralis*. Water Rail.

Abundance and distribution. One bird was captured alive in a mammal trap in GR on the E side of Lake Wartook in FWD survey; it was later released in the same area. Also recently reported in GR at Wannan Bridge (McCann pers. comm.) and in ER at Horsham (Thomas pers. comm.). Habitat. The bird trapped near Lake Wartook was in dense wet sedges under a shrub layer of Scented Paperbarks.

*Porzana pusilla*. Marsh Crane.

Abundance and distribution. Not seen in FWD survey and there are few literature references from the survey area. However, because of the dense nature of its habitat, it may be more abundant than is suggested by the few recorded sightings. Recorded in GR near Balmoral (Mitchell 1973); and in AR at Lake Fyans (McCann pers. comm.). Habitat. Dense vegetation in swamps.

*Porzana fluminea*. Spotted Crane.

Abundance and distribution. Not seen in FWD survey. The general remarks made for the Marsh Crane also apply here. Mitchell (1973) reported it as common in GR near Balmoral in December 1972; and McCann (pers. comm.) has recently observed it in AR at Lake Lonsdale and near Stawell. The NMV has specimens from Edenhope and Stawell. Habitat. Dense vegetation bordering swamps and rivers.

*Porzana tabuensis*. Spotless Crane.

Abundance and distribution. Not seen in FWD survey. Recorded in ER along the Glenelg River near Harrow (Austin pers. comm.); in GR near Balmoral (Mitchell 1973); and in AR at Lake Lonsdale (McCann pers. comm.). Habitat. Dense vegetation in swampy areas.

*Gallinula ventralis*. Black-tailed Native-hen.

Abundance and distribution. A few solitary and paired birds were in ER (usually along the N boundary) during FWD survey. The numbers of this species had been high for two or three years before our survey (Middleton pers. comm.). Such population fluctuations are normal and Wheeler (1967a) remarks that it appears in great numbers during, and immediately after, flood periods. Habitat. Temporary or permanent freshwater swamps, lakes and flooded pastures. Breeding. A pair with a brood of chicks was in ER near the Mt. Arapiles Block in early October 1974.

*Gallinula tenebrosa*. Dusky Moorhen.

Abundance and distribution. Uncommon and widespread. Habitat. Large permanent bodies of fresh water; also flooded woodlands and other temporary bodies of water during spring. Breeding. Adults with chicks were seen in a flooded River Red Gum woodland in ER near the Tallageira Block on 7 December 1974. Young moorhens were seen also in GR near Balmoral during late December 1972 (McCulloch 1973).

*Porphyrio porphyrio*. Swamphen.

Abundance and distribution. Common and widespread. Habitat. Margins of seasonal swamps and flooded pastures or woodlands; shorelines of large permanent bodies of water are important during late summer and early autumn. Breeding. Young were on swamps in GR near Balmoral in late December 1972 (McCulloch 1973). A regular breeder in AR at Lake Fyans (McCann pers. comm.).

*Fulica atra*. Coot.

Abundance and distribution. Common and widespread. Habitat. Freshwater and saline lakes, swamps and flooded pastures; occasionally on slow-flowing rivers and streams. Seen both on open water and on vegetated margins. Breeding. McCulloch (1973) noted adults with young in GR in late December 1972.

## GRUIDAE (CRANES)

*Grus rubicunda*. Brolga.

Abundance and distribution. Uncommon and widespread. Habitat. Pastures or swamps on the plains, particularly semi-cleared pastures with some low-lying, poorly drained areas. Occasionally in stubble fields, but usually near swamps. Breeding. Nesting is reported in all regions of the survey area. Conservation aspects. We suggest that a field study to determine the status of this species in Victoria be conducted. The results of this study might suggest areas which, if set aside as reserves, could lead to a permanent nucleus of successful breeding birds being established in the State.

## BURHINIDAE (STONE-CURLEWS)

*Burhinus magnirostris*. Bush Stone-curlew.

Abundance and distribution. Rare; not seen in FWD survey. Hill (1907b) presented the following information on the status of this species in the Ararat District, shortly after the turn of the

century: 'fairly numerous on the timbered rises, but, according to old residents, they are less numerous than formerly, which may be accounted for by the increase in the number of foxes'. Other factors possibly also responsible for their decline include predation by feral Cats, clearing of the woodlands and agricultural activities. Between 1919 and present other sightings or calls have been reported in ER near Lake Wallace (Wheeler 1964); in GR (Audas 1920) and N of Mt. Dundas Block (McGarvie pers. comm.); in AR at Illawarra Block (Middleton pers. comm.) and along the Wimmera River near Horsham (Thomas pers. comm.); and in HR near Cavendish and Wannon (Wheeler 1967b; Mitchell 1973). Habitat. Noted in Yellow Gum woodland in the Illawarra Block (Middleton pers. comm.) and in River Red Gum areas N of Mt. Dundas Block (McGarvie pers. comm.). Conservation aspects. Studies are required to determine the reasons for the population declines of this species. In particular, the effects of the loss and alteration of its woodland habitat should be examined.

#### ROSTRATULIDAE (PAINTED SNIPE)

##### *Rostratula benghalensis*. Painted Snipe.

Abundance and distribution. Rare. Four in GR at McGlashan's Swamp (near Balmoral) in late December 1972 (Mitchell 1973) and two N of Mt. Dundas Block in October and November 1957 (McGarvie pers. comm.). Habitat. Swamps.

#### HAEMATOPODIDAE (OYSTERCATCHERS)

##### *Haematopus ostralegus*. Pied Oystercatcher.

Abundance and distribution. Common along the S boundary of HR (Isles pers. comm.). Habitat. Sandy ocean beaches and tidal flats.

#### CHARADRIIDAE (LAPWINGS, PLOVERS AND DOTTERELS)

##### *Vanellus miles*. Masked Plover.

Abundance and distribution. Common and widespread. Pairs or small flocks were present during spring and early summer; in mid-December a few larger flocks were evident and by March-April flocks containing 20 to 50 birds were common. Habitat. Margins of permanent and temporary lakes, swamps, reservoirs, etc., particularly where receding water has left exposed flats. Also areas of flooded vegetation, pastures with new growth and crops such as lucerne. Breeding. Adults with young were seen during September and October

1974. A nest of four eggs was found in the Victoria Valley, GR, on 5 September 1974. It was in a depression on a slight rise and was lined with grasses. Another nest with four eggs was on a mud bank near Hamilton, HR, on 27 August 1971 (RAOU nest card).

##### *Vanellus tricolor*. Banded Plover.

Abundance and distribution. Not seen in FWD survey. Flocks of up to 75 birds were in GR near S end of Victoria Range in May 1954 (McGarvie pers. comm.). Two were in GR along Victoria Range Road in December 1972 (Mitchell 1973). Reported regularly at Concongella (just E of AR) near Stawell (McCann pers. comm.). Habitat. Swamps, lagoons, and a strong preference for grassy plains often far from water (Condon and McGill 1974). The birds seen by McGarvie were in open country. Breeding. Nests regularly at Concongella (McCann pers. comm.). Nesting recorded in HR near Coleraine (RAOU nest cards). A regular nesting bird in GR near S end of Victoria Range (McGarvie pers. comm.).

##### *Erythrogonys cinctus*. Red-kneed Dotterel.

Abundance and distribution. Rare; only recorded during FWD survey along the N boundary of ER at Mitre Lake (a flock of 4 in October 1974). McCann (pers. comm.) has seen it in AR at Lake Lonsdale and it has been reported elsewhere in the survey area by Sullivan (1929a), Wheeler (1964) and Mitchell (1973). Habitat. Margins of standing bodies of water.

##### *Charadrius rubricollis*. Hooded Dotterel.

Abundance and distribution. Common along the S boundary of HR (Isles pers. comm.). Habitat. Ocean beaches.

##### *Charadrius bicinctus*. Double-banded Dotterel.

Abundance and distribution. Common during winter months along S boundary of HR (Isles pers. comm.). Rare inland; recorded in ER at Lake Wallace (Wheeler 1964). Habitat. Ocean beaches and, occasionally, inland swamps and lake margins. Movements. A winter migrant to Victoria, arriving as early as February and leaving in August (Wheeler 1967a). Breeds in New Zealand (Frith 1969).

##### *Charadrius ruficapillus*. Red-capped Dotterel.

Abundance and distribution. Uncommon in ER. Most sightings were of small flocks, each with less than 10 birds, in October 1974, but a flock of about 80 birds was near Douglas on 15 April

1975. Habitat. Dry margins or beds of freshwater and, in particular, salt lakes. Breeding. Young were seen in ER at White Lake on 5 October 1957 (Bald 1957a). Also recorded nesting in GR (McGarvie pers. comm.).

*Charadrius melanops*. Black-fronted Dotterel.

Abundance and distribution. Uncommon and widespread. Habitat. Margins, particularly of sand or mud, of permanent and temporary bodies of water. Sometimes it nests far from water. Breeding. A nest in a depression in the ground and lined with bark contained two eggs on 3 October 1974. It was in a Yellow Box/Yellow Gum woodland about 100 m from a large temporary lake in the Toolondo Block, ER. The undergrowth was sparse and appeared heavily grazed. Also recorded nesting in GR (McGarvie pers. comm.); in AR near Stawell (McCann pers. comm.); and in HR near Coleraine (RAOU nest card).

#### RECURVIROSTRIDAE (STILTS, AVOCETS)

*Himantopus himantopus*. Pied Stilt.

Abundance and distribution. Uncommon and widespread; most sightings are from ER. Recorded in ER at Lake Wallace, lakes near Douglas, Lake Natimuk (N boundary of ER) and 2 km SW of Mt. Arapiles Block; in AR at Lake Lonsdale; and in HR near Macarthur. Habitat. Margins of lakes and swamps. Movements. Relatively large numbers are seen during dry years such as 1972 (Mitchell 1973) and few are seen during wet years such as 1974 (FWD survey). Possibly they move out of the arid interior to the few permanent lakes and swamps remaining on the periphery of their range during dry periods.

*Cladorhynchus leucocephalus*. Banded Stilt.

Abundance and distribution. Uncommon, only seen in ER. Recorded at Centre Lake (9 birds in October 1974) and White Lake (40 birds in April 1975). A flock of 800 was on White Lake and another flock of approximately the same size was on Centre Lake on 5 October (Bald 1957a). Austin (1962b) recorded 10,000 birds on the lakes at Douglas and implied that such numbers might be smaller than usual. Habitat. Shallow open margins or sandbars of salt lakes. Occasionally associated with Pied Stilts, Red-necked Avocets and Black Swans. Breeding. Of 9 birds at Centre Lake, two had full chest bands and the rest were without or had indistinct bands. About one-third of the 40 on White Lake had full chest bands. Most of the 800 birds on White Lake in

1957 had full chest bands (Bald 1957a). Conservation aspects. The salt lakes in ER near Douglas appear to be one of the main inland areas for this species in Victoria.

*Recurvirostra novaehollandiae*. Red-necked Avocet.

Abundance and distribution. Uncommon, only seen in ER. Reported on Centre Lake (70 birds) in October 1974 and on Mitre Lake and a lake N of Lake Natimuk (N boundary of ER). Austin (1962b) reported 10,000 on the lakes near Douglas in 1962. They were with about 100 Pied Stilts and 10,000 Banded Stilts. Habitat. Shallow open margins of salt lakes.

#### SCOLOPACIDAE (SANDPIPERS, SNIPE)

*Tringa nebularia*. Greenshank.

Abundance and distribution. Rare; not seen in FWD survey. Mitchell (1973) recorded the following for late December 1972: 'Two L. Natimuk; three McGlashan's Swamp; two L. Mulla'. All three localities are either in or near ER. Habitat. Inland swamps and shallow lakes. Movements. Breeds in N Europe and N Asia and migrates in winter through E Asia to Australia (Frith 1969).

*Gallinago hardwickii*. Japanese Snipe.

Abundance and distribution. Uncommon and widespread. Habitat. Dense vegetation in marshes, swamps and wet heaths. Movements. Breeds in Japan and migrates S in winter through New Guinea to Australia (Frith 1969).

*Calidris acuminata*. Sharp-tailed Sandpiper.

Abundance and distribution. Uncommon; not seen in FWD survey. Flocks of up to 500 birds have been reported in or near ER at White and Centre Lakes, Lake Natimuk and Lake Mullancoree; and in GR on Bryan and Marney Swamps. Habitat. Margins of saline and freshwater lakes and swamps. Movements. Breeds in NE Siberia and migrates through E Asia to Australia (Frith 1969).

*Calidris ruficollis*. Red-necked Stint.

Abundance and distribution. Common during summer months along S boundary of HR (Isles pers. comm.). Uncommon inland; a flock of about 70 was in ER on the margin of a lake near the Mt. Arapiles Block in October 1974. Also recorded on White and Centre Lakes in October 1957 (Bald 1957a). Habitat. Ocean and estuary



beaches, tidal flats, margins of saline and freshwater lakes and swamps. Movements. Breeds in NE Siberia and W Alaska and migrates through Asia to Australia (Frith 1969).

*Calidris ferruginea*. Curlew Sandpiper.

Abundance and distribution. Rare; not seen in FWD survey. Recorded at Lake Natimuk (N boundary of ER) in December 1972 (Mitchell 1973). Habitat. Margins of lakes and swamps. Movements. Breeds in E Arctic Asia and migrates in winter through E Asia to Australia (Frith 1969).

*Calidris alba*. Sanderling.

Abundance and distribution. Rare; a flock of 80 was in HR near Lake Yambuk on 23 July 1976 (Isles pers. comm.). Habitat. Ocean beaches. Movements. Breeds N of the Arctic Circle, some migrate to Australia where they are widespread from November to May. Many birds overwinter in Australia (Condon 1969).

LARIDAE (GULLS, TERNS)

*Larus novaehollandiae*. Silver Gull.

Abundance and distribution. Uncommon and widespread. Usually in flocks of 10-100 individuals. Habitat. Saline and freshwater lakes and swamps; flocks often occur around food sources far from water.

*Chlidonias hybrida*. Whiskered Tern.

Abundance and distribution. Uncommon and widespread. Occasionally in flocks of up to 300 birds (Sullivan 1929b). Habitat. Saline and freshwater lakes and swamps, flooded pastures and freshly ploughed croplands (where they feed on invertebrates). Breeding. Three nests were found in GR near Dunkeld on 22 December 1968 (RAOU nest cards).

*Gelochelidon nilotica*. Gull-billed Tern.

Abundance and distribution. Rare; in 38 years Austin (pers. comm.) recorded three small flocks flying over Nareen in HR.

COLUMBIDAE (PIGEONS AND DOVES)

*Colomba livia*. Domestic Pigeon.

Abundance and distribution. Uncommon and widespread. Usually in small flocks, seldom of more than 20 birds. Analyses of wing bones found in Peregrine Falcon eyries in the survey area indicate that some nesting pairs rely on the pigeons as a food source when feeding young.

Habitat. Areas extensively modified by human occupation (e.g. towns, farm buildings, cleared pastures, bridges, etc.).

*Geopelia striata*. Peaceful Dove.

Abundance and distribution. Uncommon in ER, GR and AR; not seen in HR. Habitat. In ER at the Mt. Arapiles Block we observed this species in Grey Box and Yellow Gum woodlands. Breeding. Commonly breeds in AR near Stawell; it has colonised this area within the past 25 years (McCann pers. comm.).

*Geopelia cuneata*. Diamond Dove.

Abundance and distribution. Rare; possibly only an accidental visitor to the survey area. Seen in ER near Lake Wallace in March 1964 (Wheeler 1964). Habitat. No data available for survey area.

*Phaps chalcoptera*. Common Bronzewing.

Abundance and distribution. Common and widespread in ER, GR and AR; not seen in HR. Habitat. Dense shrub layers. Dominant tree species are probably less important than the density of the shrub layers. Recorded in such diverse tree associations as Yellow Gum/Yellow Box, Brown Stringybark/Small Grass Tree, Messmate, and Brown Stringybark/Manna Gum. Breeding. Nests in AR near Stawell (McCann pers. comm.).

*Phaps elegans*. Brush Bronzewing.

Abundance and distribution. Rare; recorded in GR at Balmoral, Victoria Valley and along Grampians Road near Mt. William turn-off; and in HR near Hamilton. Habitat. In Victoria Valley the birds were in heaths under Scent-barks (p.c.-26).

*Ocyphaps lophotes*. Crested Pigeon.

Abundance and distribution. Uncommon and restricted mainly to N portions of ER and AR. Also recorded in ER S of Toolondo Block (Mitchell 1973) and near Stawell along Concongella Creek (just E of AR) (McCann pers. comm.). Habitat. Sightings along the N boundary of the survey area were usually in pasture lands. Breeding. Nests along Concongella Creek, an area it has colonised within the past 25 years (McCann pers. comm.).

CACATUIDAE (COCKATOOS)

*Calyptorhynchus magnificus*. Red-tailed Black Cockatoo.

Abundance and distribution. Rare and restricted to ER. Recorded in the Kadnook, Tallegeira and Jilpanger Blocks during FWD survey. Previously

reported in the Edenhope and Harrow districts (Austin 1951), the Edenhope region (Attiwill 1960), in the Toolondo Block (Middleton pers. comm.), on the Moree Bridge Road (Wheeler 1964) and along the Edenhope Road (Mitchell 1973). The NMV has three specimens from ER. Habitat. Brown Stringybark shrubland. Feeding. Our observations of this species feeding on un-ripened Brown Stringybark seeds confirm similar observations made by Austin (1951) and Attiwill (1960). The latter author also states 'The birds also feed on the seeds of banksias, hakeas, small casuarinas and other native shrubs, particularly after a bushfire has passed over a patch of this type of country. Very rarely, they have been observed on the ground feeding on prickly burrs, and they also bite into dead timber in search of the larva of wood-boring beetles'. Breeding. Attiwill (1960) gives six recent nesting records for ER: three during October/November and three during February/March. The nests were in large hollows in eucalypts. Conservation aspects. The Victorian range of this species has apparently decreased since the early days of settlement (Wheeler 1967a) and it is now restricted to the SW part of the State with ER being one of its last strongholds. Conservation of some of the larger areas of Brown Stringybark in this region is essential to the local survival of this species.

*Calyptorhynchus funereus*. Yellow-tailed Black Cockatoo.

Abundance and distribution. Uncommon and widespread. Habitat. Usually seen in flight over a wide range of habitats. The few sightings of birds not in flight were made in woodlands (Yellow Gum/River Red Gum, Yellow Gum/banksia and River Red Gum/Silver Banksia), Brown Stringybark shrubland and a pine plantation. Feeding. Five were feeding on seeds from Desert Banksia cones in the Tallageira Block (ER) and three were carrying pine cones when they flew from a roadside stand of introduced pines W of the Jilpanger Block (ER). Breeding. An adult was on a nest 5 m up in a burnt Messmate on 22 November 1969 (Mt. William, GR) (RAOU nest card).

*Callocephalon fimbriatum*. Gang-gang Cockatoo.

Abundance and distribution. Uncommon and widespread in GR; rare in ER. Seldom seen further W than the Victoria-South Australia border (Condon 1969); Middleton (pers. comm.) suggests that the N boundary of ER is the N

limit of its range in W Victoria. Habitat. Mainly open forests, particularly of Brown Stringybark. Rare in woodlands (Yellow Gum/Yellow Box). Feeding. Observed feeding on Messmate and Scrub Cypress Pine seeds during FWD survey. Breeding. McCulloch (1973) recorded young out of the nest in GR during December 1972.

*Cacatua roseicapilla*. Galah.

Abundance and distribution. Uncommon and widespread with local concentrations in ER near the Mt. Arapiles Block. Flocks usually contained less than 10 birds and occasionally Galahs were with flocks of either Sulphur-crested Cockatoos, Long-billed Corellas or Red-rumped Parrots. Comments on the southward range expansion of this species in the W portion of the survey area are made by Austin (1951). Habitat. Mainly pastures; rarely woodland remnants (Grey Box and Yellow Gum/Grey Box) on pasture land margins.

*Cacatua tenuirostris*. Long-billed Corella.

Abundance and distribution. Common and widespread; usually in flocks, occasionally of up to several hundred birds, with Sulphur-crested Cockatoos. On 3 October 1974, we counted a total of 182 Long-billed Corellas along a N-S drive of 31 km between the Mt. Arapiles Block and the E side of the Toolondo Block (ER). These birds were in nine separate flocks which ranged in size from 1 to 60 individuals. Habitat. Pastures. Large woodland trees such as River Red Gum and Yellow Gum are selected for roosting and nesting. These trees are either isolated in pastures or are parts of extensive woodlands, particularly near areas of open water. Feeding. Oats, wheat and Onion-grass bulbs are taken (Sullivan 1929c; Smith 1962). Breeding. Adults with fledged young were in ER near Noradjuha in November 1961, and they were also nesting in trees in a swamp about 32 km SE of Noradjuha (Smith 1962). Nesting also occurs in AR in dead trees in Lake Fyans (Smart pers. comm.). Conservation aspects. The survey area is one of the last strongholds of this species in southern Australia and a concerted effort to ensure its continued survival in SW Victoria is required. Immediate studies should be conducted to elucidate its life history as well as its impact on cereal crops grown in the area. It is important that methods designed to alleviate its impact on cereal crops are critically reviewed before implementation to ensure that no adverse long-term effects on the population will occur.

*Cacatua galerita*. Sulphur-crested Cockatoo.

Abundance and distribution. Common and widespread; usually in flocks of up to several hundred birds with Long-billed Corellas. Habitat. Pastures. Large woodland trees such as River Red Gums and Yellow Gums are used for nesting and roosting. Feeding. Seen feeding in GR on Onion-grass bulbs and on oats. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

## LORIIDAE (LORIKEETS)

*Trichoglossus haematodus*. Rainbow Lorikeet.

Abundance and distribution. Rare and widespread. Recorded in ER between Benayeo and the Tallageira Block, near Edenhope, S of the Tooran Block, W of the Toolondo Block, and Horsham; in GR at S end of Victoria Range, Victoria Valley, Balmoral and N of Rocklands Reservoir; and in AR at Dadswell Bridge and Stawell. Habitat. Woodlands, particularly those containing Yellow Gum, Yellow Box or River Red Gum. Conservation aspects. As for Musk Lorikeet (below).

*Glossopsitta concinna*. Musk Lorikeet.

Abundance and distribution. Common and widespread. Habitat. Yellow Gum woodlands, sometimes in association with Yellow Box, River Red Gum or both. Feeding. Nectar/pollen from Yellow Gum blossoms is commonly taken; also seen feeding on unopened flowers of River Red Gums. Breeding. Recorded nesting in GR at Cherrypool in 1954 (McGarvie pers. comm.). Conservation aspects. The extensive loss of woodlands in the survey area may ultimately result in population declines of this species. The few segments of woodland remaining in the survey area should be carefully managed to provide a continual nectar source for nomadic birds such as the lorikeets.

*Glossopsitta porphyrocephala*. Purple-crowned Lorikeet.

Abundance and distribution. Uncommon and widespread; locally common in ER at Mt. Arapiles Block in April 1975. Habitat. Woodlands; our records include River Red Gum and Grey Box woodlands. Feeding. At Mt. Arapiles Grey Box blossoms were being selected. The appearance of lorikeets in these trees coincided with the appearance of the blossoms. Conservation aspects. As for Musk Lorikeet (above).

*Glossopsitta pusilla*. Little Lorikeet.

Abundance and distribution. Uncommon and widespread; not seen in FWD survey. Recorded in

ER near Edenhope (Wheeler 1964); in GR near Balmoral and Rocklands Reservoir (Mitchell 1973); and in AR near Stawell (McCann pers. comm.). Habitat. Woodlands. Conservation aspects. As for Musk Lorikeet (above).

## POLYTELITIDAE (LONG-TAILED PARROTS)

*Nymphicus hollandicus*. Cockatiel.

Abundance and distribution. Not seen in FWD survey. Reported in most suitable areas in GR around Balmoral and the Black Range in December 1972 (Mitchell 1973). Wheeler (1967a) describes this species as one whose numbers vary considerably from year to year.

## PLATYCERCIDAE (BROAD-TAILED PARROTS)

*Melopsittacus undulatus*. Budgerygah.

Abundance and distribution. Rare; not seen in FWD survey. Recorded in GR near Balmoral in December 1972 (Mitchell 1973). Habitat. Mainly open forests in the northern districts (Wheeler 1967a). Movements. Predominantly an inland species which experiences occasional northern movements (Wheeler 1967a; Condon 1969).

*Lathamus discolor*. Swift Parrot.

Abundance and distribution. Rare and widespread; not seen in FWD survey. Recorded in ER near Edenhope in March (Wheeler 1964) and near Lar-arum in May (Middleton pers. comm.); in GR N of the Mt. Dundas Block in September 1956 (McGarvie pers. comm.); in AR near Stawell in October (McCann pers. comm.); and in HR at Coleraine in March (Austin 1953b). Habitat. Woodlands. Feeding. A flock of 12 was feeding on blossoms of a Red-flowering Gum (*Eucalyptus ficifolia*) at Coleraine (Austin 1953b). Movements. Breeds in Tasmania (Frith 1969; Slater 1970) and generally is only present in SE Australia between March and September. Conservation aspects. As for Musk Lorikeet (above).

*Platycercus elegans*. Crimson Rosella.

Abundance and distribution. Common and widespread; particularly abundant in GR. Habitat. Open forests, woodlands, shrublands; occasional in heaths and in trees remaining in pastures. Brown Stringybark associations were particularly well populated, but also seen in plant associations composed of one or more of the following trees: River Red Gum, Scent-bark, Manna Gum,

Yellow Gum, Yellow Box, Mountain Grey Gum, Messmate, Grey Box, Shining Peppermint and Swamp Gum. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

*Platycercus elegans*. Crimson Rosella.

Abundance and distribution. Common and widespread, although few birds occur in the mountain ranges of GR. Habitat. Woodlands and semi-cleared pastures. Most common in River Red Gum associations, but also in plant associations of Yellow Gum, Yellow Box, Grey Box or Manna Gum. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

*Psephotus haematonotus*. Red-rumped Parrot.

Abundance and distribution. Common and widespread, although few birds occur in the mountain ranges of GR. Particularly abundant along N and W boundaries of ER. Habitat. Semi-cleared pastures where the few remaining trees are either River Red Gum, Yellow Gum or Grey Box. Unlike the Eastern Rosella, this parrot seldom occurs in woodlands but uses woodland margins that open onto pasture. Breeding. Adults were feeding fledged young in ER between Apsley and the Tallageira Block on 7 December 1974. Adults also noted as feeding young out of the nest in GR in late December 1972 (McCulloch 1973).

*Neophema chrysostoma*. Blue-winged Parrot.

Abundance and distribution. Uncommon. One was in ER in the Kadnook Block in December 1974 (FWD survey) and Wheeler (1964) saw one near Wrattontully, South Australia (about 10 km SW of Lankoop in ER) in March 1964. Storr *et al.* (1952) recorded it in HR near Haywood (about 15 km S of the Stones Block) in October 1951 and we saw a flock of about 20 immature *Neophema* parrots, which could have been either Blue-winged or Elegant Parrots, in the Stones Block in February 1975. Five were near Lake Yambuk (HR) on 27 July 1975 (Isles pers. comm.). Habitat. The bird in the Kadnook Block was in Brown Stringybark shrubland, the immature parrots were in Manna Gum open forest and the birds near Lake Yambuk were on a primary dune. Feeding. The individual in the Kadnook Block was feeding on *Leucopogon* sp. fruits and the five near Lake Yambuk were eating seeds of *Cakile* sp.

*Neophema elegans*. Elegant Parrot.

Abundance and distribution. Rare. Sullivan (1929a) recorded two flocks near Lake Condah

(HR) in July 1928 and we saw a flock of immature *Neophema* parrots, which could have either been Elegant or Blue-winged Parrots, in the Stones Block in February 1975. Habitat. The birds near Lake Condah were feeding among heaps of scattered straw and the flock of immatures was in a Manna Gum open forest.

## CUCULIDAE (CUCKOOS)

*Cuculus pallidus*. Pallid Cuckoo.

Abundance and distribution. Uncommon and widespread. This migratory species has been recorded in the survey area as early in the spring as 9 August (Sullivan 1929a). Interestingly, it was present in substantial numbers in GR on 18-19 October 1972 (Wheeler and Pescott 1973), but only two juveniles were recorded there during late December of the same year (Mitchell 1973). Thus, it may follow a similar pattern to that in the Canberra area where, after breeding, the adults move away in the early weeks of the New Year but juveniles remain until the end of April (Frith 1969). Habitat. Brown Stringybark shrublands, heaths, open forests and trees in pastures. Breeding. Juveniles have been seen being fed by White-naped, New Holland and Fuscous Honeyeaters. Movements. Not well known and apparently complex, but it is absent from SE Australia during winter.

*Cuculus pyrrhophanus*. Fan-tailed Cuckoo.

Abundance and distribution. Uncommon and widespread; usually seen from September to March (inclusive), but one was in HR near Lake Yambuk on 27 July 1976 (Isles pers. comm.). Habitat. Brown Stringybark and Manna Gum open forests, Yellow Gum/Yellow Box woodland and River Red Gum in pastures. Breeding. Nesting recorded in GR (McGarvie pers. comm.). Movements. Not well known, apparently there is some migration away from SE Australia during winter, but it may not involve the entire population (Slater 1970). Wheeler (1967a) indicates that many winter in Victoria.

*Chrysococcyx osculans*. Black-eared Cuckoo.

Abundance and distribution. Rare; not seen in FWD survey. Recorded in GR near Balmoral in December 1972 (Mitchell 1973). Also recorded as rare in the Ararat District (E of AR) by Hill (1907b). Habitat. Open forests and plains (Wheeler 1967a). Breeding. Hill (1907b) recorded eggs in nests of Speckled Warblers and Superb Blue Wrens. Movements. Not well under-

stood, but most S populations move N during winter (Macdonald 1973).

*Chrysococcyx basalis*. Rufous-tailed Bronze-cuckoo.

Abundance and distribution. Uncommon and widespread. More plentiful than the Shining Bronze-cuckoo in the survey area (Middleton pers. comm.). Habitat. Open forests (particularly of Manna Gum) and woodlands. Breeding. Foster parents in the Ararat District (E of AR) include Scarlet Robins, Buff-rumped Thornbills and Superb Blue Wrens (Hill 1907b). Movements. Largely migratory, especially S breeding populations, most of which leave for the North in March and return S in September (Macdonald 1973). Many winter in Victoria (Wheeler 1967a).

*Chrysococcyx lucidus*. Shining Bronze-cuckoo.

Abundance and distribution. Uncommon and widespread; less plentiful than the Rufous-tailed Bronze-cuckoo in the survey area (Middleton pers. comm.). Habitat. Open forests and woodlands. Breeding. Fledglings have been seen in ER in the Mt. Arapiles Block (Middleton pers. comm.). Movements. A summer migrant to Victoria and it winters within the State only on rare occasions (Wheeler 1967a).

#### STRIGIDAE (OWLS)

*Ninox strenua*. Powerful Owl.

Abundance and distribution. Uncommon and restricted to GR; seldom recorded far from the mountain ranges in the survey area. Recorded from Victoria Valley (FWD survey), Pomonal and Roses Gap (McCann pers. comm.), N of Yarram Park (Grey pers. comm.) and Billywing (Austin 1962c; Hall and McKean 1962). Habitat. Open forest. The bird in Victoria Valley was in an area of Swamp Gum with dense sedge undergrowth.

*Ninox novaeseelandiae*. Spotted Owl.

Abundance and distribution. Common and widespread. Habitat. Most areas which support tree growth. Breeding. D'Ombraïn (1905a) mentions five nests, two of which had clutches of three, in the Casterton District (near the W boundary of HR) during October and November. Three young birds out of the nest were in GR near Balmoral in late December 1972 (Mitchell 1973; McCulloch 1973).

*Ninox connivens*. Barking Owl.

Abundance and distribution. Uncommon; not seen in FWD survey. Recorded in GR at Victoria Valley (Braithwaite pers. comm.); in AR near Stawell (McCann pers. comm.); and in or near HR by D'Ombraïn (1905a), Wheeler (1967b) and Middleton (pers. comm.). Habitat. Woodlands and open forests. Breeding. A pair has nested for a number of years in the NW portion of HR (Austin pers. comm.).

#### TYTONIDAE (BARN OWLS)

*Tyto alba*. Barn Owl.

Abundance and distribution. Common and widespread except in the mountain ranges of GR. Habitat. Woodlands, semi-cleared pastures and settled areas and it roosts in tree hollows, old buildings, caves, thick foliage or down wells (Frith 1969). Breeding. D'Ombraïn (1905b) gives details on nesting of this species in the Casterton District (near W boundary of HR) around the turn of this century.

*Tyto novaehollandiae*. Masked Owl.

Abundance and distribution. Rare; not seen in FWD survey. Recorded in the Casterton District (near W boundary of HR) during the early part of this century (D'Ombraïn 1903; 1905a). Wakefield (1963) suggests that an accumulation of bones found in a sandstone recess in GR was from the disgorged pellets of this species. It may be significant that the composition of the mammal remains indicated that this recess had not been used for many years. Habitat. Forested areas (Wheeler 1967a). Breeding. Details of a nest and its contents (one fledgling and a partly intact egg shell) found in the Casterton District in December 1902 are described by D'Ombraïn (1903).

#### PODARGIDAE (FROGMOUTHS)

*Podargus strigoides*. Tawny Frogmouth.

Abundance and distribution. Common and widespread. Habitat. Most areas where large trees are present. Breeding. A common breeder in the Casterton District (near W boundary of HR) where D'Ombraïn (1905b) found eight nests between August and November 1903. Sullivan (1929d) found three nests in the Western District in 1928. It breeds regularly in AR near Stawell (McCann pers. comm.).

## AEGOTHELIDAE (OWLET-NIGHTJARS)

*Aegotheles cristatus*. Owlet-nightjar.

Abundance and distribution. Uncommon and widespread. Recorded in ER at Mt. Arapiles Block (observed on three occasions since 1967); in GR near Rocklands Reservoir; and in AR near Stawell. Habitat. Open forests and settled areas (Wheeler 1967a). At Mt. Arapiles sightings have been made in Brown Stringybark shrubland and in Long-leaf Box low open forest (p.c.-21). Breeding. Recorded nesting near Stawell (McCann pers. comm.).

## CAPRIMULGIDAE (NIGHTJARS)

*Caprimulgus guttatus*. Spotted Nightjar.

Abundance and distribution. Rare; a nightjar was seen in GR near Moora Moora Reservoir on 31 October 1974. Our identification was only positive to genus, but previously published material on the distribution of nightjars suggests that it was a Spotted Nightjar. Also recorded in GR near Billywing (Hall and McKean 1962) and Middleton (pers. comm.) reported a road-killed specimen near Wail (N of ER). Habitat. The bird near Moora Moora Reservoir was in an open forest with a dense understorey.

## APODIDAE (SWIFTS)

*Hirundapus caudacutus*. Spine-tailed Swift.

Abundance and distribution. Uncommon and widespread. Most sightings of this migratory species in the survey area have been made between December and March although Frith (1969) states that it occurs in Australia between early October and mid-August. Habitat. Most of its time in Australia is spent in the air and it occurs over all types of habitats. Movements. It migrates to Japan and Siberia where it breeds between May and August (Frith 1969).

*Apus pacificus*. Fork-tailed Swift.

Abundance and distribution. There are few records from the survey area. Middleton (pers. comm.) records it as occasional, but not as regular as the Spine-tailed Swift. Habitat. As for Spine-tailed Swift (above). Movements. It migrates to E Asia where it breeds between May and August.

## ALCEDINIDAE (KINGFISHERS)

*Ceyx azureus*. Azure Kingfisher.

Abundance and distribution. Rare. One recorded

in GR at Cherrypool in March 1954 (McGarvie pers. comm.). A specimen was taken in either GR or AR in November-December 1891 (Anon. 1892). Hill (1907b) recorded this species along the Wimmera River (E of AR) and Sullivan (1929d) remarked that he had seen only one in the Western District of Victoria. Habitat. Along rivers, streams and lake margins (Wheeler 1967a). Breeding. Hill (1907b) reported it nesting along the Wimmera River in December.

*Dacelo novaeguineae*. Kookaburra.

Abundance and distribution. Common and widespread. Habitat. Most areas containing trees. Breeding. Adults were feeding young out of the nest in GR in late December 1972 (McCulloch 1973).

*Halcyon sancta*. Sacred Kingfisher.

Abundance and distribution. Uncommon with local concentrations; widespread. Recorded in ER near Apsley and along the Edenhope to Harrow road; in GR near Balmoral and Rocklands Reservoir; in AR in the Illawarra Block; and in HR near Wannon. Habitat. Woodlands, particularly those with River Red Gums, sometimes near bodies of fresh water. Rarely in open forest. Breeding. Nests with eggs and young, and adults feeding young out of nests were in GR in late December 1972 (McCulloch 1973). Movements. A migrant to S Australia and is absent in winter (Frith 1969).

## MEROPIDAE (BEE-EATERS)

*Merops ornatus*. Rainbow Bee-eater.

Abundance and distribution. Uncommon and widespread. A summer migrant first seen in the survey area on 2 October 1974 and last seen on 19 March 1975. Habitat. Open forests and woodlands; also seen in an olive plantation. Breeding. It nests in ER near Harrow and Edenhope (Austin 1951) and at Mt. Arapiles Block (Middleton pers. comm.); in GR near Balmoral (McCulloch 1973); and in AR near Stawell, Lake Fyans and Lake Lonsdale (McCann pers. comm.).

## ALAUDIDAE (LARKS)

*Mirafra javanica*. Singing Bushlark.

Abundance and distribution. Not seen in FWD survey. Recorded in GR just S of the Victoria Range (McGarvie pers. comm.); and near HR in the Portland District (Learmonth 1966) and at Warrnambool (Sullivan 1928). Habitat. Grasslands, crops and marshy areas (Wheeler 1967a).

*Alauda arvensis*. Common Skylark.

Abundance and distribution. We did not obtain an estimate of the abundance of this introduced species in relation to that of Richard's Pipit in the survey area. Recently recorded in or near HR by Austin (1953a) and Wheeler (1967b) and in GR by Mitchell (1973). Habitat. Grasslands, crops and cultivated areas (Wheeler 1967a).

## HIRUNDINIDAE (SWALLOWS AND MARTINS)

*Hirundo neoxena*. Welcome Swallow.

Abundance and distribution. Common and widespread. Habitat. Abundant where open flying space is available (e.g. pastures, woodlands and clearings in open forests). However, nearly all plant formations, as well as some cliff faces, various other rock formations and margins of aquatic areas are utilized. Breeding. A common breeding species in the survey area. Eggs have been found from August through November and young from September through December (FWD survey; RAOU nest cards; McCulloch 1973). Nesting sites include buildings, bridges, porches, hollow trunks of River Red Gums, along cliffs and under rock overhangs.

*Cecropis nigricans*. Tree Martin.

Abundance and distribution. Common and widespread; usually in large flocks. Habitat. Pastures with large roadside trees or pastures adjoining open forests or woodlands. Also River Red Gum woodlands, particularly those on margins of freshwater lakes. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

*Cecropis ariel*. Fairy Martin.

Abundance and distribution. Uncommon and widespread. Recorded in ER near Lake Charlegrark; in GR at Rocklands Reservoir and near Balmoral; and in AR near Stawell. Habitat. Open areas, many times near freshwater lakes or rivers. Breeding. Nests were on the main wall of Rocklands Reservoir (GR) in mid-October 1972 (Wheeler and Pescott 1973). Adults were feeding young in nests near Balmoral (GR) in late December 1972 (McCulloch 1973). It commonly nests near Stawell (AR) where it uses road culverts for supporting nests (McCann pers. comm.).

## MOTACILLIDAE (PIPITS AND WAGTAILS)

*Anthus novaeseelandiae*. Richard's Pipit.

Abundance and distribution. Common in HR and uncommon elsewhere. Habitat. Open pasture and

crop lands, rarely on roadsides in heaths of the Victoria Valley (GR). Breeding. Adults were feeding young near Balmoral (GR) in late December 1972 (McCulloch 1973).

## CAMPEPHAGIDAE (CUCKOO-SHRIKES)

*Coracina novaehollandiae*. Black-faced Cuckoo-shrike.

Abundance and distribution. Uncommon and widespread. Habitat. Woodlands and semi-cleared pastures. Occasionally open forests. Breeding. Adults were feeding young in GR near Balmoral in late December 1972 (McCulloch 1973).

*Coracina papuensis*. White-bellied Cuckoo-shrike.

Abundance and distribution. Rare; not seen in FWD survey. A number of observers have seen birds in ER, GR and AR (McCann pers. comm.; Middleton pers. comm.; Austin 1951; Wheeler 1964; Wheeler and Pescott 1973; and Mitchell 1973). Habitat. Woodlands, semi-cleared pastures and open forests. Breeding. A nest was '40 feet up' in a eucalypt near Naracoorte, South Australia (20 km W of ER) between 6 and 12 October 1951 (Storr *et al.* 1952). Two pairs were nesting in AR near Stawell in November 1975 (McCann pers. comm.). Movements. It may move in and out of the survey area in relation to climatic conditions (Austin 1951).

*Lalage sueurii*. White-winged Triller.

Abundance and distribution. Rare and widespread. Recorded in ER in Kadnook and Connewirrecoo Blocks and at the Horsham Golf Course; in GR near Balmoral and Rocklands Reservoir; and in AR near Stawell. Habitat. Woodlands, shrublands and semi-cleared pastures. Movements. Migratory, arriving in southern Australia in mid-October and leaving in February (Frith 1969).

## MUSCICAPIDAE (FLYCATCHERS, THRUSHES AND WHISTLERS)

*Zoothera dauma*. Scaly Thrush.

Abundance and distribution. Uncommon in GR, AR and HR; not seen in ER. Habitat. Plant associations with dense shrub layers. Breeding. Campbell (1906) noted a young bird with weak flight when he disturbed it in GR near Dunkeld.

*Drymodes brunneopygia*. Southern Scrub-robin.

Abundance and distribution. Rare and restricted to ER. Recorded near Mt. Arapiles Block (Chisholm 1955) and at Wonwondah North (14.5 km

SW of Horsham and 25.8 km ESE of Mt. Arapiles) (Bald 1957b). Habitat. Shrubland (mallee) p.c.-48. Breeding. Nesting occurs at Mt. Arapiles (Chisholm 1955). Five nests were found at Wonwondah North in 1955 and all contained a single egg; where mallee trees were growing the nests were in debris in the central clump of trees, but in other areas the nests were in slight hollows in the ground and lined with grass (Bald 1957b).

*Turdus merula*. Common Blackbird.

Abundance and distribution. Uncommon and widespread; an introduced species. Habitat. Suburban areas, pasture lands, blackberry thickets along watercourses, etc.

*Petroica rosea*. Rose Robin.

Abundance and distribution. Rare. A male was banded in HR at Coleraine on 27 September 1962 (Austin 1963a). A male was seen at Wail (N of ER) on 25 April 1964 (Middleton pers. comm.). Habitat. The bird at Coleraine was in a suburban garden.

*Petroica rodinogaster*. Pink Robin.

Abundance and distribution. Rare. A single male was in GR near the top of Mt. Abrupt near Dunkeld in late March 1967 (Wheeler 1967b). Habitat. It was in a fern gully.

*Petroica phoenicea*. Flame Robin.

Abundance and distribution. A migratory species which is apparently absent from most of the survey area during summer (November through February). A few birds were seen during August and early September 1974 and the first sighting in 1975 was of five pairs foraging in an open grassy area along the margin of Wartook Reservoir (GR) on 20 March (FWD survey). Data collected by McCann (pers. comm.) in AR near Stawell indicate that small numbers are present throughout winter (May through September). Sullivan (1929a) gives dates of first arrivals in HR near Hamilton as 19 April in 1928 and 14 April in 1929. Habitat. Woodlands, open forests, pastures and other open grassy areas. Four birds were in White Sallee heath on top of Major Mitchell Plateau (GR) in August 1974; this is habitat similar to that in which it nests in the E part of the State. Breeding. Nesting in GR in October 1909 is described by Campbell (1910b). McCann (pers. comm.) indicates that it regularly nests in GR on Mt. William, Victoria Range and Mt. Difficult Range. Movements. There is movement out of most of the survey area probably

sometime in September and they do not reappear until late March. Apparently most move either to high altitudes (over 1200 m) in the Australian Alps or to Tasmania to breed.

*Petroica multicolor*. Scarlet Robin.

Abundance and distribution. Uncommon and widespread. Usually in pairs or small family groups. Habitat. Generally in areas of substantial tree and/or shrub growth. Recorded most often in Brown Stringybark shrubland in ER, but also occurring in woodlands and open forests of Scentbark, Long-leaf Box, Red Stringybark and Yellow Box. Seldom in pastures or other extensive open areas. Breeding. A nest about 3 m up a small Messmate was recorded in GR in September 1927 (Cohn 1927). Adults feeding young were in GR in late December 1972 (McCulloch 1973).

*Petroica goodenovii*. Red-capped Robin.

Abundance and distribution. Rare in ER, AR and HR; not seen in GR. Recorded in ER at Mt. Arapiles and W of Lake Wallace; in HR near Narceen; and in AR near Ararat and near Stawell. Habitat. Woodlands, open forests and shrublands.

*Melanodryas cucullata*. Hooded Robin.

Abundance and distribution. Uncommon and widespread. Recorded in ER in the Dopewora, Connewirrecoo, Jilpanger and Mt. Arapiles Blocks, near Edenhope and near Kanagulk; in GR near Balmoral, Rocklands Reservoir, and Victoria Range; and in AR. Habitat. Our sightings in ER were in Brown Stringybark shrublands, River Red Gum woodland with scattered wattle undergrowth and Yellow Gum woodland with an open understorey. Breeding. McCulloch (1973) recorded adults feeding young in GR in late December 1972. McGarvie (pers. comm.) recorded nesting on the W slopes of the Victoria Range in 1954.

*Eopsaltria australis*. Eastern Yellow Robin.

Abundance and distribution. Common and widespread. Habitat. Most plant formations contain populations of this species and its presence or absence in any particular area depends on the density of the shrub layer rather than on that of the tree layer. It is common in dense shrubs, such as occur along watercourses and in lightly grazed stands of timber. Breeding. This is a common nesting bird in the survey area and details are given for GR by Cohn (1927), Wheeler and



Pescott (1973) and McCulloch (1973); and for HR by RAOU (nest card).

*Microeca leucophaea*. Jacky Winter.

Abundance and distribution. Uncommon and widespread. Usually as individuals or small family groups, seldom in flocks. Habitat. Open grassy areas in woodlands composed of large River Red Gums, Yellow Gums, Yellow Boxes and Long-leaf Boxes. Occasionally under trees remaining in semi-cleared pastures and in open areas in Brown Stringybark and Manna Gum open forests. Breeding. Nest building, eggs and young in and out of nests were in GR near Balmoral (McCulloch 1973). D'Ombrain (1905b) noted two eggs in a nest on 27 September 1903 in the Casterton District (near W boundary of HR).

*Falcunculus frontatus*. Crested Shrike-tit.

Abundance and distribution. Uncommon and widespread. Habitat. Most areas which support tree growth. Breeding. Adults were feeding young out of the nest in GR near Balmoral in late December 1972 (McCulloch 1973).

*Pachycephala inornata*. Gilbert's Whistler.

Abundance and distribution. Rare and restricted; not seen in FWD survey. Middleton (pers. comm.) reports that it regularly occurs along the N boundary of ER in the Mt. Arapiles and Tooan Blocks. Habitat. Shrublands (mallee) which extend into these two blocks from the north.

*Pachycephala pectoralis*. Golden Whistler.

Abundance and distribution. Uncommon and widespread. During spring and early summer (1974) most sightings were of pairs or individuals (males in full plumage) in GR. In late summer and early autumn sightings were mainly of plain-coloured birds in ER, AR and HR. Habitat. The spring and early summer sightings in GR were usually in low open forests (particularly in the Black Range), in mature open forests or along the few moist streamsides which support tall open forests. During late summer and early autumn there appears to be a dispersal of birds to the woodlands, shrublands and pastures of the low areas surrounding the mountains of GR. Movements. An altitudinal migration within the survey area (the ranges in summer and the low surrounding areas in winter) is suggested by our data as well as unpublished data collected near Stawell (McCann pers. comm.). Similar migrations occur in other mainland populations of this whistler (Frith 1969).

*Pachycephala rufiventris*. Rufous Whistler.

Abundance and distribution. Locally common in GR from October through March. We did not record this species away from the ranges and adjacent Crown Lands, but other workers report that it occurs throughout most of the survey area. Habitat. Brown Stringybark open forests and, occasionally, Manna Gum, Swamp Gum, Yellow Box, Yellow Gum and Scrub Cypress Pine open forests and woodlands. Breeding. Wheeler (1967b) noted a pair feeding flying young in GR in late March 1967. Adults feeding young out of the nest were also seen during late December 1972 (McCulloch 1973). Movements. There are little published data on the winter distribution of this species in the survey area. However, unpublished data from the Stawell area (McCann pers. comm.) suggest that it is absent, possibly migrating north during winter.

*Colluricincla harmonica*. Grey Shrike-thrush.

Abundance and distribution. Common and widespread. Habitat. Most areas which support some tree or shrub growth. We recorded it from the moist tall open forests growing along a few of the streams in GR to pasture lands in areas away from the ranges. Breeding. Two nests were found during FWD survey; on 3 October 1974 a nest containing two eggs was in a Desert Banksia in Brown Stringybark shrubland in the Tooan Block (ER); and on 29 October 1974 another nest with two eggs was located between the bark and trunk of a Yellow Box in a Yellow Gum/Yellow Box woodland NW of Rocklands Reservoir (GR). Adults were feeding young out of the nest in GR in late December 1972 (McCulloch 1973). Nesting was also recorded in HR near Coleraine between 12 September and 15 October (RAOU nest card).

*Myiagra cyanoleuca*. Satin Flycatcher.

Abundance and distribution. Rare. One female *Myiagra* sp. was in GR near Silverband Falls in October 1974 (FWD survey). Middleton (pers. comm.) reports recent sightings of Satin Flycatchers in GR in the S end of Victoria Range, near Golton Gorge and in the S end of Serra Range. It was a regular visitor to the Victoria Range (GR) between 1951 and 1957 (McGarvie pers. comm.). One was collected in GR either in November or December 1891 (Anon. 1892) and one was seen between Cavendish (HR) and Balmoral (GR) in late December 1972 (Mitchell 1973). Habitat. Tall open and open forests. Breed-

ing. Austin (1963b) states that it nests regularly in GR but gives no details. Movements. A regular migrant to southern Australia, arriving in September and leaving in March or April (Slater 1974).

*Myiagra inquieta*. Restless Flycatcher.

Abundance and distribution. Uncommon and widespread. Habitat. Woodlands and rarely open forests. Breeding. Nesting recorded in GR and HR (Austin pers. comm.; RAOU nest cards) and in AR (McCann pers. comm.). Our limited data indicate that nesting activities occur at least between early September and early January.

*Rhipidura rufifrons*. Rufous Fantail.

Abundance and distribution. Rare in GR and HR; not seen in ER and AR. Recorded in GR at Silverband Falls on 1 November 1974 (FWD survey) and on the slope of Mt. William on 1 December 1959 (Austin 1963b); and in HR at the Stones State Faunal Reserve in late February 1975 (FWD survey), at Hamilton on 23 March 1963 (McCann 1963), near edge of Mt. Eccles crater on 12 January 1965 (Learmonth 1965) and Austin (1963b) states that it frequently appears in the Casterton District in November and March. Habitat. Tall open forests and open forests with dense undergrowth. Breeding. The Rufous Fantail seen by Learmonth (1965) on 12 January at Mt. Eccles crater flew to a nest 9 m up in an open eucalypt in a Manna Gum open forest with little undergrowth. Movements. Austin (1963b) reports that it remains for short periods and suggests that it may be passing on migration during November and March.

*Rhipidura fuliginosa*. Grey Fantail.

Abundance and distribution. Common, particularly in GR, and widespread. Habitat. Open forests, particularly those with dense undergrowth. Occasionally on open forest/woodland margins. Breeding. Adults were feeding young in GR near Balmoral in late December 1972 (McCulloch 1973). Sullivan (1928), in commenting on the Western District of Victoria in general, indicated that young were present as early as the first of June.

*Rhipidura leucophrys*. Willie Wagtail.

Abundance and distribution. Common and widespread. Habitat. Woodlands, occasionally open forests and pastures where they adjoin woodlands. Breeding. Eggs and young in and out of nests were in GR near Balmoral in late December

1972 (McCulloch 1973). D'Ombra (1905b) noted nest building on 9 September 1903 in the Casterton District (near W boundary of HR). Other nest activities are documented (between mid-September and late December) in GR near Rocklands Reservoir and Balmoral; in AR near Lake Fyans; and in HR 19.3 km NNW of Coleraine (RAOU nest cards).

ORTHONYCHIDAE (LOG-RUNNERS, QUAIL-THRUSHES AND WHIPBIRDS)

*Cinclosoma punctatum*. Spotted Quail-thrush.

Abundance and distribution. Rare and restricted to GR; not seen in FWD survey. Recorded near Wartook Reservoir and Victoria Range (McGarvie and Middleton pers. comm.). Habitat. Confined mainly to ridges and dry gullies in light and rain forest areas (Wheeler 1967a).

TIMALIIDAE (BABBLERS AND ALLIES)

*Pomatostomus temporalis*. Grey-crowned Babbler.

Abundance and distribution. Rare. Recently recorded in ER near Edenhope (one bird) (Storr *et al.* 1952); in GR in N portion of Victoria Valley (FWD survey); and in AR at Lake Fyans (McCann pers. comm.). Apparently it was considerably more plentiful in the survey area soon after the turn of this century (Hill 1907a; Chisholm 1964), and as late as 1927 they were often seen in GR (Cohn 1927). Habitat. Dense shrub layers in woodlands, particularly River Red Gums. Conservation aspects. The decline of this species in the survey area appears associated with the removal of its primary habitat (i.e. most of the original woodlands have been cleared for pasture and crop lands). The undergrowth of the few remaining stands of woodlands have been cleared either to facilitate the removal of timber or by extensive grazing of domestic stock.

*Pomatostomus superciliosus*. White-browed Babbler.

Abundance and distribution. Uncommon and widespread in ER, GR and AR; rare in HR where we can find one reference to it occurring near Coleraine (Sullivan 1928). Habitat. Dense shrub layers in open forests, woodlands and shrublands. In heavily grazed areas they are usually in Prickly Tea-trees or Hedge Wattles which appear to be relatively unpalatable to domestic livestock. Other workers have also indicated that wattles are important to this species (Hill 1907a; Lang 1932). Breeding. Nesting in or near the area has been reported by Campbell (1906) and Lang (1932) in

AR; by Hill (1907a) in the Ararat District (E of AR); and by Wheeler and Pescott (1973) in GR. Hill (1907a) indicates that nesting commences in July, and Lang (1932) found nests containing eggs or young from August to December.

#### SYLVIIDAE (OLD WORLD WARBLERS)

*Acrocephalus stentoreus*. Clamorous Reed-warbler.

Abundance and distribution. Not seen in FWD survey, probably because of insufficient time spent searching the habitat where it would be expected to occur. It is recorded regularly in the survey area and was recorded as early as 1891 either in GR or AR (Anon. 1892). Habitat. Dense reed beds along the margins of freshwater lakes, swamps and rivers. Breeding. Hill (1907a) recorded nesting in reeds along the Wimmera River E of Ararat (slightly out of the survey area). At present it is a common nesting species in AR at Lake Fyans, Lake Lonsdale and near Stawell (McCann pers. comm.). Movements. Summer migrant, but some winter in Victoria (Wheeler 1967a).

*Megalurus gramineus*. Little Grassbird.

Abundance and distribution. Not seen in FWD survey but it has been recorded regularly throughout the survey area since 1891 (Anon. 1892; Sullivan 1929d; Wheeler 1967b; Wheeler and Pescott 1973; and Mitchell 1973). Habitat. Thick vegetation growing on the margins of permanent lakes, swamps and rivers.

*Cisticola exilis*. Golden-headed Cisticola.

Abundance and distribution. As with the previous two species we spent little time in the habitat of this species. However, it has been recorded in either GR or AR as early as 1891 (Anon. 1892) and noted as present in the Western District of Victoria by Sullivan (1929d). More recently recorded in GR near Balmoral and Marney Swamp (Mitchell 1973) and in HR near Wannon and Coleraine (Wheeler 1967b). Habitat. Wet dense grasslands bordering freshwater swamps, lakes and streams. Breeding. Between 2 and 20 January 1966 a nest in a marsh near Dunmore (HR) produced four young (RAOU nest card).

*Cinclorhamphus mathewsi*. Rufous Songlark.

Abundance and distribution. Uncommon with local concentrations in ER and AR (FWD survey); widespread throughout. It is a summer migrant

which has been recorded in the survey area (1929a). Habitat. Woodlands, particularly those with open grassy areas. Breeding. Eggs were taken in early November of both 1898 and 1899 E of Ararat, which is slightly out of the survey area. Movements. Summer migrant in fluctuating numbers (Wheeler 1967a).

*Cinclorhamphus cruralis*. Brown Songlark.

Abundance and distribution. Rare and widespread. Recorded in ER near Mt. Arapiles Block in October 1974 (FWD survey); in GR in late December 1972 (Mitchell 1973); and in AR near Willaura on 6 September 1928 (Sullivan 1929a) and E of Ararat (slightly out of the survey area) (Hill 1907a). Habitat. Pasture and crop lands. Movements. Summer migrant, but some winter in Victoria (Wheeler 1967a).

#### MALURIDAE (AUSTRALO-PAPUAN WRENS)

*Malurus cyaneus*. Superb Blue Wren.

Abundance and distribution. Common and widespread. Habitat. Dense shrub layers, particularly riparian areas and areas where there is little grazing (e.g. the Stones State Faunal Reserve, HR). Austral Bracken, Hedge Wattle and Woolly Tea-tree are commonly inhabited. Breeding. A nest with young in the Morea Block (ER) was about 1.2 m up in a Hedge Wattle on 5 December 1974 (FWD survey). Noted as nesting in October 1972 in GR (Wheeler and Pescott 1973) and eggs and young were present in late December 1972 in GR near Balmoral (McCulloch 1973; RAOU nest card). It is also the foster parent of the Black-eared Cuckoo and the Rufous-tailed Bronze-cuckoo in the Ararat District (Hill 1907b).

*Malurus lamberti*. Variegated Wren.

Abundance and distribution. Rare and restricted in ER to Mt. Arapiles Block (FWD survey) and Wonwondah North (Bald 1957b). Habitat. In Victoria mainly shrubland (mallee) in the N of the survey area. Mt. Arapiles Block and Wonwondah North contain scattered clumps of mallee which represent about the S limit of this vegetation in Victoria (and the S limit of this wren).

*Stipiturus malachurus*. Southern Emu-wren.

Abundance and distribution. Uncommon and restricted to GR and HR. Recorded in GR in the Victoria Valley, Halls Gap, creek in Mt. William Range, upper Wannon River and Victoria Range; and in HR along the Glenelg River and near

Bessiebell. Habitat. Heaths and tussock grass areas in swamp basins.

ACANTHIZIDAE (SCRUBWRENS,  
THORNBILLS, AUSTRALIAN WARBLERS  
AND ALLIES)

*Sericornis frontalis*. White-browed Scrubwren.

Abundance and distribution. Common in the mountain ranges of GR and in the Stones State Faunal Reserve and near Bessiebell in HR; uncommon in ER and AR. The N boundary of ER appears to be the N extent of the range of this wren in Western Victoria (Middleton pers. comm.). Habitat. Dense undergrowth, particularly along watercourses and in lightly grazed areas. Dense shrub layers and heaths in GR and thick Austral Bracken in the Stones State Faunal Reserve and near Bessiebell are particularly well populated. Rarely in Brown Stringybark shrublands in ER or in open areas such as those in pastures or some woodlands. Breeding. On 6 September 1959 Cooper (1960) found a nest with two eggs in a gully in GR. A nest with four eggs was in trousers hanging in a shed near Macarthur (HR) in early October 1964 (RAOU nest card).

*Sericornis pyrrhopygius*. Chestnut-rumped Hylacola.

Abundance and distribution. Rare and widespread. Recorded in ER along the Edenhope to Harrow Road (Wheeler 1964) and in the Mt. Arapiles Block (FWD survey); and in GR on or near the Victoria Range (Wheeler 1967b; McGarvie pers. comm.; Middleton pers. comm.). Regularly sighted in Red Ironbark open forests near Stawell just E of AR (McCann pers. comm.). The populations in the Mt. Arapiles Block and on the N end of Victoria Range should be examined carefully because it is possible that they are *S. cauta* rather than *S. pyrrhopygius*. Habitat. Heaths and dense shrub layers in open forests. Breeding. Nesting in ironbarks just E of Stawell (AR) in August 1975 (McCann pers. comm.). Nesting near S tip of Victoria Range in 1953 (McGarvie pers. comm.).

*Sericornis fuliginosus*. Fieldwren.

Abundance and distribution. Rare. Recorded in GR in the Victoria Valley (FWD survey); and in HR in the Stones Block (Learmonth 1951) and near Wannon (Wheeler 1967b). Sullivan (1928) states that it was seen occasionally in the Western District of Victoria. Habitat. Heaths and swamps.

*Sericornis sagittatus*. Speckled Warbler.

Abundance and distribution. Rare in GR and AR; not seen in ER and HR. Possibly the W boundary of GR is the W limit of the range of this species in Victoria. Recorded in GR near Rocklands Reservoir, in Mt. Dundas and Mooralla Blocks and near Balmoral; and in AR in the Jallukar Block. Habitat. Woodlands (particularly Yellow Gum/Yellow Box) and open forests.

*Smicronis brevirostris*. Weebill.

Abundance and distribution. Uncommon and widespread in ER, GR and AR; not seen in HR. Habitat. Woodlands (particularly Yellow Gum), shrublands (mallee) and open forests.

*Gerygone olivacea*. White-throated Warbler.

Abundance and distribution. Rare, not seen during FWD survey. Recorded in GR in November 1909 (Campbell 1910a) and near Rocklands Reservoir in December 1972 (Mitchell 1973) and in HR near Coleraine in January 1954 (Austin 1954). Habitat. Open forests, mainly E of the survey area (Wheeler 1967a). Breeding. It was nesting (three eggs) in a box-tree about 3.2 km from the foot of the Grampians on 27 November 1909 (Campbell 1910a). Movements. A summer migrant to Victoria.

*Acanthiza pusilla*. Brown Thornbill.

Abundance and distribution. Common and widespread. Particularly abundant in GR near Silverband Falls and in HR at the Stones State Faunal Reserve. Habitat. Tall open forests, open forests, woodlands, shrublands and heaths. Its distribution in the survey area appears linked to the presence of thick undergrowth rather than to the distribution of dominant tree species. Breeding. An adult was feeding a fledged young in GR near Silverband Falls on 1 November 1975 (FWD survey). Four nests recorded in HR near Dunmore (RAOU nest cards).

*Acanthiza uropygialis*. Chestnut-rumped Thornbill.

Abundance and distribution. Rare. The NMV holds a specimen collected in the Grampians in 1961. Habitat. Usually shrublands (mallee).

*Acanthiza reguloides*. Buff-rumped Thornbill.

Abundance and distribution. Common, particularly in AR, and widespread. Usually in small flocks of 5-10 birds, rarely of more than 20. Habitat. Open forests, particularly those with Long-leaf Box, Red Stringybark and Brown

Stringybark; woodlands and shrublands. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

*Acanthiza chrysorrhoa*. Yellow-rumped Thornbill. Abundance and distribution. Common and widespread, except in the mountain ranges of GR. Usually in flocks of 10-20 birds. Habitat. Usually foraging on the ground in pastures or under scattered trees along roadsides. Rarely in open forests and woodlands. Breeding. A common nesting species in and near the survey area (Campbell 1906; McGarvie pers. comm.; Hill 1907a; McCann pers. comm.; FWD survey; RAOU nest cards). Nesting commences in July and continues at least into December; clutches are usually of 3 or 4 eggs. Nesting sites include paperbarks (*Melaleuca halmatarorum*), citrus trees, pine trees, cypress trees and lower portions of occupied Wedge-tailed Eagle nests.

*Acanthiza nana*. Yellow Thornbill.

Abundance and distribution. Uncommon (with local concentrations in GR) and widespread. Habitat. Mainly open forests; occasionally woodlands, tall open forests and shrublands. Shows preference for wattles (Wheeler 1967a; Frith 1969).

*Acanthiza lineata*. Striated Thornbill.

Abundance and distribution. Uncommon and widespread. Habitat. Tree canopies in tall open forests, open forests, occasionally woodlands and shrublands. Usually in mobile flocks of up to 10 birds in each. Breeding. Regular nesting species in AR near Stawell (McCann pers. comm.). Nesting recorded in GR (McGarvie pers. comm.).

*Aphelocephala leucopsis*. Southern Whiteface.

Abundance and distribution. Uncommon and widespread. Recorded in ER at Mt. Arapiles Block, along the Edenhope to Harrow Road and near Lake Kanagulk; in GR near Rocklands Reservoir, near S end of Victoria Range and in the Wannon River floodplain on SE side of Serra Range; in AR near Stawell; and in HR along the Wannon River and N of Coleraine. Habitat. Pasture lands and margins of woodlands. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

#### NEOSITTIDAE (SITTELLAS)

*Neositta chrysoptera*. Varied Sittella.

Abundance and distribution. Uncommon and

widespread; usually in small flocks of less than 10 birds. Habitat. Seen in Long-leaf Box low open forest and Brown Stringybark open forest during FWD survey. Breeding. Nesting recorded in Victoria Range (GR) in 1954 (McGarvie pers. comm.). Adults were feeding young in GR near Balmoral in late December 1972 (McCulloch 1973; RAOU nest card).

#### CLIMACTERIDAE (AUSTRALIAN TREE-CREEPERS)

*Climacteris leucophaea*. White-throated Tree-creeper.

Abundance and distribution. Common, particularly in GR, and widespread. Habitat. Tall open forest, open forest, low open forest, shrubland and rarely, woodland.

*Climacteris picumnus*. Brown Treecreeper.

Abundance and distribution. Common and widespread except in the mountains of GR where it is rare. Habitat. Woodlands variously composed of Yellow Gum, Yellow Box, River Red Gum, Grey Box, Long-leaf Box and Buloke, occasionally in Brown Stringybark shrubland. Breeding. Adults were feeding young in GR near Balmoral in late December 1972 (McCulloch 1973).

#### MELIPHAGIDAE (HONEYEATERS)

*Anthochaera carunculata*. Red Wattlebird.

Abundance and distribution. Common and widespread. Habitat. Most areas with large trees. Feeding. Recorded taking nectar from blossoms of Yellow Gums, Manna Gums and Red-flowering Yellow Gums (cultivated). Breeding. A common breeding species with young in nest recorded as early as 5 August (RAOU nest card) and with fledged young still being fed by adults in late December (McCulloch 1973).

*Anthochaera chrysoptera*. Little Wattlebird.

Abundance and distribution. Uncommon with local concentrations in ER and GR. Habitat. Plant associations in which members of the genus *Banksia* are common. Feeding. Recorded taking nectar from flowers of Desert and Silver Banksias. Also seen feeding around the tips of new growth of Silver Banksias.

*Anthochaera rufogularis*. Spiny-cheeked Honey-eater.

Abundance and distribution. Rare in ER, GR and AR; not recorded in HR. Most sightings are from the Mt. Arapiles Block in ER. Habitat. Usually

shrublands (mallee and occasionally Brown Stringybark), rarely woodlands.

*Xanthomyza phrygia*. Regent Honeyeater.

Abundance and distribution. Rare, not seen in FWD survey. Recorded in ER along the Glenelg River at Harrow (Wheeler 1964) and at Apsley (Austin 1951); in GR in the Black Range (Wheeler and Pescott 1973), at Halls Gap (Glover 1954) and at Golton Gorge (Middleton pers. comm.); and in AR near Stawell (McCann 1957). Habitat. The common eucalypts around Stawell are Red Ironbark, Long-leaf Box and Yellow Gum (McCann 1957). Breeding. Recorded nesting in a Long-leaf Box near Stawell in 1975 (McCann pers. comm.).

*Entomyzon cyanotis*. Blue-faced Honeyeater.

Abundance and distribution. Rare. Recorded in ER near Edenhope (Austin 1951) and at Harrow (Wheeler 1964); in GR near Rocklands Reservoir (FWD survey); and in AR near Dadswell Bridge (Middleton pers. comm.) and near Stawell (McCann pers. comm.). Habitat. Woodlands, particularly River Red Gum, Yellow Gum and Yellow Box. Feeding. Recorded taking nectar from Yellow Gum blossoms. Breeding. Nesting is recorded in ER near Edenhope (Austin 1951) and in AR near Stawell (McCann pers. comm.). Conservation aspects. The continued removal of large woodland trees such as River Red Gums, Yellow Gums and Yellow Boxes from the survey area may result in the local disappearance of this species. It is currently present in very low numbers.

*Manorina melanocephala*. Noisy Miner.

Abundance and distribution. Uncommon and widespread. Habitat. Woodlands or roadside trees in semi-cleared pastures. Occasionally on pasture/shrubland margins. Feeding. Recorded taking nectar from blossoms of a Red-flowering Yellow Gum (cultivated). Breeding. Nesting recorded in GR (McGarvie pers. comm.).

*Lichenostomus chrysops*. Yellow-faced Honeyeater.

Abundance and distribution. Common in HR in the Stones State Faunal Reserve; uncommon and widespread elsewhere. Habitat. Dense shrub layers in most plant formations, but particularly in Manna Gum open forest. Feeding. Recorded taking nectar from Manna Gum and Yellow Gum blossoms. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

*Lichenostomus virescens*. Singing Honeyeater.

Abundance and distribution. Common in parts of the narrow coastal strip between Port Fairy and Lake Yambuk (just E of HR) in February 1975 (FWD survey). Habitat. In the survey area it is usually found only in coastal heaths.

*Lichenostomus leucotis*. White-eared Honeyeater.

Abundance and distribution. Common in HR in the Stones State Faunal Reserve; uncommon and widespread elsewhere. Habitat. Open forests (particularly Manna Gum), shrublands (both mallee and Brown Stringybark), woodlands and heaths. Feeding. Recorded taking nectar from Yellow Gum blossoms. Breeding. A recently constructed nest (no eggs) was found in GR in a shrub near Mt. Zero on 4 August 1957 (Binns 1957). Recorded nesting in GR (McGarvie pers. comm.).

*Lichenostomus melanops*. Yellow-tufted Honeyeater.

Abundance and distribution. Uncommon and restricted to a few localities in GR and AR. Locally common near Stawell (McCann pers. comm.). Habitat. Woodlands, open forests and low open forests. McEvey (1958) indicates that the preferred habitat is Red Ironbark/Red Stringybark open forest, which becomes extensive just E of AR. Feeding. Recorded taking nectar from Yellow Gum blossoms. Breeding. It nests frequently in grass tussocks and in shrubs less than 0.5 m tall between August and January in AR near Stawell (McCann pers. comm.). A nest with both eggs and young was in GR near Rocklands Reservoir during late October 1965 (RAOU nest card).

*Lichenostomus fusca*. Fuscous Honeyeater.

Abundance and distribution. Common in AR, reported as the commonest honeyeater at Stawell (Ashby 1927) and near Ararat (Lang 1929); uncommon in GR; rare in ER and not seen in HR. Habitat. Woodlands and low open forests, particularly those containing Grey Box, Long-leaf Box or Yellow Box. Feeding. Nectar was being taken from Manna Gum blossoms in AR near Stawell during March 1975. Breeding. An adult was on a nest in the outer canopy leaves of a 9 m tall Long-leaf Box in the Jallukar Block (AR) on 18 March 1975 (FWD survey). McCann (pers. comm.) reports that it nests regularly in AR near Stawell and has seen feathered young in a nest during November; flying young

have been seen in the same area in January (Glover 1954). Two young were in GR near Balmoral in late December 1972 (RAOU nest card).

*Lichenostomus penicillatus*. White-plumed Honeyeater.

Abundance and distribution. Common and widespread in ER, GR and AR; uncommon in HR. Habitat. Woodlands (particularly of large River Red Gums) or where large woodland trees remain in semi-cleared pastures. Breeding. Breeding activities have been recorded between early September and late December, with adults feeding fledged young as late as mid-March (FWD survey; RAOU nest cards).

*Melithreptus gularis*. Black-chinned Honeyeater.

Abundance and distribution. Uncommon and widespread. Habitat. Woodlands (particularly River Red Gum), open forests (particularly Swamp Gum), shrublands (Brown Stringybark) and heaths (Scent-bark). Breeding. Adults were feeding fledged young in GR near Balmoral in late December 1972 (McCulloch 1973).

*Melithreptus brevirostris*. Brown-headed Honeyeater.

Abundance and distribution. Uncommon and widespread. Habitat. Open forests, shrublands (both mallee and Brown Stringybark), woodlands and heaths (Scent-bark). Feeding. Seen taking nectar from Yellow Gum blossoms. Breeding. Adults were feeding flying young in GR in late March 1967 (Wheeler 1967b).

*Melithreptus lunatus*. White-naped Honeyeater.

Abundance and distribution. Common (particularly in GR near Halls Gap and in HR in the Stones State Faunal Reserve) and widespread. Habitat. Most areas with large trees, but particularly abundant in Manna Gum open forest. Feeding. Recorded taking nectar from Yellow Gum blossoms. Breeding. Two nests, each containing three young, were in trees in the Balmoral State Forest (GR) between 25 and 30 December 1972 (RAOU nest cards).

*Grantiella picta*. Painted Honeyeater.

Abundance and distribution. This rare and interesting species appeared in ER near Edenhope every year between 1916 and 1927 (Hindwood 1935). During these years it arrived either in September or October and left during February and March; it did not appear after 1927. More

recently McCann (pers. comm.) has recorded it along the E boundary of AR. Habitat. All the sightings by Hindwood (1935) were in one patch of shrubland which contained mainly stringybarks infested with mistletoe. Feeding. Mistletoe berries appeared to be the favoured food of this species near Edenhope. Tree branches near nests were covered with mistletoe seeds and the ground below was littered with them. Breeding. Nests were located near Edenhope in stringybarks and, on one occasion, in a clump of mistletoe during the month of October. The nests were at heights varying from 3 to 15 m above the ground and were woven amongst flower buds in the outer tree branches. The number of eggs in a clutch varied from one to three with the usual number being two (Hindwood 1935). McCann (pers. comm.) reports recent nesting near Deep Lead (along E boundary of AR). Movements. A summer visitor to Victoria (Wheeler 1967a).

*Phylidonyris pyrrhoptera*. Crescent Honeyeater.

Abundance and distribution. Recorded in the survey area only in GR. In August 1974 it was common on Major Mitchell Plateau and in March 1975 it was on the summit of Mt. William. In spring of 1974 it was also common upstream from Silverband Falls but was absent from this locality in autumn of 1975. Apparently the population in GR has fluctuated during the past 70 years and some of the previous information is summarized by Cooper (1960). During September 1959 Cooper considered it common in GR and states that 'there appears to be a small movement from the Grampians into the surrounding countryside at certain times of the year, but the birds do not wander far'. A few individuals were also recorded in GR along the Glenelg River below Rocklands Reservoir on 18-19 October 1972 (Wheeler and Pescott 1973). Habitat. Apparently attracted to the heaths on Major Mitchell Plateau and to banksias associated with stunted Brown Stringybarks on Mt. William. The vegetation along the creek above Silverband Falls is a Messmate/Brown Stringybark association which has an understorey structurally similar to some wet sclerophyll areas in the Otway Range and parts of eastern Victoria. The habitat of this honeyeater in GR as described by Cooper (1960) is dense gullies and thick tea-tree scrub growing on the slopes and tops of the ranges. Feeding. Recorded taking nectar from heath (*Epacris* sp.) flowers. Breeding. Cooper (1960) presents the following information: 'On September 6, 1959 in a gully in the Grampian Range, I found a nest that was being

built in the top of a clump of dead ferns that had fallen from an overhanging rockface. The nest was built into a small depression in the top of the ferns and its edges were unattached'. Five days later the nest contained eggs.

*Phylidonyris novaehollandiae*. New Holland Honeyeater.

Abundance and distribution. Common in ER, GR, AR and uncommon in HR; widespread throughout. Habitat. Plant associations with dense shrub layers. Feeding. Recorded taking nectar from the flowers of Yellow Gums, Crimson Bottlebrushes, *Cestrum parqui* (cultivated), Silver Banksias and Desert Banksias. Breeding. A common nesting species in GR (FWD survey; Wheeler and Pescott 1973; McCulloch 1973; RAOU nest card) and in AR (McCann pers. comm.).

*Phylidonyris albifrons*. White-fronted Honeyeater.

Abundance and distribution. Rare; not seen in FWD survey. Recorded in GR at Balmoral during late December 1972 (Mitchell 1973) and in AR at Stawell and Dadswell Bridge in 1972 (McCann pers. comm.). Habitat. Mainly confined to mallee vegetation which occurs N of the survey area.

*Cliciphila melanops*. Tawny-crowned Honeyeater.

Abundance and distribution. Uncommon and restricted to GR. Recorded along the upper Wannon River (McCann pers. comm.), in the Victoria Valley (FWD survey), at the SW end of Victoria Range (Middleton pers. comm.) and in the Black Range (Wheeler and Pescott 1973). Habitat. Heaths, usually in the lowlands. Breeding. Nests regularly along the upper Wannon River (McCann pers. comm.).

*Acanthorhynchus tenuirostris*. Eastern Spinebill.

Abundance and distribution. Uncommon and widespread; locally common during September in GR in Victoria Valley. Habitat. Tall open forests, open forests, low open forests, shrublands (Brown Stringybark) and heaths (particularly during spring). Rarely woodlands and suburban gardens. Feeding. Recorded taking nectar from flowers of Manna Gums, banksias and mistletoe. Breeding. Adults were feeding fledged young in GR near Balmoral in late December 1972 (McCulloch 1973).

EPHTHIANURIDAE (AUSTRALIAN CHATS)

*Epthianura albifrons*. White-fronted Chat.

Abundance and distribution. Uncommon, with

local concentrations, and widespread. Occasionally in flocks of up to 30 birds in each. Habitat. Open grassy pastures; occasionally margins of lakes and swamps. Breeding. A common nesting bird throughout SW Victoria with specific information being presented by McCulloch (1973) for GR; by Hill (1907a) and Cohn (1927) for AR; and by Sullivan (1928) and RAOU (nest card) for HR.

DICAEIDAE (FLOWERPECKERS AND ALLIES)

*Dicaeum hirundinaceum*. Mistletoebird.

Abundance and distribution. Uncommon and widespread. Habitat. Most tree-covered areas (particularly woodlands); it inhabits mistletoe which is parasitic on most eucalypt tree species in the survey area. Breeding. It nests in AR near Stawell (McCann pers. comm.).

PARDALOTIDAE (PARDALOTES)

*Pardalotus punctatus*. Spotted Pardalote.

Abundance and distribution. Common, particularly in GR, and widespread. Habitat. Open forests, particularly of Brown Stringybark; occasionally tall open forests, low open forests and shrublands. Breeding. In early December 1891, a nest with two young was in a burrow in the ground in GR (Anon. 1892). Wheeler and Pescott (1973) reported breeding in GR in October 1972.

*Pardalotus striatus*. Striated Pardalote.

Abundance and distribution. Common and widespread. Habitat. Woodlands (particularly of River Red Gum), open forests and shrublands. Characteristically an inhabitant of tree canopies. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

ZOSTEROPIDAE (WHITE-EYES)

*Zosterops lateralis*. Silvereye.

Abundance and distribution. Uncommon and widespread; usually in small flocks of up to 15 birds. Habitat. Most plant associations containing well-developed tree or shrub layers. Breeding. Young Silvereyes have been seen in the Western District of Victoria as early as the week ended 2 June (Sullivan 1928). Wheeler and Pescott (1973) reported breeding in GR on 18-19 October 1972.



## FRINGILLIDAE (FINCHES, BUNTINGS AND ALLIES)

*Carduelis carduelis*. European Goldfinch.

Abundance and distribution. Common in HR, uncommon in ER, GR and AR; widespread throughout. Introduced. Habitat. Pasture and grasslands. Breeding. Forty-six nests were examined in HR near Dunmore between 1964 and 1966 (RAOU nest cards). Eggs and young were present between September and February (inclusive). The clutch size was usually five eggs or, occasionally, four. Nesting recorded in GR (McGarvie pers. comm.).

*Carduelis chloris*. European Greenfinch.

Abundance and distribution. Uncommon; an introduced species recorded in small numbers in HR at Hamilton and Coleraine (Austin pers. comm.). Habitat. Suburban gardens.

## PASSERIDAE (OLD WORLD SPARROWS)

*Passer domesticus*. House Sparrow.

Abundance and distribution. Common, particularly in HR, and widespread; introduced. Habitat. Pastures, suburban gardens and towns. Breeding. Adults were feeding young in GR near Balmoral in late December 1972 (McCulloch 1973).

*Passer montanus*. Eurasian Tree Sparrow.

Abundance and distribution. Rare in western Victoria; one recorded in HR near Wannon in late March 1967 (Wheeler 1967b). Introduced.

## PLOCEIDAE (WEAVERS, WAXBILLS AND ALLIES)

*Emblema temporalis*. Red-browed Firetail.

Abundance and distribution. Uncommon and widespread. Habitat. Grassy areas, particularly those near dense shrub growth such as along watercourses or areas which are not heavily grazed. Feeding. Recorded taking grass seeds. Breeding. Adults were feeding fledged young in GR near Balmoral in late December 1972 (McCulloch 1973). A nest was in a wattle on SW end of Victoria Range in November 1955 (Midleton pers. comm.).

*Emblema guttata*. Diamond Firetail.

Abundance and distribution. Uncommon and widespread. Habitat. Open grassy areas in woodlands, pastures, open forests and suburban gardens. Breeding. Regularly nests in AR near Stawell (McCann pers. comm.). Adults were

feeding young in GR near Balmoral in late December 1972 (McCulloch 1973).

## STURNIDAE (STARLINGS, MYNAS AND ALLIES)

*Sturnus vulgaris*. Common Starling.

Abundance and distribution. Common and widespread with particularly large numbers in HR. As early as 1928 this introduced species was 'very common' in the Western District of Victoria (Sullivan 1928). Habitat. Pastures and near human habitation. Breeding. Nesting recorded in GR (McGarvie pers. comm.).

## ORIOOLIDAE (ORIOLES AND FIGBIRDS)

*Oriolus sagittatus*. Olive-backed Oriole.

Abundance and distribution. Rare; two seen in HR near Wannon in late March 1967 (Wheeler 1967b). One recorded in GR on W side of Victoria Range in November 1967 (McGarvie pers. comm.). Habitat. Generally confined to forested areas (Wheeler 1967a). Movements. A summer migrant to Victoria, although some winter here (Wheeler 1967a).

## CORCORACIDAE (AUSTRALIAN MUD-NESTERS)

*Corcorax melanorhamphos*. White-winged Chough.

Abundance and distribution. Uncommon and widespread; in small flocks of up to 30 birds. Habitat. Woodlands (River Red Gum, Yellow Gum and Yellow Box) and open forests (Brown Stringybark, Swamp Gum and Red Stringybark). Breeding. Recorded nesting in GR in the Black Range in October 1972 (Wheeler and Pescott 1973).

## GRALLINIDAE (MAGPIE LARKS)

*Grallina cyanoleuca*. Australian Magpie Lark.

Abundance and distribution. Common and widespread. Habitat. Pastures, crop lands, woodlands, suburban gardens and margins of standing water. Breeding. Adults were feeding young in a nest in GR near Balmoral in late December 1972 (McCulloch 1973).

## ARTAMIDAE (WOODSWALLOWS)

*Artamus personatus*. Masked Woodswallow.

Abundance and distribution. Uncommon, not seen in FWD survey. Recorded in GR along the E boundary (McCann pers. comm.) and near Rock-

lands Reservoir (Wheeler and Pescott 1973). Mixed flocks of masked and white-brows are regularly sighted in HR over Coleraine on their N migration and Austin (1972) gives details of such sightings for 3 November 1971. The White-browed Woodswallow predominates in the survey area. Habitat. A highly mobile species which may be seen in or over most habitats with woodlands being preferred in the survey area. Breeding. Both the Masked and White-browed Woodswallow nested near Portland in December of 1950 and 1952 and near Casterton in December 1962 (both areas are just W of HR). There were hundreds of nesting birds in approximately the ratio of ten white-browed to one masked. On these occasions they used only a small area of bushland, and several nests were in one tree (Austin 1972). Movements. The northward migration over Coleraine usually occurs during October and November (Austin 1972). Both the Masked and the White-browed Woodswallow mingle in mixed-species flocks and wander extensively over the continent, wintering mainly in the tropics (Frith 1969).

*Artamus superciliosus*. White-browed Woodswallow.

Abundance and distribution. Numbers fluctuate, occasionally common. Recorded in ER in the Tooan Block (FWD survey); in GR along the E boundary and near Rocklands Reservoir; and in HR over Coleraine (also see comments for Masked Woodswallow above). Habitat. As for Masked Woodswallow. Feeding. McCann (1964) gives a detailed description of this species feeding on Sugar Ants (*Camponotus* sp.) in GR. Wheeler and Pescott (1973) describe a large flock flopping in amongst Yellow Gum blossoms and feeding on insects and possibly nectar in GR near Rocklands Reservoir. Breeding. Nests with eggs or young were present in GR through the summer of 1963, until the middle of January 1964 (McCann 1964). Nests with eggs and young were in GR near Balmoral in late December 1972 (McCulloch 1973). Also see breeding information for Masked Woodswallow (above). Movements. As for Masked Woodswallow (above).

*Artamus cyanopterus*. Dusky Woodswallow.

Abundance and distribution. Common and widespread. Habitat. Woodlands and semi-cleared pastures, particularly those which provide perching sites as well as adequate open space for soaring and insect catching on the wing. Occasional in most other habitats where trees are present. Breed-

ing. Adults were feeding young in GR near Balmoral in late December 1972 (McCulloch 1973).

*Artamus minor*. Little Woodswallow.

Abundance and distribution. Rare. A single bird with a flock of Tree Martins was in ER near Edenhope in early September 1941 (Collins 1942), and a flock of 15 was in GR near Dunkeld on 8 March 1969 (Austin 1969; 1972).

CRACTICIDAE (BUTCHERBIRDS AND CURRAWONGS)

*Cracticus torquatus*. Grey Butcherbird.

Abundance and distribution. Rare. Single birds have recently been recorded in ER in the Kallungur and Dopewora Blocks (FWD survey) and along the road between Edenhope and Harrow (Wheeler 1964). In GR one was recorded in Victoria Valley (McGarvie pers. comm.) and two were seen near Rocklands Reservoir (Mitchell 1973). Habitat. Woodlands, shrublands and roadside trees in pastures. Conservation aspects. Austin (1951) comments that this species was once common throughout the whole of the SW district in Victoria, but it is now seldom seen. We suggest that more detailed studies on this bird over all of its range in Victoria might be required to ascertain its present status in relation to previous numbers and distribution.

*Gymnorhina tibicen*. Australian Magpie.

Abundance and distribution. Common and widespread. Habitat. All habitat types, but particularly pasture and crop lands. In ER on 3 October 1974 we counted 138 magpies along a secondary road between the Mt. Arapiles Block and Clear Lake (a distance of 24.5 km) or an average of about 5.6 magpies per km of road. Breeding. Many recently fledged young were present in ER during early October 1974. A high mortality of these young birds occurred along main roads where many were struck by vehicles. On 3 October 1974, we travelled 30 km on main roads around Horsham and counted 26 recently killed young (nearly one per km). Sullivan (1928), in commenting on the Western District of Victoria in general, indicated that young of the species were present as early as the 1st June.

*Strepera graculina* and *S. versicolor*. Pied and Grey Currawongs.

Abundance and distribution. Uncommon, with occasional local concentrations, and widespread. The forms of this genus are quite confusing in this part of the State and may require detailed

study to clarify the situation. Habitat. Light to moderately dense stands of timber. Breeding. Adult Pied Currawongs were feeding fledged young in GR near Balmoral in late December 1972 (McCulloch 1973).

#### CORVIDAE (CROWS)

*Corvus coronoides* and *C. mellori*. Australian and Little Ravens.

Abundance and distribution. During this survey, ravens were identified only to genus, but recent work by Rowley (1970) indicates that both Australian and Little Ravens are present. Ravens were common and widespread with a flock containing more than 1000 individuals near the coast between Lake Yambuk and Port Fairy on 21 February 1975. Habitat. Pasture and crop lands, but occasionally in all types of terrestrial habitats. Breeding. On 5 December 1974 we found a nest with two well-grown young in ER in the Morea Block. It was about 4 m from the top of a Yellow Gum (15 m tall) standing in the middle of a flooded depression in a woodland.

#### Appendix 6

Annotated list of mammals from the Grampians-Edenhope Area of southwestern Victoria

#### TACHYGLOSSIDAE (ECHIDNA)

*Tachyglossus aculeatus*. Echidna.

Abundance and distribution. Uncommon and widespread. Habitat. Most terrestrial habitats, ranging from wet cool areas in the Victoria and Mt. William Ranges, GR, to dry sandy environments with sparse vegetation in ER. Occasionally in pasture land, but usually near native vegetation. Most recent record, 1973 (FWD 9257). Observed in 1974-75 FWD survey.

#### ORNITHORHYNCHIDAE (PLATYPUS)

*Ornithorhynchus anatinus*. Platypus.

Abundance and distribution. Uncommon and restricted to major waterways (e.g. Wimmera, Wannon and Glenelg River systems). Habitat. The Platypus is an aquatic species which emerges from water only to enter burrows in stream banks. The burrows are excavated in friable silts along the streams and are vulnerable to stream bank alterations (e.g. stream 'improvements') or grazing of heavy domestic animals. Conservation aspects. There are few areas set aside for the conservation of this species in Victoria; GR offers an opportunity to protect a large area of its

habitat. The Wimmera River (once joined to the Murray River) has a population of Platypus which, in its present isolated state, may be of zoogeographic interest. Most recent record, 1970 (FWD 5269).

#### DASYURIDAE (MARSUPIAL CARNIVORES)

*Dasyurus maculatus*. Tiger Cat.

Abundance and distribution. Uncommon and apparently now restricted to the Stones Block, HR. Two individuals were trapped at one trapping site during the survey. Habitat. Manna Gum open forest with a ground layer of grass, Austral Bracken and many volcanic boulders (p.c.-22). The accumulation of rocks provides many small recesses and caves for den sites. During the breeding season males sometimes occur in adjacent pastures but these cleared areas do not support a permanent population. Breeding. Two individuals trapped in late February were juvenile males, approximately one-half to two-thirds grown. Adult and sexually active males have been recorded during the months of June, July and August. Conservation aspects. The Stones Block provides the best opportunity to protect and study the Tiger Cat in Victoria. Other areas where this species occurs, such as the Otway Range and East Gippsland, are so large and the observations are so scattered that no specific area within these can be defined with the certainty that a viable Tiger Cat population is included. Most recent record, 1975 (FWD 10020). Observed in 1974-75 FWD survey.

*Phascogale tapoatafa*. Tuan.

Abundance and distribution. Rare and widespread. Recorded in ER at Apsley and Telangatuk East; and in HR at Brit Brit, Cavendish, Bulart and Coleraine. Habitat. Woodlands (e.g. River Red Gum) and open forests (e.g. box) with grassy or sparse shrub undergrowth. These were formerly widely distributed on the plains of the survey area but are now restricted to river reserves and road margins. The extensive series of swamps and lakes in ER may provide enough woodland for small populations of Tuans to survive. Conservation aspects. Little is known about the biology of this species, which makes it difficult to suggest ways to improve its chances of survival. If the *status quo* of pasture to woodland ratio is maintained in the western plains the species may be adequately catered for. Woodlands, particularly roadside reserves, must be left untouched. Most recent record. One road-killed

specimen (NMV C13164) found during 1974-75 FWD survey.

*Antechinus flavipes*. Yellow-footed Antechinus.

Abundance and distribution. Uncommon and widespread. Recorded from all regions of the survey area but absent S of Hamilton, HR. A total of 35 individuals was trapped at 15 trapping sites and the maximum trapping rate was 4 per cent. Habitat. Woodland, open forest, low open forest and shrubland. In particular, Brown Stringybark low open forest and shrubland with tall dense heath underlayers which occur from the outwash sands of GR through to high sand dunes in ER. It occasionally occurs in wetter vegetation such as Messmate and Brown Stringybark open forest and is also recorded in swampy areas with Scent-bark and River Red Gum. Shrubs appear to be most important and where they are tall and dense, Yellow-footed Antechinus is recorded. The highest altitude at which it was recorded was 680 m. Trapped in p.c. (plant communities in Appendix 1)—6, 8, 14, 16, 18, 19, 20, 26, 31 and 33. Breeding. Trapping results indicate that male die-off was complete by mid-August. Females with pouch young were first recorded in early September; each female examined had 10 young. Lactating females without pouch young but each with 10 functioning teats were recorded in early October. The first of the year's offspring were trapped in early December and by March they had almost attained adult dimensions. Morphology. Individuals examined were of the typical *Antechinus flavipes flavipes* form as described by Wakefield and Warneke (1967). Mean dimensions for five adult female specimens are:

Weight (g)	Total Length (mm)	Tail Length (mm)	Pes (mm)	Ear (mm)
32	196	86	19	18

Most recent record. Collected in 1974-75 FWD survey (NMV C14052).

*Antechinus stuartii*. Brown Antechinus.

Abundance and distribution. Common and restricted; occurring throughout the ranges in GR and in the Stones Block, HR. A total of 89 individuals was recorded at 13 trapping sites with a maximum trapping rate of 29 per cent on Major Mitchell Plateau, GR. Habitat. Open forest, tall open forest and sub-alpine heath. In GR it was usually recorded in the ranges and foothills where the dominant trees were tall and of

typical forest form with a well-developed undergrowth of shrubs and dense herbs. However, much of the Grampians vegetation is stunted, particularly at high altitudes where adverse climatic conditions and rocky substrate have prevented significant growth. Broken rocky substrate and dense heaths on Major Mitchell Plateau supported a dense population of the Brown Antechinus. The habitat of the Stones Block was marginal and only one individual was recorded. Trapped in p.c.—1, 2, 6, 8, 9, 10, 12, 14, 22, 26, 28, 29, 30, 31 and 32. Breeding. Trapping results suggest that male die-off was complete by mid to late August. Most females captured in early September had pouch young; of 22 individuals examined, 20 had eight young, 1 had seven young and 1 had six young. All females examined had eight teats. Young examined on 8 September 1974 had crown-rump lengths of approximately 10 mm. In late October all animals trapped were adult lactating females without pouch young; juveniles were first recorded in early December. Young of the 1974 season reached adult dimensions in March 1975. Morphology. The animals recorded in the Grampians were similar to those described by Wakefield and Warneke (1967). Considerable variability was noted and weights varied in adults from 25 g for a female to a maximum 43 g for a male. Means of plastic characters measured on animals trapped between March and September are given below. The number of animals involved in each mean is given in brackets.

	Weight (g)	Total Length (mm)	Tail (mm)	Pes (mm)	Ear (mm)
Female	26.4(8)	190(20)	88(20)	18.1(19)	17.4(20)
Male	35.2(5)	211(5)	94.8(5)	17.6(5)	16.6(5)

The disparity between the number of animals in the weight sample and those used for linear measurements exists because wet specimens were measured but not weighed. Most pelage characteristics were similar to those in other Victorian populations. However, in some specimens from the survey area the orbital crescent, which is usually unnoticeable, was as prominent as that in *Antechinus flavipes* and there was a distinct (also similar to *A. flavipes*) antero-posterior differentiation in colour of the dorsal pelage, with the head and neck region being a steel, almost blue-grey hue changing abruptly to the 'normal' grizzled grey of the back. These animals were also larger than average and were sympatric with

*A. flavipes*. Most recent record. Collected in 1974-75 FWD survey (NMV C13961).

*Antechinus swainsonii*. Swainson's Antechinus.

Abundance and distribution. Common and restricted to GR and HR. Widespread in the Grampians ranges and occurs throughout the Stones and Mt. Napier Blocks, HR. Ninety-five animals were trapped at 14 trapping localities with a maximum trapping rate of 20 per cent. Habitat. Wet, dense shrub and herb layers which usually occur in areas with relatively high rainfall such as the major Grampians ranges and in dry areas along streams and around foothills of the major ranges where run-off results in luxuriant sedge and fern growth. In the Stones Block, HR, Austral Bracken rather than shrubs dominates the undergrowth and the aggregations of volcanic boulders provide numerous small caves and other recesses suitable for nesting. This is similar to the Lake Corangamite 'Stony Rises' which also support large *Antechinus swainsonii* populations (Emison *et al.* 1975). Trapped in p.c.—1, 2, 6, 7, 8, 9, 10, 12, 14, 22, 26, 28, 29, 31 and 32. Breeding. Male die-off had been completed before the start of the trapping programme on 13 August 1974. Females both with unused pouches and pouch young were recorded in mid-August. The one pouch litter examined possessed eight young on the eight available teats. At the beginning of September all animals trapped were lactating females without pouch young. The next trapping period was in late October when, of 25 individuals recorded, 22 were juveniles and there was a marked difference in juvenile size, suggesting either differing birth dates or growth rates. No second year females were recorded later than December. Morphology. Pelage characteristics and size were uniform throughout the survey area. Superficially, at least, the population in the survey area resembles the lowland populations from elsewhere in the State and contrasts markedly with the large dark animals of the moist highlands. Adult males were not trapped during the survey but means of the plastic characters for seven adult females are:

Total Length (mm)	Tail (mm)	Pes (mm)	Ear (mm)
224	99.0	20.6	17.4

Most recent record. Collected in 1974-75 FWD survey (NMV C13960).

z

*Sminthopsis murina*. Mouse Dunnart.

Abundance and distribution. Uncommon. There are two records for the survey area: a specimen collected 23 km NNW of Coleraine, HR, in 1962; and a trapping record in 1976 for the northern Victoria Valley, GR (Cockburn pers. comm.). It may be widespread in HR and ER. Habitat. Shrubland. In other parts of Victoria the Mouse Dunnart is associated with dry sandy environments such as mallee and Brown Stringybark shrubland. Large Crown Land blocks in ER (e.g. Jilpanger Block) have an environment similar to other parts of its range. Most recent record. 1962 (NMV C4510).

*Sminthopsis crassicaudata*. Fat-tailed Dunnart.

Abundance and distribution. Uncommon and widespread. Recorded in ER at Goroke and Telangatuk East; in AR at Stawell and Ararat; and in HR at Coleraine and Hamilton. The small number of records (14) is probably not a true indication of abundance because they are often confused with the House Mouse and both species are called 'field mice' in many country areas. Habitat. Grassy plains. The Fat-tailed Dunnart was undoubtedly a resident of the formerly widespread woodlands and grassy plains which once covered the Basalt Plains and Northern Plains of Victoria. These habitats have now been cleared to pasture land but Fat-tailed Dunnarts are still widespread and appear to survive well in some farm areas. Nest sites are usually located beneath logs, rocks or discarded farm implements. Most recent record. 1970 (NMV C9545).

#### PERAMELIDAE (BANDICOOTS)

*Isoodon obesulus*. Short-nosed Bandicoot.

Abundance and distribution. Common and restricted to GR and possibly AR. Recorded at Billywing, Halls Gap, Pomonal, northern Victoria Valley, Mt. Rosea and Teddy Bear Gap. Four animals were trapped at one locality with a maximum trapping rate of 3 per cent. Habitat. Dense herb layers in several different plant communities (e.g. moist swampy areas of heath usually in or near stands of trees, and wet stream side or swamp vegetation of sedges and Austral Bracken). Roadside reserves of sedges and grasses may support populations on the plains in AR. Short-nosed Bandicoots forage on lawns in Halls Gap and seek refuge in thick ground vegetation of Austral Bracken and sedges. Breeding. Three females examined on 10 September 1974 exhibited a wide range of breeding conditions. One was a

sub-adult although nearly full-grown, the second had three small unfurred pouch young and the third had four large furred pouch young which were close to leaving the pouch. Most recent record. Collected in 1974-75 FWD survey (NMV C14058).

*Perameles gunnii*. Gunn's Bandicoot.

Abundance and distribution. Uncommon and restricted. The last known population in Victoria occurs mainly in the city of Hamilton, HR, although recent specimen records indicate that the present range extends NW as far as Coleraine and S to Port Fairy. Recollections of landholders indicate that even within the last 50 years the species has been far more widespread and occurred throughout the plains and into the southern Victoria Valley of GR. They attribute the decline of the species to the upsurge of the Fox population. Habitat. Grassland and woodland. It formerly inhabited the grasslands on the volcanic plains but now occurs mainly in suburban gardens in Hamilton and some lightly farmed areas such as creekside and road reserves. Conservation aspects. The survival of this species in Victoria may be dependent upon adequate areas of suburban gardens remaining in Hamilton. In the long-term, it may be important to examine the predator-prey relationship between the Fox and this bandicoot before its re-introduction into areas where it previously occurred. Most recent record. 1971 (NMV C10997).

PHASCOLARCTIDAE (KOALA)

*Phascolarctos cinereus*. Koala.

Abundance and distribution. Common and restricted. The distribution of Koalas in the survey area is related to the liberation of animals in selected areas by FWD. As far as is known, no natural populations remained in the survey area after the decimation of Koalas in the late 1800s and early 1900s. Liberations began in 1947 and 1948 when groups of 12 and 16 animals respectively were released at Wartook Reservoir, GR. In 1957, 611 animals were released in the Halls Gap, GR, and Ararat, AR, areas. Several animals have recently been released in the Stones Block, HR. These releases have been successful and viable populations occur at each of these localities. Habitat. Open forest and woodland where suitable food trees are present. They occur in Manna Gum forests around Halls Gap, in the Stones Block and at Lake Wartook. Most recent record.

1971 (FWD 5444). Observed in 1974-75 FWD survey.

PHALANGERIDAE (LARGE POSSUMS)

*Trichosurus vulpecula*. Brush-tailed Possum.

Abundance and distribution. Common and widespread. Habitat. Most tree-covered areas; in some localities they may take shelter in sheds and the roofs of houses. Brown Stringybark shrubland which is extensive in ER and some parts of GR is unsuitable, possibly because there are few nest sites. Treeless pastures are not occupied but woodland roadside reserves are densely populated. With these few exceptions, all woodland and open forest is occupied and in GR droppings and tracks of this possum also occur throughout extensive rocky areas and broken cliffs. Most recent record. 1972 (FWD 8125). Observed in 1974-75 FWD survey.

PETAURIDAE (GLIDERS AND ALLIES)

*Pseudocheirus peregrinus*. Ring-tailed Possum.

Abundance and distribution. Uncommon and widespread. Recorded in ER at Mt. Arapiles and Nurrabiel; in GR at Victoria Valley, Mt. Frederick, Pomonal and Rocklands Reservoir; and in AR at Ararat. Habitat. River Red Gum, Yellow Box, Yellow Gum, Scent-bark, Brown Stringybark, Swamp Gum, Manna Gum and Messmate woodlands and open forests with dense shrub layers of banksias, tea-trees and wattles over 3 m tall. In GR such vegetation occurs along creeks and in some swamps, but not on dry slopes or in heath. This possum has also been reported among rock scree and on cliffs, although this was not observed during FWD survey. On the plains, cultivation has destroyed most of the original vegetation and the remnant Ring-tailed Possum populations are restricted to some roadside reserves and other reserves such as Mt. Arapiles. Most recent record. 1975 (FWD 10113). Observed in 1974-75 FWD survey.

*Petaurus breviceps*. Sugar Glider.

Abundance and distribution. Uncommon and widespread. Recorded in ER at Horsham; in GR at Rocklands Reservoir, Victoria Valley, Halls Gap, Pomonal and Mirranatwa Gap; in AR at Stawell; and in HR at Coleraine, Hamilton, Mt. Eccles and Tarrayoukyan. Habitat. River Red Gum, Yellow Gum and Yellow Box woodland and Scent-bark, Manna Gum and Swamp Gum open forest. In ER the glider is restricted

to swampy areas of River Red Gum and Yellow Gum woodland. The structure of the dominant tree species is important in determining Sugar Glider distribution and the presence of tall shrubs (e.g. Silver Wattle) may also be important. Most recent record. 1973 (FWD 9112). Observed in 1974-75 FWD survey.

*Petaurus norfolcensis*. Squirrel Glider (Plate 21, Fig. 5).

Abundance and distribution. Rare and restricted in the survey area. There are only two records in the survey area (both from AR): 5 km NW of Stawell in 1970; and Dadswell Bridge in 1968. The species is rare to uncommon throughout all of its Victorian range. Habitat. River Red Gum, Yellow Gum and Yellow Box woodlands on the plains. Most of these woodlands have been cleared for agriculture or devastated during the gold mining era. The small remaining areas are restricted to swamps and along roadsides and rivers. Squirrel Gliders have not been recorded in any of the major blocks of Crown Land. Most recent record. 1970 (NMV C9543).

*Petaurus australis*. Yellow-bellied Glider.

Abundance and distribution. Uncommon and restricted. Recorded in the Stones State Faunal Reserve, the Stones Block, HR. This population is isolated from those at Cape Otway and in the Portland district. Habitat. Manna Gum open forest. Characteristic 'V' gougings occur on many trees indicating that this glider occurs throughout the wildlife reserve. Conservation aspects. The established wildlife reserve provides an excellent opportunity to protect the species within a defined area. Most recent record. Observed in 1974-75 FWD survey.

#### BURRAMYIDAE (PIGMY POSSUMS)

*Acrobates pygmaeus*. Feather-tailed Glider.

Abundance and distribution. Uncommon but probably widespread in GR, AR and HR. Recorded in GR at Victoria Valley and in AR at Willaura. Habitat. River Red Gum, Yellow Gum and Yellow Box woodland and Manna Gum, Scent-bark and Swamp Gum open forest are probably suitable. A well-developed shrub layer of wattles is probably beneficial. The large areas of Brown Stringybark shrubland in ER and some areas of GR may be unsuitable. Most recent record. 1971 (NMV C10740). Observed in 1974-75 FWD survey.

*Cercartetus nanus*. Eastern Pigmy Possum.

Abundance and distribution. Uncommon and restricted. There is only one specimen from the survey area (Stawell in AR) but observations have been made at McKenzie Creek (Wakefield 1963b), The Pinnacle and Mirranatwa Gap, all localities in GR. Habitat. Open forest, heath and woodland. The observations at Mirranatwa Gap and The Pinnacle were in heathy areas with extensive broken rock and cliffs. Most recent record. 1965 (FWD P496).

*Cercartetus concinnus*. Western Pigmy Possum.

Abundance and distribution. Rare and probably restricted to ER. One specimen from Edenhope and an observation at Murrabiel constitute the only records from the survey area. The centre of the Victorian distribution of this species is in the mallee and banksia shrublands of the Little Desert, Big Desert and Sunset Country. Habitat. Mallee and Brown Stringybark shrublands, Yellow Gum and Black Box woodlands which have mid-dense shrub layers of proteaceous shrubs (e.g. banksias, hakeas, etc.) and some myrtaceous shrubs such as melaleucas. The species may also occasionally occur on farmland, usually in farm machinery (Wakefield 1963b). Most recent record. 1952 (NMV C2471). Observed in 1957 (Wakefield 1963b).

#### MACROPODIDAE (KANGAROOS AND WALLABIES)

*Potorous tridactylus*. Potoroo.

Abundance and distribution. Uncommon and restricted. Recorded from one locality near Pomonal, GR (Seebeck 1976). This population is isolated from others near Portland in the SW and Warrnambool in the SE. Habitat. Tall dense heath on wet sites. The optimum habitat is in the moist gullies under Swamp Gum open forest with dense layers of myrtles and tall sedges. It is less abundant on the adjacent drier slopes where Shining Peppermint is common and the shrub and herb layers are mid-dense. Most recent record. 1972 (FWD 8380).

Genus *Macropus*: Identification.

Three species of *Macropus* occur in the survey area. The Red-necked Wallaby, smaller than the two kangaroos, is distinctly marked and is not difficult to recognise. However, considerable difficulty was encountered in positively identifying animals of the Western and Eastern Grey

Kangaroo species. In the absence of blood protein analyses (Kirsch and Poole 1972), *ad hoc* identification criteria were devised by discussion with persons familiar with both species (e.g. J. K. Dempster) and by morphological and behavioural observations and resultant feedback in the field. Poole (1973) discusses species determination by using coat colour alone and found the grey or brown colouration of the forehead the only consistent distinguishing feature. Clearly, without shooting animals, the identification of forehead colouration would be difficult during the day and impossible at night. In order to obtain at least some meaningful observations we utilized the general colour difference between the two species. Eastern Grey Kangaroos in E Victoria are light grey and Western Grey Kangaroos in far NW Victoria are a distinct brown. By recording the occurrence of these extremes and disregarding the questionable intermediate forms (of which there were many), it was possible to determine some differentiation in habitat utilization and therefore distribution in the survey area. Previous confusion in the taxonomy of the grey kangaroo species precludes the use of specimen data.

*Macropus giganteus*. Eastern Grey Kangaroo.

Abundance and distribution. Common and widespread. Recorded in GR at Pomonal, Victoria Valley, Lake Wartook, Halls Gap, Billywing, Zumsteins, Mirranatwa and as far west as Rocklands Reservoir; and in HR in the Stones Block. Habitat. Open forests and woodlands with ground covers of grass and few shrubs. They are common in River Red Gum woodlands in the Victoria Valley and in open forest margins around Halls Gap where farmland and lawns provide ideal grazing conditions. The Stones Block contains Manna Gum open forest with a grass and Austral Bracken herb layer which adjoins cleared areas of old farmland. Short grasses and herbs for grazing, rather than shrubs for browsing, are prevalent in most Eastern Grey Kangaroo habitat. Breeding. Young at foot and in the pouch were present throughout the survey period. Most recent record. Observed in 1974-75 FWD survey.

*Macropus fuliginosus*. Western Grey Kangaroo.

Abundance and distribution. Recorded throughout major Crown Land blocks in ER and in GR as far east as the Serra Range. Western Grey Kangaroos are sympatric with Eastern Grey Kangaroos from Rocklands Reservoir through the Victoria Valley to the Serra Range. Habitat. Low

sandy sites covered by Brown Stringybark shrubland with a dry heath layer. Generally not recorded high in the ranges but occasionally on the foothills. This kangaroo often congregates (in some localities with Eastern Grey Kangaroos) around clearings or farmlands and emerges from cover at dusk to feed. Breeding. Young at foot and in the pouch were observed throughout the survey period. Most recent record. Observed in 1974-75 FWD survey.

*Macropus rufogriseus*. Red-necked Wallaby.

Abundance and distribution. Common and widespread. Recorded in ER in the Jilpanger, Toonan and Mt. Arapiles Blocks; in GR at Victoria Valley, Billywing, Mirranatwa, Black Range, Zumsteins and Halls Gap; and in HR at 5 km W of Bessiebelle. It was particularly common in Victoria Valley and at some of the other localities in GR, but less so in the smaller Crown Land blocks where local farmers suggest that '1080' poisoning has reduced populations. Habitat. Heath, shrubland, open forest and low open forest. Particularly common in Brown Stringybark low open forest with a heathy shrub layer and interspersed by clearings. This wallaby inhabits most mountainous areas and other moist shrub vegetation as well as most habitats occupied by the Western Grey Kangaroo. It emerges from cover at dusk to feed on grasses and regenerating shrubs in farmland and grassy woodland. Breeding. Young at foot and in pouch were observed throughout the survey period. Most recent record. Collected in 1974-75 FWD survey (NMV C13926).

*Petrogale penicillata*. Brush-tailed Rock Wallaby.

Abundance and distribution. Rare and restricted. Once common and widespread throughout rocky mountainous areas of Victoria but populations declined early this century. It is now restricted to two areas in the State, one in the Snowy River region of eastern Victoria and the other in a small area in the Victoria Range, GR. Since attention was drawn to the present population in GR (Wakefield 1971) extensive searches of nearby ranges have failed to uncover any other existing populations although old faecal material and caves which may have been used by rock wallabies were found at Mt. Stapylton and in the Hut Creek Gorge. Habitat. Rugged rocky areas. In the Victoria Range sandstone cliffs and stacks of broken rock have formed caves and shelter. The vegetation is sparse Brown Stringybark trees and a scattered growth of shrubs such as hakeas



and casuarinas. Conservation aspects. The size of the population in GR is unknown and it is difficult to know the wisest course to pursue for their conservation. One possibility is to ensure that they remain undisturbed although a study of them might lead to an understanding of the reason for their decline. Such knowledge and an active propagation programme might allow reinstatement not only throughout GR but at Mt. Arapiles and the eastern highlands as well. Most recent record. 1971 (Wakefield 1971).

#### LEPORIDAE (HARES AND RABBITS)

##### *Lepus europaeus*. Hare.

Abundance and distribution. Probably uncommon and widespread in AR and HR. Introduced into Australia last century, the species has spread widely through farming areas and some alpine areas of eastern Australia. Habitat. Grassy plains. It is probably now restricted to farmland on plains. Most recent record. None.

##### *Oryctolagus cuniculus*. Rabbit.

Abundance and distribution. Common and widespread. Introduced into Australia last century and now present throughout the survey area. Habitat. Most terrestrial environments except extensive rocky areas, dense wet forest and well-managed farmland. It inhabits virtually all types of vegetation. Most recent record. Observed in 1974-75 FWD survey.

#### MURIDAE (RATS AND MICE)

##### *Rattus fuscipes*. Bush Rat.

Abundance and distribution. Common and restricted. Recorded in HR at the Stones and Mt. Napier Blocks; 106 animals were trapped at two trap sites with a maximum trapping rate of 30 per cent. Apparently absent from suitable habitat in GR although remains are present in subfossil deposits (Wakefield 1963a). Animals in HR appear to represent the eastern limit of distribution of the subspecies *R. f. greyi*. Habitat. The vegetation in the Stones Block is mainly Manna Gum open forest with a herb layer of Austral Bracken and grasses over a stony substrate which contains a labyrinth of small holes and tunnels. Most recent record. Collected in 1974-75 FWD survey (NMV C13560).

##### *Rattus rattus*. Black Rat.

Abundance and distribution. Common and widespread; 34 individuals were trapped at 13 trap

sites in GR and ER (Mt. Arapiles Block) with a maximum trapping rate of 4 per cent. An exotic species which is now established in urban, rural and some natural surroundings. Habitat. In GR and at Mt. Arapiles (ER) the Black Rat occurs in rocky areas or near creeks, these being amongst the few areas in which it is not closely associated with man. In other parts of its Victorian range this rat inhabits rural areas in and around farm buildings and thrives in some urban environments, particularly rubbish dumps. Trapped in p.c.—6, 7, 8, 9, 10, 14, 15, 16, 21, 26, 29, 30, 31 and 43. Most recent record. Collected in 1974-75 FWD survey (NMV C13958).

##### *Rattus lutreolus*. Swamp Rat.

Abundance and distribution. Common and widespread. Recorded in GR at Halls Gap, Victoria Valley, Mt. William, Lake Wartook, Black Range, Mirranatwa Gap, Pomonal and Dunkeld; and in HR at Byaduk and Mt. Napier; 210 animals were trapped at 14 trap sites with a maximum trapping rate of 26 per cent. Habitat. A wide range of environments are occupied, from warm lowlands at Byaduk (HR) to cold sub-alpine conditions on 1160 m Mt. William (GR). Mid-dense to dense herb cover of approximately 0.3 m high is essential. Such vegetation most commonly occurs in tall dense heaths and sedge swamps such as those in Victoria Valley and in sub-alpine heaths in GR. In drier areas its distribution is restricted to dense vegetation along creeks. It has been reported from farmland margins E and SE of Dunkeld (Munro pers. comm.). It is not known how widely it is distributed in the open plains. Trapped in p.c.—1, 2, 6, 7, 8, 9, 10, 12, 14, 15, 16, 26, 28, 29, 30, 31, 32 and 33. Breeding. Males with prominent scrota but undescended testes were recorded during September; one scrotal male was recorded in March. Juveniles were first recorded in early December and were still present during March. Most recent record. Collected in 1974-75 FWD survey (NMV C13957).

##### *Rattus norvegicus*. Sewer Rat.

Abundance and distribution. Uncommon and restricted. The only record for the survey area is a specimen from Hamilton, HR. This species has spread in association with towns since its introduction from Europe. Habitat. Urban environments. The specimen was collected in tall grass beside a creek in Hamilton. Most recent record. Collected in 1974-75 FWD survey (FWD 9804).

*Pseudomys albocinereus*. Silky Desert Mouse.

Abundance and distribution. Uncommon and restricted. Recorded in ER in Jilpanger, Kallungar and Yallakar Blocks; 24 animals were trapped at four trap sites with a maximum trapping rate of 13 per cent. Habitat. High sand dunes covered by Brown Stringybark shrubland with a sparse to mid-dense layer of shrubs such as Silky Tea-tree and Desert Banksia (p.c.—17 and 18). Elaborate burrows are dug into the sides of the sandhills. Breeding. A female trapped on 8 October 1974 had three large (20 mm) embryos. A female caught on 10 December 1974 was pregnant and gave birth to three young in captivity on 13 December. An adult scrotal male was trapped on 13 December. All animals trapped in mid-April were sub-adult males and females. Most recent record. Collected in 1974-75 FWD survey (NMV C14054).

*Pseudomys fumeus*. Smokey Mouse.

Abundance and distribution. Uncommon and restricted. Recorded in GR at Mirranatwa Gap, Major Mitchell Plateau, Mt. William, Silverband Falls and both the northern and southern portions of Victoria Range; 33 individuals were recorded from four trap sites with a maximum trapping rate of 14 per cent. This is an endemic Victorian species although it may eventually be recorded in some sub-alpine regions of New South Wales. Habitat. In GR it is restricted to dense wet undergrowth in tall open forests and sub-alpine heaths of the high ranges. Elsewhere in Victoria it has been recorded in moist undergrowth of some open forest, fern gullies in tall vegetation both on broken rocky mountain tops and on hillsides. Breeding. Scrotal males were trapped in October and November of 1974. A pregnant female trapped in early November gave birth to three young in captivity in early December. Other females trapped in early November were not pregnant. Most recent record. Collected in 1974-75 FWD survey (FWD 9942).

*Pseudomys shortridgei*. Heath Rat.

Abundance and distribution. Common and widespread throughout GR; 83 animals were trapped at 10 trapping sites with a maximum trapping rate of 11 per cent. It occurs only in the SW corner of Victoria. Habitat. Heath and open forest with heath undergrowth. The distributions of this species and of the Smokey Mouse are almost mutually exclusive. Trapped in p.c.—6, 8, 14, 15, 16, 26, 29, 30 and 31. Breeding. A pregnant fe-

male was trapped in early December 1974. During the survey no single period of the year had an influx of juveniles, although sub-adults and juveniles were always present. Most recent record. Collected in 1974-75 FWD survey (NMV C13175).

*Mus musculus*. House Mouse.

Abundance and distribution. Common and widespread. An exotic species recorded throughout ER, GR and HR. It probably occurs in AR; 153 individuals were trapped at 16 trap sites with a maximum trapping rate of 18 per cent. Habitat. Most plant formations, particularly where herb cover is sparse and tall shrub layer (e.g. 2 m) is well developed; exceptions are sub-alpine heath and tall open forest. Most recent record. Collected in 1974-75 FWD survey (NMV C13953).

*Hydromys chrysogaster*. Eastern Water Rat.

Abundance and distribution. Uncommon and restricted. Recorded in ER at Horsham and Toolondo Reservoir; in GR at Fyans Creek, Silverband Falls, Pomonal, Stony Creek, Halls Gap and Mirranatwa Gap; and in AR at Lake Lonsdale. Habitat. Usually in or near freshwater lakes and swamps on the plains; occasionally in both upper fast-flowing and lower tepid stream sections. Most recent record. 1974 (FWD 9541). Observed in 1974-75 FWD survey.

## CANIDAE (DOGS AND FOXES)

*Vulpes vulpes*. Fox.

Abundance and distribution. Common and widespread. An exotic species recorded in ER at Jilpanger Block; in GR at Pomonal, Black Range, Lake Wartook and Victoria Valley; and in HR at the Stones Block. Habitat. Common in pasture lands and present throughout most areas of native vegetation. Most recent record. 1971 (FWD 5664). Observed in 1974-75 FWD survey.

## FELIDAE (CATS)

*Felis catus*. Cat.

Abundance and distribution. Uncommon and widespread throughout the survey area. Habitat. Most terrestrial environments with the possible exception of wet and cold areas such as sub-alpine heath on Mt. William. Conservation aspects. Feral populations of this species should be studied to determine the impact of its predation on native vertebrate populations. Control of some feral populations of this species in Victoria is neces-

sary. Most recent record. Observed in 1974-75 FWD survey.

#### SUIDAE (PIGS)

*Sus scrofa*. Pig.

Abundance and distribution. Rare and restricted (if extant). Audas (1925) recorded an earlier undated occurrence in both the Victoria and Wartook Valleys, GR. They are now absent from these areas. There are some recent unconfirmed reports of wild pigs in the Wannoo River area NE of Dunkeld, GR. Habitat. Areas surrounding swamps and marshes.

#### CERVIDAE (DEER)

*Cervus elaphus*. Red Deer.

Abundance and distribution. Uncommon and restricted. Recorded in GR at Victoria and Wartook Valleys, Billywing, Zumsteins and Lake Bellfield. Habitat. Open forests and woodlands with grass layers and tall sparse shrub undergrowth; some swamps and reservoir margins provide emergent vegetation which is grazed. Shrublands and heaths are seldom occupied. Most recent record. Observed in 1974-75 FWD survey.

#### BOVIDAE (CATTLE, SHEEP AND GOATS)

*Capra hircus*. Goat.

Abundance and distribution. Uncommon and restricted. Recorded throughout GR and in HR (reported by local land holders) in the Stones Block. Habitat. In GR tracks, droppings and camp sites were found in rocky localities on all of the major ranges; signs were most common in steep rugged areas. Typical situations included overhangs and caverns for camp sites and vegetation between rocks and on lower slopes for grazing. Some semi-tame animals were seen near Halls Gap but the large herds occurred in the Victoria Range. The Stones Block in HR has a rocky substrate with a grass and Austral Bracken layer beneath a Manna Gum open forest. Most recent record. Observed in 1974-75 FWD survey.

*Ovis aries*. Sheep.

Abundance and distribution. Uncommon and restricted. A feral population occurs in HR in the Stones Block. Habitat. Manna Gum open forest with grass and Austral Bracken beneath. Most recent record. Observed in 1974-75 FWD survey.

#### CHIROPTERA (THE BATS)

The species list of bats occurring in the survey area is incomplete and little is known of the habits of the species recorded. Only small insect-eating bats (microchiropterans) are resident in the area. The following annotated list includes species likely to occur in the survey area as well as those known to be present. Their likely abundance and distribution are listed.

#### VESPERTILIONIDAE (ORDINARY SMALL BATS)

*Nyctophilus timoriensis*. Greater Long-eared Bat.

Abundance and distribution. Uncommon and widespread. Habitat. Woodland and open forest. Most recent record. Recorded by Wakefield (1963a) in subfossil deposits. Most recent record. 1977 (Parnaby pers. comm.).

*Nyctophilus geoffroyi*. Lesser Long-eared Bat.

Abundance and distribution. Common and widespread. Recorded in GR at Woohlpooer, in AR at Bellellen and in HR at Hamilton. Habitat. Woodland and open forest. Most recent record. 1971 (FWD 6832). Individuals captured in 1977 (Parnaby pers. comm.).

*Miniopterus schreibersii*. Bent-winged Bat.

Abundance and distribution. Probably common and widespread. Habitat. Woodland and open forest wherever suitable caves are present.

*Chalinolobus gouldii*. Gould's Wattled Bat.

Abundance and distribution. Common and widespread. Habitat. Woodland and open forest. Most recent record. Observed in 1974-75 FWD survey. Individuals captured in 1977 (Parnaby pers. comm.).

*Chalinolobus morio*. Chocolate Bat.

Abundance and distribution. Common and widespread. Habitat. Woodland and open forest. Most recent record. Individuals captured in 1977 (Parnaby pers. comm.).

*Eptesicus pumilus*. Little Bat.

Abundance and distribution. Common and widespread. Habitat. Woodland and open forest. Most recent record. 1971 (FWD 6807). Individuals captured in 1977 (Parnaby pers. comm.).

*Pipistrellus tasmaniensis*. Tasmanian Pipistrelle.

Abundance and distribution. Only recently recorded in Victoria but found to be widespread

(Parnaby pers. comm.); recorded in GR. Habitat. Woodland and open forest. Most recent record. Individuals captured in 1977 (Parnaby pers. comm.).

*Myotis adversus*. Large-footed Bat.

Abundance and distribution. Rare and widespread. Habitat. Caves in woodland and open forest.

*Nycticeius greyi*. Little Broad-nosed Bat.

Abundance and distribution. Uncommon but possibly widespread in northern and western portions of the survey area. Habitat. Hot dry areas. Most recent record. Individuals captured in 1977 (Parnaby pers. comm.).

#### MOLOSSIDAE (MASTIFF BATS)

*Tadarida australis*. White-striped Bat.

Abundance and distribution. Probably common and widespread over most habitats in the survey area. Most recent record. 1964 at Dadswell Bridge, AR (McCann pers. comm.).

*Tadarida planiceps*. Little Flat Bat.

Abundance and distribution. Possibly common in the warm northern and western portions of the survey area. Most recent record. See Wakefield (1974).

#### EMBALLONURIDAE (SHEATH-TAILED BATS)

*Taphozous flaviventris*. Yellow-bellied Bat.

Abundance and distribution. Not recorded from survey area but possibly rare and widespread.

Appendix 7.—Annotated list of reptiles from the Grampians-Edenhope Area of southwestern Victoria

#### CHELIDAE (SIDE-NECKED TORTOISES)

*Chelodina longicollis*. Long-necked Tortoise.

Abundance and distribution. Common in the Glenelg and Wimmera River systems and in lakes in ER, GR and HR. Recorded in ER at Lake Charlegark, 10 km SSE of Gymbowen, Edenhope, 14 km SE of Edenhope, and 5 km E of Clear Lake; and in GR at Moora Moora Reservoir. Habitat. Tepid freshwater streams and lakes in the plains are most suitable; cold fast-flowing mountain streams are unsuitable. Most recent record. 1964 (NMV D10898). Observed in 1974-75 FWD survey.

#### AGMIDAE (DRAGON LIZARDS)

*Amphibolurus barbatus*. Bearded Dragon.

Abundance and distribution. Common throughout survey area except, apparently, S of Hamilton, HR. Recorded in ER at Toolondo Reservoir, Mt. Arapiles, 10 km N of Apsley, North Lake, and Clear Lake Road 5 km NE of Douglas; in GR at Muline Creek and Rocklands Reservoir; and in AR at Horsham, Stawell, Pomonal and 11 km NW of Dadswell Bridge. Habitat. Woodlands, particularly of Yellow Gum and River Red Gum; also pastures if trees (e.g. roadside reserves) or fences are present. Most recent record. 1969 (NMV D14085). Observed in 1974-75 FWD survey.

*Amphibolurus diemensis*. Mountain Dragon.

Abundance and distribution. Rare; restricted to the ranges of GR. This is the western extremity of a patchy distribution which includes the eastern highlands and Tasmania. Habitat. Tall open forests, wetter forms of open forests and sub-alpine heaths. Most recent record. About 1970 (specimen in the South Australian Museum).

*Amphibolurus muricatus*. Jacky Lizard.

Abundance and distribution. Common throughout survey area except, apparently, S of Hamilton, HR. Recently recorded in ER at Jilpanger Block; in GR at Mt. Cassel; and in AR at Pomonal. Habitat. Open forest, shrubland and woodland, particularly areas of Brown Stringybark with heath undergrowth. Most recent record. 1969 (NMV D17574). Observed in 1974-75 FWD survey.

*Amphibolurus pictus*. Painted Dragon.

Abundance and distribution. Only found in the Jilpanger Block ER, but its distribution probably includes other Crown Land blocks in ER. Habitat. Shrublands of Brown Stringybark and Desert Banksia; mainly on sands or, occasionally, on dry claypans. Most recent record. Collected in 1974-75 FWD survey (NMV D33445).

#### GEKKONIDAE (GECKOS)

*Diplodactylus tessellatus*. Tessellated Gecko.

Abundance and distribution. Two specimens, dated 1905, exist from Clear Lake, ER. It is an inland species which may still occur in the survey area. Habitat. Unknown. Most recent record. 1905 (NMV D226).

*Phyllodactylus marmoratus*. Marbled Gecko.

Abundance and distribution. Common and widespread throughout ER, GR and AR but apparently absent from HR. Recorded in ER at 17 km SW of Edenhope and Mt. Arapiles; in GR at 16 km W of Halls Gap, 1 km N of Halls Gap, Asses Ears and Black Range; and in AR at Ararat, Stawell, and Black Range S of Stawell. Habitat. Usually rocky outcrops such as occur in the Grampians or at Mt. Arapiles; occasionally in woodland beneath shedding bark and in or under logs. Most recent record. Collected in 1974-75 FWD survey (NMV D33436).

## PYGOPODIDAE (SNAKE-LIZARDS)

*Delma inornata*.

Abundance and distribution. Uncommon; four specimens from Stawell, AR. It probably occurs in other dry warm areas of AR and possibly in dry peripheral areas of GR. Habitat. Usually dense ground cover of shrubs in dry vegetation. Most recent record. 1956 (NMV D15463).

*Delma impar*.

Abundance and distribution. Originally widespread, but no specimens from the survey area since 1904. Recorded in ER at Horsham; and in HR at Hamilton and Byaduk. Habitat. Grasslands such as occurred on the basalt plains. Most recent record. 1904 (NMV R10883).

## SCINCIDAE (SKINKS)

*Anotis maccoyi*.

Abundance and distribution. Recorded in GR at White Bull Swamp and Major Mitchell Plateau; and in HR at Coleraine. Habitat. Sub-alpine heath, wetter forms of open forest and woodland. Most recent record. Collected in 1974-75 FWD survey (NMV D33432).

*Cryptoblepharus boutonii*.

Abundance and distribution. Common at Mt. Arapiles and probably widespread throughout the rest of ER. There is also a doubtful 1887 record from GR. Habitat. Woodland. It is primarily arboreal and is most common in Yellow Gum woodland where shedding bark and splitting logs and trunks provide ideal refuge sites. Most recent record. Collected in 1974-75 FWD survey (FWD 9956).

*Ctenotus robustus*.

Abundance and distribution. Uncommon and

widespread in survey area. Recorded in ER at Lake Charlegrark, Mt. Arapiles and Meereek Block; in GR at Victoria Gap and Victoria Valley; and in AR at Black Range S of Stawell. Habitat. Open warm environments, usually on sandy soils and adjacent to rocky outcrops and boulders where they seek shelter. Open forest, woodland and shrubland are all utilized. Most recent record. Collected in 1974-75 FWD survey (NMV D33439).

*Egernia luctuosa*. Mourning Skink.

Abundance and distribution. Rare; probably restricted to GR. One specimen collected near the junction of Goat Track and Victoria Range Road in the Victoria Range. Habitat. The specimen was collected in a heathy swamp at a high altitude. It occurs in swamps elsewhere in Victoria. Most recent record. 1971 (NMV D17299).

*Egernia saxatilis*. Black Rock Skink.

Abundance and distribution. Common on most rocky ranges in the survey area. Recorded in ER at Mt. Arapiles; in GR at Hut Creek Gorge, Victoria Range and Mt. Rosea Track; and in AR at Stawell. Habitat. Rocky areas. It basks on rock surfaces, forages in adjacent vegetation and shelters beneath exfoliating rocks. Most recent record. Collected in 1974-75 FWD survey (NMV D33441).

*Egernia whitii*. White's Skink.

Abundance and distribution. Common and widespread throughout the survey area although its distribution is patchy. Recorded in GR at Mt. William and Black Range; in AR at Stawell and Ararat; and in HR at Byaduk, Lake Condah near Heywood, 10 km N of Narrawong, and the Stones State Faunal Reserve. Habitat. Usually rocky substrates. However, unlike *E. saxatilis*, it is not confined to open rocky expanses, but basks on isolated rocks, forages widely through usually sparse low vegetation, and seeks refuge by digging sometimes elaborate burrows in soil beneath rocks. Most recent record. Collected in 1974-75 FWD survey (NMV D33426).

*Hemiergis decresiensis*.

Abundance and distribution. Common; restricted to the N portion of the survey area. Recorded from ER at Mt. Arapiles and 8 km SW of Nati-muk. Habitat. Warm environments, usually associated with rocky substrates. Most recent record. Collected in 1974-75 FWD survey (NMV D33434).

*Hemiergis peronii*.

Abundance and distribution. Not recorded in 1974-75 FWD survey but recent NMV specimens are listed for Stawell, AR. Habitat. The NMV specimens were from an old building site in farmland. Most recent record, 1976 (NMV D48291).

*Lampropholis delicata*.

Abundance and distribution. Uncommon; probably widespread in ER and it may occur in GR and AR. Recorded in ER at Jilpanger Block and 10 km SSE of Miga Lake. Habitat. Woodlands with much bark and leaf litter; often occurring beneath logs, particularly in Yellow Gum woodland. Most recent record. Collected in 1974-75 FWD survey (NMV D33446).

*Lampropholis guichenoti*.

Abundance and distribution. Common and widespread. Recorded in ER at Mt. Arapiles; in GR at Victoria Valley, Woohlpooer, Mt. Zero, and 13 km S of Halls Gap; in AR at 13 km S of Stawell; and in HR at Coleraine and the Stones State Faunal Reserve. Habitat. Most forest and woodland formations; particularly common in open areas with exposed rocky surfaces such as in GR. Most recent record. Collected in 1974-75 FWD survey (NMV D33428).

*Leiopisisma entrecasteauxii*.

Abundance and distribution. Uncommon in GR and HR. Recorded in GR at Mt. Rosea, Mt. William, and Victoria Valley; and in HR at Byaduk and 15 km W of Yambuk. Habitat. Usually grassy areas in open forest, woodland or pasture land. At high altitudes (e.g. Mt. William) it often basks and seeks shelter among rock screes. Most recent record. Collected in 1974-75 FWD survey (FWD 9933).

*Leiopisisma trilineata*.

Abundance and distribution. Common in GR and HR. Recorded in GR at Lake Wartook, Mt. Rosea, and 6 km W of Dunkeld; and in HR at Byaduk. Habitat. Most forest and woodland formations; usually in clearings often associated with low shrubs or grassland. Most recent record. Collected in 1974-75 FWD survey (FWD 9932).

*Leiopisisma coventryi*. Coventry's skink.

Abundance and distribution. Uncommon; restricted to GR. Recorded at Strahans Camp (Victoria Valley) and 3 km SE of Mt. Victory. Habi-

tat. Tall open forest and wetter forms of open forest including sub-alpine heath. Most recent record. 1970 (NMV D38185).

*Lerista bougainvillii*.

Abundance and distribution. Uncommon and widespread. Recorded in ER at Mt. Arapiles and 17 km SW of Edenhope; in GR at 1.5 km N of Halls Gap, Lake Wartook, Victoria Valley, Chimney Pots, and 3 km ESE of Mt. Victory; and in AR at Stawell, Black Range S of Stawell, and 13 km S of Stawell. Habitat. Open forest, woodland and a small area of mallee at Mt. Arapiles. Friable sandy soils, large accumulations of litter and a warm climate are other factors important in influencing the distribution of this species. Most recent record. Collected in 1974-75 FWD survey (FWD 9955).

*Morethia adelaidensis*.

Abundance and distribution. Rare; distribution is unknown. Recorded in ER near Lake Charlegrark; in GR (a general record from 1892); and in HR at 13 km S of Stawell. Habitat. Possibly woodland. Most recent record. 1963 (NMV D15064).

*Morethia boulengeri*.

Abundance and distribution. Common in ER and GR. Recorded in ER at Mt. Arapiles and 8 km SW of Natimuk; and in GR at Tower Hill. Habitat. Woodland and pasture land if objects suitable to shelter under are present. Most recent record. Collected in 1974-75 FWD survey (NMV D33438).

*Morethia obscura*. Ocellated Skink.

Abundance and distribution. Common; restricted to major Crown Land blocks in ER. Recorded in the Jilpanger Block at several localities and in the Meereek Block. Habitat. Brown Stringybark shrubland with heath underneath on dry sandy soils. Most recent record. Collected in 1974-75 FWD survey (FWD 9953).

*Sphenomorphus tympanum*. Cool Temperate Form.

Abundance and distribution. Common and widespread in ER, GR and HR. Specimens come from throughout the Grampians Ranges and the Stones State Faunal Reserve. Habitat. Moist sites, usually near streams. In GR records are usually associated with streams and tall open forest whereas in the Stones State Faunal Reserve in HR records are

from rocky areas. Most recent record. Collected in 1974-75 FWD survey (NMV D33424).

*Sphenomorphus* sp. Warm Temperate Form.

Abundance and distribution. One specimen is from Great Western on E edge of AR; the species may occur elsewhere on the plains of AR. Habitat. Streams or other moist environments usually in otherwise dry and warm areas. Most recent record. The Australian Museum in Sydney holds the above-mentioned specimen (Rawlinson pers. comm.).

*Tiliqua nigrolutea*. Blotched Blue-tongued Lizard.

Abundance and distribution. Uncommon and widespread in AR and HR. Habitat. Tall open forest, sub-alpine heath and coastal heath. Most recent record. About 1970 (Rawlinson pers. comm.).

*Tiliqua scincoides*. Eastern Blue-tongued Lizard.

Abundance and distribution. Uncommon and widespread in ER, GR and HR. Habitat. Woodland and grassland. Most recent record. About 1970 (Rawlinson pers. comm.).

*Trachydosaurus rugosus*. Shingle-back.

Abundance and distribution. Common and widespread in ER, GR and HR. Recorded in ER at Horsham, Mt. Arapiles, and Jilpanger Block; in GR at 3 km W of Halls Gap, and Red Rock; and in HR at Hamilton and Cavendish. Habitat. Virtually all environments except high cool ranges of GR. Open forest, shrubland, woodland, pasture land and heath are all inhabited. Most recent record. 1964 (NMV D40046). Observed in 1974-75 FWD survey.

#### VARANIDAE (MONITOR LIZARDS)

*Varanus gouldii*. Sand Monitor.

Abundance and distribution. No specimen records exist, but local farmers describe two species of goanna in the area and some burrows observed in the Jilpanger Block, ER, suggest that the Sand Monitor is present. If the species does occur in the survey area it probably is restricted to ER. Habitat. Shrubland on sandy soil. Most recent record. None.

*Varanus varius*. Lace Monitor.

Abundance and distribution. Uncommon and restricted to ER and AR. Recorded in ER at Mt. Arapiles and in AR at Illawarra. Habitat. Wood-

land with a grassy or sparse shrub underlayer. Most recent record. Collected in 1974-75 FWD survey (NMV D33442).

#### ELAPIDAE (ELAPID SNAKES)

*Austrelaps superba*. Lowlands Copperhead.

Abundance and distribution. Uncommon and restricted to GR and HR. Recorded in GR at 5 km N of Dunkeld and at Mt. William; and in HR at Macarthur, Hamilton, 3 km NE of Hamilton, Coleraine and 10 km W of Macarthur. Habitat. Lowland swamps, sub-alpine heath and possibly tall open forest. Most recent record. 1964 (NMV D40068). Observed in 1974-75.

*Drysdalia coronoides*. White-lipped Snake.

Abundance and distribution. Uncommon and restricted to GR and possibly HR. Two specimens exist, both from GR. Habitat. Grasslands on the plains and along the coast; clearings in tall open forest and sub-alpine heath. Most recent record. 1970 (NMV D33169).

*Notechis scutatus*. Eastern Tiger Snake.

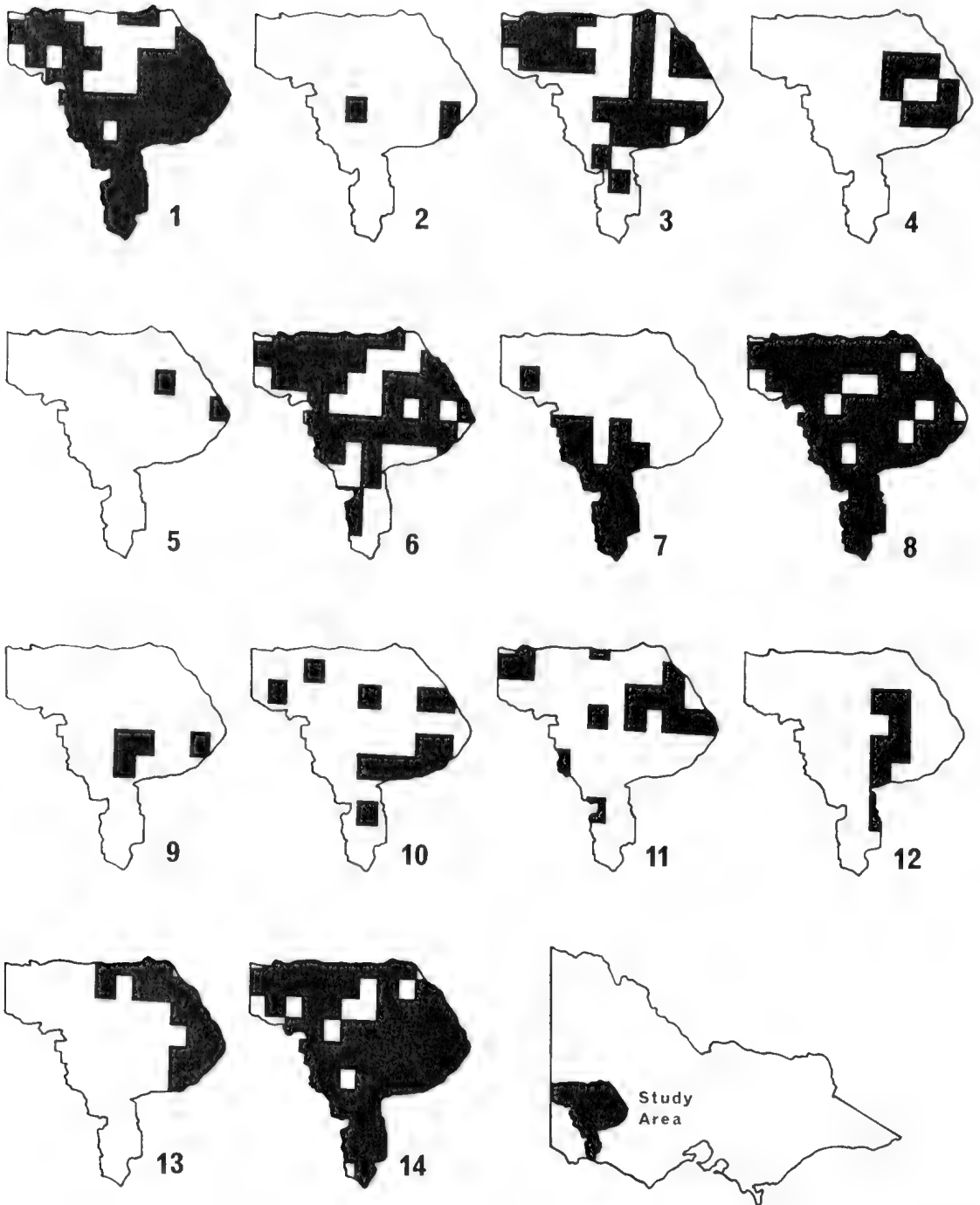
Abundance and distribution. Common and widespread. Recorded in ER at Douglas; in GR at 16 km NE of Dunkeld, 10 km E of Halls Gap, and 8 km NW of Moora Moora Reservoir; and in HR at Cavendish and the Stones State Faunal Reserve. Habitat. Usually low-lying swamps and possibly some wet sites in open forest of GR. Most recent record. Collected in 1974-75 FWD survey (NMV D42234).

*Pseudechis porphyriacus*. Red-bellied Black Snake.

Abundance and distribution. Uncommon and apparently restricted to GR and the Wimmera River System, ER. Recorded in GR at 8 km NW of Moora Moora Reservoir and 10 km N of Halls Gap. Habitat. Usually along streams or swamps; rarely among rocks and cliffs on hillsides. Most recent record. Collected in 1974-75 FWD survey (NMV D33449).

*Pseudonaja textilis*. Eastern Brown Snake.

Abundance and distribution. Common and widespread throughout all except HR. Recorded in ER at Edenhope, St. Marys Lake, Tooan Block, Mt. Arapiles Block, Natimuk, and 5 km N of Douglas; in GR at Flat Rock Crossing, Mt. William Road, Victoria Valley, and Glenisla Crossing; and in AR at Stawell. Habitat. All plant formations at low altitudes (i.e. pasture, wood-





land, heath, open forest and shrubland). Most recent record. Collected in 1974-75 FWD survey (NMV D33422).

*Unechis flagellum*. Little Whip Snake.

Abundance and distribution. Uncommon. Recorded in GR on Cassidy's Gap road and in AR at Stawell, Ararat, 13 km S of Stawell and 6 km S of Dadswell Bridge. Habitat. Grassland and woodland in dry warm areas. Most recent record. 1976 (NMV D48447).

#### TYPHLOPIDAE (BLIND SNAKES)

*Typhlina proxima*.

Abundance and distribution. Uncommon and widespread in GR and AR. Recorded in GR at Asses Ears and 13 km S of Halls Gap; and in AR at Lake Lonsdale and Stawell. Habitat. Rocky areas such as the Grampians and in pastures where logs and stumps are present. Usually found in loose soils under rocks and logs. Most recent record. 1972 (NMV D17505).

#### Appendix 8

Distribution maps of the amphibians occurring in the Grampians-Edenhope Area (after Brook 1975)

- |                               |                                   |
|-------------------------------|-----------------------------------|
| 1 = <i>Litoria ewingii</i>    | 9 = <i>Neobatrachus centralis</i> |
| 2 = <i>Litoria lesueurii</i>  |                                   |
| 3 = <i>Litoria raniformis</i> | 10 = <i>Neobatrachus pictus</i>   |
| 4 = <i>Geocrinia laevis</i>   |                                   |

- |                                       |  |
|---------------------------------------|--|
| 5 = <i>Geocrinia victoriana</i>       | 11 = <i>Pseudophryne bibronii</i>      |
| 6 = <i>Limnodynastes dermerillii</i>  | 12 = <i>Pseudophryne semimarmorata</i> |
| 7 = <i>Limnodynastes peronii</i>      | 13 = <i>Ranidella parinsignifera</i>   |
| 8 = <i>Limnodynastes tasmaniensis</i> | 14 = <i>Ranidella signifera</i>        |

#### Explanation of Plates

##### PLATE 19

Figure 1—Woodlands of River Red Gum in Victoria Valley, Grampians Region.

Figure 2—Heath in Victoria Valley, Grampians Region.

##### PLATE 20

Figure 3—Upper reaches of a slow-flowing stream in the Grampians Region.

Figure 4—Roadside reserve of River Red Gum in the Ararat Region.

##### PLATE 21

Figure 5—Squirrel Glider, an uncommon mammal in Victoria. Two records exist from the Ararat Region in the survey area.

Figure 6—Plains-wanderer, formerly in large numbers in western Victoria, but it is now very rare. It may still be present in low numbers in the Ararat and Hamilton Regions.





1



2









1



2







