A Preliminary Guide to the Identification of the Microdrile Oligochaeta of Australian Inland Waters

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PREFACE

This guide was produced for the sixth taxonomic workshop held at the Murray Darling Freshwater Research Centre in Albury, Victoria, between February 15-17, 1994. It represents a working version of a guide which will be published in full once the current review of Australian freshwater microdrile Oligochaeta is complete. The final publication will include more extensive illustrations, biological information and body length data of individual species, a brief review of oligochaete biology and ecology, a discussion on the higher taxonomy and phylogenetics of the oligochaetes and allied taxa, detailed locality and collection data and a systematic index. Taxonomic review papers will also be produced and these will provide more complete descriptions of new taxa.

Financial support for this project was provided by the Australian Biological Resources Study and by the Museum of Victoria. We are particularly indebted to Richard Marchant of the Invertebrate Survey Department of the Museum of Victoria for his early involvement in the project, provision of financial assistance and continuing support. Publication of this guide was made possible by the Cooperative Research Centre for Freshwater Ecology and we thank John Hawking of the Murray Darling Freshwater Research Centre for facilitating this. The assistance of other staff of the Aquatic Resources Center, Tennessee, U.S.A. and of the Invertebrate Survey and Entomology Departments of the Museum of Victoria is also greatly appreciated. Annabell Carle provided access to the histology laboratory of the Department of Ecology and Evolutionary Biology at Monash University and we are grateful to Sue Swann for assistance with histological techniques. Marianne Eckroth provided technical advice and arranged for the use of histological equipment at the University of Alabama, Huntsville, U.S.A.

We are, of course, grateful to all those who have provided specimens for study, these are: S. Boyd and R. Marchant of the Museum of Victoria, P. Berents and E. Turek of the Australian Museum, Sydney, T. Kingston and L. McGowan of the Queen Victoria Museum, Launceston, L. Cannon and K. Sewell of the Queensland Museum, K. Gowlett-Holmes of the South Australian Museum, E. Glaister and P.S. Lake of Monash University, J. Davis and K. Trayler of Murdoch University, M. Douglas of CSIRO Division of Wildlife and Ecology, N.T., P. Dostine and G. Rippon of the Office of the Supervising Scientist, Jabiru, N.T., W. Fulton of the Inland Fisheries Commission, Tasmania and A. Harris of the Otago Museum, N.Z.

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1. INTRODUCTION

The class Oligochaeta is usually divided into megadriles (superorder Megadrili) which are mostly robust terrestrial earthworms and microdriles (superorder Microdrili) which are mostly small, thin bodied aquatic worms. Microdriles have been recovered from a broad range of aquatic biotypes, including oligotrophic lakes and streams, organically enriched wetlands, groundwater and deep ocean sediments. Considering their ubiquity in aquatic habitats and their ecological importance in many situations, oligochaetes are perhaps one of the most neglected components of the benthic fauna in Australian freshwater studies: very few published species lists have this element of the fauna resolved further than Oligochaeta spp. The most immediate reasons for this are that the taxonomic literature is quite scattered and that the worms are considered, somewhat erroneously, to be exceptionally difficult to identify. We hope that both of these problems will be alleviated by the publication of this guide and that aquatic oligochaetes will soon be routinely identified in ecological studies.

Oligochaetes are relatively simple, soft-bodied invertebrates and the external features provide very few taxonomically useful characters. For this reason oligochaete taxonomy, at least at the generic and higher levels, is largely based on the internal anatomy, particularly the genital system. However, in practice most species can be identified using features such as the morphologically diverse setae that are readily observed on whole mounted worms. Most of the characters used in the keys are no more difficult to resolve than those used for other aquatic groups (such as the microcrustacea and some diptera) for which a compound microscope is routinely used. Identification is further simplified by the absence of sexual dimorphism (oligochaetes are hermaphrodites) and larval stages. A basic overview of the anatomy of microdrile oligochaetes, with emphasis on the characters used in the keys and described in the text, is provided in chapter 2 and chapter 3 provides advice on preparation and examination of specimens. We recommend that these chapters are read before any attempt is made to use the keys.

Scope of this guide

This guide provides keys and descriptions to ninety one species within six families of microdrile oligochaetes inhabiting inland waters of Australia and Macquarie Island. The six included families are Haplotaxidae, Capilloventridae, Phreodrilidae, Tubificidae, Naididae and Lumbriculidae. The Enchytraeidae, and the megadriles (earthworms) are not covered due to our lack of expertise. The Aeolosomatidae were once considered to be a somewhat anomalous family within the Oligochaeta and were included in Brinkhurst's (1971) review with a note concerning their probable misclassification. Several aspects of their anatomy set them apart from other members of the Oligochaeta, and they are now recognised as a separate class, the Aphanoneura (Timm, 1981 and Brinkhurst, 1982b) and so are not included here.

While there has been no intention to limit the geographic coverage of this guide to certain regions of Australia, the limits of collecting and identification effort have resulted in a bias towards the south-east. However, collections have been identified from all states, the Northern Territory and Macquarie Island and from habitats ranging from semi-arid springs to alpine glacial lakes. Notes are made on the oligochaete fauna of other sub-antarctic islands and New Zealand where relevant.

Marine species are generally omitted, other than where these also occur in inland waters. The number of marine tubificids and enchytraeids known worldwide now rivals the number from freshwaters, although they are not well known from Australia. Accounts of Australian marine oligochaetes include Baker (1984), Brinkhurst (1985a), Coates (1990), Erseus (1981, 1983, 1990b), Erseus and Jamieson (1981) and Jamieson (1976).

Twelve new species included in this guide have been referred to a genus but have not been given a species name. Instead, they have been numbered within the genus (i.e. *Phreodrilus* sp. 1, sp. 2 ...) to ensure new species names first appear in the primary scientific literature. Such primary descriptions are being prepared. It is only to be expected that further new species will be found as oligochaetes are examined from the many poorly studied regions. In fact a number of new tubificids are known which cannot be allocated to a genus for lack of mature specimens.

The keys

Keys written along taxonomic lines would be primarily based on the soft parts of the genital system and so would be less than ideal for a publication written for the non-specialist. Fortunately, most species can be readily identified using external characters, such as those associated with the morphologically diverse setae. The keys in this guide are based where possible on these easily observed features, but as these exhibit wide overlap in form between families and genera, the keys are rarely natural in a taxonomic sense. Structures mentioned in the text are illustrated on the same or opposing page and all scales are in micrometers. All illustrations are of Australian specimens unless otherwise stated. Few abbreviations are used and the only ones not explained with the illustrations are those that refer to the segmental position of setae; v = ventral, d = dorsal, ant.= anterior, post.= posterior and roman numerals refer to segment numbers (see chapter 2).

Historical Background

The earliest interest in antipodean aquatic oligochaetes centred on New Zealand with descriptions of several haplotaxids and phreodrilids (Beddard, 1888, 1890, 1891ab, and Benham, 1903, 1904ab). Aquatic oligochaetes were not recorded in Australia until Benham (1907) described two species of Tubificidae and one new genus and species of Phreodrilidae (*Phreodriloides notabilis*); all from Blue Lake, Kosciusko, N.S.W. A further four publications between 1909 and 1931 contributed seven further species (although some of these are no longer recognised as distinct species) and a new phreodrilid genus, *Astacopsidrilus* (Goddard, 1909a). Interest then waned until a review by Brinkhurst (1971) who established a new tubificid genus (*Antipodrilus*) and recorded another 21 species, including several new ones and many cosmopolitan naidids and tubificids. Other new species and records were added by Brinkhurst (1982a, 1984c, 1991b), Brinkhurst and Coates (1985), Brinkhurst and Fulton (1979 and 1980), Erseus (in press), Jamieson (1968, 1978) and Naidu and Naidu (1980ab).

The Australian Fauna

The six families covered by this guide are represented by ninety one species in Australian inland waters, including endemic, cosmopolitan and possibly introduced species (Table 1). The global relationships of the Australian fauna varies with the family and are summarized below. Further information about the distribution of taxa within Australia is provided in Table 1, at the start of each family chapter and with each species description.

Cosmopolitan Tubificidae and Naididae

These families include many genera that are cosmopolitan or are at least widely distributed on several continents and which have few species endemic to Australia (only four endemic species occur in the 14 genera in this category). These genera and species also tend to be widespread within Australia, although some naidids, for example *Branchiodrilus*, *Allonais* and some species of *Dero* tend to have an equatorial bias to their global distribution, reflected in northern distributions within Australia. Some naidids appear to be restricted to Victoria but this is likely to be an artifact resulting from the larger number of worms identified from this state.

Taxa with disjunct distributions

A few genera have markedly disjunct distributions on a worldwide scale and these contain a larger proportion of species endemic to Australia than the more cosmopolitan genera. For example, the Australian species of *Telmatodrilus* (Tubificidae) are all endemic and are mostly confined to Tasmania. This genus is otherwise found in North America, asiatic Russia and northern Europe. It should be noted however, that these species may eventually be classified seperately to those of the northern hemisphere. The endemic tubificid *Ainudrilus billabongus* is restricted to freshwaters of the Alligator Rivers region in the Northern Territory while other species within the genus inhabit the marine benthos of south-east Asia and the North Pacific (Erseus, 1989). Another endemic tubificid, *Rhizodrilus arthingtonae*, is known only from North Stradbroke Island, Queensland, whereas other *Rhizodrilus* species occur in rivers of South Africa and North America and in marine sediments off islands in the southern Indian and north Pacific oceans (Baker and Brinkhurst, 1981). The Haplotaxidae is a cosmopolitan but patchily distributed family with four species found in Australia; one endemic to Tasmania and three others shared with Africa and/or New Zealand.

Tubificidae restricted to the region

Antipodrilus, which belongs to the cosmopolitan subfamily Tubificinae, is the only tubificid genus restricted to the antipodean region. Included in this genus are four species which are restricted to Australia and one which occurs in both Australia and New Zealand. The latter, *Antipodrilus davidis* is widely distributed in Australia while the other four have narrower ranges, including two restricted to Tasmania. Another tubifid genus, the monospecific *Macquaridrilus* is found only on Macquarie Island in the form of *Macquaridrilus bennettae*.

Phreodrilidae and Capilloventridae

Most species within these families are restricted to the southern hemisphere and a high proportion are confined to Australia. Phreodrilids have been recorded from South America, Africa, Sri Lanka (but not India) and New Zealand suggesting a gondwana derived distribution, but they have also been recovered from southern oceanic islands of more recent geologic origin. Of the 22 species of Phreodrilidae recorded from Australia only four are also found in other regions. Within Australia most species are restricted to the south-east, particularly Tasmania, but one species is found in Perth and three species that are ectocommensal on freshwater crayfish occur in northern coastal New South Wales and southern Queensland. One species occurs on Macquarie Island.

Until recently the only known species of Capilloventridae were one from the Atlantic Ocean off the coast of Brazil, one from the Weddel Sea, Antarctica and one (*Capilloventer australis*) from low salinity reaches of the Hawkesbury River estuary, N.S.W. (Erseus, 1993). The family was thus considered to be mainly marine with a single estuarine incursion. *C. australis* is now known to be common in freshwater streams and rivers of south eastern Victoria and two new species have been found from the same region. The Australian capilloventrids are the only species known freshwater.

Lumbriculidae

Finally, the Lumbriculidae has an essentially holarctic distribution, apart from *Lumbriculus variegatus* and *Stylodrilus heringianus* which are probably recent introductions to the southern hemisphere (Brinkhurst, 1982c). *Lumbriculus variegatus* has been reported from New Zealand, Australia, South and Central America and South Africa. It is otherwise common in Europe and northern North America. That it commonly reproduces asexually by fragmentation and is used as live fish food may have aided its spread. In the southern hemisphere *Stylodrilus heringianus* is known from New Zealand (Marshall, 1975 and 1978) and their is one unconfirmed record from Tasmania (Fulton, 1983). This species is otherwise known from western Asia, Europe and North America.

Classification, checklist and distribution of Australian species

The classification scheme listed in Table 1 follows that of Brinkhurst (1982bc) and Brinkhurst and Nemec (1987). It also draws upon studies by Brinkhurst (1988 and 1991b) on the taxonomy of the Haplotaxidae and Phreodrilidae, Baker and Brinkhurst (1981), Giani et al. (1984) and Erseus (1990a) on subfamilies within the Tubificidae and Nemec and Brinkhurst (1987) on subfamilies within the Naididae. The taxa listed in Table 1 (opposite) belong to the following higher taxa.

PHYLUM: ANNELIDA (segmented worms)
SUPERCLASS: CLITELLATA (annelids with a clitellum: oligochaetes, leeches and leech allies)
CLASS: OLIGOCHAETA
SUPERORDER: MICRODRILI

Table 1: Classification and Species Checklist of Australian Freshwater Microdrile Oligochaetes

(*) = species incertae sedis, ? = uncertain identification, Mac. = Macquarie Island.

	Mac.	Tas	Vic	SA	WA	NSW	Qld	NT
ORDER: HAPLOTAXIDA (one family)								
Family HAPLOTAXIDAE (four species)								
Haplotaxis heterogyne		Tas						NT
Pelodrilus africanus(*)					WA		Qld?	
Hologynus hologynus					WA			
H. ornamentus		Tas						
ORDER: TUBIFICIDA (four families)								
Suborder ENCHYTRAEINA								
Family CAPILLOVENTRIDAE (three species)								
Capilloventer australis			Vic			NSW		
C. sp. nov. 1			Vic					
C. sp. nov. 2			Vic					
Suborder TUBIFICINA								
Family PHREODRILIDAE (two subfamilies, 23 species)								
Subfamily Phreodrilinae								
Phreodrilus branchiatus		Tas	Vic					
P. palustris		Tas						
P. mauienensis			Vic?					
P. sp. 1		Tas						
P. sp. 2		Tas	Vic					
Antarctodrilus niger		Tas						
A. proboscidea		Tas	Vic	SA		NSW		
A. sp. 1		Tas						
Subfamily Phreodriloidinae								
Phreodriloides notabilis						NSW		
P. sp. 1(*)		Tas						
Astacopsidrilus novus					WA			
A. notabilis						NSW		
A. fusiformis						NSW		
A. jamiesoni							Qld	
A. sp. 1		Tas						
Insulodrilus uniseta		Tas						
I. plumaseta		Tas						
I. magnaseta		Tas						
I. nudus		Tas	Vic					
I. lacustris		Tas?	Vic?					
I. campbellianus	Mac?							
I. breviatria		Tas						
I. sp. 1		Tas						

cont...

Table 1 (cont.)

	Mac	Tas	Vic	SA	WA	NSW	Qld	NT
Family TUBIFICIDAE (three subfamilies, 28 species)								
Subfamily Tubificinae								
Tubifex tubifex		Tas	Vic		WA		Qld	
Limnodrilus hoffmeisteri		Tas	Vic	SA	WA		Qld	
L. udekemianus		Tas		SA	WA	NSW	Qld	
L. claparedeianus						NSW		
Potamothrix bavaricus			Vic		WA			
Spirosperma sp.			Vic?					
Antipodrilus davidis		Tas	Vic	SA	WA	NSW		
A. timmsi			Vic					
A. magelensis				SA				NT
A. plectilus		Tas						
A. multiseta		Tas						
Aulodrilus pluriseta							Qld	NT
A. pigueti			Vic		WA		Qld	NT
A. limnobius			Vic		WA		Qld	NT
Subfamily Rhyacodrilinae								
Bothrioneurum vejdovskyanum		Tas				NSW		
Rhyacodrilus coccineus		Tas	Vic			NSW		
R. fultoni		Tas						
R. bifidus			Vic			NSW		
Rhizodrilus arthingtonae							Qld	
Ainudrilus billabongus								NT
Branchiura sowerbyi			Vic		WA		Qld	
Subfamily Telmatodrilinae								
Telmatodrilus multiprostatus		Tas						
T. pectinatus		Tas	Vic					
T. papillatus		Tas						
T. bifidus		Tas						
T. sp. 1		Tas						
T. sp. 2		Tas						
Macquaridrilus bennettae	Mac							

cont...

Table 1 (cont.)

	Mac	Tas	Vic	SA	WA	NSW	Qld	NT
Family NAIDIDAE (two subfamilies, 31 species)								
Subfamily Naidinae								
Nais elinguis	Mac		Vic				Qld	
N. pseudobtusa			Vic				Qld	
N. bretscheri			Vic		WA			
N. variabilis/communis		Tas	Vic		WA			
Dero (subgenus *Dero*) *pectinata*							Qld	
D. (D.) dorsalis							Qld	
D. (D.) digitata			Vic		WA		Qld	NT
D. (D.) nivea			Vic		WA		Qld	NT
D. (D.) sp. nov							Qld	
Dero (subgenus *Aulophorus*) *furcata*			Vic		WA			
D. (A.) flabelliger			Vic				Qld	
D. (A.) vagus								NT?
Branchiodrilus hortensis							Qld	NT
Allonais inequalis							Qld	NT
A. paraguayensis							Qld	NT
A. pectinata							Qld	
A. ranauana				SA				
Pristina proboscidea							Qld	NT
P. longiseta			Vic		WA		Qld	
P. aequiseta			Vic		WA		Qld	
Pristinella osborni			Vic					
P. jenkinae			Vic		WA			
P. bilobata			Vic					
Chaetogaster diastrophus			Vic					
C. diaphanus			Vic					
C. limnaei			Vic					
Paranais litoralis			Vic				Qld	
Subfamily Stylarinae								
Stylaria lacustris			Vic					
Slavina appendiculata			Vic					
S. sp. 1			Vic					
ORDER LUMBRICULIDA (one family)								
Family LUMBRICULIDAE (two species)								
Lumbriculus variegatus		Tas	Vic			NSW	Qld	
Stylodrilus heringianus		Tas?						

2. ANATOMY OF MICRODRILE OLIGOCHAETES

The following discussion is centred around characters that are either used in the keys or are useful to check identifications. Although the keys in this guide are based on external characters where possible (and for most species this is sufficient), examination of the genital anatomy of mature specimens will occasionally be required to reach a species decision. In any case, if mature specimens are available then these should be used to confirm key-derived identifications. This is not a difficult task and usually involves examination of either cleared whole mounts or simple dissections (refer to chapter 3 for procedures).

External anatomy

General

As segmented coelomates, oligochaetes have an alimentary canal which is separated from the body wall by a cavity known as the coelom and this is divided into segments by septa. The septa are usually represented externally by intersegmental furrows which enable the segments to be counted, although secondary annulations are sometimes present between the furrows. Roman numerals are conventionally used to number the segments and the septa and the intersegmental furrows are denoted by the arabic numerals corresponding to the two adjacent segments (1/2, 2/3, 3/4...).

The most anterior part of the oligochaete body, the prostomium, is considered to be pre-segmental. It is presumably tactile in function and this is enhanced in some species by the development of a proboscis and in one tubificid (*Bothrioneurum vejdovskyanum*) by a dorsal sensory pit. The peristomium follows the prostomium and is occupied by the oral cavity which opens to the exterior ventrally in a wide mouth. Simple pigmented eye spots may be present on the lateral surface of the peristomium of a few naidids but setae are never present. Some annelid biologists, particularly those that work on polychaetes, prefer to count the segment after the peristomium as the first true segment as it is usually the first to bear setae (i.e. the first setiger) and this is probably the more correct terminology from an evolutionary perspective. However, for this guide the usual oligochaete tradition of counting the peristomium as the first segment (segment I) will be followed. Body length depends upon the age of the worm and, along with the number of segments, is variable because of asexual reproduction by budding or fragmentation and the ability to regenerate after damage, particularly in the Naididae. Thus, where body lengths are given in the text these are general guides only and are not taxonomically reliable.

External features useful for identifying aquatic oligochaetes include gills, papillations on the body wall, the position of genital pores and the various characters associated with the setae. The clitellum is a useful indicator of maturity and location of the genital region but is rarely used in keys.

Gills

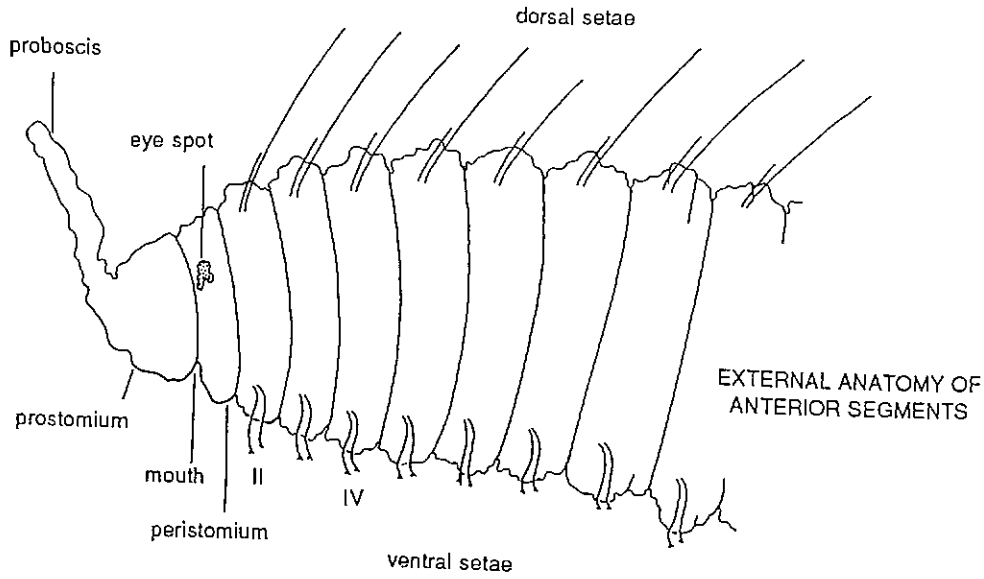
Respiratory appendages occur in some naidids, one species of tubificid and one phreodrilid. In the genus *Dero* (Naididae), they occur as finger or knob-like projections arising from a dorsal branchial fossa (cavity) on the terminal segment. The only other naidid genus with gills is *Branchiodrilus*, which has dorso-lateral gills on most segments from IV or VI onwards. Similar gills occur mid-dorsally and mid-ventrally on each of the posterior segments of *Branchiura sowerbyi* (Tubificidae) and the phreodrilid *Phreodrilus branchiatus* has lateral gills on the posterior segments.

Papillae

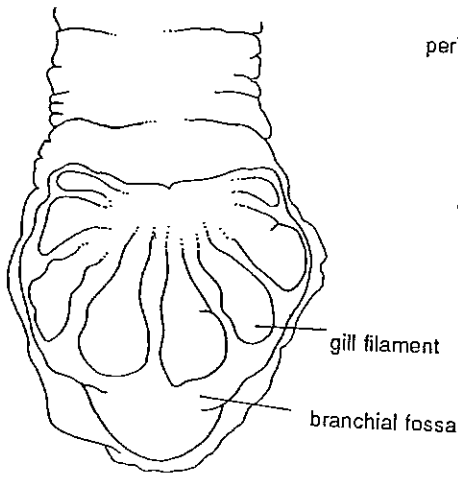
Most species appear to have sensory organs (papillae) on the body wall. These are usually inconspicuous, particularly in fixed specimens, but have become particularly prominent and retractile in those species which protect the body wall with secretions that trap bacteria and foreign matter in an external crust. In Australia this applies to the naidid genus *Slavina*, the tubificid *Telmatodrilus papillatus* and an as yet un-named tubificid which appears to belong to the genus *Spirosperma*.

Pores

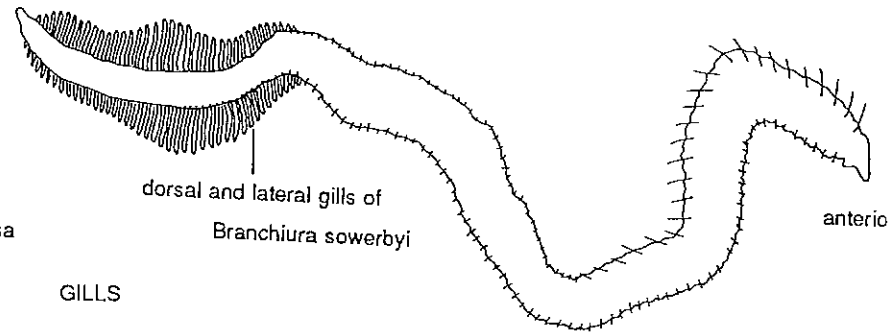
The genital pores are often visible on the body wall of mature specimens as neat slits or cavities. The location of these is dependant upon the family or genus and is discussed below in the section on the reproductive system. The female pores are usually not visible externally.



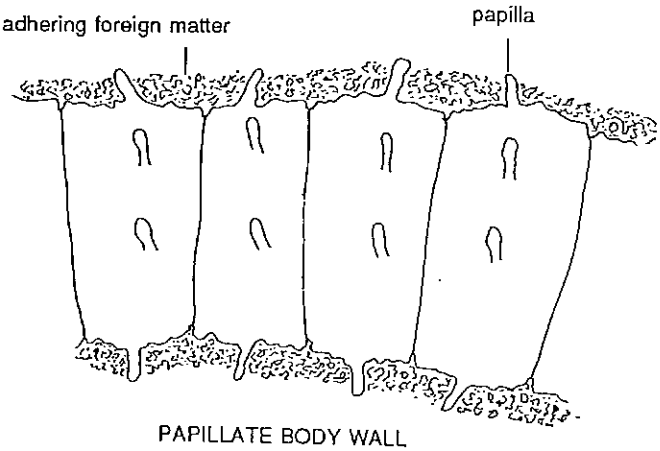
EXTERNAL ANATOMY OF ANTERIOR SEGMENTS



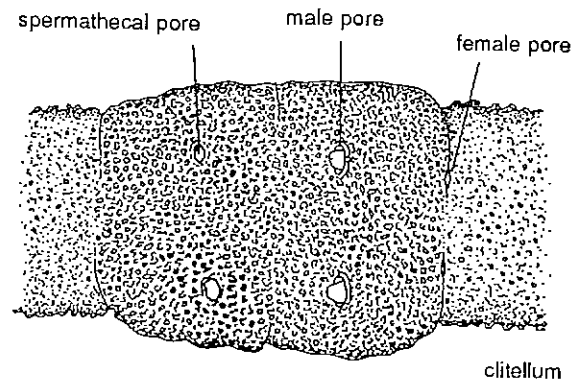
gills of Dero digitata



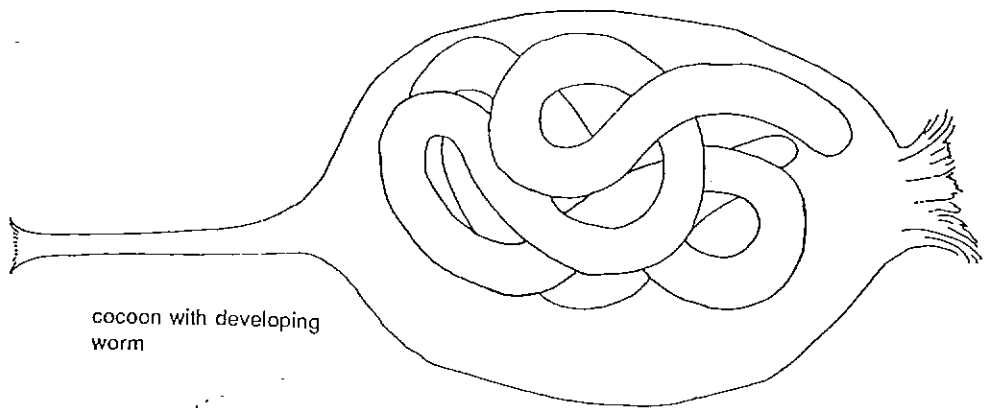
GILLS

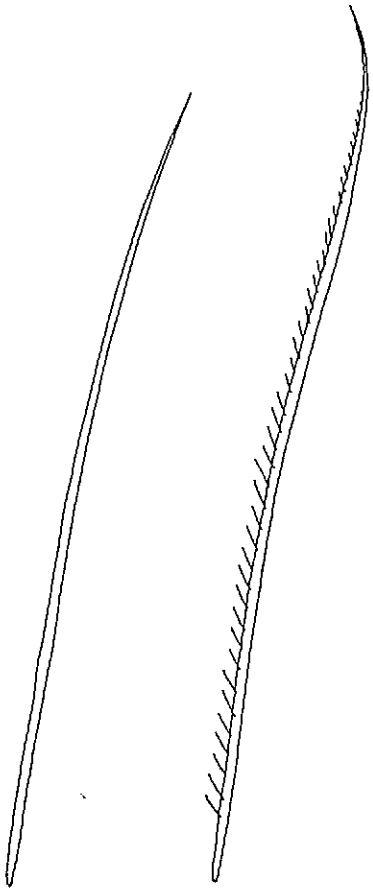


PAPILLATE BODY WALL



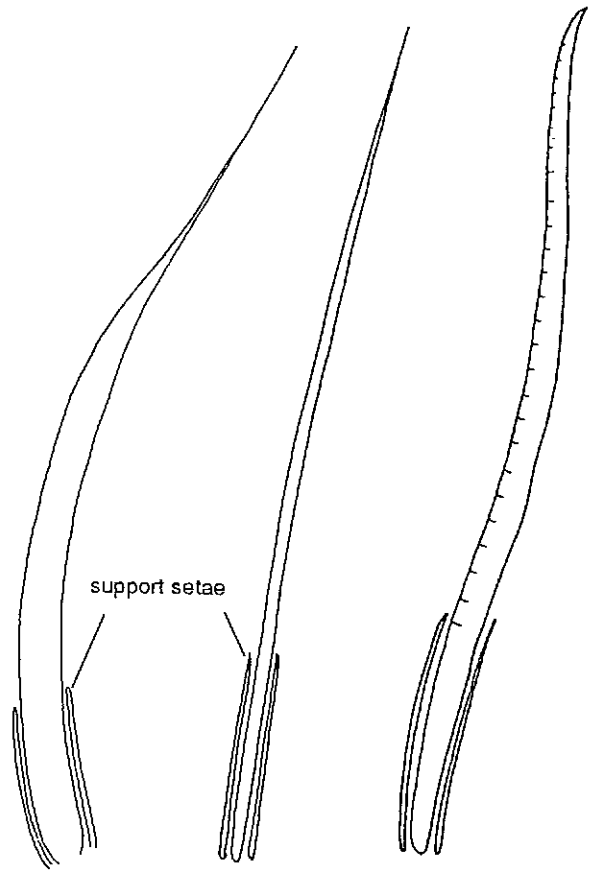
VENTRAL BODY WALL
SHOWING GENITAL PORES



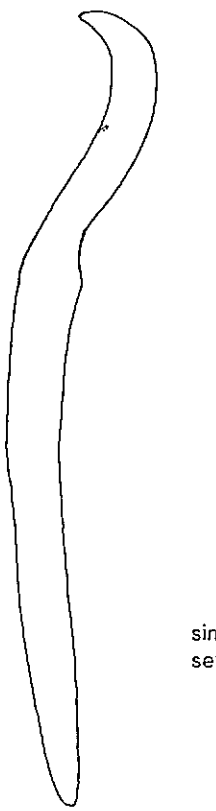


non-hispid and hispid capilliform hairs

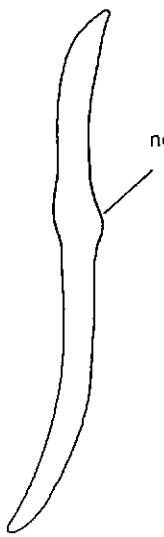
brush tipped hair seta



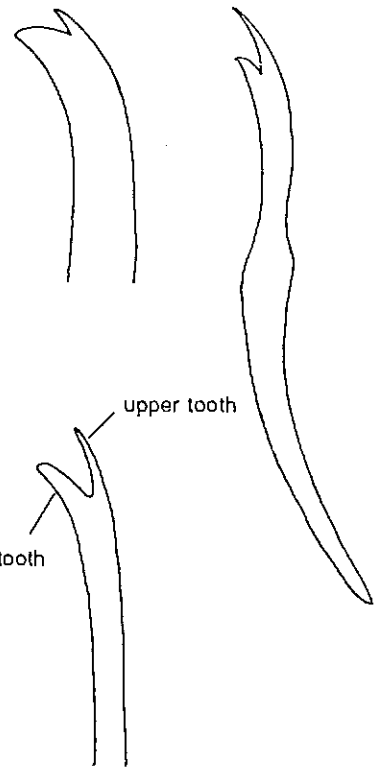
phreodrilid hair setae



sickle shaped simple pointed seta of *Haplotaxis*

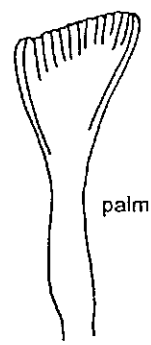


simple pointed seta



bifid setae

pectinate seta



palmate seta

Clitellum

The body wall of mature specimens is usually thickened on two to six segments in the genital region. This clitellum may completely surround the segments or may be absent or reduced ventrally. It consists of a single layer of epidermal cells that are taller than normal and has a greater density of glandular cells than the normal epidermis. The appearance of the clitellum varies from almost imperceptible to much more opaque and thicker than the epidermis of other segments. Secretions arising from the clitellum form a cocoon which receives the eggs and stored sperm at fertilization and which is then shed by the worm.

Setae

Variation in the form and number of the ventral and dorsal setae make them the most useful of the external features. The setae of microdriles usually occur in four bundles per segment, two dorso-laterally and two ventro-laterally, each bundle containing from one to many setae. In some megadriles (which are not considered beyond the family level in this guide) the setae may appear to be evenly distributed around the segment (a condition known as perisetine). The ventral setae almost always begin in segment II whereas the dorsal setae may begin from II or more posteriorly or, rarely, be absent. This is important to remember as the simplest way to locate a particular segment is to count the ventral setal bundles. Each seta is situated in a setal sac which is accompanied by glands and setal muscles.

The length of a seta is the shortest distance between its proximal and distal ends and width refers to the widest part of the seta (usually the nodulus). The form, number and size of the setae may change along the length of the body and the dorsal and ventral bundles may have different types of setae. Both ventral and dorsal setae should be examined from various parts of the body to ensure that the full range of setae are examined. Inspection of more than two bundles on a segment will ensure that both dorsal and ventral bundles have been seen. Replacement setae can often be observed in some bundles before the old setae have been shed, this can cause confusion when more than the expected number of setae per bundle are encountered. Where scales are given with illustrated setae these should be used as a general guide only; setal length can vary considerably between individuals. Recent work by Chapman and Brinkhurst (1987) and Loden and Harman (1980) has shown that some fine details of setal form, or even the presence or absence of certain types such as hairs can be affected by simple environmental variables such as pH or conductivity. Seasonal variation in setal form has also been demonstrated Smith (1985). Increased recognition of genetic and environmentally induced intraspecific variation has already led to some synonomies and more are likely.

The various forms of setae are described below and illustrated opposite.

Hair setae: Usually thin and capilliform, but may be thicker, blade like, or brush-tipped in phreodrilids. On some species they may bear fine lateral hairs which either appear as transverse lines giving the hair a segmented appearance or make the main shaft appear serrated or hispid. One or both sides of the hair may bear the lateral hairs or they may be present on some hairs of a specimen but not others. These lateral hairs appear to result from a fraying of the micro-fibrils that compose the hairs but are characteristic of some species. Hair setae occur dorsally in many tubificids, phreodrilids and naidids, dorsally and ventrally in capilloventrids but are absent in haplotaxids and lumbriculids. The hairs of phreodrilids are accompanied by short thin hair-like setae which do not emerge from the setal sac, these appear to be unique to the family and provide a useful diagnostic character.

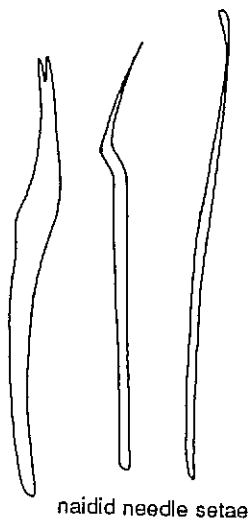
Bifid setae: Generally sigmoid (S-shaped) to varying degrees, with bifurcate tips and a swelling on the shaft referred to as the nodulus. The upper tooth may be replicated or so reduced as to be almost invisible (this may be enhanced by wear). The relative width and length of the upper (distal) and lower (proximal) teeth are useful diagnostic features and are used in the keys.

Pectinate and palmate setae: Usually found in the presence of hair setae in dorsal bundles of tubificids and naidids. Pectinate setae are bifid setae with a row of very fine teeth between the main (lateral) teeth. These may merge to form a web between the main teeth and when the main teeth are no larger than the web, the setae are termed palmate. Ventral setae in some tubificids may also show some traces of intermediate teeth.

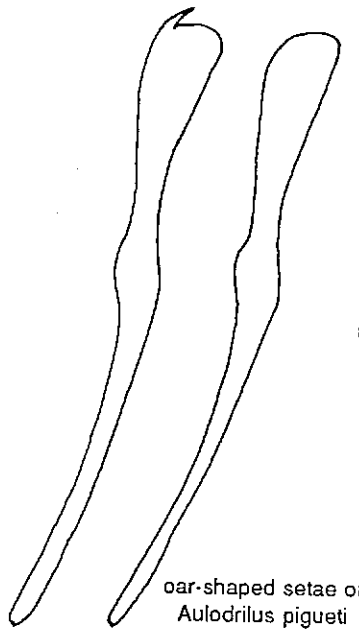
Simple pointed setae: Non-hair setae with simple pointed or rounded tips, with or without noduli. Present in dorsal bundles of some naidids and in ventral and/or dorsal bundles of some species of other families.

Naidid needle setae: These are bifid, pectinate, palmate or simple pointed setae which usually accompany hairs in dorsal bundles of the Naididae. They are termed needle setae because they are usually smaller, finer and less sigmoid than the ventral setae. By contrast, the non-hair dorsal setae of most other families are generally the same size and form as the ventral setae.

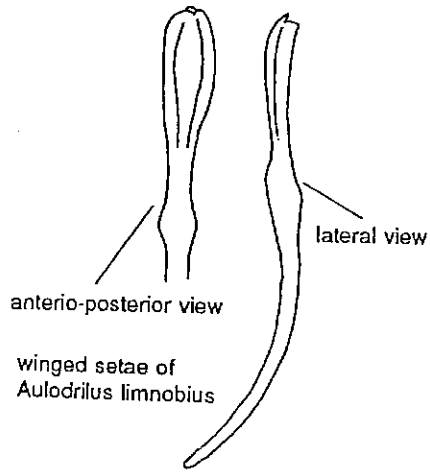
Other somatic setae: Unusual somatic setae make some species instantly recognizable. This is particularly true of two tubificids; *Aulodrilus pigueti*, which has oar shaped setae and *Aulodrilus limnobius*, which has setae with lateral flanges, giving them a winged appearance. Greatly enlarged setae are found in some segments of a few species, e.g. *Nais bretscheri* and *Pristina aequiseta* (Naididae) and the phreodrilid *Astacopsidrilus jamiesoni*. The setae of some species have markings (ornamentations) on the distal surface and some capilloventrids have a subdental ligament below the lower tooth of bifid setae.

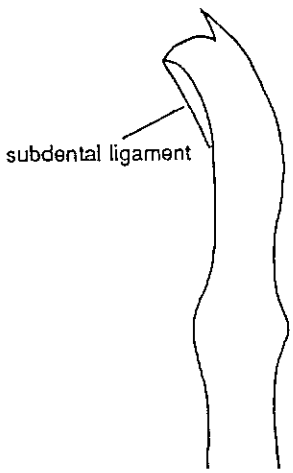


naidid needle setae

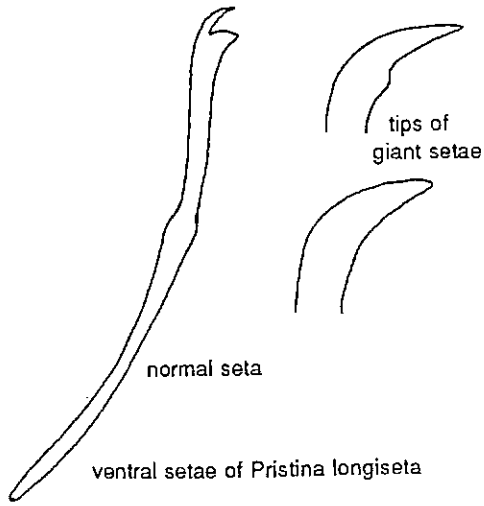


oar-shaped setae of
Aulodrilus pigueti

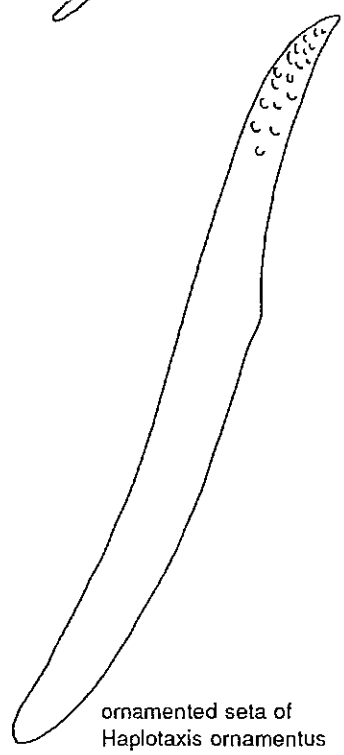




bifid setae of Capilloventer



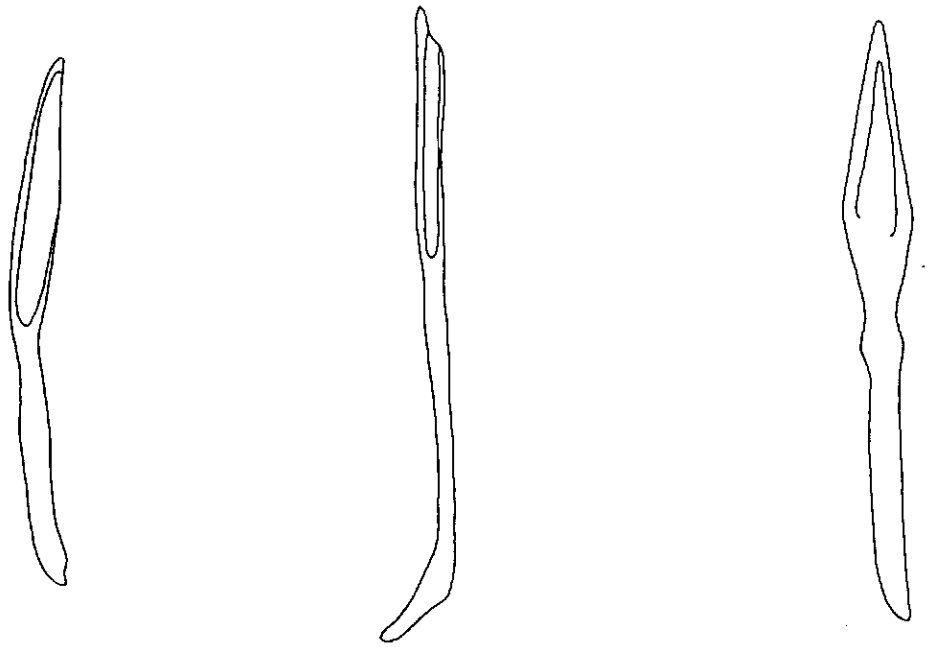
ventral setae of Pristina longiseta



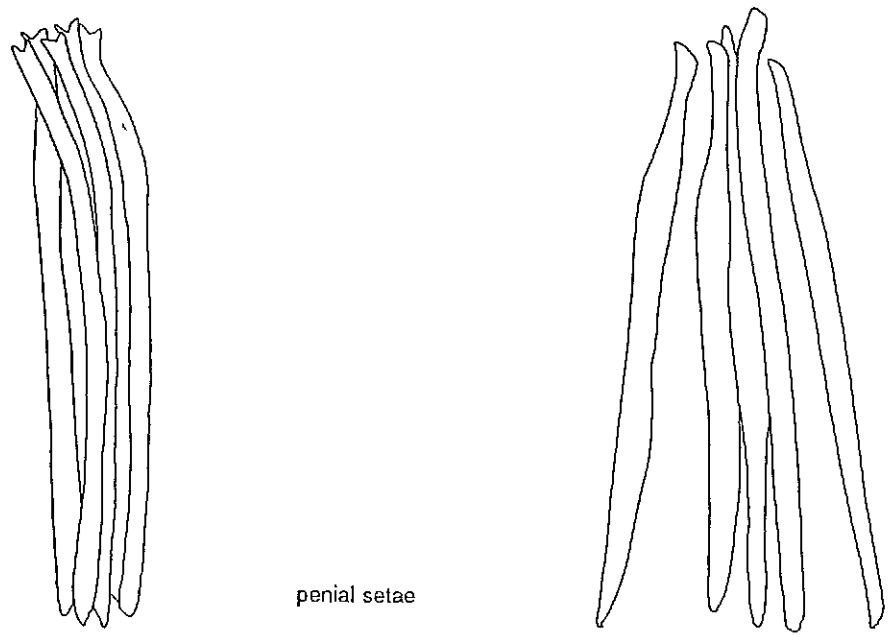
ornamented seta of
Haplotaxis ornamentus

Genital setae: The ventral setae of some oligochaetes are modified in the genital region of mature specimens. These may be more buried in the body wall than other setae or may project into the penial sacs or spermathecal vestibulae but are still usually visible in whole mounted specimens. Those on segments bearing the spermathecal pores are generally termed spermathecal setae and when modified tend to have blade like or gutter shaped ends. Ventral setae of adjacent segments may be similarly modified. The form of the tips suggest that these setae are involved with sperm transfer. This type of modified seta may be found in some, but not all, species in certain genera, including several tubificids such as *Potamothrix*, *Antipodrilus* and *Telmatodrilus*, the phreodrilid genus *Insulodrilus* and the naidid genus *Pristina*.

Setae on the segment with the male pores are termed penial setae and when modified are often club shaped or bifid and arranged in a fan with the tips together so that they probably act as claspers. Within the tubificidae this form is common in the genus *Telmatodrilus* (Telmatodrilinae), and several genera of the subfamily Rhyacodrilinae. They are also present in many naidids. In the Capilloventridae the penial setae are long hairs with thick bases.



spermathecal setae



penial setae

Internal Anatomy

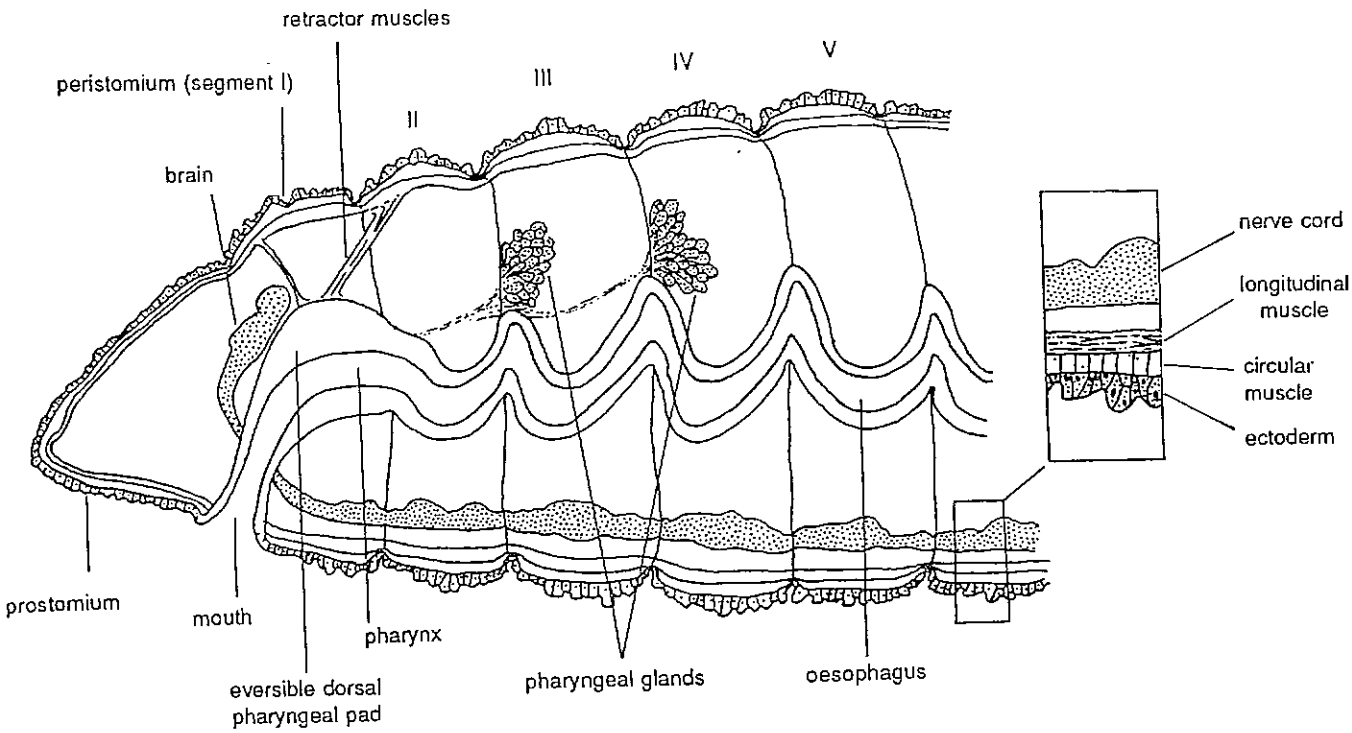
While much of the following information is not required to reach a decision using the keys, a general familiarity with the organization of the oligochaete body may help the user to become more confident with the group. Oligochaete taxonomy is based primarily on the reproductive system and examination of this system provides a means of confirming many of the identifications from the keys. Descriptions of most species in this guide include details of the genital anatomy.

Body organization

Oligochaetes are bilaterally symmetrical animals and so the organ systems which are usually paired within any one segment. These systems, including the reproductive, alimentary and excretory systems, are located in the coelom and are suspended from the septa and body wall by muscles and mesentaries. Also within the coelomic cavity are free floating cells known as coelomocytes. These are probably present in all oligochaetes and perform various functions (Cook, 1971) but are particularly large and abundant in some tubificids of the subfamily Rhyacodrilinae. The body wall consists of a cuticle covered epidermis overlying circular and longitudinal muscles. The latter allow for movement of the body, peristalsis of the gut and eversion and contraction of certain other internal organs.

Alimentary system

The alimentary canal begins with the ventral mouth on the peristomium (segment I) which leads to a pharynx located in the first few segments. The pharynx is usually thickened dorsally and usually has muscular attachments to the dorsal body wall which allow it to be protruded through the mouth to pick up food material. Capilloventrids have a ventral pharyngeal pouch which may also be protrusible. The pharynx leads to a narrow oesophagus which extends over several segments and which then widens into the stomach and the rest of the gut. In mature specimens the gut is much narrower in the genital region than in adjacent segments. The digestive system terminates in the anus on the last segment.

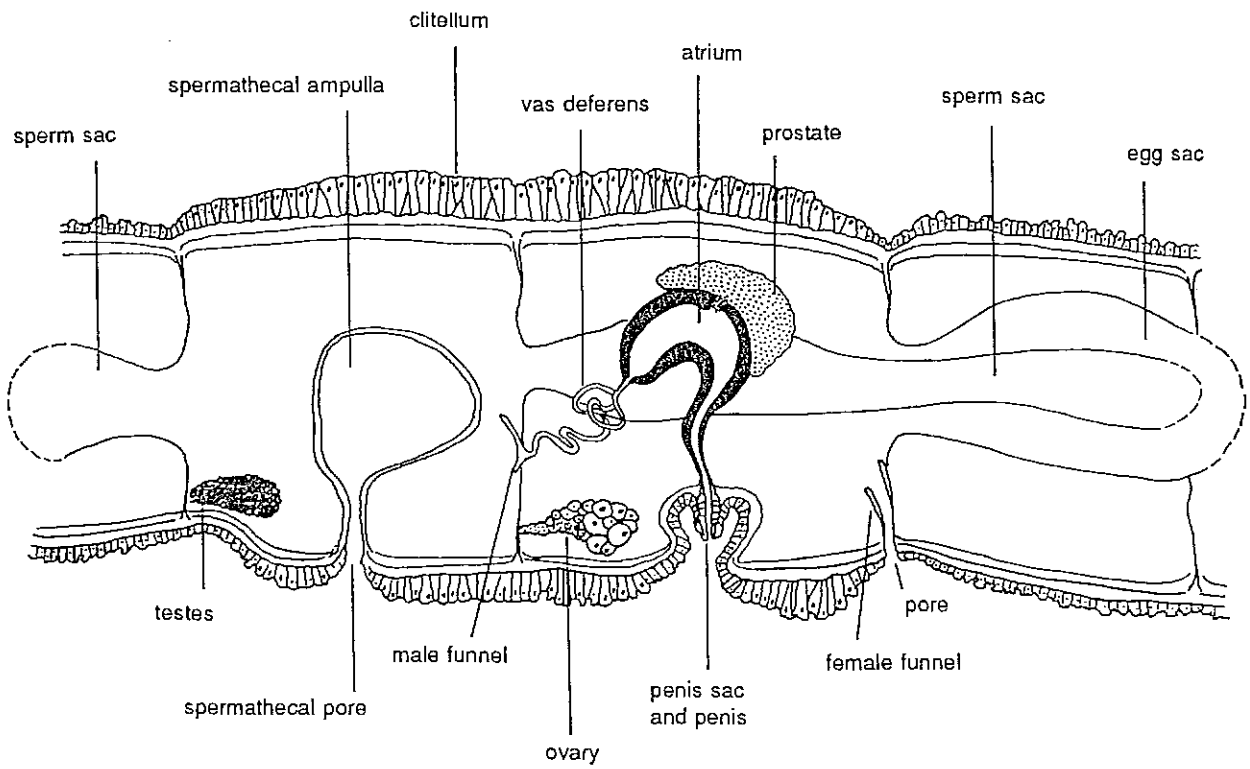


INTERNAL ANATOMY OF ANTERIOR SEGMENTS

Reproductive system

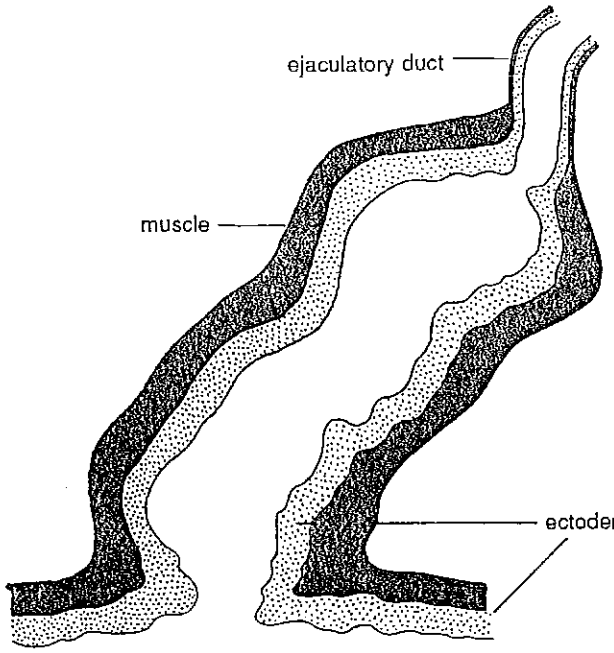
The Oligochaeta are simultaneous hermaphrodites, that is, mature individuals possess both male and female reproductive organs at the same time. During copulation a pair of worms exchange sperm which is then stored in internal sacs (spermathecae) and later released with mature eggs into a cocoon secreted by the clitellum. The cocoon is then shed with the fertilized eggs. After reproduction is complete the genital organs and ducts are usually resorbed and the worm reverts to the immature state. The male, female and spermathecal components of the reproductive system are discussed separately below and then the reproductive systems of each taxon are briefly described and illustrated.

The male system usually consists of a pair of testes in one segment which release sperm into the coelom of the same segment. The anterior and/or posterior septa of the testes bearing segment may protrude through several other segments so that the coelom forms un-paired sperm sacs which contain maturing sperm. A pair of funnels channel the mature sperm into ciliated vasa deferentia which lead to the ventral pores, often via atria and penes (see below). The testes are usually located in the segment prior to the segment in which the associated male pores are located, thus the funnel usually penetrates the posterior septa of the testes segment. In *Lumbriculus variegatus* (Lumbriculidae) there are sometimes two pairs of testes and associated ducts in consecutive segments and in the Haplotaxidae this is always the case.

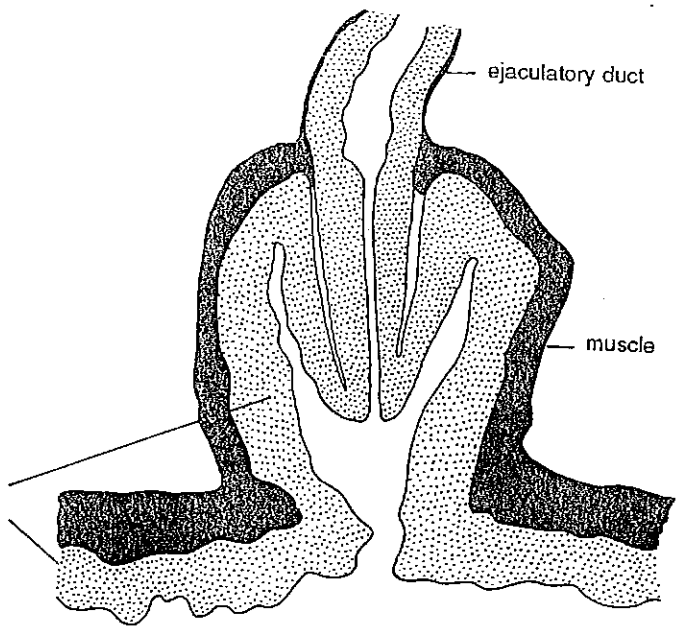


GENERAL ARRANGEMENT OF THE GENITAL ANATOMY

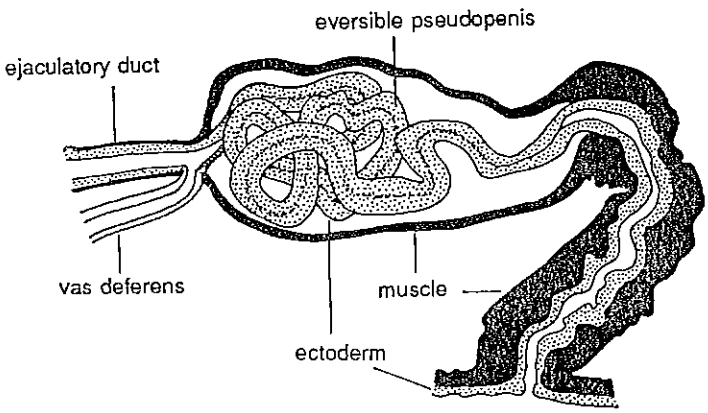
In some families (Lumbriculidae, Naididae, Tubificidae and Phreodrilidae) inversions of the body wall have resulted in additional organs or structures between the vasa deferentia and the male pores. One such inversion has resulted in muscular atria. These organs were originally lined with partially glandular ectodermal tissue which presumably nourished and lubricated the sperm stored within. In some taxa these glandular cells are thought to have migrated through the muscle layers and now form prostate tissue on the outside of the atria or even on the vasa deferentia. The form of the prostate tissue (attached at a single point, or by multiple attachment points, diffuse or in well defined glands) is thought to reflect the ways in which the gland cells passed through the atrial walls and now provides useful taxonomic features. The Phreodrilidae do not have external prostate glands but the cells within the atria usually fill the entire organ, leaving little if any lumen within.



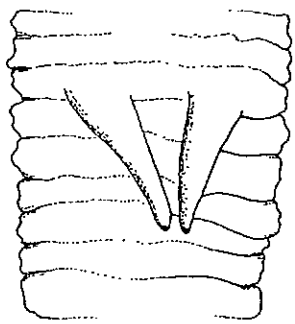
PROTRUSIBLE PSEUDOPENIS



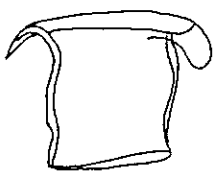
PENDANT PENIS



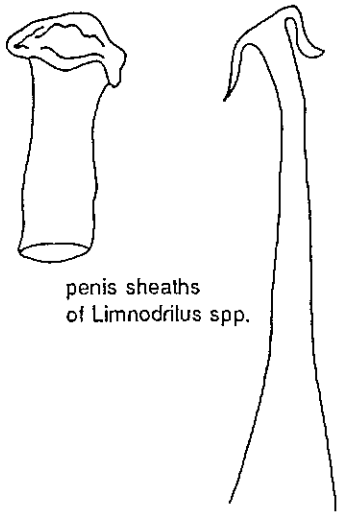
EVERSIBLE PSEUDOPENIS



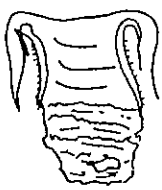
non-retractable penes
of Stylodrilus heringianus



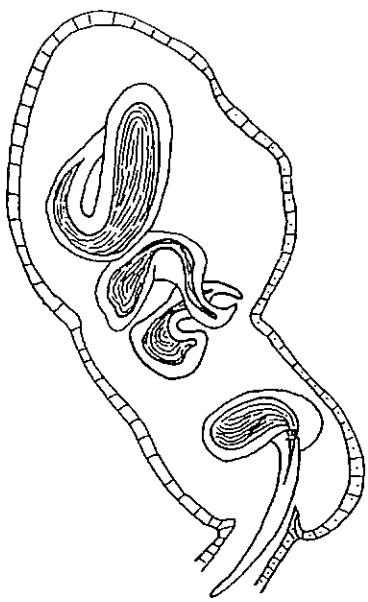
penis sheath
of Tubifex tubifex



penis sheaths
of Limnodrilus spp.



apparent penis sheath
of Antipodrilus magelensis



tubificid spermathecae with
spermatozeugmata

Additional inversions of the body wall in the tubificids, phreodrilids and lumbriculids have produced penes of various form, with the pore now located at the apex of the penis. The simplest form is the protrusible pseudopenis in which the male pore empties into a sac formed by a single inversion of the body wall. Muscles around this sac and attached to the body wall allow this sac to be protruded. This type of organ is common in the Tubificidae. In the genus *Phreodrilus* (Phreodrilidae) and some tubificids the ectodermal tissue has become separated from the muscle layers of the innermost part of the protrusible pseudopenis. This has resulted in a muscular bulb containing a loose tube (formed from the separated ectodermal tissue) which has become longer than the bulb itself, forcing the tube to become coiled. Contraction of the bulb then results in the eversion of this entire long tube through the in-folded body wall. This highly developed form is here termed an eversible pseudopenis. A third form, termed the pendant penis results from a double folding of the body wall around the pore, the first forming a penis sac and the second forming a penis within the sac. Musculature around the folds allow the pendant penis to be protruded during copulation. This form is found in some tubificids and phreodrilids.

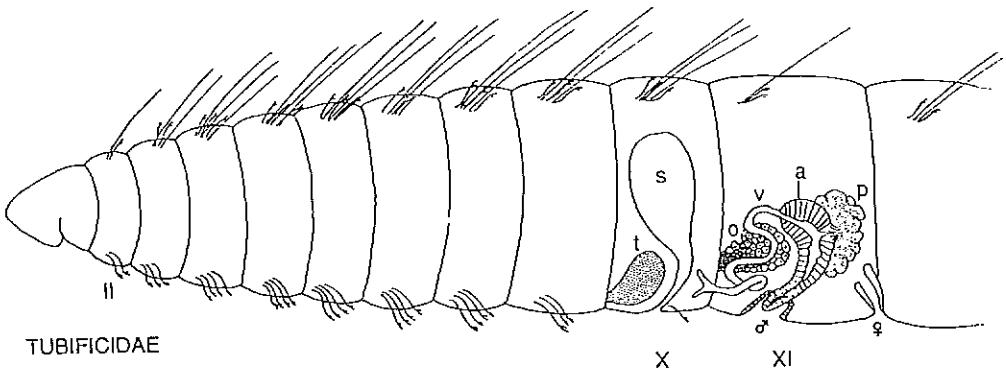
Stylodrilus heringianus (Lumbriculidae) has large non retractable penes formed from the body wall.

Since penes are formed from the body wall they are covered by a layer of cuticle. When the cuticle of pendant penes is thick enough to be visible in cleared whole mounts as a distinct structure of consistent shape it is termed a penis sheath. In some protrusible pseudopenes the cuticular linings are also visible; these appear crumpled in whole mounts but presumably straighten out when the penis is everted. In addition, the basement membranes of the penial muscle cells can form thick clear layers that resemble penis sheaths in a few species (e.g. some *Antipodrilus*). The last two forms are termed apparent penis sheaths and are usually less distinct than true penis sheaths.

The female system is much simpler. A pair of ovaries lie near the anterior septa, usually in the segment containing the male pores. Funnels on the posterior septa of this segment lead directly to inconspicuous ventral pores on either the posterior septa of the ovarian segment or the anterior edge of the next segment. The female funnels and pores are rarely visible except in sectioned specimens. In *Astacopsidrilus* (Phreodrilidae) the female pores open into the vestibulae of the ventral spermathecal pore in XIII. The posterior septa of the ovarian segment is often protruded back through one or more segments to form egg sacs. Microdrile eggs are yolky compared to those of megadriles and in preserved worms the yolk is reduced to yellowish oil droplets that appear spherical but are otherwise formless. This mass is often very conspicuous in the voluminous egg sacs. In some haplotaxids and lumbriculids there may be two pairs of ovaries and funnels in successive segments.

Spermathecae are sperm storage organs that receive sperm during copulation. Most families have a single pair but the Lumbriculidae and Haplotaxidae may have more than one pair of such organs in successive segments. Ducts connect the organs (ampullae) to ventral, lateral or dorsal pores which may be located within muscular vestibulae formed by inversions of the body wall. The ampullae can be located anywhere from within the same segment as the pore to many segments posteriad and may occupy one to many segments, depending upon the taxon or even the individual. The location of the spermathecal pores depends upon the family. In the Tubificidae, Naididae, Capilloventridae and Haplotaxidae they are located one to several segments anterior to the male pores, in the Phreodrilidae they are usually located one segment posterior to the male pores and in the Lumbriculidae they may be located anterior or posterior to the male pores. Sperm is aggregated within the ampullae in various forms, including free sperm, loose bundles or well defined bundles of aligned sperm called spermatozeugmata. The latter consist of differentiated sperm cells, some of which form a coating around the normal sperm. These forms of sperm aggregation are not well delimited as pointed out by Jamieson (1978) but the shape of the spermatozeugmata, where present, can be characteristic to a genus.

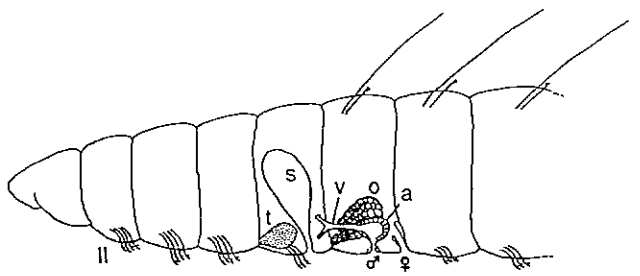
This is the basic form of the reproductive system, but there is wide variation between species in the form, extent of development, normal location, sequence and multiplicity of the various components. In addition, the position of the segments normally occupied by the gonads can vary from their "normal" location, especially when a worm has undergone asexual reproduction by budding or fragmentation. The stylised diagrams overleaf show the typical form for each of the six families considered here and a brief description of the reproductive system of each family follows.



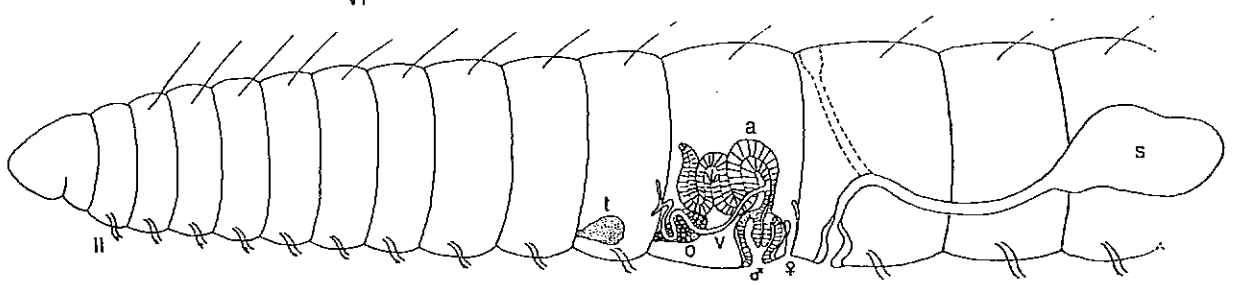
TUBIFICIDAE

LEGEND

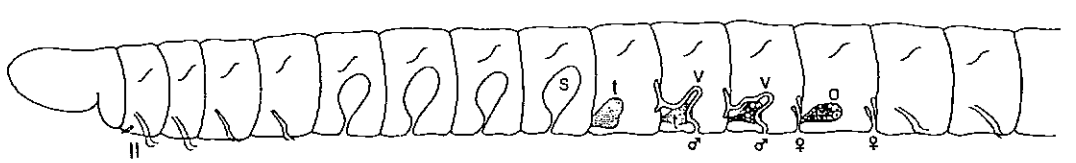
t	testis
v	vas deferens
a	atrium
p	prostate
o	ovary
s	spermatheca
♂	male pore
♀	female pore
ps	penial setae



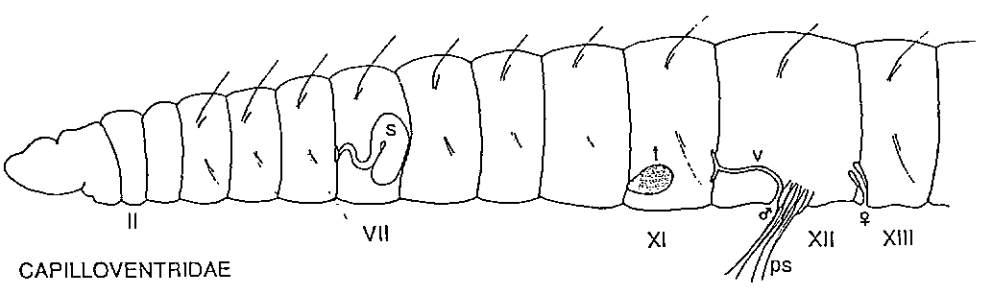
NAIDIDAE



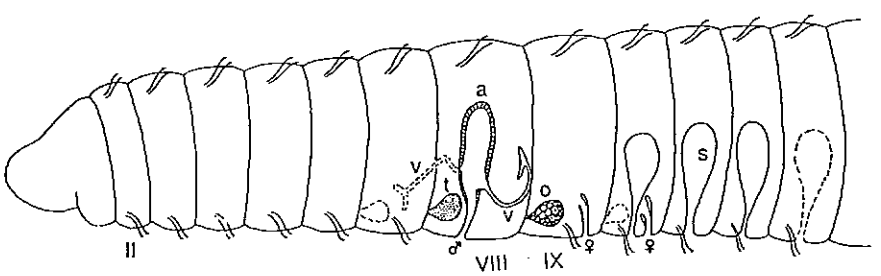
PHREODRILIDAE



HAPLOTAXIDAE (with full complement of gonads)



CAPILLOVENTRIDAE



LUMBRICULIDAE (*Lumbriculus variegatus*, with additional gonads and organs dotted)

Tubificidae: One pair of each type of gonad and associated ducts. Testes and ventral spermathecal pores in X. Spermathecal ampullae in X or more posterior. Ovaries and male pores in XI. Female pores in intersegmental furrow 11/12. Atria present, usually with prostates. Pendant penes or protrusible pseudopenes present. Asexual reproduction known for some species.

Naididae: One pair of each type of gonad and associated ducts. Testes, ventral spermathecal pores and ampullae in either IV, V or VII. Ovaries and male pores in next segment. Ventral female pores posterior intersegmental furrow of segment with male pores. Atria present. Prostates usually diffuse on atria and/or vasa deferentia where present. Penes absent. Asexual reproduction by budding or fragmentation common.

Phreodrilidae: One pair of each type of gonad and associated ducts. Testes in XI, ovaries and male pores in XII. Spermathecal pores ventral or dorsal on XIII, often within vestibulae, spermathecal ampullae in XIII or usually more posterior. Female funnels on septa of 12/13 or entering into spermathecal vestibulae. Atria present, usually with very narrow lumen, without prostates. Pendant penes or eversible pseudopenes usually present. Asexual reproduction rare.

The genital anatomy of the following families is hard to discern without microtome sections.

Haplotaxidae: Two pairs of testes and male ducts, one or two pairs of ovaries. Testes usually in X and XI, inconspicuous male pores on XI and XII or both on XII. Atria, prostates and penes absent. Ovaries in XII or XII and XIII. Female pores usually on 12/13 or 12/13 and 13/14. Spermathecae one to four pairs in V to IX with ventral to lateral pores in same segment. Asexual reproduction rare.

Capilloventridae: One pair of each type of gonad and associated ducts. Testes in XI, ovaries and male pores in XII. Atria, prostates and penes absent. Female pores in XIII (to be confirmed in some species). Spermathecal pore lateral on septa of 6/7, ampullae in VII. Asexual reproduction not recorded.

Lumbriculidae: There is a great deal of interspecific variation in the genital anatomy of lumbriculids but the intraspecific variation has often been exaggerated. Asexual reproduction and the subsequent regeneration can lead to great instability in the arrangement of the genital anatomy in a few species, including *Lumbriculus variegatus* but in most species there are fixed genital arrangements.

Lumbriculus variegatus usually has one pair of male pores and atria, located between VII and XII and a pair of testes in the same segment. A second pair of testes and ducts may be present in the preceding segment, but these ducts feed the same atria. Prostate absent. One or two pairs of ovaries and female pores in adjacent segments beginning in the post-atrial segment. Usually four pairs of spermathecae and pores beginning one or two segments after the atrial segment.

Stylodrilus heringianus is the only other lumbriculid recorded from the southern hemisphere. Mature specimens of this species are instantly recognizable by the large non-retractable penes created from the body wall of segment X. There are two pairs of testes in IX and X, both feeding the same pair of atria in X. One pair of ovaries occur XI and a single pair of spermathecae in IX. This species is illustrated in chapter 10.

3. PREPARATION AND EXAMINATION OF AQUATIC OLIGOCHAETES

Fixation and preservation

Worms may be killed and preserved 5 to 10% formalin (2 to 4% formaldehyde) or in other histological fixatives such as Bouins. After fixation for a day, they may be stored in 70% alcohol. Well stoppered vials are preferable to cotton wool plugs as smaller worms tend to get enmeshed in the cotton fibres and are easily damaged during removal.

Staining and slide mounting

For large routine collections the worms can be mounted, stained or unstained, in a clearing agent and identified in bulk. Several worms can be mounted whole on the one slide; five worms under each of two cover slips works well and orienting the bodies in one direction will speed identification. Trays of slides can be prepared for large ecological collections and examined after the worms have cleared (which can take hours to days depending upon the size of the worm). Slight pressure on the coverslip can help flatten the worms so internal features are more visible and setae on both sides of the worm can be seen. Amman's lactophenol (recipe below) clears well but is less destructive than glycerol. This medium remains liquid and so the worms can be removed from the slide at any time for re-orienting, storage, dissection or even sectioning if not cleared for too long.

Amman's lactophenol:

Carbonic acid	400g
Lactic acid	400ml
Glycerol	800ml
Water	400ml

Dissolve carbonic acid in water then add glycerol and lactic acid. The solution should be kept in tightly sealed dark bottles as it is hygroscopic and loses it's efficiency after some months, particularly if kept in the light.

Media such as Canada Balsam or artificial resin media such as Permount are preferable for more permanent slide mounts. Media such as polyvinyl lactophenol, Hydramount or CMCP-10 can be used but these tend to be quite destructive and soft parts will not be useable if the worms are unstained, even if the worms are recovered by soaking slides in water. The refractive index of CMCP-10 is particularly useful for examining setae, especially if a stain such as acid fuchsin is added to the media before mounting. Such slides should be sealed with glyceel or nail varnish to prevent drying out of the media. For examining the internal anatomy best results are obtained when the worms are stained (Grenacher's borax carmine, recipe below, is particularly effective), dehydrated and cleared before being mounted in Permount.

Grenacher's borax carmine:

Carmine (C.I. 75470)	3.0g
Borax	4.0g
70% alcohol	100ml
Distilled water	100ml

Dissolve borax in water and then add carmine, boil or leave to stand until the carmine is dissolved. Add 70% alcohol and allow to stand for 1 to 2 days before filtering. A protocol for staining is provided overleaf.

Protocol for staining with Grenacher's borax carmine.

1. Slightly re-hydrate worms in 50% alcohol if previously stored in 70% alcohol.
2. Transfer to stain, leave for 15 minutes to several hours depending upon size of the worm.
3. Add concentrated hydrochloric acid one drop at a time, agitating, until carmine has precipitated and is brick red (one drop of acid per millilitre of stain is usually sufficient).
4. Let stand for about the same time that the worm was left the in stain without acid, or up to 6 to 8 hours.
5. Transfer worm to 3% HCl (in 70% alcohol) to de-stain. Repeat several times with fresh acid/alcohol until most of the carmine is removed and the worm is light pink in colour. This may take several hours but if the process is too slow then the concentration of the acid may be increased.
6. Dehydrate through alcohol series with two or more changes each of 80, 95 and 100% alcohol. This will only take 30 minutes for small worms.
7. Clear with xylene, methyl salicylate, histoclear or other clearing agents.
8. Mount whole or dissect in a resinous mounting media.

Examination of specimens

Ensure that the microscope is correctly adjusted; some anatomical features are only visible on good quality, properly adjusted microscopes with clean lenses. Illumination should be parallel and the condenser should be correctly focused and then left alone, at every lens change the light should be adjusted with the iris diaphragm and not the condenser. Setae and penis sheaths have a refractive index that does not differ much from the background and too much light makes them difficult to see. An oil immersion lens is often required to see pectinations on tubificid setae and must be used to determine the form of the needles in naidids.

The procedure for examining a worm mounted whole on a slide is as follows. Check the prostomium for a proboscis or sense organ, the peristomium for eye spots and the body itself for gills or papillae. Next, examine the setae; determine where the dorsal setae begin and establish the number and form of the ventral and dorsal seta from a number of anterior and posterior segments. Remember that segment I, does not bear setae and the ventral setae almost always begin in II. Determine the relative lengths of the teeth of any bifid or pectinate setae. Examine at least three bundles in those segments examined to make sure that both dorsal and ventral setae have been seen. Care should be taken to examine several setae from an exactly lateral aspect because slight deviations can produce apparent distortion of the relative lengths of the teeth. The worm should then be searched for genital characters if required. Carefully check the appropriate segments (X-XI in tubificids for example) to see if the ventral setae of mature specimens are modified. Check the penial segment to see if there are penis sheaths; these may be thin and inconspicuous. Other components of the genital system, such as penes, atria and sperm and eggs in sacs may also be visible through the body wall.

For more detailed examination of the internal anatomy, particularly the genital systems, dissections or sagittal sections can be made of larger species or specimens. However, it should be pointed out that while these techniques are useful to check identifications they are not usually required to examine features used in the keys. These techniques are best performed after staining and clearing, while the worm is in the final mounting media. Sagittal sections simply involve cutting the worm in half longitudinally while dissections involve opening up the body wall and removing the gut and sometimes the genital organs. For dissections, fine mounted entomological pins and fine dissecting scissors are generally used. The genital segments are isolated, with a few buffer segments either side, the body wall is cut longitudinally on one side and the body wall opened out. Good staining and clearing will allow the individual organs to be seen even with a dissecting microscope. The opened out body wall can be covered at this stage or, with practice and luck, the organs can be teased out; the gut should at least be removed so that the other organs can be seen. Orientation is made easier by the fact that the nerve cord, which usually stains well, lies along the mid-ventral line and analysis is made easier by a knowledge of the expected location of the various organs, i.e. read the anatomy chapter. Microtome sectioning is usually only required for more serious taxonomic work or for some haplotaxids and is not discussed here.

4. KEY TO FAMILIES

This key allows specimens to be placed within one of the six families covered by this guide or within one of the groups not considered further. The latter include the microdrile family Enchytraeidae, the superorder Megadrili (earthworms) and the class Aphanoneura (which contains the family Aeolosomatidae, formerly placed within the Oligochaeta). Oligochaete families are almost entirely defined on characters associated with the internal genital anatomy and there are few external characters without significant overlap between the families. For this reason, a key to families based on external characters can appear somewhat ambiguous depending upon the species being examined. However, with a little experience a specimen can be readily placed within a family without reference to the key and often using only a binocular microscope. Many of the characters used below are illustrated in the anatomy chapter.

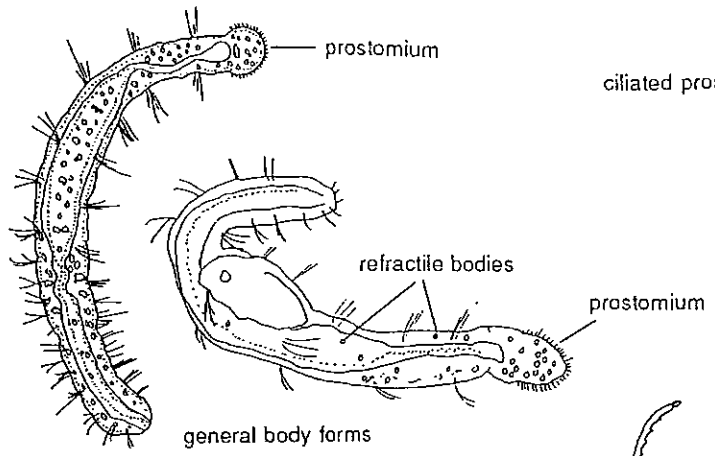
1a. Minute worms (1 to 2mm long or chains of animals up to 10mm); dorsal and ventral setae consisting of hairs only; prostomium highly ciliated; body wall with coloured or refractile epidermal glands; pharynx without thickened eversible dorsal pad; clitellum not present in mature specimens but with ventral copulatory glands in rare mature worms; uses prostomial cilia for locomotion ....**Class Aphanoneura (family Aeolosomatidae)**

b. Small to large worms; hair setae usually restricted to dorsal bundles or absent, present in ventral bundles of one family (but then usually with bifid setae in some segments); prostomium not so ciliated; coloured or refractile epidermal glands not present; pharynx with thickened eversible dorsal pad; clitellum present in mature specimens; moves by contraction and expansion of the body wall .. ..**Class Oligochaeta 2**

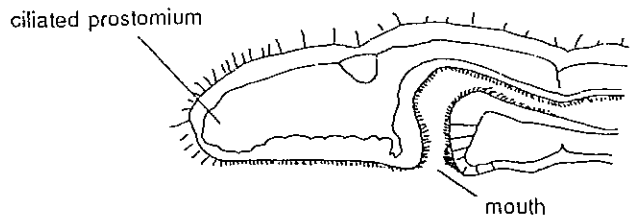
2a. Small worms (≤ 5mm); hair setae present in both ventral and dorsal bundles, may be absent posteriorly; setae usually absent in II and often in III; ventral setae of segment with male pores (XII) modified as a bundle of much longer, stouter hairs in mature specimens; prostomium very glandular; pharynx with ventral pouch .....**Capilloventridae** pg. 33

b. Small to large worms; hair setae absent or in dorsal bundles only[1]; ventral setae almost always present in II, may be absent anteriorly (rarely entirely) in dorsal bundles, prostomium not so glandular; ventral setae of XII not modified as long, stout hairs in mature specimens 3

[1] The exception to this is *Telmatodrilus papillatus* (Tubificidae) which has hair-like setae in posterior ventral and dorsal bundles.

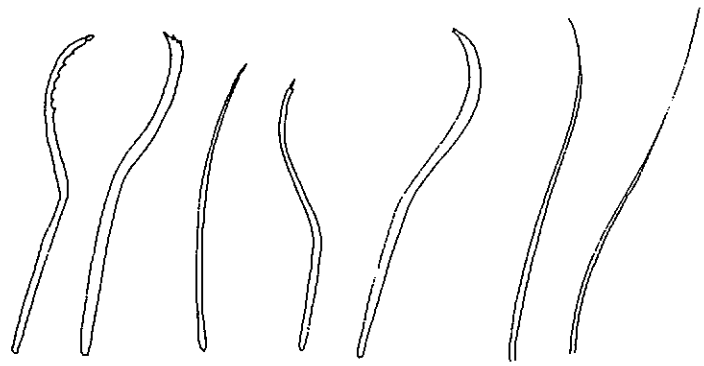


general body forms

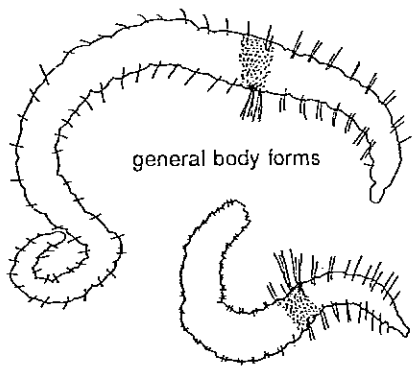


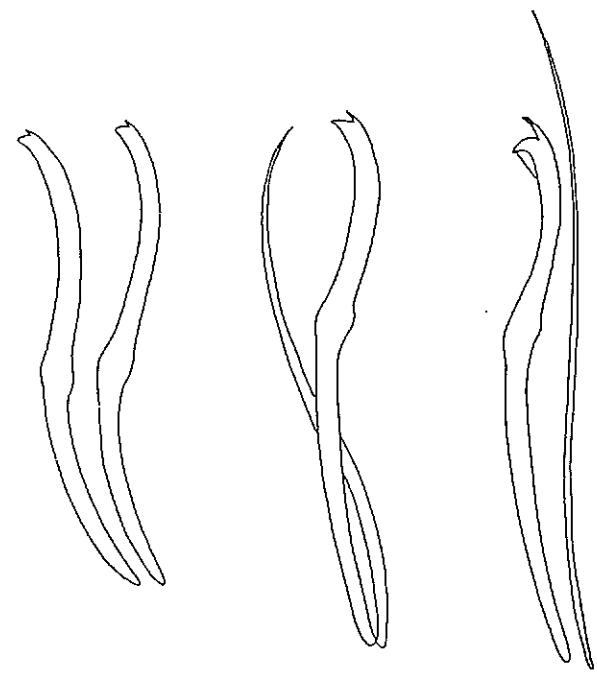
anterior segments

APHANONEURA (AEOLOSOMATIDAE)

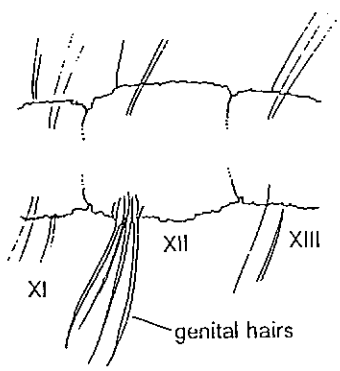


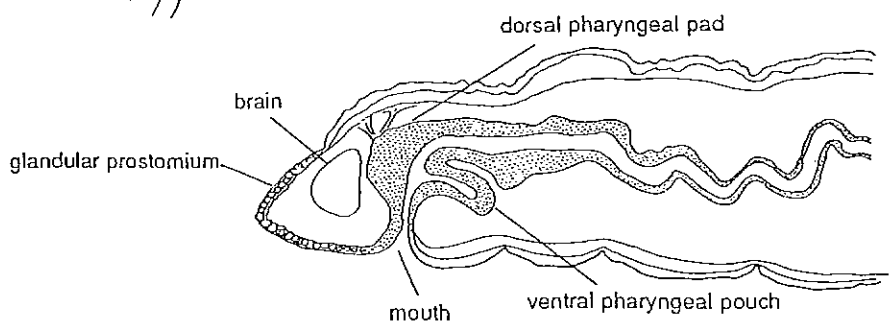
setae (not neccesarily Australian species)





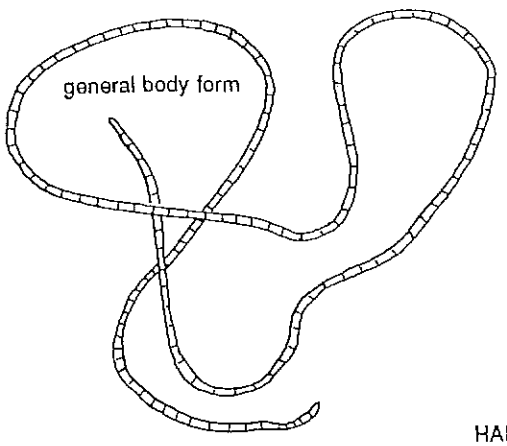
posterior setae

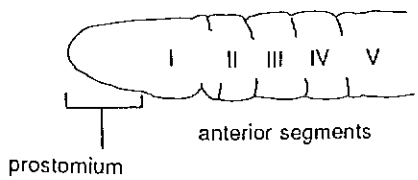




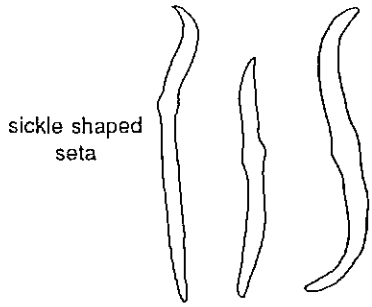
CAPILLOVENTRIDAE

anterior segments

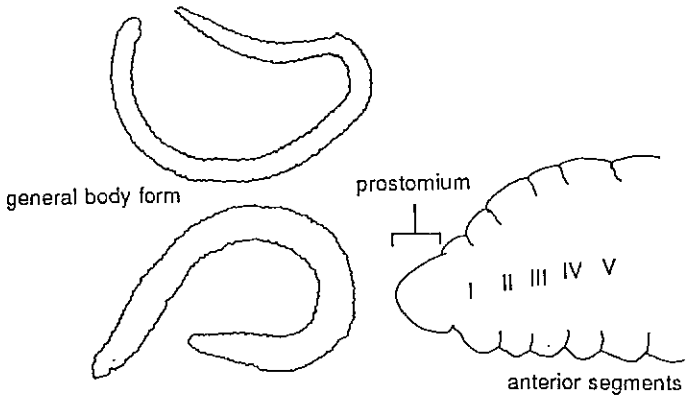




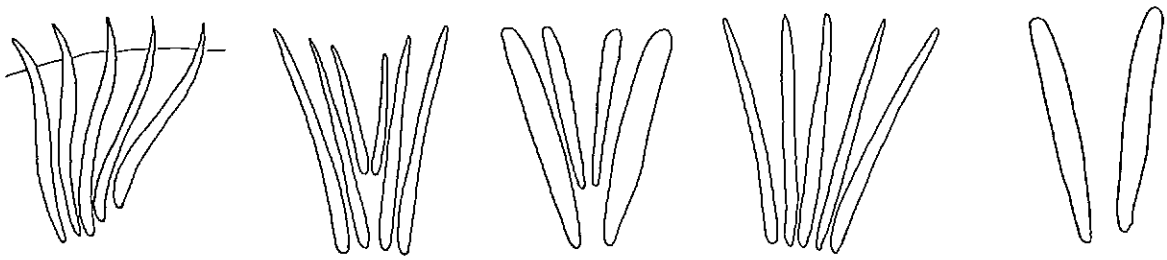
HAPLOTAXIDAE



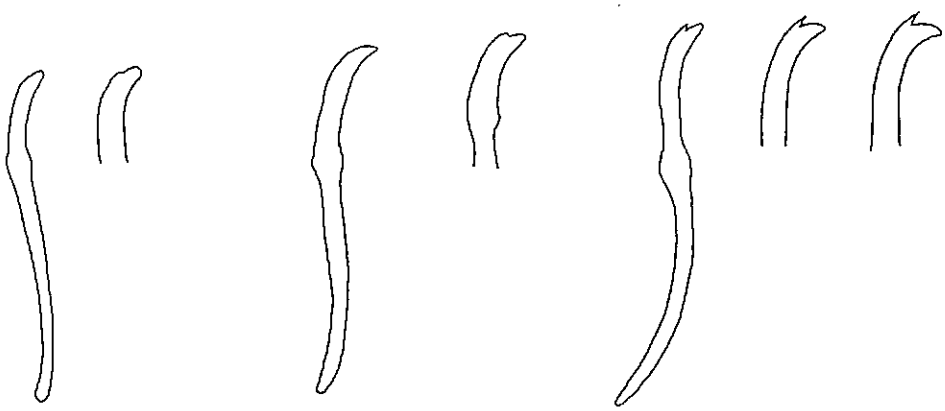
setae



MEGADRILI



setae of ENCHYTRAEIDAE



setae of LUMBRICULIDAE

3a. Worms wide with thick body walls (earthworm-like), not particularly long in relation to width (usually 2 to 10cm long), clitellum more than one cell thick and often located posterior to male pores; hair setae absent, usually two simple pointed setae per bundle (rarely with numerous setae evenly distributed around each segment - termed perisetine), setae usually stout and straight but may be sigmoid, usually all setae equal in size; pre-oral portion of body not elongate; commonly encountered .....**Megadrili** (earthworms).

b. Worms not earthworm-like, usually very long (2 to 30cm) in relation to width, body wall quite thick but clitellum one cell thick and located in the region of the male pores; hair setae absent, all setae simple pointed, one or two per bundle, if single then setae sickle shaped and the ventral setae much larger than the dorsal setae, if paired then setae sigmoid; elongate peristomium forming an extended pre-oral region; rarely encountered .....**Haplotaxidae** pg. 28

c. Worms thin with thin body walls, not earthworm-like and body not particularly long in relation to width, usually 0.5mm to 3cm, (rarely up to 10cm), clitellum one cell thick in the region of the male pores; hair setae present or absent, usually more than two setae per bundle[2] but in distinct bundles rather than perisetine.....**4**

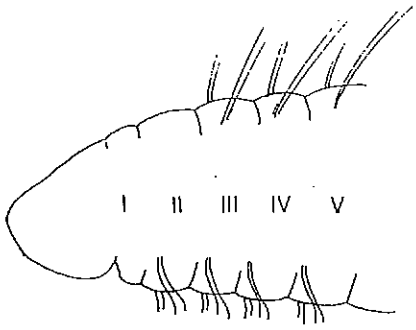
4a. Hair setae absent; all setae paired, sigmoid and at least rudimentarily bifid, may appear simple pointed if upper teeth very worn or rudimentary .....**Lumbriculidae** pg. 127

b. Hair setae absent; usually more than two setae per bundle, all simple pointed and either straight or sigmoid .....**Enchytraeidae**

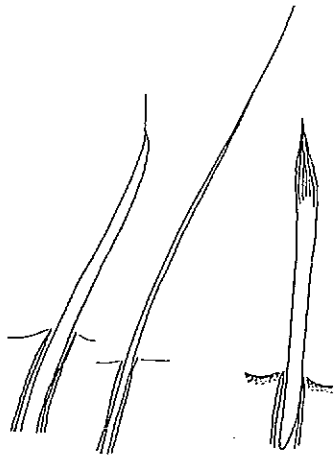
c. Hair setae present or absent; usually more than two setae per bundle (may be paired ventrally or posteriorly); non-hair setae usually sigmoid and either bifid, pectinate, simple pointed or otherwise (rarely all simple pointed)[3] **5**

[2]All Lumbriculidae and some Enchytraeidae have all paired setae. All Phreodrilidae have paired ventral setae but these usually have hairs in dorsal bundles (except *Insulodrilus uniseta*).

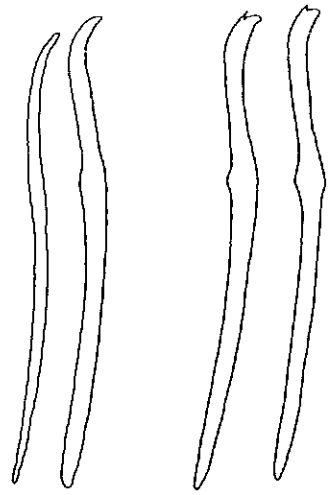
[3] *Telmatodrilus multiprostatus* (Tubificidae) has all simple pointed setae and immature specimens may be confused with some Enchytraeidae. Mature specimens of *T. multiprostatus* have distinctive genital setae, see text.



anterior segments with dorsal setae from III

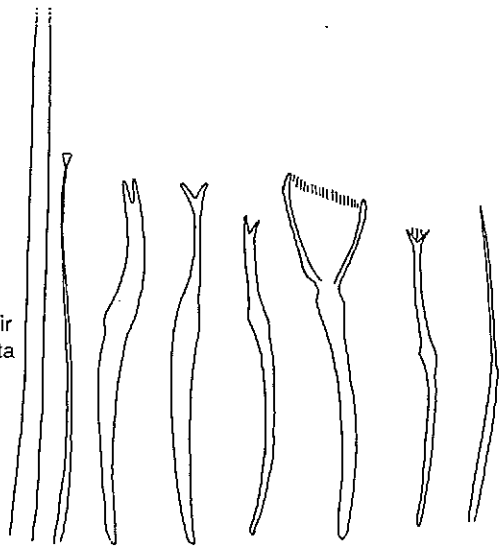


dorsal hairs



paired ventral setae

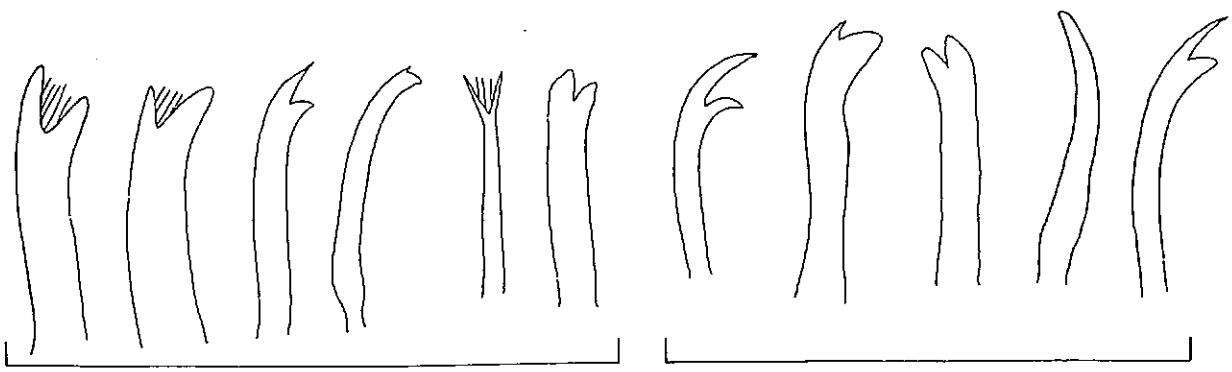
PHREODRILIDAE



needle setae

ventral setae

NAIDIDAE



dorsal setae

ventral setae

TUBIFICIDAE

5a. Ventral setae paired and either bifid or simple pointed or one of each; dorsal setae begin in III, usually consisting of one to many hairs and fine inconspicuous support setae not emerging from the body wall, dorsal setae rarely similar to the ventral setae; spermathecal pores in XIII, male pores usually in XII .....**Phreodrilidae** pg. 36

b. Ventral setae usually more than two per bundle, usually bifid, rarely simple pointed; dorsal setae begin in II or between IV to VI, rarely in III or more posteriorly than VI, consisting of either bifid pectinate, palmate or simple pointed setae, with or without hair setae; spermathecae anterior to the male pores **6**

6a. Dorsal setae usually begin between II and VI (rarely absent); dorsal bundles usually consisting of hair setae and fine bifid, simple pointed or pectinate setae (termed needles) which are usually of a very different form to (and thinner and smaller than) the ventral setae, rarely all setae of the same form; ventral setae bifid, those of II to V often longer and thinner than the rest; eye spots may be present on the peristomium or the prostomium may bear a proboscis; a branchial fossa may be present anally, with or without gills or gills may be present as dorso-lateral filaments on most segments; spermathecae in IV, V or VI with the male pores one segment behind; worms usually 1mm to 1cm long .....**Naididae** pg. 100

b. Dorsal setae usually from II; hair setae present or absent, non-hair dorsal setae generally resembling the ventral setae in size and shape, usually pectinate (particularly if hairs present), bifid or simple pointed; ventral setae usually bifid, rarely simple pointed, pectinate or hair-like, those of II to V generally not longer and thinner than the rest; neither eyes nor proboscis present; gills present as mid-dorsal and mid-ventral filaments on posterior segments of one species; spermathecae normally in X, male pores normally in XI; worms usually $\geq$ 1 cm long .....**Tubificidae** pg. 61

5. HAPLOTAXIDAE

A cladistic study by Brinkhurst (1988) showed that this family, as currently defined, is probably polyphyletic but is retained for convenience at this stage pending resolution of a number of outstanding taxonomic questions. The family is sparsely distributed on all continents but there are some generic disjunctions and most species appear to have very limited distributions.

Four of the 22 species recognised by Brinkhurst (1988) have been identified from Australia. The only endemic species, *Hologynus ornamentus*, is known from Great Lake and Arthurs Lake in Tasmania (Brinkhurst and Fulton, 1980) and its only congener, *Hologynus hologynus*, is known from islands south of New Zealand and from a single record near Harvey in Western Australia (Michaelsen, 1907, Jackson, 1931). The single Antipodean representative of the widely distributed genus *Haplotaxis* is *Haplotaxis heterogyne*, which is known from Lake Wakatipu in New Zealand and an uncertain record from Tasmania (Brinkhurst, 1982). Finally, *Pelodrilus africanus* has been recorded from Collie in Western Australia, as *Pelodrilus darlingensis* (Michaelsen, 1907, Jackson, 1931) and a specimen was tentatively identified from coastal Queensland (Brinkhurst, 1971). This species also occurs in Africa, New Zealand and islands south of New Zealand, while other *Pelodrilus* species occur in New Zealand (*Pelodrilus violaceus*) and Central Asia.

Very little is known about the biology and ecology of haplotaxids. Many appear to inhabit the groundwater and appear in marshy soil, caves, wells and deep lakes. These worms are very rarely collected and so a significant number of species are incompletely described and most are known from very few, often fragmentary or immature specimens. Species of the genus *Haplotaxis* are predatory, particularly on other oligochaetes such as tubificids (Brinkhurst, 1988, Brinkhurst and McKey-Fender, 1990).

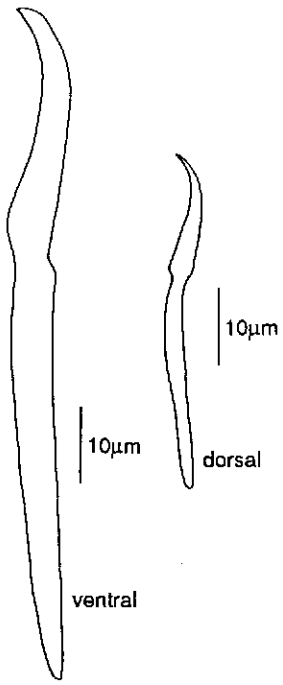
Haplotaxids are of great interest from an evolutionary perspective. According to one view of oligochaete evolution this family contains descendants of the earliest line of oligochaetes (Brinkhurst 1982b, 1984ab, 1991, 1992 and Brinkhurst and Nemec 1987). This view proposes that all of the extant oligochaete groups are derived from an ancestor that had two pairs of testes and two pairs of ovaries (the octogonadal condition). It is thought that loss of gonads from certain segments gave rise to stem lines from which the modern families arose. A large proportion of haplotaxids have all eight gonads, a condition that otherwise occurs rarely in only a few other groups.

Taxonomy of the Haplotaxidae

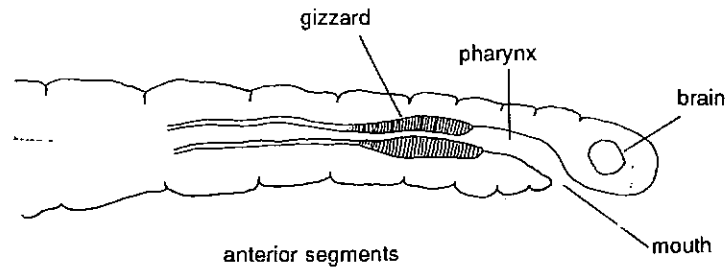
Brinkhurst (1966), noting that the existing haplotaxid genera showed overlaps in the characteristics used to separate them, united all haplotaxids within a single genus, *Haplotaxis*. This classification remained unchanged, apart from a few new species placed in new genera, until a cladistic analysis by Brinkhurst (1988). This later study concluded that, although the family could not be considered monophyletic, retaining most of the species in a single family, albeit with some genera placed incertae sedis infamilia, was nevertheless more logical at that stage than creating separate families for each of the identified groups. Some of the more recently described anomalous genera were either removed to an order of earthworms (*Metataxis*) or were elevated to the rank of separate family (*Tiguassu*: Tiguassidae). The genus *Haplotaxis* now consists of just eight species with a large muscular pharynx and large, single, sickle shaped ventral setae, characters presumably related to their predatory habit. The remaining species were either placed in one of seven other new, existing or re-instated genera . As noted above, some of these genera were only tentatively retained in the family until additional evidence is obtained from fresh specimens and/or new characters.

Family diagnosis

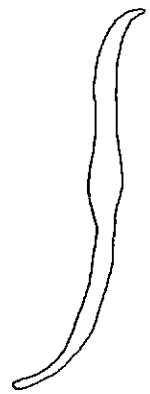
Worms usually very long (usually 2 to 30cm) in comparison to width. Peristomium often enlarged, creating an extended region between the mouth and the prostomium. The transverse furrow reported for some species is now known to be the furrow dividing the prostomium and peristomium. Proboscis, eyes and gills absent. Setae one or two per bundle, usually simple pointed, rarely bifid or pectinate, often sickle shaped and sometimes with ornamentations or keels. Genital setae rarely modified in mature specimens. Pharynx



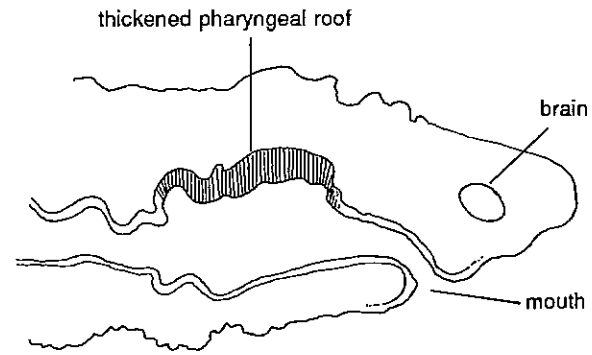
sickle shaped setae



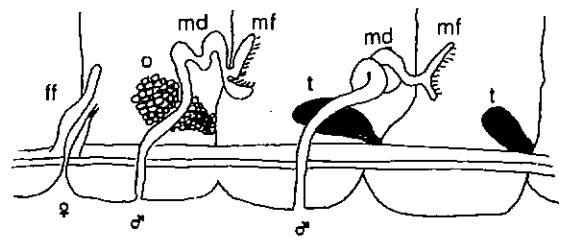
HAPLOTAXIS HETEROGYNE



sigmoid seta
of HOLOGYNUS

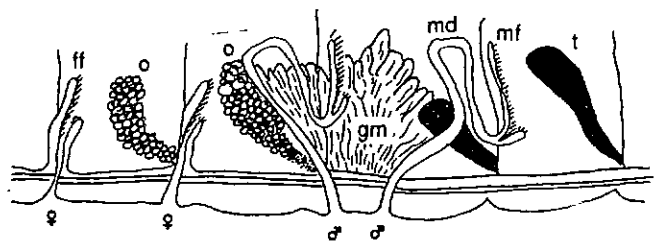


anterior segments
of HOLOGYNUS



genital segments of
PELODRILUS AFRICANUS

o	ovary
t	testes
gm	glandular mass
md	male duct
mf	male funnel
ff	female funnel
♂	male pore
♀	female pore



genital segments of
HOLOGYNUS HOLOGYNUS

eversible or with a ring of muscles forming a gizzard in one or more segments (in predatory species). Testes usually two pairs in X and XI (rarely in IX and X), rarely with anterior pair absent. One or two pairs of ovaries in the segments following the testicular segments. Male funnels paired, each associated with a single pair of testes, feeding simple ducts (without atria or penes), leading to ventro-lateral or lateral pores, usually located in the segment posterior to the associated testes, rarely both in XII. Large masses of glandular tissue sometimes present in the male segments. Female pores in posterior intersegmental furrows of ovarian segments or anteriorly in the next segment. Egg sacs and sperm sacs may be present. One to four pairs of spermathecae anterior to testes bearing segments, usually with lateral pores in the intersegmental furrow, spermathecae rarely single and with dorsal pores.

Identification of the Haplotaxidae

The generic and specific taxa are defined primarily on genital characters or, in the case of *Haplotaxis*, on the unusual setae and anterior alimentary system. Cleared and stained whole mounts of mature specimens are therefore usually minimum requirements and microtome sections are often essential to see the gonads and the simple male ducts.

Key to species

1a. A single sickle shaped seta per bundle (four per segment), those in ventral bundles larger than the dorsal setae; pharynx not eversible but thickened posteriorly to form a gizzard ..... ***Haplotaxis heterogyne*** pg. 31

b. Setae two per bundle (eight per segment), not sickle shaped, ventral setae not larger than the dorsal setae; gizzard not present, pharynx eversible and usually thickened dorsally **2**

2a. One pair of ovaries in XII; male pores not close together (located medially in XI and XII) and not associated with a glandular mass ..... ***Pelodrilus africanus*** pg. 31

b. Two pairs of ovaries, in XII and XIII; male pores close together (medially to posteriorly in XI and anteriorly in XII) and associated with a glandular mass ..... ***Hologynus*** **3**

3a. One pair of spermathecae, in VII to VIII with lateral pores in intersegmental furrow of 6/7 ..... ***Hologynus hologynus*** pg. 32

b. Two pairs of spermathecae, in VII and VIII with ventro-lateral pores in intersegmental furrows of ... 6/7 and 7/8 ..... ***Hologynus ornamentus*** pg. 32

Species descriptions

Genus ***Haplotaxis*** Hoffmeister, 1843

This genus is defined by characters associated with a predatory habit; pharynx with thickened muscular region forming a gizzard, pharyngeal glands not present. Setae single, ventral setae large and sickle shaped, dorsal setae smaller, not so sickle shaped and often absent in many or all segments.

One species.

Haplotaxis heterogyne Benham, 1904

Prostomium long. Gizzard in IV. Setae single and sickle shaped, ventral setae two to three times larger than the dorsal setae in all but the anterior segments. Dorsal setae present from II. Two pairs of spermathecae with pores lateral on VIII and IX. Male pores not observed. One pair of ovaries in XII with female pores in XIII. Clitellum from XII to 1/2 XIV. Length 20 mm.

Tas; three immature specimens tentatively identified from Arthurs Lake, Tasmania.
Otherwise known from the type specimens; two worms collected from Lake Wakatipu, S. Island, New Zealand.

Genus ***Pelodrilus*** Beddard, 1891

This genus consists of a loose grouping of three species. The type species, *H. violaceus*, has the single apomorphy of both male pores in segment XII but this is not shared by the two other species placed here incertae sedis by Brinkhurst (1988). All three species have paired setae, a single pair of ovaries, usually only one pair of spermathecae (at least in some specimens) and have an eversible pharynx with pharyngeal glands. This combination of character states is not found elsewhere in the family but no single character state can be seen as unique to the group.

One species.

Pelodrilus africanus Michaelsen, 1908

Prostomium short and broad. Septal glands from V to VII. Setae paired. Spermathecae large and single in VIII with pores lateral in the intersegmental furrow of 7/8. Male pores medial on XI and XII. Ovaries single in XII with pores in intersegmental furrow of 12/13. Clitellum 1/2 XI to XIII or XIV. Length 25 to 70 mm.

WA; in marshy ground on the bank of a brook near Collie (described as *P. darlingensis*). **Qld**; acid stream in Melaleuca swamp, opposite Bribie Island (tentative identification).
Also South Africa and the Adam, Auckland, Stewart and Campbell Islands, south of New Zealand.

Genus *Hologynus* Brinkhurst, 1988

Pharynx eversible(?) and with pharyngeal glands. Setae paired. Male pores close together and associated with a glandular mass.

Two species.

Hologynus hologynus (Michaelsen, 1907)

Prostomium conical. Pharynx eversible(?) with pharyngeal glands in V to VIII or IX. Elongate spermathecae in VII (often partly occluding VIII) or in VIII, with lateral pores in 6/7 or 7/8. Male pores posterior on XI and anterior on XII. Ovaries in XII and XIII with female funnels in intersegmental furrows of 12/13 and 13/14. Clitellum XII to 1/2 XIV. Length: 48 to 55 mm.

WA; in moist rich earth on bank of a brook near yarloop, Harvey.
Also Adam, Auckland and Stewart Islands, south of New Zealand.

The Stewart Island specimens have oesophageal diverticula in XIV from XIII and spermathecae in VIII with distinct ducts(?) and with pores in 7/8 and are referred to the subspecies *H. hologynus bipapillatus* (Michaelsen, 1924). Specimens from other localities without oesophageal diverticula, spermathecae in VII with indistinct ducts and pores in 6/7 are referred to *H. hologynus hologynus* (Michaelsen, 1907).

Hologynus ornamentus (Brinkhurst and Fulton, 1980)

Prostomium bluntly conical. Pharynx eversible with pharyngeal glands in IV to VIII. Two pairs of cylindrical spermathecae in VII and VIII with ducts not much narrower than ampullae and with ventro-lateral pores in the intersegmental furrows of 6/7 and 7/8. Ovaries in XII and XIII with pores in intersegmental furrows of 12/13 and 13/14. Length: up to 120 mm. Body coloured purple red when alive.

Tas; Great Lake and Arthurs Lake.

6. CAPILLOVENTRIDAE

This family, which consists of five very small marine and freshwater species in a single genus, *Capilloventer*, was established by Harman and Loden (1984) for a species from the Bay of Rio de Janeiro, Brazil. Two other species, one from the Weddell sea, Antarctica and one, *Capilloventer australis*, from the Hawkesbury River, N.S.W were described by Erseus (1993) and recently, *C. australis* and two new species have been found in freshwater streams and rivers of Victoria. Almost nothing is known about the biology or ecology of this family, other than an apparent preference for sandy sediment.

Family diagnosis

Dorsal and ventral bundles with similar setae, usually hairs and bifid or simple pointed setae. Bifid setae often with a subdental ligament. Setae in II (and sometimes in III) absent. Hairs often reduced or absent posteriorly. Ventral and dorsal bundles of one side usually located close together. Ventral setae of XII modified into long broad hairs. Pharynx with ventral pouch (?salivary glands). Testes in XI and ovaries in XII (to be confirmed for some species). Male funnels on 11/12, leading to simple male ducts (atria, prostate glands and penes absent), opening into simple copulatory chambers or directly to the exterior of XII. Female pores in XIII (to be confirmed for some species). Spermathecal ampullae in VII, with lateral pores in intersegmental furrow of 6/7.

Identification of the Capilloventridae

Only three species are currently known from Australia and these can be separated using somatic characters. The genital anatomy is very simple and has not been studied in sufficient detail to be used taxonomically.

Key to species

1a. Prostomium elongate; posterior bundles with bifid setae only .....***Capilloventer* sp. 2** pg. 35

b. Prostomium rounded; posterior bundles with bifid setae accompanied by hairs or simple pointed setae **2**

2a. Pre-clitellar bundles with one to four hairs hairs only; posterior bundles without hairs but with one thin, simple pointed seta and one bifid seta .....***Capilloventer* sp.1** pg. 35

b. Pre-clitellar bundles with one or two long hairs and one or two bifid setae; posterior bundles one, rarely two bifid setae and one (rarely two) short hairs .....***Capilloventer australis*** pg. 35

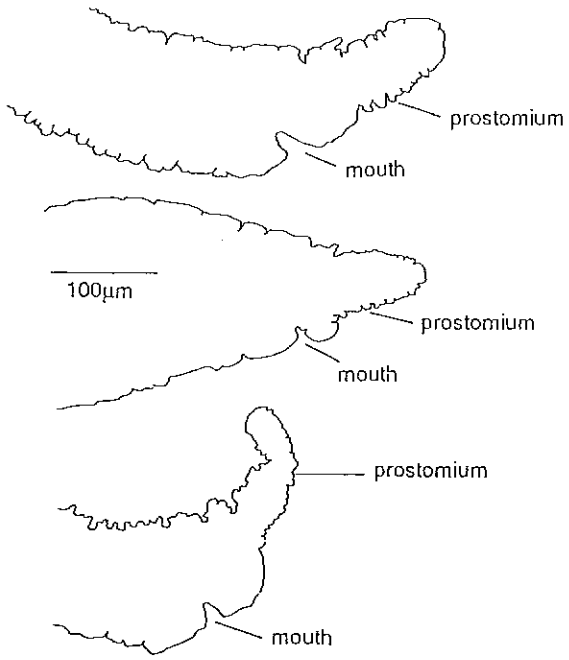
Ventral and dorsal bundles with three to eight setae anteriorly with upper teeth two to three times as long as, but thinner than, the lower. Six to ten bifid penial setae per bundle in XI, about twice the length of the somatic setae and slightly curved towards the tips. Vasa deferentia as long as atria. Atria tubular, four times longer than broad, ending in wide bulbs with narrow pores to the anterior face of continuations of the penis sacs. Prostate tissue abundant, attached to atria subapically. Coelomocytes not abundant.

Vic; Thomson River and Acheron River. NSW; Blue Lake (Kosciusko) and Wentworth River.

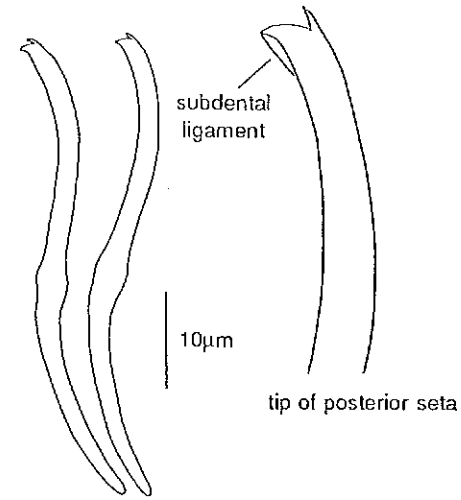
Rhyacodrilus fultoni Brinkhurst 1982

Ventral and dorsal bundles with 10 to 13 setae anteriorly, fewer posteriorly, all with teeth equally long. Six to nine straight simple pointed penial setae per bundle in XI, not much longer than the somatic setae, slightly hooked at the tip, may be rudimentarily bifid if not fully formed. Vasa deferentia short, entering the curved over distal part of the atria. Prostate absent. Atria lead to voluminous sacs with narrow external openings. Coelomocytes large and fairly abundant.

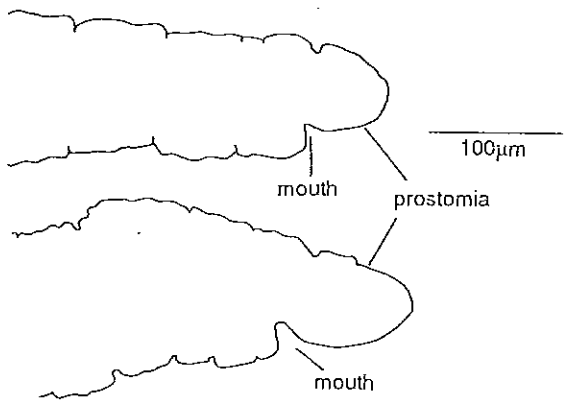
Tas; Lake Sorell.



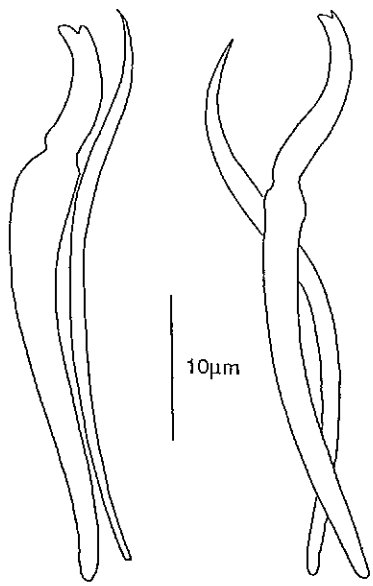
anterior segments of
CAPILLOVENTER SP. 2 specimens



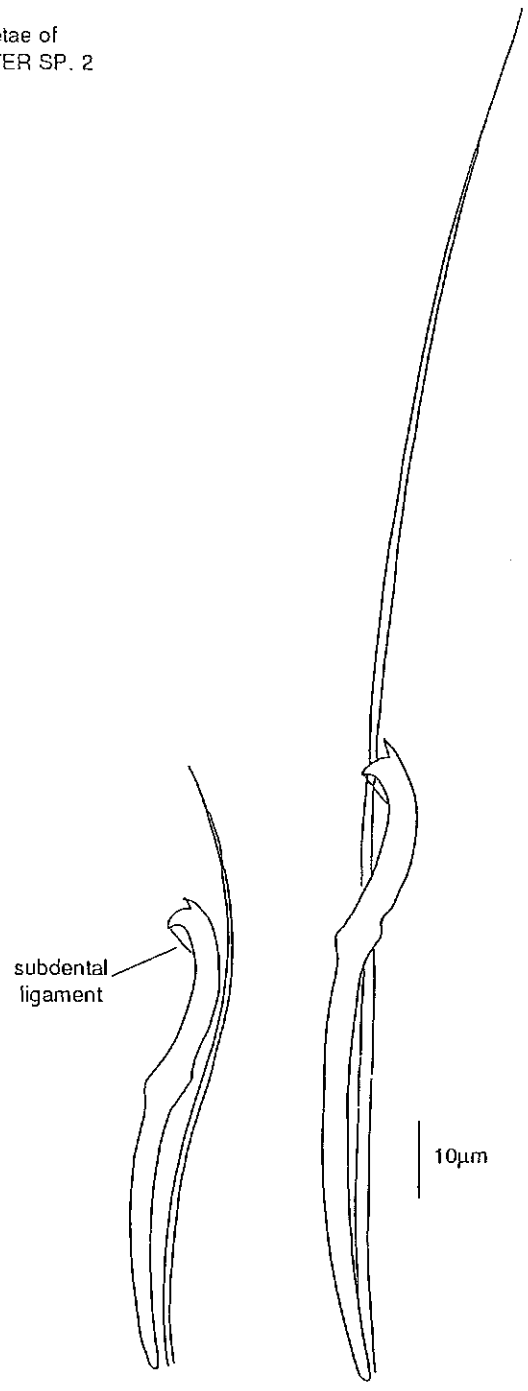
posterior setae of
CAPILLOVENTER SP. 2



anterior segments of species
with short rounded prostomia



posterior setae of CAPILLOVENTER SP. 1



posterior setae of CAPILLOVENTER AUSTRALIS

Species descriptions

Genus *Capilloventer* Harman and Loden, 1984

Generic diagnosis as for family.

Three species

Capilloventer australis Erseus, 1993

Setae from IV. Anterior bundles with one or two hairs (which may be hispid) and one or two bifid setae with small upper teeth and feint subdental ligament; the hairs two to three times the length of the bifid setae. Posterior bundles usually with one hair, not much longer than the bifid setae, and one or two bifid setae which are larger than those in anterior bundles and have a more conspicuous subdental ligament. Setal glands conspicuous. Prostomium rounded. Length: 2.5 to 5 mm.

Vic; Keppel Creek, Acheron River, Mitta Mitta River, Taggerty River, Steavenson River, Mitchell River and La Trobe River. NSW; 500m downstream from junction of Colo and Hawkesbury Rivers.

Capilloventer sp. 1

Setae from III (may appear to start from II if intersegmental furrow of 1/2 inconspicuous). Setal bundles of III to XV with one to four short, thin, non-hispid hairs. Posterior bundles each with one thick bifid seta with a distinct nodulus, a small upper tooth and no subdental ligament and one thin simple pointed seta without a distinct nodulus. Without distinct setal glands. Prostomium rounded. Length 2.0 to 3.4 mm.

Vic; Acheron River and La Trobe River.

Capilloventer sp. 2

Setae from III. Anterior bundles with up to five setae, consisting of a combination of hairs and thin straight setae without distinct noduli and with blunt tips that often appear to be bifid or trifid or even frayed. Posterior bundles with one to three (usually two) sigmoid bifid setae with small upper teeth, distinct noduli and usually with distinct subdental ligaments. Without distinct setal glands. Prostomium variable in shape but generally elongate and proboscis-like. Length 1.0 to 1.6 mm.

Vic; Mitta Mitta River.

7. PHREODRILIDAE

The family Phreodrilidae, which consists of six genera with 34 species[1], has been recorded from Australia, South America, Africa, Sri Lanka, New Zealand and many southern oceanic islands. Australia has a particularly rich and diverse phreodrilid fauna, consisting of 22 species within five genera. Endemicity is confined to the species level with eighteen species restricted to Australia and four also known from New Zealand and/or South America. Four of the genera have representatives in South America, Africa, Sri-Lanka and/or isolated islands of the South Atlantic while the fifth was known only from Australia until recently, but may now be found on Macquarie and Campbell Islands. The only genus without Australian representatives is the poorly known *Schizodrilus* of New Zealand (Stout, 1958).

Within Australia the family exhibits a primarily southern distribution. Twelve species, including most *Insulodrilus*, are restricted to Tasmania. Five further species are found in both Tasmania and eastern Victoria, and one of these (*Antarctodrilus proboscidea*) also occurs in southern New South Wales and on Kangaroo Island in South Australia. One unusual species, *Phreodriloides notabilis* is restricted to the glacial lakes of Kosciusko, N.S.W. The most northerly occurrences of phreodrilids are of three *Astacopsidrilus* that are ectocommensal on freshwater crayfish, these are from coastal New South Wales and south-east Queensland. The only record of this family from Western Australia is the free-living *Astacopsidrilus novus*, which was described from the foot of Lesmurdie Falls in Perth by Jackson (1931) but has not been found since. One species found on Macquarie Island appears to be a species previously known only from the nearby Campbell Island.

Phreodrilids are generally slender worms which vary in length from only a few mm up to about three centimetres. Very little is known about the biology or ecology of this family, other than that they have a preference for cool freshwater environments such as mountain steams and rivers, deep or glacial lakes, groundwater or a variety of habitats on isolated islands below latitude 45° S. A few species have been collected from the seashore of remote islands, although at least one of these was collected close to a freshwater stream. Most species appear to be sediment dwellers, although, as mentioned above, some *Astacopsidrilus* have been found in association with freshwater crayfish. The precise relationship between the worms and the crayfish has not been investigated but the lack of any obvious adaptations to a parasitic habit suggest an ectocommensal or symbiotic relationship. Sexual reproduction appears to be the primary means of propagation, although *Schizodrilus* is known to reproduce asexually. Gut contents generally consist of detritus with diatoms and other algal cells but the extent of selectivity is unknown.

Family diagnosis

Prostomium with a proboscis in two species. Eyes absent. Gills present on posterior segments of one species. Dorsal bundles usually with thin hairs, rarely broad hairs with brush tips or simple pointed setae, usually from III (rarely from IV or V). Hairs accompanied by small, thin "support" setae on either side of each hair that do not protrude from the body wall. Paired ventral setae from II, often dissimilar in length and thickness, often one simple pointed and without a distinct nodulus and one bifid with a distinct nodulus although both may be of the same form. Bifid ventral setae usually with rudimentary upper teeth. In mature specimens the ventral setae of XII are usually absent and those of XIII (the segment with spermathecal pores) may be replaced by a pair of modified spermathecal setae with grooved tips. Testes and ovaries anteriorly in XI and XII respectively. Male ducts and ventral pores in XII, female pores ventral, either at the 12/13 intersegmental furrow or anteriorly in XIII (but then usually within ventral spermathecal vestibulae). Spermathecal pores either dorsal or ventral in XIII, often entering small to large muscular vestibulae. Spermathecal ampullae may be one to several segments posterior to pores. Atria present, without separate prostate glands, but usually with thick glandular epithelial lining internally, leaving little lumen. Vasa deferentia thin, usually entering atria basally. Pendant penes or eversible pseudopenes usually present.

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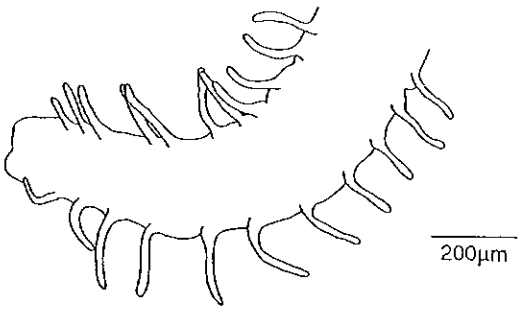
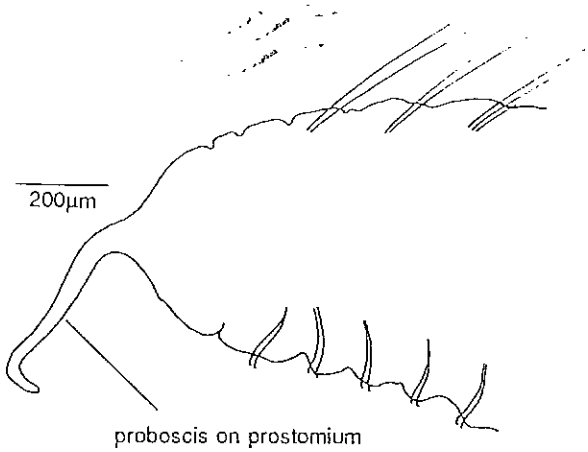
[1]These numbers include the new species listed in this chapter but exclude two species considered species inquirendae (Brinkhurst, 1991). These are *Phreodrilus mauianus* Benham, 1903 of New Zealand and *Tasmaniadrilus tasmaniaensis* Goddard and Malan, 1913 of Tasmania. The latter is the only species within the genus.

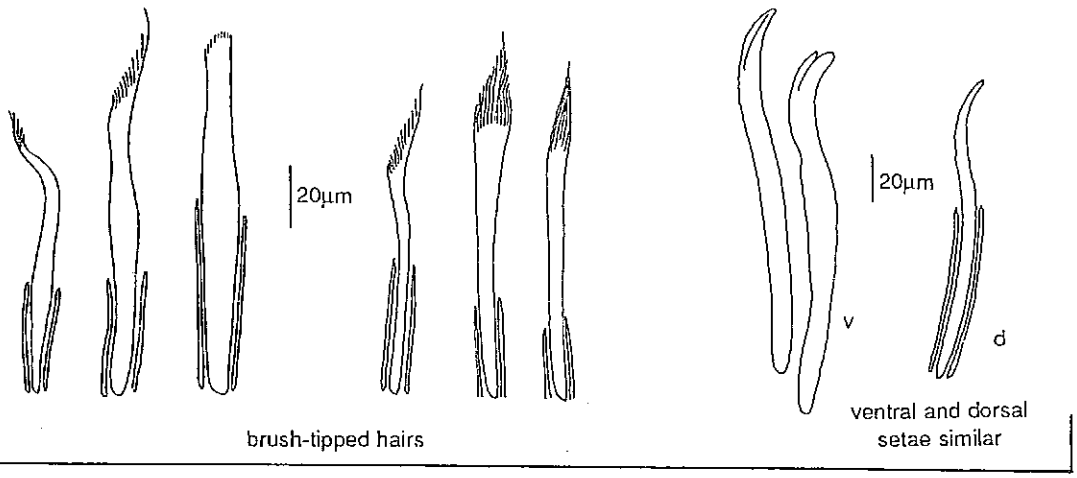


lateral gills on posterior segments

GROUP B



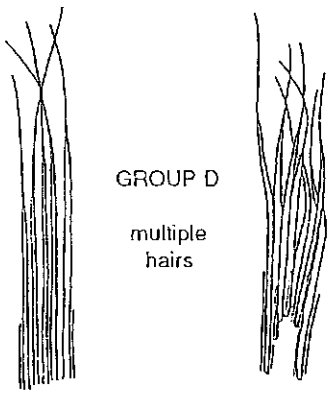
proboscis on prostomium



brush-tipped hairs

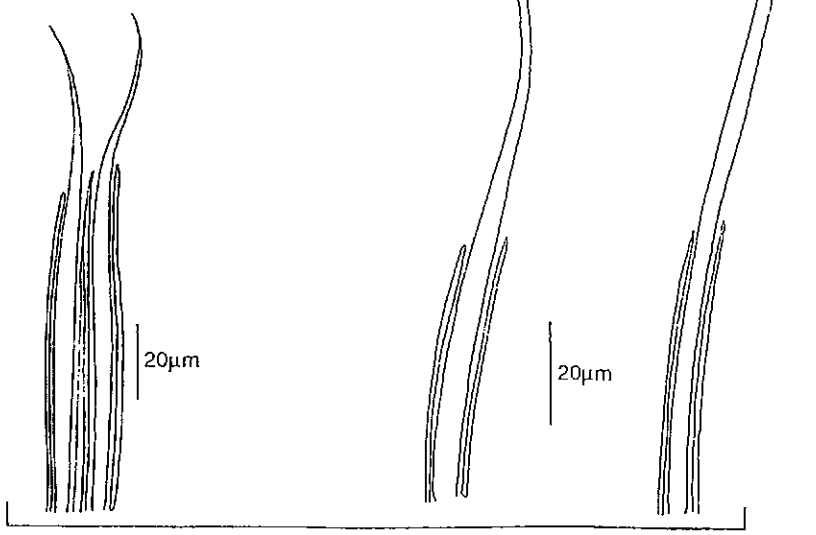
ventral and dorsal setae similar

GROUP C



GROUP D

multiple hairs



hairs of GROUP E

Identification of the Phreodrilidae

The following artificial key is primarily based on external, non-genital characters, allowing even immature specimens of most species to be identified. However, there are a number of species which are virtually indistinguishable externally and which require mature specimens for identification. Details of the genital anatomy are included in the descriptions but are not illustrated in this version of the guide. Particular care needs to be taken when examining the ventral setae for upper teeth which may be rudimentary.

Key to major groups

1a. Worms ectocommensal on freshwater crayfish ..... **Group A** pg. 40

b. Worms free-living 2

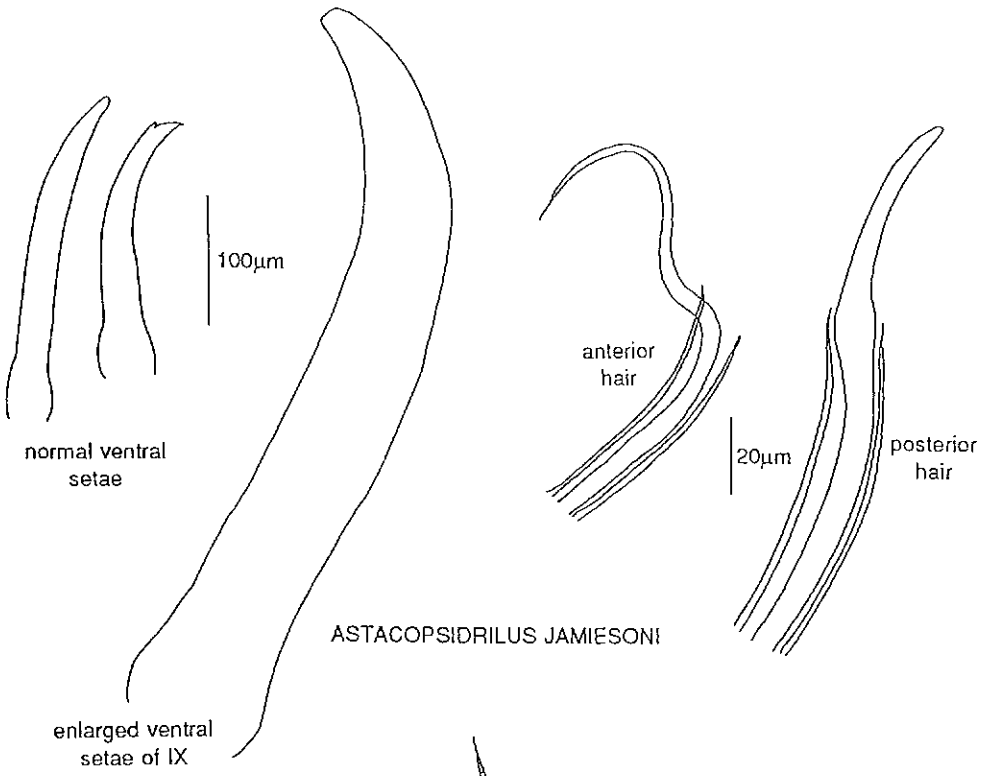
2a. With lateral gills posteriorly or prostomium with proboscis ..... **Group B** pg. 40

b. Without gills or proboscis 3

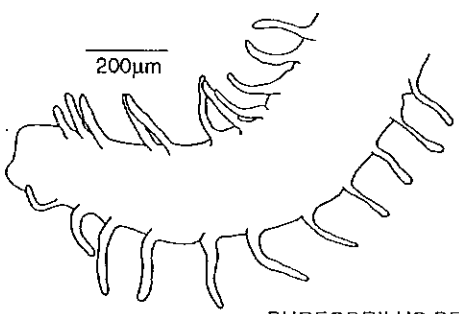
3a. Dorsal bundles with either a single brush-tipped hair or with one or two setae which resemble those in ventral bundles ..... **Group C** pg. 42

b. Dorsal bundles with one to six hairs anteriorly, increasing in number to 10 to 20 posteriorly, neither brush-tipped nor resembling the ventral setae ..... **Group D** pg. 44

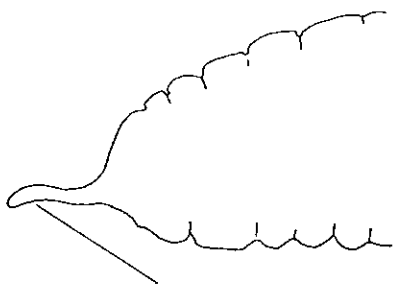
c. Dorsal bundles with at most 1 to 3 hairs, not significantly increasing in number posteriorly, neither brush-tipped nor resembling the ventral setae ..... **Group E** pg. 46



ASTACOPSIDRILUS JAMIESONI

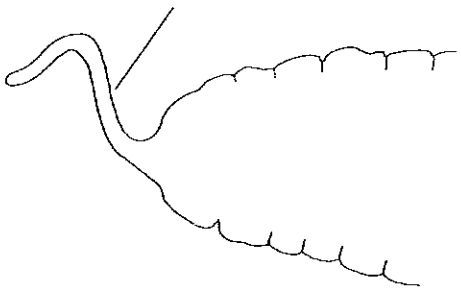


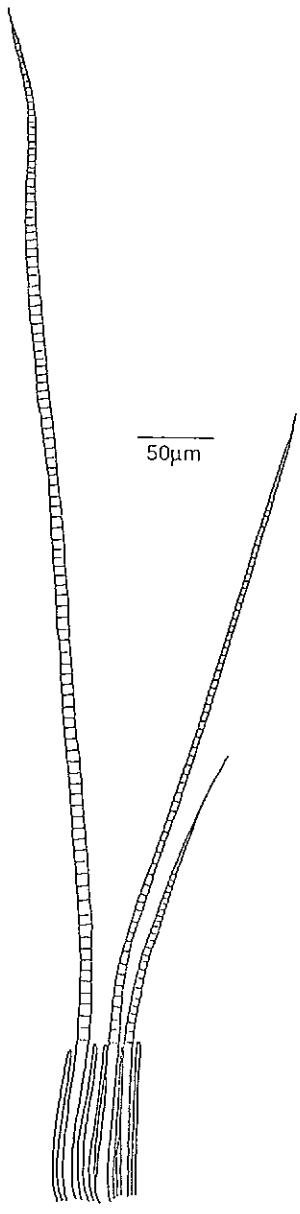
PHREODRILUS BRANCHIATUS



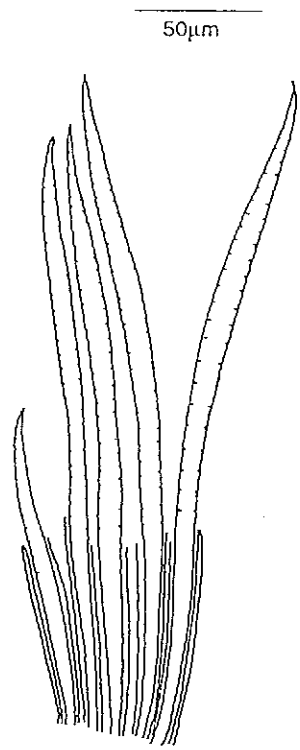
probosces of ANTARCTODRILUS SPP.

200µm





anterior hairs of ANTARCTODRILUS SPP.



posterior hairs of ANTARCTODRILUS SP. 1

Keys to species

Group A: *Astacopsidrilus* species ectocommensal on freshwater crayfish (Parastacidae). These species have not been found away from their host crayfish.

1. Dorsal setae single hairs from III, becoming shorter, broader and more sigmoid posteriorly; ventral setae enlarging to mid-body region; vasa deferentia short, joining short, slightly twisted atria basally where atria enter large penes ..... *Astacopsidrilus jamiesoni* pg. 55

2. Dorsal setae single hairs (from III?) possibly broader posteriorly; ventral setae not greatly enlarging to mid-body region; vasa deferentia long, joining long, curved (but not twisted) atria sub-basally before atria enter small penes .....*Astacopsidrilus* spp. pg. 56

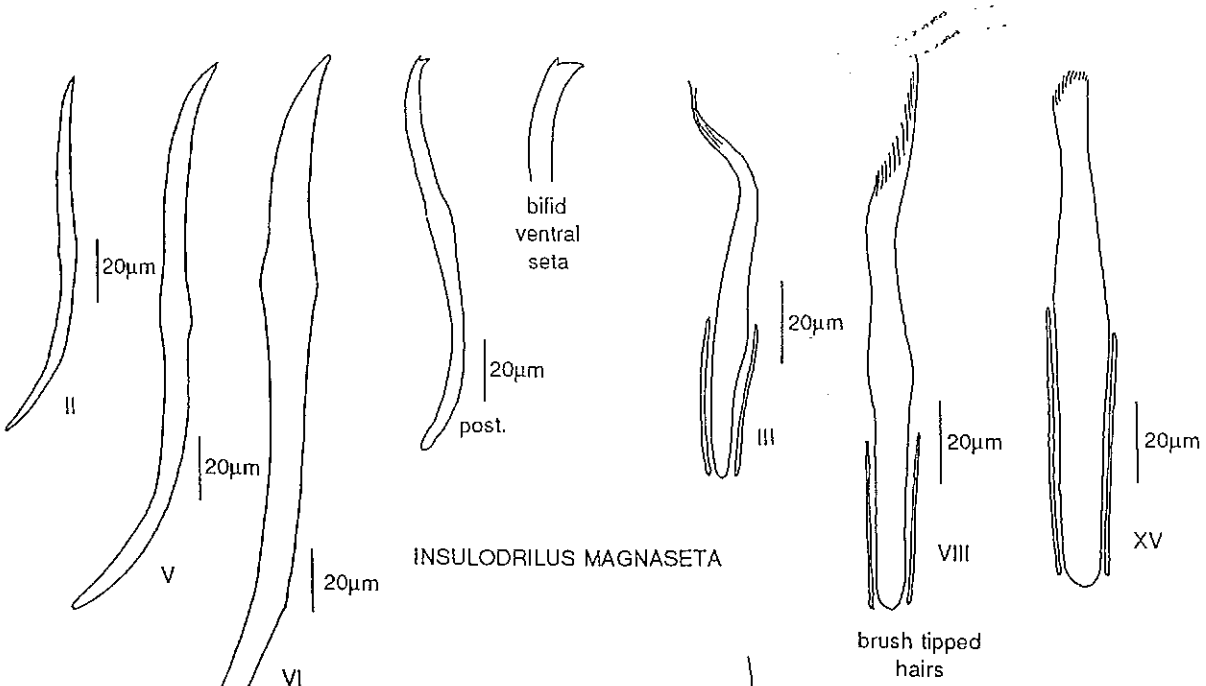
Astacopsidrilus spp. consists of two poorly known species from NSW. These were described by Goddard (1909a) but have not been collected since. The descriptions of some taxonomically important characters are vague or ambiguous and there is some doubt as to whether they are in fact two species. This is discussed further on page 56.

Group B: Species with gills or a proboscis.

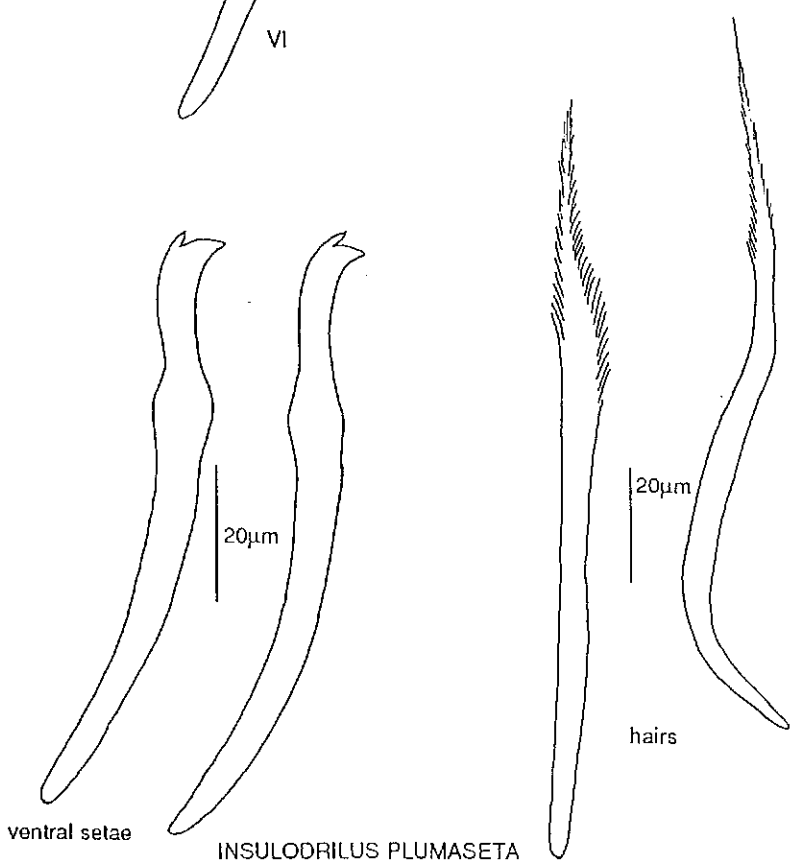
1. With a pair of dorso-lateral gills on posterior segments; proboscis absent; dorsal setae one or two non-hispid hairs per bundle .....*Phreodrilus branchiatus* pg 51

2. Gills absent; proboscis present on prostomium; dorsal setae two to four long, thin hispid hairs per bundle, not changing in form posteriorly .....*Antarctodrilus proboscidea* pg 53

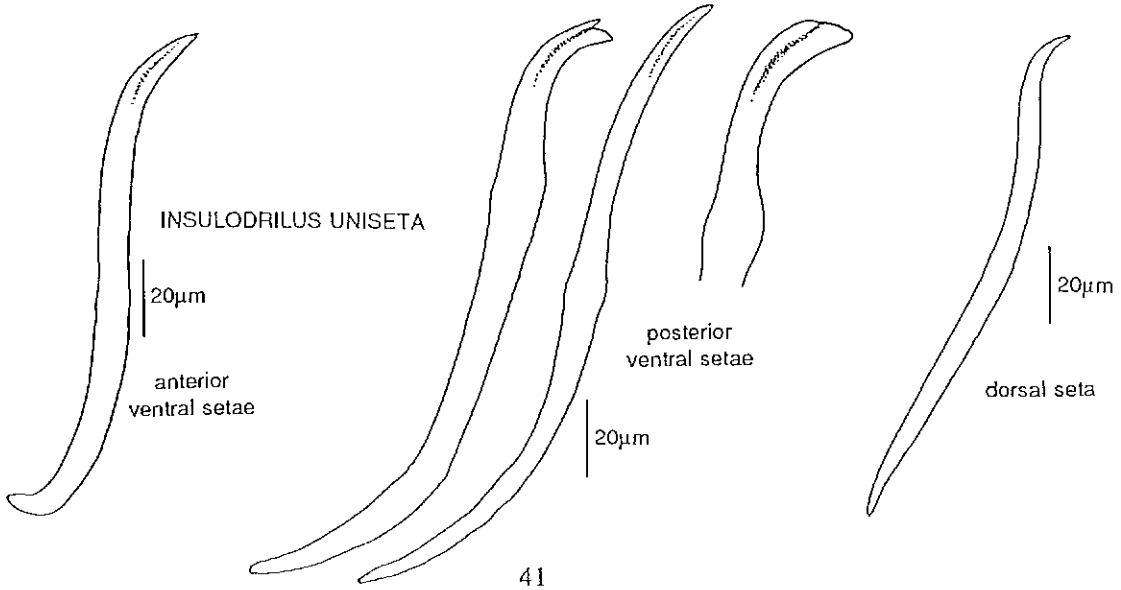
3. Gills absent; proboscis present on prostomium; dorsal setae two to four long, thin, gradually tapering hispid hairs per bundle anteriorly; four to six stout hairs per bundle posteriorly, tapering abruptly towards the tip .....*Antarctodrilus* sp. 1 pg 53



INSULODRILUS MAGNASETA



INSULODRILUS PLUMASETA



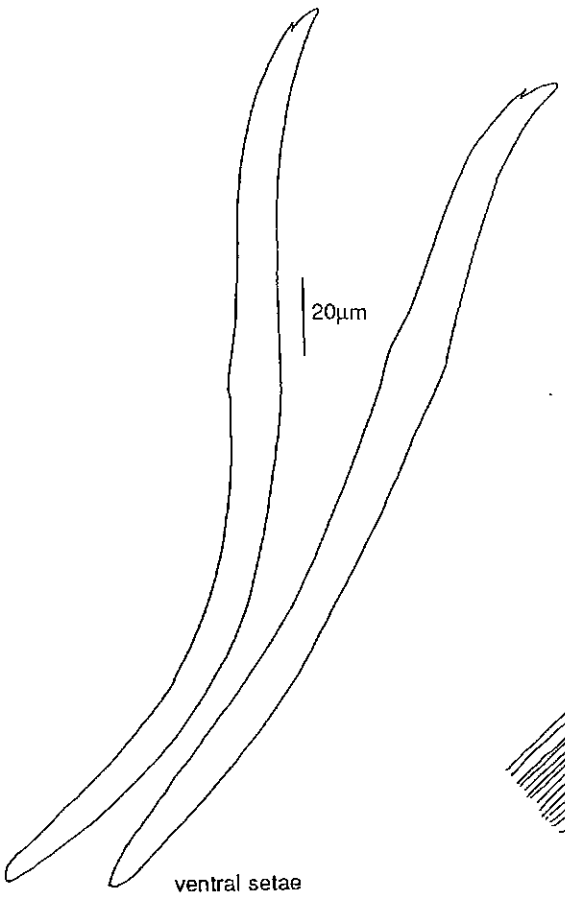
Phreodrilidae (cont.)

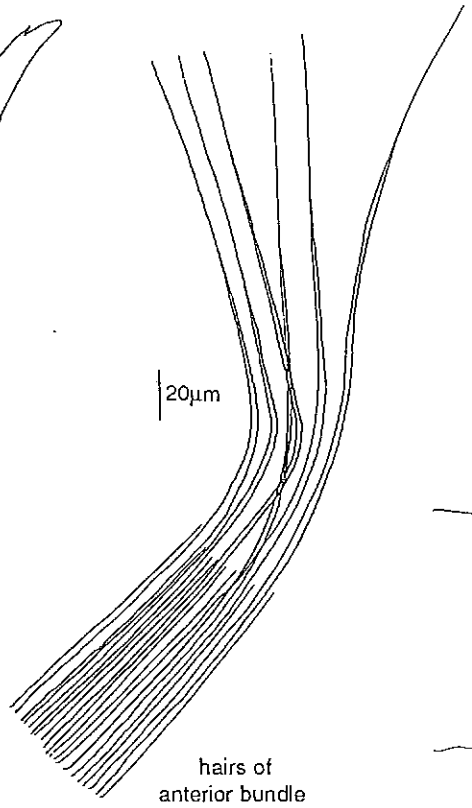
Group C: Species with single brush-tipped hairs dorsally or with dorsal setae resembling the ventral setae.

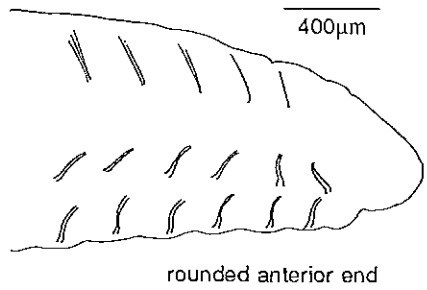
1. Dorsal hairs stout and brush-tipped, becoming increasingly stout and blunt posteriorly; ventral setae becoming enlarged to VII, smaller from VIII, mostly simple pointed or with reduced upper teeth from VIII on some specimens .....*Insulodrilus magnaseta* pg 57

2. Dorsal hairs brush-tipped, not becoming more stout or blunt posteriorly. Ventral setae all bifid with small upper teeth, not enlarged anteriorly .....*Insulodrilus plumaseta* pg 57

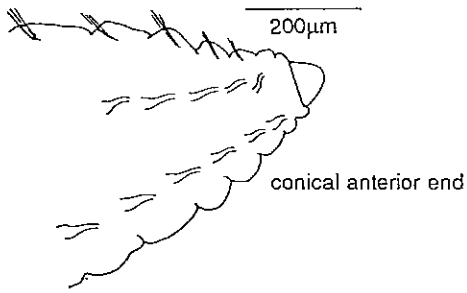
3. Dorsal hairs not brush tipped, one or two sigmoid, simple pointed setae resembling the ventral setae; ventral setae one simple pointed and one bifid with a small upper tooth, both with a distal groove, rarely both simple pointed anteriorly or both bifid, not enlarged anteriorly ....*Insulodrilus uniseta* pg 57



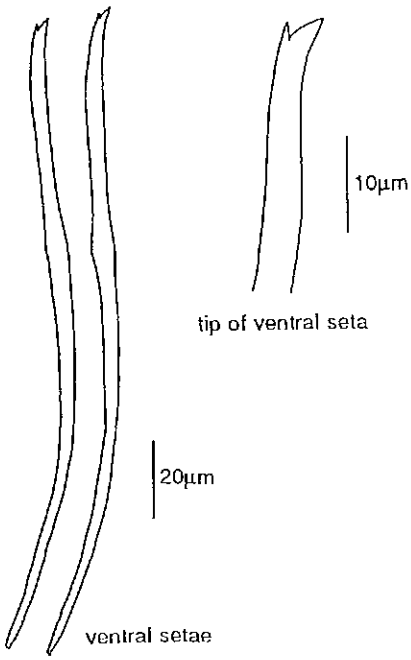


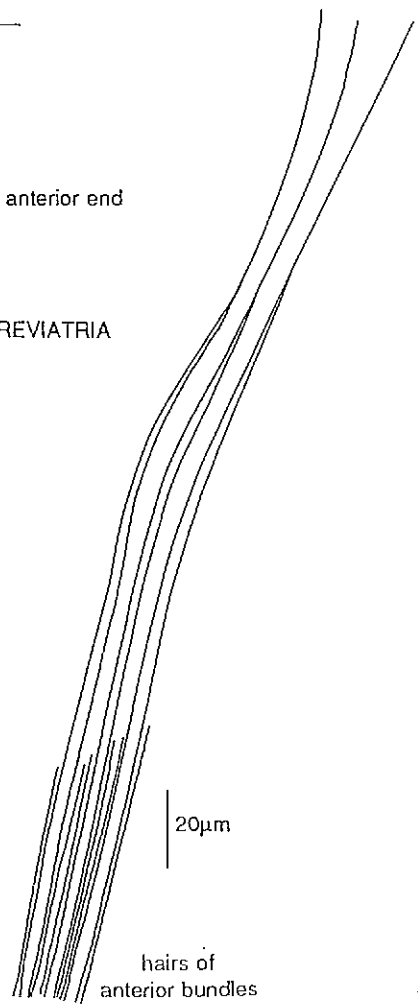


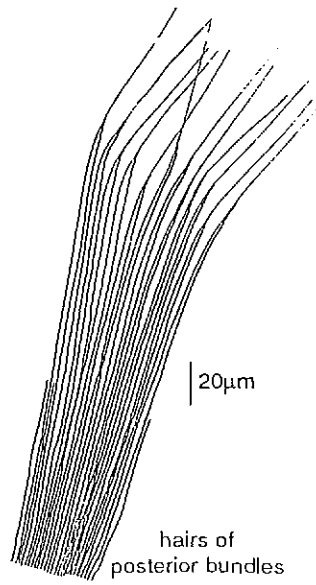
PHREODRILUS PALUSTRIS



INSULODRILUS BREVIATRIA



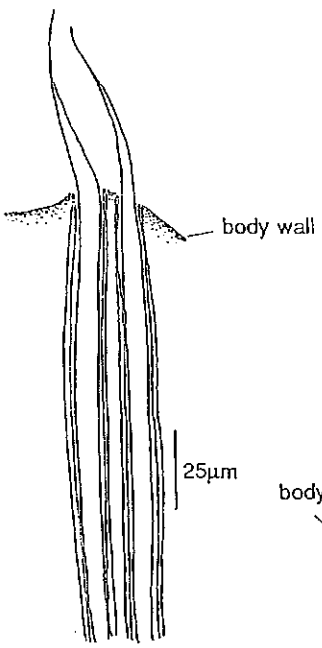




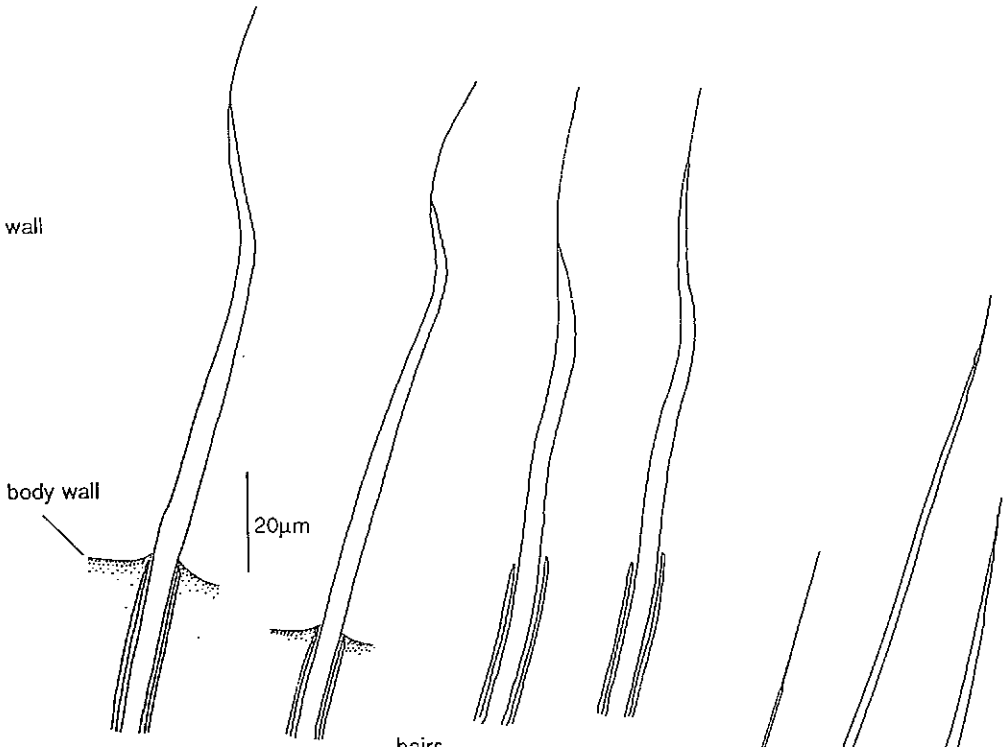
Group D: Species with hairs becoming more numerous posteriorly.

1. Dorsal setae one or two thin hairs anteriorly, progressively increasing in size and number posteriorly to five, eight and eventually up to as many as 20 per bundle, diminishing in size and number posteriorly; body not rounded anteriorly, diameter of segments not significantly increasing after segment I .....*Phreodrilus palustris* pg 51

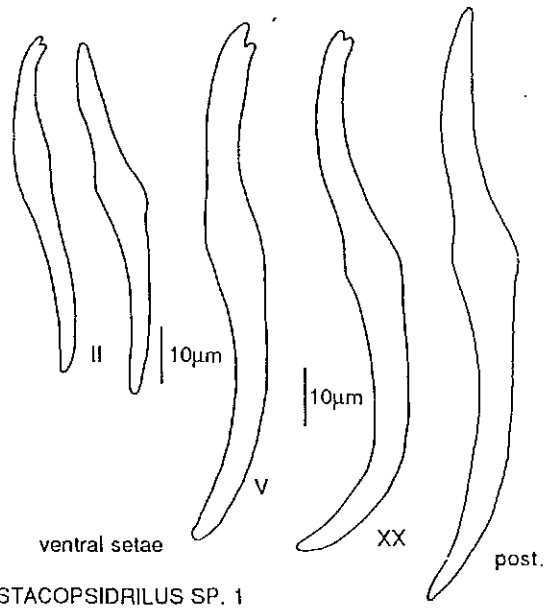
2. Dorsal setae distinct and thick, tapering beyond a bend, increasing in number from three to six anteriorly to 13 to 16 setae medially; body conical anteriorly due to increasing diameter of segments from segment I to the clitellar region .....*Insulodrilus breviatria* pg 57



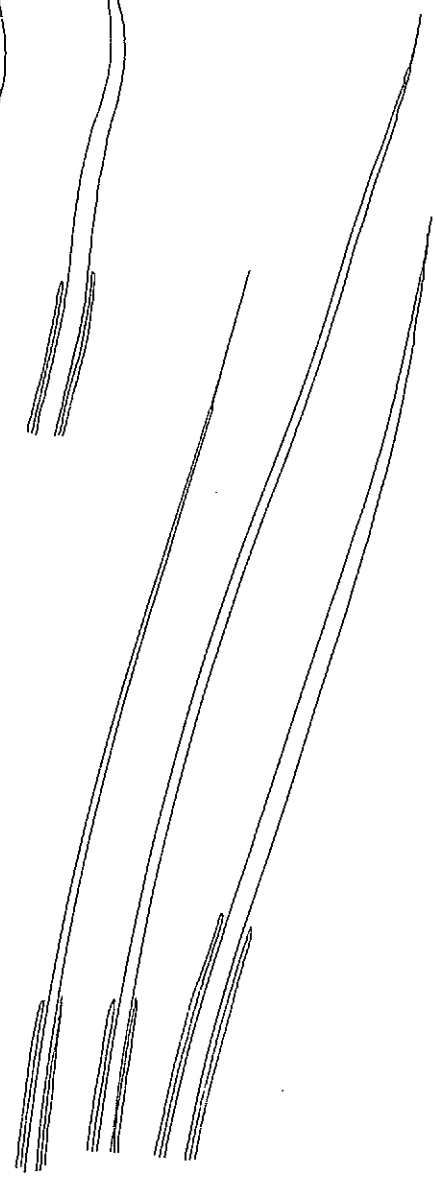
INSULODRILUS SP. 1



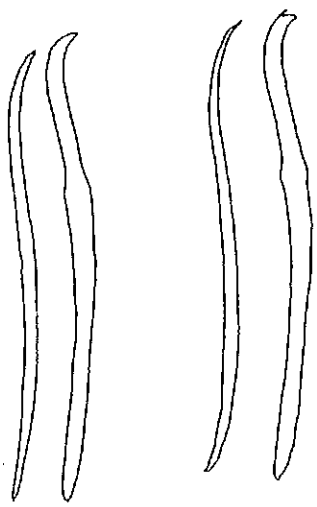
INSULODRILUS NUDUS



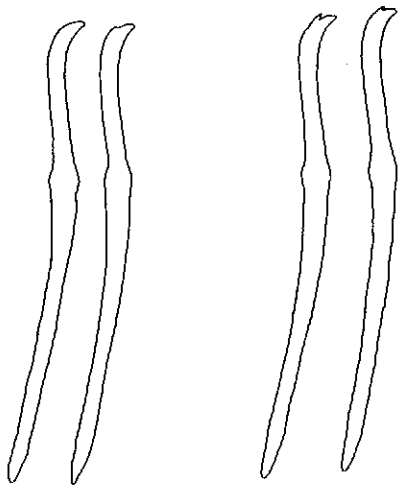
ASTACOPSIDRILUS SP. 1



capilliform hairs



ventral setae dissimilar



ventral setae similar

Group E: Species with at most 1 to 3 non-brush tipped hairs per dorsal bundle.

1a. Dorsal bundles with one to three very small, inconspicuous hairs, narrowing abruptly towards the tip after bending and with only the whip like tips protruding from the body wall .... *Insulodrilus* sp. 1 pg. 58

b. Dorsal bundles with single, broadly based hairs, narrowing abruptly towards the tip after bending but with the wide shafts of hairs also protruding from the body wall .....*Insulodrilus nudus* pg. 58

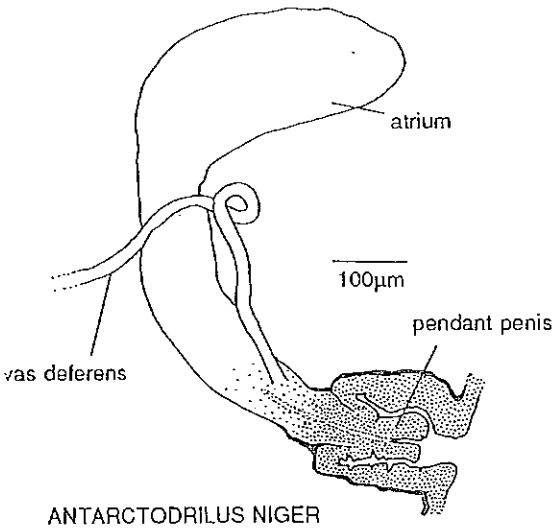
c. Dorsal bundles with one to three hairs, either long and capilliform or if stout then hair not narrowing so abruptly after a bend 2

2a. Some anterior ventral setae bifid with upper teeth longer than the lower (may be simple pointed or teeth equal in II and III), teeth becoming equally long medially and then simple pointed posteriorly. .....*Astacopsidrilus* sp. 1 pg 55

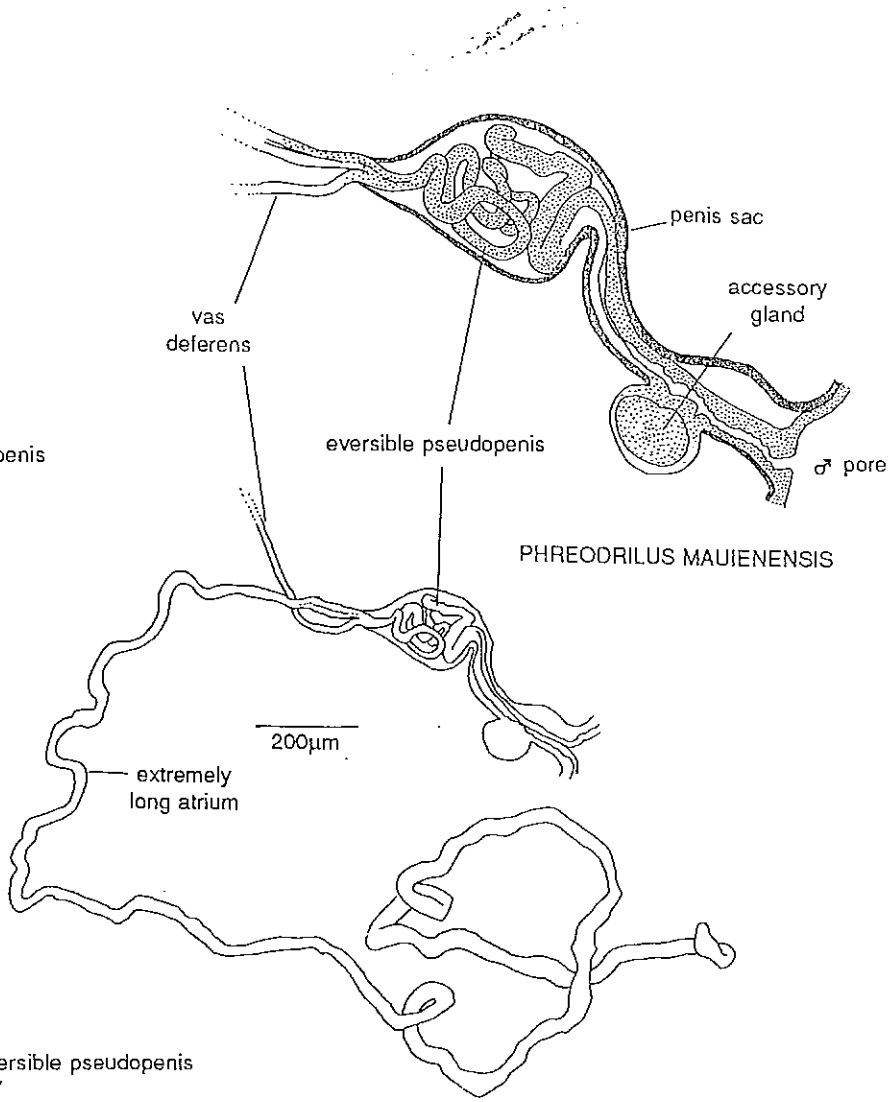
b. Anterior ventral setae either simple pointed or bifid with very short upper teeth, if simple pointed then usually at least one or both setae bifid with short upper teeth posteriorly 3

3a. Ventral setae dissimilar, usually one thin and simple pointed without a distinct nodulus and the other thicker and either bifid or simple pointed but with a distinct nodulus .....4 pg. 48

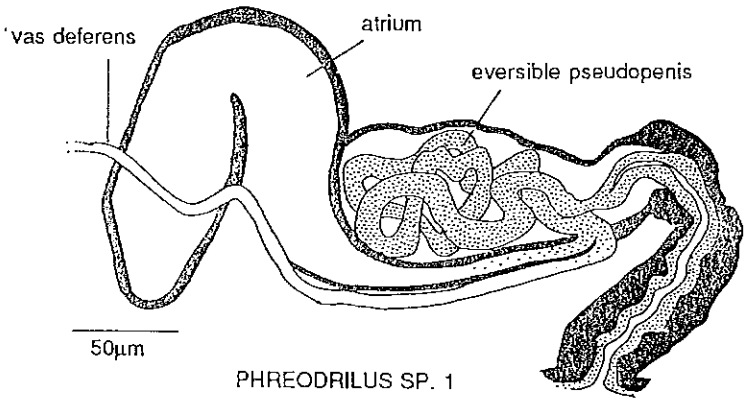
b. Ventral setae similar, approximately equal in width and usually both with a distinct nodulus, usually both bifid but the upper tooth of one or both may be rudimentary .....6 pg. 50



ANTARCTODRILUS NIGER

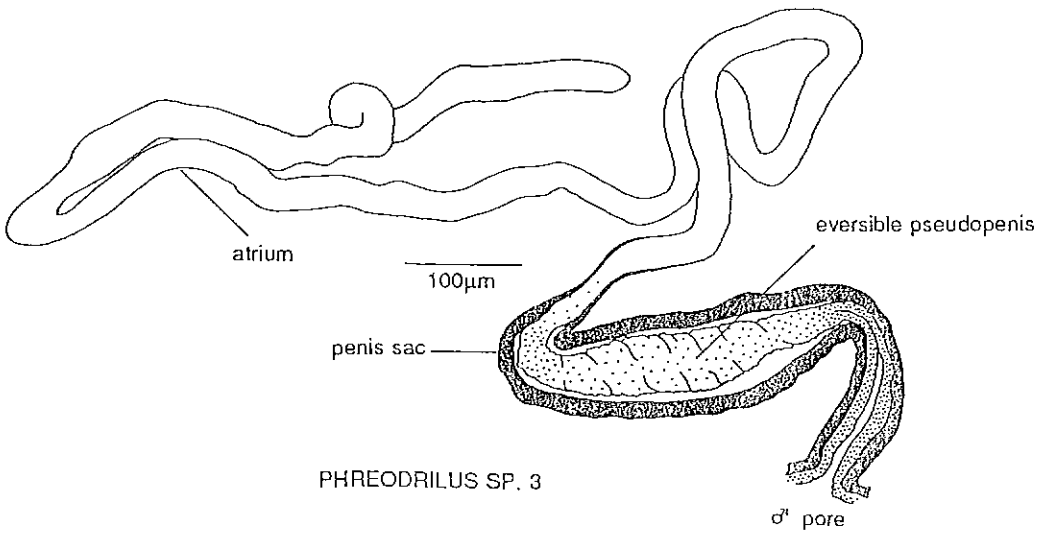


PHREODRILUS MAUIENSIS



PHREODRILUS SP. 1

♂ pore



PHREODRILUS SP. 3

♂ pore

Group E (cont.)

The following species require mature specimens for identification.

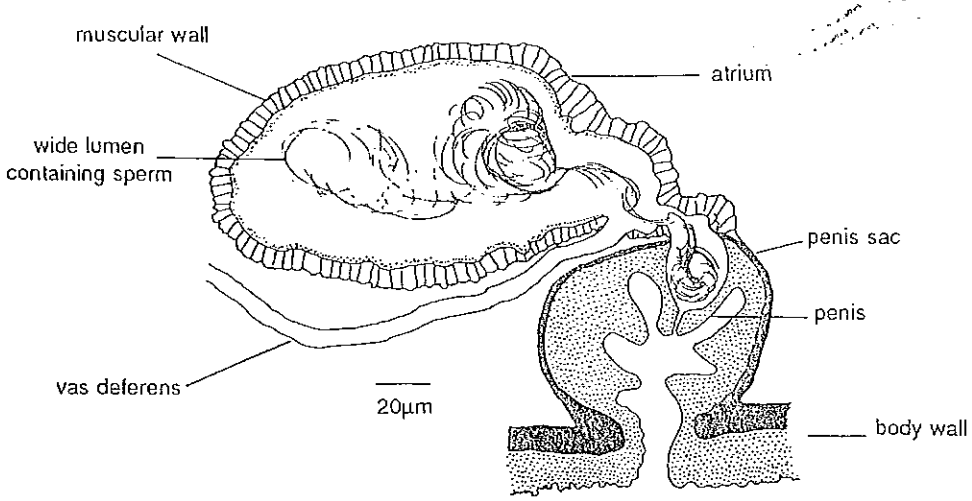
4a. Pendant penes present ..... *Antarctodrilus niger* pg. 53

b. Eversible pseudopenes present 5

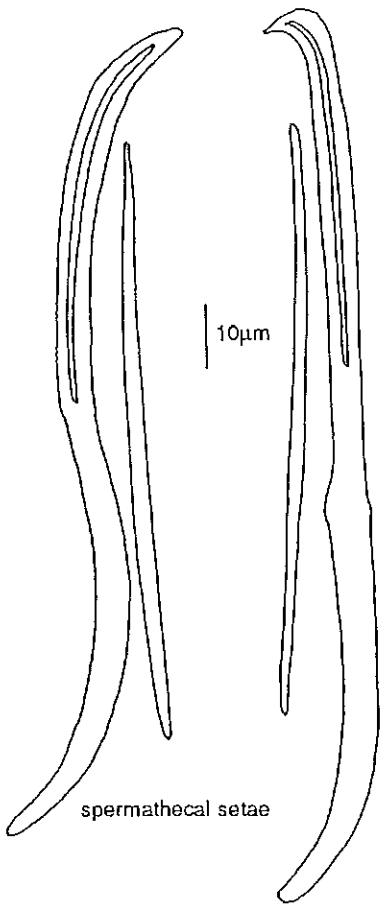
5a. Atria extremely long and thin; eversible penes strongly coiled within ovoid penis sacs; accessory gland present on penis sac ..... *Phreodrilus mauienensis* pg. 52

b. Atria short and teardrop shaped; eversible pseudopenes strongly coiled within ovoid penis sacs; accessory gland not present ..... *Phreodrilus* sp. 1 pg 52

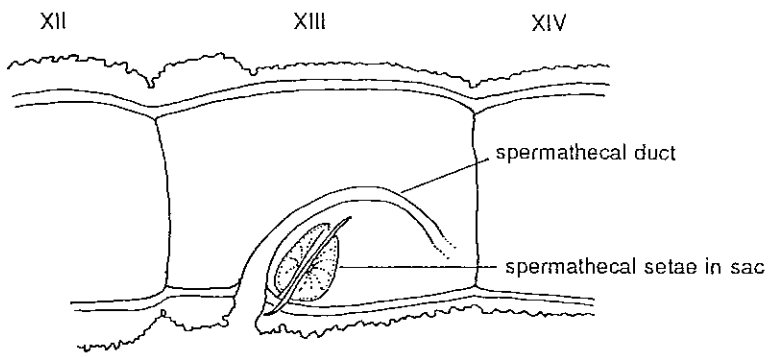
c. Atria moderately long, wide and tubular; eversible pseudopenes not coiled, but may be slightly twisted, within long, thick penis sacs; accessory gland not present ..... *Phreodrilus* sp. 2 pg 52



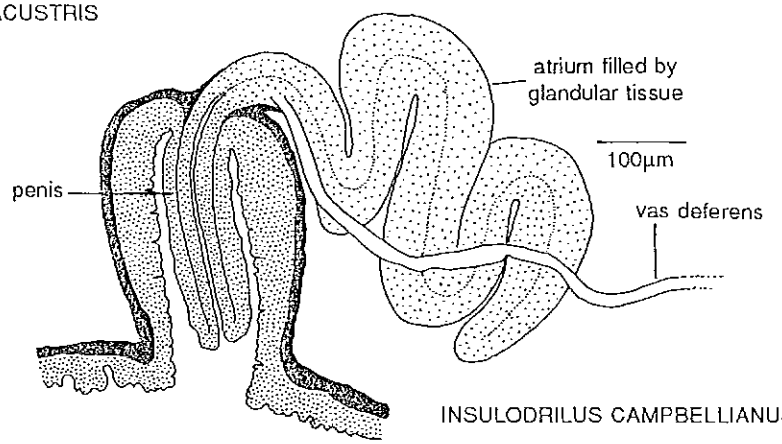
PHREODRILOIDES NOTABILIS



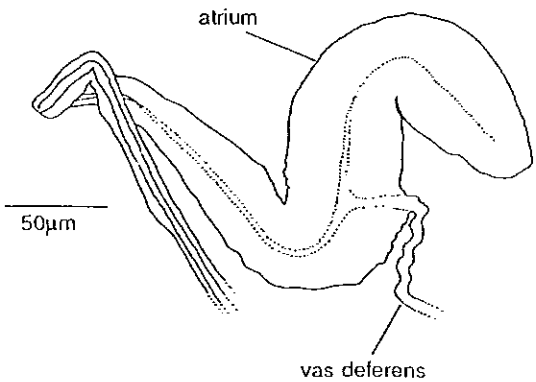
INSULODRILUS LACUSTRIS

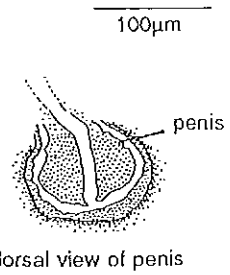


body in region of spermathecal pore
showing location of spermathecal setae

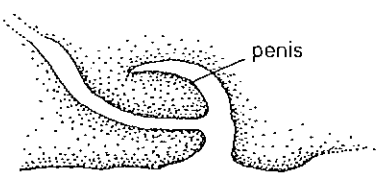


INSULODRILUS CAMPBELLIANUS





dorsal view of penis



lateral view of penis

PHREODRILOIDES SP. 1

Group E (cont.)

6a. Spermathecae absent; atria ovoid, composed of a thick outer layer of circular muscle over a very thin layer of epithelial tissue, leaving a wide lumen which usually contains sperm ..... ***Phreodriloides notabilis*** pg. 54

b. Spermathecae present with ventral pores; atria elongate and usually folded, not so muscular and with epithelial tissue occupying the whole of the interior 7

7a. A pair of modified spermathecal setae in a sac beside each spermathecal pore; dorsal bundles with one or two long thin hairs .....***Insulodrilus lacustris*** pg. 58

b. Spermathecal setae not modified beside each spermathecal pore; dorsal bundles with single short hairs 8

8a. Large pendant penes present within large penis sacs; atria elongate and tightly folded ....***Insulodrilus campbellianus*** pg. 59

b. Pendant penes small, created by a fold of the lateral wall of the small penis sacs; atria not so elongate and not tightly folded .....***Phreodriloides* sp. 1** pg. 54

Species descriptions

Genus *Phreodrilus* Beddard, 1891

Spermathecal pores dorsal, within muscular vestibulae. Atria without significant lumen. Female pores not associated with spermathecal vestibulae. Eversible pseudopenes present within muscular sacs. Ventral setae not modified in the genital region.

Five species

Phreodrilus branchiatus Beddard, 1891

Dorsal setae one to three long thin straight hairs per bundle from III. Ventral setae dissimilar, one thick with a distinct nodulus and usually with a small upper tooth and the other thinner, simple pointed and without a distinct nodulus. Sixteen to fifty pairs of dorso-lateral gills posteriorly. Vasa deferentia join long, broad atria basally. The atria enter elongate penis sacs which contain broad, slightly coiled eversible pseudopenes. Spermathecal pores within small vestibulae.

Tas; widespread in streams, rivers and lakes. Vic; La Trobe River, Acheron River and Whitehorse Creek. Also Chile.

Phreodrilus palustris Brinkhurst and Fulton, 1979

Dorsal setae from III, one or two thin hairs per bundle anteriorly, progressively increasing in number and size medially to as many as 19 setae per bundle, decreasing again in size and number posteriorly. The hairs are bent and narrow abruptly towards the bend. Ventral setae both more or less blunt with small upper teeth. Long, strongly coiled vasa deferentia with thin proximal portion and thicker distal portion, joining atria basally within sacs containing coiled eversible pseudopenes. Atria moderately long and broad. Spermathecal pore within moderately large vestibulae.

Tas; Great Lake, Arthur's Lake and Lake Sorrel.

Phreodrilus mauienensis Brinkhurst, 1971

Dorsal setae one or two long hairs per bundle from III. Ventral setae dissimilar, one thick seta with a small upper tooth and distinct nodulus, the other slightly thinner, simple pointed and without distinct nodulus. The long vasa deferentia join the extremely long, thin atria where the latter enter the apical end of the penis sacs. Large, ovoid penis sacs (with a small globular accessory organ attached basally) contain long but tightly coiled eversible pseudopenes. Spermathecal pores within small muscular vestibulae.

NSW; Lake Hiawatha. Tas; Lake St. Clair and Dove Lake.
Also New Zealand.

This species was originally described from Lake Okataina, New Zealand. It was subsequently reported from New South Wales and Tasmania by Naidu and Naidu (1980b). However, the Australian specimens were all immature and may in fact have been either *Phreodrilus* sp. 1 or sp. 2 below, both of which have dissimilar ventral setae.

Phreodrilus sp. 1

Dorsal setae one or two long thin hairs per bundle from III. Ventral setae dissimilar, one thick with a small upper tooth and distinct nodulus, the other slightly thinner, simple pointed and without a distinct nodulus. Vasa deferentia join atria basally. Atria short, bulbous apically and thin and tubular at the base, joining the penis sacs medially. Penis sacs small and ovoid containing strongly coiled eversible pseudopenes. The spermathecal ducts and elongate vestibulae appear continuous.

Tas; Melaleuca Creek.

Phreodrilus sp. 2

Dorsal setae one or two thin hairs per bundle from III. Ventral setae dissimilar, one thick with a small upper tooth and distinct nodulus, the other slightly thinner, simple pointed and without a distinct nodulus. Point of entry of vas deferens into atria not known. Atria thick and elongate, entering penis sacs apically. Elongate muscular penis sacs contain thick, straight eversible pseudopenes. Spermathecal pores within small vestibulae.

Tas; Southwell River and Melaleuca Creek. Vic; Acheron River.

Genus *Antarctodrilus* Brinkhurst, 1991

Spermathecal pores dorsal within muscular vestibulae. Atria without a significant lumen. Pendant penes present. Female pores not associated with spermathecal vestibulae. Ventral setae not modified in genital region.

Three species

Antarctodrilus niger (Beddard, 1891)

Prostomium without a proboscis. Dorsal setae one or two short hairs per bundle from III, absent in XII and XIII in mature specimens. Ventral setae one thick and one thin, both simple pointed or the thicker with a small upper tooth. Vasa deferentia very long and tightly coiled, joining relatively short, broad atria basally. Penes large within sacs without accessory glands. Spermathecal pores within small vestibulae.

Tas; widely distributed in streams and rivers.
Also Argentina, South Africa and the Falkland Isles.

Antarctodrilus proboscidea Brinkhurst and Fulton, 1979

Prostomium with a proboscis. Dorsal setae two to four or more long, thin, straight hispid hairs per bundle from III. Ventral setae dissimilar, one thick and bifid with a distinct nodulus and one thin and simple pointed without a nodulus, both sometimes simple pointed in II and/or III. Vasa deferentia and atria unite to form elongate ejaculatory ducts that enter large pendant penes. Penis sacs each bear a solid accessory structure (presumably of glandular function). Spermathecal pores within small vestibulae.

This is the most widespread phreodrilid within Australia.
Tas; common in lakes, streams and rivers. Vic; streams and rivers in eastern Victoria. NSW; streams and glacial lakes in the Kosciusko region. SA; Breakneck River, Kangaroo Island.

Antarctodrilus sp. 1

Prostomium with a proboscis. Dorsal setae from III, anteriorly with one to four long, straight, gradually tapering hispid hairs per bundle, posterior bundles with four to six stouter, more curved, less obviously hispid hairs which taper abruptly towards the tip. The change in form occurs gradually between segments XVII and XXXV. Ventral setae dissimilar; one thick and bifid with a short upper tooth and distinct nodulus and one thinner, simple pointed and without a distinct nodulus. Both setae may appear simple pointed in the most anterior and posterior bundles. The point of union of the vasa deferentia and atria not known. Atria small, narrowing to short ejaculatory ducts leading to large penes in sacs without accessory gland. Spermathecal pores within small vestibulae.

Tas; Melaleuca Creek and a creek near Charlies Hill.

Genus *Phreodriloides* Benham, 1907

This genus is currently under review. It holds the basal position in the phylogenetic tree produced by Brinkhurst (1991b) and does not appear to be defined by any apomorphic characters; rather, it is a group of species that share a number of characters in the plesiomorphic (presumed ancestral) condition. The type species (*P. notabilis*) is being re-described from fresh material, possibly leading to a re-definition of the genus. Brinkhurst (1991b) placed three species incertae sedis within *Phreodriloides* and these, together with the new species described below, may need to be classified separately.

The genus was defined by Brinkhurst (1991b) as being without eversible or pendant penes and without spermathecal vestibulae. The latter at least is still common to all species within the genus. The atria of the type species have very wide lumina used for sperm storage; a unique condition within the family. One species has spermathecal setae but this is not found in Australia.

Two species

Phreodriloides notabilis Benham, 1907

Dorsal setae one to three thin, usually bent hairs per bundle from III. Ventral setae simple pointed in II (and often III), bifid with rudimentary upper teeth from III or IV, upper teeth becoming relatively larger posteriad. Vasa deferentia enter atria basally. Atria voluminous and surrounded by thick circular muscles, ectodermal lining thin, leaving a wide lumen which is used for sperm storage. Penes formed from large lobes arising from the medial wall of large penis sacs. Spermathecae absent.

NSW; Blue Lake, Club Lake and Lake Albina (Kosciusko Plateau).

The absence of spermathecae means that normal copulation, involving transfer of sperm directly from the penis of the concopulant into the spermathecae via a spermathecal pore, cannot occur. Some tubificids which do not possess spermathecae (such as *Bothrioneurum*) use external spermatophores attached to the body wall to store sperm, but such have not been observed in *P. notabilis*. It is possible that the worms transfer sperm from atria to atria but this is unlikely given the anatomy of the male pores. It is possible that this species is self fertilizing, with the atria being used as autospermathecae.

Phreodriloides sp. 1

Dorsal setae from III, each bundle with a single, short, broad hair. Ventral setae both bifid with small upper teeth, (these appear simple pointed posteriorly but rudimentary teeth are visible under high magnification). Ventral setae absent in XII and XIII. Vasa deferentia join atria medially. Atria short and tubular, covered by spiral muscles, narrowing to form long muscular ejaculatory ducts. Simple penes formed by a fold in the outer lateral wall of the penis sacs, giving the sacs a crescentic shape when viewed dorsally. Spermathecae present.

Tas; Southwell River.

Genus *Astacopsidrilus* Goddard, 1909

Spermathecal pores and female pores both within the same large ventral muscular vestibulae. Atria almost entirely filled with glandular ectodermal tissue, or with narrow lumen containing discrete bundles of glandular cells arising from the ectodermal tissue. Pendant penes present. Ventral setae not modified in genital region of mature specimens. Some species ectocommensal on freshwater crayfish (Parastacidae).

Four species

Astacopsidrilus jamiesoni Brinkhurst, 1991

Dorsal setae from III, single, hair-like anteriorly, becoming shorter, stouter and more sigmoid posteriorly. Ventral bundles with one seta clearly bifid with a reduced upper tooth, the other simple pointed, both bifid in some specimens, becoming progressively larger from II to VIII, large and somewhat hooked in IX to XI and largest between XXX to XXXV. Atria moderately long and slightly twisted with narrow ejaculatory ducts leading to large penis sacs. Spermathecal vestibulae with separate external openings. Length: 4 to 4.5mm. Ectocommensal on the freshwater crayfish.

Qld; streams in Lamington National Park.

Astacopsidrilus sp. 1

Dorsal setae one (occasionally two) thin hairs from III. Ventral setae of some pre-clitellar segments with upper teeth longer than the lower (teeth may be equal or the upper shorter in II and II), teeth becoming equal in medial segments and setae simple pointed posteriorly. Atria long and folded with discrete glandular cells arising from the epithelial walls and protruding into the lumen. Spermathecal vestibulae large and in the shape of an inverted L, attached to dorsal body wall by retractor muscles. Vestibulae enter a median inversion of the ventral body wall. Length 8 to 13.5mm. Apparently free living.

Tas; Melaleuca Creek.

Two other ectocommensal species (*Astacopsidrilus notabilis* and *Astacopsidrilus fusiformis*) were described by Goddard (1909a) from specimens collected in central coastal New South Wales. These two species are very similar and the characters that supposedly separate them are ambiguously or vaguely described. The descriptions do not indicate any significant differences in the setae although these are poorly described and inadequately illustrated. The tall "female" ducts (anteriorly in XIII) described by Goddard (1909a) are most likely the spermathecal vestibulae found in *A. jamiesoni* and the new unnamed species from Tasmania, into which inconspicuous female funnels enter. *A. fusiformis* and *A. notabilis* were found "on the surface of the carapace" or "among the eggs of temnocephelids" attached to the crayfish. The whereabouts of the serially sectioned type specimens is not known and no other collections have been made since their description. The descriptions below have been produced by referral back to the original descriptions.

Astacopsidrilus notabilis Goddard, 1909

Dorsal setae one hair per bundle, segmental position of first setae not known. Ventral setae dissimilar, one more curved and bifid with small upper tooth and one simple pointed, the bifid setae slightly more curved. Ventral setae absent in XII, present but not modified in XIII. Atria L-shaped with the blind vertical portion anteriorly and with the horizontal (posterior) portion curling downwards, completing one complete spiral before entering penes dorsally. Spermathecae asymmetrically positioned on opposite sides of the gut in XIV, one dorso-lateral and one ventro-lateral, with a dubious connection between the ventral wall of the upper ampulla and the dorsal wall of the lower ampulla. The lower ampulla has a duct (which is either rudimentary or being resorbed) which leads to a single posterior pore in XIII on the same side of the body as the lower ampulla. In addition, each ampulla has a duct which leads from it's ventro-posterior wall ventrally through septum 13/14 and which then proceeds anterio-dorsally to join tall "female" ducts (vestibulae?) which lead to down to ventral pores anteriorly in XIII. Body elongate. Length 5.5 mm.

NSW; Gosford district (no other locality or habitat data known).

Astacopsidrilus fusiformis Goddard, 1909

Dorsal setae one hair per bundle from III. Ventral setae dissimilar, one more curved and distinctly bifid, the other either simple pointed or with very faint upper tooth. Ventral setae absent in XII, present but not modified in XIII. Atria in the shape of a backward L, with blind vertical portion posteriorly and with horizontal (anterior) portion curling upwards and backwards before entering penes dorsally. Spermathecae consisting of ampullae on either side of the gut in XIV, united by a dubious ventral tube. Each ampulla also has a duct which leads from it's ventral wall through septum 13/14 and which then proceeds anterio-dorsally to join "female" ducts anteriorly in XIII which lead down to ventral pores anteriorly in XIII. Ampullae without signs of direct connection to the body wall posteriorly in XIII. Body short and stout. Length 2.8 mm.

NSW; Bulli District (no other locality data known).

The positioning, length and even segmental location of the spermathecae are now known to show great intraspecific variation in the Phreodrilidae and such characters are rarely used taxonomically. Thus, the differences in the relative location of the ampullae and their spurious connecting ducts are probably not of use for differentiating the two species. The only reliable distinguishing character that remains is the alignment of the atria but fresh specimens are needed to confirm this difference.

Free-living specimens named *Astacopsidrilus novus* by Jackson (1931) were collected from a pool by the foot of Lesmurdie Falls in Kalamunda, W.A. These apparently had 4 or 5 hairs per bundle in some anterior segments, declining to single hairs after the clitellar region. The incomplete description of the genital anatomy suggested some unusual arrangements (e.g. two pairs of testes) and the dorsal hairs were said to start from II. Until further specimens are found and the genitalia completely described this species cannot be taxonomically placed with certainty.

Genus *Insulodrilus* Brinkhurst, 1991

Spermathecal pores ventral within muscular vestibulae of variable size. Atria almost entirely filled with glandular ectodermal tissue, leaving little lumen. Female pores not associated with spermathecal vestibulae. Pendant penes present. Ventral setae of XIII sometimes modified as paired spermathecal setae with grooved tips, usually longer than the somatic setae and usually one of each pair much smaller and less obviously grooved.

Eight species

Insulodrilus magnaseta Brinkhurst and Fulton, 1979

Dorsal bundles with single, brush-tipped hairs from III, becoming hispid in succeeding segments, and shorter and blunter behind the clitellum. Ventral setae simple pointed anteriorly, becoming progressively larger from II to VII and then smaller from VIII, sometimes with a small upper tooth. Ventral setae of mature specimens absent on XII and present but not modified on XIII. Vasa deferentia enter long, cylindrical, tightly coiled atria basally. Pendant penes within cuticular sacs. Spermathecal pores within small vestibulae.

Tas; Great Lake, Arthur's Lake and Lake Sorell.

Insulodrilus plumaseta Brinkhurst and Fulton, 1979

Dorsal bundles with single, short, brush-tipped hairs from III, tapering to a fine point. Ventral setae both bifid with upper teeth shorter and thinner than the lower. Ventral setae of mature specimens absent on XII and modified as paired spermathecal setae on XIII. The latter are two to three times the length of the somatic setae and are either deeply grooved or with two long prongs distally. Vasa deferentia join thin, elongate, loosely coiled atria basally. Pendant penes present. Spermathecal pores within small vestibulae.

Tas: Great Lake, Arthur's Lake and Lake Sorell.

Insulodrilus uniseta Brinkhurst and Fulton, 1979

Dorsal bundles with one or two sigmoid, simple pointed setae from III, IV or V resembling the simple pointed setae of ventral bundles. Ventral setae dissimilar, one simple pointed, and one rudimentarily bifid, both with a distal groove. Ventral setae of mature specimens not modified in XIII. Strongly coiled vasa deferentia join the relatively short, broad, atria basally to form short ejaculatory ducts. Robust, conical, penes present in large penis sacs. Spermathecal pores within small muscular vestibulae.

The support setae which accompany the dorsal setae of other phreodrilids can now be reported for this species after re-examination of the type specimens.

Tas; Flowerdale River, Southwell River and a trickle 1 km west of King William Saddle.

Insulodrilus breviatria Brinkhurst and Fulton, 1979

Dorsal bundles with thick, bent hairs from III, tapering beyond the bend, three to six anteriorly, increasing in number to 13 to 16 setae medially. Ventral setae both bifid with thin short upper teeth. Ventral setae of mature specimens absent in XII, not modified in XIII. Vasa deferentia join short, thick, cylindrical atria submedially. Penes small in large penis sacs. Spermathecal pores within small vestibulae.

Tas; Great Lake and Arthur's Lake.

Insulodrilus nudus Brinkhurst and Fulton, 1979

Dorsal bundles with single, broad based, bent hairs from III, tapering abruptly after the bend to form whip-like distal portion, the hairs emerging from the body wall well before the they taper. Ventral setae similar, usually both bifid with small upper teeth, although the upper teeth may be rudimentary or, rarely, absent on one both setae. In mature specimens the ventral setae are absent on XII and modified as paired spermathecal setae on XIII which are longer than the somatic setae. Vasa deferentia join elongate, tightly folded atria basally. Cell walls of basal portion of atria well defined, atria otherwise appearing uniformly granular (cf. *I. lacustris*). Pendant penes present. Spermathecal pores within well developed vestibulae.

Tas; South Esk River, Que River Southwell River and Lake Pedder. Vic; Acheron River, Thomson River and Steavenson River.

Insulodrilus sp. 1

Dorsal bundles with one to three, broad based bent hairs from III, narrowing abruptly towards the tip and with only this whip-like tip protruding from the body wall. Ventral setae similar, both with a distinct nodulus, usually both bifid with short upper teeth, although the teeth are less pronounced or occasionally absent on one of each pair. In mature specimens the ventral setae are absent on XII and replaced by paired spermathecal setae on XIII which are larger than the somatic ventral setae. Vasa deferentia join elongate, tightly folded atria basally. Cell walls of basal portion of atria well defined, atria otherwise. appearing uniformly granular. Pendant penes present. Spermathecal pores within well developed vestibulae.

Tas; Que River and Southwell River.

This species is clearly very similar to *Insulodrilus nudus* except for the number of hairs in the dorsal bundles and the proportion of each hair buried within the body wall.

Insulodrilus lacustris (Benham , 1903)

Dorsal bundles with one or two long, thin evenly tapering hairs from III. Ventral setae similar, both with distinct nodulus and both bifid with very small upper teeth, although the teeth are less pronounced or occasionally absent on one of each pair. In mature specimens the ventral setae are absent on XII and replaced by paired spermathecal setae on XIII which are longer than the somatic setae. Vasa deferentia join elongate, tightly folded atria basally. Atria with well defined cell walls along it's entire length (cf. nudus). Pendant penes present. Spermathecal pores within rudimentary vestibulae.

Tas; Que River and Southwell River. Vic; Mitta Mitta River, Acheron River, Thomson River and Wentworth River.
Also New Zealand and Argentina.

Specimens previously identified as *I. lacustris* from Lake Coleridge in New Zealand (Brinkhurst, 1971) are probably a new species. These have hair setae in anterior dorsal bundles but these become virtually indistinguishable from the ventral setae in posterior bundles.

Insulodrilus campbellianus (Benham, 1909)

Dorsal setae a single short hair per bundle from III. Ventral setae both bifid with small upper teeth and distinct nodulus. Ventral setae not modified in the genital region. Vasa deferentia enter long convoluted atria basally just before the latter enter the large elongate penes. Spermathecal ducts enter large vestibulae apically.

The small support setae that are known for other phreodrilids can now be reported for this species after re-examination of the type specimen.

Campbell Island (N.Z.); collected from under stones on the sea shore, near the exit of a stream from the flanks of Mount Honey. **Macquarie Island?**; widespread in streams.

Benham (1909) originally described the ventral setae with one of each pair bifid and the other simple pointed, or with both bifid on some segments. However, he did not mention the noduli or the relative widths of the setae. The type, and only, specimen has all intact pre-clitellar setae bifid with very small upper teeth and both setae of a pair are of equal width and both have a distinct nodulus, although some setae are broken anteriorly.

This species was reported from the Thomson River, Victoria (Brinkhurst, 1982a) but these specimens have ventral setae with one of each pair thick and bifid with a distinct nodulus and the other thinner and simple pointed without a distinct nodulus. The only mature specimen is mounted in CMCP and is extremely faded, making examination of the genital anatomy difficult. These were probably one of the new *Phreodrilus* species.

Specimens which very closely resemble *I. campbellianus* were recently collected from streams on Macquarie Island (Marchant and Lillywhite, in press). The female funnels of these specimens pass through septum 12/13 and the female ducts enter the large ventral spermathecal vestibulae. The vestibulae have muscular attachments to the dorsal body wall. These character states would place the Macquarie Island specimens in the genus *Astacopsidrilus*. According to Benham's description of *I. campbellianus* 'the oviduct is quite small and opens at 12/13', however, the female ducts of the type (and only) specimen are not visible as many of the sections are damaged and the series is incomplete. Female funnels which enter the spermathecal vestibulae had not been described when Benham examined *I. campbellianus* and it is possible that he simply assumed that the female ducts opened in the usual place for the family without actually observing them. The full extent of the vestibulae is also not visible because of damage to the sections. The Macquarie Island worms resemble *I. campbellianus* in all other respects, including the size and form of the atria, penes and setae. If the Campbell Island worm and those from Macquarie Island are the same species then *campbellianus* will need to be transferred to *Astacopsidrilus*. These issues and the new specimens from Macquarie Island will be described in full in a separate publication, although fresh specimens of the Campbell Island worms will be needed to confirm that the worms are the same species.

8. TUBIFICIDAE

The Australian tubificid fauna consists of twenty eight species belonging to thirteen mostly cosmopolitan genera. Some patterns in the regional distribution of tubificids are becoming apparent within Australia but it remains to be seen how these will be modified as more specimens are identified. Approximately one third of the genera and species are cosmopolitan, and these, such as *Limnodrilus* spp., *Aulodrilus* spp., *Tubifex tubifex* and *Branchiura sowerbyi* tend to be the most widely distributed tubificids in Australia. By contrast, the species restricted to Australia tend to have comparatively narrow distributions and mostly belong either to *Antipodrilus* (which is restricted to Australia and New Zealand) or to genera such as *Telmatodrilus*, *Rhizodrilus* and *Ainudrilus*, which are otherwise very patchily distributed around the world. *Macquaridrilus bennettae* is restricted to the sub-antarctic Macquarie Island.

Seven of the thirteen[1] endemic tubificids are restricted to Tasmania; these are two species of *Antipodrilus*, four of the endemic *Telmatodrilus* and *Rhyacodrilus fultoni*. *Telmatodrilus pectinatus*, of Tasmania and Victoria, is the only endemic tubificid to be found on both sides of Bass Strait. *Rhyacodrilus bifidus* was described from the Kosciusko region of New South Wales and has otherwise only been found in streams of eastern Victoria. Of the remaining *Antipodrilus* species, one is restricted to Victoria and one is found only in the Northern Territory and northern South Australia. The other two endemic tubificids have extremely narrow distributions: *Ainudrilus billabongus* is known only from billabongs in the Alligator Rivers region of the Northern Territory while *Rhizodrilus arthingtonae* is apparently restricted to a freshwater lake on North Stradbroke Island, Queensland. Two other species, *Telmatodrilus multiprostatus*, of Victoria and Tasmania and *Antipodrilus davidis*, a species widely distributed in Australia, are otherwise known only from New Zealand.

Tubificids are commonly thought of as lake dwelling worms and while some species may be abundant in lentic habitats, ranging from alpine lakes to tropical billabongs, they are also commonly encountered in lotic habitats from lowland rivers to mountain streams. Indeed, a number of Australian species are known only from running waters. In addition, the often observed dominance of tubificids in polluted sites has contributed to the perception that tubificids are generally tolerant of pollution or favour enriched habitats. Certainly, some species do appear to be particularly tolerant to a range of conditions that adversely affect other members of the benthic community; for example, *Limnodrilus hoffmeisteri* is often very abundant in organically enriched situations and *Branchiura sowerbyi* appears to be particularly tolerant of heat pollution (Brinkhurst and Jamieson, 1971). However, other tubificids can be sensitive to pollutants and may be common in, or even restricted to, unpolluted or oligotrophic habitats.

Family Diagnosis

Prostomium without eyes or a proboscis. Gills present in one species. Dorsal setae an indefinite number, usually from II, often with hair setae accompanied by pectinate or palmate setae, or if no hairs then dorsal setae usually bifid or simple pointed. Ventral setae an indefinite number from II, usually bifid, rarely simple pointed or pectinate or hair-like. Ventral setae of XI sometimes modified as penial setae, those of X and often adjacent segments sometimes modified as spermathecal setae in mature specimens. Testes and ovaries one pair each, in X and XI respectively. Male funnels on posterior septa of X, atrium and male pores in XI. True pendant penes or eversible or protrusible pseudopenes often present. Female pores in posterior intersegmental furrow of XI. Spermathecae paired in X, rarely single or absent. Asexual reproduction by fragmentation possible, sometimes resulting in the reproductive organs being shifted from one to several segments forward.

[1] This figure excludes *Macquaridrilus bennettae* of Macquarie Island and ?*Spirosperma* sp. which may be endemic but cannot be identified or described at this stage for want of mature specimens.

Identification of the Tubificidae

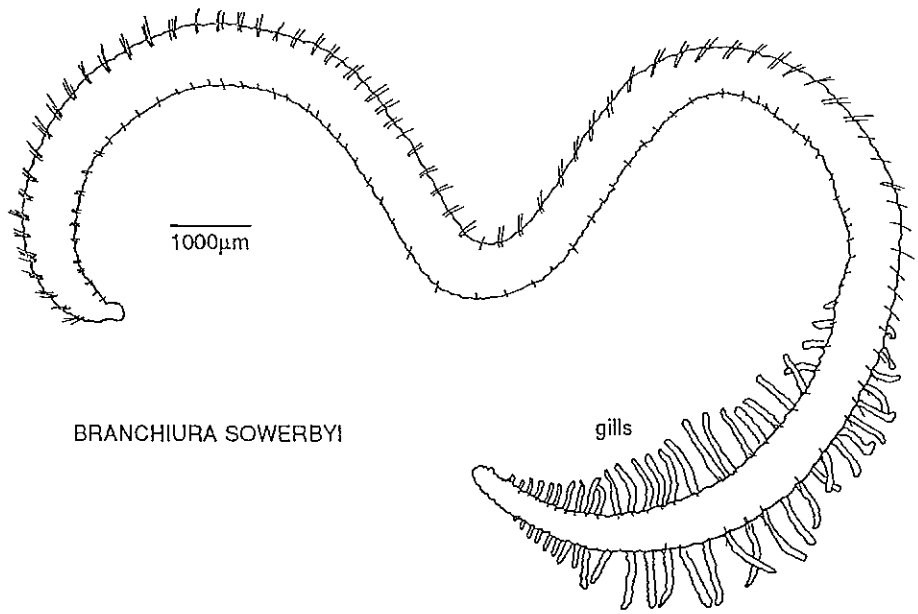
Tubificidae setae exhibit a narrow range of forms, with wide overlaps between genera, necessitating examination of the genital anatomy of many species. While this can make generic identification of tubificids more difficult, or at least more time consuming, than in the Naididae, this emphasis on genital characters has meant that outstanding taxonomic problems usually involve generic placement rather than species separation.

With practice, immature specimens of most species can be identified using setal characters alone. However, it will sometimes be necessary to divide the immature specimens into those with unexceptional bifid setae in all bundles and those with unexceptional hair and pectinate setae in dorsal bundles. Where quantitative data is required immature specimens can be allocated to species in the same ratio as any mature identified specimens.

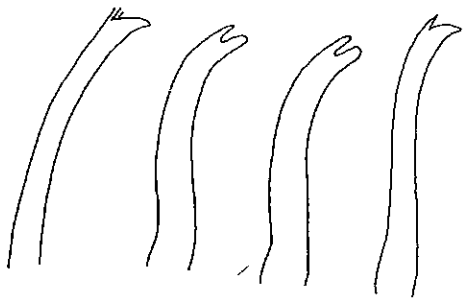
The possible influence of environmental factors such as water chemistry and pollution on setal form should be kept in mind. For example, Chapman and Brinkhurst (1987) were able to reduce or eliminate hairs and pectinations of *Tubifex tubifex* and *Ilyodrilus frantzi*, thereby producing forms previously recognised as subspecies, by varying salinity, water hardness and pH. Contaminant induced deformities of setae are also known (Milbrink, 1983).

The key overleaf either proceeds directly to species or genus (particularly for genera with one to three species) or to two groups of species with very similar setal form. Mature specimens of species within these groups are required to proceed to genus. For genera with more than one Australian representative a choice between several species descriptions is often required.

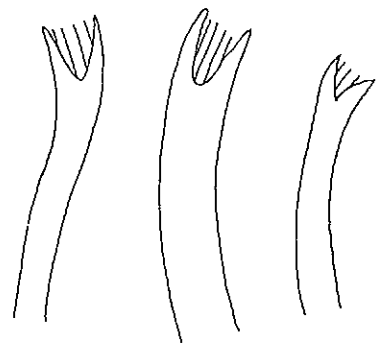
Three species Tasmania and one from N.S.W. cannot be taxonomically placed or properly described for lack of mature specimens. These are briefly mentioned at the end of the chapter so that they might be recognized and described if mature specimens are found. Another species from Victoria closely resembles species of *Spirosperma*, a genus created by the breakup of the now defunct genus *Peloscolex*. This species also requires mature specimens before it can be properly identified but is tentatively placed in ?*Spirosperma* in the key.



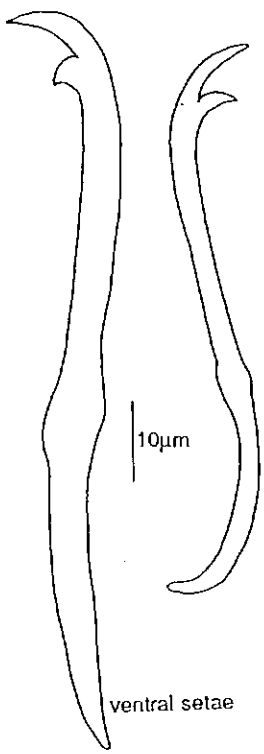
BRANCHIURA SOWERBYI



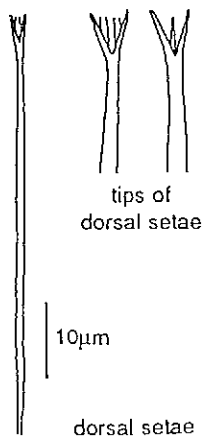
anterior setae of
AULODRILUS spp.



GROUP A: hairs present dorsally
with pectinate setae

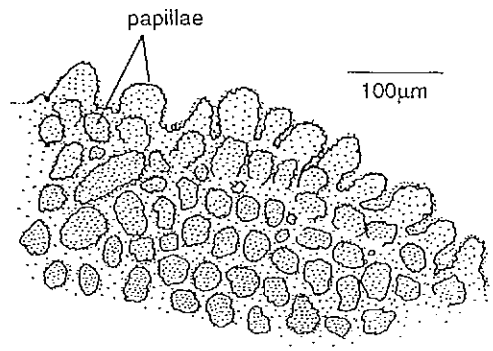


ventral setae



dorsal setae

?SPIROSPERMA



papillate body wall

Key to genera

1a. Hair setae present in anterior dorsal bundles 2

b. Hair setae absent in anterior dorsal bundles (present posteriorly in one species) ..... 4 pg. 66

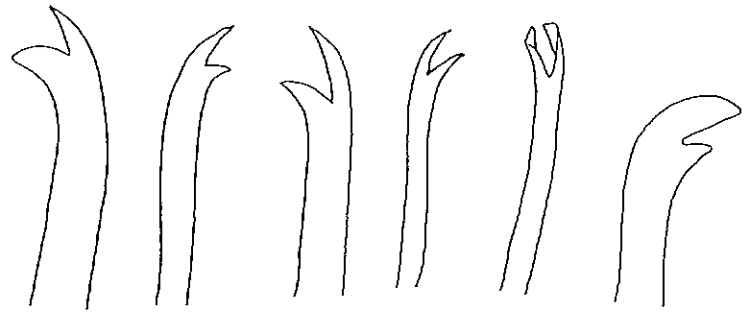
2a. Gills present as mid-dorsal and mid-ventral filaments on each posterior segment ..... ***Branchiura sowerbyi*** pg. 97

b. Gills absent 3

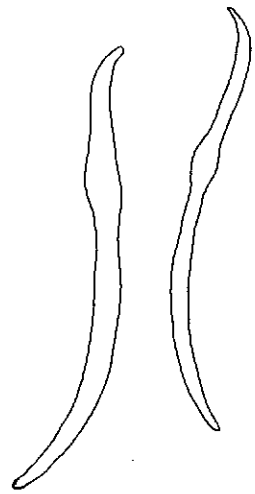
3a. Non-hair dorsal setae bifid anteriorly with upper teeth shorter than the lower and sometimes replicated; dorsal and ventral setae approximately the same size; ventral setae bifid with upper teeth shorter than the lower; body not covered with small papillae ..... **Aulodrilus** (in part) pg. 84

b. Non-hair dorsal setae pectinate and approximately the same size as the ventral setae, usually with lateral teeth equal in length; ventral setae bifid with upper teeth as long as or longer than the lower, rarely pectinate; body not covered with small papillae ..... **Group A** pg. 68

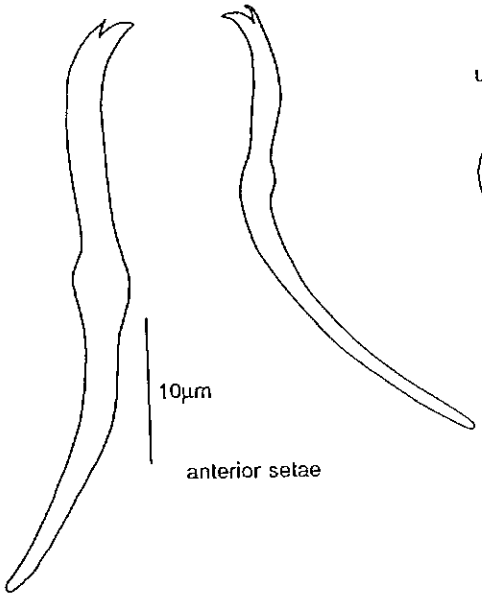
c. Non-hair dorsal setae pectinate and much smaller than the ventral setae; pectinations only visible under high magnification; ventral setae bifid with upper teeth much longer than the lower; body covered by small papillae ..... ?***Spirosperma*** pg. 78



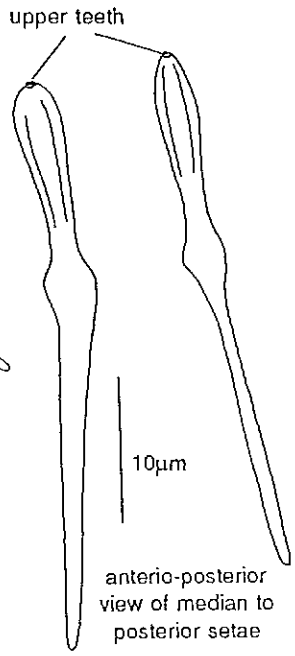
GROUP B: hairs not present dorsally,
anterior setae with upper teeth
at least as long as lower



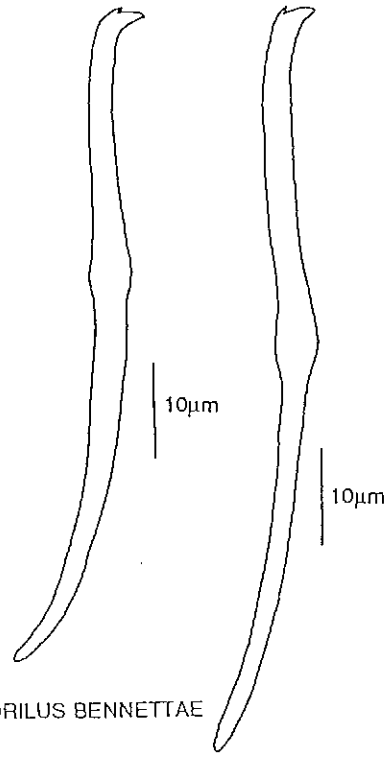
TELMATODRILUS MULTIPROSTATUS



AULODRILUS LIMNOBIUS



anterio-posterior
view of median to
posterior setae



MACQUARIDRILUS BENNETTAE

Tubificidae (cont.)

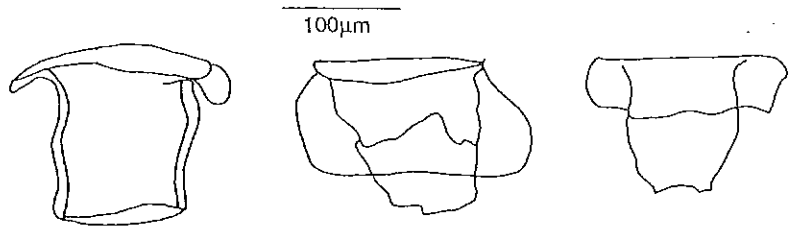
4a. Anterior setae bifid (rarely pectinate) with upper teeth varying from almost as long as to longer than the lower (upper teeth of II much shorter in one species) ..... **Group B** pg. 70

b. All setae bifid with upper teeth much shorter and thinner than the lower 5

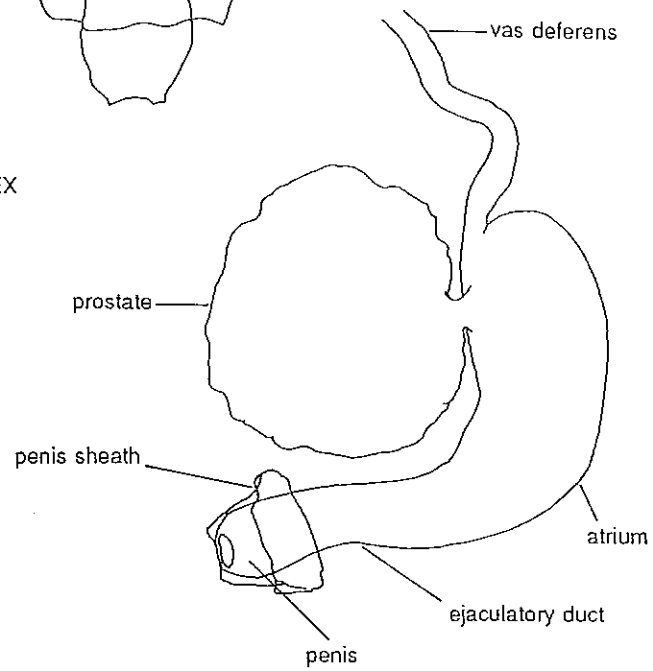
c. All setae simple pointed ..... *Telmatodrilus multiprostatus* pg. 86

5a. Up to 10 setae per bundle; setae of mid and posterior segments with lateral wings distally, which, when viewed from the anterio-posterior aspect give the seta an oar shaped appearance with the upper teeth visible as a small projection above the blade; common in Victoria ..... *Aulodrilus limnobius* pg. 84

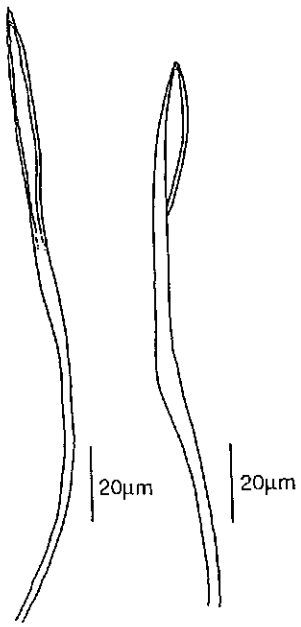
b. Three to five setae per bundle, without lateral wings (restricted to Macquarie Island)..... *Macquaridrilus bennettae* pg. 92



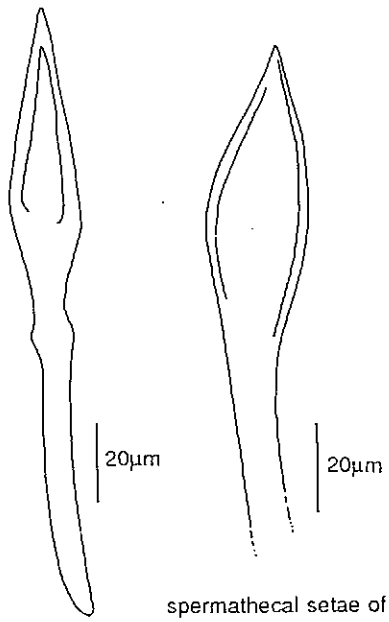
penis sheaths of TUBIFEX TUBIFEX



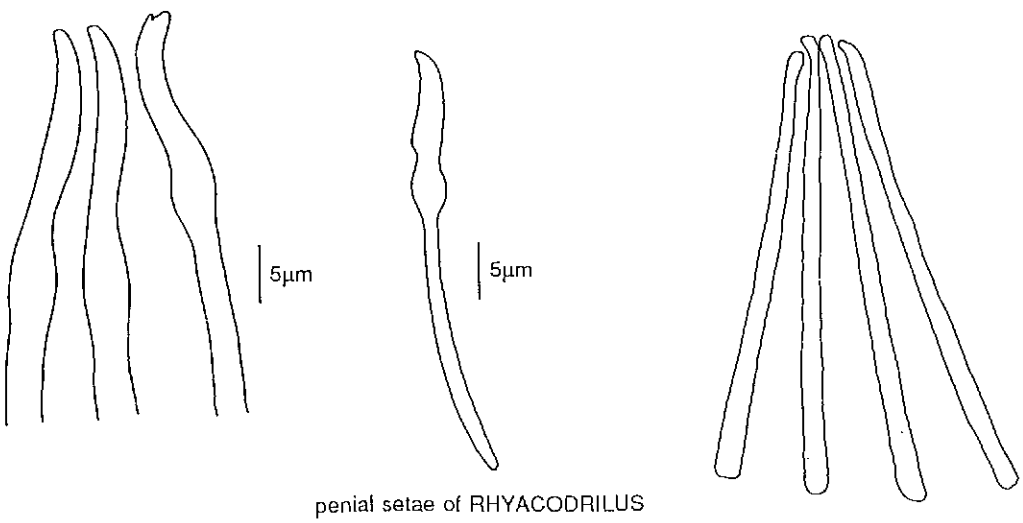
male ducts of
TUBIFEX TUBIFEX



spermathecal setae
of ANTIPODRILUS



spermathecal setae of
POTAMOTHRIX BAVARICUS



penial setae of RHYACODRILUS

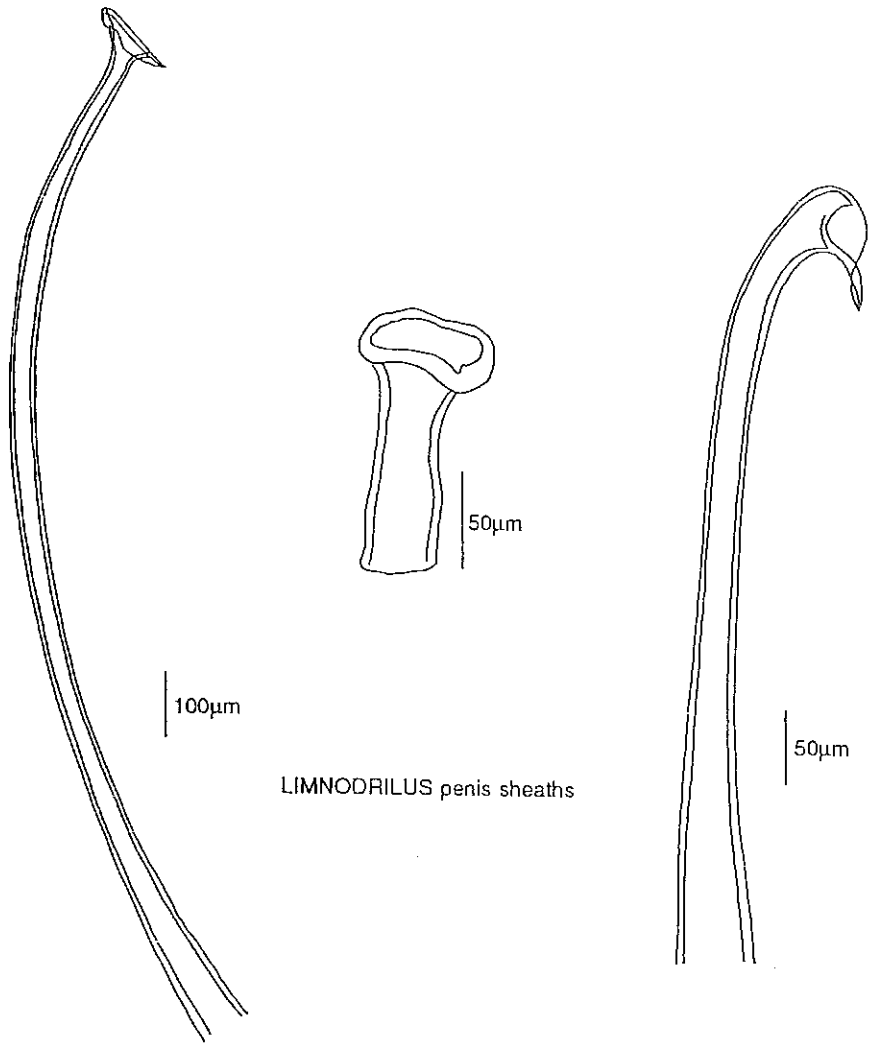
Group A: Species with hair and pectinate setae dorsally. Mature specimens required for further identification.

1. Short, tub shaped penis sheaths present; ventral setae not modified in the genital region .... *Tubifex tubifex* pg. 74

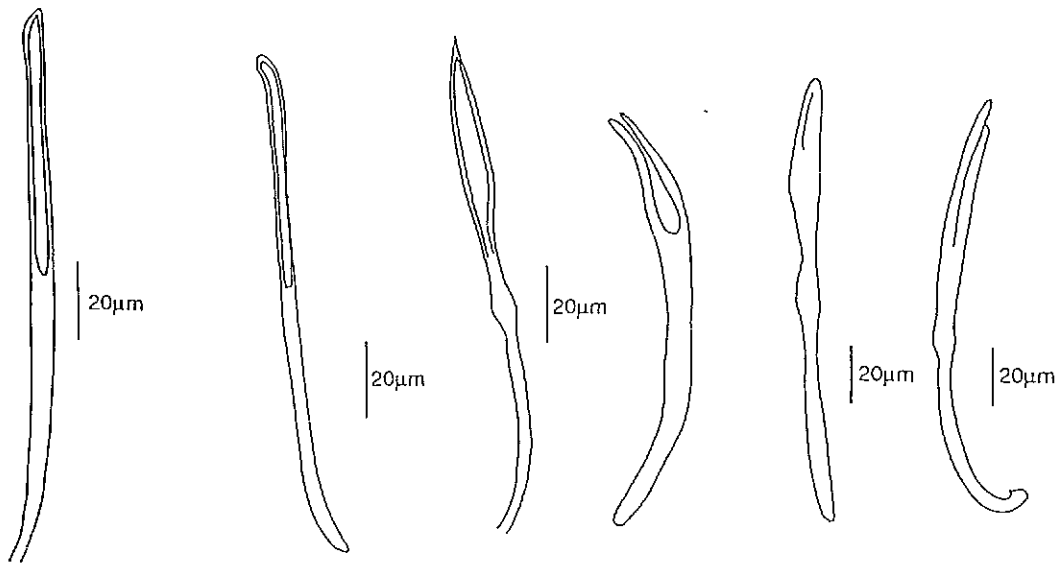
2. Usually one (rarely two) thin spermathecal seta present beside each spermathecal pore in X; penial setae not modified in XI; true penis sheaths absent .....*Antipodrilus* (in part) pg. 80

3. One or two broad, spatulate spermathecal setae present beside each spermathecal pore in X; penial setae not modified in XI; penis sheaths absent .....*Potamothrix bavaricus* pg. 77

4. A number of penial setae present beside each male pore in XI; spermathecal setae not modified in X; penis sheaths absent .....*Rhyacodrilus* (in part) pg. 94



LIMNODRILUS penis sheaths



ANTIPODRILUS spermathecal setae

Group B: Species with hairs absent and with most anterior setae bifid (rarely pectinate) with upper teeth as long as or longer than the lower. Mature specimens required for further identification.

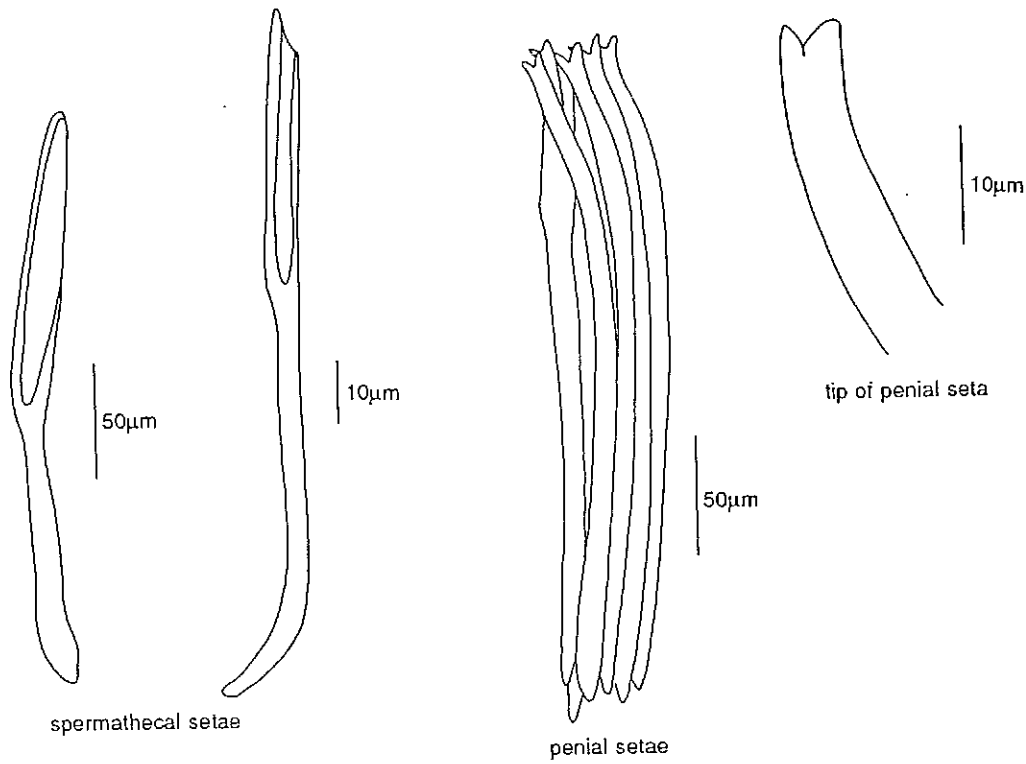
1a. Long penis sheaths present; ventral setae not modified in the genital region.....*Limnodrilus* pg. 76

b. True penis sheaths absent, apparent penis sheaths may be present; ventral setae modified in either the segment with male pores (penial setae in XI) or in the segment with spermathecal pores (spermathecal setae in X) or in both 2

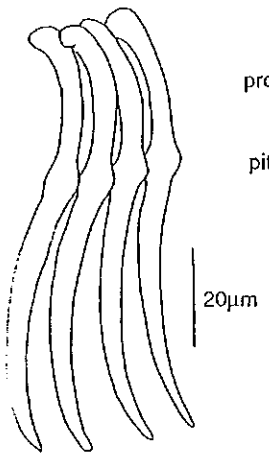
2a. Modified spermathecal setae beside each spermathecal pore in X; penial setae not modified in XI ....*Antipodrilus* (in part) pg. 82

b. Spermathecal and penial setae modified in X (and/or preceding segments) and XI respectively, or if spermathecal setae absent or not modified then setae hair-like posteriorly ....*Telmatodrilus* (in part) pg. 86

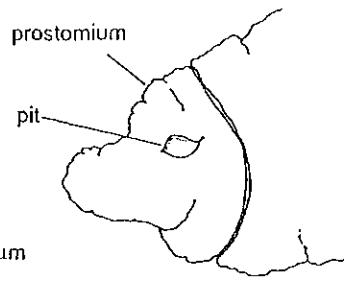
c. Penial setae modified beside each male pore in XI; spermathecal setae not modified in X ....3 pg. 72



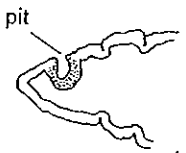
TELMATODRILUS



penial setae

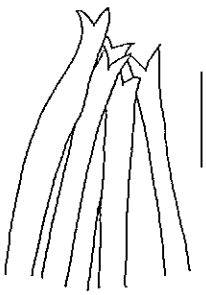


oblique view of dorsal sensory pit

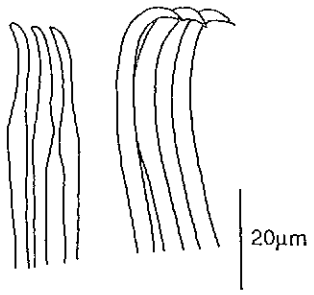


lateral view of dorsal sensory pit

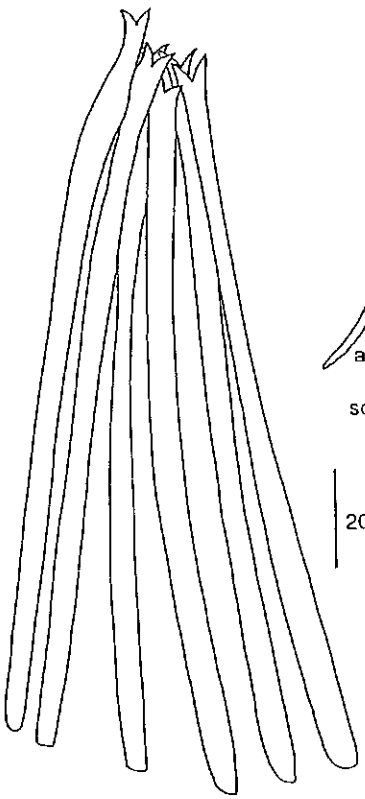
BOTHRIONEURUM VEJDOVSKYANUM



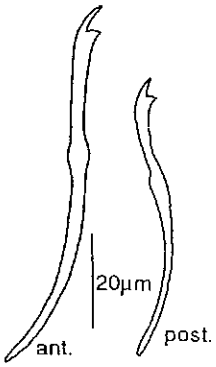
bifid penial setae



simple pointed penial setae

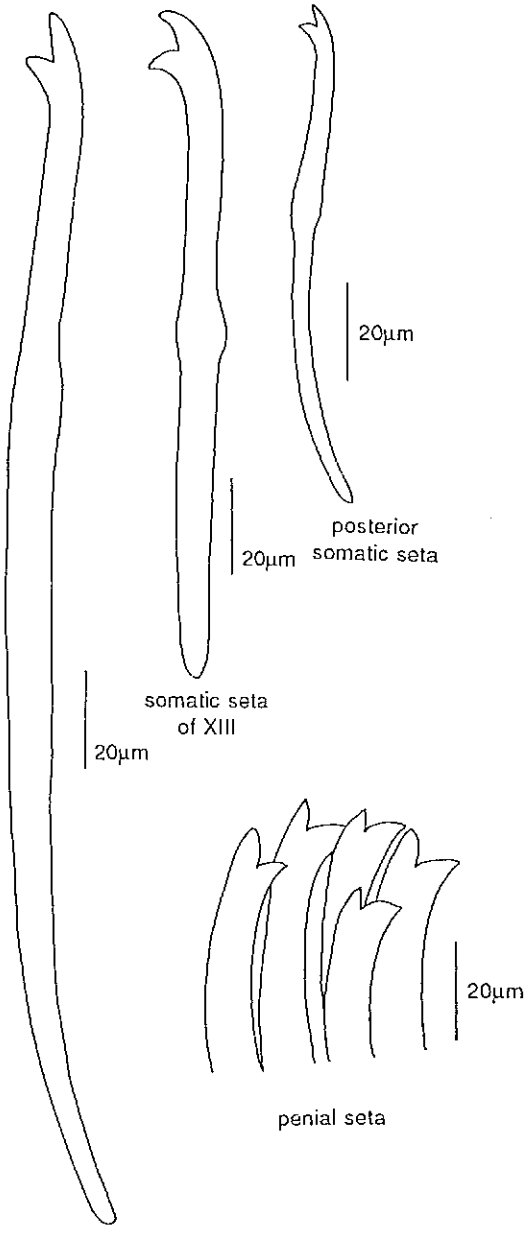


penial setae



somatic setae

RHYACODRILUS BIFIDUS



posterior somatic seta

somatic seta of XIII

somatic seta of XII

penial seta

RHYACODRILUS ARTHINGTONAE

Group B (cont.)

3a. Penial setae slightly hooked distally with club-shaped heads formed by swollen upper teeth, the lower teeth rudimentary or absent, penial setae not much longer than the somatic setae; prostomium with a sensory pit on the dorsal surface, appearing as a thickened region in lateral aspect ..... ***Bothrioneurum vejdovskyanum*** pg. 92

b. Penial setae clearly bifid, without club shaped-tips, slightly curved towards the tip and much longer than the somatic ventral setae; prostomium without sensory pit on the dorsal surface 4

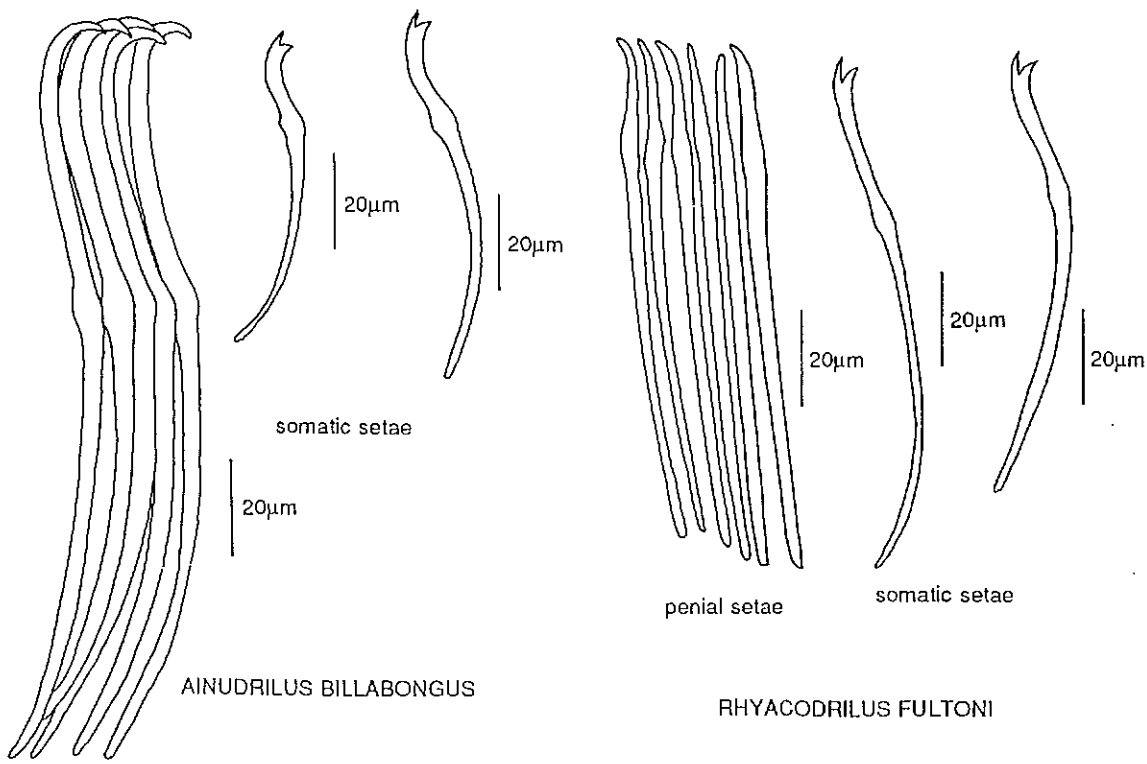
c. Penial setae usually simple pointed, without club-shaped tips, may be bifid if not fully formed but then not much longer than the somatic ventral setae, either straight or strongly recurved at the tips; prostomium without sensory pit on the dorsal surface 5

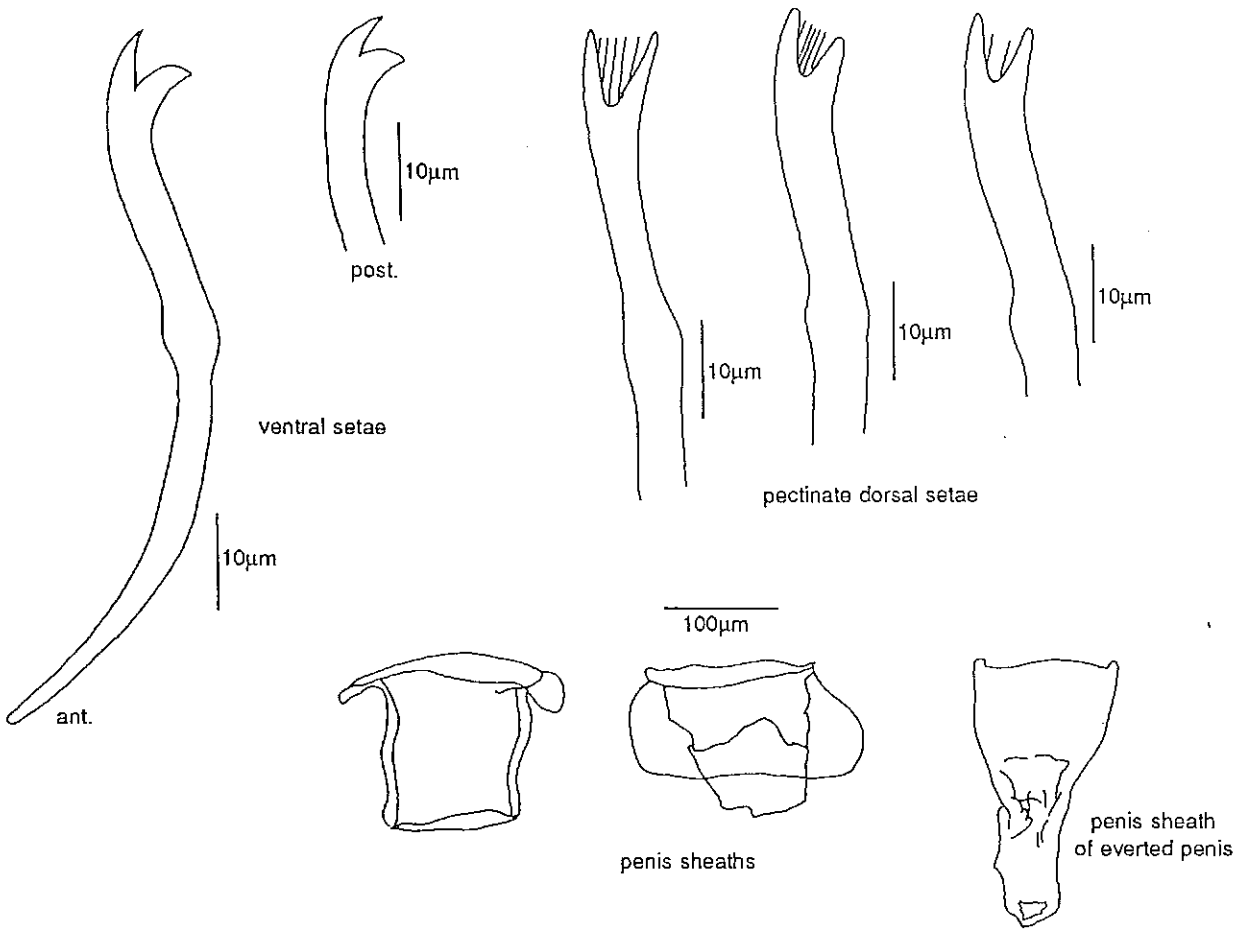
4a. Six to ten bifid penial setae per bundle in XI, about twice the length of the somatic setae and slightly curved towards the tips; ventral and dorsal bundles with three to eight setae anteriorly with upper teeth two to three times as long as, but thinner than, the lower .....***Rhyacodrilus bifidus*** pg. 95

b. Several bifid penial setae per bundle in XI, 1.5 to 2x longer than most of the somatic setae and slightly curved towards the tips; ventral and dorsal bundles with three to five setae anteriorly with upper teeth only slightly longer than the lower .....***Rhizodrilus arthingtonae*** pg. 96

5a. Six to nine straight simple pointed penial setae per bundle in XI, not much longer than the somatic setae, slightly hooked at the tips, may be rudimentarily bifid if not fully formed; ventral and dorsal bundles with 10 to 13 setae anteriorly with teeth equal in length, fewer posteriorly, some setae may be pectinate .....***Rhyacodrilus fultoni*** pg. 95

b. Up to six simple pointed penial setae per bundle in XI, strongly recurved at the tip, about twice the length of the somatic setae; ventral bundles with four to six setae anteriorly with teeth equal in length .....***Ainudrilus billabongus*** pg. 98





TUBIFEX TUBIFEX

Species Descriptions

Genus *Tubifex* Lamarck, 1816

Hairs usually present in dorsal bundles. Vasa deferentia long, joining atria apically or subapically. Atria pear shaped to cylindrical. Prostate glands large, closely connected to the atria sub-apically. Pendant penes within thin, tub shaped, penis sheaths. Genital setae not modified. Spermatozeugmata present.

One species.

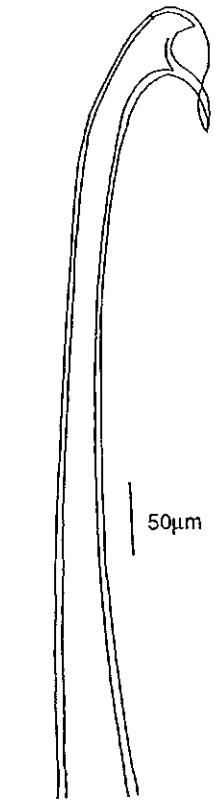
Tubifex tubifex (Muller, 1774)

Anterior dorsal bundles normally with one to six hispid hairs and three to five pectinate setae with several irregular intermediate teeth. Hairs shorter and reduced in number and pectinate setae with fewer intermediate teeth posteriorly. Ventral setae bifid, six to 10 per bundle anteriorly with upper teeth thinner than but not much longer than the lower, posteriorly with fewer setae and upper teeth becoming relatively shorter. Vasa deferentia extremely long, atria comma shaped, with large prostate, leading to penes within thin, thimble shaped sheaths.

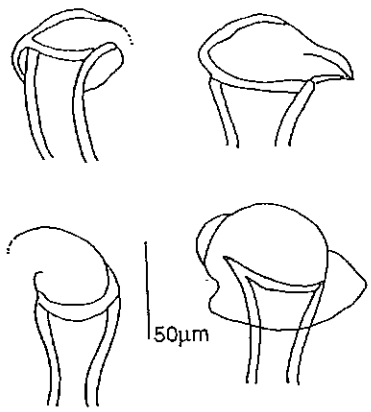
Tas; Arthur River and Lake St. Clair. Vic; Thomson River. WA; Lake Monger. Qld; Downfall Creek (Chermside).
Cosmopolitan.

The normal form has hair and pectinate setae in dorsal bundles, but higher conductivity in the ambient water can induce first a reduction in size and number of hairs and a loss of pectination of the other dorsal setae, followed, under more stringent conditions, by loss of all hairs and pectinations, leaving all dorsal setae bifid. This can be achieved experimentally with this and other species (Chapman and Brinkhurst, 1987). These forms were previously ascribed to the species *bergi* and *blanchardi*.

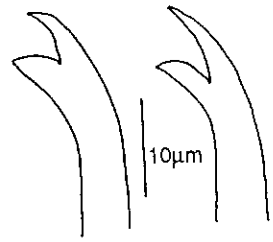
Contrary to popular belief this species is not commonly encountered, especially if other tubificid species are present. It is often found in marginal situations such as grossly polluted streams or oligotrophic lakes where there is little competition.



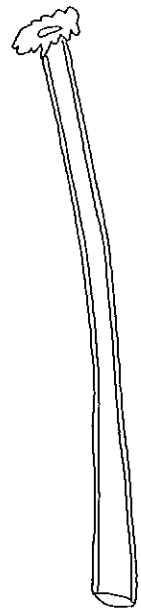
normal penis sheath



appearance of penis sheath heads in whole mounted worms

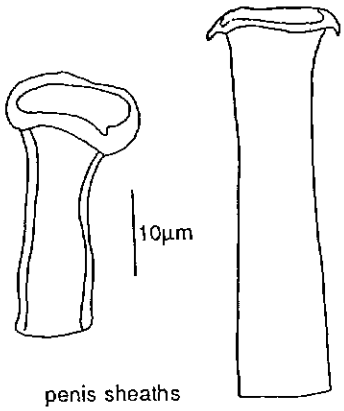


setae

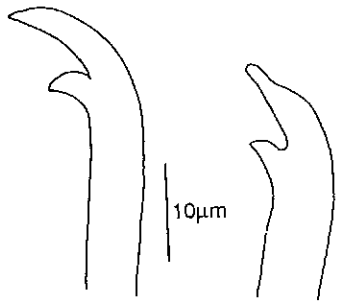


penis sheath with scalloped head

LIMNODRILUS HOFFMEISTERI

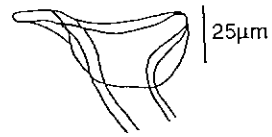


penis sheaths

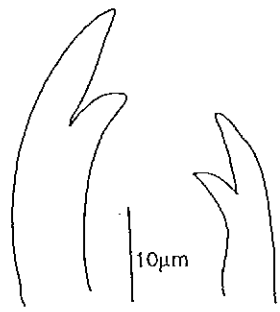


setae

LIMNODRILUS UDEKEMIANUS



head of penis sheath



setae

LIMNODRILUS CLAPAREDEIANUS

penis sheath

Genus *Limnodrilus* Claparede, 1862

Hairs absent, all setae bifid. Vasa deferentia long, joining atria apically. Atria small, globular or bean shaped, leading to long ejaculatory ducts. Large prostate gland associated with each atrium. Pendant penes within elongate, thick, cylindrical penis sheaths. Genital setae not modified. Spermatozeugmata present.

Three species.

Limnodrilus hoffmeisteri Claperede, 1862

Anterior bundles with three to 10 bifid setae, with upper teeth varying from slightly shorter than to slightly longer than the lower, fewer setae posteriorly. Penis sheaths up to 20 times longer than broad (usually 300 to 600µm, rarely up to 1000µm long), slightly flared for the basal one third. Usually with the opening at an angle to the main shaft, the head plate usually forming a flared hood around the opening or with the head set squarely on the shaft and then often with the head scalloped around the edges.

Tas; Lake St. Clair, Dove Lake, Lake Sorell, Lake Crescent, Lake Leake, Lake Toombs, Great Lake and Arthurs Lake. **Vic**; La Trobe River and Mitta Mitta River. **SA**; Valley Lake (Mt. Gambier). **NSW**; Georges River. **Qld**; Bulimba Creek.
Cosmopolitan.

Limnodrilus udekemianus Claparede, 1862

Anterior bundles with three to eight bifid setae, with upper teeth markedly thicker and longer than the lower, fewer setae posteriorly with teeth more nearly equal. Penis sheaths up to four times longer than broad (usually 160 to 200µm long), with a simple plate like hood usually reflected back over the shaft.

Tas; Lake Pedder, Lake St. Clair and Dove Lake. **SA**; Valley Lake (Mt. Gambier). **WA**; Lake Monger and Munday Swamp. **NSW**; Dairy Drains (Taree). **Qld**; Bulimba Creek, Downfall Creek (Chermside) and Moggill Creek (Brisbane).
Cosmopolitan.

Limnodrilus claparedeianus Ratzel, 1868

Anterior bundles with four to nine bifid setae, some with upper teeth much longer than and as thick as or thicker than the lower, fewer setae posteriorly. Penis sheaths up to 50 or even 80 times longer than broad (usually 800 to 1100µm or rarely up to 1300µm long), with small, triangular head plates set at an angle to the shaft.

NSW; Thirlmere Lake.
Cosmopolitan.

Genus *Potamothrix* Vejdovsky and Mrazek, 1902

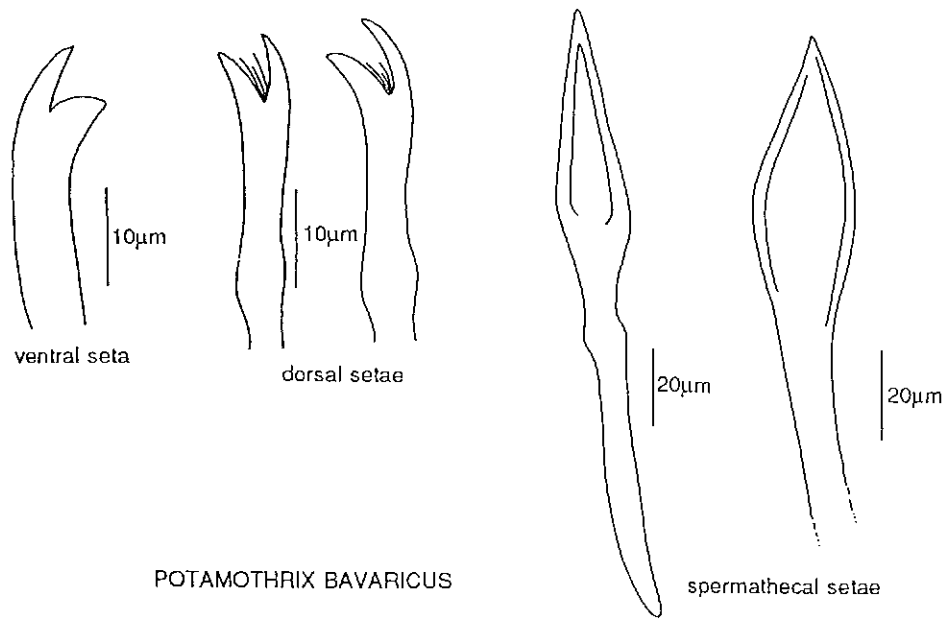
Hairs usually present in dorsal bundles. Vasa deferentia short, joining atria apically. Atria long, wide and tubular, prostate glands small or absent, ejaculatory ducts absent. Pendant penes small, without cuticular sheaths. Spermathecal setae may be modified. Spermathecae with spermatozeugmata.

One species.

Potamothrix bavaricus (Oschmann, 1913)

Dorsal anterior bundles with one to five straight hairs and two to five pectinate setae. Ventral setae with teeth equally long but with the upper teeth thinner than the lower. Spermathecal setae usually single with broad, triangular blade-like tips. Atria tubular, without prostate glands.

Vic; Lake Purrumbete and Curdies River. WA; Corio Pool, Rottnest Island.
Otherwise holarctic.



POTAMOTHRIX BAVARICUS

Genus *Spirosperma* Eisen, 1879

Hair and fine to hair-like pectinate setae present in dorsal bundles. Vasa deferentia long, joining elongate to crescent shaped atria apically. Prostate glands single and large, entering atria medially. Long ejaculatory ducts between atria and moderate to large penes. Penes with or without sheaths. Body wall papillate and covered with a secretitious layer mingled with adhered foreign particles. Ventral setae may be modified in the genital region and may be present in one central bundle in X. Spermathecae with spermatozeugmata.

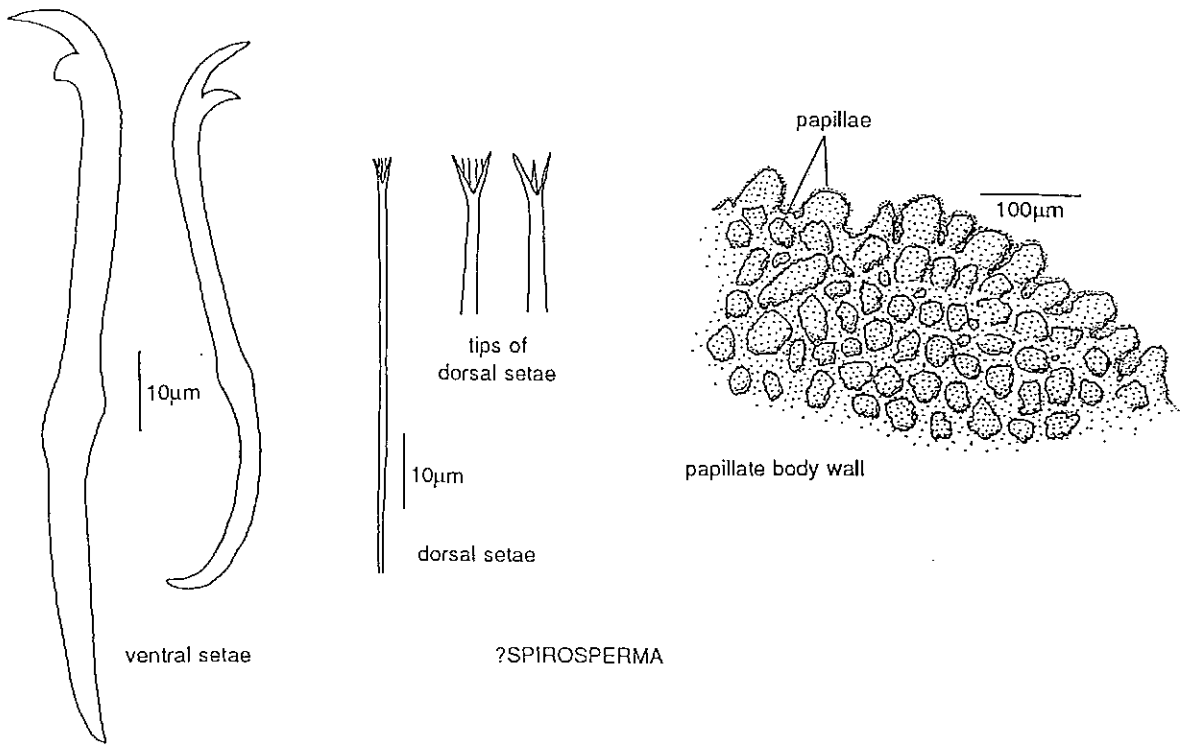
One species.

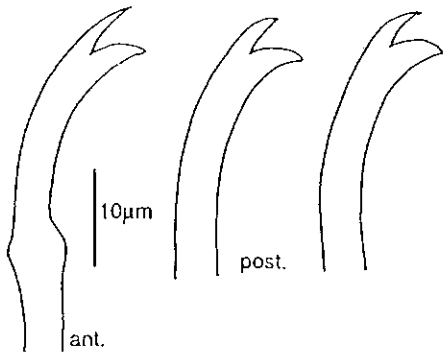
?*Spirosperma* sp. 1

Body wall densely papillate and with adhered foreign matter. Dorsal bundles with one to three long hairs and one or two pectinate setae. Pectinate setae with very small diverging lateral teeth and fine pectinations. Ventral setae three to six per bundle, all bifid with upper teeth much longer than the lower. Length (immature) 3.8 to 6.4 mm.

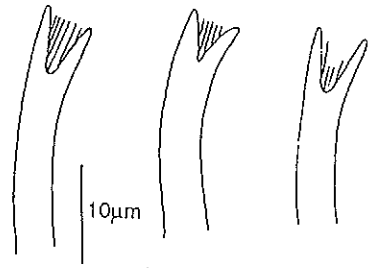
Vic: Curdies River and La Trobe River.

A single immature specimen has been identified from each of the above rivers. The papillate body wall and the setae would suggest that this species belongs in *Spirosperma*, as defined by Holmquist (1978), but mature specimens are required to confidently assign this species to a genus. *Spirosperma* was re-erected by Holmquist (1978) in a review of *Peloscolex* and then expanded by synonymy (Brinkhurst, 1981) so that it now contains most of the species formerly assigned to the genus *Peloscolex*. *Peloscolex* sensu-strictu is no longer used as a generic name as all of the species placed within it, including the original type species are considered to be species dubious (Brinkhurst, 1979, Brinkhurst and Wetzel, 1984).



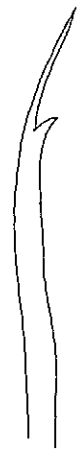


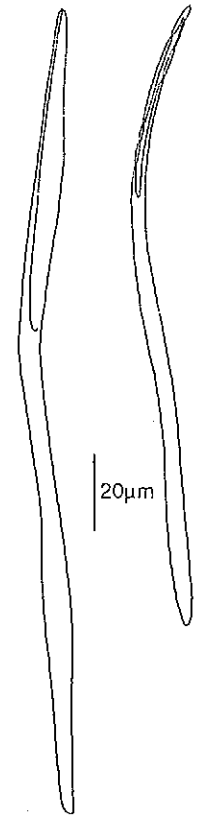
ventral setae



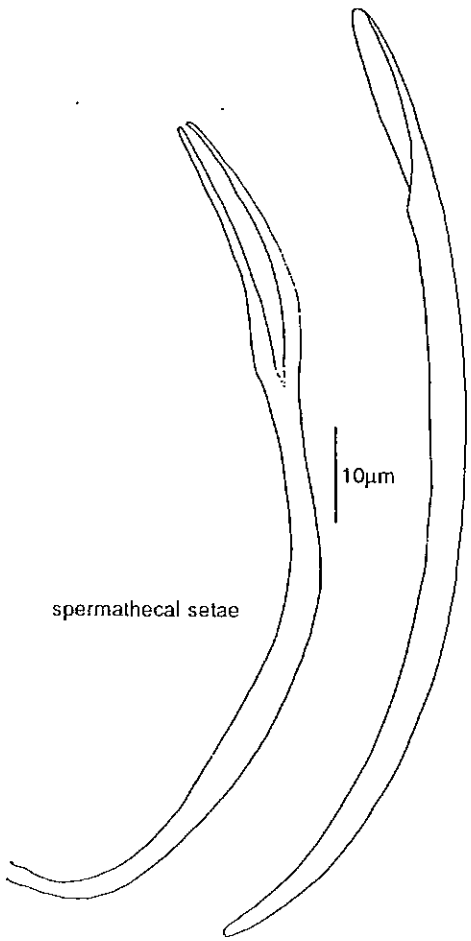
dorsal setae

ANTIPODRILUS DAVIDIS

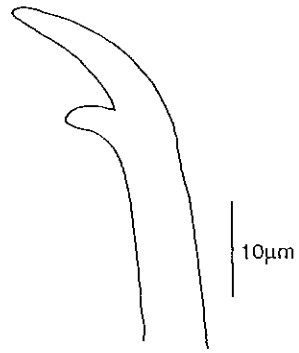




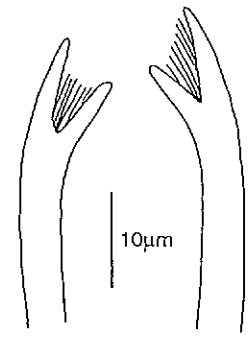
spermathecal setae



spermathecal setae



anterior
ventral seta



dorsal setae

ANTIPODRILUS TIMMSI

Genus *Antipodrilus* Brinkhurst, 1971

Dorsal bundles with or without hairs. Vasa deferentia long and narrow, joining atria apically or subapically. Atria globular, narrowing to form tubular ejaculatory ducts terminating in pendant penes (with apparent penis sheaths in two species). Prostate glands joining atria anteriorly. Spermathecae containing elongate spermatozeugmata. Spermathecal setae modified; usually thin and with grooved tips which appear to become pronged.

From group A: Species with hair and pectinate setae dorsally. Two species.

Antipodrilus davidis (Benham, 1907)

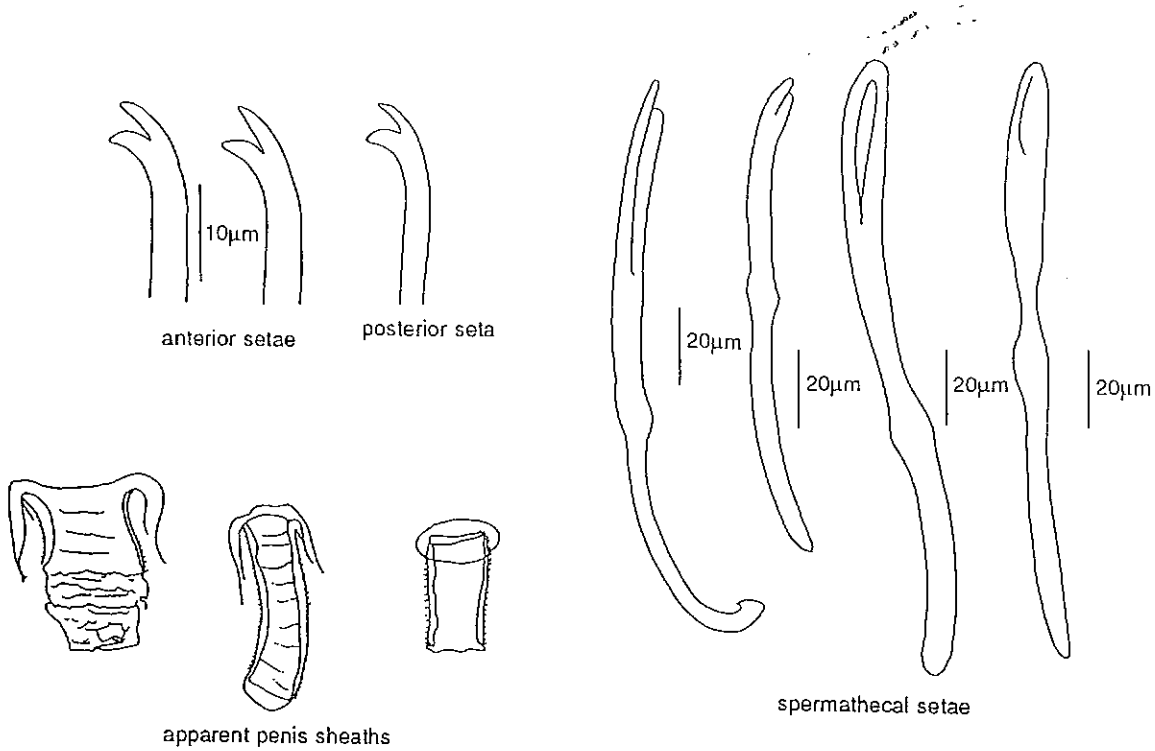
Dorsal bundles with three to seven non-serrate hairs and two to four pectinate setae with teeth approximately equal. Ventral bundles with three to five bifid setae, anteriorly with the upper teeth longer and thinner than the lower, posteriorly with the teeth equal or the upper shorter. Spermathecal setae single grooved or with short lower teeth distally (the latter probably representing incompletely modified setae). Vasa deferentia long, atria small and narrowing abruptly to form ejaculatory ducts. Penes small.

Tas; Cambridge. Vic; Lake Mumblin and Lake Surprise. SA; springs/bores/lakes near Lake Eyre, Lake Leake (Glencoe). NSW; glacial lakes (Kosciusko). WA; wetlands in the Perth region.
Also New Zealand.

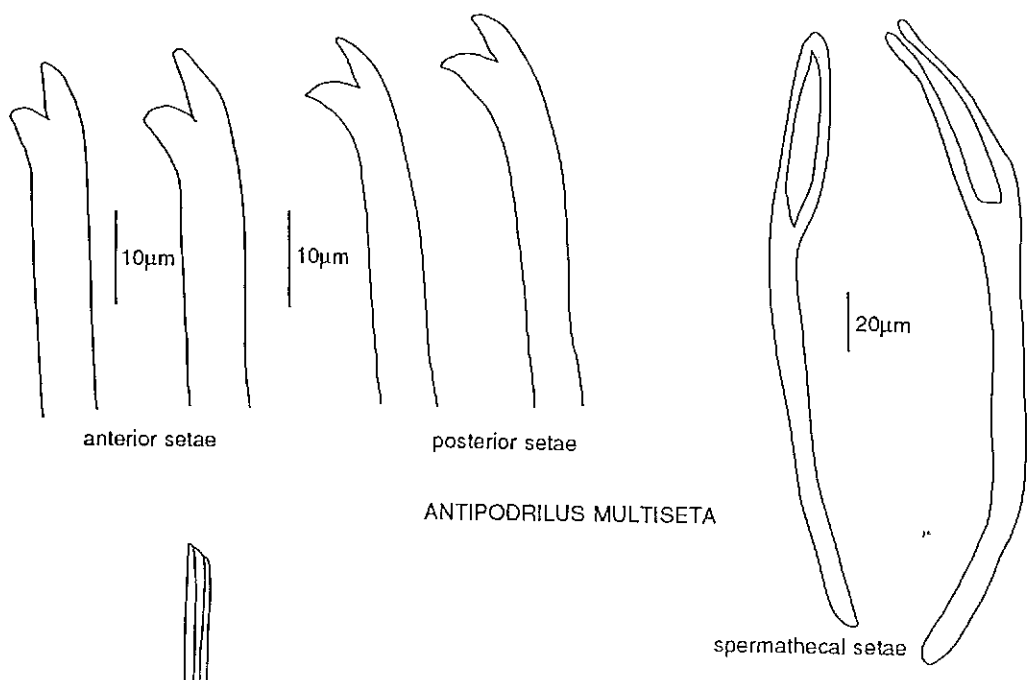
Antipodrilus timmsi Brinkhurst, 1971

Anterior dorsal bundles with two to five serrate hairs and three to five pectinate setae with the upper teeth slightly longer than the lower, fewer setae posteriorly with upper teeth becoming longer and pectinations less apparent or absent. Ventral bundles with three to five setae anteriorly with the upper teeth markedly longer and somewhat thinner than the lower, fewer setae posteriorly with upper teeth less markedly longer than the lower. Spermathecal setae single, grooved and narrowly blade-shaped distally. Vasa deferentia long, atria small and almost spherical, narrowing abruptly to form long ejaculatory duct. Penes long with basal membranes of the penial muscle cells thickened to form apparent penis sheaths.

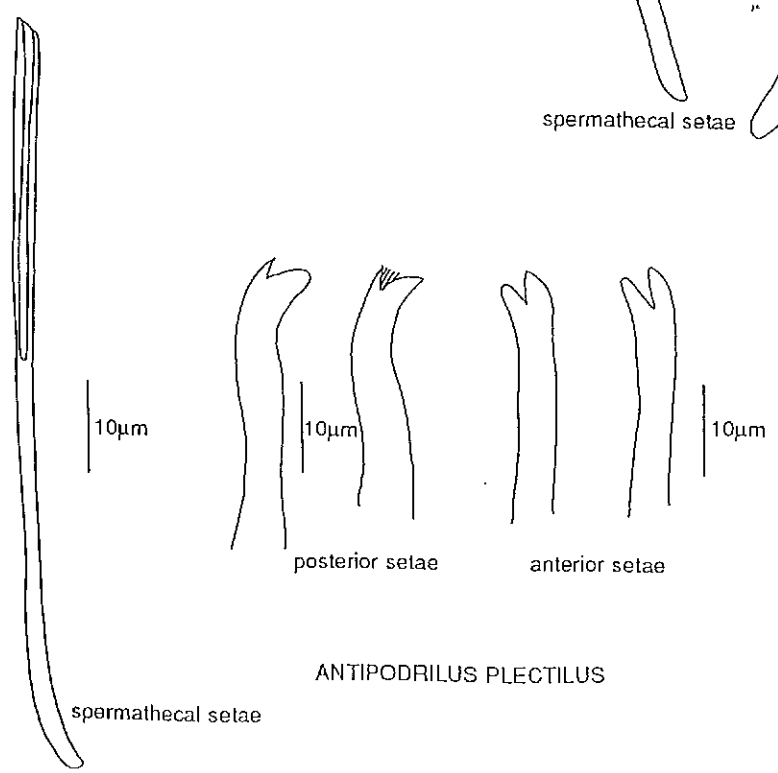
Vic; lakes in the Camperdown region (e.g. Lake Colac and Lake Corangamite).



ANTIPODRILUS MAGELENSIS



ANTIPODRILUS MULTISETA



ANTIPODRILUS PLECTILUS

From group B: Species without hairs, setae either bifid or pectinate. Three species.

Antipodrilus magelensis Brinkhurst 1984

Anterior bundles with four to six setae with teeth equal in length and breadth, diminishing in number posteriorly to two per bundle with the upper teeth becoming shorter and thinner than the lower. Spermathecal setae single with grooved tips. Vasa deferentia moderately long, joining atria subapically. Short atria terminate in coiled ejaculatory ducts. Large muscular penes with basal membranes of the penial muscle cells forming thick apparent penis sheaths.

SA; Charles Angas bore and Coopers Creek (near Lake Eyre). NT; billabongs associated with Magela Creek.

Antipodrilus multiseta Brinkhurst 1979

Twelve to 15 setae per bundle in II, gradually diminishing in number to three or four posteriorly. Anterior setae with blunt teeth of equal thickness, the upper slightly longer, posterior setae with upper teeth shorter than the lower. Spermathecal setae single, thin and groove tipped. Vasa deferentia moderately long, atria and prostate glands small, ejaculatory ducts long and thin, leading to small penes. Posterior end of body tapering to a coiled tail.

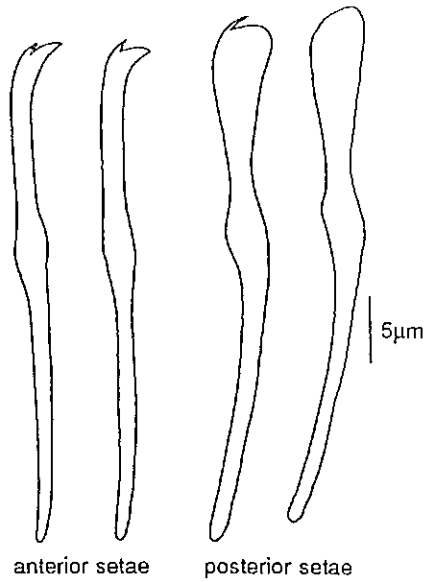
Tas; Great Lake and Lake Sorell.

Antipodrilus plectilus Brinkhurst 1979

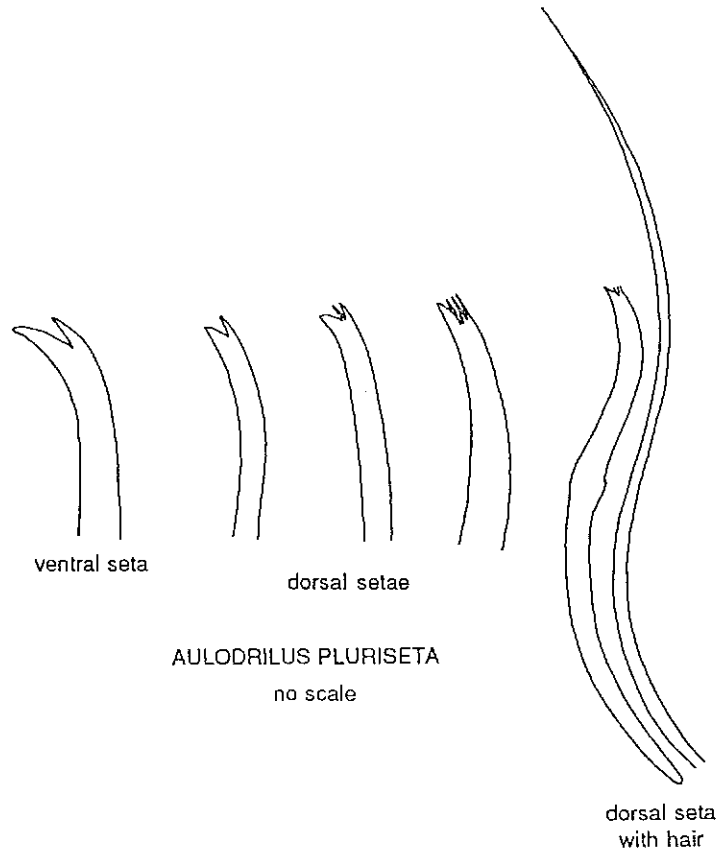
Dorsal and ventral bundles with seven to nine setae anteriorly, reduced in number posteriorly to three and then one per bundle. Setae of II with upper teeth shorter and thinner than the lower, setae of other pre-clitellar bundles with teeth equally long and with teeth equal in width or the upper teeth thinner than the lower. Posterior setae with upper teeth shorter and thinner than the lower. Spermathecal setae single, thin and groove tipped. Vasa deferentia moderately long, atria elongate, distended where vasa deferentia and prostates attached. Ejaculatory ducts moderately long. Small thin red worms that may be found in clusters of up to 50 specimens where abundant.

Tas; Great Lake, Arthur's Lake and Lake Sorell.

The type specimens of *A. plectilus*, which are all from Great Lake, Tasmania, have all bifid setae but specimens from Lake Sorrel (specimens in the collection of R.O. Brinkhurst) have pectinate setae posteriorly.

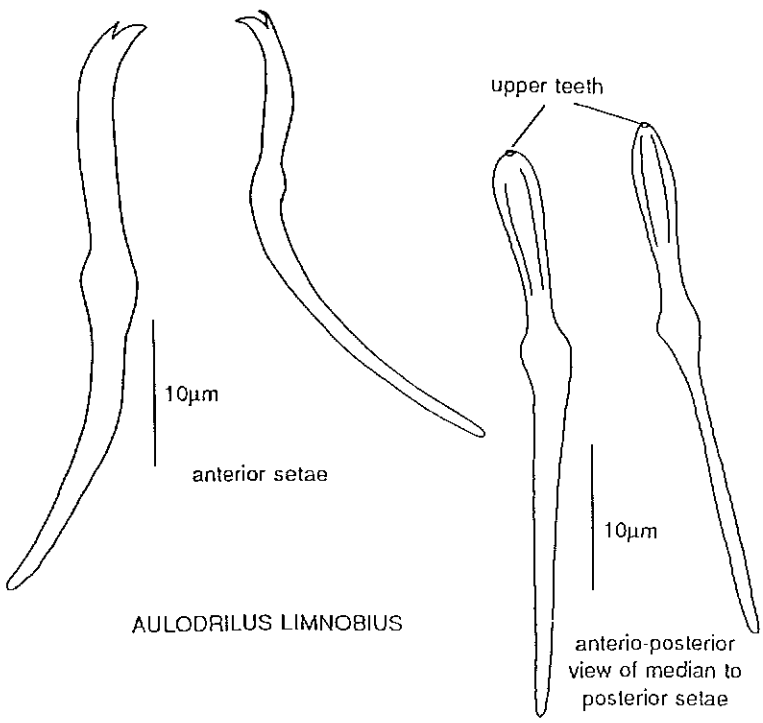


AULODRILUS PIGUETI



AULODRILUS PLURISETA

no scale



AULODRILUS LIMNOBIUS

Genus *Aulodrilus* Bretscher, 1899

Dorsal bundles with or without hairs. Vasa deferentia usually short, atria globular, bean shaped or cylindrical with solid prostate glands. Pendant penes present without cuticular sheaths. Penial setae may be modified. Sperm stored in spermathecae as loose bundles, not as spermatozeugmata. Worms often very narrow posteriorly. Aulodrilus species often reproduce asexually and are often found in tubes of bound sediment.

Three species. *A. pluriseta* and *A. pigueti* have hairs in the dorsal bundles whereas *A. limnobius* does not.

Aulodrilus pluriseta (Piguet, 1906)

Anterior dorsal bundles with up to eight short hair setae and up to 10 bifid setae with one to several upper teeth which are thinner and shorter than the lower. Anterior ventral setae up to 16 per bundle with very thin, short upper teeth. Vasa deferentia fairly long, atria globular.

Specimens of *Branchiura sowerbyi* which have bifid dorsal setae and posterior segments missing may be confused with *A. pluriseta* but the finer, relatively longer hairs of *B. sowerbyi* should allow these to be distinguished.

Qld; Yule Creek (Yanda Yarra). NT; billabongs associated with Magela Creek.
Cosmopolitan.

Aulodrilus pigueti Kowalewski, 1914

Dorsal anterior bundles with two to five hairs and four to five (or rarely up to 10) other setae which are either simple pointed or bifid with the upper teeth shorter and thinner than the lower. Beyond VII the bifid setae become oar shaped when viewed from lateral aspect, often with rudimentary upper teeth visible. Dorsal setae, or at least the hairs, may be absent from II to VII. Ventral bundles with four to 11 bifid setae with upper teeth shorter and thinner than the lower. Two spoon shaped penial setae per bundle on XI in mature specimens. Vasa deferentia short, atria bean shaped. Pendant penes open via a median inversion of the body wall.

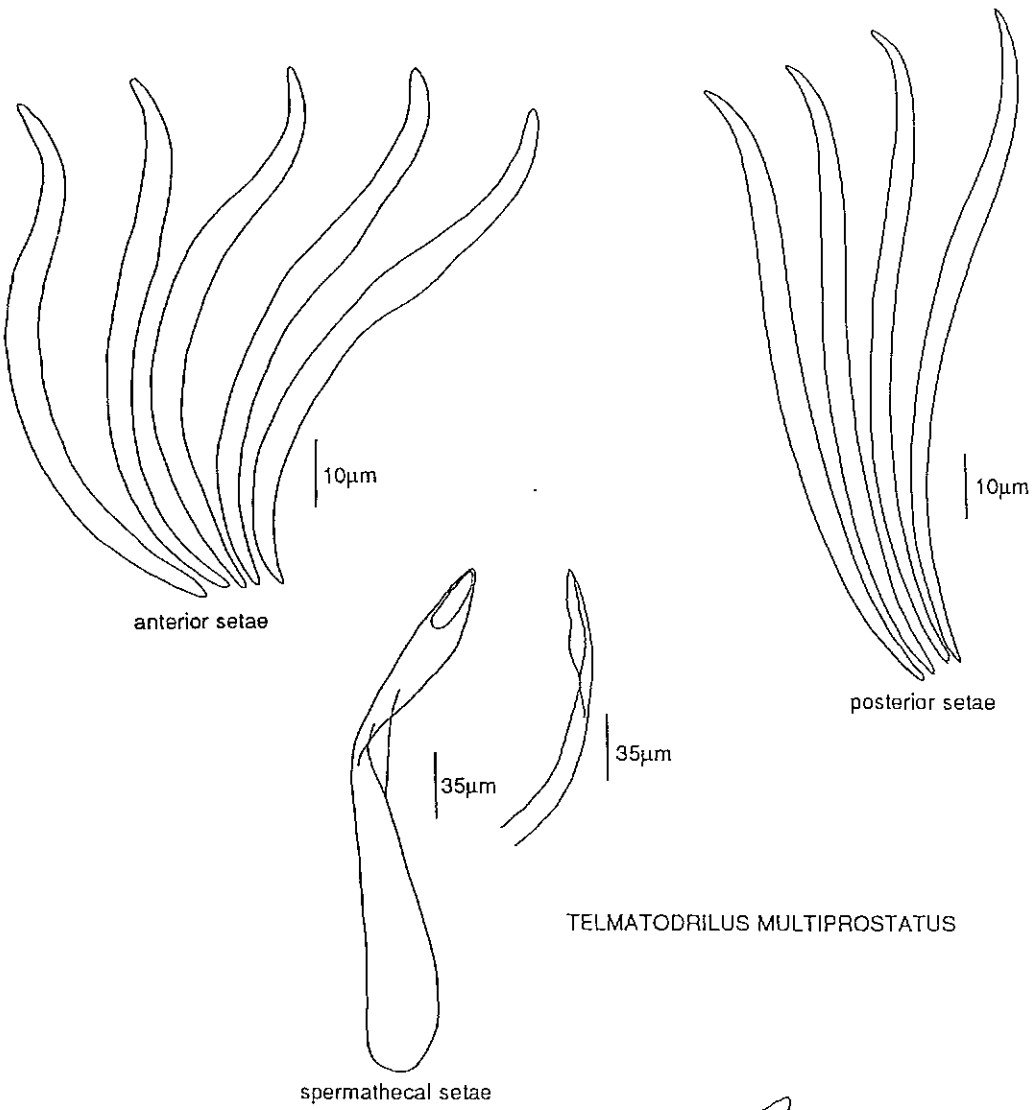
Vic; Branjee Creek (Goulburn Valley) and La Trobe River. WA; Balladonia, Pine Hill Rock. Qld; Pond near Tully. NT; billabongs associated with Magela Creek.
Cosmopolitan.

From Group D: Species without hairs and with all setae bifid with upper teeth shorter than the lower. One species

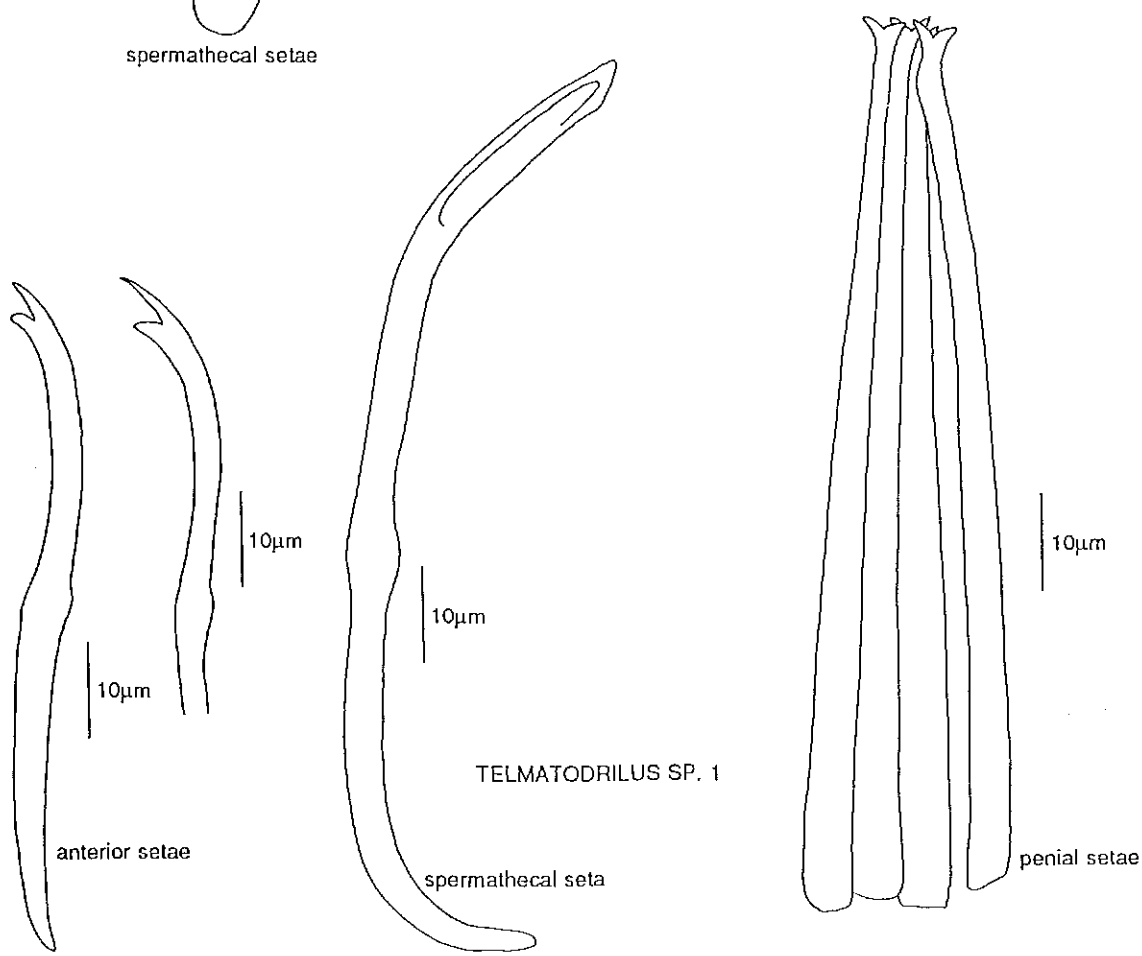
Aulodrilus limnobius Bretsher, 1899

Anterior dorsal and ventral bundles with up to 10 bifid setae all with the upper teeth shorter and thinner than the lower. The setae of the first bundles shorter, thicker and more strongly sigmoid than the rest. Setae of mid and posterior segments with lateral wings, which, when viewed from the anterio-posterior aspect, give the setae a narrow oar shaped appearance with the upper teeth visible as small projections above the tips of the blade. The wings are visible as a line down the distal part of the setae when viewed laterally. Vasa deferentia long, atria long and cylindrical.

Vic; Branjee Creek (Goulburn Valley), Wentworth River and Mitta Mitta River.
Cosmopolitan.



TELMATODRILUS MULTIPROSTATUS



TELMATODRILUS SP. 1

Genus *Telmatodrilus* Eisen, 1879

Dorsal hairs present or absent, ventral and dorsal setae often of the same form. Vasa deferentia moderately long, atria globular or tubular, with two to many discrete prostate glands. Pendant penes present or absent, may have protrusible pseudopenes. Spermathecal setae and sometimes the penial setae modified.

Telmatodrilus multiprostatus has all setae simple pointed while the other five species have at least the anterior setae bifid and a key is provided for these below.

Telmatodrilus multiprostatus Brinkhurst, 1971

All setae simple pointed (describe in more detail), up to eight per bundle anteriorly, finer posteriorly with as few as three per bundle. Spermathecal setae single, large and spatulate, setae absent on penial segment of mature specimens. Atria elongate pear-shaped with many small prostate glands apically. Ejaculatory ducts may be protrusible and enter a shallow inversion of the body wall.

Tas; Lake Pedder, Lake Sorell, Lake Crescent, Cuvier River, Collingwood River and tributaries, North Lune River, trickle 1km west of King William Saddle, Tyenna River, South Esk River, Lake Surprise, trickle under the needles, creek at Frodhams pass and Crossing River.
Also New Zealand.

From group B: Species with anterior setae bifid. Five species.

Key to species

1a. Posterior setae all simple pointed, anterior setae bifid with upper teeth longer than the lower ....*Telmatodrilus* sp. 1 below

b. Posterior setae hair-like, anterior setae bifid with equal shovel-shaped teeth .....*T. papillatus* pg. 88

c. Posterior setae all pectinate .....*T. pectinatus* pg. 88

d. All setae bifid 2

2a. Posterior setae with upper teeth shorter than the lower .....*T. bifidus* pg. 90

b. Posterior setae with upper teeth longer than the lower .....*Telmatodrilus* sp. 2 pg. 90

Telmatodrilus sp. 1

Anterior bundles with four to six bifid setae with upper teeth longer than the lower, posterior bundles with four to eight simple pointed setae. Spermathecal setae single and grooved tipped, penial setae three or four per bundle in XI, bifid with short teeth. Genital anatomy not described yet but apparently similar to *T. bifidus* and *T. papillatus.*

Tas; Que River and Southwell River.

Telmatodrilus papillatus Brinkhurst and Fulton, 1979

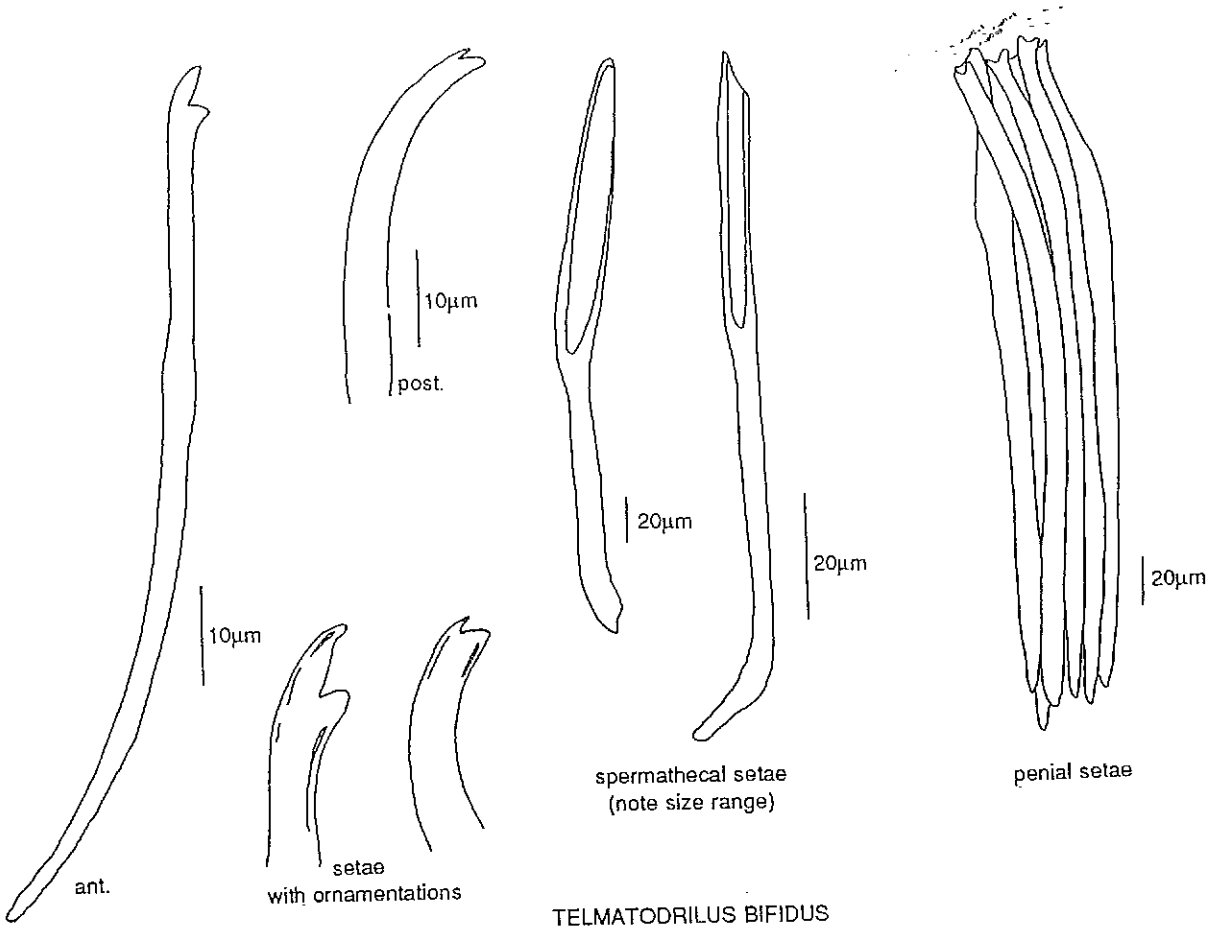
Anterior bundles with five to seven broad, bifid setae with shovel shaped tips to the teeth. Setae gradually change to hair-like form posteriorly, with five to nine hairs in dorsal and ventral bundles of post clitellar segments. Penial setae three to four per bundle with bifid tips, spermathecal setae not modified. Body wall papillate and covered in adhered foreign particles, usually a ring of large papillae present between each ring of setal bundles and one or more secondary rings of smaller papillae between the main ring and the setal bundles. Short atria enter common median protrusible chamber close together. Each atrium with at least two or three prostate glands apically.

Tas; Great Lake, Lake Sorell and Arthur's Lake.

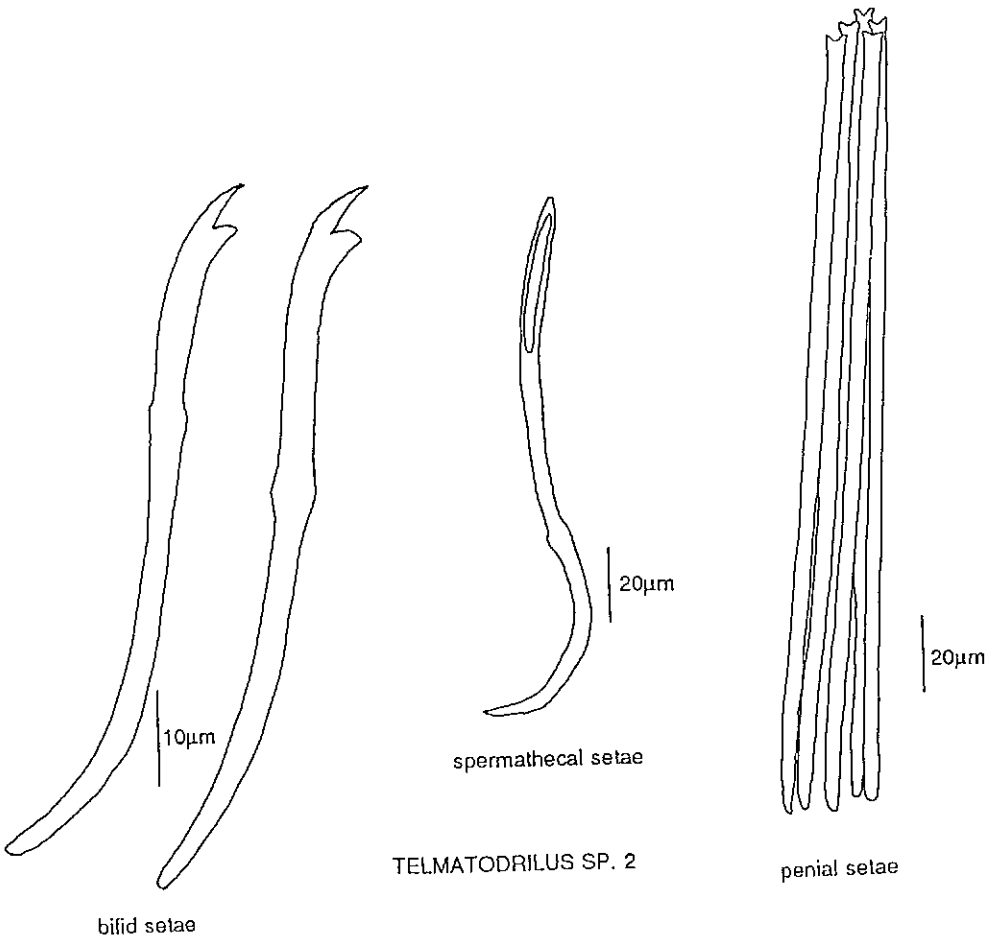
Telmatodrilus pectinatus Brinkhurst 1971

Anteriorly bundles with nine to 12 bifid setae dorsally and 11 to 14 bifid setae ventrally, the upper teeth longer than the lower and often slightly hooked. Posterior ventral and dorsal bundles with five to eight pectinate setae with upper teeth not so long relative to the lower. Modified spermathecal setae single and thin with grooved tips, penial setae with rough, blunt to slightly bifid tips. Atria pear shaped with numerous prostates. Ejaculatory ducts may be protrusible and enter a common median chamber.

Tas; Lake Pedder and Lake St. Clair. Vic; Lake Tali Karng.



TELMATODRILUS BIFIDUS



TELMATODRILUS SP. 2

Telmatodrilus bifidus Brinkhurst and Fulton, 1979

Anterior bundles with up to 13 setae with upper teeth longer than the broad lower. Number of setae diminishing from VIII to X with upper teeth becoming shorter than the lower after the clitellar region and setae becoming more sigmoid. Some setae may appear ornamented. Spermathecal setae single and straight with grooved tips. Six to seven bifid penial setae per bundle, twice as long and thick as the somatic ventral setae. Atria small, spherical on short stems, two large prostate glands per atrium, one anterior lobe extending around the vasa deferentia and one posterior lobe. Male pores and penial setae open into the lateral walls of a large median depression.

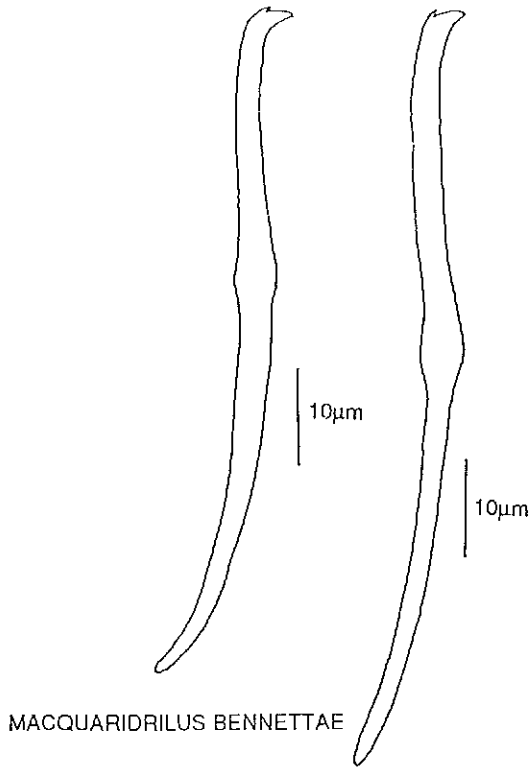
Tas; Great Lake and Arthur's Lake.

Telmatodrilus sp. 2

All setae bifid with upper teeth about twice the length of the lower, four to seven setae anteriorly, fewer posteriorly. Spermathecal setae single, long, thin and grooved tipped, in the segment with the spermathecal pores and/or in one or more other segments anterior to the spermathecal segment. Four to seven penial setae per bundle in XI with bifid tips, about twice the length of the somatic setae. Atria small, spherical on short stems, two large prostate glands per atrium, one anterior extending around the vasa deferentia and one posterior. Male pores and penial setae open into the lateral walls of a large median depression.

Tas; Que River, Southwell River and Douglas Creek.

The only other species which have been placed in this genus are *T. vejdovskyi* and *T. mcgregori* of North America and two species from eastern Russia with sensory papillae on the body wall which Hrabe (1962, 1964) placed in the genus *Alexandrovia*. There has been some debate about the relationships of these northern hemisphere taxa, including the synonymy of the two genera (Brinkhurst and Jamieson, 1971, Holmquist, 1974, Brinkhurst and Wetzel, 1984) but it is clear that all they differ from the southern hemisphere species in numerous respects. All of the northern hemisphere species have tubular atria with numerous prostates along their length and have rudimentary or well developed pendant penes which do not enter a median inversion of the body wall. By contrast, the Australian species have globular or pear shaped atria with two to several prostates attached to the apical portion only. The ejaculatory ducts may be protrusible but there are no pendant penes and the male pores usually enter a median inversion of the body wall. These differences may be sufficient to warrant the establishment of a separate genus (or genera) for the Australian species but this should be delayed until properly fixed specimens of some of these species can be studied in more detail.



MACQUARIDRILUS BENNETTAE

Genus *Macquaridrilus* Jamieson, 1968

Vasa deferentia long, atria tubular with many prostate glands, stout muscular ejaculatory ducts and small conical penes in elaborate glandular penis sacs, without penis sheaths. Spermathecae with diverticulae. Ventral setae not modified in the genital region.

One species

Macquaridrilus bennettae Jamieson, 1968

Three to five setae per bundle, all bifid with the upper teeth shorter and thinner than the lower, absent on XI in mature specimens. Vasa deferentia long, atria tubular with numerous small prostate glands. Ejaculatory ducts long with tightly spiral muscle layers and continuous with the spout-like penes. The penes lie within penis sacs which open into ventral chambers bearing post prostate glands. The spermathecae open laterally and are associated with short diverticulae ending in small spherical bulbs.

Restricted to streams and ponds on Macquarie Island.

Genus *Bothrioneurum* Stolc, 1888

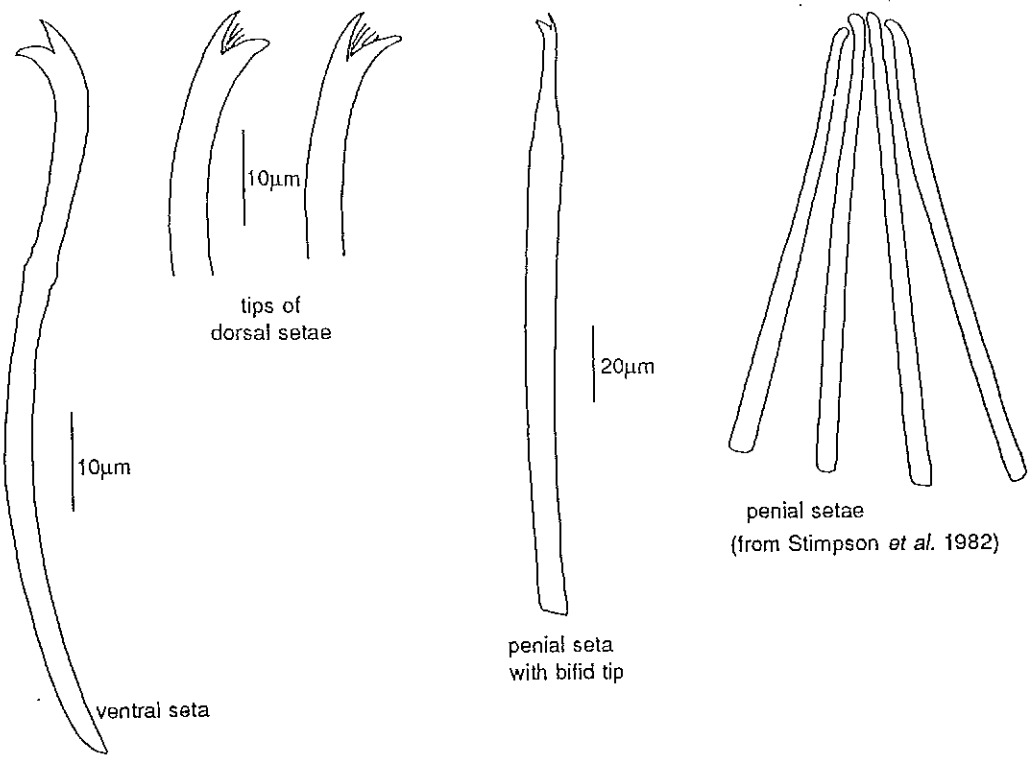
Hairs absent, all setae bifid. Prostomium with a dorsal sensory pit. Vasa deferentia short to long. Atria tubular and covered with diffuse prostate cells except for basal portion, leading to voluminous protrusible pseudopenes, the latter with paratria which bear accessory glands. Spermathecae absent but sperm contained within external spermatophores attached to the body wall of mated specimens. Penial setae may be modified. Coelomocytes conspicuous.

One species

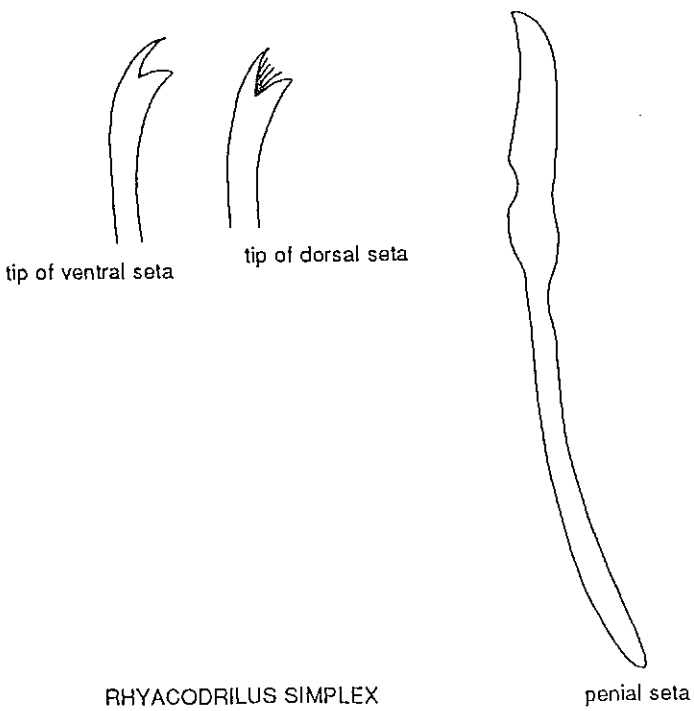
Bothrioneurum vejdovskyanum Stolc, 1888

Anterior bundles with four to six setae with upper teeth longer than lower, posteriorly fewer setae with the teeth equally long. Prostomium with a dorsal sensory pit, apparent as a thickening of the body wall when viewed from the lateral aspect. Ventral bundles of XI with four slightly hooked, club headed penial setae (often with a small lower tooth) arranged in a fan. Vasa deferentia long, atria tubular, covered with diffuse prostate tissue except for terminal section leading to protrusible pseudopenes. Cuticle of body wall ornamented and may appear spotted or papillate.

Tas; Arve River. NSW; Barrington River.
Cosmopolitan.



RYHACODRILUS COCCINEUS



RHYACODRILUS SIMPLEX
(from Brinkhurst and Jamieson, 1971)

scale not known

Genus *Rhyacodrilus* Bretscher, 1901

Dorsal hairs present or absent. Vasa deferentia moderately long, entering atria sub-apically, atria usually bulbous or rounded, usually covered with diffuse prostate cells. Protrusible pseudopenes present or absent but male ducts not usually entering median inversion of the body wall (bursa). Penial setae often modified. Coelomocytes usually large and abundant.

From group A: Species with hair and pectinate setae dorsally. One species in Australia and one so far found only in New Zealand.

Rhyacodrilus coccineus (Vejdovsky, 1875)

Anterior dorsal bundles with three to five hairs and up to five pectinate setae, hair setae missing in many posterior segments. Ventral setae two to five per bundle with upper teeth thinner than but not much longer than the lower. Ventral setae of XI with three to five club-headed penial setae per bundle. Vasa deferentia not coiled around the atria. Atria globular, covered with a layer of prostate cells. Coelomocytes present.

Tas; Southwell River. Vic; Grassy Creek (Otway Ranges) and Branjee Creek (Goulburn Valley). NSW; lakes, pools and rivers of the Kosciusko region.
Also Asia, Europe and North America.

Branchiura pleurotheca (Benham, 1907) of Blue Lake, Kosciusko (NSW) was found to belong to *R. coccineus* by Brinkhurst and Jamieson (1971).

Rhyacodrilus simplex (Benham, 1903)

Anterior dorsal bundles with one or two hairs and three or four pectinate setae. Ventral setae four to six per bundle with the upper teeth thinner than and as long as or longer than the lower, some with pectinations. Ventral setae of XI with up to eight simple pointed and distally hooked penial setae. Vasa deferentia coiled around atria before entering atria apically. Atria broadly cylindrical with bulbous apices. Prostate tissue absent. Coelomocytes present.

This species is known only from New Zealand (Lake Taupo, Lake Waikare, Lake Manapouri and Lake Coleridge).

The lack of prostate tissue in *R. simplex* caused Benham (1903) to establish the genus *Taupodrilus* for this species, separating it from the only other species described at that time, *Rhyacodrilus falciformis* Bretscher (1901), which possessed prostate. It was subsequently transferred to *Rhyacodrilus* by Hrabe (1931) as other characters clearly allied it with other members of this genus. This and other *Rhyacodrilus* without prostate may need to be transferred to a reinstated *Taupodrilus* once a much needed revision of this genus is undertaken (Brinkhurst, 1984c).

From group B: Species without hairs, all setae bifid with upper teeth as long as or longer than the lower. Two species.

Rhyacodrilus bifidus Brinkhurst, 1982

Ventral and dorsal bundles with three to eight setae anteriorly with upper teeth two to three times as long as, but thinner than, the lower. Six to ten bifid penial setae per bundle in XI, about twice the length of the somatic setae and slightly curved towards the tips. Vasa deferentia as long as atria. Atria tubular, four times longer than broad, ending in wide bulbs with narrow pores to the anterior face of continuations of the penis sacs. Prostate tissue abundant, attached to atria subapically. Coelomocytes not abundant.

Vic; Thomson River and Acheron River. NSW; Blue Lake (Kosciusko) and Wentworth River.

Rhyacodrilus fultoni Brinkhurst 1982

Ventral and dorsal bundles with 10 to 13 setae anteriorly, fewer posteriorly, all with teeth equally long. Six to nine straight simple pointed penial setae per bundle in XI, not much longer than the somatic setae, slightly hooked at the tip, may be rudimentarily bifid if not fully formed. Vasa deferentia short, entering the curved over distal part of the atria. Prostate absent. Atria lead to voluminous sacs with narrow external openings. Coelomocytes large and fairly abundant.

Tas; Lake Sorell.

Genus *Rhizodrilus* Smith 1900

Hairs absent, all setae bifid. Vasa deferentia moderately long, entering atria sub-apically. Atria tubular with diffuse prostate tissue, terminating in an ejaculatory duct which exits either into the inner aspect of a large ventro-lateral fold in the body wall (porophore) or into a median invagination of the ventral body wall (copulatory bursa), sometimes via an eversible pseudopenis. Spermathecal setae and/or penial setae modified in mature specimens. Some or all of the spermathecal system occupies IX as well as or instead of X, probably because the large copulatory bursa push the atria forward into X. Coelomocytes usually not apparent.

One species.

Rhizodrilus arthingtonae (Jamieson, 1978)

Ventral and dorsal bundles with three to five bifid setae, anteriorly with upper teeth slightly longer than the lower, posteriorly teeth not so different in length. The setae are smaller anteriorly and posteriorly, largest in the clitellar region. Several clearly bifid penial setae per bundle in XI, 1.5 to 2x longer than the somatic setae and slightly curved towards the tip. Vasa deferentia coiled anteriorly, entering atria sub-apically. Prostate tissue covering distal portion of elongate or slenderly bulbous atria and surrounding the vasa deferentia where the latter enters the atria. Atria connect with the male pores as a slender ejaculatory duct. Male pores exit into the inner side of a ventro-lateral fold in the body wall (porophore). Worm squarish in cross-section.

Qld; Brown Lake (North Stradbroke Island).

This species was described and placed within *Rhyacodrilus* by Jamieson (1978) before Baker and Brinkhurst (1981) transferred it to *Rhizodrilus* Smith, 1900. This latter genus was re-erected for those species of *Monopylephorus*, *Rhyacodrilus* and *Torodrilus* with tubular atria and diffuse prostate, well defined vasa deferentia which enter the atria sub-apically, with some or all of the spermathecal system in segment IX and with coelomocytes small or absent.

Genus *Branchiura* Beddard, 1892

Hairs usually present in dorsal bundles. Vasa deferentia short, joining elongate atria medially. Eversible pseudopenes present. Atria covered with diffuse prostate cells. Large atrial diverticulae arising from pseudopenes. Coelomocytes not conspicuous. Dorsal and ventral gill filaments on each segment posteriorly.

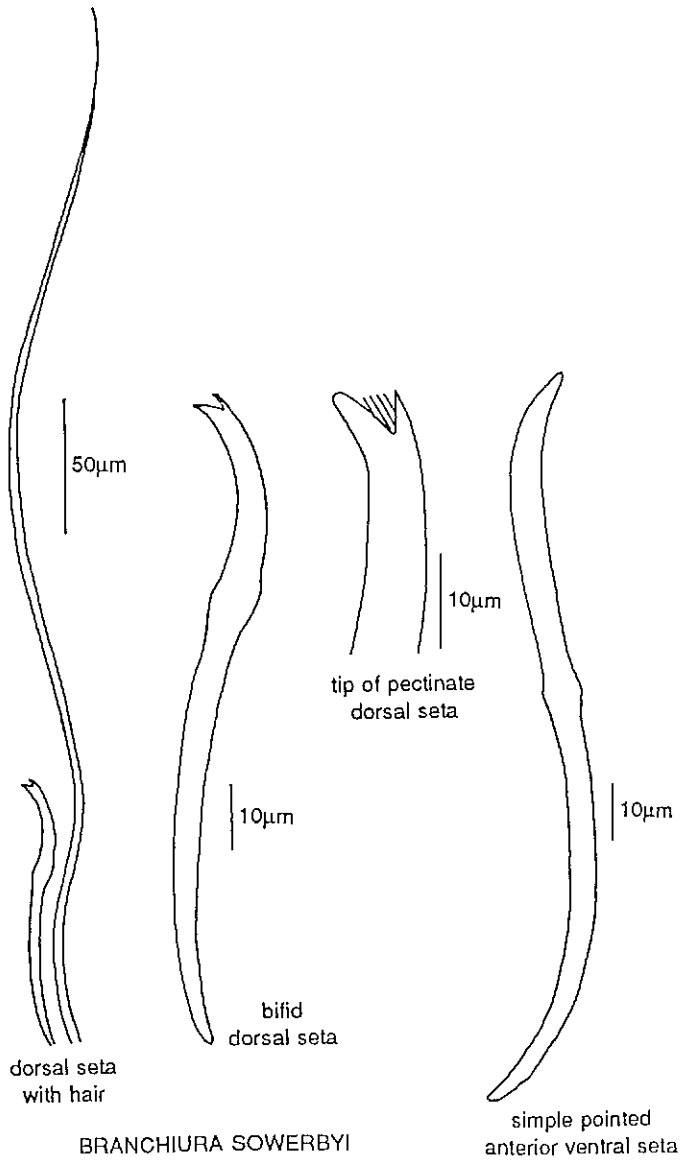
One species.

Branchiura sowerbyi Beddard, 1892

Dorsal anterior bundles with one to four short hair setae and five to 12 bifid or pectinate setae, often with the upper teeth rudimentary or absent. Posteriorly hairs reduced in number or absent and other setae reduced in number and with pectinations less apparent. Ventral bundles with six to 11 bifid setae with upper teeth shorter than lower, may be simple pointed anteriorly. Dorsal and ventral gill filaments on each segment posteriorly. Genital anatomy as for the genus.

Vic; junction of Thomson and Macalister Rivers, Thomson River and Mitta Mitta River. WA; wetlands in the Perth region. NSW; Parramatta River. Qld; Goldcreek (Brookfield), water hole on the Leichhardt River. Cosmopolitan.

Specimens with gills missing (e.g. damaged specimens) may be confused with *Aulodrilus pluriseta* but the finer hairs of *B. sowerbyi* should allow these to be distinguished.



BRANCHIURA SOWERBYI

Genus *Ainudrilus* Finogenova, 1982

Hairs present or absent. Vasa deferentia usually wide and at least partly granulated (?glandular), entering atria sub-apically. Atria more or less erect or directed towards the posterior, consisting of ampullae with spacious lumen leading to ducts ending in protrusible pseudopenes. Prostate tissue absent on atria. Coelomocytes large and abundant.

One species

Ainudrilus billabongus (Brinkhurst, 1984)

Ventral bundles with four to six setae anteriorly with teeth equal in length. Up to six simple pointed penial setae per bundle in XI, strongly recurved at the tip and about twice as long as the somatic setae. Vasa deferentia wide and glandular, about twice the length of the upright atria.

NT: Bowerbird Billabong (Magela Creek.).

Brinkhurst (1984c) noted that the wide glandular vasa deferentia of this species were similar to those of two marine species from the North Pacific, *Ainudrilus oceanicus* Finegenova (1982) and *Vadicola aprostatus* Baker (1982), but preferred to place it within *Rhyacodrilus* because other characters (position of union of the vasa deferentia and atria and form of the atria) allied it with that freshwater genus. Erseus (1986) placed more emphasis on the glandular nature of the vasa deferentia and transferred *billabongus* to *Ainudrilus*. He also regarded *V. aprostatus* as a junior synonym of *A. oceanicus* and described two other marine *Ainudrilus* from Hong Kong.

Unidentified species

Immature specimens of three potentially new species found in Tasmania cannot be generically placed with certainty. One of these, from the Que River, appears similar to *Telmatodrilus pectinatus* but has equal lateral teeth on the anterior setae rather than setae with the upper teeth longer than the lower. Another, from "a creek near Charlies Hill" has all setae simple pointed with the posterior dorsal setae longer and more numerous than in other bundles, unlike *Telmatodrilus multiprostatus* which has stouter simple pointed setae which become less numerous posteriorly and equal numbers of setae in both dorsal and ventral bundles. Other specimens from Southwell River and Que River have bifid setae with short upper teeth anteriorly and simple pointed setae posteriorly. A species from the Koscisuko region of NSW has all simple pointed setae anteriorly becoming bifid with short teeth posteriorly. Mature specimens are required of all of these before their taxonomic status can be assessed.

9. NAIDIDAE

Cosmopolitan genera and species form the largest component of the naidid fauna of most continents and this certainly applies to the Australia fauna. Of the ten genera and 31 species that have been recorded from Australia, all but two new species are either cosmopolitan or are found on at least one other continent. Three quarters of these occur in Asia although none are restricted to the Australasian region. Many also occur in Africa, Eurasia and the Americas. The two endemic species also belong to cosmopolitan genera.

Some species of *Dero* and *Pristina* are currently known to be very widely distributed in Australia and two species of *Nais* are at least known from the south-west and south-east. Most other species currently have more limited distributions but the ranges of these will undoubtedly be expanded with further work. For example, a comparatively large number of worms have been identified from eastern Victoria and most of the recent additions to the Australian naidid fauna, including *Slavina* spp., *Stylaria lacustris*, *Chaetogaster* spp. and *Pristinella* spp. are known only from this region. In New South Wales there is only one record of this family, despite the presence of many more species in both Victoria and Queensland. The single species recorded from Tasmania (*Nais ?communis*) is probably a more accurate indication of naidid richness in this state since a large number of worms from various localities have been identified without further records. Some naidids, particularly *Allonais*, *Branchiodrilus* and some *Dero* tend to be circum-tropical in distribution and this is reflected in northern distributions within Australia. *Paranais litoralis*, an inhabitant of brackish or saline waters, has so far been recorded from Fraser Island, Queensland and Port Phillip Bay and the Gippsland Lakes, Victoria, but is probably widespread in coastal and estuarine waters.

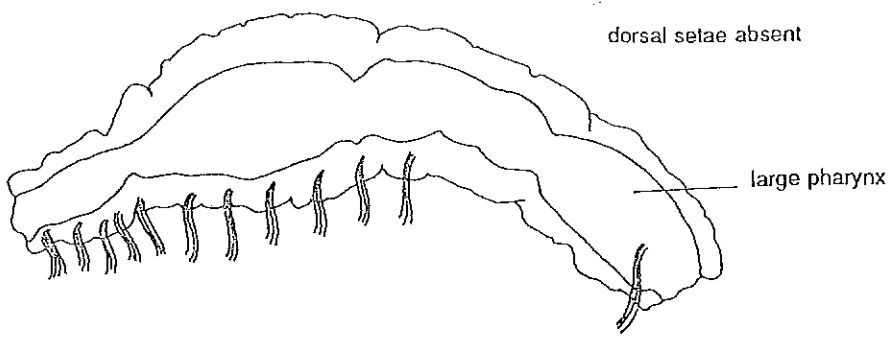
Naidids tend to be small worms, usually less than 1cm long, but chains of asexually reproducing worms may be longer. They are often abundant in stony streams, but are also common in larger rivers, lakes and wetlands and some inhabit brackish or saline waters. Some naidids, such as *Dero* spp., inhabit the organic silts of wetlands and rivers, whereas others can be found living in the water column of still or slow moving waters, among rooted or floating macrophytes. Some species are able to swim above or along the sediment. *Chaetogaster limnaei* is ecto- or endocommensal or endoparasitic on pulmonate gastropods and it's congeners are predatory.

Family diagnosis

Proboscis or eyes may be present. Gills may be present as dorso-lateral filaments along the body or located within a branchial fossa on the terminal segment. Dorsal setae either absent or beginning between II and VI, consisting of setae resembling the ventral setae or, more commonly, hairs accompanied by needle setae. Needle setae usually much shorter, thinner and less sigmoid than the ventral setae. An indefinite number of bifid ventral setae from II. Ventral setae often modified as penial setae in segment with male pores. One pair of testes in IV, V or VII, one pair of ovaries in following segment. Male funnels in segment with testes, vasa deferentia, atria and male pores in segment with ovaries. Diffuse prostate gland cells often present on vasa deferentia or atria. Paired spermathecae present in segment bearing testes. Usually an un-paired sperm sac and ovisac formed. Mature specimens rare, asexual reproduction by budding or fragmentation common.

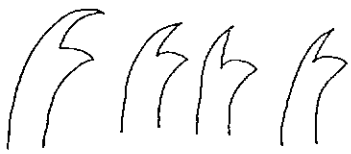
Identification of the Naididae

In general, the Naididae are easy to key to genus and many species are also easily distinguished. However, within some genera there are small groups or pairs of species which are very similar and difficulties may be encountered at this level. Interspecific variation in the reproductive system of this family is less well studied than in the Tubificidae and Phreodrilidae, partly because of the infrequency of sexual reproduction and so species level taxonomy has traditionally relied on setal morphology. There is growing recognition of intra-specific variation of setal morphology which may account for much of the confusion. For example, electron microscopy is revealing pectinations and lateral hairs in species where they were previously thought to be absent (Grimm, 1986, 1987 and 1988) and seasonal changes in setal form have been recorded (Smith 1985). Evidence that bifid setae may become pectinate and that hairs may become hispid, depending on the chemical nature of the water in which they live (Harman and Loden, 1980) also has implications for naidid

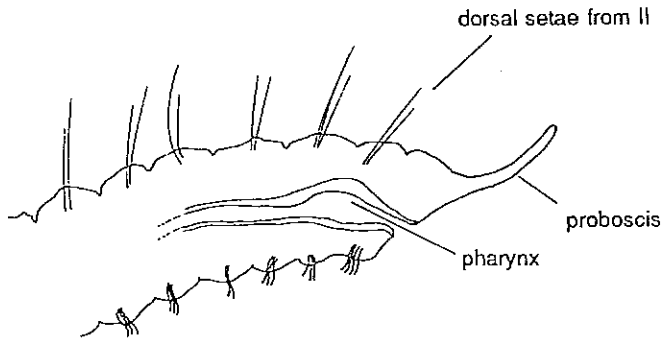


ventral setae absent from III to V

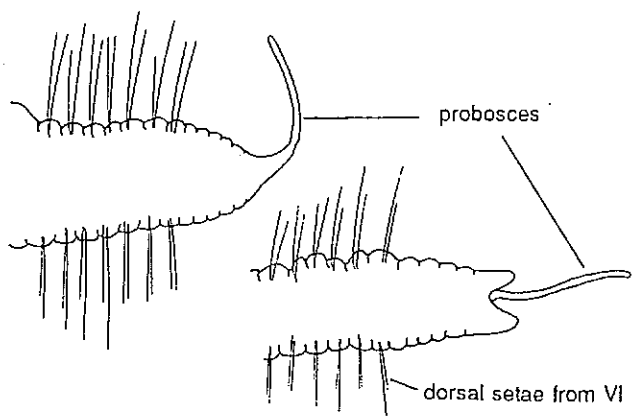
lateral view of CHAETOGASTER



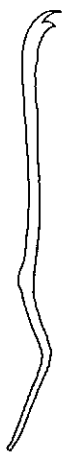
PARANAIS setae



lateral view of PRISTINA



dorsal views of STYLARIA



ventral seta
of STYLARIA

taxonomy at the species level. Recognition of the extent of setal variation has led to several synonymies of species in recent years (Kathman, 1985, Loden and Harman, 1980) and others are likely.

Where a genus contains more than one species a comparison between several descriptions will be required.

Key to genera

1a. Dorsal setae usually absent; ventral setae of III to V usually missing; prostomium rudimentary; pharynx extremely large ..... *Chaetogaster* pg. 122

b. Dorsal setae and ventral setae of III to V present; prostomium usually well developed; pharynx not enlarged 2

2a. Hairs absent in dorsal bundle, dorsal and ventral setae bifid and of similar size and shape ..... *Paranais* pg. 124

b. Hair setae present in dorsal bundles, accompanied by setae (needles) which are usually much finer than and distinctly different in form to the ventral setae 3

3a. Dorsal setae from II 4

b. Dorsal setae from IV, V or VI ..... 5[1]

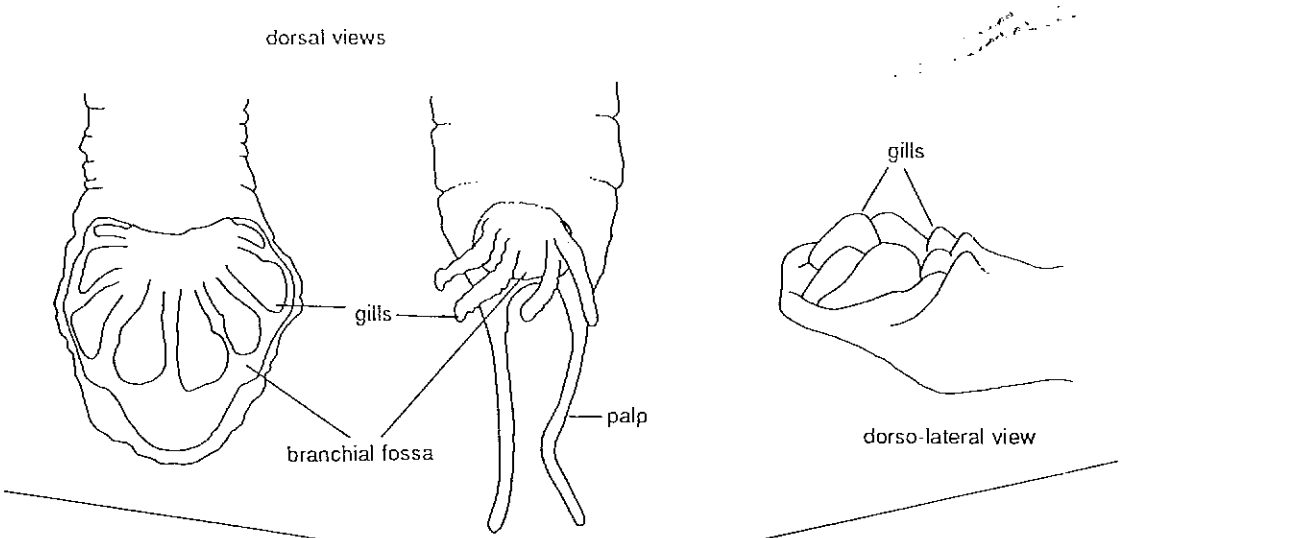
4a. Proboscis present on prostomium ..... *Pristina* pg. 118

b. Prostomium without proboscis ..... *Pristinella* pg. 120

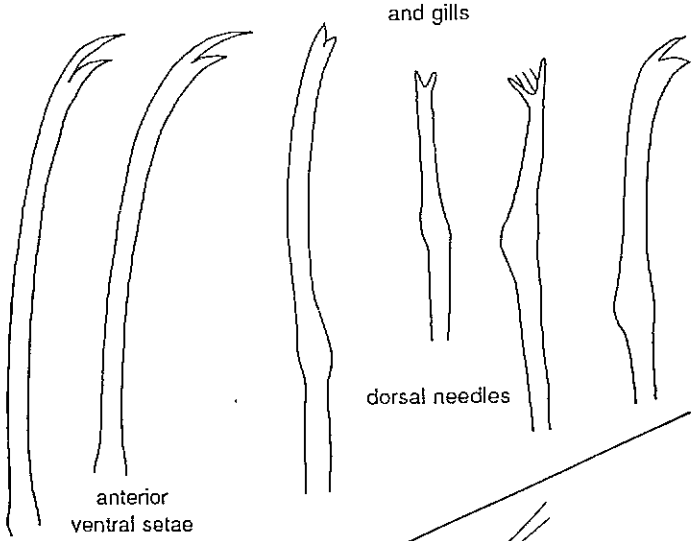
5a. Proboscis present on prostomium ..... *Stylaria* pg. 124

b. Prostomium without proboscis ..... 6 pg. 104

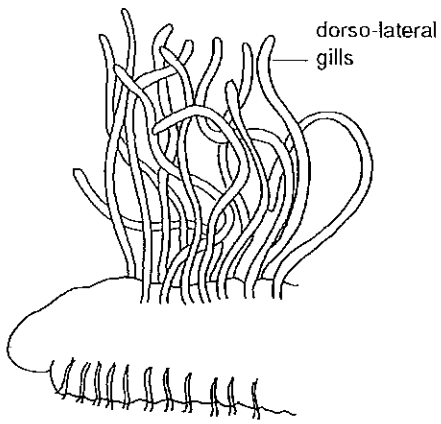
[1] Two specimens which appear to have dorsal hairs and bifid needles from III were recovered from the Thomson River. These may belong to *Bratislavia* (which has dorsal setae from III) but these do not fit the descriptions of the only two known species. Alternatively the anterior regions of these specimens may have been in the process of regeneration as some of the anterior ventral setae were not fully formed. These are not considered further at this stage.



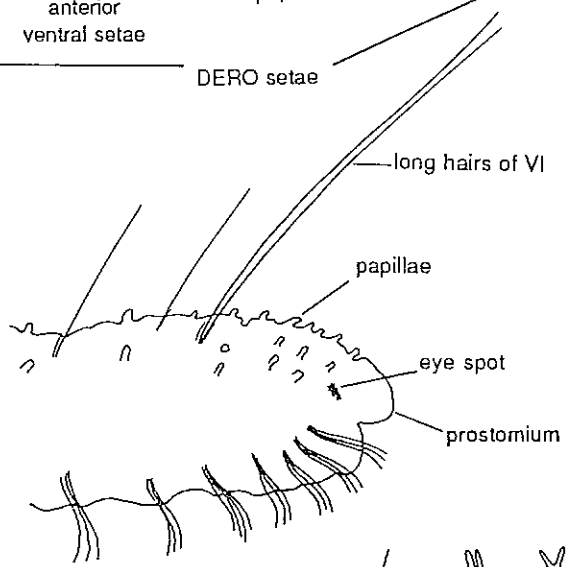
DERO branchial fossa and gills



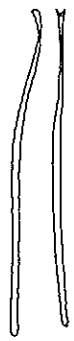
DERO setae



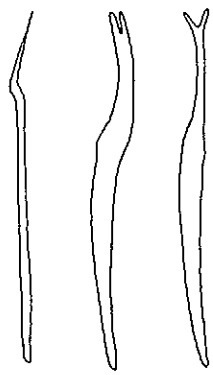
lateral view of anterior of BRANCHIODRILUS HORTENSIS



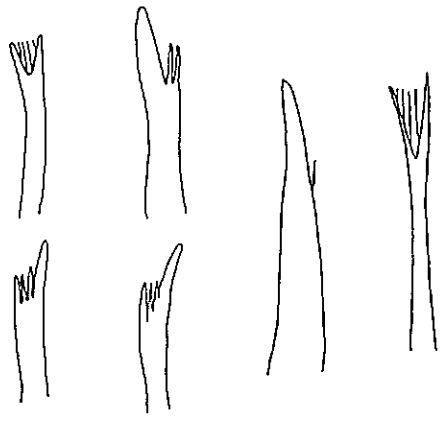
lateral view of SLAVINA



SLAVINA needles



NAIS needles



ALLONAIS needles

6a. Gills present as paired dorso-lateral processes on each segment from between IV to VII onwards ..... ***Branchiodrilus*** pg. 114

b. Dorso-lateral gills not present along body **7**

7a. Dorsal branchial fossa present around anus on terminal segment, usually containing paired gills and often with palps on the posterior edge; anterior ventral setae with long, thin teeth compared to the posterior ventral setae ..... ***Dero*** pg. 110

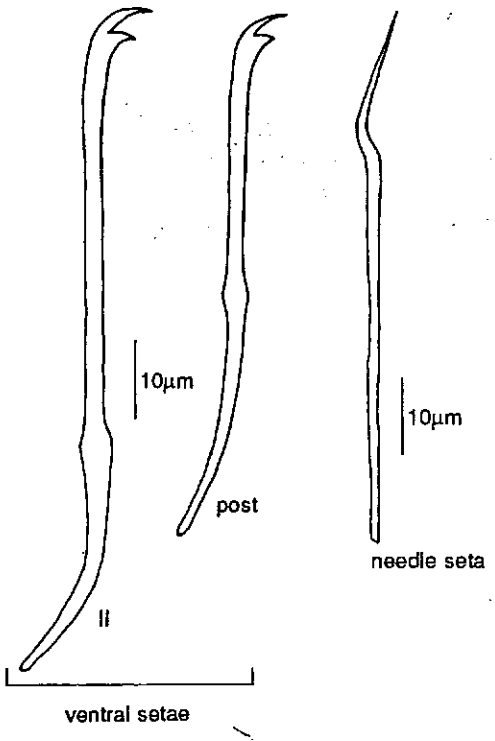
b. Branchial fossa not present; anterior ventral setae usually with teeth not so long and thin compared to the posterior ventral setae **7**

8a. Body with small sensory papillae and usually covered with adhering organic matter; needle setae fine with narrow hair-like distal ends terminating in a slightly distended or minutely bifid tip; hairs of VI (the first to bear setae) may be especially elongate ..... ***Slavina*** pg. 126

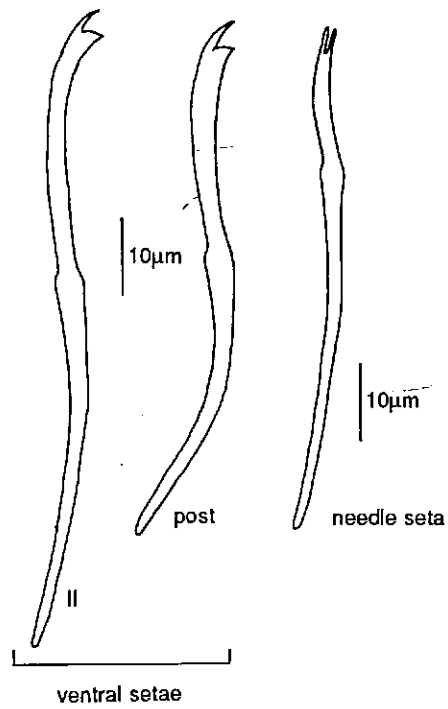
b. Body wall without sensory papillae; needles may be small and either simple pointed, bifid or pectinate, but tips not hair-like, hairs of VI not especially elongate **9**

9a. Needles obviously pectinate or with lateral teeth of obviously unequal thickness ..... ***Allonais*** pg. 116

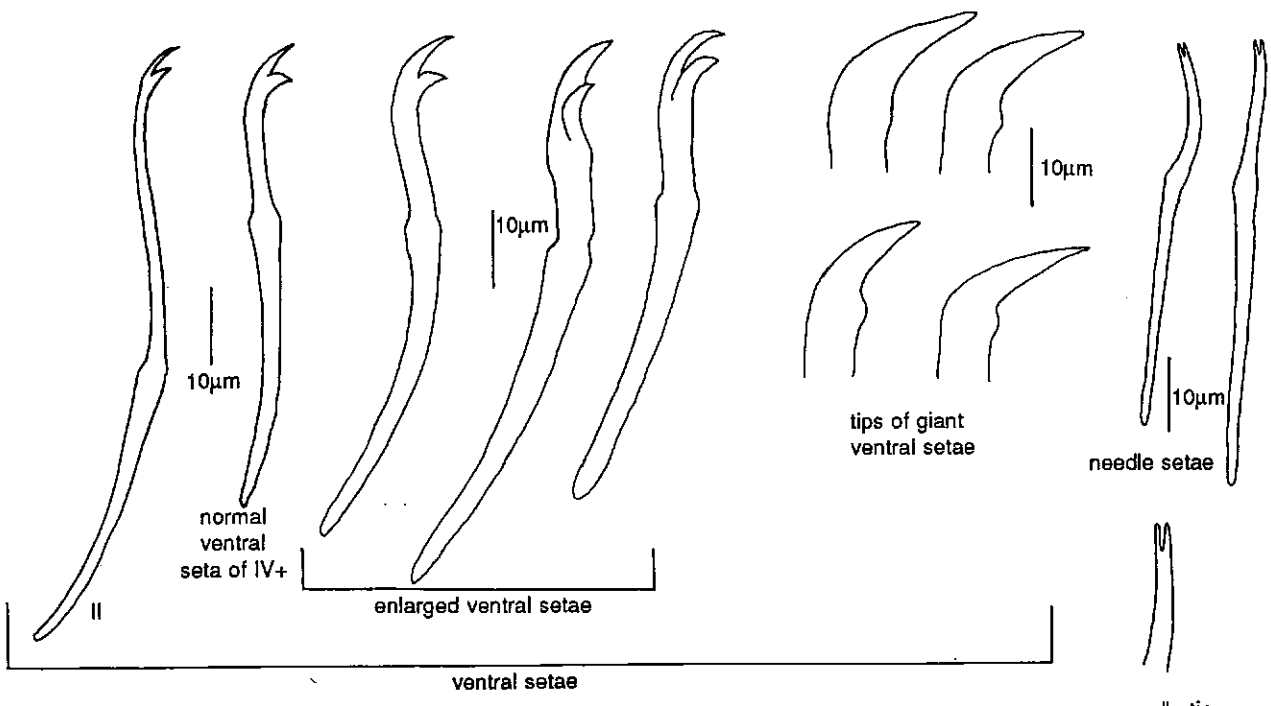
b. Needles usually simple pointed or bifid, rarely pectinate, with lateral teeth of equal thickness ..... ***Nais*** pg. 106



NAIS PSEUDOBTUSA



NAIS ELINGUIS



NAIS BRETSCHERI

Species descriptions

Genus *Nais* Muller, 1773

Dorsal setae from VI, consisting of hairs and simple pointed or bifid (or rarely pectinate) needles with equal teeth. Ventral setae of II to V usually differing in size and relative length of teeth to those of VI onwards. Eyes sometimes present. Prostomium without proboscis.

Five species

Nais pseudobtusa Piguet, 1906

Dorsal bundles with one to three hairs and one to three simple pointed needles with a double bend towards the finely tapered tip. Ventral setae three or four per bundle with upper teeth about 1.5 times longer than the lower. No enlarged or giant ventral setae. Eyes absent.

Qld; Lake Eacham.
Also Asiatic Russia, Africa, Afghanistan, Europe and North America.

Nais elinguis Muller, 1773

Dorsal bundles with one to three hairs and one to three bifid needles with long, parallel teeth, the upper teeth slightly to moderately longer than the lower. Ventral setae two to five per bundle, all with upper teeth twice as long as the lower, those of II to V only slightly longer, straighter and thinner than the rest. No enlarged or giant ventral setae. Eyes present or absent. May be found in brackish, saline or freshwater habitats.

Vic; Curdies River. **Qld**; Tinaroo Falls Dam Reservoir (Atherton Tablelands) and Trevethan Creek (Cook Highway, Cape York Peninsula). **Macquarie Island**; streams.
Cosmopolitan.

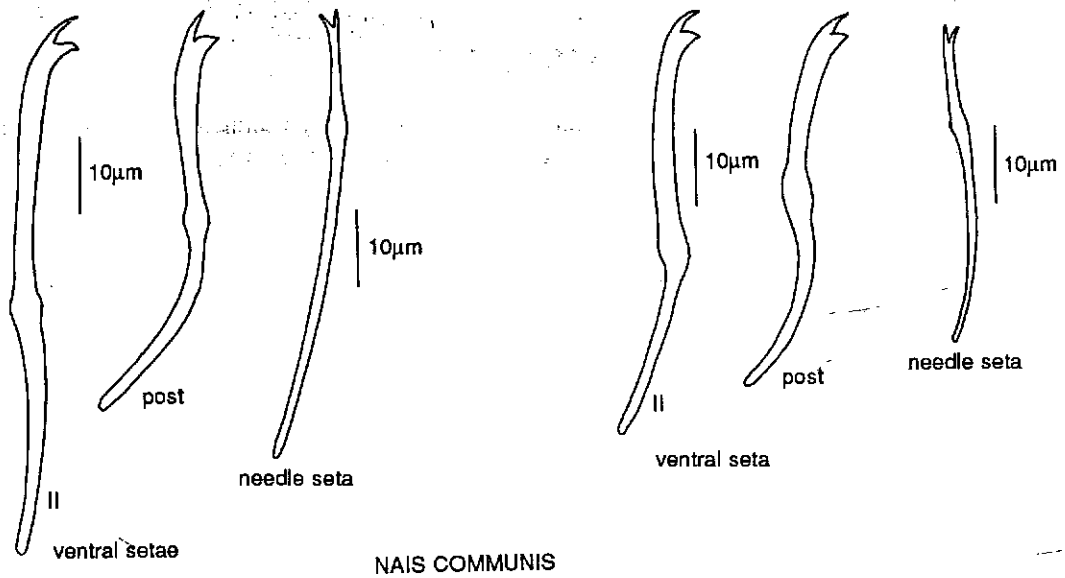
The Macquarie Island specimens have hispid hairs, a feature not noted previously. However, studies by Smith (1985) show that this character can be present or absent on the same species, but rarely the same specimen, of *Dero* and may vary with season.

Nais bretsheri Michaelson, 1899

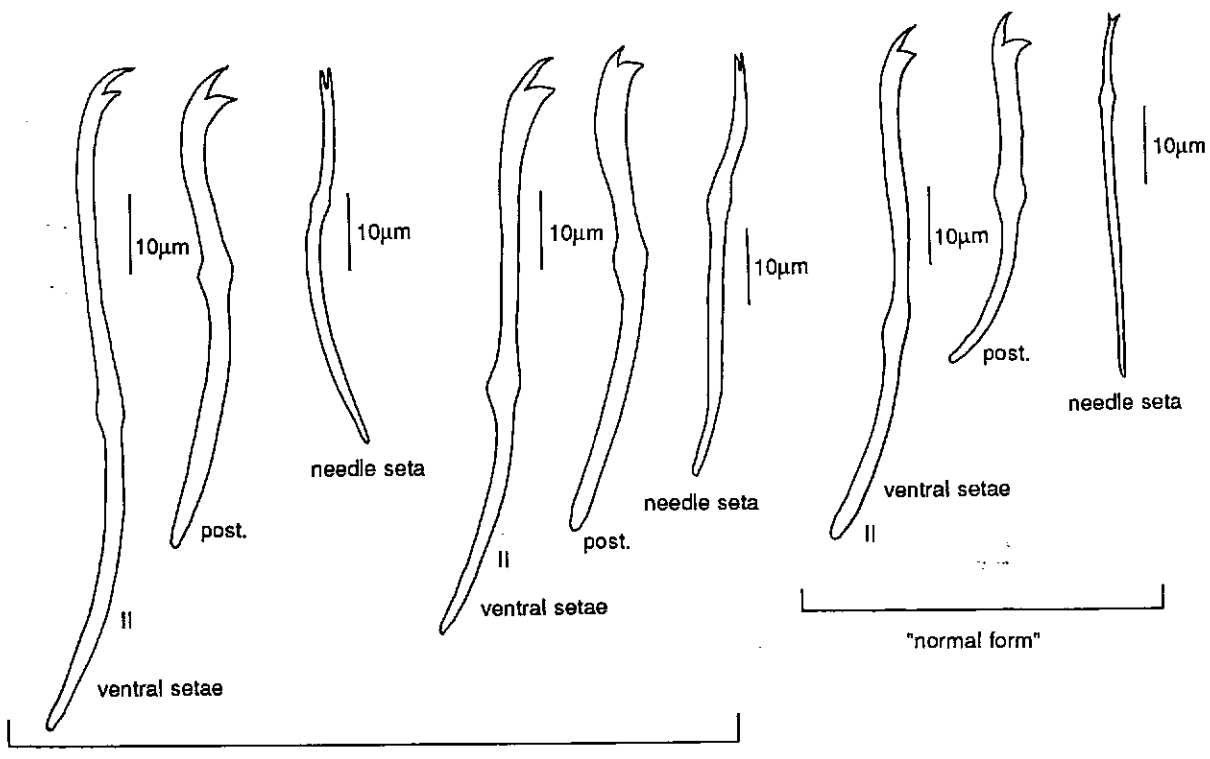
Dorsal bundles with one or two short hairs and one or two bifid needles with short, equal, parallel teeth. Ventral setae two to seven per bundle in II to V, with the upper teeth about twice as long as the lower. One to six setae per bundle from VI onwards, these being exceedingly variable but usually including some enlarged setae, with upper teeth two to three times longer than the lower, and often with solitary giant setae with lower teeth rudimentary or absent. Eyes present or absent.

Vic; La Trobe River. **WA**; Bibra Lake and Gibbs-Bartram Rd Swamp (Perth).
Also Europe and Central and Eastern Asia.

Nais pardalis (of North America, Asia and Europe) is almost certainly a variant of *N. bretscheri*; this species has some enlarged setae anteriorly but lacks the giant setae of *N. bretscheri*.



NAIS COMMUNIS



NAIS VARIABILIS

Nais communis Piguet, 1906

Dorsal bundles each with one or two hairs and one or two needles with distinctly divergent teeth which are clearly visible using a 40x objective. Ventral setae two to six per bundle, those of II to V only slightly longer and thinner than the rest. Stomach widening gradually. Eyes usually present.

Nais variabilis Piguet, 1906

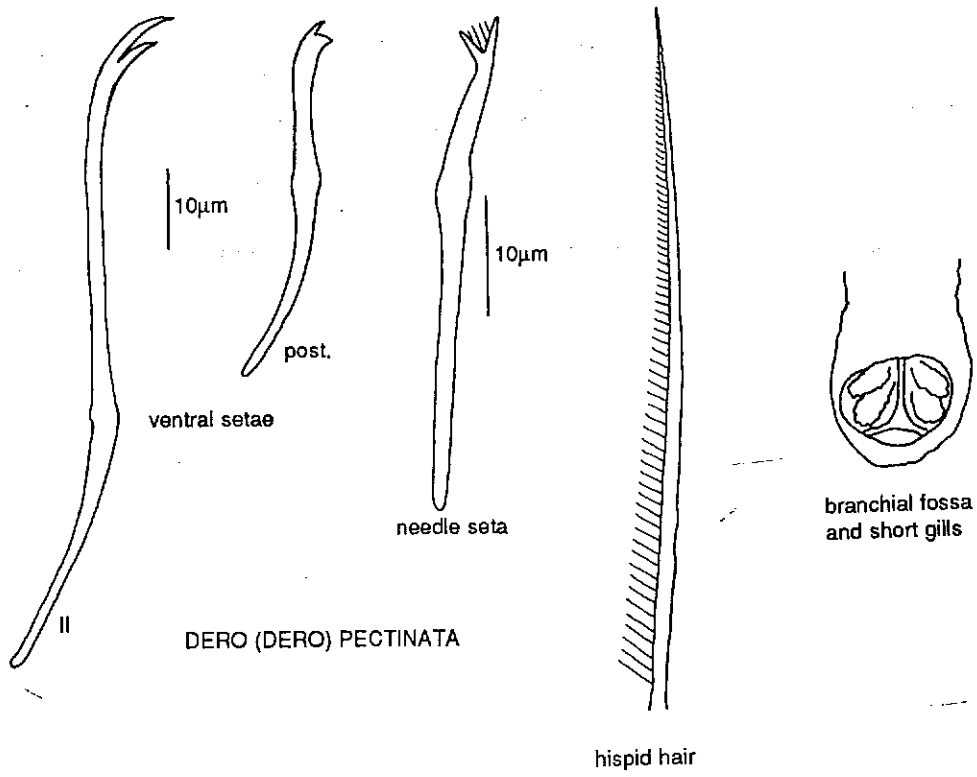
Dorsal setae one or two hairs and one or two needles per bundle. The teeth of the needles are short (generally inconspicuous with a 40x objective) and slightly divergent. Ventral setae two to seven per bundle, those of II to V distinctly longer and thinner than the rest, with upper teeth twice as long as the lower, teeth becoming equal posteriorly. Stomach widening abruptly. Eyes present or absent.

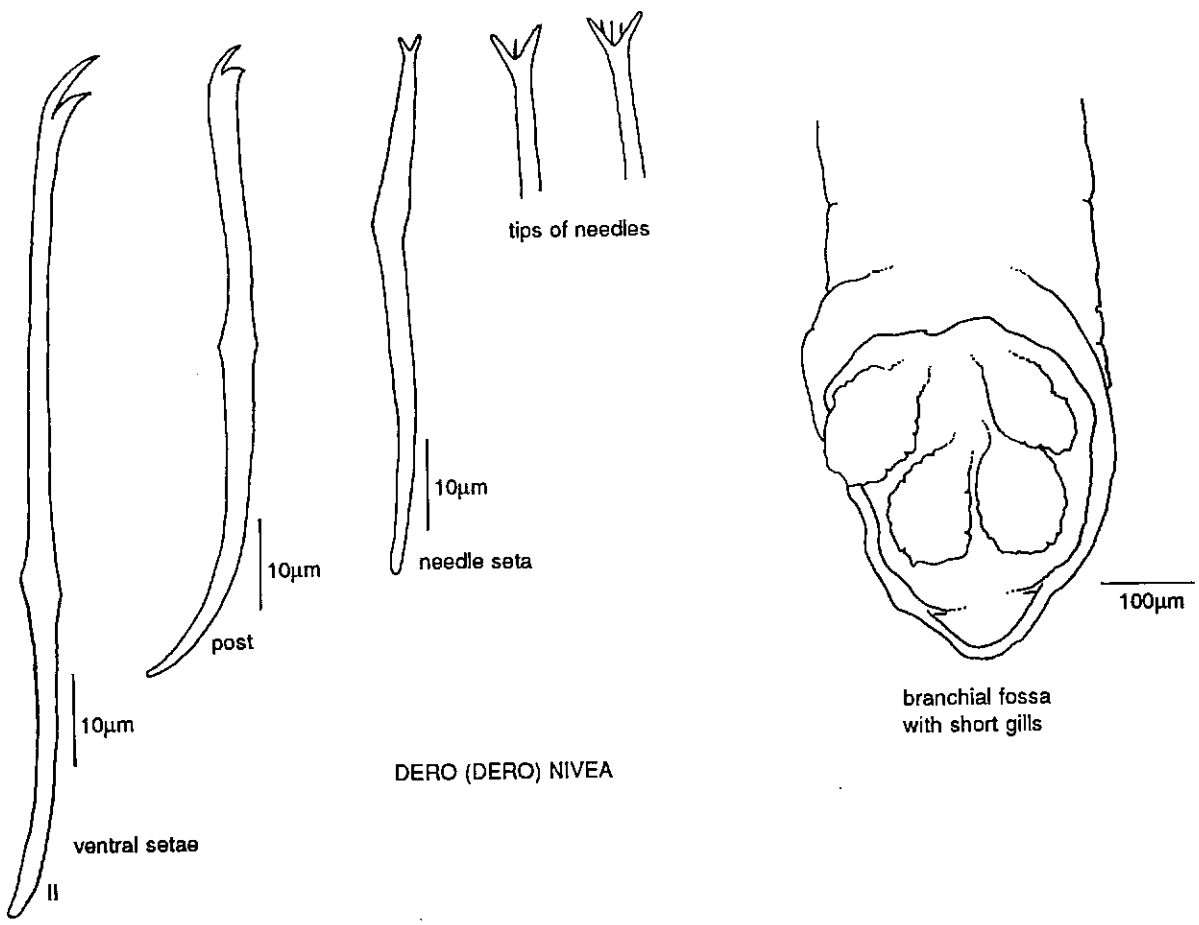
The following localities refer to both *N. communis* and *N. variabilis*.

Tas; Que and Southwell Rivers. **Vic**; Mitta Mitta River, Thomson River and La Trobe River. **WA**; Malaga wetlands (Perth). **Qld**; Big Spring, (41km north of Aramac).
Cosmopolitan

Nais communis and *variablis* are notoriously difficult to differentiate as there appears to be considerable overlap in many of the characters currently used to separate them. A thorough study of large numbers of specimens is required to determine if these are really separate species. For now they may have to be lumped as *N. variabilis/communis* in ecological studies.

To further complicate matters, some specimens with very short parallel teeth on the needles and with significant differences between the anterior and ventral setae are probably also *N. variabilis*. These resemble the *simplex* variety of *N. variabilis* described by Grimm (1986) from Africa. The needles of these *simplex* type specimens resemble those of *Nais bretscheri* and *Nais pardalis* (pg. 106) and these species would be almost indistinguishable if not for the enlarged and giant setae in the latter species. The development of enlarged setae has been found to vary with the age of the individual in other genera (e.g. *Pristina*, Loden and Harman, 1980) and so some or all of these species may be part of the same complex.


10µm
post.
ventral setae
II
10µm
needle seta
DERO (DERO) PECTINATA
hispid hair
branchial fossa
and short gills


tips of needles
10µm
needle seta
10µm
post
10µm
ventral setae
II
DERO (DERO) NIVEA
100µm
branchial fossa
with short gills

Genus *Dero* Oken, 1815

Anus opens dorsally into a ciliated branchial fossa, usually containing gills which vary in form from long digitiform processes to short knobs. In the subgenus *Aulophorus* a pair of elongate palps arise from the posterior edge of the fossa. Eyes not present. Dorsal setae from IV, V or VI, consisting of hairs and bifid, pectinate or palmate needles. Ventral setae of II to V usually longer and thinner than the rest with upper teeth much longer than the lower, from VI on with upper teeth not so long compared to the lower.

Several species are known from only a few specimens and these identifications should be considered tentative at this stage. The gills are best observed in live specimens as they contract when preserved, although the illustrations show gills in the preserved state. Many species were originally described with bifid needles but the electron microscope studies of Grimm (1986, 1987, 1988) are showing that many of these needles actually have pectinate tips. However, with light microscopes it is often not possible to see the pectinations and the needles therefore appear bifid. For some species both bifid and pectinate needles are illustrated.

Two subgenera as follows;

1. Branchial fossa without palps on posterior edge .....***Dero*** below

2. Branchial fossa with palps on posterior edge .....***Aulophorus*** pg. 114

Species belonging to a third subgenus, *Allodero* Sperber, 1948, which inhabit the ureters of frogs, are known from Asia but have not yet been recorded from Australia. Branchial fossa with gills are generally absent in the commensal forms of these species but have been shown to develop (with palps) in free-living specimens. This has led to the suggestion that *Aulophorus* and *Allodero* cannot be maintained as separate subgenera (Grimm, 1989).

Subgenus *Dero* Oken 1815

Five species

Dero* (*Dero*) *pectinata Aiyer, 1929

Dorsal setae from VI, each bundle with one hispid hair and one pectinate needle with long, strongly divergent lateral teeth. Two pairs of small knob-like gills on ventral wall of fossa.

Electron microscope studies have shown that the presence of lateral hairs (giving the hairs a hispid appearance) may also occur in other species of *Dero* in which the hairs were previously thought to be absent (Smith, 1985, Grimm, 1987). Smith (1985) also revealed seasonal variation in this character. However, under light microscopes the hispid nature of the hairs is particularly apparent in *D. pectinata*.

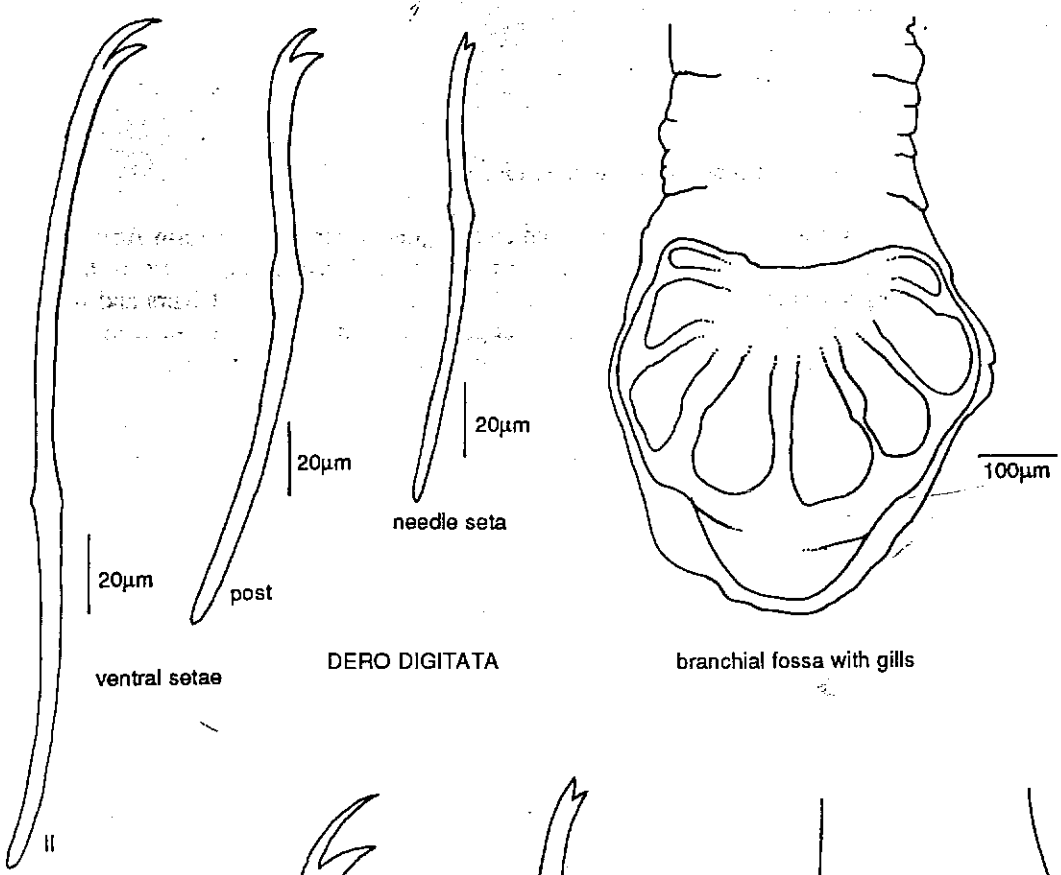
Qld; Specimens resembling this species were found at Rockhampton.
Also India, North America and the Caribbean.

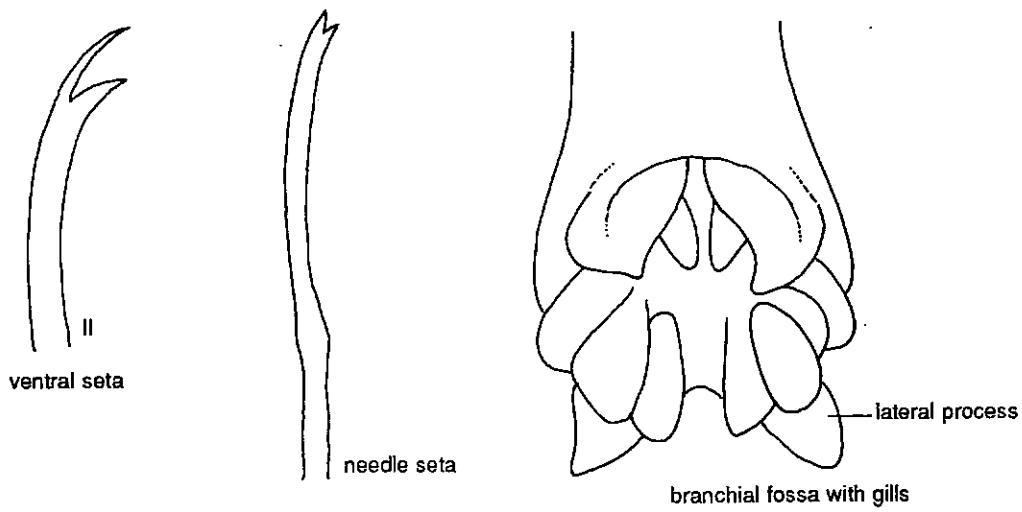
Dero* (*Dero*) *nivea Aiyer, 1929

Dorsal setae from VI, each bundle with one hair and one bifid (or pectinate) needle with short, equal, divergent lateral teeth. Branchial fossa with two or three pairs of short knob-like gills.

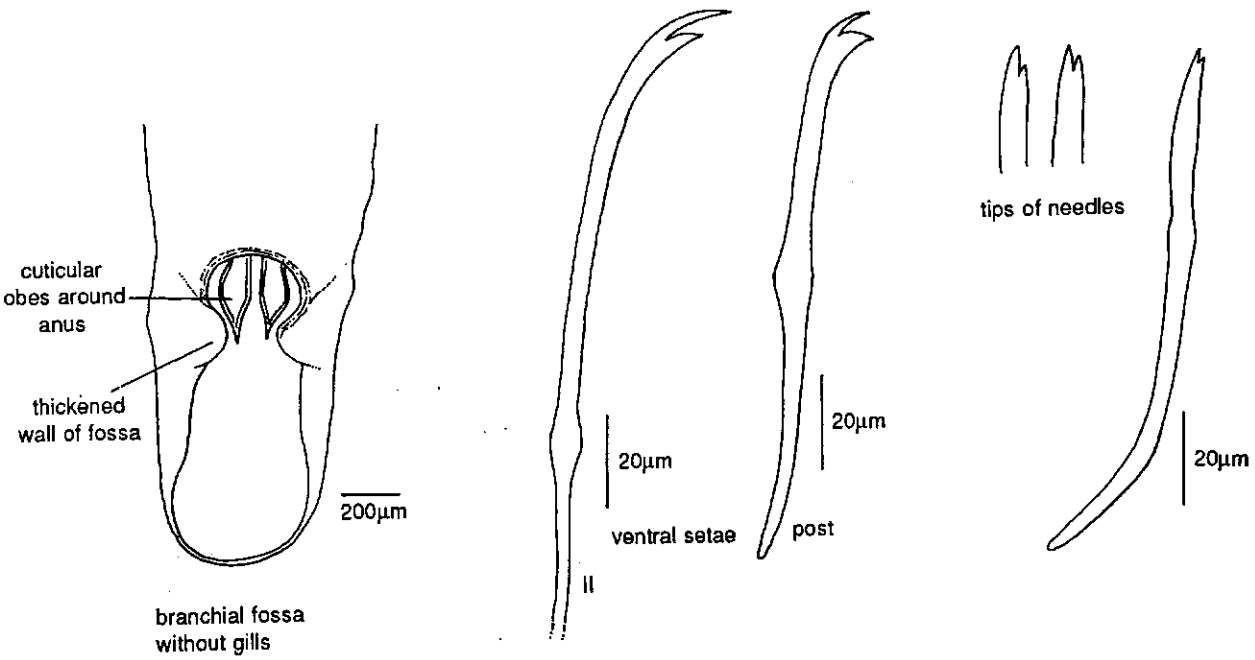
In some descriptions of this species the branchial fossa is stated to be elongated posteriorly to form a shovel like tip but this has also been observed in other species such as *Dero digitata*.

Vic; La Trobe River, Mitta Mitta River and Curdies River. **WA**; Bibra Lake, Lake Thomson, Lake Yonderup and Lake Goollelal (all in the Perth region). **Qld**; Laura River, creek near Tully, Trevethan Creek (Cook Highway), Gregory River, artesian spring near Edgebaston. **NT**; Magela Creek.
Also Asia, Africa and North America.





DERO (DERO) DORSALIS



DERO (DERO) SP. 1

Dero* (*Dero*) *digitata (Muller, 1773)

Dorsal setae from VI, each bundle with one hair and one bifid needle with upper tooth up to twice as long as the lower. Branchial fossa normally with four pairs of gills, sometimes one or more pairs missing or one to three pairs cleft forming supernumerary gills.

Vic; Mitta Mitta River and Curdies River. **WA**; Lake Kogolup, Malaga Wetlands, Lake Gwelup, Lake Carabooda and Mussel Pool. **Qld**; bank of dry Elliot River. **NT**; Magela Creek.
Cosmopolitan.

Dero* (*Dero*) *dorsalis Ferronniere, 1899

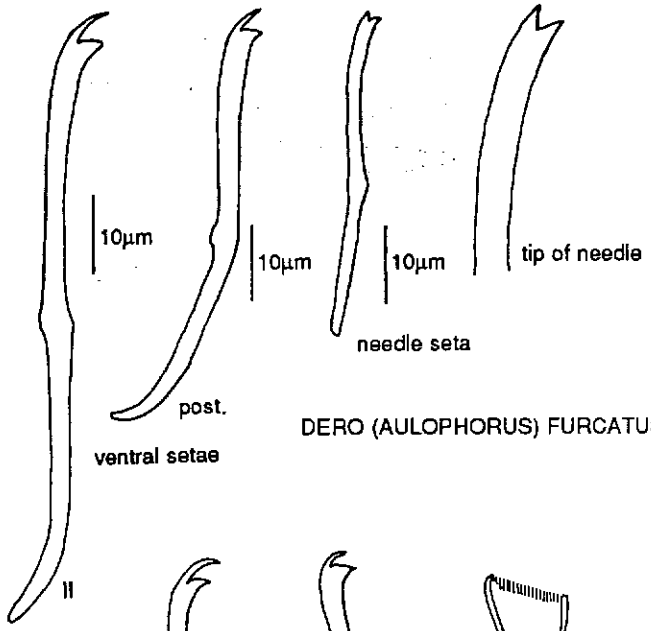
Dorsal setae from IV, each bundle with one hair and one bifid needle with the upper tooth slightly longer than the lower. Branchial fossa with two diverging triangular processes from posterio-lateral border and normally five pairs of gills.

Qld; Cape Hillsborough.
Also Asia and Europe.

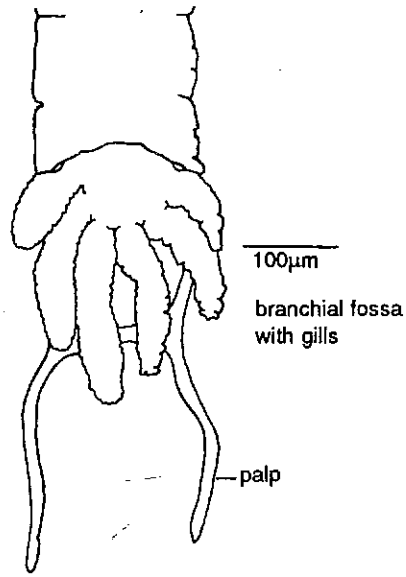
***Dero* (*Dero*) sp. 1**

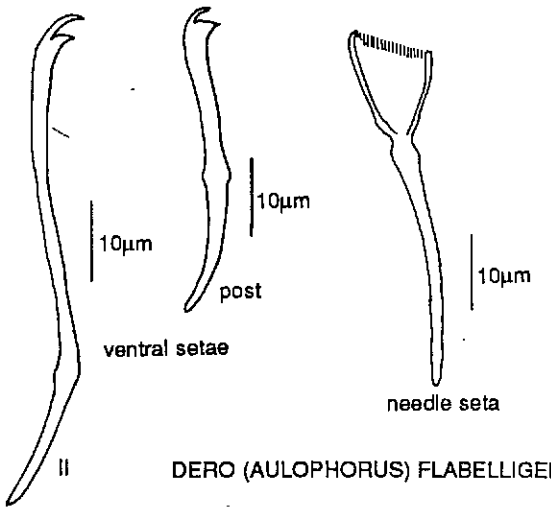
Dorsal setae from VI, each bundle with one hair and one bifid needle with the upper tooth longer than the lower. Branchial fossa elongate, gills apparently absent but with thickened regions on the anterio-lateral wall of the fossa in some preserved specimens. Cuticular lobes surround the anus.

Qld; permanent waterhole on the Leichhardt River and Harris Lake (9km S of Burketown).

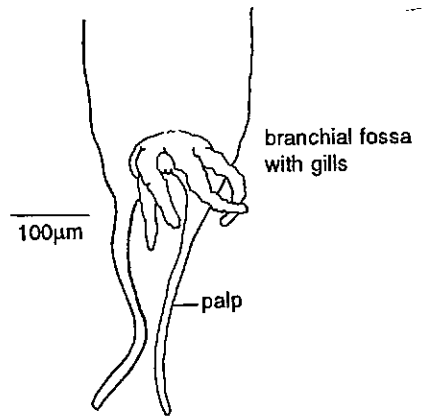


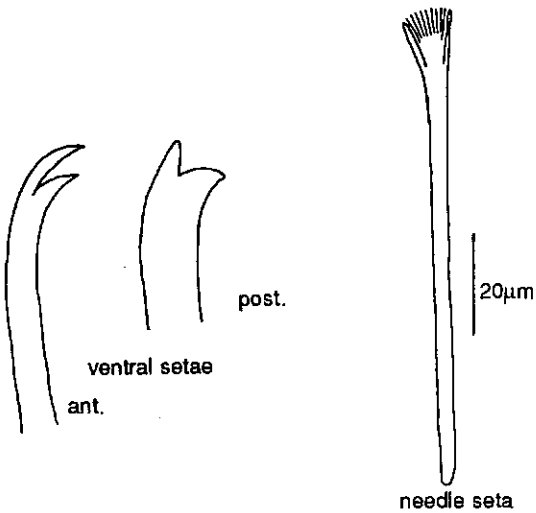
DERO (AULOPHORUS) FURCATUS

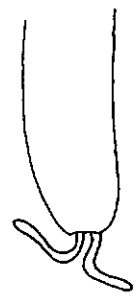




DERO (AULOPHORUS) FLABELLIGER



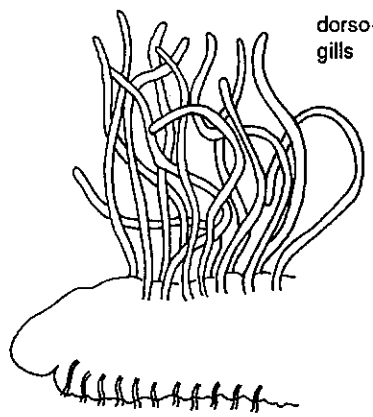




palps arising
from inconspicuous fossa

DERO (AULOPHORUS) VAGUS
(from Brinkhurst and Jamieson, 1971)

ventral seta



BRANCHIODRILUS HORTENSIS

Subgenus *Aulophorus* Schmarda, 1861

Dero* (*Aulophorus*) *furcata (Muller, 1773)

Dorsal setae from V, each bundle with one hair and one bifid needle with upper tooth slightly longer than the upper. Branchial fossa with parallel palps and three to four pairs of elongate gills.

Vic; Branjee Creek (Goulburn Valley) and La Trobe River. **WA**; Yangebup and Thomson Lakes and Malaga Wetlands (all in Perth) and in a horse trough in South Perth fed by a deep bore (*Dero roseola* see below).
Cosmopolitan.

This species includes *Dero roseola* Nicholls, 1921.

Dero* (*Aulophorus*) *flabelliger Stephenson, 1931

Dorsal setae from VI, each bundle with one hair and one broad palmate needle with strongly divergent lateral teeth and obliquely cut web with lines of intermediate teeth not distinct. Branchial fossa with two or three pairs of elongate gills and long parallel palps.

Vic; Mitta Mitta River. **Qld**; Big Spring (41km north of Aramac), Leichhardt River and University of Queensland campus pool and farmers artificial lake.
Also China and Africa.

Dero* (*Aulophorus*) *vagus Leidy, 1880

Dorsal setae from VI, each bundle with one to three hairs and one to three palmate needles with distinct intermediate teeth. Branchial fossa indistinct but containing one or two pairs of small gills and with strongly diverging palps. Length 5 to 10mm.

NT; Several specimens tentatively identified by R. O. Brinkhurst (1984c) from the Leichhardt Billabong (Magela Creek).
Also North America.

Genus ***Branchiodrilus*** Michaelson, 1900

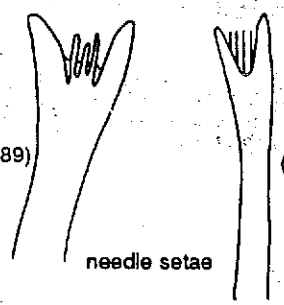
Dorso-lateral gill filaments present along the body from between IV and VII, usually enclosing the dorsal setae. Eyes not present. Dorsal setae from IV or VI, consisting of hairs and simple pointed needles.

One species

Branchiodrilus hortensis (Stephenson, 1910)

Dorso-lateral gills present on nearly all segments from VI on. Dorsal setae from VI, each bundle with two to five hairs and two to five short, thin simple pointed needles. Hairs and needles enclosed within gill filaments anteriorly but usually with one or more hairs projecting freely on posterior segments. Ventral setae three to six per bundle, all bifid setae with the upper teeth thinner and either as long as or longer than the lower. Length: up to 50 mm.

Qld; Rockhampton. **NT**; Georgetown and Nankeen Billabongs (Kakadu National Park) and Magela Creek.
Also Asia and Africa.



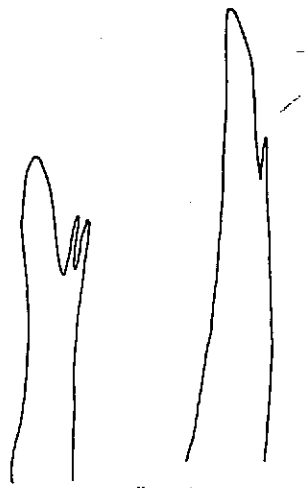
drawn from electron micrograph (Grimm, 1989)

needle setae

drawn from light microscope (Brinkhurst and Jamieson, 1971)

length of needles 42 - 68µm (Sperber, 1948)

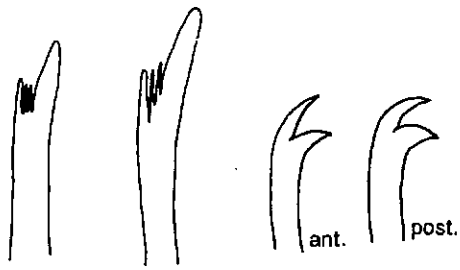
ALLONAIS PECTINATA



needle setae

ALLONAIS PARAGUAYENSIS
(from Brinkhurst and Jamieson, 1971)

length of needles 60 - 192µm (Sperber, 1948)

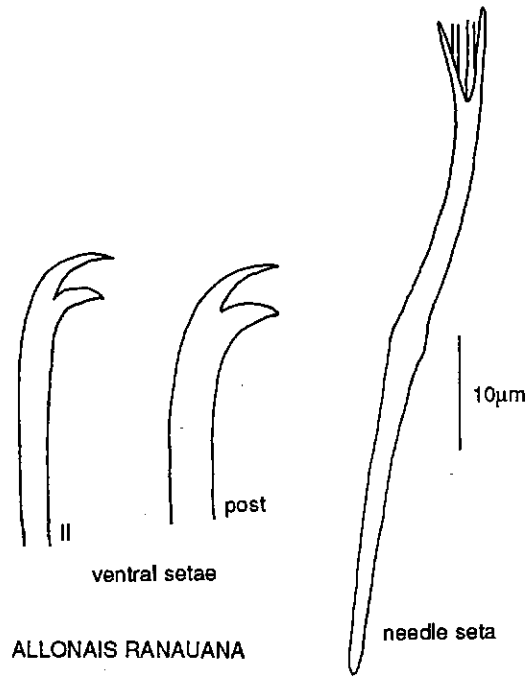


needle setae

ventral setae

ALLONAIS INEQUALIS
(from Brinkhurst and Jamieson, 1971)

length of needles 67 - 112µm (Sperber, 1948)



ventral setae

needle seta

ALLONAIS RANAUANA

Genus *Allonais* Sperber, 1948

Dorsal setae from V, VI or VII, consisting of hairs and bifid or pectinate needles, usually with unequal lateral teeth. Eyes not present.

Four species

Allonais pectinata (Stephenson, 1910)

Dorsal bundles from VI, each bundle with one or two hairs and one or two pectinate needles. The needles with short lateral teeth which are either equal in length or the upper longer and with one to five intermediate teeth. Ventral setae three to five per bundle in II to V, with upper teeth slightly longer than the lower, from VI onwards with two to seven per bundle with teeth equal.

Qld: Creek near Tully (Cape York), Trevethan Creek (Cook Highway, Cape York Peninsula).
Also Asia and Africa.

Allonais paraguayensis (Michaelson, 1905)

Dorsal setae from VI, each bundle with one or two hairs and one or two needles. The needles either simple pointed or with rudimentary upper teeth which may be replicated. Ventral setae two to six per bundle, the upper teeth slightly longer than the lower anteriorly and slightly shorter than the lower posteriorly.

Qld; foot of Mount Etna. **NT**; Magela Creek and Corndorl billabong.
Also Asia, Africa and North and South America.

Allonais inaequalis (Stephenson, 1911)

Dorsal setae from VI, each bundle with one or two hairs and one or two pectinate needles with short lateral teeth, the upper teeth usually shorter than the lower and with one to four intermediate teeth. Ventral setae four to eight per bundle, the upper teeth slightly longer than the lower in II to V and teeth equal or the upper slightly shorter from VI.

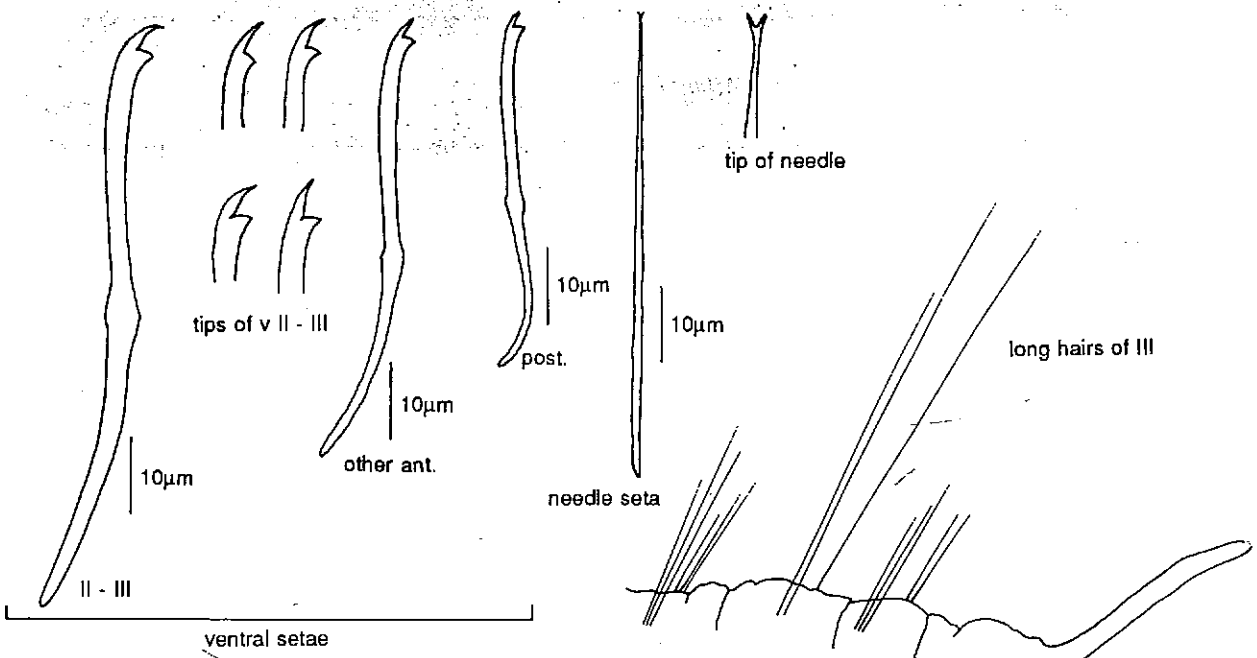
Qld; Laura River (50 miles south of Cooktown, Cape York), creek near Tully (30 miles from Innisfail, Cape York), Trevethan Creek (Cook Highway, Cape York) and University Lake (Brisbane).
NT; Billabongs associated with Magela Creek.
Also Asia, Africa and South America.

Allonais ranauana (Michaelsen and Boldt, 1932)

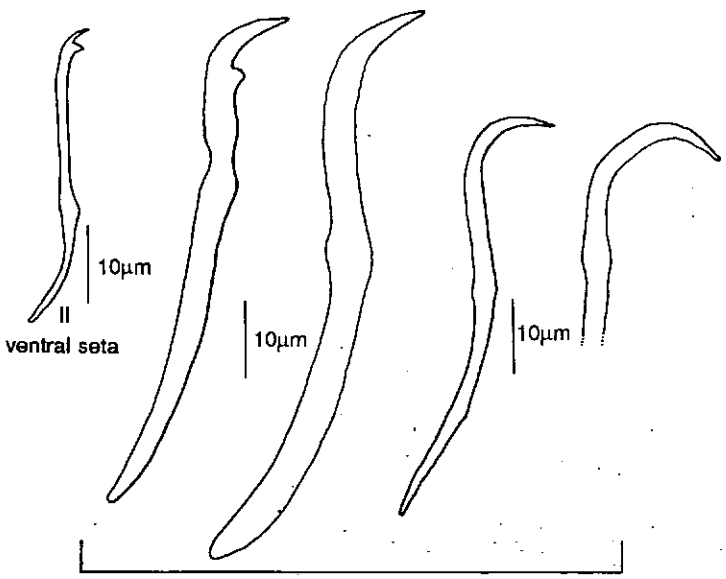
Dorsal setae from VI, each bundle with one or two hairs and one or two pectinate needles with long lateral teeth, the teeth almost equal or the upper teeth slightly shorter than the lower and with several long intermediate teeth. Ventral setae two to five per bundle anteriorly with the upper teeth somewhat longer and thinner than the lower, up to eight per bundle posteriorly with teeth more equal in length but with the lower teeth thicker than those of anterior setae.

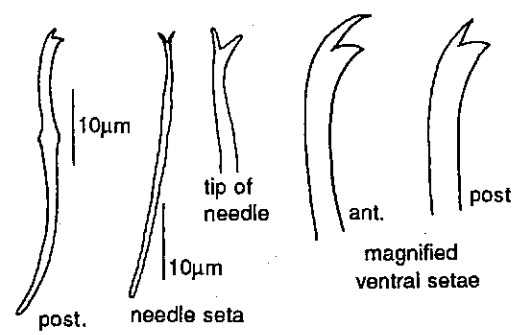
SA; north-west branch of Coopers Creek (east of Lake Eyre).
Also Africa and Asia.

This species was named *A. pectinata* var. *ranauana* by Michaelsen and Boldt (1932) but Sperber (1948) referred them to *A. inequalis* because the relative lengths of the teeth was closer to this species than *A. pectinata*. Grimm (1989) elevated this to the rank of an independent species because the differences between this form and the other species was of the same order of magnitude as the differences between the already recognized species.

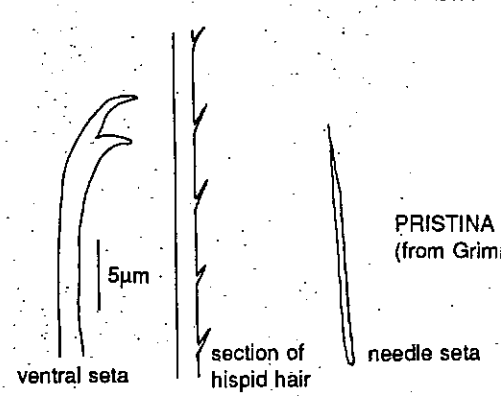


PRISTINA LONGISETA





PRISTINA AEQUISETA



PRISTINA PROBOSCIDEA
(from Grimm, 1974 and Brinkhurst and Jamieson, 1971)

Genus *Pristina* Ehrenberg, 1828

Proboscis present on prostomium. Eyes not present. Dorsal setae from II, consisting of hairs and small bifid or simple pointed needles.

Three species

Pristina longiseta Ehrenberg, 1828

Dorsal setae one to four hairs and two to five needles per bundle. Hairs of III non-hispid and obviously longer than the rest (unless broken), those of other segments shorter and hispid. Needle setae fine, straight and either simple pointed or minutely bifid. Ventral setae of II and III usually longer and often thicker than the rest with upper teeth two to three times longer than the lower. Setae from IV with upper teeth less than twice the length of the lower. Ventral bundles without enlarged setae.

Vic; at the confluence of the Thomson and Macalister Rivers. **WA**; Thomson, Yangebup and Joondalup Lakes and Gibbs-Bartram Road Swamp (all near Perth). **Qld**; Rockhampton, Elliot River (at Townsville Road), creek near Tully, Trevethan Creek (Cook Highway, Cape York), and Big Spring (3km SE of Edgebaston) and an artesian spring (4km N of Edgebaston).
Also Asia, Africa, Europe and ?North America.

Specimens with bifid setae have been variously referred to as a separate species, *Pristina leidyi* (Smith, 1896, Harman and MacMahan, 1975 and Harman, 1982), as a subspecies, *P. longiseta leidyi* (Sperber, 1948 and Hiltunen and Klemm, 1980) or, more recently just as forms of *P. longiseta* by Rodriguez (1987) who found both simple pointed and bifid specimens in the same localities and even in the same samples. In this publication they are included in *P. longiseta*.

Pristina proboscidea Beddard, 1896

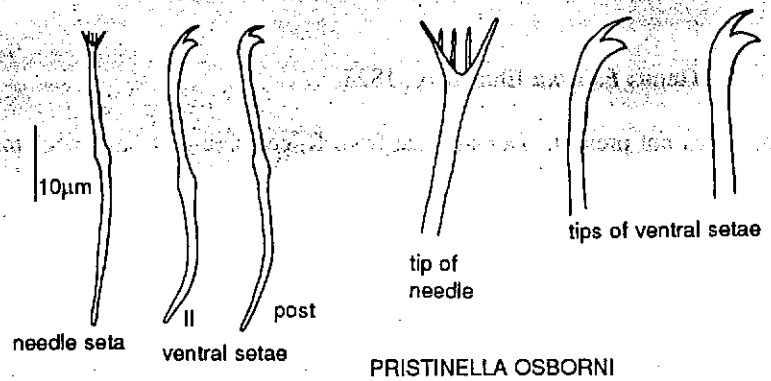
Dorsal setae one to four hairs per bundle and one to four straight, fine, simple pointed needles per bundle. Dorsal hairs of III not obviously longer than the rest. Ventral setae two to four per bundle anteriorly, up to nine per bundle posteriorly, all with upper teeth longer than the lower, setae of II longer and thicker than the rest. Ventral bundles without enlarged setae.

Qld; Myrtle Creek (Prosperine). **NT**; Magela Creek and Bowerbird Billabong.
Also Africa, South America and Asia.

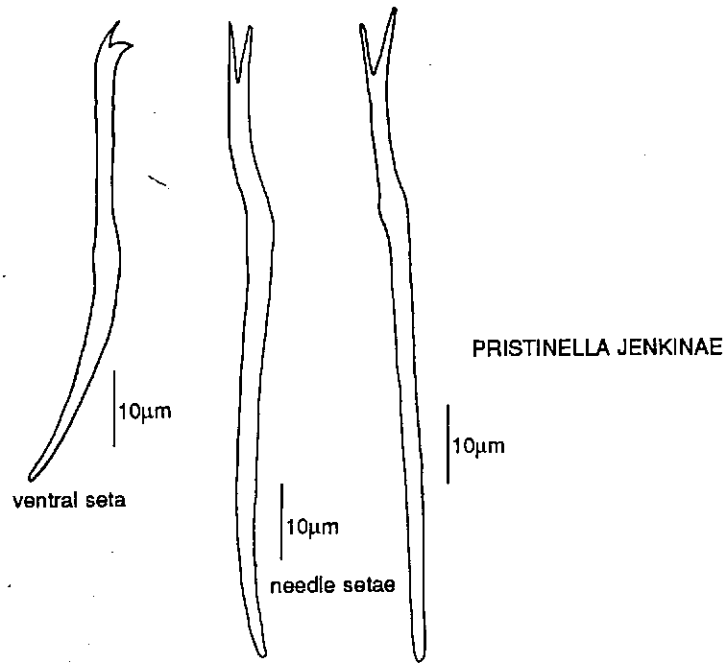
Pristina aequiseta Bourne, 1891

Dorsal setae one or two finely hispid hairs and one or two finely bifid needles with short divergent teeth. Dorsal hair setae of III not significantly longer than the rest. Ventral setae five to eight per bundle in most segments. Those of II longer and thinner than the rest, with upper teeth twice as long as the lower; those of III to VII shorter and slightly thicker than those more posterior, with upper teeth slightly longer than the lower. In addition, there are usually some enlarged setae in IV, V, or VI, with upper teeth more than twice as long as the lower, or the lower missing.

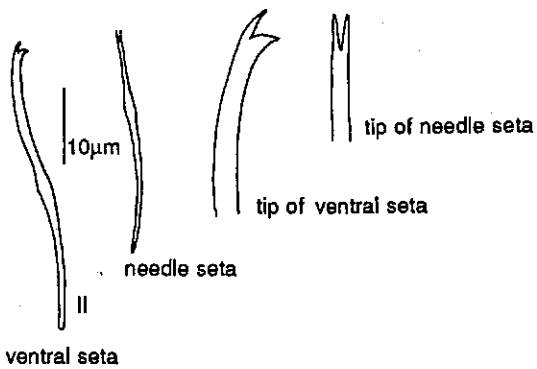
Vic; La Trobe River, Thomson River and Mitta Mitta River. **WA**; Piney Lakes, Lake Yonderup Lake Goolellal and Bartram Swamp (all in the Perth region). **Qld**; Creek near Tully, Trevethan Creek (Cook Highway, Cape York) and Elliot River (on Townsville Road).
Also Asia, India, Africa, Europe, North and South America.



PRISTINELLA OSBORNI



PRISTINELLA JENKINAE



PRISTINELLA BILOBATA

Genus *Pristinella* Brinkhurst, 1985

Prostomium without proboscis. Eyes not present. Dorsal setae from II, consisting of hairs and bifid or pectinate needles.

This genus was erected for former species of *Pristina* without a proboscis (Brinkhurst, 1985b).

Three species

Pristinella osborni (Walton, 1906)

Dorsal setae one hair and one bifid or pectinate needle per bundle. Needles with strongly divergent, equal lateral teeth. Ventral setae three to five per bundle anteriorly, two or three posteriorly. Those of II finer than the rest with upper teeth longer than the lower, teeth becoming equally long after II.

Vic; Thomson River, Acheron River and Mitta Mitta River.
Also India, Africa and North and South America.

Pristinella jenkinae (Stephenson, 1931)

Dorsal setae one or two hairs and one or two bifid needles per bundle. Needles with long parallel or slightly divergent teeth, the lower slightly longer than the upper. Ventral setae three to seven per bundle with teeth approximately equal in length.

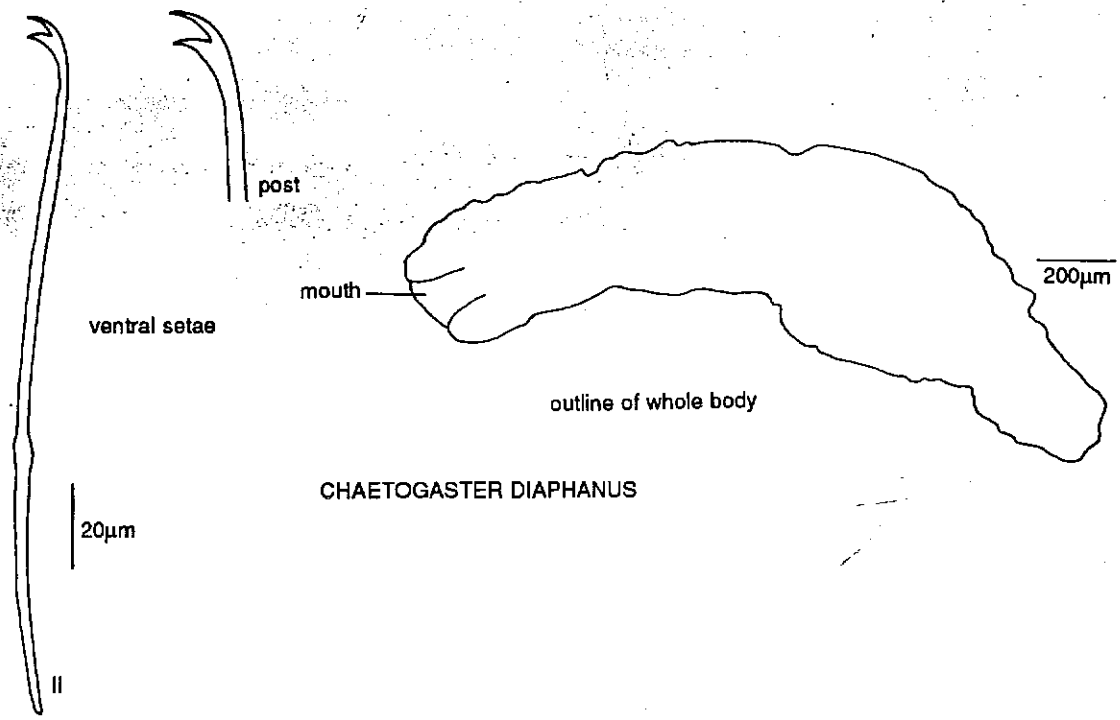
Vic; Thomson River, Curdies River and La Trobe River. **WA**; Kogolup Lake North.
Also New Zealand, Asia, Africa, South America and Europe.

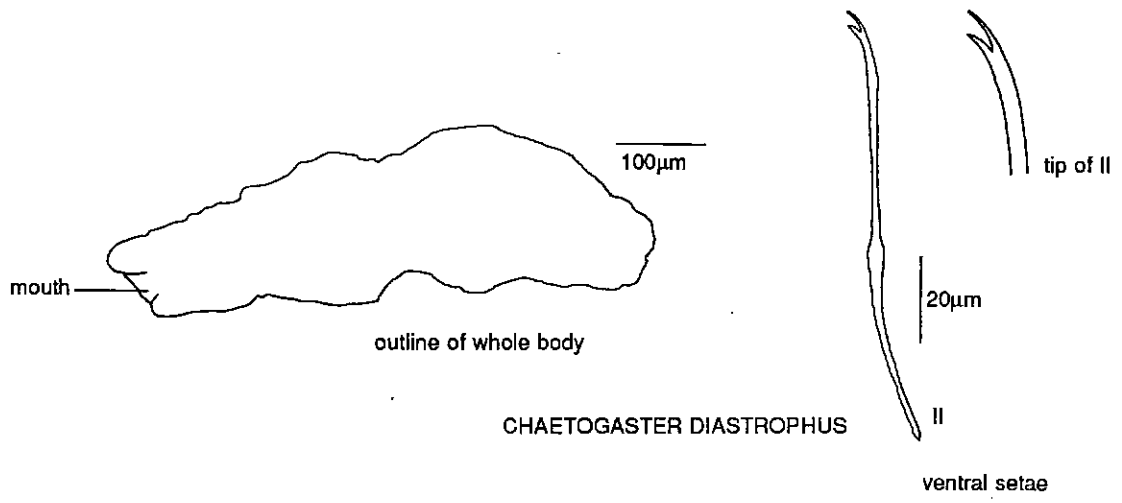
Pristina idrensis Sperber, 1948, listed in Brinkhurst (1971) was found to be synonymous with *P. jenkinae* by Kathman (1985).

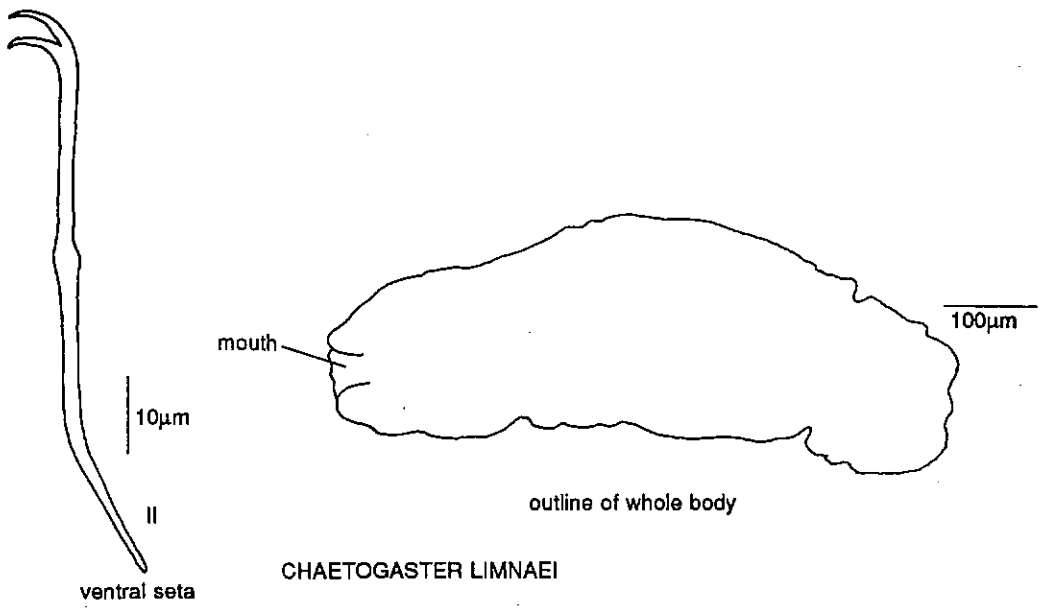
Pristinella bilobata (Bretscher, 1903)

Dorsal setae one or two hispid hairs and one or two bifid needles per bundle, the needles with short parallel or slightly divergent teeth of equal length. Ventral setae three to eight bifid setae per bundle, all with teeth equally long. Length about 4mm.

Vic; La Trobe River.
Also Africa, Middle East and Europe.


post
ventral setae
mouth
200µm
outline of whole body
CHAETOGASTER DIAPHANUS
20µm
II


100µm
mouth
outline of whole body
tip of II
20µm
CHAETOGASTER DIASTROPHUS
II
ventral setae


mouth
100µm
10µm
outline of whole body
II
CHAETOGASTER LIMNAEI
ventral seta

Genus *Chaetogaster* von Baer, 1827

Prostomium weakly developed. Eyes not present. Segment III elongate. Large obvious pharynx in I to III. Ventral setae bifid with long teeth, present in II but absent in III to V. Dorsal setae usually absent but setae reported in some specimens of *C. diaphanus* in North America. Predatory or commensal, prey such as other worms or small insect larvae can often be observed in the gut. If the prey is another worm, then care must be taken not to confuse the setae of the prey with the *Chaetogaster* setae in cleared specimens.

Three species

Chaetogaster diaphanus (Gruithuisen, 1828)

Ventral setae six to 13 per bundle in II, four to 10 from VI onwards. Setae of II more than 140µm long, up to 350µm. Length 2 to 25mm.

Vic; Thomson River, Curdies River and Mitta Mitta River.
Also Asia, Europe and North America.

Chaetogaster diastrophus (Gruithuisen, 1828)

Ventral setae four to eight per bundle in II and three to seven from VI onwards. Setae of II 70 to 110 µm long. Penial setae?? Length 1 to 5mm.

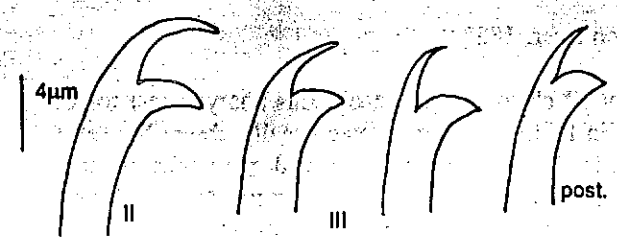
Vic; La Trobe River.
Also Asia, India, Afghanistan, Europe, North and South America.

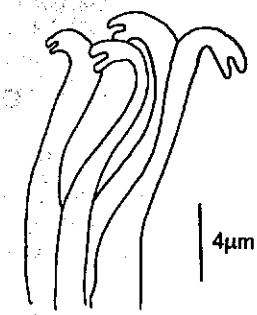
Chaetogaster limnaei von Baer, 1827

Ventral setae bifid, five to 20 per bundle in II, four to 20 per bundle from VI onwards, all setae strongly hooked distally with long curved teeth. Length 1 to 2.5mm. Ecto- or endocommensal or endoparasitic on pulmonate gastropods.

Vic; Mitta Mitta River.
Also Asia, Europe and North America.

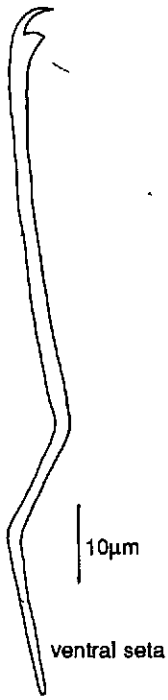
This species includes *Chaetogaster australis* and *Chaetogaster victoriensis* of Davies (1913). No localities were provided with the descriptions of these.





penial setae

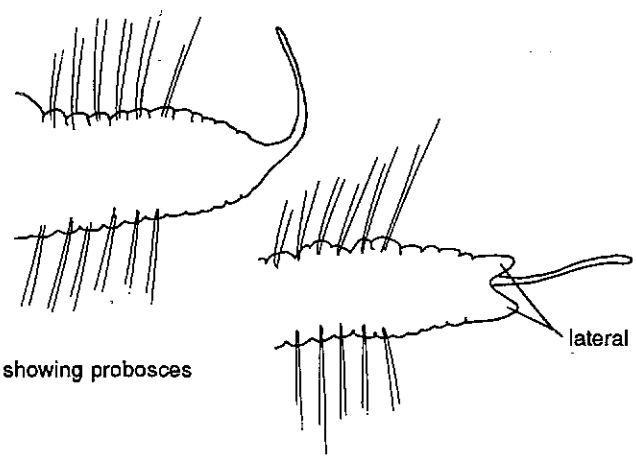
PARANAIS LITORALIS



ventral seta

needle setae and hair

STYLARIA LACUSTRIS



dorsal views showing probosces

Genus *Paranais* Czerniavsky, 1880

Prostomium without proboscis. Eyes not present. Dorsal setae from V. Ventral and dorsal setae of the same form, usually bifid.

One species

Paranais litoralis (Muller, 1784)

All setae bifid. Dorsal setae two to four per bundle from V with teeth equal in length. Ventral setae of II four to seven per bundle with upper teeth distinctly longer than the lower, two to four per bundle from III, with upper teeth varying from slightly longer than to slightly shorter than the lower. Length 2 to 14 mm. Inhabits saline or brackish water.

Vic; Port Phillip Bay and the Gippsland Lakes. **Qld**; Fraser Island.
Also Asia, Africa, Europe and North America.

Genus *Stylaria* Lamarck, 1816

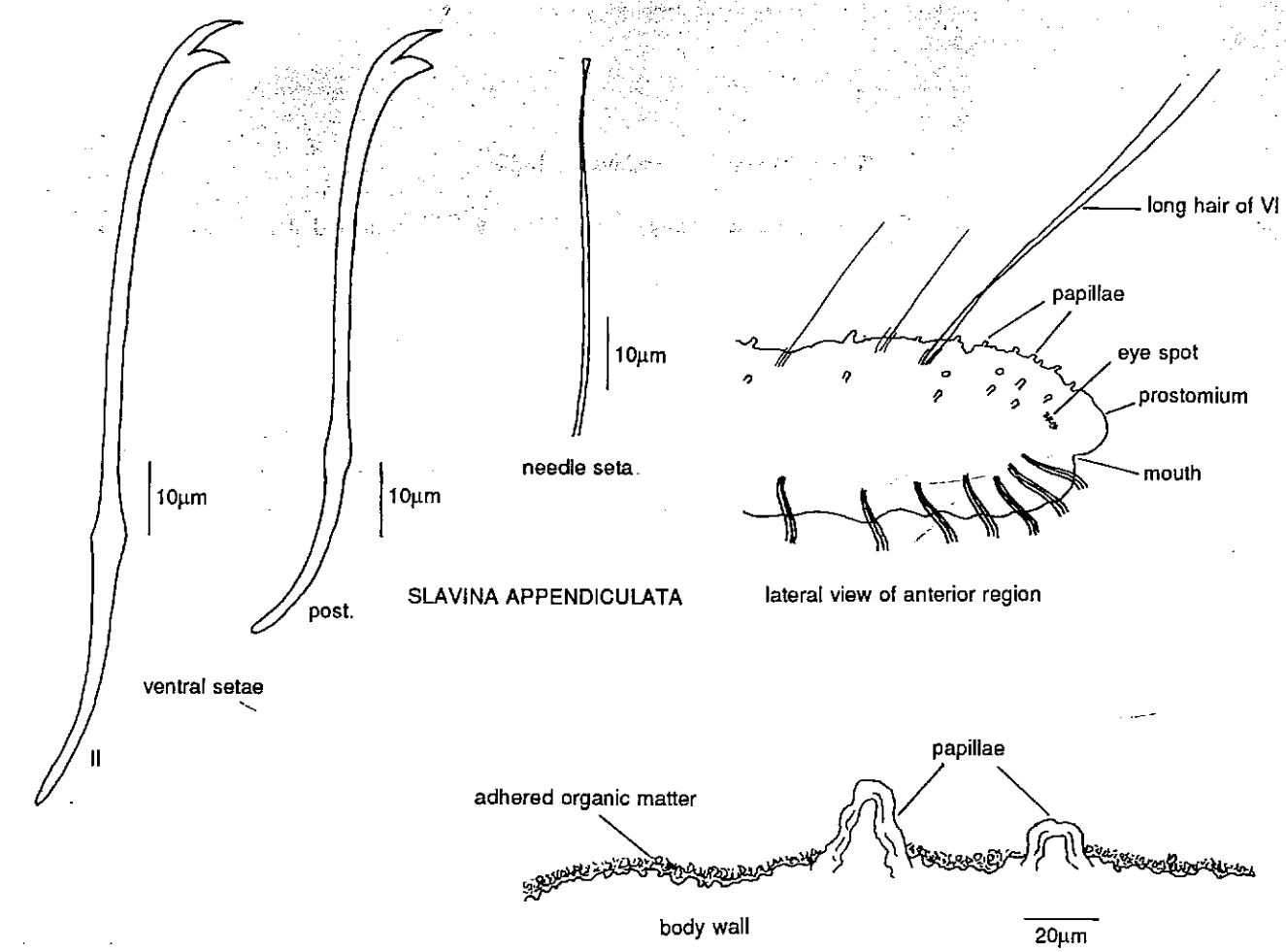
Proboscis arising either from the tip of a rounded prostomium or from an invagination on the prostomium. Eyes may be present. Dorsal setae from VI, consisting of hairs and simple pointed needles.

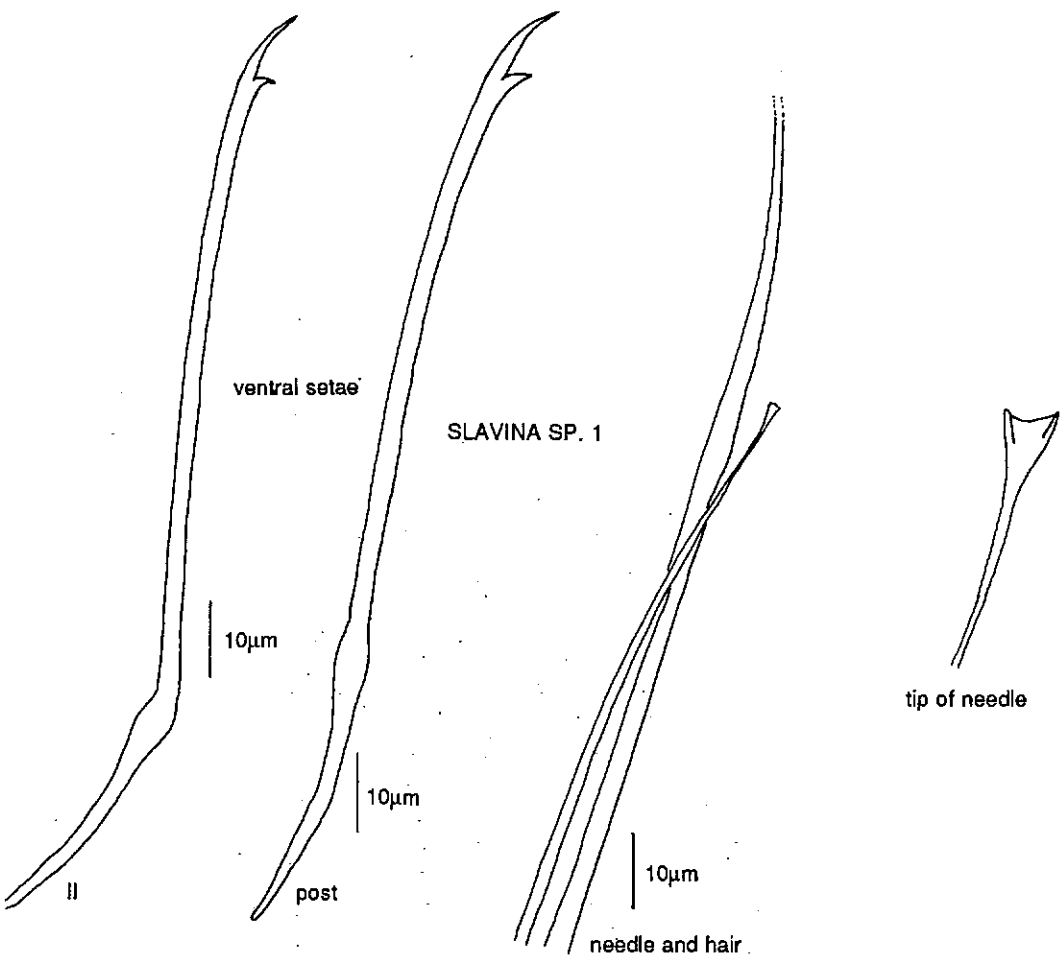
One species

Stylaria lacustris (Linnaeus, 1767)

Proboscis either projecting from between two lobes or from pointed tip of the prostomium. Eyes normally present. Each dorsal bundle with one or two hairs and one to three very short simple pointed needles. Ventral setae five to 14 per bundle with upper teeth longer than lower. Found in fresh or brackish water.

Vic: La Trobe River and Lake Purrumbete.
Also Asia, India, Middle East, Europe and North America.


10µm
10µm
10µm
needle seta
long hair of VI
papillae
eye spot
prostomium
mouth
post.
ventral setae
II
SLAVINA APPENDICULATA
lateral view of anterior region
papillae
adhered organic matter
body wall
20µm


ventral setae
10µm
10µm
II
post
SLAVINA SP. 1
10µm
needle and hair
tip of needle

Genus *Slavina* Vejdovsky, 1883

Body wall usually surrounded by adhered foreign matter and provided with rows of sensory papillae. Eyes usually present. Dorsal setae from IV to VI, consisting of hairs and very fine needles.

Two species

Slavina appendiculata d'Udekem, 1855

Dorsal setae from VI, each bundle with one or two hairs and one or two fine, short needles with narrow hair-like distal ends terminating in a slightly distended tip. Up to three much longer hairs in VI. Ventral setae two to five per bundle with upper teeth thinner and slightly longer than the lower. Those of II slightly longer than the rest and those of II to V thinner than the rest. Eyes present. Body wall papillate and glandular, with adhered foreign matter.

Vic: La Trobe River.
Cosmopolitan.

***Slavina* sp. 1**

Dorsal setae from V, each bundle with one to three hairs and one to three fine, short needles with hair-like distal ends terminating in very small bifid or palmate tips. Hairs of VI not especially elongate. Ventral setae two to four anteriorly and one or two posteriorly, all with upper teeth about twice the length of the lower. No significant change in length or width of the ventral setae along the body. Eyes not present. Body wall papillate and glandular, with adhered foreign matter.

Vic: La Trobe River and Acheron River.

10. LUMBRICULIDAE

Only two species of this essentially holarctic family have been recorded in the southern hemisphere. The cosmopolitan *Lumbriculus variegatus* was first recorded in Australia and New Zealand by Brinkhurst (1971) and *Stylodrilus heringianus* was noted in New Zealand by Marshall (1978) and tentatively in Tasmania by Fulton (1983). The latter species is otherwise known from Europe, North America and west Asia as are other *Stylodrilus* species, including some that are endemic to Lake Baikal. Both of these worms may be recent introductions to the southern hemisphere. *L. variegatus* commonly reproduces asexually by fragmentation and has been used as live food for fish aquaculture in Australia and elsewhere, factors which may have aided its spread around the globe.

Family diagnosis

Ventral and dorsal setae paired from II, sigmoid and either simple pointed, or bifid with small upper teeth. Prostomium may bear a proboscis. Eyes absent. Often with distinctive blind ending lateral blood vessels in posterior segments. Testes one to four pairs, variable in position. Atria one to four pairs, located between VII and XV (usually between IX and XI), paired or un-paired, always in a testes bearing segment, each associated with one or two pairs of testes. Commonly two pairs of testes in adjacent segments, both with funnels and vasa deferentia feeding a single pair of atria in the same segment as the posterior pair of testes. Sometimes with the anterior testes and ducts absent, leaving a single pair of atria, testes and vasa deferentia within one segment and then often with this arrangement serially replicated. Ovaries one or two pairs beginning one, or rarely two, segments behind the most posterior testes bearing segment. Spermathecae variable in number and either anterior or posterior to testes bearing segments.

Identification of the Lumbriculidae

The genital system provides the most important characters for identifying the majority of lumbriculids and microtome sections are often required to resolve these characters. Fortunately such procedures are not required to distinguish the two species described here, although mature specimens are helpful.

Species descriptions

Genus ***Lumbriculus*** Grube, 1844

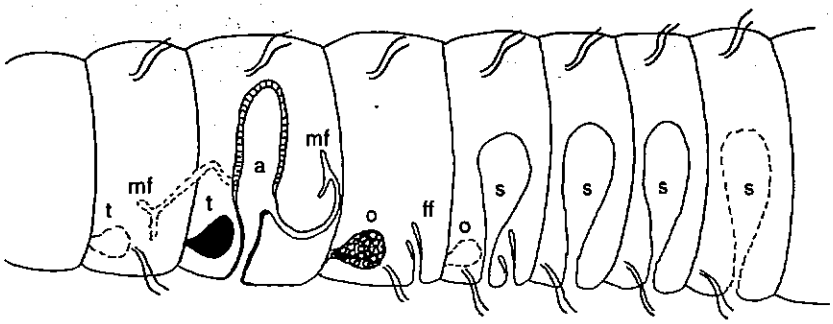
One to four pairs of atria and male pores between VII to XIII. Up to four pairs of testes with one or two pairs associated with each atria. One or two pairs of ovaries in segments after last pair of testes. Number of spermathecae variable but usually two to five beginning two segments behind last atrial segment.

One species

Lumbriculus variegatus (Muller, 1774)

Elongate slender worms (up to 100mm or more in length), the front end often green in life, the rest dark red to black (body usually remains darkly pigmented even when fixed). Prostomium conical. Anterior segments not secondarily divided. Setae all bifid with rudimentary upper teeth. Elaborately branched lateral blood vessels in body wall of posterior segments. Usually one pair of cylindrical atria associated with one or two pairs of testes between VII and XII, male pores in atrial segment. Penes retractable. Usually one or two pairs of ovaries, beginning in post-atrial segment. Usually four pairs of spherical to ovoid spermathecae beginning two, or rarely one, segment after atrial segment. Mature worms scarce, usually reproduces asexually by fragmentation. Swims with spiral undulations.

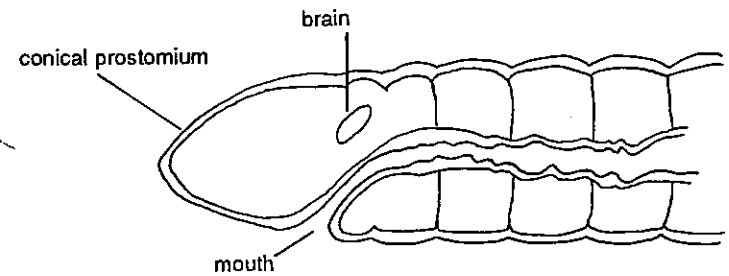
Tas; Lake St. Clair, South Esk River, Nive River, tributary of Rubicon River. **Vic**; Rainbow Creek, Mitta Mitta River, La Trobe River, Branjee Creek, Coolart Estate Swamps (Melbourne University). **NSW**; Bantry Bay Reservoir, Sydney. **Qld**; Farmers Creek (University of Queensland).



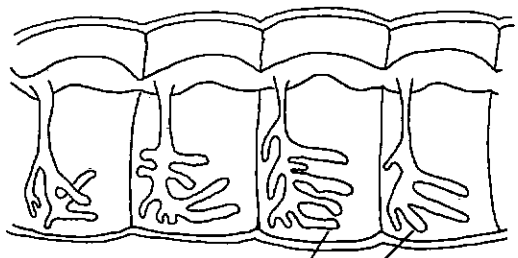
o ovary
t testes
mf male funnel
ff female funnel
s spermatheca
a atrium
p penis

additional organs dotted

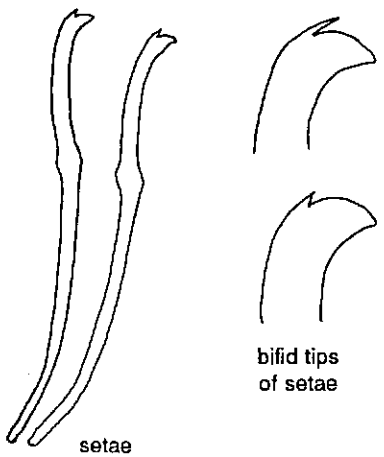
genital anatomy



anterior segments



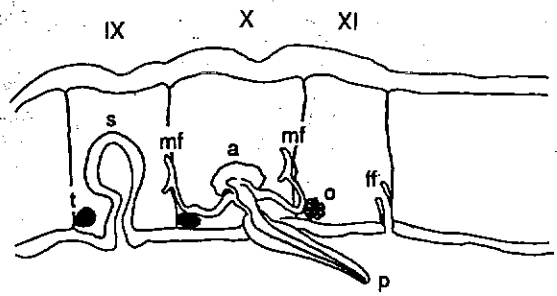
branching lateral blood vessels of the posterior region



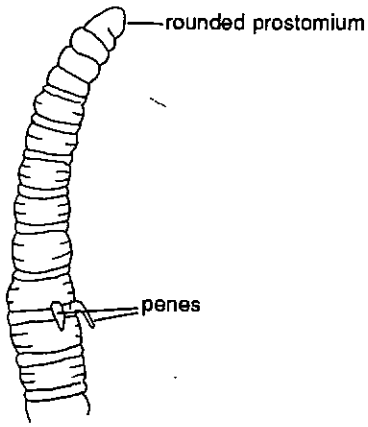
bifid tips of setae

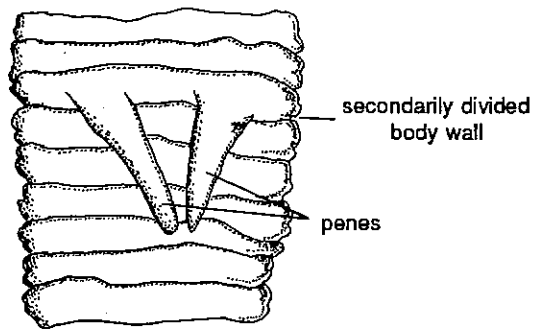
LUMBRICULUS VARIEGATUS

o ovary
t testes
mf male funnel
ff female funnel
s spermatheca
a atrium
p penis

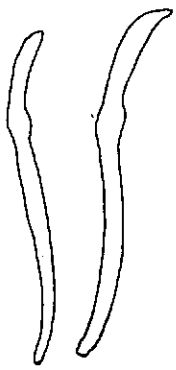


genital anatomy

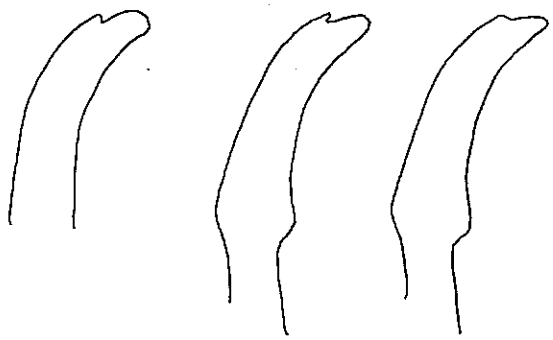




ventral view of penes



setae



tips of setae with rudimentary upper teeth

STYLODRILUS HERINGIANUS

Genus *Stylodrilus* Claparede, 1862

One pair of atria in X, associated with two pairs of testes (in IX and X). One pair of ovaries in XI. One pair of spermathecae in IX.

One species

Stylodrilus heringianus Claparede, 1862

Short tapering worms (up to 40mm), live specimens pale to white in colour. Prostomium rounded. Anterior segments secondarily divided. Setae bifid with rudimentary upper teeth, or with upper teeth absent. Lateral blood vessels of body wall short and not branched in posterior segments. One pair of pear shaped atria in X associated with testes in IX and X. Long non-retractable penes formed from deep fold in body wall of X project posteriorly along the ventral body wall. Single pair of spermathecae located in IX. Reproduction primarily sexual. Coils body when stimulated.

Tas; tentative record from Lake Sorell
Also from New Zealand, otherwise holarctic.

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