A Guide to Identification of Rotifers, Cladocerans and Copepods from Australian Inland Waters: Identification Guide Series No. 3

Book · January 1995

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A GUIDE TO IDENTIFICATION OF ROTIFERS, CLADOCERANS AND COPEPODS FROM AUSTRALIAN INLAND WATERS

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Identification Guide No. 3

Presented at the Taxonomy Workshop held at
The Murray-Darling Freshwater Research Centre, Albury
8-10 February 1995.

First published 1995 by Co-operative Research Centre for Freshwater Ecology, Murray-Darling Freshwater Research Centre, Ellis Street, Thurgoona, P.O. Box 921, Albury, NSW 2640

National Library of Australia Cataloguing-in-Publication.

Shiel, Russell J. (Russell John), 1945-
A guide to identification of rotifers, cladocerans and copepods from Australian inland waters.

Bibliography.
Includes index.
ISSN 1321-280X
ISBN 0 646 224107

1. Rotifera - Australia - Identification.
2. Cladocera - Australia - Identification.
3. Copepoda - Australia - Identification.
4. Freshwater Invertebrates - Australia - Identification.
I. Co-operative Research Centre for Freshwater Ecology.
II. Title. (Series: Identification guide (Co-operative Research Centre for Freshwater Ecology); no. 3).

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PREFACE

This guide was produced for the seventh taxonomic workshop held at the Murray-Darling Freshwater Research Centre, Albury, N.S.W., between February 8-10, 1995. It summarizes published and unpublished work on rotifers, cladoceran and copepod microcrustaceans from Australasian inland waters. Full citations are provided to the published literature, which should be referred to for more detail on the relevant groups than is possible, or even desirable, in a guide of this nature. This guide is aimed at non-specialist use, whereby an interested non-taxonomist wishing to identify aquatic microfauna can reach the best current level of discrimination - if possible to genus or species. A glossary is included for specialized terms which are unavoidable.

Support for projects from which this guide has been compiled came from the Australian Biological Resources Study (Rotifera and Anomopoda: Chydoridae), the Frey Bequest (Indiana University) (thanks to the late David G. Frey and subsequently Libby Frey) and the Murray-Darling Freshwater Research Centre (thanks to David Mitchell and Terry Hillman, respective Directors). Material referred to or figured here was collected by many people throughout Australia and New Zealand, without whose efforts the guide could not have been compiled. They include Carolyn Burns (Univ. of Otago., N.Z.), David Cartwright (Werribee Treatment Complex), Roger Croome (La Trobe University), Ian Duggan (Univ. of Waikato, N.Z.), Larelle Fabbro (Univ. of Central Qld), Peter Gehrke (then of IFRS, Narrandera), John Green (Univ. of Waikato, N.Z.), Stuart Halse (CALM, Wanneroo), Brett Ingram (Snobs Creek Fish Hatchery, Alexandra), Yoshi Kobayashi (EnSight, North Ryde), Phil Parr (Levin, N.Z.), Lor-Wai Tan (MDFRC), Brian Timms (then of Avondale College, Cooranbong), Simon Townsend (NTP&WA, Darwin), Peter Tyler (then of Univ. of Tasmania), Robert Walsh (Univ. of Tasmania), Garth Watson (MDFRC); Bill Williams (Univ. of Adelaide) and many other collectors acknowledged in the various rotifer papers cited in the reference list.

Thanks also to: Ian Bayly (Monash University] for a section on calanoid copepods; ; Jackie Dickson [MDFRC] for her efforts on draft keys to the chydorid cladocerans; Janet Jackson [Royal Society of Victoria], who, at short notice, kindly found and faxed parts of an early rotifer reference.

This manual would not have been possible without the continued support of Walter Koste, Quakenbrück, Germany, whose encyclopaedic knowledge of the Rotifera has been freely given during almost 20 years of collaboration. Herzlichen Dank, 'Onkel' Walter!

CONTENTS

1. INTRODUCTION

The animal component of the microbiota of lakes and ponds generally consists of two broad assemblages - that of open water is termed *zooplankton* (from Gk zoo=animal, planktos=floating), and that of the fringing or submerged vegetation, termed *littoral microfauna*. Both communities include a complex assemblage of bacteria, protozoans, rotifers, microcrustacea and juveniles of various macroinvertebrates. Microfauna may be subdivided into categories by both size and habitat type, e.g. zooplankton size categories are: *pico*plankton (0.2-2.0 µm, mostly bacteria), *nano*plankton (2-20 µm mostly protozoa), *micro*plankton (20-200 µm, protozoa, rotifers, juveniles of microcrustacea) and *macro*plankton (>200 µm, larger protozoa, some rotifers and most microcrustacea). The habitat categories are: *limno*plankton (that of lakes and deep reservoirs), *heleo*plankton (the assemblage found in smaller ponds) and *potamo*plankton (the community specific to flowing waters, particularly lowland rivers such as the R. Murray). The species composition of each of these assemblages differs in response to habitat characteristics. Potamoplankton generally has fewer species and lower population densities than limnoplankton, and heleoplankton generally has more species and higher population densities than limnoplankton. Heleoplankton tends to differ geographically in response to local geographic differences in, for example, water chemistry. Limnoplankton (in the Murray-Darling Basin, for instance) tends to be more similar in composition in response to the broadly similar habitats provided by the reservoirs on the Murray-Darling tributaries. As for the heleoplankton, if there are geographic divides or marked chemical differences between even closely situated lakes, e.g. on and off the Central Plateau in Tasmania, marked disparities in species composition of the respective limnoplankton communities may be evident.

Distinct from the zooplankton community are the microfauna inhabiting macrophyte stands, whether attached to stems, leaves/fronds, sessile on other animal inhabitants, mobile over surfaces, or free-swimming. Littoral microfaunal. assemblages occasionally have some taxa common to the zooplankton, particularly in billabongs, where fluctuations in water level are the rule, however different species are to be expected in the two broad habitats. The same size categories apply as noted above for planktonic communities, however very little published work exists on the ecology of littoral microfauna, and there has not been the same proliferation of terms to distinguish components or subsets of it.

For MDFRC's 7th taxonomic workshop, this guide deals only with rotifers and cladoceran and copepod microcrustacea. Although patchily studied, these groups are better known than the bacterial and protist communities of our inland waters, which remain virtually ignored. Hopefully these latter groups will be the subject of later workshops. Also excluded from this guide are minor groups (in the sense that they commonly do not make a significant numerical or biomass contribution to the aquatic microfauna), e.g. nematodes, oligochaetes, mussel glochidia, arachnids, larvae of various insects.

For each of the three groups, brief outlines are given of morphology, physiology, ecology and current systematics. Methods of collection, preservation and identification are summarised. Dichotomous and pictorial keys are provided to reach the best possible discrimination based on current taxonomic resolution of each group. Where published work exists, an abbreviated summary only is given in this guide. The published work should be referred to for more detailed study. As far as possible, keys are aimed at non-specialist use - specialized morphological or other technical terms are kept to a minimum, with a glossary provided for those which were unavoidable or in common usage for the particular organism(s). Feedback is invited- if you have problems using the keys, or find animals which cannot be identified using them, please contact the author to facilitate updating and improving the guide.

2. ECOLOGICAL ROLE OF THE MICROBIOTA

Microinvertebrates provide the major links in aquatic food chains between bacteria/algae and higher order consumers. Linkages may be short, with a grazer (e.g. rotifer) eaten directly by a juvenile fish, or longer, e.g. a heterotrophic flagellate eaten by a ciliate, in turn eaten by a rotifer, by a succession of copepods, then a fish. Fig 1 shows a simplified view of the interactions that may take place within the microfaunal community, however in reality food webs are much more complex. There may be hundreds of protozoan species, 30-100 species of rotifers and 10-30 species of microcrustaceans in a pond at any time. Some of these are generalist feeders, taking a range of food items, some are more specialized, concentrating their grazing efforts on a small size range of algae or other microinvertebrates. The rotifer *Ascomorphella volvocicola*, for example, feeds only on *Volvox* cells, while another rotifer, *Trichocerca longiseta* sucks cell contents from filamentous green algae.

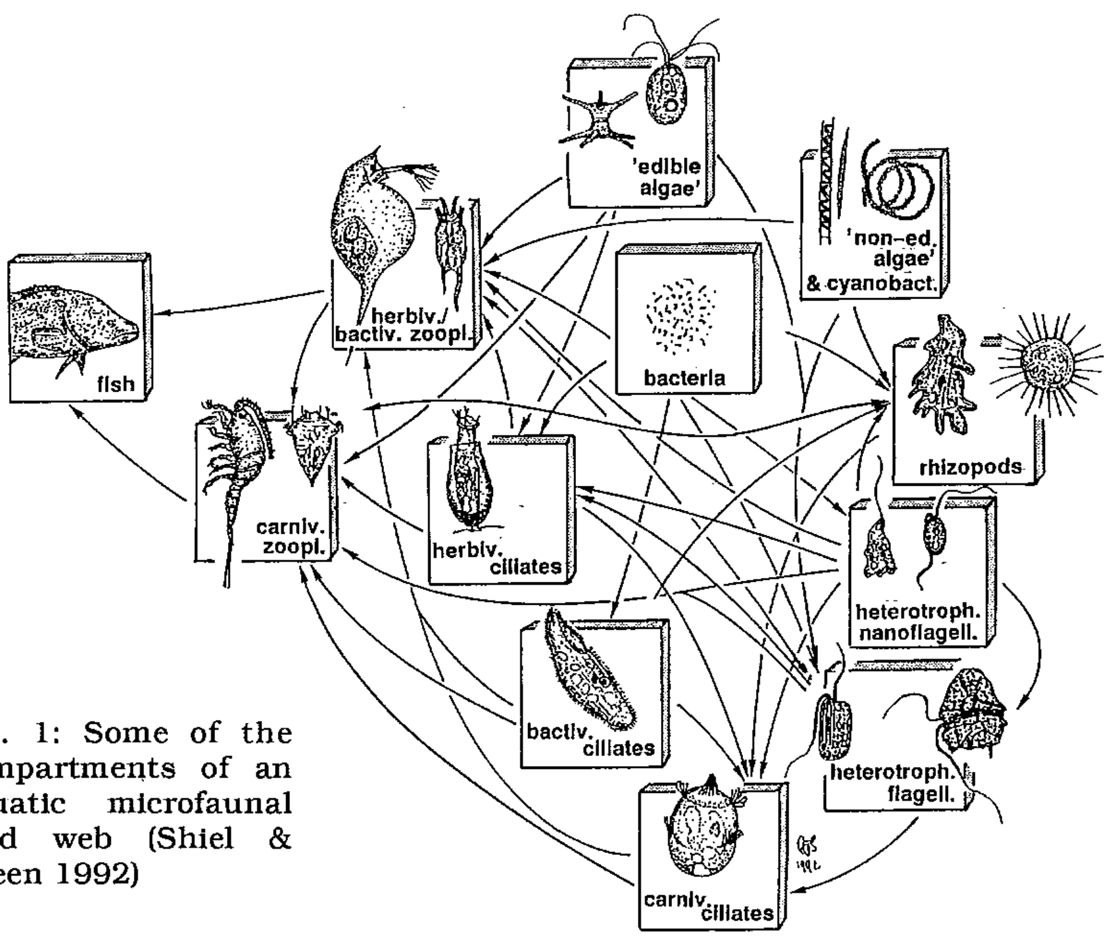


Fig. 1: Some of the compartments of an aquatic microfaunal food web (Shiel & Green 1992)

Each level of the community has a suite of species with characteristic life cycles responding to local environmental conditions, diurnal cycles, seasonal events, etc, so that rapid changes in community composition are usual. Rotifers, for example, may have only a 4-5 day life cycle at 25-30 ^{o}C. Species succession can occur in this time frame, with species of the same or different genera replacing the dominants. Microcrustacea have proportionately longer life cycles - weeks to months.

It is increasingly evident that we know very little of the interactions of Australian aquatic microbiota, e.g. few local references could be found for a recent review of cyanobacterial grazing in Australia (Boon *et al.* 1994). Without the basic taxonomic and ecological information at this level, we cannot produce meaningful environmental impact assessments for our inland waters, nor understand the complexity of their ecosystems. Even if the baseline data could be acquired tomorrow, who is to assess, for example, the impact of exotic fish introductions on the native Australian microbiota 150+ years after the event?

3. TAXONOMIC AND ZOOLOGICAL REFERENCES

A list of pertinent literature for each of the groups in this Guide was given in the 2nd Guide (Hawking 1994). The aging Williams (1980) remains the only general reference to earlier works on Australian aquatic microfauna. Chapters in De Deckker & Williams (1986) also are relevant. The microfauna of hatchery ponds in southeastern Australia are detailed in Ingram *et al.* (1995). New Zealand microcrustacea are treated briefly in Chapman & Lewis (1976), with ecological aspects given in chapters edited by Viner (1987). A recent comprehensive North American work on freshwater invertebrates (Thorp & Covich 1991) includes useful ecological information and reference lists for rotifers and microcrustacea, despite differences in taxonomic assemblages in the two hemispheres. In general, caution is advised when using any northern hemisphere taxonomic work for Australasian microbiota. Indiscriminate use of such works in the past has led to the present proliferation of 'cosmopolitan' species. At least some of these are good endemic taxa 'shoehorned' into European or North American identities when they are clearly not conspecific (nor in some cases congeneric!).

A series of guides presently in preparation ultimately will provide a single taxonomic resource for global use, with specialists on several continents, including Australia and New Zealand, dealing with their animals of interests. The published volumes of these *Guides to the Identification of the Microinvertebrates of the Continental Waters of the* World (SPB Academic Publishing) are listed with the relevant organisms in the systematic sections. The papers cited in the systematic section provide a complete listing of earlier publications on the three groups treated in this Guide.

4. SAMPLING AND IDENTIFICATION METHODS

Sampling frequency

Sampling intensity should be tuned to the level of community information desired. At the microinvertebrate level, monthly sampling, for example, may miss most, if not all, significant environmental cues and population responses, and probably a good proportion of the species. More frequent sampling is necessary at the 'lower' taxonomic levels for more comprehensive information -weekly or more often (cf. Tan & Shiel 1993). Also likely to yield more information is to sample more intensively at break of season, particularly after the first heavy rains of autumn, or the first significant spring floods (in S.E. Australia at least). It is these events, after all, which have cued the microinvertebrates over a long evolutionary time frame.

Sampling methods
Qualitative samples of net plankton may be collected with 'standard' pond nets of <100 µm mesh-size. If eggs of rotifers are to be collected adequately, the mesh-size needs to be 20-35 µm. Larger mesh can be used if the smaller components of the plankton are not of interest, e.g. 200 µm mesh is adequate for microcrustacea. Nets are not quantitative, and certainly do not sample a volume of water equivalent to the net diameter X the length of tow. Bow waves, clogging, towing speed, etc., are variables which reduce the volume of water filtered. For a comparison of sampling methods and efficiencies, see Bottrell *et al.* (1976). Bucket samples of 10 l or so often give an adequate idea of proportions of animals in the community. Perspex Schindler or Patalas traps (Fig. 2) provide greater accuracy. Such traps can be fitted with a plug or nets of various mesh size. The trap is open while being lowered to a desired depth, triggered to close the door(s), and raised to collect the whole volume, or the filtered residents of that volume. Smaller volume containers tend to undersample the speedier components of the community, i.e. those which can 'flip' or 'skip' away from containers. These samplers are at best semi-quantitative. Pumps can sample a larger volume rapidly.

Preservation
Rotifers are best identified live, as preservation induces contraction and other changes. Where live identification is not feasible, samples should be preserved for later identification. Preserved rotifers can still be identified to species, but more effort is required. Common preservatives are: formalin (2-3%), ethanol or methanol (50-75%) and Lugol's iodine (5%). Microcrustacea also can be preserved in these solutions. All have disadvantages - formalin because of its toxicity, alcohols because they clear and may distort specimens, and Lugol's because it may stain excessively. Methanol is the most economical preservative, but alcohols are not ideal for long-term storage because of volatility. Formalin remains an effective long-term preservative, but stringent caution needs to be used. If samples are to be kept for an extended period, whatever the preservative used, addition of glycerol (to make up a 1-2% solution in the final volume) protects against loss of specimens in the event of the sample drying out. This is likely if clear polystyrene containers are used - they may craze and crack over time. Glass containers with screw on lids, preferably with a neoprene or other seal insert, appear to be safest for long-term storage. Some curation of stored collections is necessary; lids loosen over time, fluids evaporate, so that topping up and checking tightness of lids should be planned once or twice a year. Refrigeration or maintenance in controlled-temperature conditions is preferable to exposure to ambient variations.

Sorting
Bulk sorting of collections for rotifers and microcrustacea can be done adequately in a petri dish on a dissecting microscope stage. A dark-field transmitted-light stage offers significantly better resolution of transparent animals than does a bright-field transmitted or reflected light stage (see Fig. 3). If proportional composition of organisms is required, the first 200-300 individuals encountered can be enumerated and identified at this point. Tally counters or multi-channel electronic counters are valuable for species-rich collections. This proportional

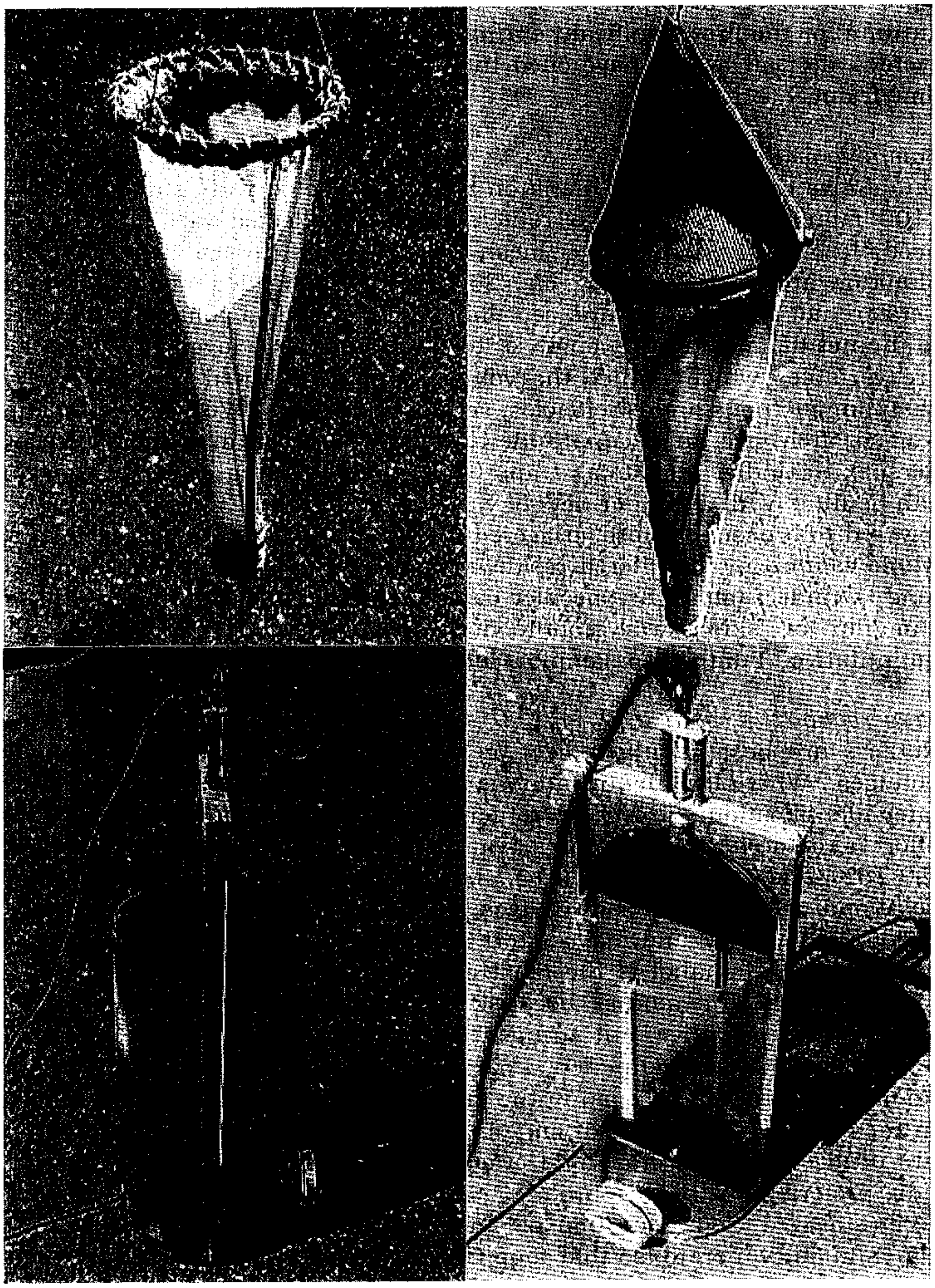


Fig. 2: Top (left) 37 μm-mesh plankton net with PVC ferrule on the end into which a sampling jar screws; (right) 53 μm-mesh Birge cone net, with stainless-steel mesh over the net opening to minimize entry of macrophytes; Bottom (left) Perspex plankton trap in closed position. Removable nets slip over the bayonet mount on the lower right; (right) The trap open. The weight of the trap, or a slight tug on the line, lifts the clip holding the doors, and the spring-loaded bottom doors close, pulling the top doors closed by an attached line. (Trap built by Brian Roberts, Botany Department, University of Adelaide)

count enables comparison of species composition and compositional representation between consecutive samples, but does not reflect population densities in the samples. For quantitative counts, all animals in a known volume of sample must be counted. The entire collection from one of the volume samplers mentioned above can be counted, or if animal densities are high, the volume of the sample can be measured and a known aliquot (subsample), for example 1 ml, can be withdrawn using a calibrated pipette (Gilson or similar). The count from the subsample is then multiplied by the fractional volume of the original volume to give an estimate of the total population, i.e. if a 1 ml subsample was withdrawn from a 55 ml original volume, the total count from 1 ml would be multiplied by 55. If several replicates are done in this way, calculation of mean and variance of the counts enable the accuracy of subsampling to be estimated. For statistical analyses, see, for example, Elliot (1973).

Examination and preparation for identification.

The level of taxonomic resolution possible from a petri dish sample on a dissecting microscope varies with the quality of the microscope, the condition of the sample, i.e. live or preserved, the density of animals vs. the amount of phytoplankton or debris, the experience of the user, and so on. The dissecting microscope can be used for identification to family or better, but for accuracy a compound microscope is required. Again, the quality of the microscope is important - phase contrast condenser and objectives are valuable, as is Nomarski Interference Contrast. Both of these enhance or contrast the perceived image. A range of objectives is required in view of the different sizes of microfauna - 4X, 10X, 20X and 40X are common, with 100X oil immersion for fine details.

Fig. 3 below shows some useful implements for handling microfauna. Left to right: Very fine forceps (sharpened using a diamond whetstone under a stereo microscope); a pair of tungsten dissecting needles (sharpened electrolytically in NaOH using a microscope light transformer as the power source), which can also be converted into loops for picking up single animals; pasteur pipette for bulk transfers; microcapillary pipettes (may be drawn out in a flame to a 100 µm aperture or finer, smoothed off with a diamond whetstone, and used to pick up individual animals or pieces thereof, e.g. rotifer trophi after erosion of body tissues); a Sedgwick-Rafter counting tray (perspex or glass); a Taylor microcompressor, invaluable in restraining rapidly-moving animals without distortion. Below the stage are bottles of PVA-lactophenol-lignin pink (for microcrustacea) and 10% glycerol-H_2O mountant.

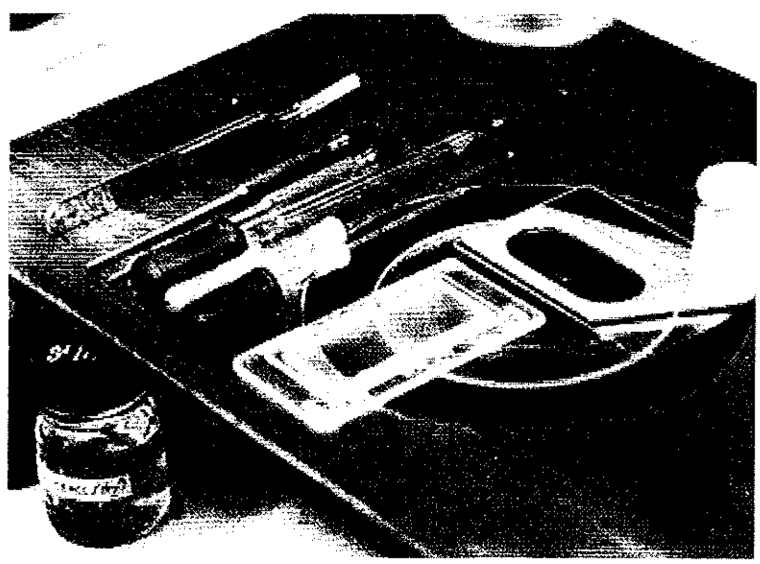


Fig. 3: Micromanipulation implements for microscope use: forceps, needles, pipettes, counting tray, microcompressor

Fig. 4: Comparative light microscopy. a. *Simocephalus* (Daphniidae) by dark-field stereo; b. by bright field stereo; c. plain optics, compound; d. *Ceriodaphnia* (Daphniidae), Nomarski Interference Contrast optics, compound. Sony video prints from an Olympus BH-2-mounted Sony video camera.

Once the specimen of interest is extracted from the sample and transferred to a glass microslide on the stage of a compound microscope, high magnification observation of it facilitates specific identification. A summary of particular requirements for each group is given in the systematic section. If a permanent record of the animal or its features are to be made, there are several means of recording images much improved from the old *camera lucida*. A *camera lucida* is still useful, however modern technology has produced various format film and video cameras, and more recently electronic image capture, video and laser printers, and scanning (SEM) and transmission (TEM) electron microscopy. Comparative images using some of these methods are shown in Fig. 4, with some SEM views of one of each of the subjects of the Workshop on the front cover. A reference collection of drawings, photographs, videotapes or electronic images can be assembled, the long-term utility of which usually repays the initial expense of the equipment required.

PHYLUM ROTIFERA

Rotifers are often the most abundant metazoans in inland waters, both numerically and in terms of species numbers. Globally, around 2000 species are known, with ca. 640 recorded to date from Australia and ca. 400 from New Zealand (70% species shared on present evidence). It is likely that these numbers represent less than half of the rotifers likely to be found in both regions in view of the low sampling effort to date. Most rotifers are found in fresh waters, however a small group of halophiles may be found in athallasic saline waters, often at very high densities, with a few species tolerating concentrations above that of sea water. Marine rotifers are known, but are not well-reported from the Australasian region, and are not considered further here.

There are creeping, planktonic, semiplanktonic, semisessile and sessile forms. Several species are parasitic. The planktonic forms tend to reduction of the foot, and float with the aid of an inflated, balloon-like morphology, e.g. *Trochosphaera*. Other species have appendages such as bristles, fins or rudders, or produce internal oil droplets. Semiplanktonic species which live in the plant-poor or plant-free zone may retain the foot and use an adhesive secreted from the toe-tips to attach occasionally to flocculent detritus, algal filaments, crustacea or other rotifers.

Most common species are small (<200 μm), although occasionally the predatory genus *Asplanchna*, or colonial taxa, e.g. *Lacinularia* (S.E. Australia only), may exceed 1 mm and be visible to the naked eye. Rotifers have the fastest reproductive rates of any metazoan (Nogrady *et al.* 1993), and can rapidly fill available niches. High population densities can thus be achieved when food is not limiting - 24,000 rotifers l^{-1} (Mt Bold Reservoir, S.A. Shiel *et al.* 1987) is not particularly high compared to some of the population densities reported from sewage ponds and aquaculture systems (500,000 l^{-1}; Lubzens 1987). Although such high densities are to be expected in highly eutrophic habitats, more commonly rotifer densities in zooplankton are <1,000 l^{-1}, with proportionately higher densities in littoral areas as increased partitioning by macrophytes increases available niches.

Relatively few taxa inhabit or are specialized for a pelagic existance, i.e. most rotifers are littoral or benthic in habit, and are found in the floating or submerged vegetation of billabongs, lake and river margins, weedy puddles, in damp moss, in fact any place that holds water for more than a few days. These rotifers belong to the *littoral microfauna* and are not commonly found in open water. Nevertheless the littoral rotifer fauna in natural habitats may provide a significant dietary input for macroinvertebrates, tadpoles or juvenile fish, particularly those species which use the sheltered waters of billabongs as nursery areas, or species which utilise freshly flooded areas of riverine forests to forage for emergent micro- and macroinvertebrates.

Definitions of specialised terms used in following sections:

auricles: ciliated lateral protrusions of the anterior (head) end of synchaetids ;

corona: the ciliary disc by which rotifers feed and move;

fins: lateral serrated paddles of *Polyarthra* species (locomotion);

loricate/illoricate: possessing/or not a firm rigid cuticle (lorica) which maintains its shape even on preservation. Some illoricate species can be identified to family or genus even when contracted, but most contract to indeterminate 'blobs' and cannot;

trophus/trophi: the specialized 'dentition' - characteristic sclerotized teeth of all rotifers, which are particularly important in identification of illoricate taxa.

Rotifer life cycles

The three classes of rotifers have three different reproductive strategies: Seisonidea are bisexual, Bdelloida are asexual parthenogens (no males), and Monogononta have evolved alternation of generations (heterogony)(cf. Fig. 5). In monogononts, after asexual (parthenogenetic) phases, male generations may occur, with synchronous reorganization to dwarf males (Fig. 5). Oocytes with yolk provided are released from the paired (digonont) or single (monogonont) ovary through a nutritive part of the female sexual system (vitellarium). The abdominal cavity is described as a pseudocoel. The integument and the tissue of the organs are not completely organized into cells (syncytial formation). The animals of some species possess an identical number of cells (eutely). Postembryony there is an enlargement without mitosis through the swelling and divergence of the cells. The general stretching results in allometry with considerable shape changes.

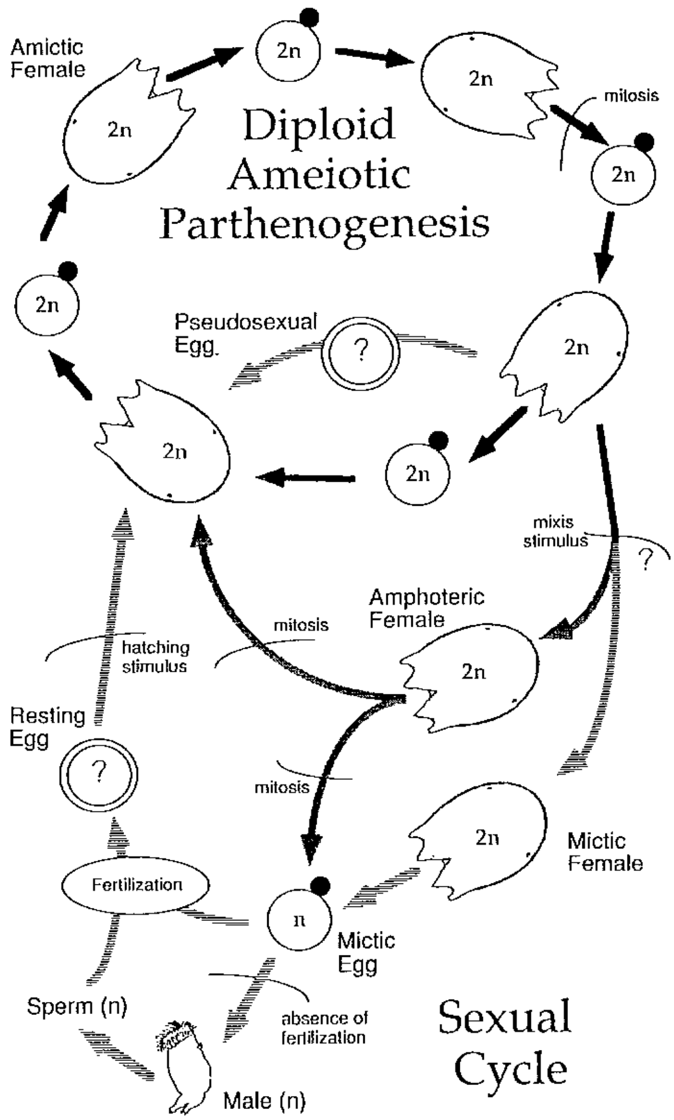


Fig. 5: Life cycle of a brachionid rotifer (From Nogrady *et al.* 1993)

Morphology: external anatomy and internal organization

Only the female morphology is considered here. Summary descriptions provide the essential information for the systematic work. Males, which usually occur in the population only in a short mictic phase, and have rudimentary digestive organs, are treated separately.

Body shape

It is difficult in this diverse group to represent a general underlying body plan as a "typical" form. The generalised form in Fig. 6, a spindle-shaped, wormlike, elongated type, is seen in the creeping Notommatidae and Dicranophoridae (cf. Ruttner-Kolisko 1972, Fig. 2, Koste 1978, Fig. 1a-b). In the following section, refer to Figs 6 and 7, which show comparative organisation of four dissimilar taxa.

Due to pseudosegmentation of the rotifer body, a head, trunk and foot are distinguished. In several groups these demarcations are indistinct or completely unrecognizable, e.g. Asplanchnidae, Gastropodidae, Synchaetidae, Trochosphaeridae, Flosculariacae and Collothecidae. In several groups the foot is absent. Some taxa have longitudinal folding, e.g. bdelloids, *Synchaeta*, while others only have such folds laterally on the trunk, e.g. Dicranophoridae, and the genera *Euchlanis* and *Lecane*. Segmentation is unknown in loricate forms or pelagic genera with body appendages.

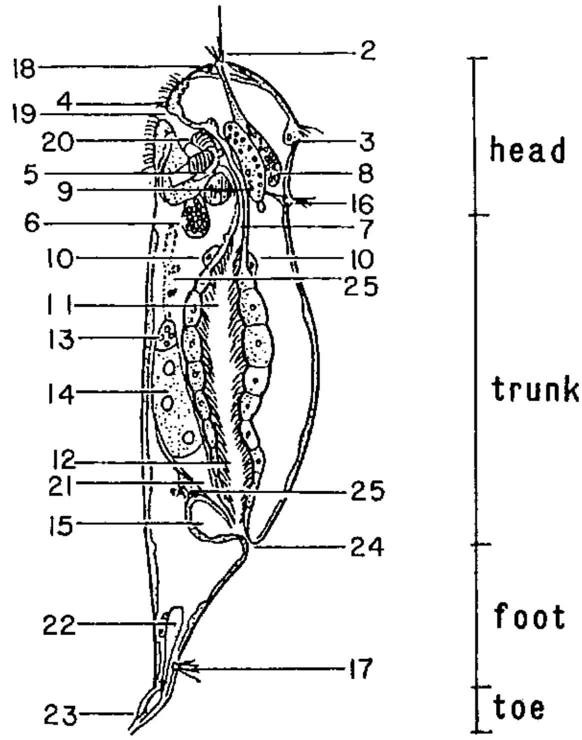


Fig. 6: Rotifer, lateral; 1, orifice of retrocerebral sac; 2. apical sensillae; 3, cellular base of corona; 4, buccal field; 5, ventral salivary gland; 7, oesophagus; 8, retrocerebral sac; 9; brain with subcerebral gland; 10, gastric gland; 11, stomach; 12, intestine; 13, ovary; 14,vitellarium 15, bladder; 16, dorsal antenna; 17, caudal antenna; 18, eye; 19, mouth; 20, pharynx; 21, oviduct; 22, foot gland with reservoir; 23, toe; 24, anus; 25, protonephridium. (After Remane 1929 and Koste 1978)

The corona

The head (Fig. 8), which is often two-segmented, carries the corona (wheel-organ), which gathers food and, with few exceptions e.g. sessile forms, also serves in locomotion. This ciliary apparatus gave the group its' name. It is essential for the systematic diagnosis of higher categories. The primitive or ancestral form can be deduced from the recognized coronas of different families (Fig. 9).

The mouth is located on a ciliary disc (buccal field). A circumapical band (Fig. 8: #2) forms rings around an apical field (Fig. 8: #5). The ciliary row at the anterior margin of the circumapical band (large dots on Figs 8 & 9) is defined as the trochus (Fig. 8: #20); the ciliary row at the posterior margin as the cingulum (Fig. 8: #17). Frequently, the apical field is filled with tactile organs, cirri and membranelles. Light-sensitive organs (frontal or lateral eyes [Fig. 8: #7)) also are located here, and the opening of the secretory duct of the retro-cerebral organ.

Because of the dissimilar head shapes, e.g. ciliated auricles, and reduction and elongation of the ancestral ciliation, several corona types can be distinguished in the Rotifera (see Koste & Shiel 1987). A series of systematically unrelated Rotifera possess palpar organs, peg- or fingerlike, occasionally movable retractile processes at the anterior end of the apical field. In the planktonic and semiplanktonic species they occur in the Trichocercidae and Gastropodidiae. They are mostly peg- or club-shaped tentacles which play a sensory role in food-gathering, e.g. *Ploesoma.*

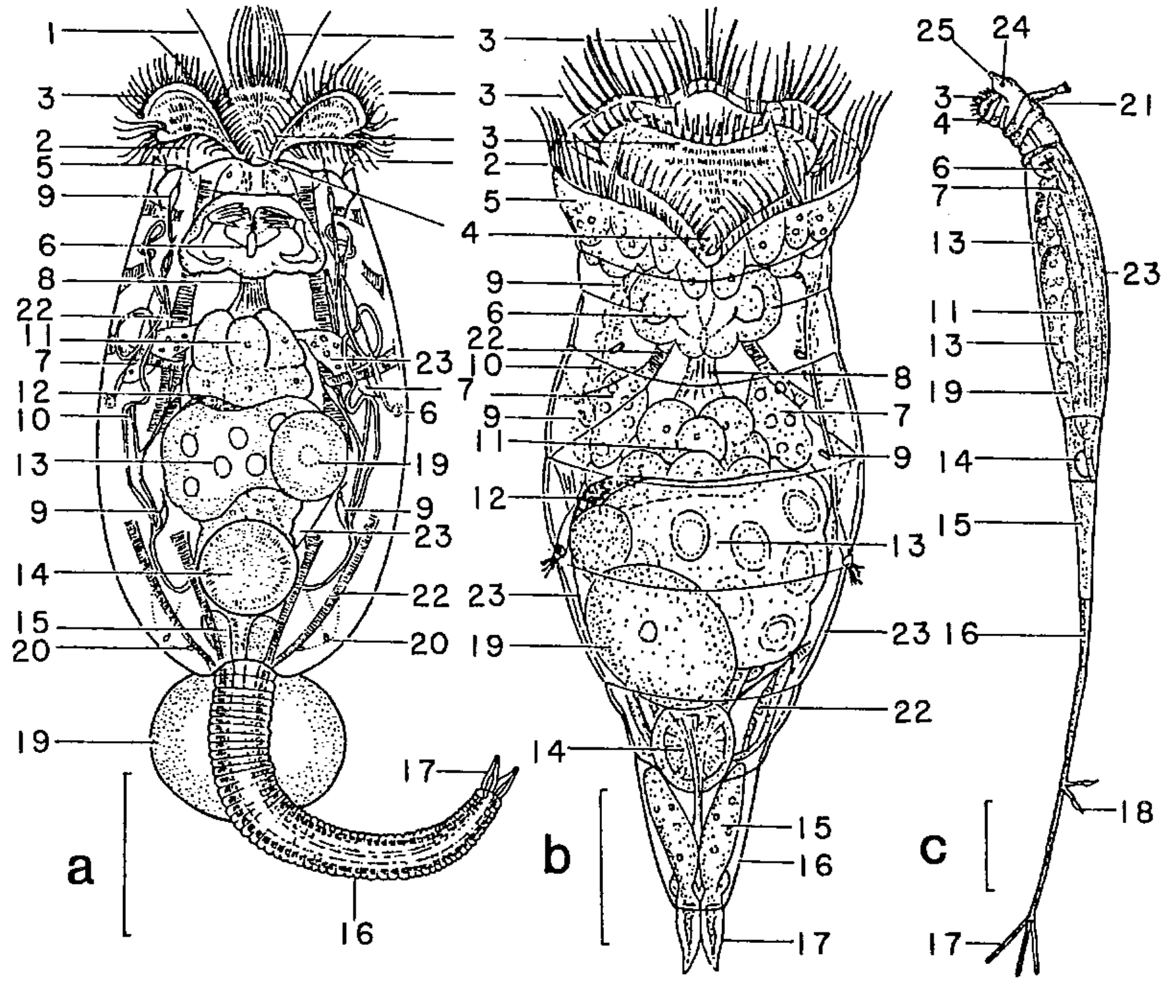


Fig. 7: Comparative anatomy of three rotifer species: (*a*) *Brachionus plicatilis* female, ventral; (*b*) *Epiphanes senta* female, ventral; (*c*) *Rotaria neptunia*, ventral: 1, apical sensory bristle; 2, cingulum; 3, buccal cilia; 4, mouth; 5, syncytial and single cells of the corona basis (hypodermis hump); 6, mastax with trophi; 7, gastric glands; 8, oesophagus; 9, flame bulb (cyrtocyte); 10, protonephridium; 11, stomach; 12, ovary; 13, vitellarium; 14, contractile vesicle; 15, foot gland; 16, foot; 17, toe; 18, spurs; 19, egg; 20, nerve cells; 21, dorsal antenna; 22, muscles; 23, integument; 24, eye; 25, proboscis and rostrum; after Koste (1978). Scale lines, 100 μm.

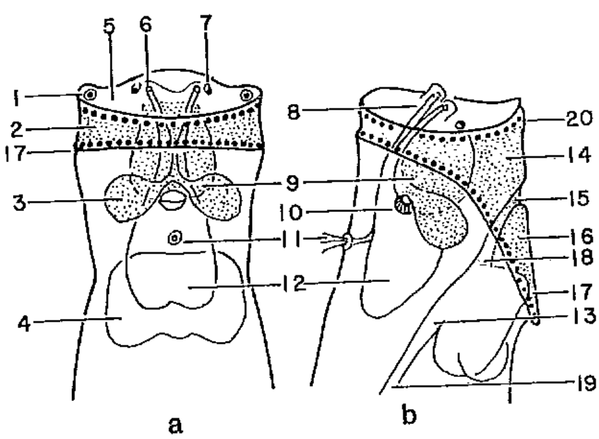


Fig. 8: Features of the rotifer head: a, dorsal; b, ventral: 1, lateral eye; 2, circumapical band; 3, subcerebral sac; 4, mastax; 5, apical field; 6, orifice of retrocerebral organ; 7, frontal eye; 8, duct of retrocerebral organ; 9, brain; 10, cerebral eye; 11, dorsal antenna; 12, retrocerebral sac; 13, orifice of oesophagus; 14, buccal area; 15, mouth; 16, suboral buccal area; 17, cingulum; 18, pharynx; 19, oesophagus; 20, trochus. (After Donner (1965) and De Beauchamp (1965))

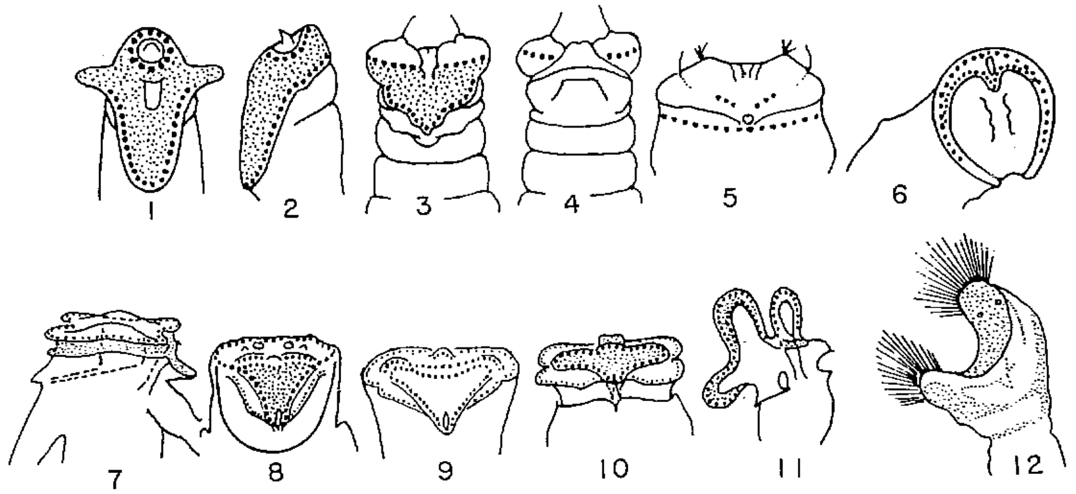


Fig. 9: Rotifer coronae. 1/2, *Notommata,* ventral/lateral; 3/4, *Macrotrachella* (Bdelloidaea) ventral/dorsal; 5, *Asplanchna,* ventral; 6, *Conochilus,* ventral; 7, *Hexarthra,* lateral; 8, *Euchlanis,* ventral; 9, *Epiphanes,* ventral; 10, *Brachionus,* ventral; 11, *Floscularia,* lateral; 12, *Collotheca,* lateral. Large dots, trochus; medium dots, cingulum; small dots, ciliation of the circumapical band. (Various authors, Koste (1978).

Integument

The rotifer integument is either thick and rigid (loricate) or supple (illoricate). The latter comprises the anterior of most rotifers. In the diagnosis of the Rotifera, mostly as a result of light microscopy, several semiplanktonic groups with a more or less structured, rigid lorica can be distinguished from the illoricates, with a pliable integument. The integument is important for identification in the genera *Brachionus, Keratella, Euchlanis, Ploesoma, Lepadalla, Lecane* and *Colurella.* Bristles and fins also are distinguished as cuticular structures. Lorica cross-sectional views also may be important. Some loricas consist of 2-5 plates held together by a laminated connection e.g. *Lepadella, Lecane, Euchlanis.* Completely smooth loricas are rare. Many are structured, covered with pronounced fillets and facets (see genera *Brachionus, Keratella, Trichotria* and *Ploesoma.* In several species the integument (except the head) is surrounded by a mucilaginous envelope, e.g. *Collotheca pelagica, Gastropus stylifer.*

Feet & toes

Most rotifers have a foot, beginning at the anus (Fig. 6:24), with one or two toes (Fig. 7: 17). The genus *Trichocerca* has asymmetrical toes with short bristles at the base. Some planktonic groups, e.g. *Asplanchna, Collotheca,* have no toes. In keeping with the different habits and types of movement necessary, spring- and creeping- [haptic] feet with corresponding toes can be distinguished. *Testudinella* species, larvae and males of the adult stage of sessile Gnesiotrocha, and Collothecacea which are free-swimming a short time after hatching, have a tuft of cilia instead of toes. At the tips of the toes is the orifice for the secretions of foot glands. All foot glands (Fig. 7: 15) have reservoirs and bulbs from which thin secretory ducts lead to the toes. The *Trichocerca* spp. have these orifices at the bases of their stylii. The foot can be rudimentary e.g. *Asplanchna herricki.*

Digestive system & trophi

The digestive system (Fig 6) as a rule consists of a mouth with adjacent pharynx, the mastax (with characteristic trophi in different taxa), oesophagus, stomach, a more or less distinguishable intestine, cloaca and anus. The latter generally is dorsal, but may be ventral (*Ploesoma*) or terminal (*Filinia*). Some taxa lack cloaca and anus, e.g. all *Asplanchna* species. Other genera, e.g. *Gastropus* or *Ascomorpha* have a stomach with blind sacs. The cloaca and anus of these rotifers are functionless and can be reduced entirely. While Asplanchniidae eject food remains throught the mouth, Gastropodidae retain wastes in the blind sacs as dark pellets. Philodinidae have very thick stomach walls which enclose a tube-shaped lumen. In Habrotrochidae the stomach is filled with a syncytial mass in which food pellets are digested. The faeces are expelled as pellets. Bdelloid taxa have a cloacal bladder.

The Collothecacea, instead of a pharynx, have a wide funnel (Fig. 9: 12) ending in a pharyngeal tube, which often contains pharyngeal sensory cilia. Dorsal and ventral salivary glands lead to the mastax (Fig. 7: 6). Gastric glands usually are located at the distal end of the oesophagus (Fig. 7: 7). In *Asplanchna* the glands are further forward.

The muscular pharynx region with the trophi skeleton (jaws) is referred to as the mastax (Fig. 7:6). The trophi consist of a variable number of hard cuticularized elements (Figs 10, 11). They are important systematic features, essential to identification. Fig. 10 shows the plan of a forcipate rotifer jaw. The fulcrum (fu) lies below the middle line of the trophi. It supports the paired rami (ra). The unci (un) rest on the outer sides of the rami and are hinged to two manubria (man). Under the unci teeth can be preuncinal teeth (Fig. 10: preu). Between the unci and manubria is the intramalleus (in). The alula (al) are wing-like projections often found at the base of the ramus (bul). Characteristic types of jaws usually are recognized in each family, but there are many transitional stages, often of very varied and complicated structure. The main types of trophi are:

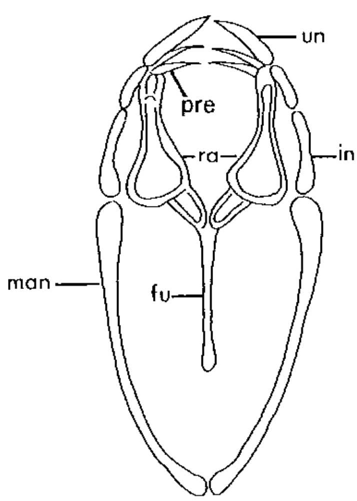


Fig. 10: Forcipate rotifer trophus

1. Malleate (Fig. 11:1): Fulcrum short, unci 4-7 toothed, rami and manubria powerful. The action is to cut and chew. Brachionidae, Lecanidae. In the sub-malleate type the manubria and fulcrum are longer.
2. Virgate (Fig. 11:2): This is a suction type, often asymmetrical. All parts tend to be slender. Fulcrum and manubria long, rami small, broad with anterior cups. Unci broad with small teeth, usually the first of which are strongly built. In the space between the surfaces of the rami a piston muscle operates to pump in food (Fig. 11:2b hypm). *Cephalodella, Ascomorpha, Notommata*, Trichocercidae.
3. Cardate (Fig. 11:3): With suction function but without piston. Fulcrum broad, rami lyre-shaped. Epipharynx elements abundant. Lindiidae.
4. Forcipate (Fig 10): Seizing type, formed like pincers, which can be thrust out from the mouth. Unci paired or more teeth. Characteristic of creeping Dicranophoridae, e.g. *Encentrum*, or parasites e.g. *Albertia, Balatro*. No planktonic or semiplanktonic species.
5. Incudate (Fig 11:4): Seizing type. Large, curved rami, pincerlike. Fulcrum short, boardlike, of variable size. Manubria and unci degenerate. *Asplanchna*, predatory in the plankton.

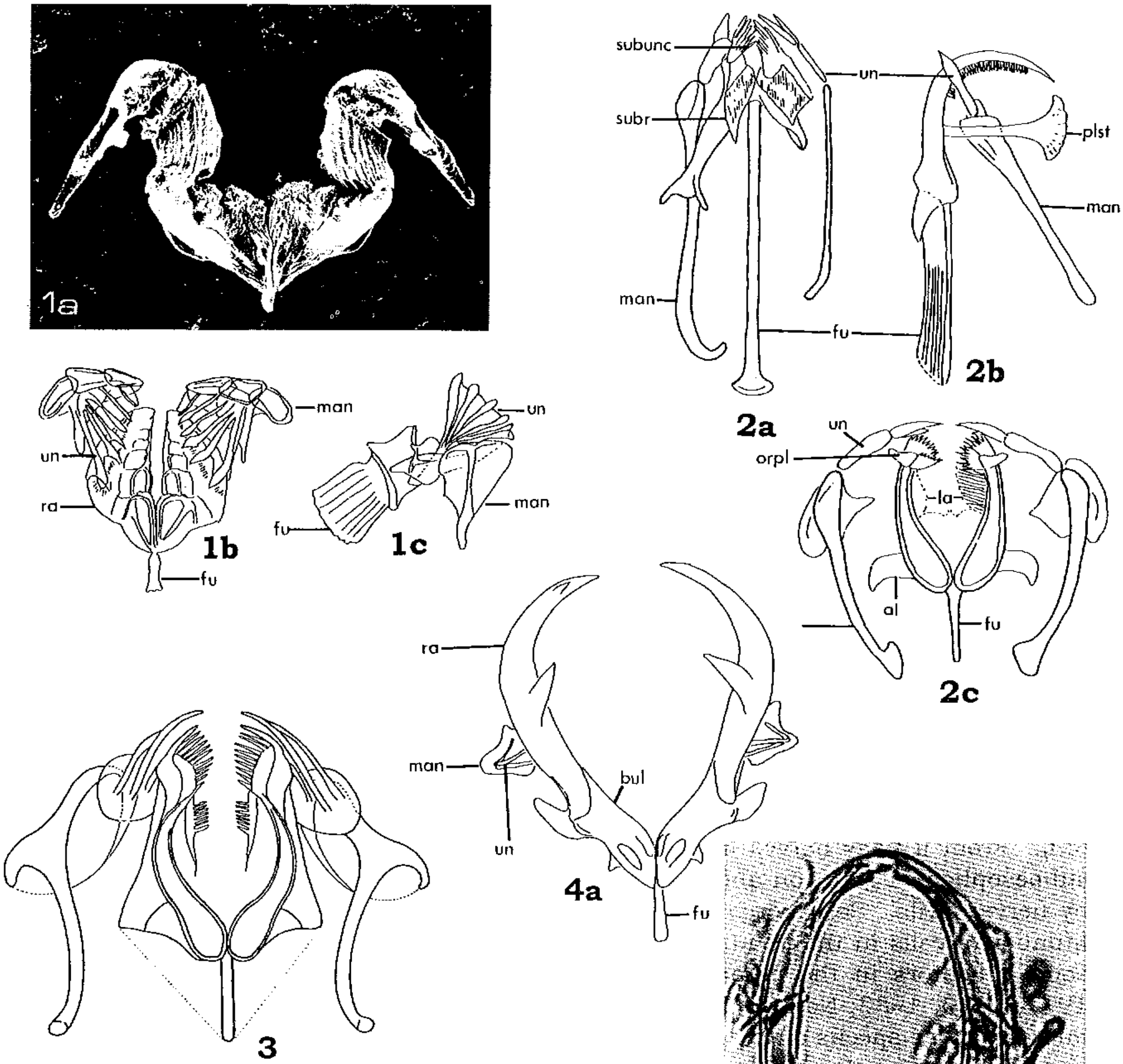


Fig. 11: Rotifer trophi types: 1, **malleate:** (*Epiphanes*) a, SEM; b. anterior, c. lateral; 2. **virgate:** a, ventral, b, lateral (*Trichocerca rattus*); c, *Itura*; 3. **cardate:** Lindia deridderi; 4. **incudate:** a, *Asplanchna sieboldi*, b, *A. brightwelli.* (after various authors).

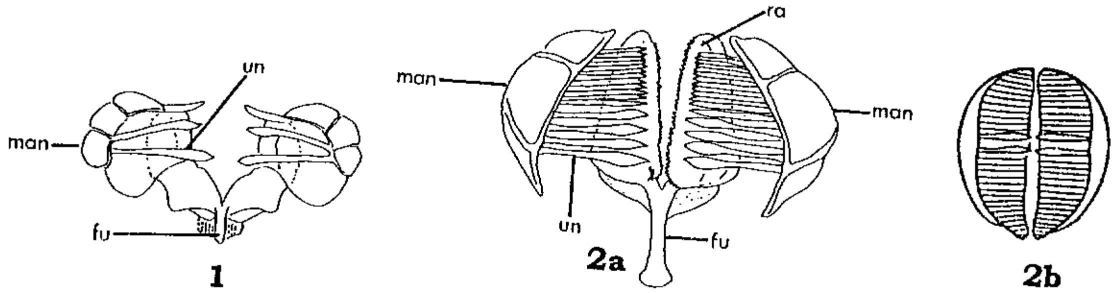


Fig. 12: Rotifer trophi types: 1. **uncinate** (*Collotheca*); 2a, **malleoramate** (*Ptygura*), b. **ramate** (Bdelloidea). (After Koste, 1978, various authors).

6. Uncinate (Fig. 12:1): Tearing type. Rami well developed, unci with 3-5 paired teeth, fulcrum and manubria weak, degenerate. Only in Collothecidae. Some free-swimming species.
7. Ramate (Fig. 12:2): There are two types; a. malleoramate: manubria with some cavities, rami strongly toothed, unci with many thin teeth (Fig. 12:2a). Floscularidae (*Testudinella, Filinia, Hexarthra*); b. ramate s. str.: Unci broad, curved/sickle-shaped plates, grooved and toothed. Often two or three main teeth on the unci plates. Most bdelloids (Fig. 12:2b).

Nervous system and sense organs

All rotifers have a brain, the central ganglion, which lies above the pharynx (Fig. 8:9). From it pass nerves in all directions. Other ganglia are: mastax ganglion, suboesophageal ganglion and caudal ganglion. The different ganglia are connected by nerve fibrils. Sense organs can be grouped as eyes, external antennae, and a number of cells in the caudal part of the pseudocoel, e.g. supra-anal organ, with some receptors in the corona, pharynx lumen and in the integument (Clement 1977, 1980, 1983; Nogrady *et al.* 1993). The photoreceptors can be seen in light microscopy as specks of red or darker pigments. According to their position, single cerebral eyes can be distinguished (usually in monogonont rotifers) at the end of the brain (Fig. 8:10) and paired frontal eyes situated on either side of the head (Fig. 8:7). Bdelloid groups also have paired cerebral eyes, e.g *Habrotrocha* and *Philodina.* Some of the bdelloids, e.g. *Rotaria,* have eyes on the rostrum (Fig.15). Ultrastructural evidence (Clement 1977, 1980) indicates that the organization of the photoreceptors is complex.

The dorsal and lateral antennae are tactile or sense organs. Bdelloids have no lateral antenna, only a dorsal sense organ and sensory hairs on the trochus, and often cilia at the end of the rostrum. With a light microscope, the apical antenna and lateral antenna display a bunch of longer cilia which penetrate the integument. Ultrastructural research (e.g. Clement & Amsellem 1977) shows a complex fine structure.

Excretory and osmoregulatory system

The excretory and osmoregulatory system consists generally of paired protonephridia and a contractile vesicle, the bladder (Fig. 7:14). Pontin (1978) described the protonephridium as a coiled tubule bearing at its distal end a number of flame bulbs (= flame cells = cyrtocyts). The number varies with the species and can be variable within a species. Within each flame bulb, a bunch of cilia forms the flagellum. During life the flagellum is in continuous motion. The movement gives the impression of a flickering flame. Fluid from the pseudocoel of the body passes through the bulb face into the bulb cavity and then in a fine capillary tubule to join the main channel. Regular filling and emptying of the contractile vesicle ensures the removal of surplus fluid or urine.

Female reproductive organ and egg types

The sexual organ of female rotifers lies on the ventral side in the pseudocoel (Fig. 7). It consists of the ovary, vitellarium and oviduct (Fig. 7:12, 13). These parts lie in a common fine membrane, which is seen only with difficulty using the light microscope. From birth a female possesses a fixed number (10-50) nuclei for oocytes, entirely constituted from maternal material (oogonium)(Clement 1977). Each oocyte is well separated from others, but each is connected to the vitellarium by a cytoplasmic bridge (Bentfeld 1971a). The ovary-vitellarium, also called germovitellarium, as a whole is a syncytium. In small species like Trichocerca rattus there seems to be no oviduct (Clement 1977).

While the ovary in the syncytium is difficult to differentiate by light microscopy, especially in prefertile females, the vitellarium, with its large nuclei, is readily distinguished. This organ is paired in the Bdelloidea and single in the Monogononta. There are usually 8 nuclei, but sometimes only four, or many more. The nuclei contain a large nucleolus. In *Asplanchna*, the number of nuclei varies from one animal to another, particularly with the diet (Birky & Field 1966).

Three different egg types are recognized in Monogononta: subitaneous (asexual), sexual and resting eggs. The subitaneous eggs are diploid (2n) parthenogenetic reproductive cells produced by amictic females. These have the thinnest shells. In response to specific stimuli (high population density, changes in temperature, pH, conductivity, diet and other biotic and abiotic factors), the asexual phase ends and a mictic (sexual) phase begins. A survey of the investigations in this field may be found inter alia in Birky & Gilbert (1971), Gilbert (1974) and Jones & Gilbert (1976). In the mictic phase females produce haploid (n) sexual eggs. Unfertilized, they develop into small eggs from which hatch males (Fig. 5). Fertilized (2n), they become resting eggs, which generally have double, dark, thickened and often ornamented shells. Resting eggs already contain an embryo, and often are larger than subitaneous eggs. They may take months or years to hatch, and can withstand great extremes, enabling monogonont species to survive. Bdelloids, which produce only subitaneous eggs, survive extreme conditions in anabiosis. After contraction of the head and foot they remain encysted and are able to preserve latent vitality, thus extending their life span of a few months to years (Hyman 1951, Donner 1965, Nogrady *et al.* 1993).

Mictic and amictic female monogonont rotifers are indistinguishable from their appearance, but are separated by the egg-type which they produce. Resting eggs frequently remain attached to dead females. Subitaneous or small sexual eggs develop predominantly in planktonic species at the base of the foot or on the caudal lorica and are carried until hatching (*Ascomorpha, Brachionus, Keratella, Synchaeta*).

A third female type occasionally is observed, described as an amphoteric female by Bogoslovsky (1958). It can produce diploid and haploid eggs by vivipary and males and resting eggs are seen internally, e.g. *Sinantherina socialis* (Bogoslovsky 1958, Champ & Pourriot 1977a & b), *Conochilus coenobasis* (Bogoslovsky 1960) *Asplanchna herricki* (Mrazek 1897), *Asplanchna priodonta* (Sudzuki 1955, Ruttner-Kolisko 1974). See also Ruttner-Kolisko (1977) and Snell & King (1977).

Oviparous, ovoviviparous and viviparous species have evolved. Whereas in ovipary the embryonic development occurs outside the female's body, ovovivipary occurs within the oviducts. In the latter, the generally thin eggshell is ruptured immediately afterward, or leave by the female's anus, so that the juvenile animal can directly swim away. Frequently, the oviduct of the viviparous female, e.g. *Rhinoglena, Asplanchna* may contain embryos in different developmental stages and fully developed juvenile animals simultaneously. The planktonic *Collotheca* species lay eggs with well developed male or female embryos in their gelatinous casing. In this refuge they persist until hatching. Bdelloids lay only subitaneous eggs. For further details, see Voigt 1957, Clement 1977, Koste 1978, Amsellem & Ricci 1982.

Morphology and anatomy of the male
Sexual dimorphism is characteristic for the monogonont (heterogont) Rotifera. It is not yet known for all species. Males (Fig. 5) hatch from small, unfertilized (haploid) sexual eggs, and often are of significantly smaller body size than the female, hence the term "dwarf" males. With a few exceptions (*Rhinoglena, Asplanchnopus*), the digestive system is nearly or totally (*Keratella*) rudimentary. Dark-coloured granules, or an oil droplet, may be present as an energy-carrier (Buchner et al. 1970). In this respect the organism is a closed system, utilizing this stored energy during the relatively short life-span (12 hr to 5 days).

Protonephridia and a contractile vesicle are present. The corona projects from a strongly constructed hypodermal cushion, and serves only for locomotion. Often there is a large red-pigmented light sensitive organ, and choreceptors, tactile sensillae and sensory bristles. Dorsal- and lateral antennae are present. The brain is relatively large. The single testis is pear-shaped, filled with sperm. Needle-like structures (also known as atypical sperm) in the lower part serve to penetrate and hold open the female's integument during copulation. In the inner end of the spermatic duct and in the opening of the penis are found cilia. Paired prostate glands also open here. The dorsally located sexual opening protrudes from a conical projection of the body. It functions also as a copulatory organ. A foot, frequently short, with foot glands and also toes are known for most taxa. A few males are footless (*Trichocerca, Gastropus, Filinia*), while others are toeless (*Asplanchna*).

Identification
Live material:
1. Specimens of interest are extracted from a petri dish sample on the dissecting microscope stage using a drawn-out pasteur- or microcapillary pipette, and placed in a small drop on a clean glass slide. Check that the animal does not adhere to the wall of the pipette;
2. Transfer the slide to the compound microscope stage and focus under low magnification. No coverslip is required at this stage, as details of motion, morphology, etc are best made while the specimen is uncontracted;
3. If swimming speed of the animal is a problem, tease a few strands of cotton wool and place them into the drop - these will impede motion. Purpose-built compression slides are available (Fig. 3) to restrain animals undistorted, however satisfactory results can be obtained by placing 3-4 pinhead-sized plasticine "feet" on a coverslip, and lowering the coverslip over the drop containing the rotifer. A dissecting needle or fine forceps tapped on the coverslip compresses the plasticine a little until the animal is restrained. This procedure should be done while the animal is kept in view under low magnification, to

avoid squashing it. An alternative to plasticine feet is fragments of a #1 coverslip placed at opposite sides of the drop (3-4 <1 mm chips) and a cleaned coverslip supported by them. This is less effective for very small rotifers;

4. With the animal restrained, any required measurements can be made, e.g. body length, width, toes, setae, etc., or drawings or photographs made. To prevent the specimen drying, add water at the margin of the preparation using a capillary pipette or fine entomological forceps. If accurate identification is made to this point, no further treatment is necessary.

Preserved material

The only differences in treatment for identifying preserved rotifers are:

1. the advisability of rinsing preserved samples, particularly those in formalin, through to water before dissecting-microscope examination. Even after washing, formalin-preserved material may give off formaldehyde fumes, which are insidious and toxic to humans, so that adequate ventilation, e.g. fume hood or bench extractors, should be used. Alcohol-preserved samples also may need to be rinsed, as evaporation can roil the surface of the sample and make observation and extraction of specimens difficult;
2. the animal for identification should be placed in a small drop of 10% glycerol/water and treated as for live material.

Permanent mounts

If the identified specimen or a conspecific idividual from the same sample is to be kept for reference, a permanent mount can be made by immersing the animal(s) in a serial concentration of glycerol (10-20-40-60-80-100%) over a period of a week in a well-slide until the animal has equilibrated to 100% glycerol. A small chip (<1 mm) of solid Kaiser's glycerin-gelatine is then placed on a cleaned slide, the slide heated slightly over a low flame, or on heating element, until the chip just melts, and the rotifer is transferred by micropipette or fine loop from the glycerol to the glyerin-gelatine before it hardens. A coverslip is then placed over the glycerin-gelatine, preferably with tiny plasticine feet as above, and any space between the edge of the glycerin-gelatine drop and the margin of the coverslip filled with mallinol or similar run under the edge. This preparation should be left in a dust-free environment for several weeks while the mountant dries. Additional mallinol is then run in to fill any contraction, and the coverslip sealed with, for example, nail polish. The life expectancy of such preparations is at least decades.

Trophi preparation

When trophi must be cleared from the tissues to enable positive identification, follow on from the animal-under-coverslip stage, regardless of whether living or preserved. The following procedure is best done on the compound microscope while keeping the specimen in view:

1. Draw out excess fluid from the edge of the coverslip using a lens tissue. Keep the specimen centred so that it is not drawn out. Work from the side opposite the specimen if it is markedly off centre;
2. Place a small drop of sodium hypochlorite (NaOCl, 5-10%) at the edge of the coverslip, using a microcapillary pipette or fine forceps. Less is better than too much, as the trophus can be flushed out and be difficult or impossible to find again;
3. When the body is almost eroded, carefully soak up excess fluid again using the edge of a tissue (here, lens tissue or Kimwipes® are better than Kleenex® or

similar - absorption is slower), watching that the exposed trophus is not withdrawn;

4. Add a small amount of 10% glycerol/water to the edge of the coverslip closest to the trophus. This will recentre it, otherwise careful application of tissue or glycerol/H2O will do so. This step is necessary because the trophus provides a focus of recrystallization for the NaOCl, and will be rapidly obscured;
5. When the trophus has stabilized, examine at the highest dry magnification possible. Larger trophi can be identified readily at 20-40X, however if the details of smaller trophi cannot be seen, 100X oil immersion may be necessary. If so:
6. Keeping the trophus in view, lock down the coverslip by carefully applying a small drop of nail-varnish to opposite sides. This step is required because movement of the objective in the immersion oil may be enough to disarticulate or force the trophus out of the field of view by smearing the coverslip laterally;
7. With the coverslip locked, centre the specimen, and obtain a focus at 40X.
8. Without moving the stage, swing the objectives aside, and carefully place a small drop of immersion oil at the focal point. Swing the 100X objective into the oil and focus accordingly. Alternatively, place the oil, lower the stage, and by watching from the side, slowly raise the stage until the objective just enters the oil. Then, watching through the oculars, continue raising the stage using the fine focus control and watching for the trophus to come into focus. If there is excessive fluid under the coverslip it can be removed with tissue as above. Extreme care has to be taken to avoid loss of the delicate trophus.

All this sounds finicky, but a little practice guarantees almost 100% success. Using these methods and the available keys, most rotifers can be identified to family and genus (bdelloids) and species (monogononts). Bdelloids are difficult to identify to species even in life, almost impossible preserved, because their trophi appear to be relatively uniform, and they contract into amorphous 'blobs' on preservation. A few of the common bdelloids in plankton samples are recognizable, e.g. *Rotaria neptunia* (Fig. 7c). These have been detailed, with keys to identification, by Koste & Shiel (1986).

SYSTEMATICS

For a review of rotifer systematics see Koste & Shiel (1987), Wallace & Snell (1991). The current systematic status of the phylum is given by Nogrady *et al.* (1993). For the purposes of this Workshop, systematic and nomenclatural minutae are omitted in the following identification section. Table 1 shows the classical system, and the number of genera and species in each family at present known from Australia/New Zealand. The following taxonomic key (compiled from the above sources) enables placement into families and genera. The key below is split into bdelloids and monogononts for convenience; families are treated sequentially according to the key. Page references to the start of each group are included.

Key to families of Rotifera known from Australian/New Zealand inland waters
[Abbreviations used: BL=body length; TR=trophi]

1. Paired ovaries; ramate TR (Fig. 12:2b)..........Digononta:.Bdelloidea...**2** (p. 20)
\- Single ovary; TR not ramate (Figs 11, 12:1, 2a)..Monogononta: 3 Orders...(p. 31)

Table 1: List of rotifer families, with numbers of genera and species at present recognized from Australia and New Zealand. Format: **8**:59/**8**:72 = 8 genera: 59 species (Australia)/8 genera:72 species (New Zealand). For list of genera see Appendix 1.

Order	Family	Australia / New Zealand
Order Bdelloidea	Adinetidae	**1**:6 / **2**:10
	Habrotrochidae	**3**:20 / **3**:37
	Philodinavidae	- / **1**:1
	Philodinidae	**8**:59 / **8**:72
Order Collothecacea	Atrochidae	**1**:1 / **1**:1
	Collothecidae	**2**:15 / **1**: 5
Order Flosculariacea	Conochilidae	**1**:5 / **1**:4
	Filiniidae	**1**:10 / **1**:8
	Flosculariidae	**7**:34 / **3**:6
	Hexarthridae	**1**:6 / **1**:4
	Testudinellidae	**2**:24 / **2**:7
	Trochosphaeridae	**2**:2 / -
Order Ploimida	Asplanchnidae	**2**:9 / **2**:7
	Brachionidae	**6**:48 / **6**:31
	Colurellidae	**3**:46 / **3**:22
	Dicranophoridae	**7**:32 / **4**:7
	Epiphanidae	**6**:11 / **3**:4
	Euchlanidae	**2**:15 / **3**:15
	Gastropodidae	**2**:7 / **2**:5
	Ituridae	**1**:3 / **1**:1
	Lecanidae	**1**:82 / **1**:38
	Lindiidae	**1**:5 / **1**:4
	Microcodonidae	**1**:1 / **1**:1
	Mytilinidae	**3**:11 / **2**:5
	Notommatidae	**13**:71 / **6**:37
	Proalidae	**3**:13 / **2**:8
	Synchaetidae	**3**:20 / **2**:14
	Trichocercidae	**3**:48 / **3**:38
	Trichotriidae	**3**:10 / **2**:3

Digononta: Bdelloidea

2(1). Stomach without a tubular lumen; food and excreta formed into pellets..1..**Habrotrochidae** (p. 21)
\- Stomach with a tubular lumen, sometimes indistinct; food and excreta not formed into pellets..**3**

3(2). Corona well-developed trochus discs or vestigial lobes..**4**
\- Corona a ventral ciliary field, non-retractible, proboscis non-retractible, rake apparatus present (Fig. 13:2)..**4. Adinetidae** (p. 22)

4(3). Corona large paired retractible trochus discs resembling two wheels (Fig. 13:1a-b)..**2. Philodinidae** (p. 22)
\- Corona lobed, rostrum present, both ciliated (Fig. 17:9)..**3. Philodinavidae** (p. 28)
(1 species known from N.Z. Not recorded from Aust.)

Class Digononta: Order Bdelloidea

Bdelloid rotifers are poorly known in this region. Largely as a result of the efforts of Murray early this century, the bdelloids of New Zealand became better known than those of Australia. The great number of taxa (cf. Table 1 & Appendix 1) from a relatively smaller area also may reflect climatic and environmental diffferences between the two regions (Shiel & Green, 1995). In any event, the bdelloids of the region are badly in need of detailed work and taxonomic revision. It is likely that more, possibly many more, bdelloids remain to be discovered from both areas. Some 350 spp. occur worldwide (Dr C. Ricci pers. comm.).

Bdelloids are very difficult to identify alive, and almost impossible when preserved, when they contract into characteristic barrel-shaped indeterminate "blobs". Narcotics generally are inefficient, although success with marcain was reported by Ricci & Melone (1984). Contracted bdelloids usually can be identified by compression on a slide and checking for malleate trophi. Resolution beyond order usually is difficult in such specimens. Taxa identified from Australian plankton collections are included in Koste & Shiel (1986), and those listed from New Zealand in Shiel & Green (1995). The systematics followed here are those of Donner (1965), which remains the most comprehensive global work on bdelloids. It is beyond the scope of this Workshop to attempt a species key to all the Bdelloidea, most of which are not collected in aquatic habitats, but frequent soil, damp moss, lichens, etc. The following keys enable discrimination at least to genus, with some of the most common species keyed and figured. For a full listing of bdelloids known from Australia and New Zealand, see Shiel & Koste (1979, 1986) and Shiel & Green (1995). The earlier taxonomic works listed in these reviews will enable species determination of the known taxa. The papers of Haigh (see Reference list) are significant for the N.Z. Bdelloidea.

Diagnosis
Body subdivided into pseudosegments which can be retracted teloscopically. Gonad and vitellarium paired. For fine structure of the genital organs see Amsellem & Ricci (1982). The corona usually consists of paired trochus discs on shorter or longer columnar bases (pedicels, Fig. 13:1a-b, **tr**). These are separated by a sulcus (**su**), which may be narrow, e.g. Fig. 14:3 Habrotrochidae, or wider, e.g. Fig. 13:1 Philodinidae. Dorsally there is an upper lip (**ul**), ventrally the mouth (**mu**) and the lower lip (**unl**). Below the lower lip the rostrum (proboscis) can be seen in lateral or dorsal view. This can also carry cilia. The proboscis is absent in the Adinetidae, which have only a non-retractile ciliary field (Fig. 13:2). Trochal discs mostly have a sensory hair (Fig. 13:1, sh). The lower part of the trochus stalk and the sulcus are ciliated. The shape of the upper lip is species-specific and therefore an important taxonomic character, e.g. bowed, triangular, 1-3 lobed. Occasionally it carries a small projection (ligula). Lateral antennae are absent, however the dorsal antenna (da) always is present. Light sensitive organs are found as cerebral eyes on the end of the brain (*Philodina*) or on the proboscis (*Rotaria*), however also may be absent (*Macrotrachela*). The foot has paired spurs of variable length (Fig. 13:3). The end segment of the foot is either toeless (Fig. 13:3e) or with 2-4 toes (Figs 13:3a-d). The foot glands (Fig. 13:3b) are well-developed. The mouth opening (Fig. 13:1b, **pha**) often opens into a long oesophagus (**pht**) leading to the mastax. The unci plates (Fig. 12:2b) strike here. Light grooves and often strong teeth or ridges are present. These enable each species to be given a tooth index, e.g. 2/2, 3/3/, 10/10. In addition to the main teeth, there may be weaker side teeth, which can be shown by a plus sign, e.g. 2+1/3 or 1/1+1.

1. Fam. Habrotrochidae Bryce, 1910

Habrotrochids are the most common bdelloids in both regions (Appendix 1). The three known genera are *Otostephanus*, *Scepanotrocha* and *Habrotrocha*. All are moss, leaf-litter and moist-soil dwellers, with *Habrotrocha* species occurring occasionally in plankton samples, mostly in those from billabongs and floodplain waters, where the animals may be dislodged from submerged or emergent macrophytes (Koste & Shiel 1986). Habrotrochids accumulate food in pellets in the oesophagus, which is elongated, sometimes with loops. The gut often has a frothy appearance, due to a syncytial mass of food vacoules (Wallace & Snell 1991).

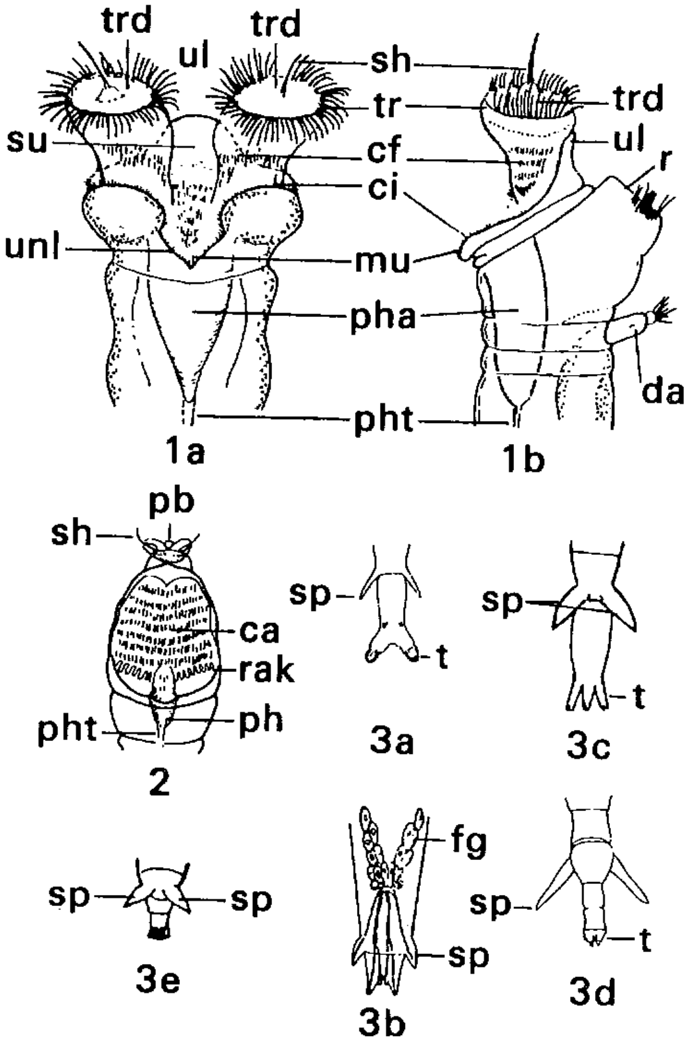


Fig. 13: 1. Corona of a bdelloid (Philodinidae). a., vental; b, lateral. **da**=dorsal antenna; **ci**=cingulum; **cf**=ciliary field; **ul**=upper lip; **unl**=lower lip; **mu**=mouth; **pha**=pharynx; **pht**=oesophagus; **r**=rostrum (proboscis with cilia); **sh**=sensilla; **su**=sulcus; **tr**=trochus; **trd**=trochus disc; **2.** Corona of *Adineta.* **ca**=ciliated area; **pb**=proboscis; **ph**=pharynx; **rak**=rake apparatus (teeth at base of ca); **sh**=sensilla.
3. Feet of different bdelloids. a, *Philodina gregaria* with four toes; b, *Philodina vorax* with four toes and foot glands; c, *Habrotrocha* with three toes; d, *Rotaria socialis*; e, *Mniobia* sp. without toes. fg=foot glands; sp=spur; t=toe. (Various authors, Koste & Shiel 1986)

Key to genera of Habrotrochidae from Australian/ N.Z. inland waters

1. A fine band or ring seen behind the coronal ciliary wreath of the trochus (Fig 14:1)........ *Otostephanus* Milne
\- No ring visible........ **2**

2(1). Upper lip with hood-like expansion (Fig. 14:2)........ *Scepanotrocha* Bryce
\- Upper lip without such expansion.(Fig. 14:3)........ *Habrotrocha* Bryce

To identify species from these genera, refer to Donner (1965) and the earlier reference lists therein.

2. Fam. Philodinidae Bryce, 1910

Most are inhabitants of mosses, soils, and sands of lakes and river beaches. A few species of philodinids may occur in plankton samples, particularly *Macrotrachela, Philodina* and *Rotaria.* The key to genera below is modified from Donner (1965), which should be referred to for species descriptions. *Anomopus* and *Zelinkiella* are not recorded from either Australia or N.Z., however their preferred habitats, the branchial chamber of crustaceans, and holothurians respectively, probably have not been well-investigated. They are included in the key below. For further information, see Donner (1965).

Key to the Genera of Philodinidae from Australian/ N.Z. inland waters

1. Foot with 4 toes (Fig. 13:3a-b)........ **2**
\- Foot with less than 4 toes or adhesive disc........ **5**

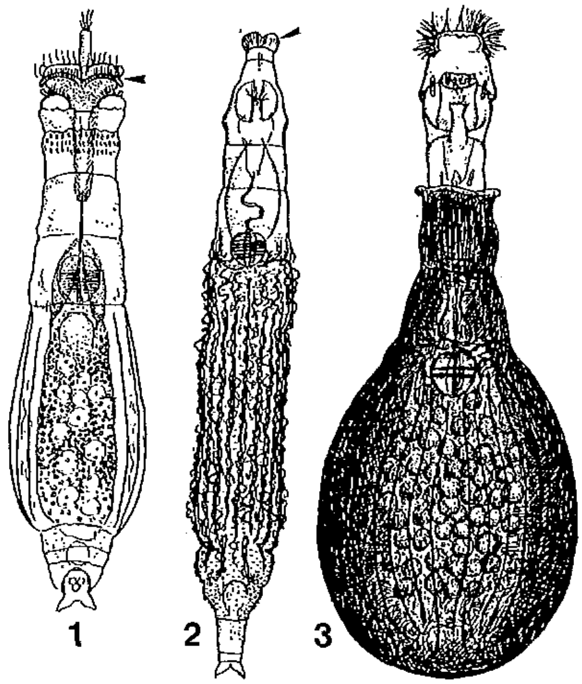


Fig. 14: Habrotrochid genera. 1, *Otostephanus* Milne (arrow indicates ciliary wreath); 2, *Scepanotrocha* Bryce (arrow indicates cowled expansion); 3, *Habrotrocha* Bryce. (From Donner (1965))

2(1). Cuticle of integument soft, slightly flexible..**3**
Cuticle firm, leatherlike, very flexible..**4**

3(2).- Foot long (ca. ½ the elongated body); spurs long and wide, coniform or hooked, oviparous or viviparous; often epizoic on crustaceans..*Embata* Bryce
\- Spurs not very long and broad; most with 2 cerebral eyes; most oviparous; seldom epizoic..*Philodina* Ehrenberg

4(1). Integument rigid; spurs very long; trunk broad with marked constriction; up to 5 longitudinal striae on the the ventral side of the trunk pseudosegment; viviparous..*Dissotrocha* Bryce
\- Spurs short; many striae (to 15) on the trunk; oviparous........*Pleuretra* Bryce

5(1). Foot with 2 distinct toes; spurs on rounded pedicels....*Didymodactylus* Milne (Not recorded from Australia; known from N.Z.. Requires revision, poorly known.)
\- Foot with 3 toes or disc which can have 2 stumpy toe-like papillae; spurs otherwise..**6**

6(5). Foot with 3 toes (may be difficult to see or doubtful)..**7**
\- Foot with adhesive disc, possibly with papillae; eyeless..**8**

7(6). Viviparous; eyes, when present, on rostrum; foot, spurs, toes, rostrum, antennae usually long..*Rotaria* Scopoli
\- Oviparous; foot, etc., exceptionally short; eyeless..........*Macrotrachela* Milne

8(6). Epizoic in branchial chamber of *Telphusa fluviatilis* (Crustacea); foot long; dental formula 1+1/1+1; corona very wide....................*Anomopus* Piovanelli
Habitat otherwise, dental formula otherwise..**9**

9(8). Epizoic on holothurians; rostrum without lamellae; viviparous..*Zelinkiella* Harring
\- Free-living; rostrum with lamellae; oviparous..**10**

10(9). Cingulum pad elongated anteriorly; corona displaced laterally, with a step, small horn or elongated process (Fig. 21)........................*Ceratotrocha* Bryce
- Cingulum pad not so constructed..*Mniobia* Bryce

Macrotrachela Milne, 1886

Twenty-two species are known from both Australia and N.Z., nine of them shared (Shiel & Koste 1979; Shiel & Green 1995).mostly in drying mosses, submersed plants, leaf litter and soil, but very rarely in the plankton. Two species have been recorded from plankton samples in S.E. Australia: *M. quadricornifera* Milne and *M. plicata* (Bryce) (Figs. 16:1, 2). For details and key to other *Macrotrachela* species, see Donner (1965).

Rotaria Scopoli, 1777

Of 26 described species, ten are known from Australia, nine from N.Z., with eight shared. By far the most common bdelloid in S.E. Australian plankton samples is *R. neptunia* (Fig. 15:2), which also is one of the more readily recognized bdelloids. The abbreviated key below is modified from Donner (1965) and Koste & Shiel (1986) for the species known from Australia and some of the N.Z. taxa. For other species keys, and full descriptions of the known taxa, see Donner (1965).

Key to species of the Rotaria from Australian/N.Z. inland waters

1. Dental formula always 3/3; striae on abdomen reach to foot; foot as long as rest of body (Fig. 15:1)..*R. tridens* (Montet)
Dental formula 2/2, occasionally 2/3...**2**

2(1). Foot extraordinarily long and thin (>1.5X BL) (Fig. 15:2)...*R. neptunia* (Ehrenberg)
- Foot when fully extended BL or shorter...**3**

3(2). Antenna very long [>70 µm) (Fig. 15:3).........................*R. macroceros* (Gosse)
- Antenna usual (cf. Fig. 15:8)...**4**

4(3). Head and feet colourless, trunk yellow-green (Fig. 15:5).*R. citrina* (Ehrenberg)
Head, feet and trunk not yellow-green..**5**

5(4). Ventral toes longer than spurs; spurs >2X as long as width of foot segment they derive from (Fig. 15:4)....................................*R. tardigrada* (Ehrenberg)
- Toes not longer than spurs...**6**

6(5). Rostrum exceptionally long; conspicuous protuberances on each side of dorsal antenna (Fig. 15:6)...*R. sordida* (Western)
- Neither of the above...**7**

7(6). Trunk sticky, usually covered with debris; darkly coloured; last (lumbar) segments, foot and spurs short (Fig. 15:7)......................*R. montana* (Murray)
Not as above...**8**

8(7). Trunk sharply demarcated from lumbar segments; foot and toe segments always <½ BL (Fig. 15:8)..*R. macrura* (Ehrenberg)
- Trunk tapering, not sharply demarcated...**9**

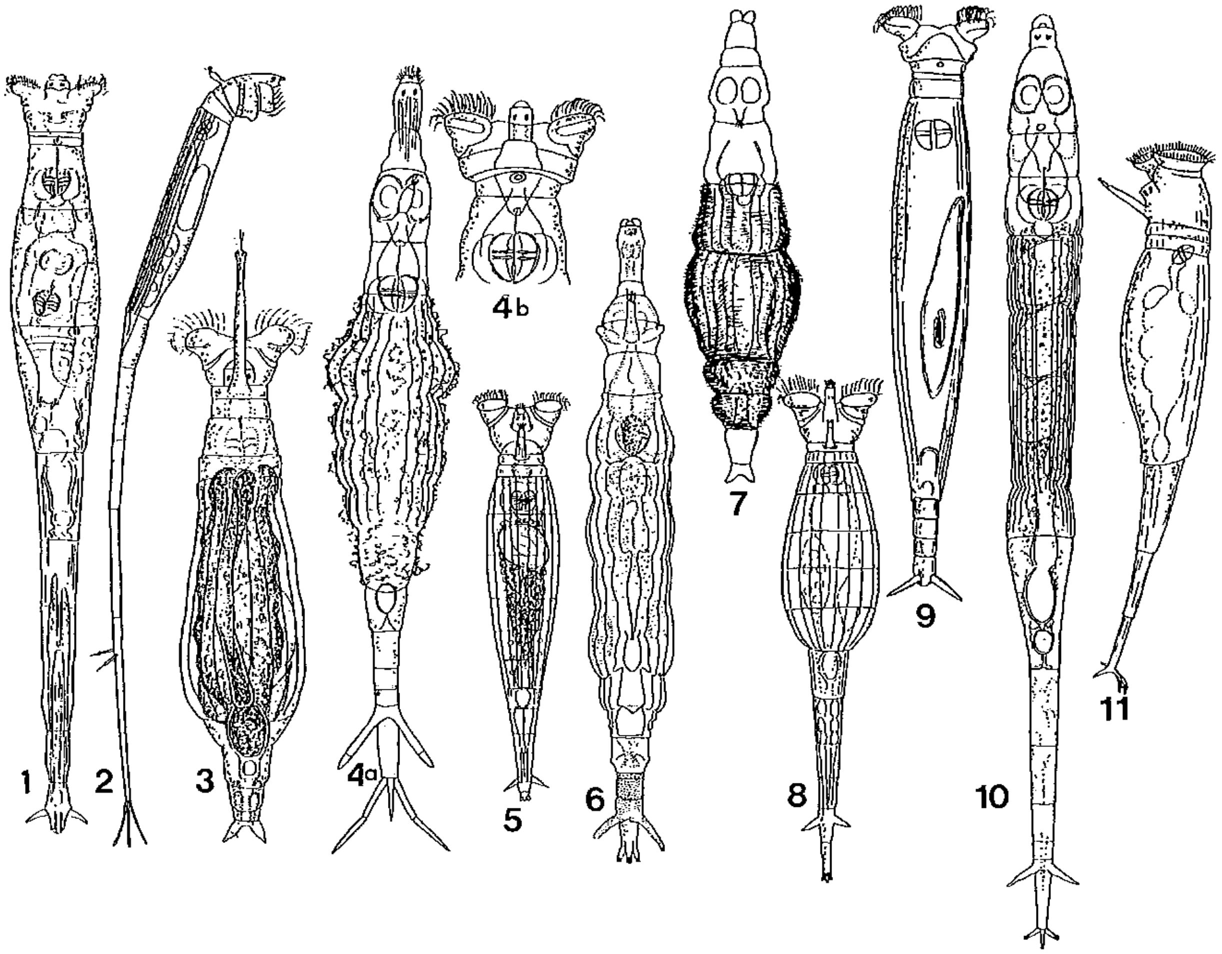


Fig. 15: *Rotaria* species: 1.*R. tridens* (Montet); 2, *R. neptunia* (Ehrenberg); 3, *R. macroceros* (Gosse); 4, *R. tardigrada* (Ehrenberg): a, corona contracted; b, extended; 5. *R. citrina* (Ehrenberg); 6, *R. sordida* (Western); 7, *R. montana* (Murray); 8, *R. macrura* (Ehrenberg); 9, *R. exoculis* De Koning; 10, *R. rotatoria* (Pallas); 11, *R. haptica* (Gosse). (Various authors, modified after Donner 1965)

9(8). Foot very short; dorsal toes longer than ventral; eyeless (Fig. 15:9)..*R. exoculis* De Koning
- Foot variable; dorsal toes not longer than ventral..**10**

10(9). Body whitish to light yellow-brown; trunk generally striated (Fig. 15:10)..*R. rotaria* (Pallas)
- Body clear, transparent; no obvious striae on trunk (Fig. 15:11)..*R. haptica* (Gosse)

Dissotrocha Bryce, 1910

Three species of *Dissotrocha* are recorded from Australia and N.Z., with two shared. The following key (modified after Donner, 1965 and Koste & Shiel 1986) discriminates the known Australian taxa. Others undoubtedly remain to be recorded.

Key to species of Dissotrocha from Australian inland waters

1. Trunk with spines or hook-like projections (Fig. 16)...*D. aculeata* (Ehrenberg)
- No obvious hooks (may be small spinules); trunk granulated, ornamented or smooth..2

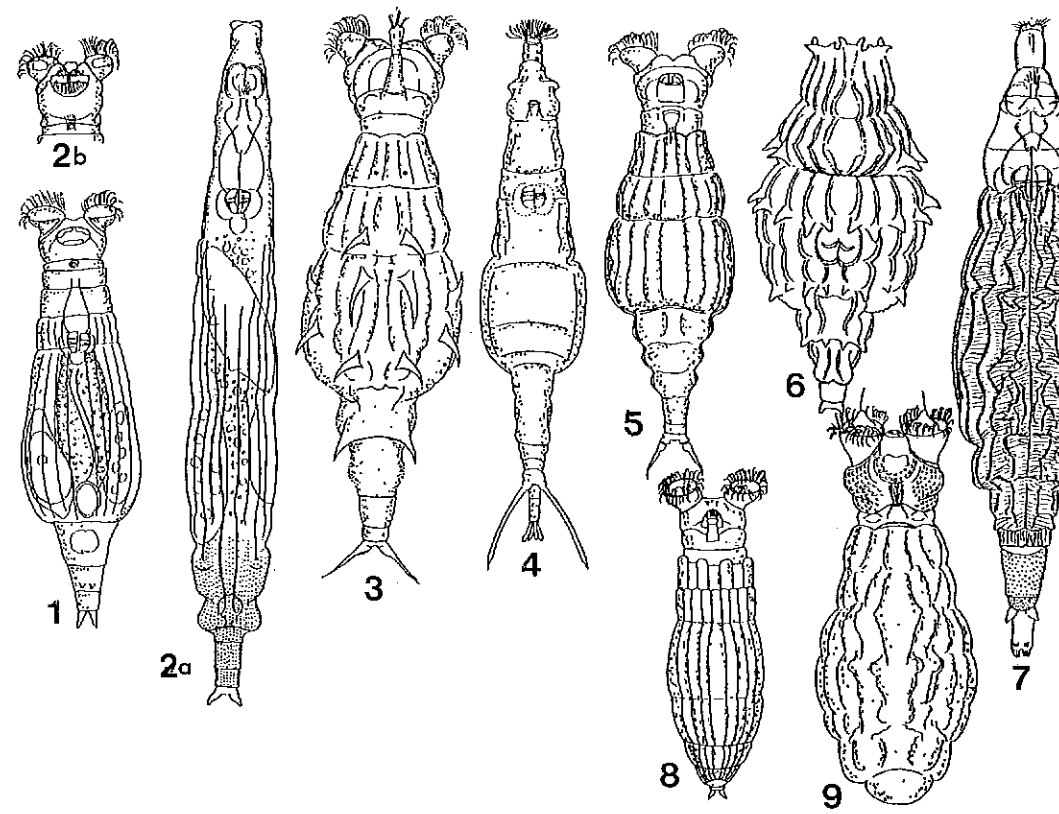


Fig. 16: 1, *Macrotrachela quadricornifera* Milne; 2, *M. plicata* (Bryce) a, head, extended; b, creeping; 3, *Dissotrocha aculeata* (Ehrenberg); 4. *D. hertzogi* Hauer; 5, *D. macrostyla* (Ehrenberg); 6. *Pleuretra brycei* (Weber); 7, *P. alpium* (Ehrenberg); 8, *P. lineata* Donner; 9, *P. humerosa* (Murray) (Various authors, after Donner 1965)

2(1). Spurs exceptionally long; rostrum cilia notably elongated..*D. hertzogi* Hauer (Fig. 16:1)
- Neither of the above..............................*D. macrostyla* (Ehrenberg) (Fig. 16:2)

Pleuretra Bryce, 1910

Three *Pleuretra* species are recorded from Australia, four from N.Z. All can be identified from the following key. Other species are detailed in Donner (1965).

Key to species of Pleuretra from Australian/N.Z. inland waters

1. Trunk with 3-4 rows of denticle-like projections (Fig. 16:6)...*P. brycei* (Weber)
- Trunk otherwise ornamented or smooth..**2**

2(1). Distinctive crinkled cuticle, finely striated; rostrum unusually long, laterally convex, clearly demarcated.(Fig. 16:7).................................*P. lineata* Donner
- Neither of the above...**3**

3(2). Obvious longitudinal grooves but no fine striae (Fig. 16:8)...*P. alpium* (Ehrenberg)
- No longitudinal grooves, trunk ornamented as Fig 16:9; distinctive granular region behind head...*P. humerosa* (Murray)

Embata Bryce, 1910

Five species are described, only one (*E. hamata*) from Australia and none from N.Z.. The most common species elsewhere (*E. laticeps*) also may occur here. Epizoic on crustacea and aquatic insects, sporadically between water plants. The genus is difficult to distinguish from *Philodina.*

Key to species of Embata from Australian inland waters

1. Spurs hook-shaped...*E. hamata* (Murray) (Fig. 17:1)
- Spurs straight...*E. laticeps* (Murray) (Fig. 17:2)

Philodina Ehrenberg, 1830

Nine of the 43 recognized species are known from Australia. All are recorded from N.Z., plus another seven taxa (Shiel & Green 1995). *Philodina* species are common in *Sphagnum* and other damp terrestrial habitats. Three species have been recorded incidentally in plankton samples in S.E. Australia (Koste & Shiel 1986) (cf. Figs 17:3, 4, 5). Refer to Donner (1965) for species identification.

Didymodactylus Milne, 1916

This rare bdelloid (Fig. 17:6) was recorded by Haigh (1968) from near Auckland, N.Z. It is not known from Australia. Donner (1965) describes it as an inhabitant of moss, leaf-litter and humus.

Mniobia Bryce, 1910

Nine species of *Mniobia* have been recorded from Australia, 15 from N.Z. (*Sphagnum,* damp terrestrial habitats). All Australian records appear to be from moss and lichens. See Donner (1965) for identification.

Ceratotrocha Bryce, 1910

Only *C. cornigera* (Bryce, 1893) (Fig. 17:7) known from Australia, also from N.Z., where a second species, *C. delicata* (Donner, 1949) (Fig. 17:8) also is recorded. The genus is recognizable by the characteristic elongation of the cingulum. Moss and damp habitats, see Donner (1965) for details.

3. Fam. Philodinavidae Harring, 1913

Of the three genera listed in the family (Donner 1965: 265). viz. *Abrochtha* Bryce, 1910, *Henoceros* Milne, 1916 and *Philodinavus* Harring 1913, only a single species of the latter genus (*P. paradoxus* (Murray, 1905) is recorded from N.Z. None are known from Australia. *P. paradoxus* may occur here - it is distinguished by the absence of coronal lobes - the ciliary area is a reduced field in the mouth area (Fig. 17:9). It is eyeless, and commonly entirely or in part carotene red. It appears to be littoral in habit, also collected in flowing water.

4. Fam. Adinetidae Bryce, 1910

Two genera (*Adineta, Bradyscela*) described, both known from N.Z. (10 spp. of *Adineta* and *Bradyscela clauda* Bryce, 1893 (Haigh 1963) (Fig. 18:1) , only *Adineta* known from Australia (six spp.). *Adineta* occurs occasionally in plankton collected over sandy or gravel substrata. Most are soil and moss dwellers. The key below includes *A. oculata,* which is not recorded from Australia, but in view of its occurrence in New Zealand, may be found here.

Key to species of the Adineta known from Australian inland waters

1. Rostrum with conspicuous red eyes with lenses...*A. oculata* (Milne) (Fig. 18:2)
- Rostrum eyeless...**2**

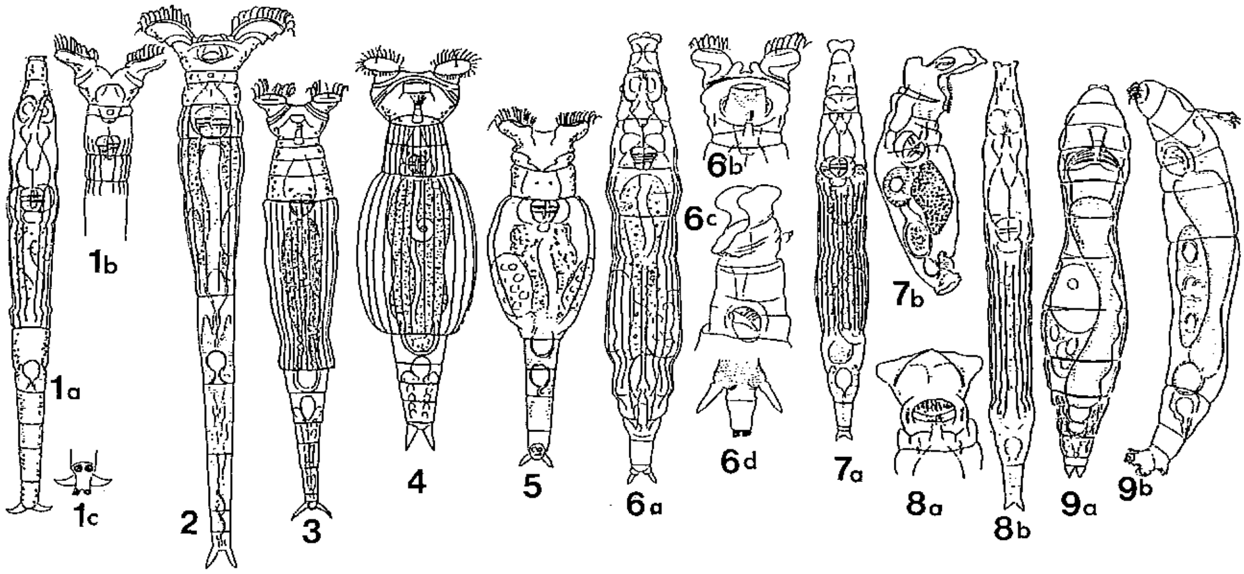


Fig. 17: 1, *Embata hamata* (Murray), a, creeping; b, corona extended; c, toes extended; 2, E. laticeps (Murray); 3, *Philodina roseola* Ehrenberg; 4, *P. citrina* Ehrenberg; 5, *P. megalotrocha* Ehrenberg; 6, Didymodactylus carnosus Milne, a, creeping; b, corona extended; c, head lateral; d, toes extended; 7, Ceratotrocha cornigera (Bryce), a, creeping; b, head lateral; 8, C. delicata (Donner), a, corona extended; b, creeping; 9, Philodinavus paradoxus (Murray), a, creeping;, b. lateral, creeping. {Various authors, after Donner (1965))

2(1). Cuticle, including foot, heavily granulated...*A. tuberculosa* Janson (Fig. 18:3)
Cuticle not granulated..**3**

3(2). Rostrum has long lateral auricles and/or very long lateral antennae............**4**
\- If either of these present, short or reduced..**5**

4(3). Spurs long (1/16 BL), tapering to hairlike; rostrum lamellae elongated..*A. longicornis* Murray (Fig. 18:4)
\- Spurs medium, not hairlike; rostrum with 3 or more long sensillae on each side...*A. barbata* Janson (Fig. 18:5)

5(3). Spur segment demarcated from foor by deep incision; spurs short, ca. <3 µm placed laterally on segment.................................*A cuneata* Milne (Fig. 18:6)
\- Spurs and segment offset not as above..**6**

6(5). Rostrum lamellae with wide, short auricles.............*A. vaga* (Davis) (Fig. 18:7)
\- Rostrum lamellae without auricles......................*A. gracilis* Janson (Fig. 18:8

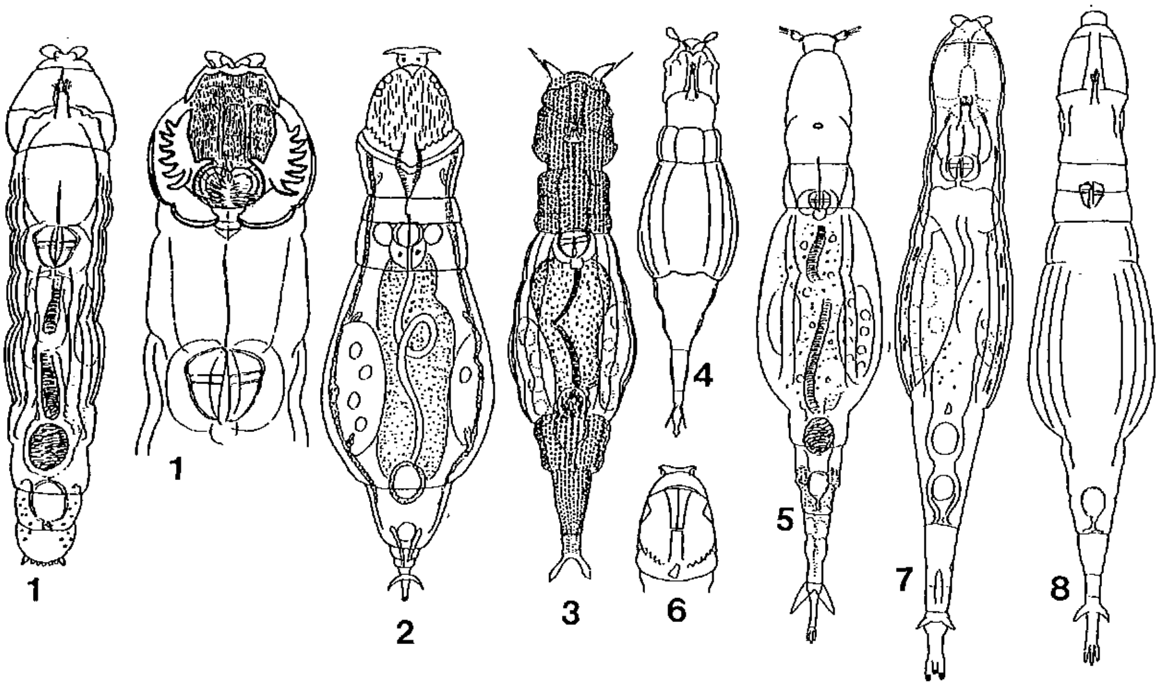


Fig. 18: 1, *Bradyscela clauda* Bryce, a, dorsal; b, head, ventral; 2, *Adineta oculata* (Milne); 3, *A. tuberculosa* Janson; 4, *A. longicornis* Murray; 5; *A. barbata* Janson; 6, *A. cuneata* Milne, head only; 7, *A. vaga* (Davis); 8, *A. gracilis* Janson. (Various authors, after Donner (1965))

Class Monogononta: Orders Collothecacea, Flosculariacea, Ploimida

The three orders of monogononts have received considerably more attention in Australia than have bdelloids, and as a result are somewhat better known taxonomically and ecologically. At present, >500 monogonont species are recognized from Australian inland waters, with ca. 280 from New Zealand (Appendix 1). As for the bdelloids, in view of the relatively poor coverage of both regions by collectors, it is likely that many monogononts are yet to be recorded. Some 2000 taxa are recognized globally.

Monogononta

1. TR uncinate (Fig. 12:1), corona as Fig. 20 (Collothecacea)............................**2**
\- TR not uncinate...**3**

2(1). Corona as Fig. 19..**1. Atrochidae** (p. 33)
\- Corona as Figs 20...**2. Collothecidae** (p. 33)

3(1). TR malleoramate (Fig. 12:2a); body morphology one of Figs 21-28...(Flosculariacea)..**4**
\- TR not malleoramate; body morphology otherwise...(Ploimida)....................**9**

4(3). Body as Fig. 21 with six setose appendages.............**3. Hexarthridae** (p. 36)
\- Body lacking such appendages...**5**

5(4). Corona U-shaped (Fig. 22); solitary or colonial.........**4. Conochilidae** (p. 36)
\- Corona not U-shaped; solitary, colonial, sessile, pelagic.............................**6**

6(5). Elongate, tubular rotifers, may have a tube or gelatinous sheath, some colonial, pelagic; corona in anterior view one of Fig. 23...**5. Flosculariidae** (p. 40)
\- Not elongate - body spherical, with or without 2-3 setae, or discoid............**7**

7(6). Spherical to ovoid rotifers without setae; corona terminal (*Horaëlla*) or equatorial band (*Trochosphaera*) (Fig. 27)...........**6. Trochosphaeridae** (p. 43)
Body globular with or without lateral setae, or discoid.................................**8**

8(7). Body globular, two antero-lateral setae behind corona, one or no posterior seta (Fig. 28)..**7. Filiniidae** (p. 45)
\- Small globular body (may be lobed in section), without setae, or discoid body (cf. Fig. 29)...**8. Testudinellidae** (p. 46)

9(3). TR forcipate (Fig. 10); corona resembling *Notommata*-type (Fig. 9:1,2); creeping, littoral forms.....................................**9. Dicranophoridae** (p. 49)
TR not forcipate...**10**

10(9). TR cardate (Fig. 11:3)...**11**
TR not cardate..**12**

11(10). Manubria with hooks, which can be seen laterally; creeping littoral forms..**10. Lindiidae** (p. 55)
- Elements of TR merge into one another (Fig.); epipharynx gripping hooks. Rare rotifers in the littoral (N. America). Not known from Aust./N.Z...**Birgeidae**

12(10). TR incudate (Fig. 11:4). Corona as Fig. 9:5. Trunk saccate, transparent, illoricate. Foot very short or absent...................**11. Asplanchnidae** (p. 57)
- TR not incudate...**13**

13(12). TR malleate (Fig. 11:1)...**14**
- TR virgate (Fig. 11:2)..**21**

14(13). Not loricate...**15**
- Loricate..**16**

15(14). Mouth in oblique, ventrally placed ciliated field, body shape wormlike, fusiform (deformed or swollen in parasitic species); TR nearly virgate in character...**12. Proalidae** (p. 58)
- Mouth in funnel-shaped buccal area (Fig. 7b); body & TR not as above...**13. Epiphanidae** (p. 61)

16(14). Lorica without sulci...**17**
- Lorica with sulci..**18**

17(16). Head, foot and toes loricate.................................**14. Trichotriidae** (p. 62)
- Only trunk loricate, except *Plationus patulus* (Fig. 38); corona of *Brachionus* type (Fig. 9:10); foot may be absent.......................**15. Brachionidae** (p. 64)

18(16). Lorica occasionally with medial ventral furrow; corona with broad lateral lamellae or shield which is not retractible; foot segments with needle-like paired toes, seldom single or asymmetric; littoral, rarely in plankton..**16. Colurellidae** (p. 72)
- Lorica without medial ventral furrow...**19**

19(18). Dorsal part of lorica without median sulcus...**20**
- Dorsal part of soft lorica with median sulcus; hard lorica with or without caudal apical spines..**17. Mytilinidae** (p. 78)

20(19). Dorsal and ventral plates of lorica connected by deep inward folded lamella; ventral plate generally narrower than dorsal corona (cf. Fig. 7:8)...**18. Euchlanidae** (p. 79)
- Dorsal and ventral plates of lorica connected by more or less simple sulci; first foot segment united with ventral plate; one or two toes; weak corona; mostly littoral...**19. Lecanidae** (p. 83)

21(17). Trunk, toes symmetrical...**22**
- Trunk, toes and trophi asymmetrical; trunk usually cylindrical, often arched and with asymmetrical dorsal crest; foot short with bristle-like toes; lateral antennae asymmetrically placed; eye on brain......**20. Trichocercidae** (p. 91)

22(21). Globular to pyriform rotifers; free-swimming in plankton................**23**

\- Wormlike, creeping, in littoral, only some species in plankton samples. Trunk symmetrical; corona ventral (Fig. 9:1, 2); trophi as Fig. 11:2 with many genus-specific variations............................**21. Notommatidae** (p. 96)

NB: Genus *Itura* relocated to new family, Ituridae (p. 108)

23(22). Stomach with 1-4 dark spots (blind sacs); trophi elements sometimes united; foot small or lacking; cuticle approaching loricate condition...**22. Gastropodidae** (p. 108)

Stomach without blind sacs..**24**

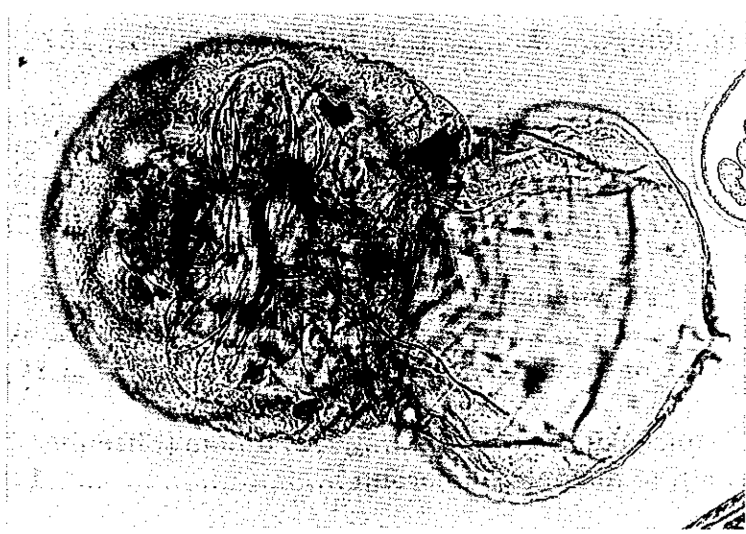
24(23). TR with complex V-shaped strong paired hypopharynx muscles; manubria with pronounced lamellae forming boundary of pumping chamber (Fig.65); one cerebral eye; corona with auricles (*Synchaeta*) or sword-shaped appendages (*Polyarthra*); inner organs not strongly coloured...**23. Synchaetidae** (p. 109)

TR with weak paired hypopharynx muscles; unci and manubria very reduced; trunk club-shaped, dorsum strongly arched; single toe; corona inclined ventrally; single eye; brain and organs coloured...**24. Microcodonidae** (p. 113)

Order Collothecacea Remane, 1933

1. Fam. Atrochidae Bartos, 1959

Three genera of atrochids are known: *Cupelopagis, Acyclus* and *Atrochus.* A key to the genera is given by Koste (1978). *Cupelopagis vorax* (Leidy, 1857) (Fig. 19) is the only atrochid known from Australia/N.Z. The large hood-like corona is so distinctive that *C. vorax* cannot be confused with anything else. It is a predator of smaller rotifers, and inhabits submersed macrophytes, particularly the underside of floating leaves.



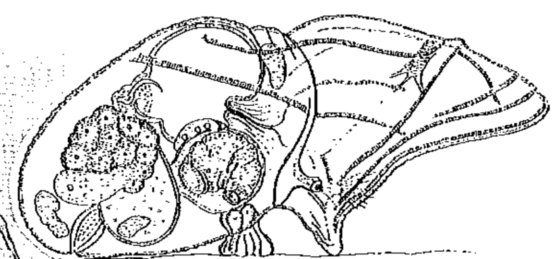


Fig. 19: *Cupelopagis vorax* (Leidy) a. feeding; b, lateral. (Both original, Walter Koste)

2. Fam. Collothecidae Bartos, 1959

Collothecids are largely epiphytic or epibenthic, inhabiting submerged or fringing vegetation. Three species, *C. pelagica, C. libera* and *C. mutabilis* are adapted to a pelagic existence. They can be distinguished from similar small amorphous plankters (e.g. *Conochilus*) by the elongate morphology, even when preserved, and the presence of a gelatinous sheath, which often contains eggs adjacent to the foot.

The family has not yet been revised for Australia or New Zealand. The key below is provisional, modified from Koste (1978) pending completion of an Australasian revision (Shiel & Koste, in prep.). Of two genera, *Stephanoceros* (1 spp.) and *Collotheca* (11 spp.) are known from Australia. Only one appears to be endemic - *Collotheca evansonii*, described by Anderson & Shephard (1892) from a pond near Oakleigh,Vic., and apparently not seen since. Five species of *Collotheca* are known to date from New Zealand (Shiel & Green, 1995).

Key to genera and species of Collothecidae known from Australia and New Zealand.

1. Coronal margin with five long tentacles set with stiff cilia (Fig. 20:1)....................*Stephanoceros fimbriatus* Goldfusz, 1820
- Margin with lobulate, tentaculate or other form, not set with rigid cilia (cf. Figs. 20:2-12)....................*Collotheca* Harring...2

2. Adult sessile....................**5**
- Pelagic in gelatinous matrix....................**3**

3(2). Corona smooth margined with rudimentary lobes (Fig. 20:2)....................*C. pelagica* (Rousselet)
- One or two obvious ciliated lobes....................4

4(3). One large dorsal lobe (Fig. 20:3)....................*C. libera* (Zacharias)
- Two lobes (Fig. 20:4)....................*C. mutabilis* (Hudson)

5(2). Corona margin with lobes, tentacles or triangular projections....................**6**
- Corona margin smooth (Fig. 20:5)....................*C. edentata* (Collins, 1872)

6(5). Corona margin tentaculate or with pointed projections....................**9**
- Corona margin with three or five broad lobes....................**7**

7(6). Corona with five lobes....................**8**
- Corona with three lobes (Fig. 20:6)....................*C. trilobata* (Collins, 1872)

8(7). Foot long with holdfast of variable length (Fig. 20:7)....................*C. campanulata* (Dobie, 1849)
- Foot short in relation to body; holdfast with strong adhesive disc (Fig. 20:8)....................*C. ambigua* Hudson, 1883)

9(6). Corona with body-length tentacles (Fig. 20:9)....................*C. tenuilobata* (Anderson, 1889)
- Corona with five short tentacles or knobbed triangular apices....................**10**

10(9). Corona with short knobbed apices (Fig. 20:10)....................*C. ornata* (Ehrenberg)
- Apices/tentacles longer, length to diameter of corona....................**11**

11(10). Corona with five long knobbed apices arising from smooth margin (Fig. 20:11); animal large (to 1.2 mm) in clear gelatinous sheath....................*C. coronetta* (Cubitt, 1869)
- Tentacles arise from distinct rim; animal small (<400 µm) in fluffy opaque or translucent sheath (Fig. 20:12)....................*C. evansonii* (Anderson & Shephard)

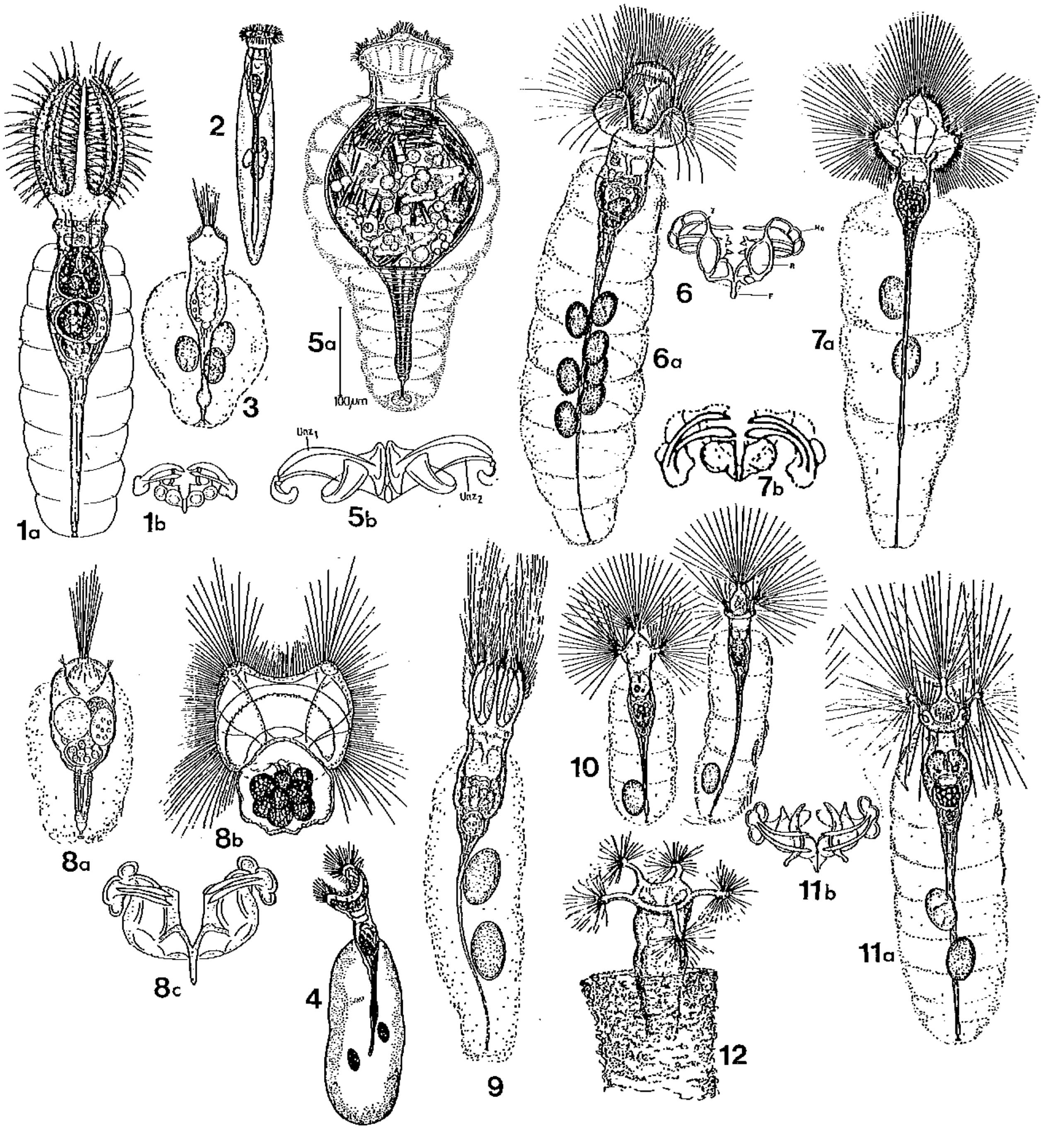


Fig. 20: 1, *Stephanoceros fimbriatus* Goldfusz, 1820; 2, *Collotheca pelagica* (Rousselet); 3, *C. libera* (Zacharias); 4, *C. mutabilis* (Hudson); 5, *C. edentata* (Collins, 1872); 6, *C. trilobata* (Collins, 1872); 7, *C. campanulata* (Dobie, 1849); 8, *C. ambigua* Hudson, 1883); 9, *C. tenuilobata* (Anderson, 1889); 10, *C. ornata* (Ehrenberg); 11, *C. coronetta* (Cubitt, 1869); 12, *C. evansonii* (Anderson & Shephard). (Original authors and Koste (1978).

Order Flosculariaceae Remane, 1933

3. Fam. Hexarthridae Bartos, 1959

The single genus, *Hexarthra*, is readily recognized by its characteristic pyriform body with six setose arms: 1 dorsal, 2 dorsolateral, 2 ventrolateral and 1 ventral (Fig. 21). Six species of *Hexarthra* are recorded from Australia, seasonal or perenial in the plankton of most inland waters. Three of them also occur in New Zealand, plus *H. propinqua* (Bartos, 1948) (Russell 1959), which is not known from Australia.. Of the known taxa from Australia, *H. mira* and *H. intermedia* are the most common freshwater species, *H. fennica* and *H. jenkinae* in brackish-saline waters. *H. oxyuris* and *H. polyodonta* are rare. Any of the global taxonomic works on rotifers (e.g. Kutikova 1970, Koste 1978) provide general taxonomic and ecological details for *Hexarthra* species.) The family has not been revised for Australia; the provisional key below is modified from Koste (1978), based on trophi dentition and known habitat preference. Trophi structure is more readily observed than armature of the limbs and general morphology for this peculiar plankter. For other morphological discriminators, see Koste (1978).

Key to species of Hexarthra known from Australia/N.Z.

1. Paired caudal appendages present (Fig. 21:1)..**2**
\- Paired caudal appendages absent...**3**

2(1). Trophus with 3 large and 2 small unci teeth.(Fig. 21:1)...*H. intermedia* Wiszniewski
\- Trophus with 3 large and 3 small unci teeth (Fig 21:2).........*H. mira* (Hudson)

3(1). Only found in saline or brackish water...**4**
\- Only in fresh water (N.Z.), 5/5 unci teeth (Fig. 21:3)......*H. propinqua* (Bartos)

4(3). 6-8 pairs of unci teeth; (chloride dominated saline waters)..........................**5**
\- 9-13 pairs of teeth; (soda dominated waters)..**6**

5(4). 7/7 unci teeth; obvious caudal spine (Fig. 21:4)...............*H. oxyuris* (Sernov)
\- 7/7 (may be ±1) unci teeth; no caudal spine(Fig. 21:5)...*H. fennica* (Levander)

6(4). 9-10 pairs of unci teeth (Fig. 21:6); body <200 µm...*H. jenkinae* (De Beauchamp)
\- 10-11 pairs of unci teeth; body >200 µm (Fig. 21:7)......*H. polyodonta* (Hauer)

Niche: Detritivore/bacteriovore/algivore (small cells, e.g. *Spirulina, Chlorella*)

4. Fam. Conochilidae Remane, 1933

The single genus, *Conochilus* Ehrenberg, is a common component of the plankton in inland fresh waters. There are solitary and colonial species. Five taxa have been recorded from Australia, three of them also from New Zealand. In addition, there is a single record of *C. exiguus* Ahlstrom (Shiel & Green 1995). *Conochilus* spp. can be identified by a combination of colony morphology, individual morphology and trophi dentition. The family has not been revised from Australia. The key to species is provisional, modified from Koste (1978).

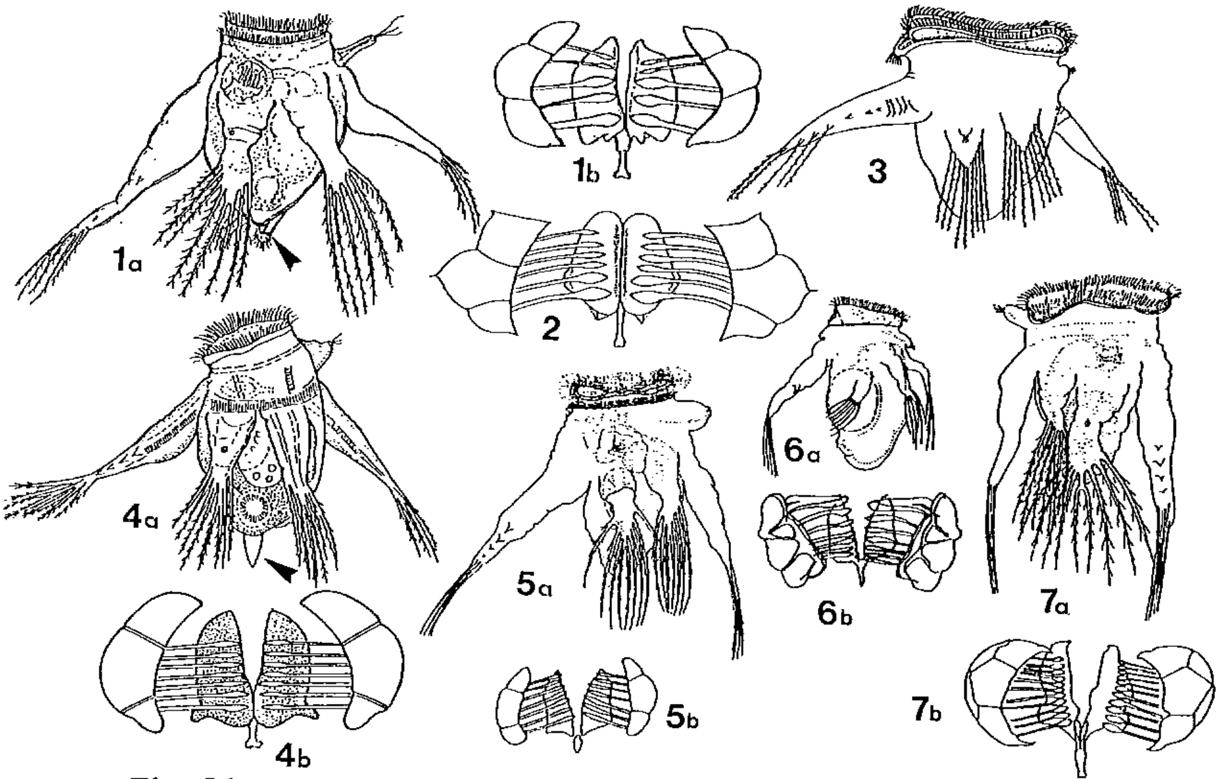


Fig. 21: *Hexarthra* species and trophi: 1, *H. intermedia* Wiszniewski, a, lateral, caudal appendages arrowed; b, trophus; 2, *H. mira* (Hudson), trophus; 3, *H. propinqua* (Bartos) lateral; 4, *H. oxyuris* (Sernov) a, lateral; b, trophus; 5, *H. fennica* (Levander), a, lateral; b, trophus; 6, *H. jenkinae* (De Beauchamp), a, lateral; b, trophus; 7, *H. polyodonta* (Hauer), a, lateral; b, trophus. (After Bartos (1959), Koste (1978), Shiel & Koste (1986))

Key to species of Conochilus known from Australia/N.Z.

1. Colonial, many individuals (when alive - preserved colonies may disintegrate)........**2**
\- Solitary (or with 1-2 juveniles in gelatinous sheath with adult)........**3**

2(1). Colonies 30-200 individuals; ventral antennae separate (Fig. 22:1)........*C. hippocrepis* (Schrank)
Colonies <30 individuals; ventral antennae completely or partly fused (Fig. 22:2)........*C. unicornis* Rousselet

3(1). Trophi symmetric (Fig. 22:3)........*C. natans* (Seligo)
\- Trophi asymmetric (Fig. 22:4, 5, 6)........**4**

4(3). Three large unci teeth opposed by 3 partly fused large teeth (Fig. 22:4)........*C. coenobasis* (Skorikov)
4-5 unci teeth........**5**

5(4). Four slender main uncus teeth opposed by four (last may be bifurcate) main teeth; adult <200 µm.(N.Z. record) (Fig. 22:5)........*C. exiguus* Ahlstom
Uncus with five distinct large teeth opposed by 5-6 indistinctly fused teeth (Fig. 22:6); adult >200 µm........*C. dossuarius* Hudson

Niche: Planktonic detritivore/bacteriovore/herbivore (small algae, *viz.* diatoms, chrysophytes, monads) (Pourriot 1965)

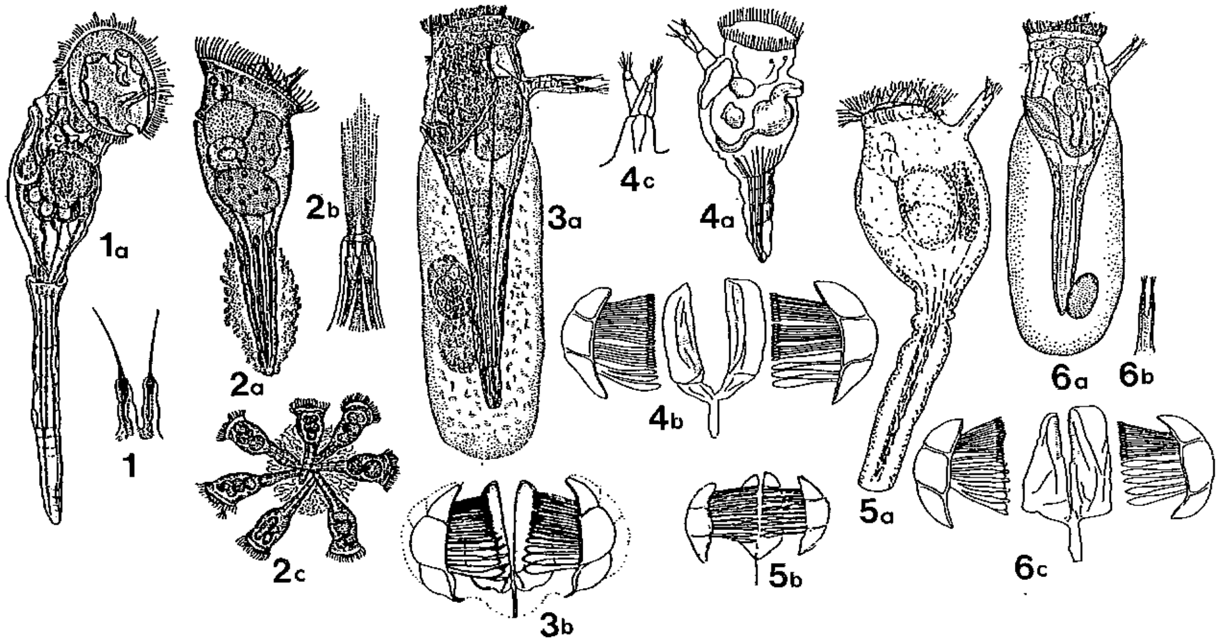


Fig. 22: *Conochilus* species: 1, *C. hippocrepis* (Schrank): a, lateral; b, ventral antennae; 2, *C. unicornis* Rousselet: a, lateral; b, ventral antennae; c, colony; 3, *C. natans* (Seligo): a, lateral; b, trophus; 4, *C. coenobasis* (Skorikov): a, lateral; b, trophus; c, ventral antennae; 5, *C. exiguus* Ahlstrom: a, lateral; b, trophus; 6, *C. dossuarius* Hudson: a, lateral; b, ventral antennae; c, trophus. (Various authors: Ahlstrom (1938), Koste (1978), Kutikova (1970))

5. Fam. Flosculariidae Harring, 1913

Flosculariids are tubular solitary or colonial, sessile or planktonic rotifers, some of which build distinctive cases for shelter. Thirty-three species in all seven known genera of flosculariids are reported from Australia. Only six species of flosculariids in three genera are known from N.Z. Of these, only *Ptygura velata* (Gosse) is not known from Australia. Other species of flosculariids may be expected in both regions. The family has not yet been revised here, hence the key to genera and species below is is provisional until such a revision is completed. The key is modified in part from Koste (1978). The shapeof the corona is significant in determining genera (Fig. 23:8-13).

Key to genera of Flosculariidae known from Australia/N.Z.

1. Dorsal antenna exceptionally long (Fig. 23:1).....*Beauchampia* Harring (p. 39)
\- Dorsal antenna on only short papilla...**2**

2(1). Corona with 2-, 4- or 8 distinct lobes (Fig. 23:2).......................................**3**
Corona not lobed..**5**

3(2). Corona bilobed..*Limnias* Schrank (p. 39)
\- Corona with >2 lobes..**4**

4(3). Corona 4-lobed; gelatinous case or sheath of pellets..*Floscularia* Cuvier (p. 39)
\- Corona 8-lobed (Fig. 21:13)....................................*Octotrocha* Thorpe (p. 39)

5(2). Corona cruciform, occasionally lightly indented......*Ptygura* Ehrenberg (p. 40)
\- Corona heart-, kidney- or egg-shaped...**6**

6(5). Corona kidney-shaped; egg carried behind anus; colonial or solitary; pelagic or sessile............................*Sinantherina* Bory De St Vincent (p. 42)
- Corona heart-shaped to ovoid; egg not carried behind anus; colonial; pelagic or attached to vegetation....................*Lacinularia* Schweigger (p. 42)

Beauchampia Harring

A monospecific genus, with *Beauchampia crucigera* Dutrochet (Fig. 23:1) recorded from Australia, and likely to be found in New Zealand. It is cosmopolitan according to Koste (1978). The long dorsal antenna is characteristic. The rotifer builds a long tubular case, commonly on vegetation. The case is brownish, often has detritus attached.

Niche: ?detritivore/herbivore.

Limnias Schrank

Another case-builder, both known species of *Limnias* are recorded from Australia, only *L. ceratophyli* from N.Z.

Key to species of Limnias known from Australia

1. Small horns behind corona; case with distinct annular rings (Fig. 23:2)....................*L. melicerta* Weisse
- No horns behind corona; case unstructured (Fig. 23:3)....................*L. ceratophylli* Schrank

Niche: ?detritivore/herbivore.

Floscularia Cuvier

Adults are sessile on vegetation, sometimes on macroinvertebrates, e.g. Trichoptera. Cases are formed from gelatinous secretions or faecal pellets, can be used in species discrimination. Three species are known from Australia, two of them also from N.Z.

Key to species of Floscularia

1. Case formed from large or small pellets....................2
- Diffuse gelatinous case (Fig. 23:4)....................*F. melicerta* (Ehrenberg)

2(1). Case of small brownish, tightly-packed pellets (Fig. 23:5)....................*F. ringens* (Linneaus)
- Pellets large, spongy (Fig. 23:6)....................*F. janus* (Hudson)

Niche: ?detritivore/herbivore.

Octotrocha Thorpe

Monotypic genus. There is a single record of *Octotrocha speciosa* Thorpe (Fig. 23:7) from Buffalo billabong, Magela Ck, N.T. (Koste & Shiel 1983). This distinctive large rotifer (to 2 mm long) is sessile in a gelatinous case on submerged vegetation. If animals are contracted and lobes of corona not visible, trophi structure is characteristic Fig. 23:7b).

Niche: ?detritivore/herbivore.

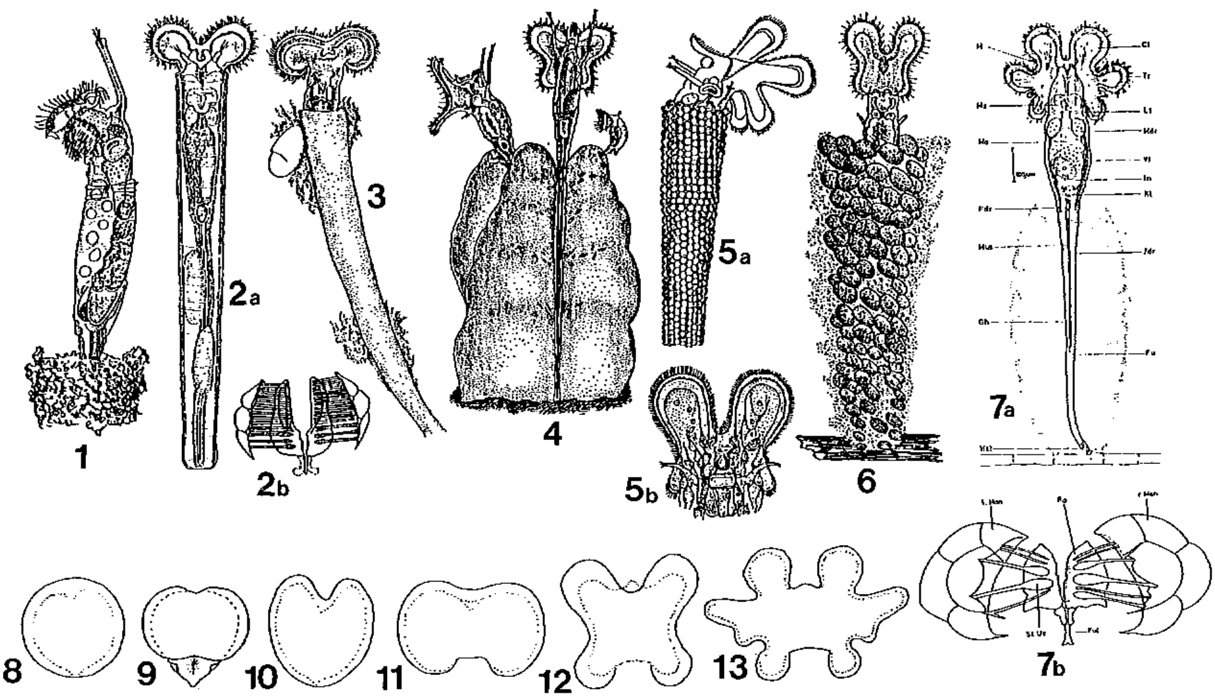


Fig. 23: Flosculariid genera and species: 1, *Beauchampia crucigera* Dutrochet; 2, *Limnias melicerta* Weisse; 3, *L. ceratophylli* Schrank; 4. *Floscularia melicerta* (Ehrenberg); 5, *F. ringens* (Linneaus); 6, *F. janus* (Hudson); 7, *Octotrocha speciosa* Thorpe; 8-13 coronae outlines of: 8, *Ptyugura*; 9, *Beauchampia*; 10, *Lacinularia* & *Sinantherina*; 11, *Limnias*; 12, *Floscularia*; 13. *Octotrocha*. (Various authors: Koste (1978); Kutikova (1970); Remane (1933))

Ptygura Ehrenberg

Common in the littoral of billabongs, on submerged vegetation, *Ptygura* species also are case-builders. Thirteen species are known from Australia, three from N.Z. The following key is based on observation of living animals. Until the trophi structure of the known species is detailed, there will be difficulty in keying preserved specimens. Refer to Koste (1978) for more detailed descriptions, distributions, etc.

Key to species of Ptygura known from Australia

1. Ventral antenna on short or indistinct papilla..**6**
\- Long ventral antenna..**2**

2(1). Case formed from pellets (Fig. 24:1)....................................*P. pilula* (Cubitt)
Case otherwise..**3**

3(2). Case tubular; animal has processes ('hooks', 'pegs') behind corona.............**4**
\- Case not tubular; no processes on neck (Fig. 24:2).........*P. longicornis* (Davis)

4(3). Dorsal neck 'hooks' bifurcate..**5**
\- Dorsal neck hooks single, long, acute (Fig. 24:3)...........*P. tacita* Edmondson

5(4). Dorsal neck processes arise from paired tubercles; BL <300 µm (Fig. 24:4)..*P. barbata* Edmondson
\- Dorsal neck processes arise from curved stumpy structures; BL >300 µm (Fig. 24:5)..*P. brachiata* (Hudson)

6(1). Corona with conspicuous ribs..**7**
- Corona without distinct ribs..**9**

7(6). Trophi <30 µm..**8**
- Trophi >35 µm (Fig. 24:6).......................................*P. crystallina* (Ehrenberg)

8(7). cf. Fig. 24:7, corona small, widely elliptical...........*P. beauchampi* Edmondson
- cf. Fig. 24:8, corona to 140 µm (N.Z.)...................................*P. velata* (Gosse)

9(6). Corona held almost at right angle to trunk; antennae in extended animal on broad papilla (Fig. 24:9)...........................*P. wilsonii* (Anderson & Shephard)
- Corona and antennae not as above..**10**

10(9). Case annulated; corona unusally wide; ventral antennae short, tubular; BL 700-720 µm (not figured)..*P. intermedia* Davis
- Features not as above..**11**

11(10).Corona with variable apical process (Fig. 24:10)..........*P. pectinifera* (Murray)
- Corona without apical process..**12**

12(11).Stalked forked process behind corona...**13**
- Small unforked pegs or hooks behind corona (Fig. 24:11)...*P. melicerta* (Ehrenberg)

13(12).Single stalked process as Fig. 24:12.............................*P. furcillata* (Kellicott)
- Dorsal process as Fig. 24:13..*P. elsteri* Koste

Niche: ?detritivore/herbivore.

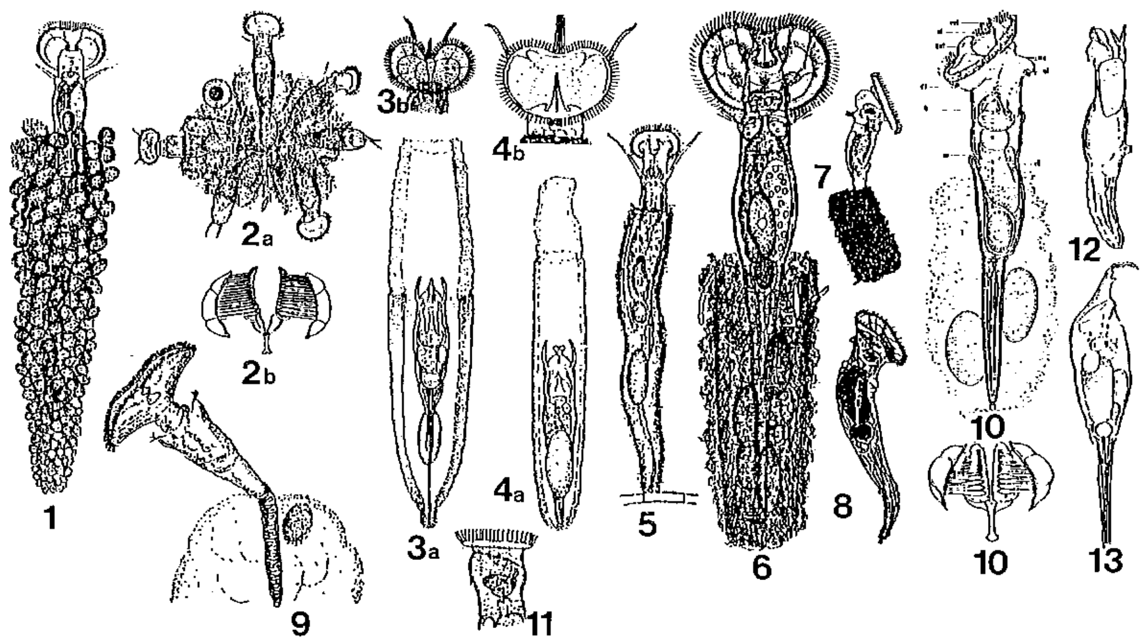


Fig. 24: *Ptygura* species: 1, *P. pilula* (Cubitt); 2, *P. longicornis* (Davis): a, colony, b, trophus; 3, *P. tacita* Edmondson: a, contracted; b, corona; 4, *P. barbata* Edmondson: a, contracted; b, corona; 5, *P. brachiata* (Hudson); 6, *P. crystallina* (Ehrenberg); 7, *P. beauchampi* Edmondson; 8, *P. velata* (Gosse); 9, *P. wilsonii* (Anderson & Shephard); 10, *P. pectinifera* (Murray); 11; *P. melicerta* (Ehrenberg); 12, *P. furcillata* (Kellicott); *P. elsteri* Koste. (Various authors, from Koste (1978))

Sinantherina Bory De St Vincent

Most often collected as colonies attached to vegetation, *Sinantherina* species may be found in pelagic colonies, or as individuals. Most readily confused with *Lacinularia* species, the two genera usually can be separated by the shape of the corona, which is commonly more rectangular in *Sinantherina* (cf. Figs. 23:10 & 25:3), the egg location, and trophi structure. Five species are known from Australia, none from N.Z. The following key is provisional until the genus is revised.

Key to the species of Sinantherina known from Australia

1.	Ventral side of trunk spinulated (Fix. 25:1)	*S. spinosa* (Thorpe)
-	Trunk not spinulated	**2**
2(1).	Dark tubercles ('neck-warts') present behind corona	**3**
-	Tubercles absent (Fig. 25:2)	*S. aripripes* Edmondson
3(2).	Two tubercles present (Fig. 25:3)	*S. semibullata* (Thorpe)
-	Four tubercles present	**4**
4(3).	Solitary animal with long foot (Fig. 25:4)	*S. procera* (Thorpe)
-	Colonial; foot short or medium (Fig. 25:5)	*S. socialis* (Linnaeus)

Niche: ?detritivore/herbivore.

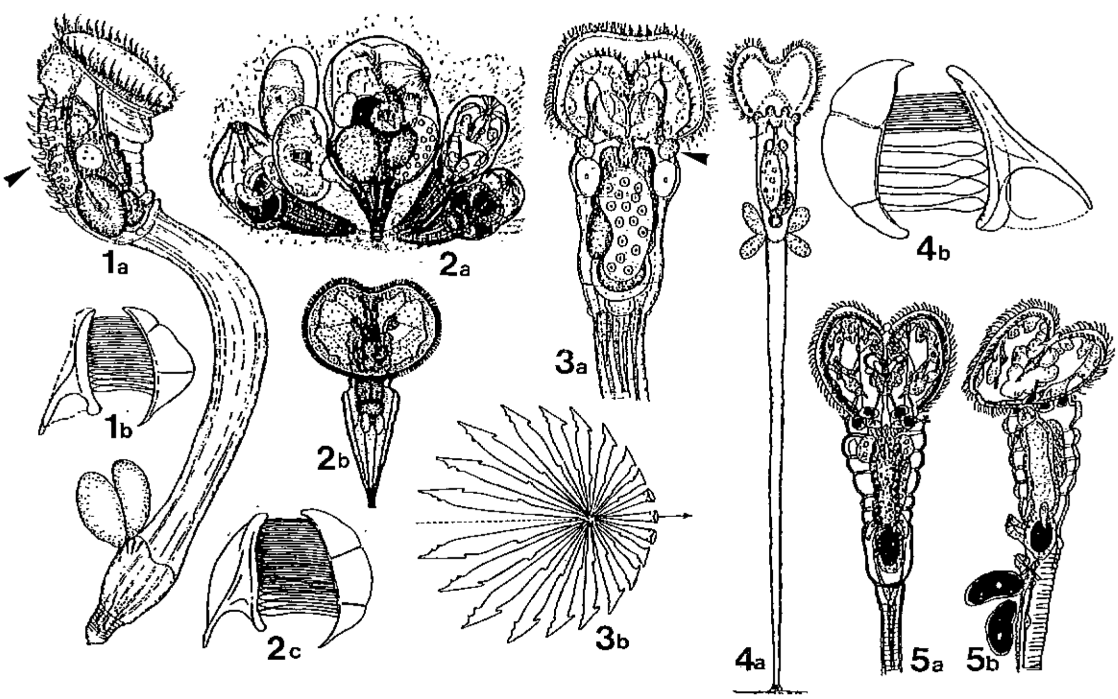


Fig. 25: *Sinantherina* species: 1, *S. spinosa* (Thorpe): a, extended; b, ½ trophus; 2, *S. aripripes* Edmondson: a, contracted colony; b, individual; c, ½ trophus; 3, *S. semibullata* (Thorpe): a, head; b, colony; 4, *S. procera* (Thorpe): a, extended; b, ½ trophus; 5, *S. socialis* (Linnaeus): a, ventral; b, lateral. (Various authors, after Koste (1978))

Lacinularia Schweigger

Colonial rotifers common in the plankton of reservoirs and billabongs, *Lacinularia* colonies also may be found attached to vegetation in littoral areas. Eight

Lacinularia species are known from Australia, none have been recorded from New Zealand. The genus requires revision for Australia - several of the species described from Victoria by Anderson & Shephard late last century have not been recorded (or recognized?) again, and have generally been neglected in global revisions. As for the other unrevised genera, the following working key is provisional, in part modified from Koste (1978), and in part from the original authors' descriptions. Other species of *Lacinularia* may be expected in Australia.

Key to the species of Lacinularia known from Australia

1. Colony sessile, attached to submerged stems..**2**
\- Colony free-floating/pelagic..**3**

2(1). Colony (variable size) looks like wattle blossom, yellow to greenish; individuals to 2.6 mm; coronae heart-shaped, held at 45° angle to trunk; entire cuticle noticeably striated longitudinally (Fig. 26:1)..*L. striolata* Shephard
\- Colony (to 2.5 mm diam.) brownish in colour; individuals to 1 mm; coronae slightly oval, with short axis at right angle to trunk (Fig. 26:2); no striae...*L. elongata* Shephard

3. Colony ellipsoidal, organized in an elongated gelatinous sheath along a rod axis...**4**
\- Colony spherical, of variable size, radially arranged, no median rod............**5**

4(3). Corona circular, slightly wider than body; trunk constricted at peduncle; large and obvious foot glands; colony to 250 individuals (Fig. 26:3)...*L. elliptica* Shephard
\- Corona ovoid with shallow ventral sinus; trunk not contricted; ?foot glands not obvious; colony of ca. 150 individuals....................*L. racemovata* Thorpe
[NB: These taxa were regarded by Koste (1978) as possibly the same species, however the separation is maintained here in view of Shephard's (1897) comment that although similar, they differed in the form of the corona, trophi structure, trunk constriction and foot glands.]

5(3). Corona nearly circular with shallow ventral embayment.............................**6**
\- Corona heart-shaped, with deep ventral sinus...**7**

6(5). Ventral antennae on short widely-spaced tubercles · (Fig. 26.4)...*L. pedunculata* Hudson
\- Ventral antennae on long papillae (Fig. 26:5).......*L. ismaeloviensis* Poggenpol

7(5). Small colonies, <20 individuals; coronae appear reticulated on ventral surface (Fig. 26:6).....................................*L. reticulata* Anderson & Shephard
\- Large colonies (to 5mm diameter); coronae not as above (Fig. 26:7)...*L. flosculosa* (Müller)

Niche: bacteriovore/?detritivore/herbivore

6. Fam. Trochosphaeridae Bartos, 1959

One species from both genera of trochosphaerids is known from Australia. Neither genus is recorded from New Zealand. *Trochosphaera aequatorialis* Semper is a rare plankter to date recorded only from tropical Australia, *Horaëlla brehmi* Donner

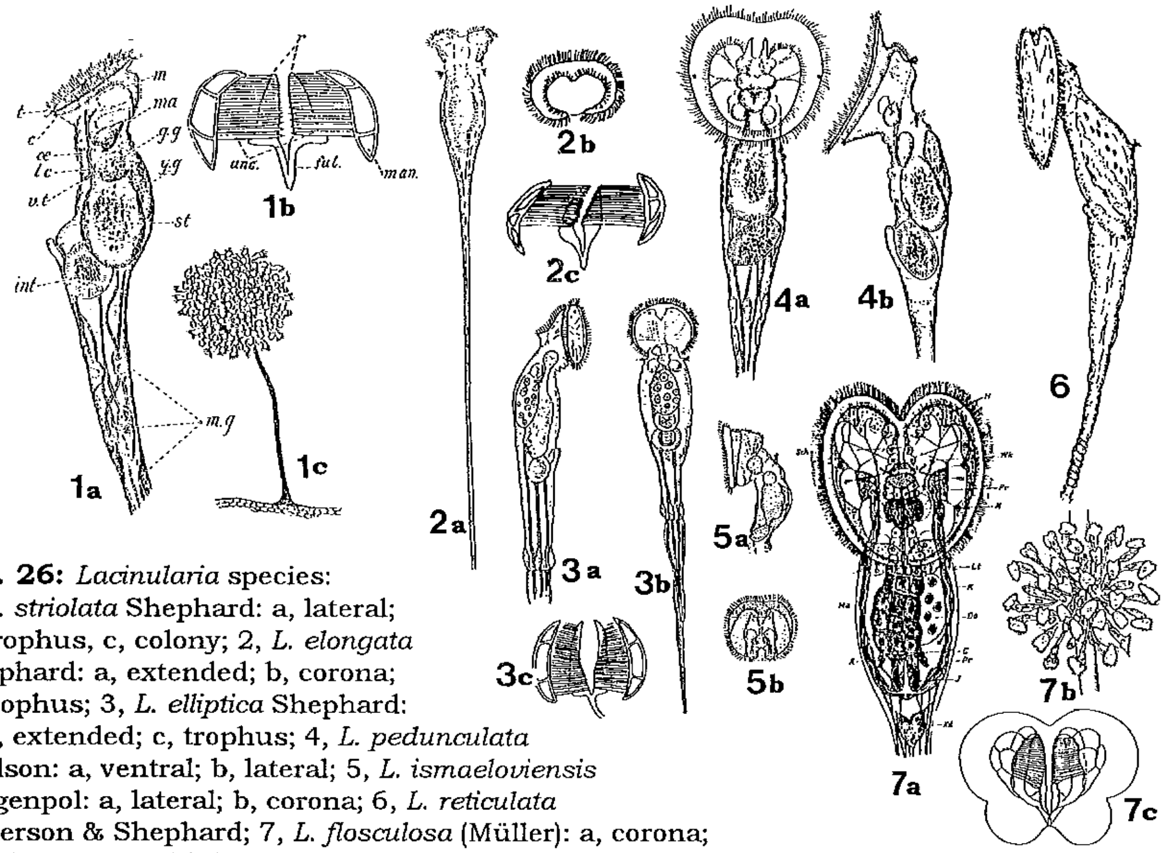


Fig. 26: *Lacinularia* species:
1: *L. striolata* Shephard: a, lateral;
b, trophus, c, colony; 2, *L. elongata*
Shephard: a, extended; b, corona;
c, trophus; 3, *L. elliptica* Shephard:
a, b, extended; c, trophus; 4, *L. pedunculata*
Hudson: a, ventral; b, lateral; 5, *L. ismaeloviensis*
Poggenpol: a, lateral; b, corona; 6, *L. reticulata*
Anderson & Shephard; 7, *L. flosculosa* (Müller): a, corona;
b, colony; c, trophi. (After original authors and Koste (1978).

more widespread in billabongs and ponds in eastern Australia, including Tasmania. *Trochosphaera* is not readily confused with other planktonic rotifers, but *Horaëlla* superficially resembles a small *Asplanchna*. Corona and trophi structure are distinctive.

Key to genera of Trochosphaeridae known from Australia

1. Spherical body to 1mm; equatorial ciliary band; vitellarium ribbon- or sickle-shaped, multinucleate..*Trochosphaera* Semper
[Single species recorded: *Trochosphaera equatorialis* Semper (Fig. 27:1)]
- Ovoid body <350 µm long; circular apical corona; spherical vitellarium with eight nucleii..*Horaëlla* Donner
[Single species recorded *Horaëlla brehmi* Donner (Fig. 27:2)]

Niche: Planktonic ?bacteriovore/herbivore

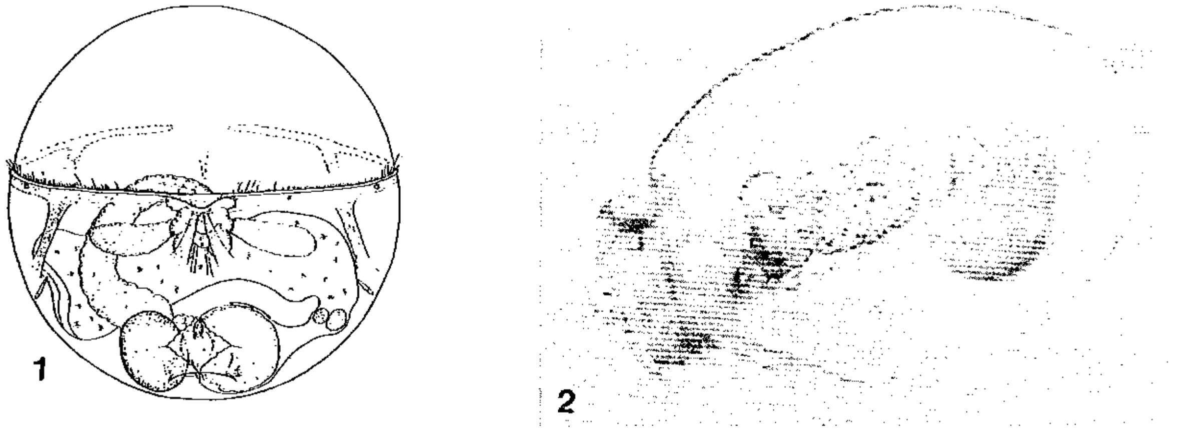


Fig. 27: 1, *Trochosphaera aequatorialis* Semper; 2, *Horaëlla brehmi* Donner

7. Fam. Filiniidae Bory De St Vincent, 1824

Common in the plankton of ponds and lakes, *Filinia* species (adults) are distinguished by body/setae lengths and/or ratios. Juveniles of larger species may overlap with adults of smaller species, so to discriminate juveniles requires trophus examination. Ten taxa are recorded from Australia, six of them also from N.Z., which also has *F. novaezealandiae* Shiel & Sanoamuang. The species called cf. *terminalis* here may not be the same as the European *F. terminalis*, which is a cold stenotherm found at <15 °C. The local species has a higher thermal tolerance (>20 °C) and is regarded as "cf." until the family is revised for Australia. A recent work by Sanoamuang (1993) includes Australian species and taxonomic information. The following key is provisional until detailed systematic work on the genus is completed (Shiel & Koste, unpubl.)

Key to species of Filinia known from Australia/N.Z.

1. Two anterior setae (AS) only, no caudal seta (CS) (Fig. 28:1)........*F. saltator* (Gosse)
- Two AS (may be held directed forward, or parallel to the body), 1-2 CS........**2**

2(1). Body globular or saccate........**5**
Body elongated, spindle-shaped/pyriform........**3**

3(2). Firm, rigid cuticle of elongated ovoid shape; lateral AS of different lengths, arising from broad paddle-like bases, commonly held directed forward; two (one minute) CS (Fig. 28:2)........*F. opoliensis* (Zacharias)
- Not as above, pyriform animals resembling Figs 28:3, 4........**4**

4(3). BL <200 μm, CS <460 μm, 16/17 unci teeth (Fig. 28:3).*F. pejleri* Hutchinson
BL >200 μm, CS >600 μm, 19/20 unci teeth.(Fig. 28:4).......*F. grandis* (Koste)

5(2). Small triangular animal with very short setae (AS<BL) (Fig. 28:5)........**6**
- All setae >BL........**7**

6(5). 8-9/9-10 unci teeth (2 large, 6-8 small)........*F. cornuta* (Weisse)
- 12-13/13-14 unci teeth (Fig. 28:5)........*F. brachiata* Rousselet

7(5). Saccate body; setae generally <500 μm (adults); CS inserted slightly forward of posterior end of body, i.e. slight projecting 'rump'; <20 unci teeth........**8**
Globose body; setae generally >500 μm; >20/20 unci teeth........**9**

8(7). AS 300-460 μm, CS <370 μm, 15/15 unci teeth (Fig. 28:6)........*F.* cf. *terminalis* (Plate)
[*F. novaezealandiae* Shiel & Sanoamuang, 1993, known only from L. Okaro, N.Z., resembles *F. terminalis*, but has 18-19/19-20 unci teeth.]
- AS 200-365 μm; CS <250 μm; 12/14 unci teeth (Fig. 28:7)..*F. passa* (Müller)

9(7). AS to 640 μm, CS< 340 μm, 21/21 unci teeth (Fig. 28:8)........*F. longiseta* (Ehrenberg)
AS >640 μm, CS to 520 μm, 28/28 unci teeth.(Fig. 28:9)........*F. australiensis* Koste

Niche: Planktonic bacteriovore/herbivore

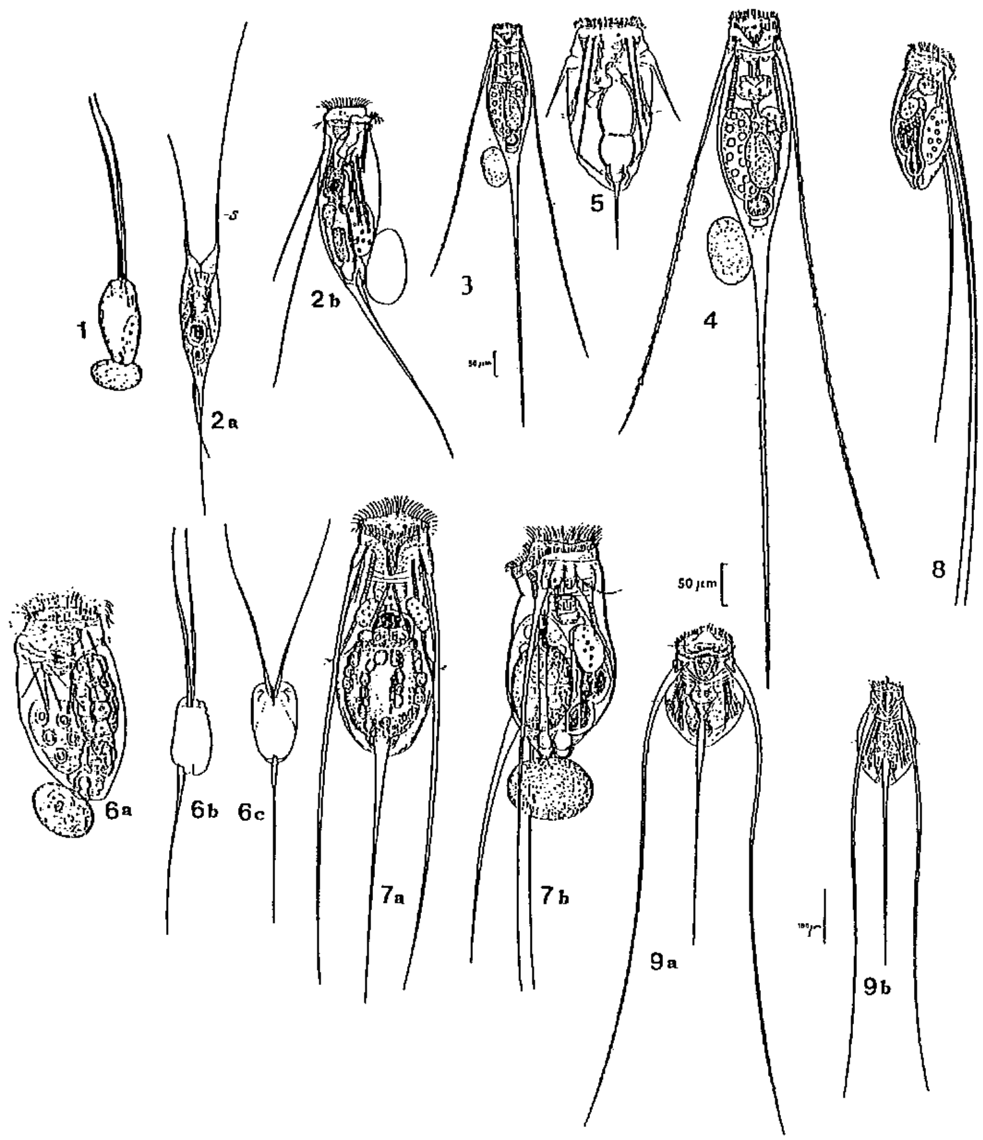


Fig. 28: *Filinia* species: 1, *F. saltator* (Gosse); 2, *F. opoliensis* (Zacharias): a, with anterior spines forward; b, with spines folded back; 3, *F. pejleri* Hutchinson; 4, *F. grandis* Koste; 5, *F. brachiata* Rousselet; 6, *F. terminalis* Plate: a, body morphology; b, lateral; c, ventral; 7, *F. passa* (Müller): a, ventral; b, lateral; 8, *F. longiseta* (Ehrenberg); 9, *F. australiensis* Koste: a, b, two individuals, ventral. (Various authors, from Koste (1978)

8. Fam. Testudinellidae Bory De St Vincent, 1826

Two genera of testudinellids are common seasonally or perennially in the plankton of most inland freshwaters: two spp. of *Pompholyx* are known from both Australia and N.Z. and 19 spp. of *Testudinella* from Australia, 5 from N.Z., including *T. mucronata* (Gosse) and *T. striata* (Murray) not known from Australia. Several *Testudinella* spp. from Tasmania, King and Flinders Is. are not yet described (Shiel unpubl.), and are not included in the key. Also not included are *T. munda* (Fig . 29:14) and *T. neboissi* (Fig. 29:15), described from Victoria by Berzins (1982) from long-preserved material. These were considered to be artefacts of preservation, representing *T. amphora* and *T emarginula* respectively (Shiel & Koste 1985). The family has not yet been revised for Australia. In view of the poor description and/or figures for some species, the following key to known taxa should be used with caution for animals which differ from figured individuals. It is modified from

Koste (1978) and original descriptions, and is provisional until work in progress (Shiel & Koste, unpubl.) is completed.

Key to genera and species of Testudinellidae known from Australia/N.Z.
Abbreviation: HA=head aperture

1. Small spherical rotifers with median occipital lip or undulating margin; may have longitudinal grooves..*Pompholyx*...**2**
Discoid, circular to pyriform or ovoid, dorsoventrally flattened 'plate', slightly convex to triangular in section..*Testudinella*...**3**

2(1). BL <100 µm, cuticle without longitudinal striae (Fig. 29:1)..*P. complanata* Gosse
BL 100-130 µm, cuticle with striae..................................*P. sulcata* (Hudson)

3(1). Lorica tapers to caudal tubular foot-opening..**4**
- Caudal lorica not tapered, no tubular opening..**5**

4(3). BL <150 µm; median dorsal HA spine not appreciably longer than laterals (Fig. 29:2)..*T. tridentata* Smirnov
- BL >250 µm; median dorsal spine notably elongated (Fig. 29:3)..*T. greeni* Koste

5(3). Foot-opening at or near posterior end of ventral lorica..............................**10**
- Foot-opening central or slightly posterior to midline....................................**6**

6(5). Circular outline, may have slight convexity at dorsal margin of head-opening, but no acute or scalloped projection (Fig. 29:4).T. p*atina* (Hermann)
- Circular, elongate or pyriform, distinct scalloped or acute dorsal lorica projection; if not acute, lorica densely granulated.......................................**7**

7(6). Lorica granulated; HA narrows, with distinct striae (N.Z.) (Fig. 29:5)..*T. striata* (Murray)
- None of the above; single apical projection on dorsal margin.......................**8**

8(7). Dorsal margin projects as a scalloped 'tongue' (Fig. 29:6)...*T. husseyi* Shiel & Koste
- More or less acute apex, with or without striae and scalloped margins.........**9**

9(8). Acute, unornamented 'tooth' on dorsal margin; BL to 170 µm (N.Z. record) (Fig. 29:7)..*T. mucronata* (Gosse)
- HA lightly flared, dorsal margin an acute tooth with convex 'shoulders'; distinct striae; BL to 210 µm (Fig. 29:8)...........*T. tasmaniensis* Koste & Shiel

10(5). Lorica circular..*T. parva* (Ternetz) (Fig. 29:9)
Includes *T. insinuata* Hauer, 1938 (Fig. 29: 11) synonymized with *T. parva*, and *T. semiparva* Hauer, 1938 (Fig. 29:10), regarded as a ssp., by Koste (1978)
- Lorica cuboidal, elliptical, vasiform or pyriform..**11**

11(10). Flared expansions of dorsolateral rim of neck aperture to form auricles...**12**
- No auricles, although HA may be slightly flared.......................................**13**

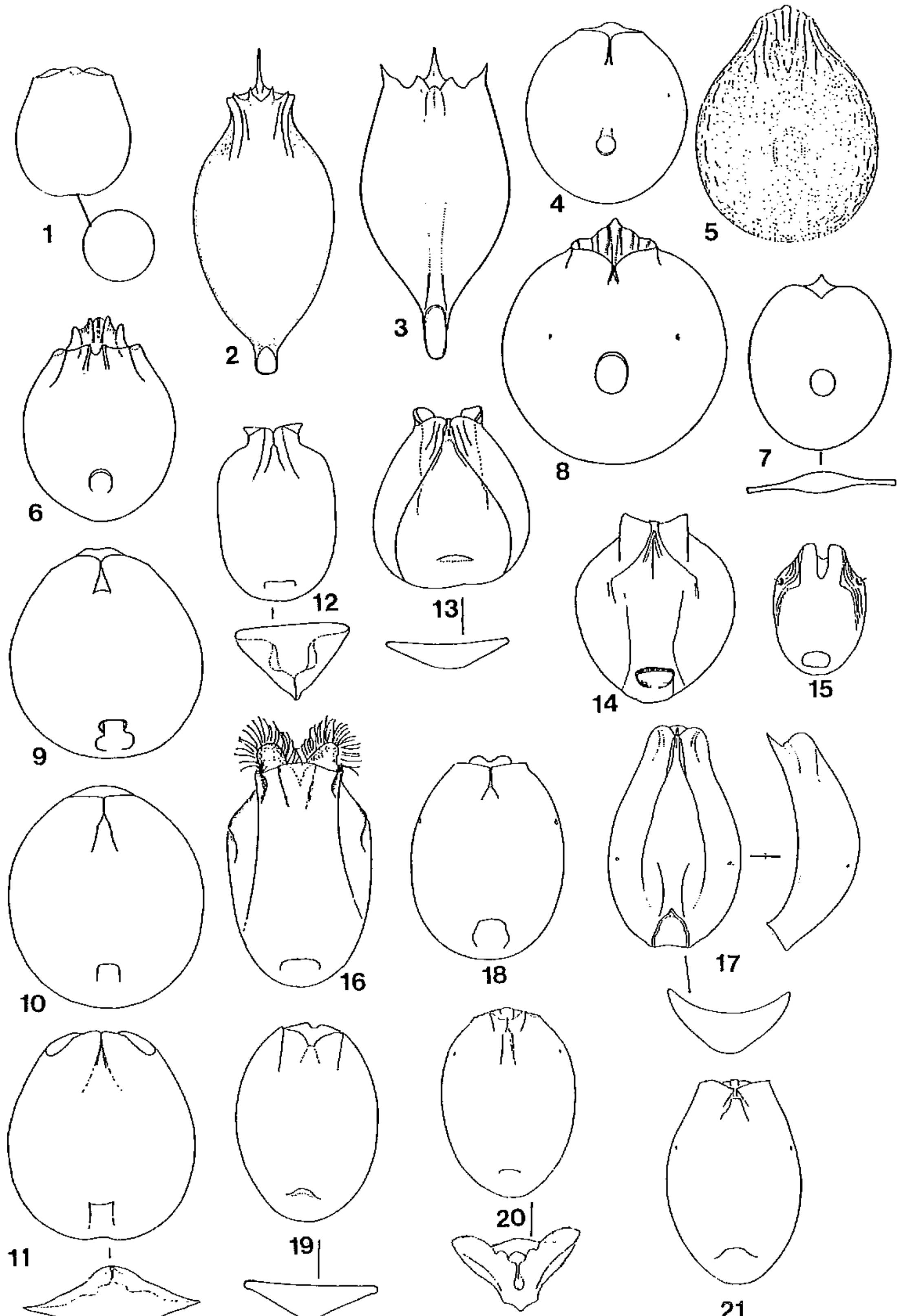


Fig. 29: 1, *Pompholyx complanata Gosse*, 1851 with egg; 2, *Testudinella greeni* Koste, 1981; 3, *T. tridentata* Smirnov, 1931; 4, *T. patina* (Hermann, 1783); 5, *T. striata* (Murray, 1913); 6, *T. husseyi* Shiel & Koste, 1985; 7, *T. mucronata* (Gosse, 1886); 8, *T. tasmaniensis* Koste & Shiel, 1986; 9, *T. parva* (Ternetz, 1892); 10, *T. semiparva* Hauer, 1938; 11, *T. insinuata* Hauer, 1938; 12, *T. amphora* Hauer, 1956; 13, *T. walkeri* Koste & Shiel, 1980; 14, *T. munda* Berzins, 1982; 15, *T. neboissi* Berzins, 1982; 16, *T. emarginula* (Stenroos, 1898); 17, *T. unicornuta* Koste & Shiel, 1986; 18, *T. incisa* (Ternetz, 1892); 19, *T. vidzemensis* Berzins, 1943; 20, *T. ahlstromi* Hauer; 21, *T. reflexa* (Gosse, 1887). (1 orig., remainder re-drawn from original author, or Koste (1978) some detail omitted).

12(11). Body cuboidal, BL <100 μm; triangular section (Fig. 29:12)..*T. amphora* Hauer
- Pyriform, BL>100 μm; shallow section (Fig. 29:13)..*T. walkeri* Koste & Shiel

13(11). Body ovoid; HA slightly flared (Fig. 29:16)................*T. emarginula* Stenroos
- Body ovoid to pyriform, HA not flared; median indentation in posterior dorsal rim, or projection..**14**

14(12). Body ovoid, HA various..**15**
- Body distinctly pyriform, with obvious ventral spine (Fig. 29:17)...*T. unicornuta* Koste & Shiel

15(13). Dorsal HA with median sinus..**16**
- No median sinus, dorsal aperture projects slightly..................................**17**

16(15). HA with parallel sides as in *T. emarginula*; median sinus on smooth dorsal rim; no distinct ventral tooth; BL to 135 μm (Fig. 29:19)...*T. vidzemensis* Berzins
- Not as above; projecting lip on dorsal margin with median sinus; distinct ventral tooth below lower HA margin; BL to 124 μm (Fig. 29:18)...*T. incisa* (Ternetz)

17(15).Ventral spine as Fig. 29:20; triangular section to 20 μm high; BL to 120 μm..*T. ahlstromi* Hauer
- Ventral spine truncate; HA full width of anterior margin; BL to 150 μm (Fig. 29:21)...*T. reflexa* (Gosse)

Niche: Planktonic ?bacteriovores/herbivores

Order Ploimida

9. Fam. Dicranophoridae Remane, 1933

Thirty spp. of dicranophorids in seven genera are known from Australia, only seven spp. in four genera from N.Z. (four shared). All are littoral taxa, found in and around submerged vegetation or in interstitial spaces of sandy shores. Dicranophorids occasionally occur in plankton samples, particularly from billabongs. Habits range from herbivory to carnivory and parasitism. The family is not yet revised from Australia, hence the following keys are provisional until a MS in preparation (No. XI in the revision series) is completed. For full details of these and other genera not yet recorded from Australia, see Koste (1978). The family is under review globally in the *Guides to the Microinvertebrates*... series (De Smet, in prep.). Identification is based on trophi structure and general morphology.

Key to genera of Dicranophoridae known from Australian inland waters

1. Trophi asymmetrical (Fig. 30:1)....................*Aspelta* Harring & Myers (p. 49)
- Trophi symmetrical (teeth on inner margins of rami often unpaired)............**2**

2(1). Rami slender, bent almost at right angles medially, each with long slender distal tooth; morphology as Fig. 31:1.........*Erignatha* Harring & Myers (p. 50)
- Rami and morphology not as above...**3**

3(2). Intramalleus present between manubrium and incus (Fig. 31:2)....................**4**
- Without intramalleus between manubrium and incus, manubrium attached directly to uncus (or on ramus)..**5**

4(3). Foot long, ca. 1/4-1/3 total length; toes rod-shaped, tips rounded (Fig. 30:8)................................*Wierzejskiella* Wiszniewski (p. 50)
- Foot short, <1/5 total length; toes tapering to acute tips (Fig.)..*Encentrum* Ehrenberg (p. 50)

5(3). Body stout, distally rounded; trunk with deep transverse and longitudinal furrows; cuticle sticky, covered with detritus; foot rudimentary, displaced ventrally; toes short, slender, acute (Fig. 31:12) (N.Z.)...*Paradicranophorus* Wiszniewski (p. 51)
- Body fusiform or cylindrical, without deep furrows; cuticle not sticky; foot in line with trunk; toes lacking to very long..**6**

6(5). Toes short to very long; eyespots present or absent; rostrum conspicuous; rami with1-3 terminal teeth each, inner margins rarely without teeth; free-living (Fig. 32)...*Dicranophorus* (p. 51)
- Toes minute, rudimentary or lacking; eyespots lacking; rostrum minute or absent; rami with single terminal tooth; inner margins of rami without teeth; ecto- and endoparasites of oligochaetes and slugs, sometimes found free...**7**

7(6). With corona (Fig. 33:4)..*Albertia* Dujardin (p. 54)
- Without corona (Fig. 33:5).....................................*Balatro* Claparède (p. 54)

Niche: epibenthic/epiphytic, herbivorous or carnivorous, parasitic.

Aspelta Harring & Myers

Six species of this carnivorous genus are known from Australia, with *A. aper* also known from N.Z. They are found among submerged mosses, algae and on submerged macrophytes.

Key to species of Aspelta *known from Australian inland waters*

1. Toes very long, c. 80 μm, 2/5 total length (Fig. 30:1).........*A. neboissi* Berzins
NB: Probably not an *Aspelta* on the basis of Berzins' figures
- Toes short, <50 μm, ca. 1/5 total length **2**

2(1). With eyespots at base of rostrum; toes decurved ventrally, incurved and forceps-shaped in dorsal view (Fig. 30:2)..*A. circinator* (Hudson & Gosse, 1886)
- Without eyespots at base of rostrum; toes otherwise..................................**3**

3(2). Rostrum with 2 lateral conical projections; toes straight in dorsal view; trophi almost symmetrical, rami of equal length (Fig. 30:3)...*A. aper* (Harring)
- Rostrum simple, rounded, without lateral conical projections.....................**4**

4(3). Toes straight **5**
- Toes ventrally decurved in lateral view; alulae absent; right ramus with oblique projection prior to terminal tooth; unci long, slender, rod-shaped, two teeth right uncus, one tooth left (Fig. 30:4).......*A. psitta* Harring & Myers

5(4). Toes long, to 50 µm, c. 1/7 total length; trophi nearly symmetrical; rami without prominent alulae (Fig. 30:5)........... *A. tilba* Koste & Shiel
- Toes short, <30 µm, c. 1/9 - 1/10 total length; trophi asymmetrical; right ramus with rounded alula (Fig. 30:6)....*A. angusta* Harring & Myers

Niche: littoral carnivores - eat protists, other rotifers, nematodes (Koste 1978)

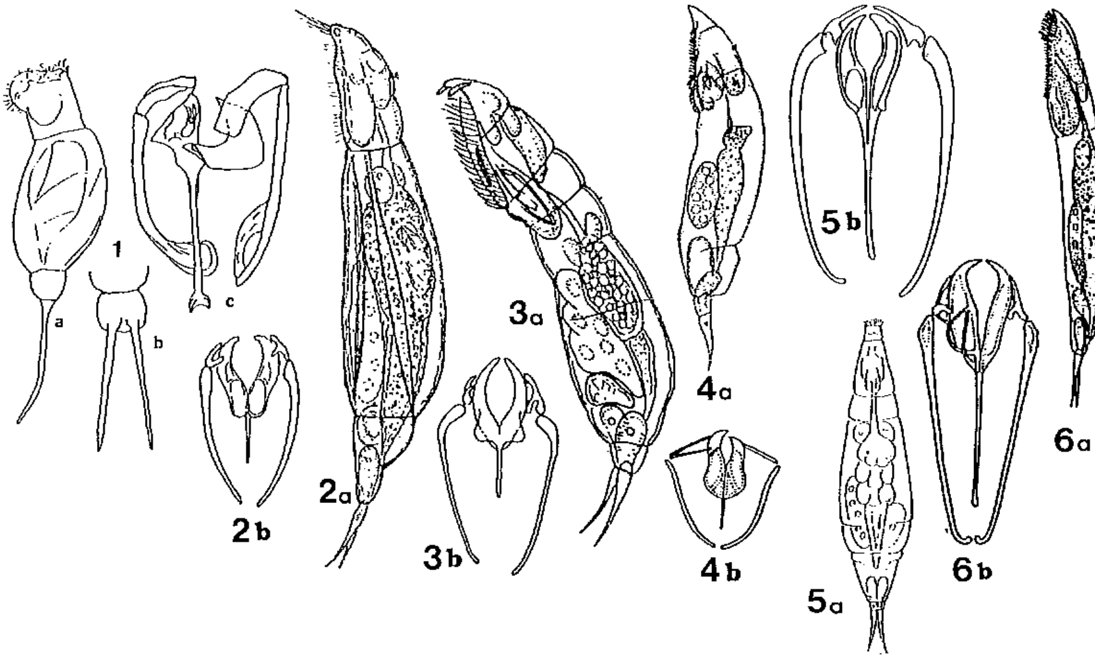


Fig. 30: 1, (?)*Aspelta neboissi* Berzins, 1982 a, lateral; b, toes; c, trophus; 2, *A. circinator* (Hudson & Gosse, 1886): a, lateral; b, trophus; 3, *A. aper* (Harring): a, lateral; b, trophus; 4, *A. psitta* Harring & Myers: a, lateral; b, trophus; 5, *A. tilba* Koste & Shiel: a, dorsal; b, trophus; 6, *A. angusta* Harring & Myers: a, lateral; b, trophus. (After Berzins (1982, Koste (1978), Koste & Shiel (1987).

Erignatha Harring & Myers

A single individual resembling *E. clastopis* (Gosse, 1886) (Fig. 31:1) was found in a net tow from a billabong at Tallandoon, Vic. (Koste & Shiel unpubl.). The taxon has not been recorded again, and requires verification. *Erignatha* is not recorded from N.Z.
Niche: ??

Wierzejskiella Wiszniewski

Wierzejskiella velox (Wiszniewski, 1932) (Fig. 31:2) is known from a single locality, Yarnup Swamp. W.A. (Koste *et al.* 1983). The genus is not recorded from N.Z.
Niche: ??

Encentrum Ehrenberg

Species of *Encentrum* may be found in detritus and periphyton, psammon etc., from freshwater, inland saline, brackish and marine littoral; rarely epizoic on crustaceans and cases of insect larvae, or parasitic on fish. Eight species of *Encentrum* have been recorded from Australia, two from N.Z. One, *E. marinum* (Dujardin) (Fig. 31:5), from an ocean beach at Otago (Russell 1962), is not recorded from Australia. Interstitial rotifers are virtually unknown for Australian beaches, but elsewhere, *Encentrum* species appear to be well-represented in the psammon fauna. In view of poor figures or descriptions, several of the recorded taxa need verification. The following key is provisional only. Any taxa of *Encentrum* which cannot be discriminated using the key should be referred to Koste (1978). The forthcoming global keys in the *Guides to the Microinvertebrates* series (De Smet, in prep.) will help resolve taxonomic uncertainties in the genus.

Key to Encentrum species known from Australia/N.Z.

1. Cuticle with distinct transverse pleats (Fig. 31:3)..*E. saundersiae* (Hudson, 1885)
- Cuticle smooth or with light longitudinal striae..................................2

2(1). Habitat saline..3
Habitat fresh..4

3(2). Salivary glands stalked; BL to 165 µm; TR to 24 µm (Fig. 31:4)... *E. cruentum* Harring & Myers
- Salivary glands not stalked; BL to 200 µm; TR to 35 µm (Fig. 31:5) (N.Z.)...*E. marinum* (Dujardin)

4(2). Foot long; 3-4 segmented (Fig. 31:6)......................*E. gibbosum* Wulfert
- Foot short, 2-3 segmented or indistincly segmented...........................5

5(4). Morphology and TR as Fig. 31:7..............................*E. putorius* Wulfert
- Not as above..6

6(5). Retrocerebral sac with distinct red pigment granules enclosing red cerebral eyespot..7
- No obvious pigment granules or eyespot..8

7(6) Fulcrum <1/5 manubrium length (Fig. 31:8)...................*E. felis* (Müller)
- Fulcrum 1/3-1/4 man. length (Fig. 31:9).......*E. diglandula* (Zawadowski)

8(7). Morphology & TR as Fig. 31:10.................................*E. mnium* Berzins
- Morphology & TR as Fig. 31:11..........................*E. prosdendrus* Berzins

NB. Both these taxa were poorly described and figured, and lack of pigment granules or eyespot may represent deterioration of the specimens. Both require verification/redescription.

Niche: Various - bacteriovores/herbivores/predatory on ciliates, rotifers/

Paradicranophorus Wiszniewski

Not known from Australia. A record of *Paradicranophorus hudsoni* Glasscott, 1893 (Fig. 31:12) from N.Z.'s Chatham Islands by Russell (1953) is the only record in the region.

Dicranophorus (Müller)

Species of *Dicranophorus* are almost exclusively littoral in habit, although *D. caudatus* (Fig. 33:1) is collected occasionally in plankton samples. 12 species of *Dicranophorus* have been named from Australia, with 2-3 undescribed (Shiel, unpubl.). Three spp. are known from N.Z., including *D. dolerus* Harring & Myers, 1928 (Fig. 32:3), not known from Australia. The following key is provisional, using attributes of the trophi in the first instance, with reference to De Smet (in prep.). As for *Encentrum*, an ecological attribute is used in view of the single species known to date to occupy such a niche. If species

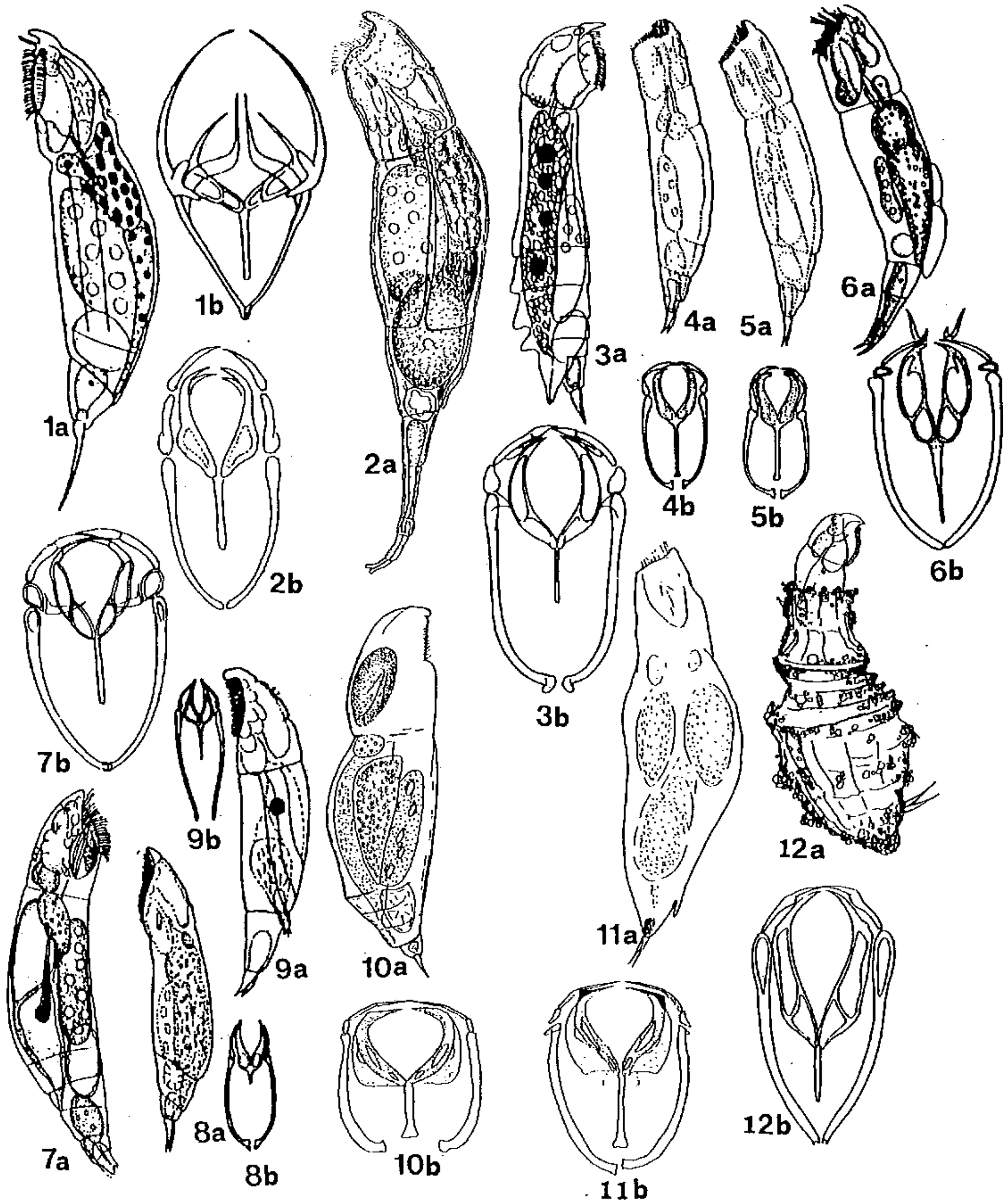


Fig. 31: (a, lateral; b, trophi in each case); 1, *Erignatha clastopis* (Gosse); 2, *Wierzejskiella velox* (Wiszniewski, 1932); 3, *Encentrum saundersiae* (Hudson); 4, *E. cruentum* Harring & Myers; 5, *E. marinum* (Dujardin); 6, *E. gibbosum* Wulfert; 7, *E. putorius* Wulfert; 8, *E. felis* (Müller); 9, *E. diglandula* Zawadowski; 10, *E. mnium* Berzins; 11, *E. prosdendrus* Berzins; 12, *Paradicranophorus hudsoni* Glasscott. (Various authors, from Berzins (1982) and Koste (1978))

which vary significantly from the relevant figures are found in similar habitats, refer to specialist literature.

Key to species of Dicranophorus known from Australian inland waters

1. Free-living..**2**

\- In the branchial chamber of crustaceans; margins of rami straight or slightly curved anteriorly; foot 2 segmented; without double caudal papilla (Fig. 32:1)..*D. hauerianus* Wiszniewski

2(1). Trophi with medium-large shearing teeth on inner rami margins..........**3**
- Inner rami margins with very small or no shearing teeth, or with a lamellar row of rounded knobby teeth..**7**

3(2). A pair of palps projecting ventrally on rostrum anterior; eyespots absent; foot with ± large dorsal projection; rami with (1)-2(3) incurved terminal teeth, inner margins with variable number of small, acute shearing teeth (e.g. 4/8, 5/5)(Fig. 32:2)...............*D. lütkeni* (Bergendal)
- Not as above...**4**

4(3). Inner rami margins with 5 large teeth (Fig. 32:3) (N.Z.)..*D. dolerus* Harring & Myers
- Inner rami margins with >5 large teeth..**5**

5(4). Unci single-toothed...**6**
- Unci 3-toothed; toes parallel-sided, or slightly tapering, tips short, blunt, bases without septum; foot unsegmented (Fig. 32:4)...*D. epicharis* Harring & Myers

6(5). Rami tips bifurcate; 5-12 teeth on inner margins; distal ends of manubria knobby; toes gradually tapering towards acute tip, slightly outcurved in dorsal view, bases with septum; foot 2- segmented (Fig. 32:5)...*D. forcipatus* Müller
- Rami tips single; distal ends of manubria flared; toes parallel-sided; inner margins of rami with 7-9 teeth; foot unsegmented (Fig. 32:6)...*D. grandis* (Ehrenberg)

7(2). Rami with median row of very small shearing teeth or lamellar knobby teeth..**8**
- Inner rami margins unarmed..**9**

8(7). Inner margin with row of 5-10 small shearing teeth (Fig. 32:7)...*D. hercules* Wiszniewski
- Inner rami margin with 11-20 knobby lamellar teeth (Fig.32:8)...*D. robustus* Harring & Myers

9(7). Rami tips single, ventral projection supports unci (Fig. 32:9)...*D. halbachi* Koste
- Rami tips bifurcate or 4-toothed **10**

10(9) Rami terminate in two teeth, each with bifurcate tip (Fig. 32:10)...*D. australiensis* Koste & Shiel
- Rami terminate in bifurcate single tooth..**11**

11(10). TR >30 µm, structure as Fig. 33:1....................*D. caudatus* Ehrenberg
- TR <30 µm, structure as Figs 33:2 or 33:3...**12**

12(11). Intramallei lamellar, incurved part drawn out into needle-like tip(s); tail prominent, often lying over foot (Fig. 33:2).......*D. uncinatus* (Milne)
- Intramallei with broad, posteriorly rounded, incurved lamellar plate; tail minute (Fig. 33:3)...*D. aquilus* (Gosse)

Niche: Littoral carnivores, sometimes herbivorous; free-living, rarely epizoic.

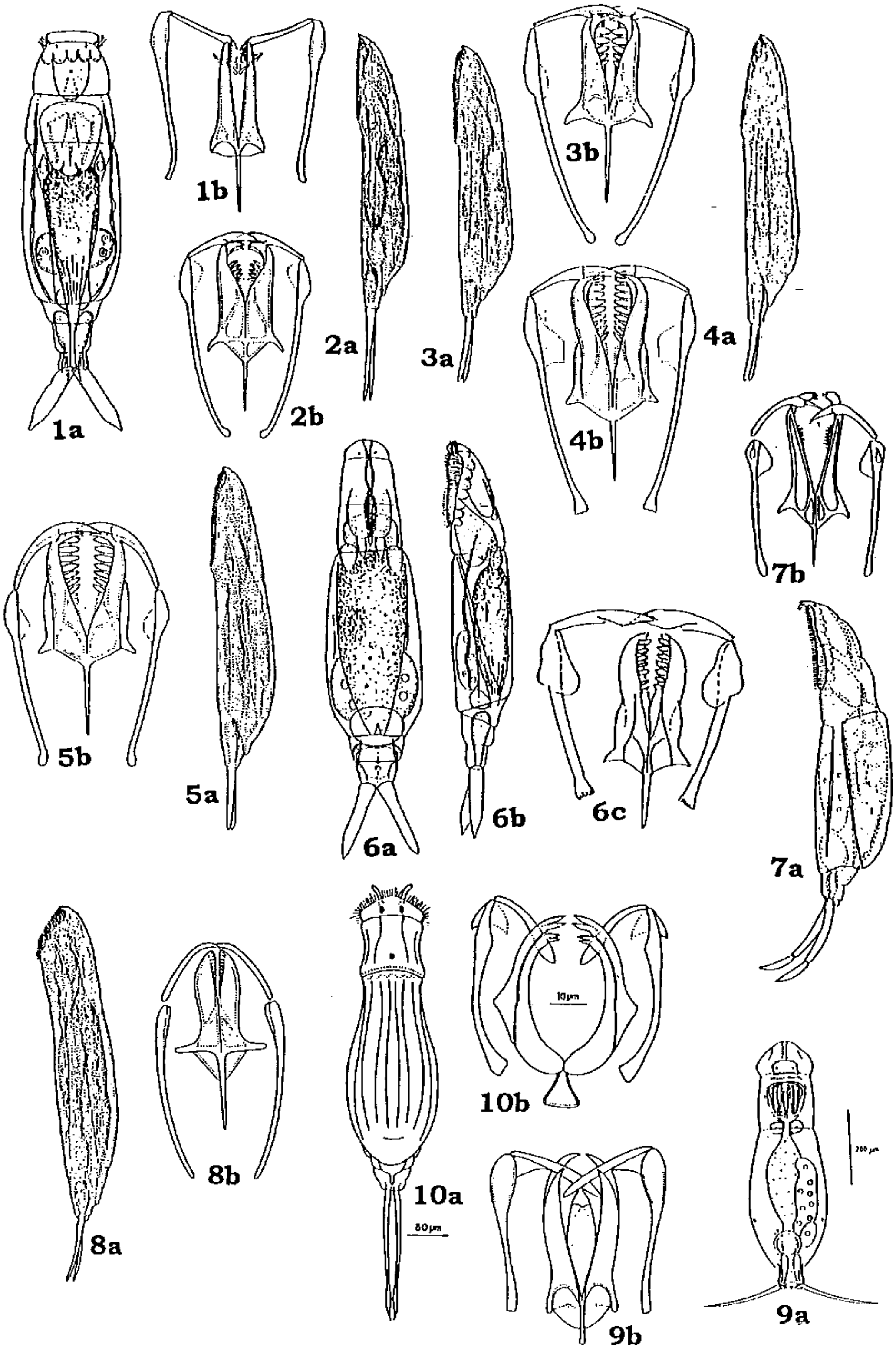


Fig. 32: (a, dorsal; b, trophi in each case); 1, *Dicranophorus hauerianus* Wiszniewski, 1939; 2, *D. lütkeni* (Bergendal, 1892); 3, *D. dolerus* Harring & Myers, 1928; 4. *D. epicharis* Harring & Myers, 1928; 5, *D. forcipatus* Müller, 1786; 6, *D. grandis* (Ehrenberg, 1832): b, lateral, c. trophi; 7, *D. hercules* Wiszniewski; 8, *D. robustus* Harring & Myers, 1928; 9, *D. halbachi* Koste, 1981: a. dorsal; 10, *D. australiensis* Koste & Shiel, 1980. (After Kutikova (1970), Harring & Myers (1928), Koste (1981)).

Albertia Dujardin

Albertia species are parasitic in freshwater oligochaetes (e.g. *Nais, Ripistes, Stylaria* spp.); occasionally free-swimming. There is a single record of *A. naidis* Bousfield, 1886 (Fig. 33:4) in *Stylaria* from a N.T. billabong (Koste 1981).

Balatro Claparède

Endoparasitic, in intestine of terrestrial oligochaetes (Enchytraeidae, Lumbriculidae); ectoparasitic on terrestrial and freshwater oligochaetes. Only one species, *B. calvus* Claparède, 1867, (Fig. 33:5) known from Australia (N.T.). Not recorded from N.Z.

10. Fam. Lindiidae Dujardin, 1841

Lindia species are rare littoral rotifers collected in and around vegetation in shallow waters, e.g. billabongs, or at lake margins, where they graze on detritus, bacteria or algae. Five taxa have been recorded from Australia, three from New Zealand, with two shared. *Lindia* species are illoricate, however characteristic features enable identification even in contracted individuals. The family was revised by Koste & Shiel (1990), and the revision should be consulted if more details are required. A global revision in the *Guides to Microinvertebrates......*series is in progress (De Smet in prep.). The key below is modified from Koste & Shiel (1990) to incorporate *Lindia pallida* Harring & Myers, 1922 known from New Zealand.

Key to species of Lindia known from Australian/N.Z. inland waters

1(1). Toes >30 µm...*L. ecela* Myers (Fig. 33:6)
- Toes <30 µm..**2**

2(1). Distinct bilateral spherical protrusions of integument in contracted individuals (Fig. X); trophi >50 µm long.............*L. deridderi* Koste (Fig. 33:7)
- No obvious protrusions; TR <50 µm long...**3**

3(2). Ciliary auricles stalked...**4**
- Auricles not stalked...**5**

4(3). Ciliary auricles short, slender; TR <20 µm...*L. annecta* Harring & Myers (Fig. 33:8)
- Auricles short, wide; TR 30-43 µm..................*L. truncata* Jennings (Fig. 33:9)

5(3) Head without rostrum; two unci teeth; TR to 25 µm; toes to 16 µm (N.Z.)..*L. pallida* Harring & Myers (Fig. 33:10)
- Head with rostrum; three unci teeth; TR to 32 µm; toes to 11 µm..*L. torulosa* Dujardin (Fig. 33:11)

Niche: Herbivore, various cyanobacteria and algae.

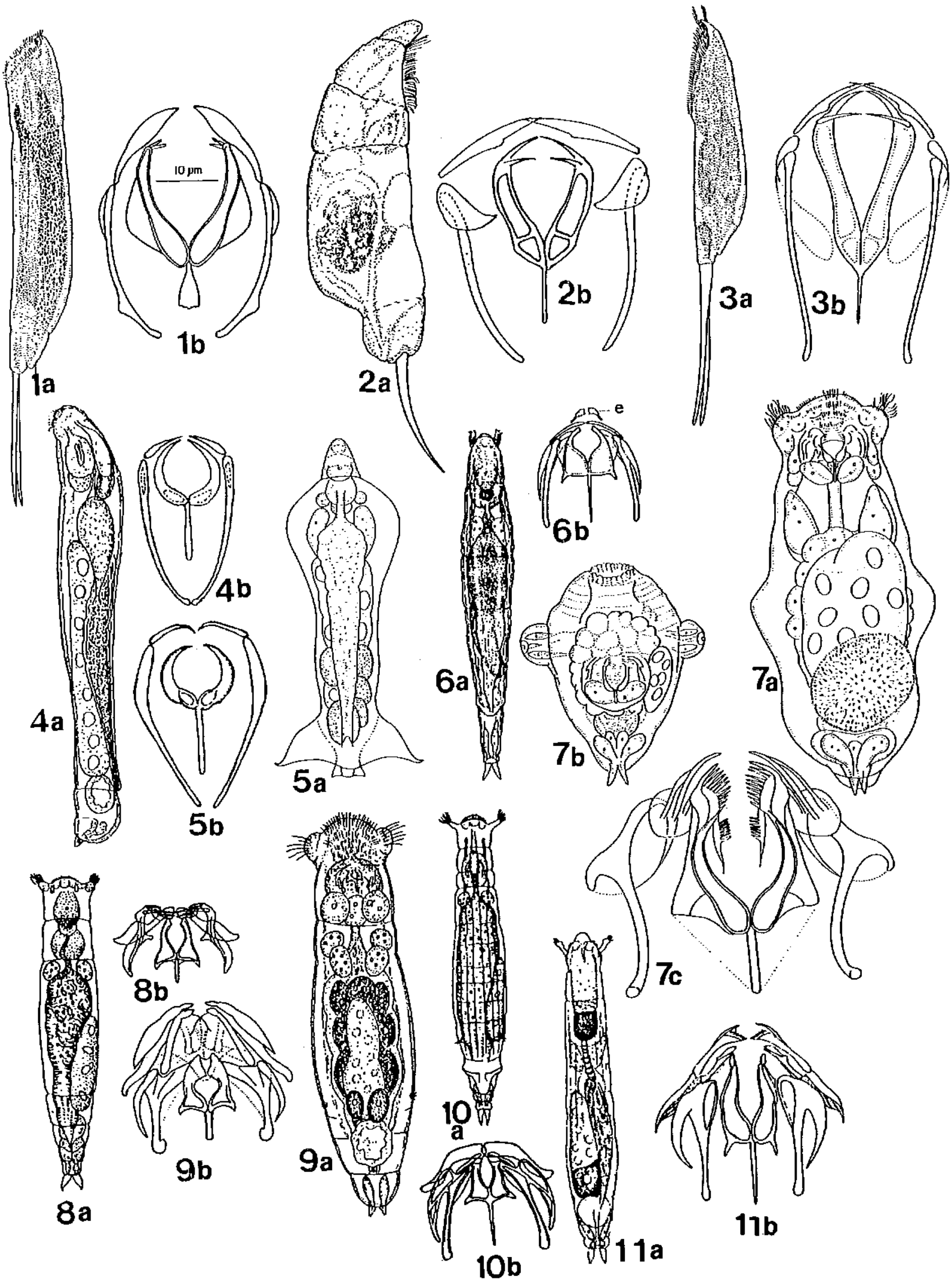


Fig. 33: (1-4 a, lateral; 5-11 a, dorsal; b, trophi); 1, *Dicranophorus caudatus* Ehrenberg; 2, *D. uncinatus* (Milne); 3, *D. aquilus* (Gosse); 4, *Albertia naidis* Bousfield; 5, *Balatro calvus* Claparède; 6, *Lindia ecela* Myers; 7, *L. deridderi* Koste: b, contracted; c, trophi; 8, *L. annecta* Harring & Myers; 9, *L. truncata* Jennings; 10, *L. pallida* Harring & Myers; *L. torulosa* Dujardin. (Various authors, after Koste (1978, 1979)).

Fam. 11. Asplanchnidae Harring & Myers, 1926

Large omnivorous or carnivorous saccate rotifers which may reach ca. 2.5 mm. They are common in most standing waters, where it is not unusual to find two or three co-occurring species of the two known genera, *Asplanchna* and *Asplanchnopus*. In both, the trophi are incudate, horizontal in the mastax with apices facing posteriorly, everted and extruded to seize prey. For details, see review by Shiel & Koste (1993). Two species of *Asplanchnopus* and seven species of *Asplanchna* are recorded from Australia. N.Z. has one *Asplanchnopus* and six *Asplanchna* to date, including *A. silvestris* Daday, 1902, not known from Australia (Shiel & Green 1995). Species discrimination within each genus is by trophi and vitellarium structure.

Key to genera and species of Asplanchnidae known from Australia/N.Z.

1. WIth rudimentary foot and toes..*Asplanchnopus*..**2**
\- Without foot and toes...*Asplanchna*..**3**

2(1) Trophus >100 µm long (Fig. 34:1).............*Asplanchnopus multiceps* Schrank
\- Trophus <75 µm long (Fig. 34:2)..................................*A. hyalinus* Harring

3(1). Rami clearly asymmetric under low magnification, left ramus with with median inner tooth, lamellar plate behind ramus tip, right ramus without either (Fig. 34:3)...*A. asymmetrica* Shiel & Koste
\- Rami symmetric under low magnification...**4**

4(3). Vitellarium spherical...**5**
\- Vitellarium ribbon-like...**6**

5(4). Vitellarium with up to 8 nuclei; rudimentary foot glands absent; four pairs of protonephridial flame cells; TR as Fig. 34:4.......................*A. priodonta* Gosse
\- Vitellarium with 12-15 nuclei; footglands present; 20-40 flame cells; TR as Fig. 34:5...*A. herricki* De Guerne

6(4). Trophus without apophyses (Fig. 34:6); constant 16 flame cells..*A. girodi* (De Guerne)
\- Trophus with robust apophyses...**7**

7(6). Apophyses straight, elongated from base of rami (Fig. 34:7) (N.Z.)...*A. silvestris* (Daday)
\- Apophyses curved (Fig. 34:8, 9, 10)..**8**

8(7). Rami inner margin with distinct, large tooth (Fig. 34:9, 10)........................**9**
\- Inner margin tooth absent or rudimentary (Fig. 34:8)....*A. intermedia* Hudson

9(8). Broad lamellae behind rami apices, which are symmetrical, acute; ca. 32 nuclei in vitellarium; 10-20 flame cells; resting egg with vesicular structure (Fig. 34:9)...*A. brightwelli* (Gosse)
\- Lamellae absent, apices asymmetric: left bifurcate, right single; >50 nuclei in vitellarium; 40-100 flame cells; RE with pleated outer shell (Fig. 34:10)...A. *sieboldi* (Leydig)

Niche: Planktonic carnivores, eating algae, protozoans, other rotifers and small microcrustaceans, e.g. chydorid cladocerans.

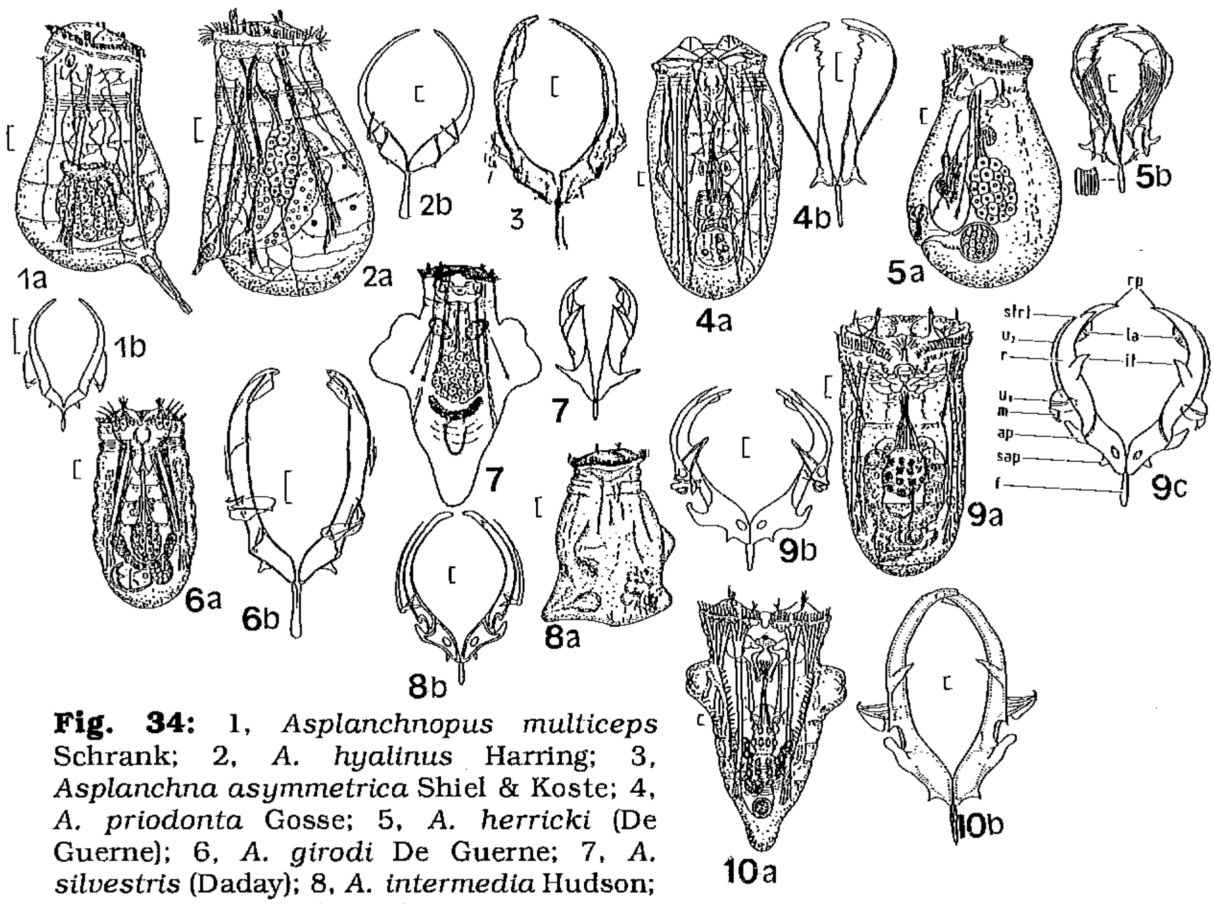


Fig. 34: 1, *Asplanchnopus multiceps* Schrank; 2, *A. hyalinus* Harring; 3, *Asplanchna asymmetrica* Shiel & Koste; 4, *A. priodonta* Gosse; 5, *A. herricki* (De Guerne); 6, *A. girodi* De Guerne; 7, *A. silvestris* (Daday); 8, *A. intermedia* Hudson; 9, *A. brightwelli* (Gosse); 10, *A. sieboldi* (Leydig). Scale bars: adults 50 µm; trophi 10 µm (Various authors, after Shiel & Koste (1993)).

12. Fam. Proalidae Bartos

Predominantly littoral, although species of *Proales* (Fig. 35) may occur occasionally in plankton. . Of four genera, *Proalinopsis* (2 spp.) and *Proales* (10 spp.) are known from Australia. *Bryceella* (1 sp.) is a doubtful record, and *Wulfertia* has not been recorded here. N.Z. to date has seven spp. of *Proales* and one of *Brycella*. The family in Australia was reviewed by Koste & Shiel (1990). The modified key below includes the N.Z. taxa.

Key to genera of the Family Proalidae

1. Corona with stout cirri with which the animal moves rapidly in a jerky motion; head with rostrum; body fusiform or pear-shaped with transverse pseudosegmentation; uncus 5-7 toothed...*Bryceella* Remane.
   Corona without cirri, with lateral ciliary tufts....................................2

2(1). Spinulate papilla above cloaca; unci 8-9 toothed.......*Proalinopsis* Weber
   No papilla above cloaca; unci 1-6 toothed.........................*Proales* Gosse

Bryceella Remane

The only Australian record is of *Bryceella voigti* (Fig. 35:1) by Berzins (1982) from two localities at Bombala, N.S.W., both from moss on *Eucalyptus* trunks. No figures or description were given, and Koste & Shiel (1990) commented that it was "as an unverified record of an indeterminate taxon". *Bryceella tenella* was recorded from N.Z. by Murray (1911) (Fig. 35:2).

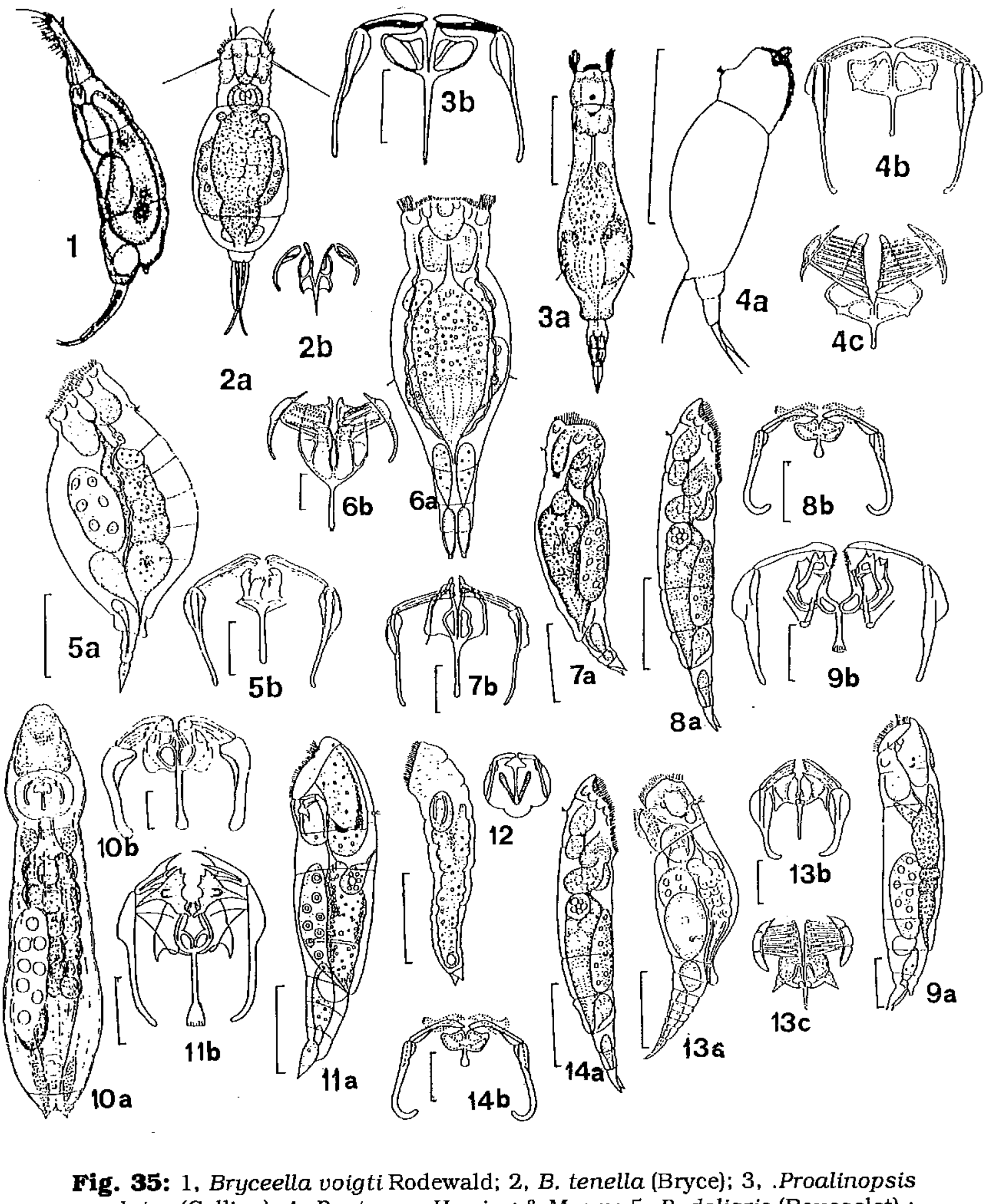


Fig. 35: 1, *Bryceella voigti* Rodewald; 2, *B. tenella* (Bryce); 3, .*Proalinopsis caudatus* (Collins); 4, *P. staurus* Harring & Myers; 5, *P. doliaris* (Rousselet) ; 6, *P. daphnicola* Thompson; 7, *P. parasita* (Ehrenberg); 8, *P. wernecki* (Ehrenberg); 9, *P. fallaciosa* Wulfert; 10, *P. gigantea* (Glasscott); 11, *P. sordida* Gosse; 12, *P. micropus* (Gosse); 13, *P. similis* De Beauchamp; 14, *P. decipiens* (Ehrenberg). (Various authors, from Koste (1978) and Koste & Shiel (1990).

Proalinopsis Weber

Two species of Proalinopsis have been recorded from Australia:

Key to species of Proalinopsis known from Australia

Fine needle-like spinules on posterior dorsal papilla..*P. caudatus* (Collins) (Fig. 35:3)
Papilla with robust spine.............*P. staurus* Harring & Myers (Fig. 35:4)

Proales Gosse

A diverse series of taxa,. Fusiform illoricate body in free-living species, more swollen in parasitic taxa. Ten species are known from Australia and seven from N.Z., including *P. longidactyla* Edmondson, 1948 and *P. theodora* (Gosse, 1887) not known from Australia. The species known from Australia were reviewed by Koste & Shiel 1990.

Key to species of Proales known from Australia

1. Foot with single toe............................*P. doliaris* (Rousselet) (Fig. 35:5)
\- Foot with two-toes..**2**

2(1). Eyespot below base of brain; body bulbous; toes coniform; commonly epizoic on *Daphnia*.........................*P. daphnicola* Thompson (Fig. 35:6)
\- Eyespot, body and toes not as above; not epizoic on *Daphnia*..............**3**

3(2). Parasitic in colonies of *Volvox* or in *Vaucheria* cells............................**4**
\- Free-swimming, not parasitic...**5**

4(3). In *Volvox* colonies (not to be confused with *Ascomorphella volvocicola*); trophi small (to 15 µm)......................*P. parasita* (Ehrenberg) (Fig. 35:7)
\- In *Vaucheria* filaments.....................*P. wernecki* (Ehrenberg) (Fig. 35:8)

5(3). Toe:body ratio >18..**6**
\- Toe:body ratio <17..**7**

6(5). Trophi <30 µm; small dorsal knob between toes...*P. fallaciosa* Wulfert (Fig. 35:9)
\- Trophi >30 µm; pointed spine on dorsal margin of foot..*P. gigantea* (Glasscott) (Fig. 35:10)

7(5). Foot long (2-3x toe length)........................*P. sordida* Gosse (Fig. 35:11)
\- Foot short (<2x toe length)..**8**

8(7). Eyespot absent; body vermiform...........*P. micropus* (Gosse) (Fig. 35:12)
\- Eyespot present, median or laterally displaced; body fusiform.............**9**

9(8). Median eyespot, ventral to base of brain, no lens; 6 unci teeth (Fig. 35:13)..*P. similis* De Beauchamp
\- Eyespot displaced to right, crystalline lens; 4/5 unci teeth (Fig. 35:14)..*P. decipiens* (Ehrenberg)

Niche: From free-living to parasitic, freshwater to halophile; bacteriovore/detritivore/herbivore.

13. Fam. **Epiphanidae** Bartos, 1959

Epiphanids, particularly *Epiphanes* sp., may be important seasonally in plankton of reservoirs and ponds. Larger *Epiphanes* sometimes may be confused with superficially similar *Asplancha species.* All can be separated on unci dentition. Other species of epiphanids are littoral in habit. The Australian species were reviewed by Koste & Shiel (1987).

Key to genera of the family Epiphanidae

1. Apical area with proboscis carrying two eyes................*Rhinoglena* Ehrenberg
\- Without proboscis; single eye..**2**

2(1). Foot with long toes..**5**
\- Toes short, rudimentary or lacking..**3**

3(2). Toes lacking or retractible; body worm-shaped........*Proalides* De Beauchamp
\- Toes .short..**4**

4(3). Corona with groups of large cilia; often large forms.......*Epiphanes* Ehrenberg
\- Corona without groups of strong cilia..**5**

5(4). Body arched; corona ventrally inclined; foot with long, curved, slender toes...*Cyrtonia* Rousselet
\- Body not arched; plications in integument of dorsum; *M. chlaena* with prominent spur on dorsal side of last foot segment....*Microcodides* Bergendal

Rhinoglena Ehrenberg

Rhinoglena frontalis (Ehrenberg, 1853) (Fig. 36:1) is the only species in the genus recorded from Australia and N.Z.

Niche: herbivore, particularly on monads.

Proalides De Beauchamp

Two species of *Proalides, P. subtilis* Rodewald, 1940 and *P. tentaculatus* De Beauchamp, 1907 are known from Australia. *Proalides* in plankton may have the size and texture of calanoid faecal pellets, however the latter don't carry eggs.....

Key to species of Proalides known from Australia

1. Foot rudimentary with retractible toes (Fig. 36:2)............*P. subtilis* Rodewald
\- Toes not visible; dorsal antennae long (Fig. 36:3)..*P. tentaculatus* De Beauchamp

Niche: ?bacteriovore/detritivore

Epiphanes Ehrenberg

More common in shallow waters, e.g. billabongs, than in larger lakes and reservoirs, four spp. of *Epiphanes* are widely distributed in Australia, two of them also known from N.Z. Saccate forms may be larger than smaller co-occurring *Asplanchna*, e.g. *A. priodonta*, but presence of a foot, and malleate trophi readily separate the genera. The species can be separated by general morphology and/or number of unci teeth.

Key to species of Epiphanes known from Australia

1. Pyriform body, resembles *Synchaeta*..............*E. senta* (Müller)(Figs 7b; 36:4)
- Saccate body, resembles *Asplanchna*..**2**

2(1). With 7 unci teeth.(Fig. 36:5)...........................*E. macrourus* Barrois & Daday
- with <7 unci teeth..**3**

3(1). With 6 unci teeth (Fig. 36:6)....................................*E. clavulata* (Ehrenberg)
- With 4 unci teeth.(Fig. 36:7)..................................*E. brachionus* (Ehrenberg)

Niche: Planktonic herbivore - green algae, flagellates.

Cyrtonia Rousselet

A monospecific genus, with *Cyrtonia tuba* Ehrenberg, 1834 (Fig. 36:8) a rare component of the plankton of billabongs and other small waters. Not known from N.Z.

Niche: ?herbivore

Microcodides Bergendal

Two species of this rare rotifer genus have been recorded from Australian pools. Not known from N.Z. They can be separated by differences in TR length

Key to species of Microcodides known from Australia

1. TR length to 20 μm (Fig. 36:9)...........................*M. chlaena* Gosse, 1886
- TR length 40 μm (Fig. 36:10)....................*M. robustus* (Glasscott, 1893)

14. Fam. Trichotriidae Bartos 1959

Three genera with loricate head and body; surface with facets, mostly granulated and with spicules or spines, sec. on dorsum; foot freely movable or with stiff joints; trophi malleate. Generally occur between aquatic macrophytes and in periphyton. In plankton only as migrants.

Key to genera of Trichotriidae known from Australian inland waters

1. Lorica with anal segment..2
- Lorica without anal segment..*Wolga* Skorikov

2(1). Lorica with distinct elongated spines on dorsum.............*Macrochaetus* Perty
- No long spines on lorica....................................*Trichotria* Bory de St Vincent

Wolga Skorikov

A monospecific genus, with *Wolga spinifera* (Western, 1894) (Fig. 37:1) known from a few localities in Australia. It is not known from New Zealand. Characteristic facettation or ribbing of the dorsal lorica is distinctive.

Macrochaetus Perty

Macrochaetus species are distinctive for their spines and flat lorica morphology. Four species are known from Australia, with *M. collinsi* also known from N.Z. All species live between or on water plants and are rare in open water.

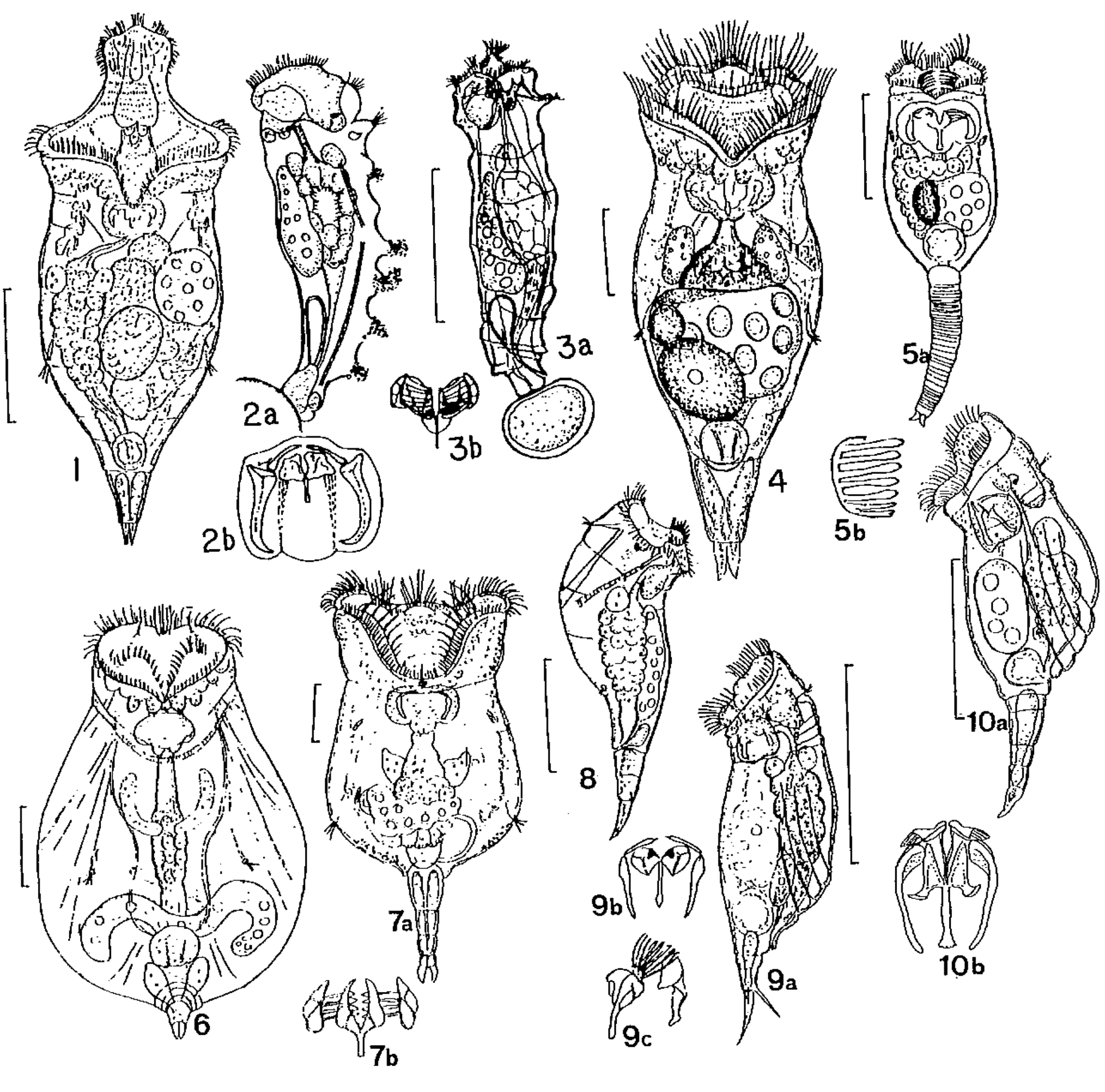


Fig: 36: 1, *Rhinoglena frontalis* (Ehrenberg); 2, *Proalides subtilis* Rodewald: a, lateral; b, trophus; 3, *P. tentaculatus* De Beauchamp: a, lateral, b, trophus; 4, *Epiphanes senta* (Müller), ventral; 5, *E. macrourus* Barrois & Daday: a, ventral; b, unci teeth; 6, *E. clavulata* (Ehrenberg); 7, *E. brachionus* (Ehrenberg): a, ventral; b, trophus; 8, *Cyrtonia tuba* Ehrenberg; 9, *Microcodides chlaena* Gosse: a, lateral; b, trophus, c, trophus lateral; 10, *M. robustus* (Glasscott): a, lateral; b, trophi. Scale lines 100 µm. (Various authors, after Koste (1978), Koste & Shiel (1987)).

Key to species of Macrochaetus known from Australia
[refer to Fig. 37:2]

1. Only one pair of rudimentary anteriosubmedian spines present (2a, b)..*M. danneeli* Koste & Shiel (Fig. 37:3)
- More spines present..**2**

2(1). Two anterolateral spines, two anteriomedian spines, two posteriomedian spines present, central dorsal spine pair absent (4a, b)..*M. collinsi* (Gosse) (Fig. 37:4)
- Central dorsal spine pair present..**3**

3(2). Two anteriolateral- , two anteriomedian- , two central median- and two anteriosubmedian spines present (Fig. 37:5)..........*M. altamirai* (Arevalo)
- Two anteriolateral-, two anteriomedian, two anteriosubmedian- and two posteriomedian spines present (Fig. 37:6)..........*M. subquadratus* (Perty)

Trichotria **Bory de St Vincent**

Trichotria species are unmistakeable, with head, body and three foot segments heavily loricate. *Trichotria* occurs rarely in the plankton (as migrants). Five species are known from Australia, two of them also from N.Z. For details, see review by Koste & Shiel (1989).

Key to Species of the Trichotria known from Australia/N.Z.

1. Cross-section hexagonal, three foot segments..**2**
- Cross-section triangular, two foot-segments (Fig 37:7) ....*T. buchneri* Koste *et al.*

2(1). Only distal end of terminal foot segment and toes projecting beyond posterior lorica margin; lorica elongated U-shape (Fig. 37:8)..*T. pseudocurta* Koste *et al.*
- All three, or at least two, foot segments and toes projecting beyond lorica margin..**3**

3(2). Last foot joint with dorsal minute spine between the toe bases (Fig. 37:9)..*T. pocillum* (Müller)
- No minute spine between the toe bases..**4**

4(3). Lateral part of dorsal lorica conspicuously large; marginal spicules of lorica directed forward (Fig. 37:10)......................*T. truncata* Whitelegge
- Lateral lorica not very expanded; spicules if present not directed forward (Fig. 37:11)..*T. tetractis* (Ehrenberg)

Niche: herbivore - eat algae and detritus, diatoms preferred.

15. Fam. Brachionidae Wesenberg-Lund, 1899

Six genera with about 47 species are known from Australia. *Notholca, Platyias* and *Plationus* are rare inhabitants of smaller water bodies. *Anuraeopsis, Brachionus*, and *Keratella* are common and abundant in a wide range of habitats. The northern hemisphere genus *Kellicottia* is not recorded from Australia. Differences between the Australian/N.Z. brachionids are noted with the relevant genera.

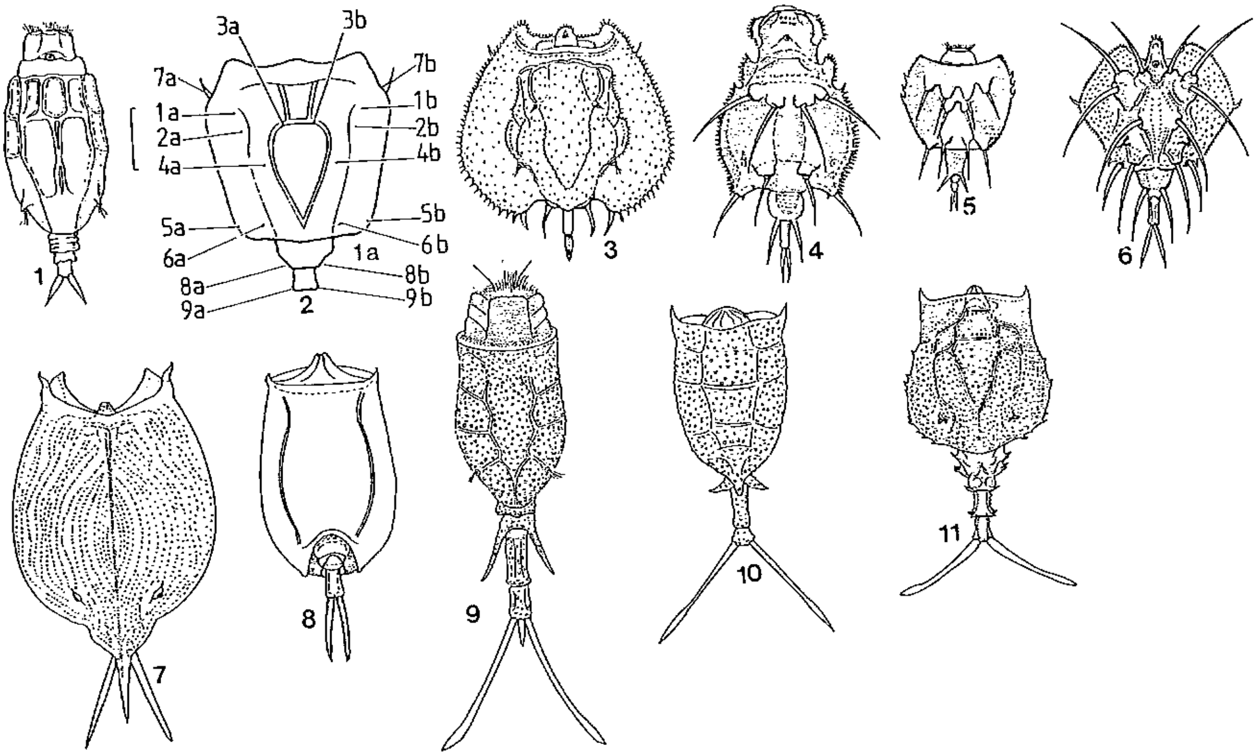


Fig: 37: 1, *Wolga spinifera* (Western); 2, *Macrochaetus* spine locations; 3, *M. danneeli* Koste & Shiel; 4, *M. collinsi* (Gosse); 5, *M. altamirai (Arevalho)*; 6, *M. subquadratus* (Perty); 7, *Trichotria buchneri* Koste *et al.*; 8, *T. pseudocurta* Koste *et al.*; 9, *T. pocillum* (Müller); 10, *T. truncata* Whitelegge; 11, *T. tetractis* (Ehrenberg). (Various authors, after Koste (1978), Koste & Shiel (1990)).

Key to genera of Brachionidae known from Australia/N.Z.

1. Foot present..2
- Foot absent..3

2(1) Foot jointed, lorica cf. Fig. 38:1..........................*Platyias Harring*
- Foot jointed, lorica cf. Fig. 38:2..........................*Plationus Segers*
- Foot annulated, hose-like, lorica cf. Fig. 38:3-:28..............*Brachionus Pallas*

3(1) Dorsal lorica with facets, 1, 2 or no posterior spines (Fig. 39)..........................*Keratella* Bory De St Vincent
- Dorsal lorica smooth or with longitudinal striae..........................4

4(3) Lorica cf. Fig. 40:1, resembles *Brachionus*, may be striated.....*Notholca Gosse*
- Lorica as Fix. 40:3..........................*Anuraeopsis Lauterborn*

Platyias Harring

A single species of this distinctive genus is known from both Australia and New Zealand. *Platyias quadricornis* (Ehrenberg, 1832) (Fig 38:1) is commonly collected in shallow waters, occasionally venturing into the plankton of deeper reservoirs.

Niche: ?herbivore

Plationus Segers

One species of *Plationus, P. patulus* (Müller, 1786) (Fig. 38:2) is known from both Australia and N.Z. A second species recently collected in NW W.A. (Halse, pers. comm.) is undescribed. *P. patulus* is a littoral inhabitant of shallow waters.

Niche: detritivore/algivore

Brachionus Pallas

The apparent radiation of brachionids in southeastern Australia was noted by Dumont (1983); approximately 40% of the 26 species and 22 subspecies of *Brachionus* known from the region are endemic (Shiel 1983, Koste and Shiel 1986a). Several have been found subsequently in Thailand, Papua-New Guinea and New Zealand (Segers & Sanoamuang (in press); Shiel & Green (1995)). Taxonomy is based on the features of the lorica, in particular on the spines and the shape of the anterior margin, the posterior, lateral and foot-opening spines, and morphology of the lorica surface. For systematic information see Ahlstrom 1940, Kutikova 1970, Ruttner-Kolisko 1974 and Koste 1978, 1979.

Key to species of Brachionus known from Australian/N.Z. inland waters

1. Ventral anterior lorica margin toothed; caudal lorica without spines (short extensions beside foot opening)..........*B. baylyi* Sudzuki & Timms (Fig. 38:3)
\- Ventral margin more or less undulate..........**2**

2(1). Lorica with basal plate..........**3**
\- Lorica without basal plate..........**4**

3(2). Anterior lateral spines mostly longer than median and submedian..........*B. bidentatus* Anderson (Fig. 38:4)
\- Anterior lateral spines not longest; median spines longest..........*B. leydigi* Cohn (Fig. 38:5)

4(2). Ventral lorica with tubular foot opening..........*B. quadridentatus* Hermann (Fig. 38:6)
\- Ventral lorica without tubular foot opening..........**5**

5(4). Anterior dorsal margin with 6 spines..........**6**
\- Anterior dorsal margin with 2-4 spines, submedian seldom developed..........**18**

6(5). Submedian anterior spines very long (Fig. 38:7)..........*B. falcatus* Zacharias
\- Submedian anterior spines of equal length..........**7**

7(6). Epizoic on crustaceans..........**15**
\- Not epizoic..........**8**

8(7). Lorica with strong stripes or pustulated..........**12**
\- Lorica occasionally weakly ornamented, soft..........**9**

9(8). Foot opening with pointed spines..........**13**
\- Foot opening without pointed spines..........**10**

10(9). Foot opening displaced to ventral side..........**17**
\- Foot opening terminal..........**11**

11(10). Occipital margin spines on broad bases with curved lines..........*B. plicatilis* (Müller) (Fig. 38:8)
\- Occipital spines on small bases..........*B. urceolaris* (Müller) (Fig. 38:9)

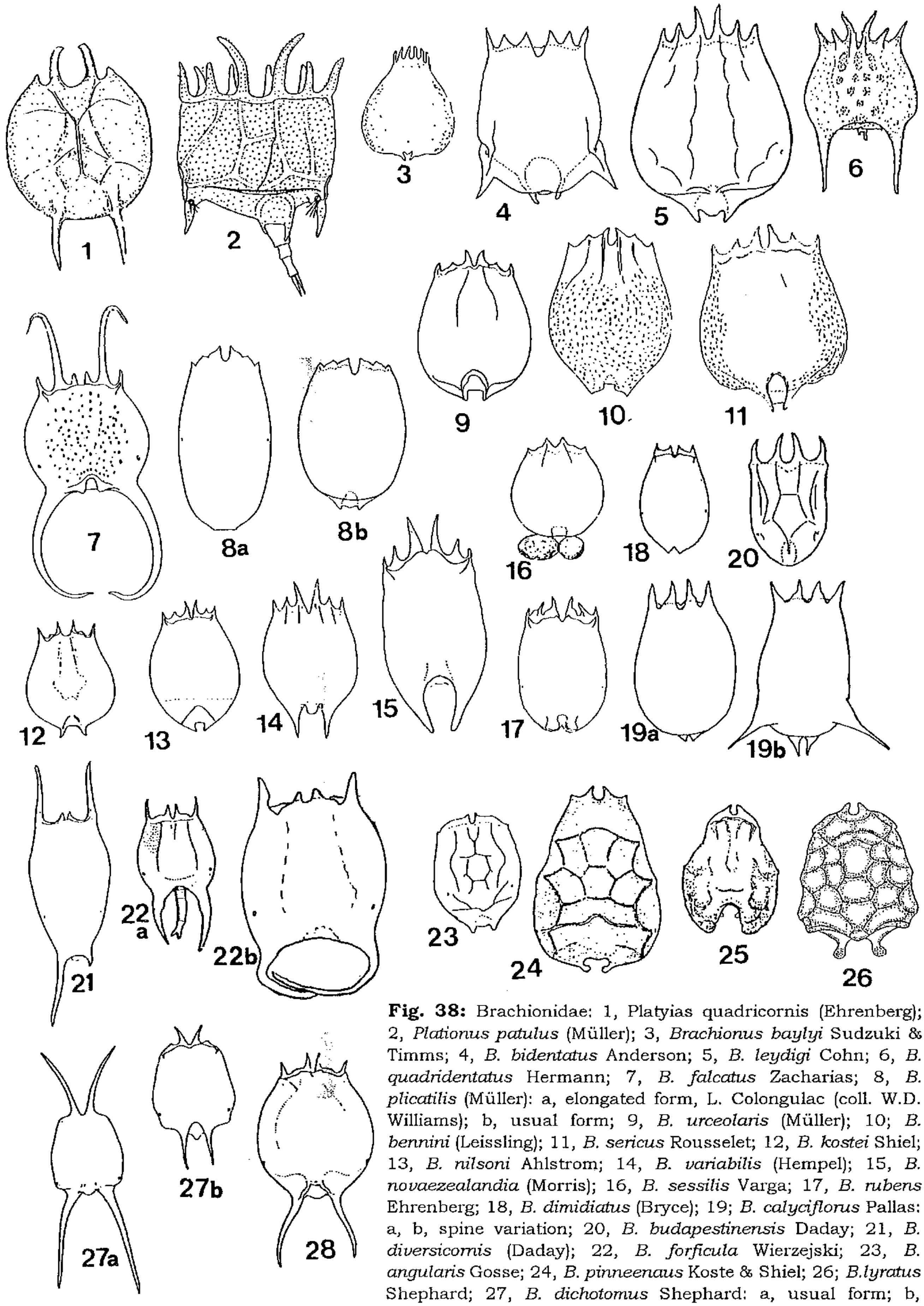


Fig. 38: Brachionidae: 1, Platyias quadricornis (Ehrenberg); 2, *Plationus patulus* (Müller); 3, *Brachionus baylyi* Sudzuki & Timms; 4, *B. bidentatus* Anderson; 5, *B. leydigi* Cohn; 6, *B. quadridentatus* Hermann; 7, *B. falcatus* Zacharias; 8, *B. plicatilis* (Müller): a, elongated form, L. Colongulac (coll. W.D. Williams); b, usual form; 9, *B. urceolaris* (Müller); 10; *B. bennini* (Leissling); 11, *B. sericus* Rousselet; 12, *B. kostei* Shiel; 13, *B. nilsoni* Ahlstrom; 14, *B. variabilis* (Hempel); 15, *B. novaezealandia* (Morris); 16, *B. sessilis* Varga; 17, *B. rubens* Ehrenberg; 18, *B. dimidiatus* (Bryce); 19; *B. calyciflorus* Pallas: a, b, spine variation; 20, *B. budapestinensis* Daday; 21, *B. diversicornis* (Daday); 22, *B. forficula* Wierzejski; 23, *B. angularis* Gosse; 24, *B. pinneenaus* Koste & Shiel; 26; *B.lyratus* Shephard; 27, *B. dichotomus* Shephard: a, usual form; b, 'reductus' dwarf form; 28, *B. caudatus* Barrois & Daday. (Various authors, after Koste (1978), Koste & Shiel (1987).

12(8). Lorica granulated/pustulate........................*B. bennini* (Leissling) (Fig. 38:10)
- Lorica with strong stripes............................*B. sericus* Rousselet (Fig. 38:11)

13(9). Anteromedian spines remarkably longer than other anterior spines...........**15**
- Anteromedian spines not appreciably longer..**14**

14(13). Foot opening spines diverging, convoluted...........*B. kostei* Shiel (Fig. 38:12)
- Foot opening spines not diverging, very pointed..*B. nilsoni* Ahlstrom (Fig. 38:13)

15(13). Lorica elongate-oval...**16**
- Lorica spherical or resembling *B. urceolaris* (Fig. 38:9)..............................**17**

16(15). Foot opening with short dorsal flap of variable length..*B. variabilis* (Hempel) (Fig. 38:14)
- Foot opening without flap..................*B. novaezealandia* (Morris) (Fig. 38:15)

17(15). Lorica spherical...*B. sessilis* Varga (Fig. 38:16)
- Lorica resembling *B. urceolaris* (Fig. 38:9)....*B. rubens* Ehrenberg (Fig. 38:17)

18(5). Two median occipital spines always present, submedian reduced or lacking; lateral of varying lengths or absent...**23**
- Four occipital spines of varying length...**19**

19(18). Spines on anterior margin very short or absent..*B. dimidiatus* (Bryce) (Fig. 38:18)
- Spines longer, crooked...**20**

20(19). Lorica thick, with dorsal plaques..**21**
- Lorica thin, without plaques, anterior margin spines variable..*B. calyciflorus* Pallas (Fig. 38:19)

21(20). Lorica with caudal spines...**22**
Lorica without caudal spines...............*B.budapestinensis* Daday (Fig. 38:20)

22(21). Anterior lateral spines much elongated; posterior spines divergent..*B. diversicornis* (Daday) (Fig. 38:21)
- Anterior lateral spines not elongated; posterior spines convergent, occasionally with characteristic knee-like swelling..*B. forficula* Wierzejski (Fig. 38:22)
NB: The individual shown in Fig. 38:22b (Fitzroy R., Qld) has unusually long caudal spines (Coll. L. Fabbro, Rockhampton).

23(18). Median anterior spines much elongated (see Fig. 38:27), or short if lateral spines present (Fig. 38:28)..**28**
- Median anterior spines short, no lateral spines..**24**

24(23). Foot-opening spines short...........................*B. angularis* Gosse (Fig. 38:23)
- Foot-opening spines absent or reduced..**25**

25(24). Lorica saccate, dorsally hemispherical..**27**
- Lorica pyriform, dorsoventrally compressed...**26**

26(25). Foot opening ventral..................*B. pinneenaus* Koste and Shiel (Fig. 38:24)
- Foot opening displaced dorsally.........................*B. keikoa* Koste (Fig. 38:25)

27(25). Aperture of foot opening dorsal with a short flap...................................**28**
- Resembles *B. angularis*, but caudal spines lyre-shaped, knob-ended and granulated...*B.lyratus* Shephard (Fig. 38:26)
  NB: The individual shown is from a Tasmanian population. Mainland *B. lyratus* are less heavily ornamented, readily confused with *B. angularis*.

28(23, 27). Median anterior dorsal spines long.*B. dichotomus* Shephard (Fig. 38:27)
- Median anterior spines short..........*B. caudatus* Barrois & Daday (Fig. 38:28)

Other species of these genera may occur in local regions. For full taxonomy, see Koste & Shiel (1987).

Niche: bacteriovore/herbivore

Keratella Bory De St Vincent

Keratella species are found in most standing fresh waters. Taxonomy is based on the lorica characteristics. Most important is the arrangement of facets on the dorsal lorica. The fine structure (granulation or spinules on the lorica surface) has little significance for taxonomic purposes, similarly, there may be environmentally-induced variations in presence or absence of caudal spines, relative spine length, etc. The genus can be divided roughly into two form groups. The first, the "*quadrata*" group, has a row of median plaques on the dorsal lorica (Fig. 39:1). The second, the "*cochlearis*" group (Fig. 39:14)(after Ruttner-Kolisko 1972, 1974) has a median keel with plaques on either side, and generally a single posterior spine (which can, however, be absent e.g. the *tecta* morph (Fig. 39:15), variously considered a valid species, a subspecies, or an infrasubspecific ecotypic variant. Thirteen *Keratella* species are known from Australia, ten of them also from N.Z. *K. ahlstromi* Russell, 1951 (Fig. 39:17), *K. crassa* Ahlstrom, 1943 (Fig. 39:18) and *K. sancta* Russell, 1944 (Fig 39:9), recorded by Russell from N.Z., are not known from Australia.

Key to species of Keratella known from Australia/N.Z.

1. Dorsal plate with median row of plaques..**2**
- Dorsal plate with median ridge or keel..**11**

2(1). Posteromedian plaque hexagonal..**3**
- Posteromedian plaque other than hexagonal...**6**

3(2). Lorica broader at posterior end, nearly rectangular or trapezoid.................**4**
- Lorica broader at anterior end..**5**

4(3). Lorica nearly rectangular................................*K. quadrata* (Müller) (Fig. 39:1)
- Lorica trapezoid..*K. australis* (Berzins)(Fig. 39:2)

5(4). Posteromedian remnant under posteromedian plaque..*K. tropica* (Apstein) (Fig. 39:3)
- Posteromedian remnant absent.......................*K. valga* (Ehrenberg) (Fig. 39:4)

6(2). Posteromedian plaque terminates with a rounded ridge towards posterior margin...*K. slacki* (Berzins) (Fig. 39:5)
- No rounded ridge behind posteromedian plaque...**7**

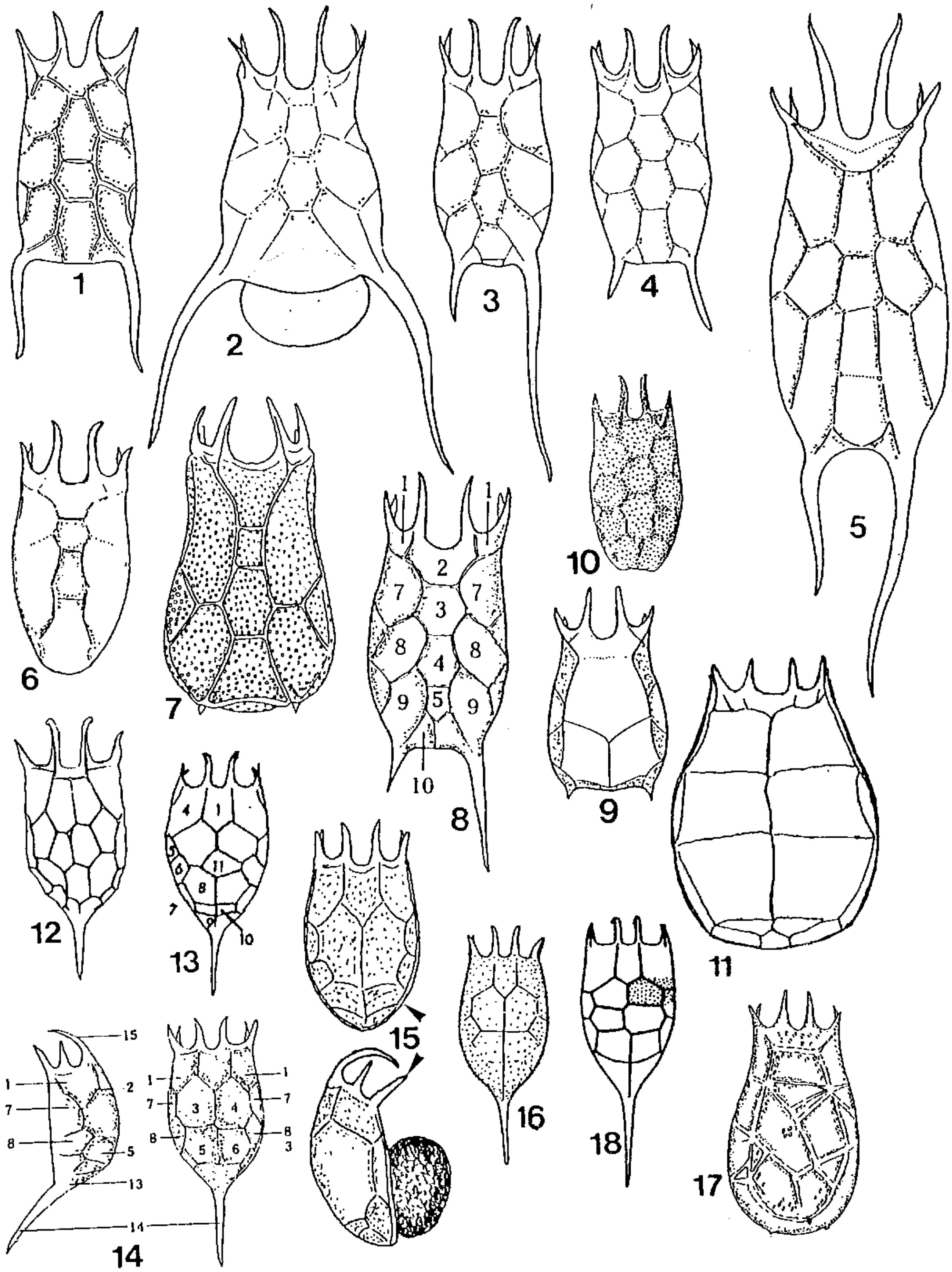


Fig. 39: 1, *K. quadrata* (Müller); 2, *K. australis* (Berzins); 3, *K. tropica* (Apstein); 4, *K. valga* (Ehrenberg); 5, *K. slacki* (Berzins); 6, *K. lenzi* Hauer; 7; *K. shieli* Koste; 8, *K. procurva* (Thorpe); 9, *K. sancta* Russell; 10, *K. serrulata* (Ehrenberg); 11, *K. cruciformis* (Thompson); 12, *K. javana* (Hauer); 13, *K. irregularis* (Lauterborn); 14, *K. cochlearis* (Gosse); 15, *K. tecta* Lauterborn; 16, *K. hispida* (Lauterborn); 17, *K. ahlstromi* Russell; 18, *K. crassa* Ahlstrom. (Various authors, after Koste & Shiel (1987).

7(6). Lorica rounded caudally..*K. lenzi* Hauer (Fig. 39:6)
- Lorica not rounded caudally...**8**

8(7). Central row of plaques terminates in a median line....................................**9**
- Central row of plaques does not terminate with median line..*K. shieli* Koste (Fig. 39:7)

9(8). Posteromedian plaque pentagonal, terminates in median line...*K. procurva* (Thorpe) (Fig. 39:8)
- Posteromedian plaque absent..**10**

10(9). Only a single large anteromesomedian plaque on the dorsal lorica...*K. sancta* Russell (Fig. 39:9)
- Anterior median and mesomedian plaques present..*K. serrulata* (Ehrenberg) (Fig. 39:10)

11(1). 6 facets; median paired rectangular plaques...*K. cruciformis* (Thompson) (Fig. 39:11)
- Lorica has no rectangular facets...**12**

12(11). Median frontal plaque pentagonal...**13**
Median frontal plaque rectangular...................*K. javana* (Hauer) (Fig. 39:12)

13(12). Median keel straight or with a slight kink; plaques nearly symmetrical....**14**
Median keel with definite kink; accessory median panel under anterocarinal plaques...*K. irregularis* (Lauterborn) (Fig. 39:13)

14(13). Lorica surface areolated.............................*K. cochlearis* (Gosse) (Fig. 39:14)
- Stout lorica, granulated or spinulated......*K. hispida* (Lauterborn) (Fig. 39:16)

Niche: bacteriovores/herbivores

Notholca Gosse

N. squamula Müller (Fig. 40:1) was the only representative of this cold stenothermal northern hemisphere genus known from Australia until a record of *N. labis* (Fig. 40:2) from Tasmania (Sudzuki 1985). *N. squamula, N. foliacea* Ehrenberg and *N. striata* (Müller) are known from New Zealand or its offshore islands (Shiel & Green 1995). All are rare.

Anuraeopsis Lauterborn

All species warm stenotherm; great variability in lorica shape, size, keel and surface structures of the lorica. Three species are known from Australia, one of them, *A. fissa*, from N.Z.

Key to species of Anuraeopsis known from Australian/N.Z. inland waters

1. Shape ovate...**2**
- Shape navicular...**3**

2(1). Anterior margin smooth......................................*A. fissa* (Gosse) (Fig. 40:3)
- Anterior margin serrated, lorica with ribs and keels...................................**3**

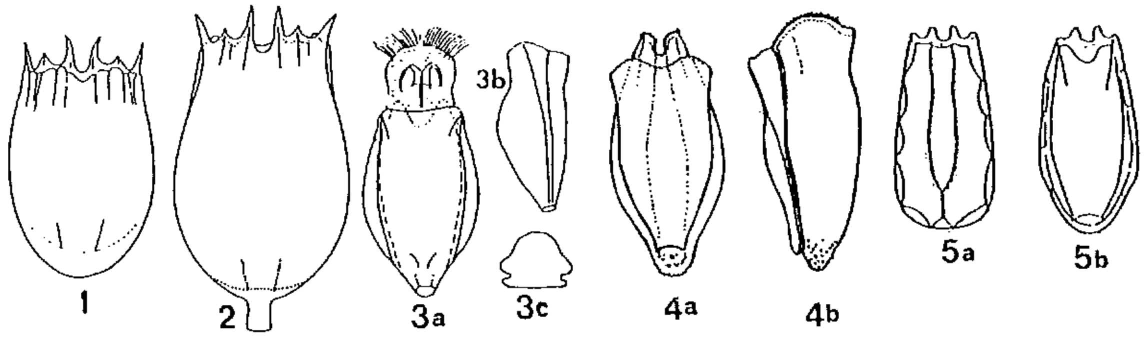


Fig. 40: 1, *Notholca squamula* (Müller); 2, *N. labis* Gosse; 3, *Anuraeopsis fissa* (Gosse): a, ventral; b, lateral; c, section; 4, *A. navicula* Rousselet: a, ventral; b, lateral; 5, *A. coelata* (De Beauchamp): a, dorsal; b, ventral. (After Koste (1978), Koste & Shiel 1987)).

3(1). Lorica only granulated with finely serrated anterior border, shape elongated...*A. navicula* Rousselet (Fig. 40:4)
- Dorsal plate with ribs, facets, ventral plate with structure..*A. coelata* (De Beauchamp) (Fig. 40:5)

Niche: ?Bacteriovore/herbivore

16. Fam. Colurellidae Bartos, 1959

Small rotifers occasionally found in plankton, but more often in littoral vegetation. The family was revised by Koste & Shiel (1989). Three genera are knwon from Australia/N.Z., with 46 and 22 spp. respectively.

Key to genera of Colurellidae

1. Lorica laterally compressed, with ventral or dorsal and ventral apertures.....**2**
- Lorica dorso-ventrally flattened, without such apertures............................**3**

2(1). Lorica a single structure, with ventral aperture (Fig. 41:2)...*Colurella* Bory De St Vincent
- Lorica two plates, with dorsal and ventral apertures (Fig. 41:1) ....*Paracolurella* Myers (not known from Australia)

3(1). Hood or head-shield large, non-retractible (cf. Fig. 41:9)...*Squatinella* Bory De St Vincent
- Hood small, retractible (Fig. 42).......................*Lepadella* Bory De St Vincent

Colurella Bory de St Vincent

One piece lorica, in lateral view oval, egg- or hatchet-shaped (outline of lorica differs according to degree of contraction, particularly ventral margin). Variants are known in the five species of *Colurella* recorded from Australia. Seven taxa are recorded from N.Z. It is likely that other species occur here; in view of their small size (most <100 µm) colurellids are easily overlooked in detritus-rich samples.

Key to species Colurella known from Australian inland waters

1. Lorica surface smooth...**2**
- Lorica surface with longitudinal furrows or facets (Fig. 41:2)..*C. tesselata* (Glasscott)

2(1). Lorica valve (lateral) slender, posteriorly with variable apices...............**3**
- Lorica valve rounded, plump (Fig. 41:3).......................*C. obtusa* (Gosse)

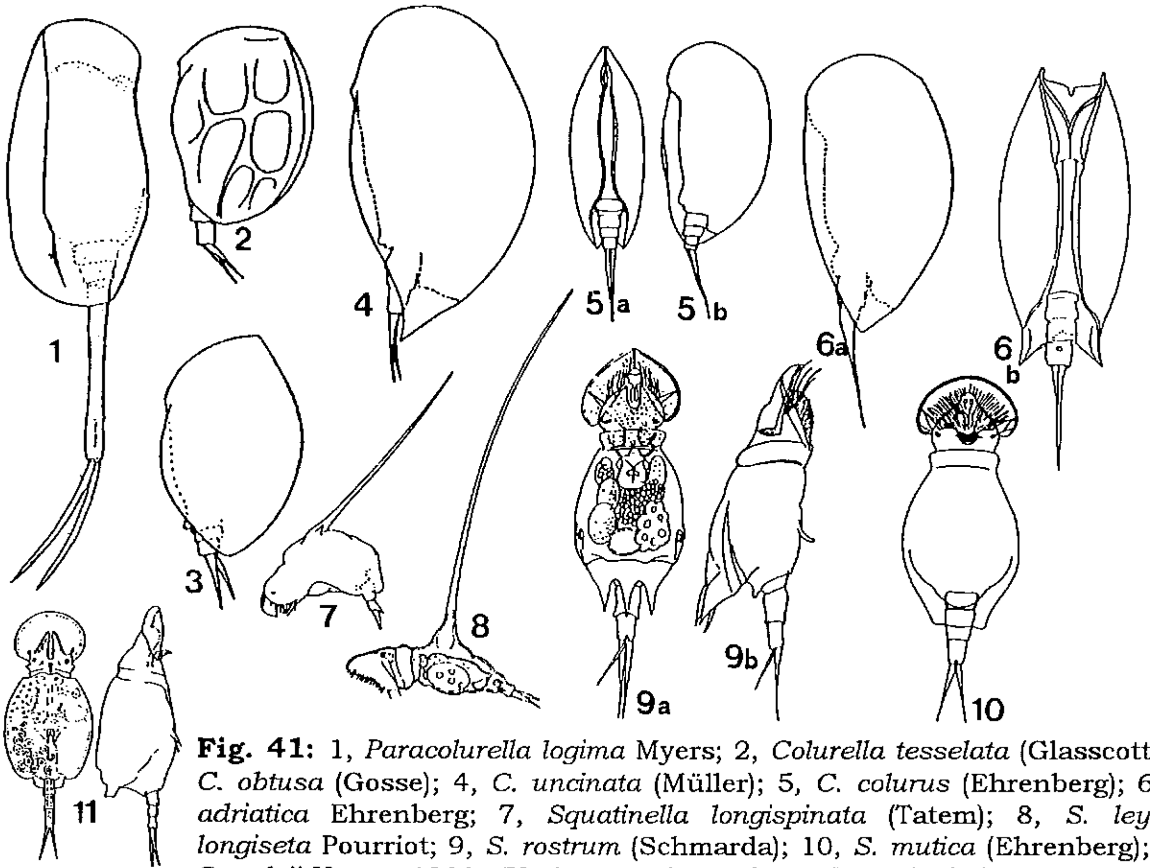


Fig. 41: 1, *Paracolurella logima* Myers; 2, *Colurella tesselata* (Glasscott); 3, *C. obtusa* (Gosse); 4, *C. uncinata* (Müller); 5, *C. colurus* (Ehrenberg); 6, *C. adriatica* Ehrenberg; 7, *Squatinella longispinata* (Tatem); 8, *S. leydigii longiseta* Pourriot; 9, *S. rostrum* (Schmarda); 10, *S. mutica* (Ehrenberg); 11, *S. geleii* Varga, 1933. (Various authors, from Koste (1978), Koste & Shiel (1989)).

3(2). Posterior end of lorica with raised lines terminating in variable tapering, downward-curving (occasionally lightly upward-curving) spines; lorica high (length/height ratio <1.8); toes short (Fig. 41:4)..............*C. uncinata* (Müller)
- Posterior end of lorica broadly rounded, or blunt-spined or tapering; lorica low (ratio >1.8); toes long..**4**

4(3). Lorica valve posteriorly rounded, or at most extended to a blunt apex (Fig. 41:5)..*C. colurus* (Ehrenberg)
- Lorica valve posteriorly with curved spines (Fig. 41:6)...*C. adriatica* Ehrenberg

Niche: bacteriovorous/herbivorous

Squatinella Bory De St Vincent

Squatinella species are rare components of littoral microfauna. Ecology of *Squatinella* is little known. Four species are recorded from Australia, two of them also from N.Z., which has in addition *S. geleii* Varga, 1933 (Fig. 41:11). For details of other species and variants, see Koste (1978:175-179).

Key to species Squatinella known from Australian inland waters

1. With dorsal spine..**2**
- Without dorsal spine..**3**

2(1). Foot 3-segmented; short spine at base of toes..*S. longispinata* (Tatem) (Fig. 41:7)
- Foot 2-segmented; spine absent.........................*S. leydigii* (Zacharias) (Fig. 41:8)

NB: The figured taxon is *S. leydigii longiseta* (Pourriot), which is recorded from Barmah Forest. *S. leydigii* (s.str.) is not known from Australia.

3(1). With a short spine above the base of the toes..*S. rostrum* (Schmarda) (Fig. 41:9)
- Without spine above toe bases....................*S. mutica* (Ehrenberg) (Fig. 41:10)

Lepadella Bory de St Vincent

Lepadella species are benthic, common in billabongs and ponds, occasionally collected in the plankton of reservoirs and rivers. Further details are given by Koste (1978), who notes that all species can be identified from preserved material, although caution must be taken with preservation artefacts, particularly in the case of formalin-preserved specimens. Several of the 35 taxa of *Lepadella* identified from Australia probably are misidentified for this reason. About half of the known species appear to be indigenous; the genus is thus second only to *Brachionus* (Koste & Shiel 1987b) in its complement of endemic taxa.

Three subgenera are recognized on the basis of toe morphology:

(i) *Lepadella* (s.str.) (toes of equal length, entirely separated) - all but three of the known taxa ;

(ii) L. *Heterolepadella* (toes of unequal length) 2 sp. L. (*H.) apsicora* Myers, 1934 (Fig. 42:1) and L. (*H.) ehrenbergi* (Perty, 1850) (Fig 42.2);

(iii) L. *Xenolepadella* (toes completely or partly fused); 1 sp. *L. (X.) monodactyla* Berzins, 1960 (Fig. 42:3).

Key to species Lepadella (s. str.) known from Australian inland waters

1. Dorsal lorica without keel or ribs (may be lightly punctate, but otherwise unornamented)..**2**
- Dorsal lorica with keel and/or longitudinal ribs or other ornamentation...**17**

2(1). Lorica length >3x lorica width, almost cylindrical (Fig. 42:4)...*L. angusta* Berzins
- Lorica length <3x lorica width, ovoid, circular, trapezoidal or rhomboidal...**3**

3(2). Dorsal lorica cross-section 1/3 of circle to highly-domed hemisphere..........**6**
- Dorsal lorica a shallow dome, or dorsoventrally flattened............................**4**

4(3). Lorica oval to circular; head aperture notched both dorsally and ventrally (Fig. 42:5)..*L. ovalis* (Müller)
- Lorica 2x wider in posterior third than anterior; dorsal margin of head aperture straight, ventral margin only weakly v-shaped..............................**5**

5(4). Ventral lorica with two lateral spines directed forward; toes straight (Fig. 42:6)...*L. tana* Koste & Shiel
- Ventral lorica spineless; toes curved (Fig. 42:7)................*L. neboissi* Berzins

6(3). Occipital margin of head aperture protruding..**10**
- Occipital margin of head aperture concavely notched.................................**7**

7(6). Lorica outline elongate oval to circular...**8**
- Lorica outline rhomboidal (Fig. 42:8]................................*L. chengalathi* Koste

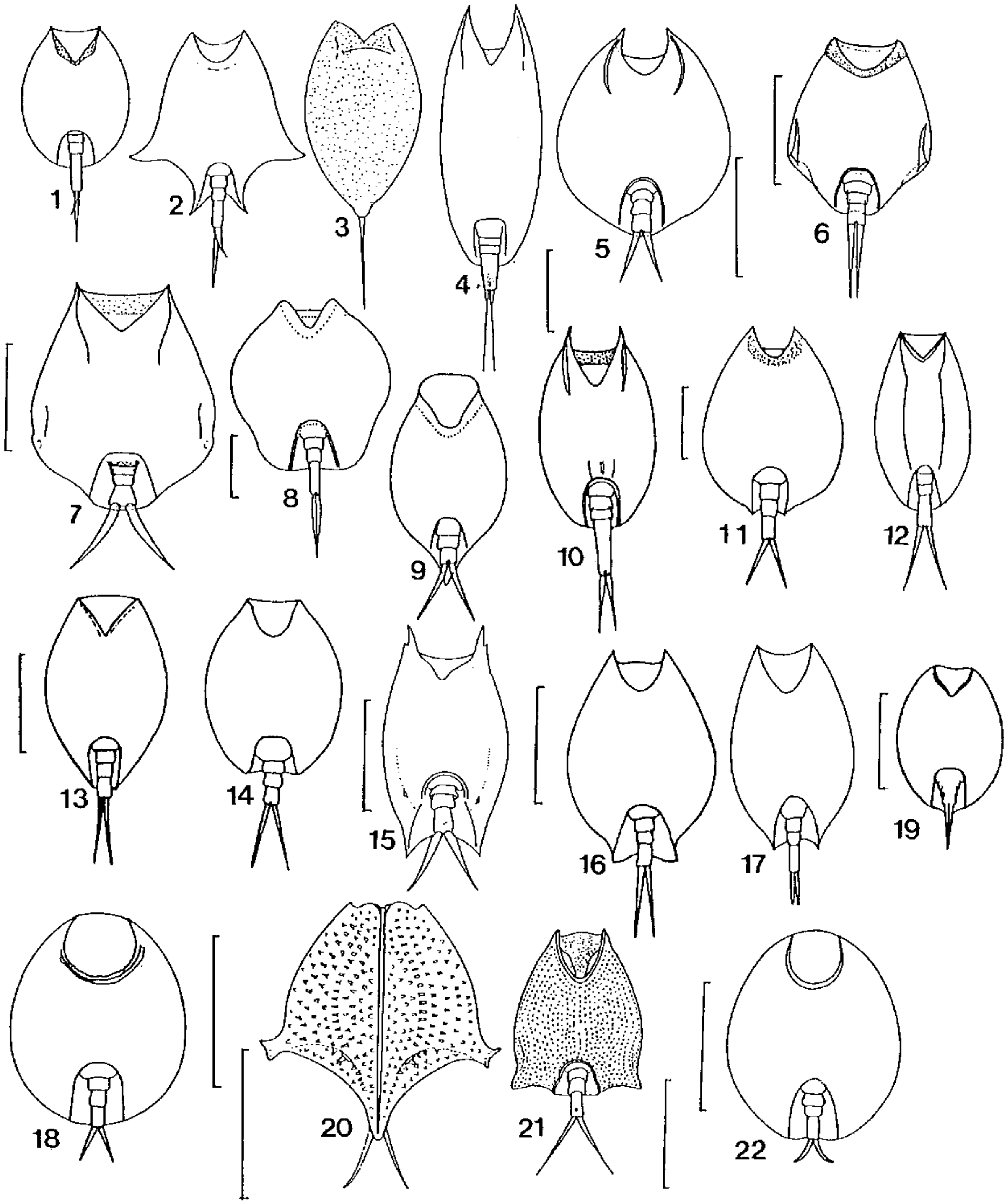


Fig. 42: 1, L. *Heterolepadella apsicora* Myers, 1934; 2, L. (*H.*) *ehrenbergi* (Perty, 1850); 3, L. *Xenolepadella monodactyla* Berzins, 1960; 4, *L. angusta* Berzins; 5, *L. ovalis* (Müller); 6, *L. tana* Koste & Shiel; 7, *L. neboissi* Berzins; 8, *L. chengalathi* Koste; 9, *L. vandenbrandei* Gillard; 10, *L. elliptica* Wulfert; 11, *L. patella* (Müller); 12, *L. triba* Myers; 13, *L. dactyliseta* (Stenroos); 14, *L. benjamini* Harring; 15, *L. cornuta* (Koste); 16, *L. latusinus* (Hilgendorf); 17, *L. vitrea* Shephard; 18, *L. apsida* Harring; 19, *L. rottenburgi* (Lucks); 20. *L. minorui* Koste; 21, *L. tyleri* Koste & Shiel; 22, *L. lindaui* Koste. Scale lines 50 µm. (Various authors, after Koste & Shiel (1989)).

8(7). Posterior margin of lorica rounded or truncate, never pointed (Fig. 5:7a)......**9**
- Posterior margin of lorica tapers to a pointed projection extending beyond base of toes (Fig. 42:9)..*L. vandenbrandei* Gillard
Senior synonym of L. williamsi Koste & Shiel, 1980

9(8). Head aperture ventral sinus with parallel cuticular ribs; dorsally with a wide granulated collar (Fig. 42:10)....................................*L. elliptica* Wulfert
- Head aperture without ribs or dorsal collar (Fig. 42:11).......*L. patella* (Müller)

10(6). Ventral lorica with longitudinal pleats (Fig. 42:12)...................*L. triba* Myers
- Ventral lorica unpleated...**11**

11(10). Cross-section with rounded bead-like lateral margins (Fig. 42:13)...*L. dactyliseta* (Stenroos)
- Cross-section lateral margins produced to acute-angled tips......................**12**

12(11). Foot-opening excised dorsally..**13**
- Foot-opening not excised dorsally...**16**

13(12). Extremely wide foot-opening, longer than wide; corners with outwardly-curved points...**14**
- Foot opening wider than long, no points on corners (Fig. 42:14)..*L. benjamini* Harring

14(13). Head aperture ventrally with lateral bifurcate pointed extensions extending beyond dorsal margin (Fig. 42:15)......................*L. cornuta* (Koste)
- No lateral points on head aperture...**15**

15(14). Head aperture with convex dorsal margin; last foot segment <½ toe length (Fig. 42:16)..*L. latusinus* (Hilgendorf)
- Head aperture with concave dorsal margin; last foot segment >½ toe length (Fig. 42:17)...*L. vitrea* Shephard

16(12). Head aperture circular (Fig. 42:18)..................................*L. apsida* Harring
- Head aperture with deep ventral sinus (Fig. 42:19).........*L. rottenburgi* (Lucks)

17(1). Lorica outline trapezoidal; lorica ornamented (appears punctate or granulated under LP)...**18**
- Lorica outline circular or oval..**19**

18(17). Lateral extensions ("horns") from posterior lorica; rows of tiny rodlike structures cover lorica (Fig. 42:20)..*L. minorui* Koste
- Lateral horns absent; punctiform ornamentation of dorsal and ventral lorica (Fig. 42:21)..*L. tyleri* Koste & Shiel

19(17). Lorica outline circular; head aperture circular, ventrally placed; lorica cross-section an inverted saucer (Fig. 42:22).........................*L. lindaui* Koste
- Lorica outline ovoid; head aperture not circular; lorica cross-section lightly domed, ribbed or triangular...**20**

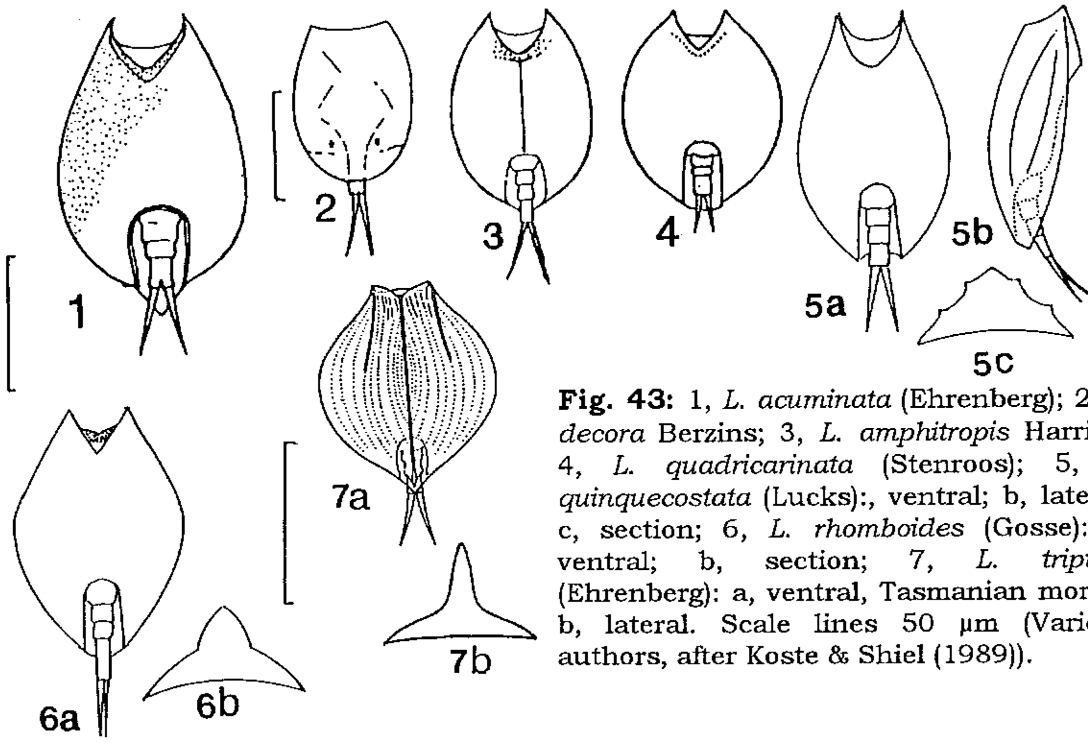


Fig. 43: 1, *L. acuminata* (Ehrenberg); 2, *L. decora* Berzins; 3, *L. amphitropis* Harring; 4, *L. quadricarinata* (Stenroos); 5, *L. quinquecostata* (Lucks):, ventral; b, lateral, c, section; 6, *L. rhomboides* (Gosse): a, ventral; b, section; 7, *L. triptera* (Ehrenberg): a, ventral, Tasmanian morph; b, lateral. Scale lines 50 µm (Various authors, after Koste & Shiel (1989)).

20(19). Posterior lorica tapers to an acute point, which may be ridged dorsally (Fig. 43:1)..*L. acuminata* (Ehrenberg)
- Posterior lorica rounded, indented, or concavely notched...........................**21**

21(20). Dorsal lorica with median keel...**24**
- Dorsal lorica without median keel...**22**

22(21). Dorsal lorica with open-squared pattern (three rows); occipital margin straight (Fig. 43:2)...*L. decora* Berzins
- Dorsal lorica unpatterned, with 1-4 short ribs over foot-opening...............**23**

23(22). 1-3 short ribs at posterior end over foot-opening; cross-section rhombic (Fig. 43:3)..*L. amphitropis* Harring
- 4 parallel short ribs over foot-opening; cross-section a shallow dome with lateral concavities of ventral margin (Fig. 43:4).........*L. quadricarinata* (Stenroos)

24(21). Median keel of dorsal lorica without side ribs...**25**
- Median keel with 2-3 pairs of side ribs (Fig. 43:5)....*L. quinquecostata* (Lucks)

25(24). Median keel low and wide, bordered by lateral grooves; granulated collar (Fig. 43:6)...*L. rhomboides* (Gosse)
- Median keel high, triangular, arising from narrow base; no granulated collar. Some forms have fine striped/pustulated lorica surface (Fig. 43:7)...*L. triptera* (Ehrenberg)

Niche: bacteriovorous/herbivorous

17. **Fam. Mytilinidae** Bartos, 1959

Loricate rotifers; cross-sections of lorica mostly triangular or nearly rhombic; ventral plate and dorso-lateral plates firmly fused; long dorsum with or without sulcus, latter common with double keel; three or less foot sections; toes pointed, straight or slightly curved ventralwards; malleate trophi. All species littoral and benthic, occasionally (but rarely) in the plankton. Two genera (see Bartos 1959, Kutikova 1970, Koste 1978, Koste & Shiel 1989).
Seven species of *Mytilina* and three of *Lophocharis* are known from Australia, four and one of which respectively also occur in N.Z.

Key to genera of Mytilinidae known from Australian/N.Z. inland waters

1. Lorica thin or rigid with dorsal sulcus and double keel; lorica unornamented; toes long..*Mytilina* Bory de St Vincent
- Lorica without dorsal sulcus, one strong keel; lorica ornamented with distinct pattern and cavities; toes short.......................*Lophocharis* Ehrenberg

Mytilina Bory de St Vincent

Reasonably common in vegetated lake margins, in billabongs and similar habitats, rarely in the plankton of larger lakes/reservoirs.

Key to species of Mytilina known from Australian/N.Z. inland waters

1. Lorica stout, anterior margin granulated, toes sword-shaped.......................**2**
- Lorica thin, anterior margin not granulated, toes long and curved..............**3**

2(1). Anterior lorica margin with two short dorsal and two short ventral spines (Fig. 44:1)...*M. mucronata* Müller
- Anterior lorica margin with only two ventral spines (Fig. 44:2)..*M. ventralis* (Ehrenberg)

3(1). Ventral margin of lorica with variable projections (Fig. 44:3)..*M. acanthophora* Hauer
- Ventral anterior margin without projections...**4**

4(3). Toes with claws...**5**
- Toes without claw..**6**

5(4). Head part loricate; 3 foot segments (Fig. 44:4)................*M. crassipes* (Lucks)
- Head part illoricate; 2 foot segments (Fig. 44:5)..............*M. unguipes* (Lucks)

6(4). Toes relatively short; anterior margin of lorica with folds (Fig. 44:6)...*M. bisulcata* (Lucks)
- Toes long, straight; anterior margin without folds (resembles *M. acanthophora*) (Fig. 44:7)..*M. trigona* (Gosse)

Niche: herbivorous

Lophocharis Ehrenberg

Strongly loricate with cross section nearly rhomboid. Specimens with flexible integument may be nearly oval or compressed. Littoral and benthic in habit, *Lophocharis* species are seldom found in the plankton. Three taxa are known from Australia, one of them also from N.Z.

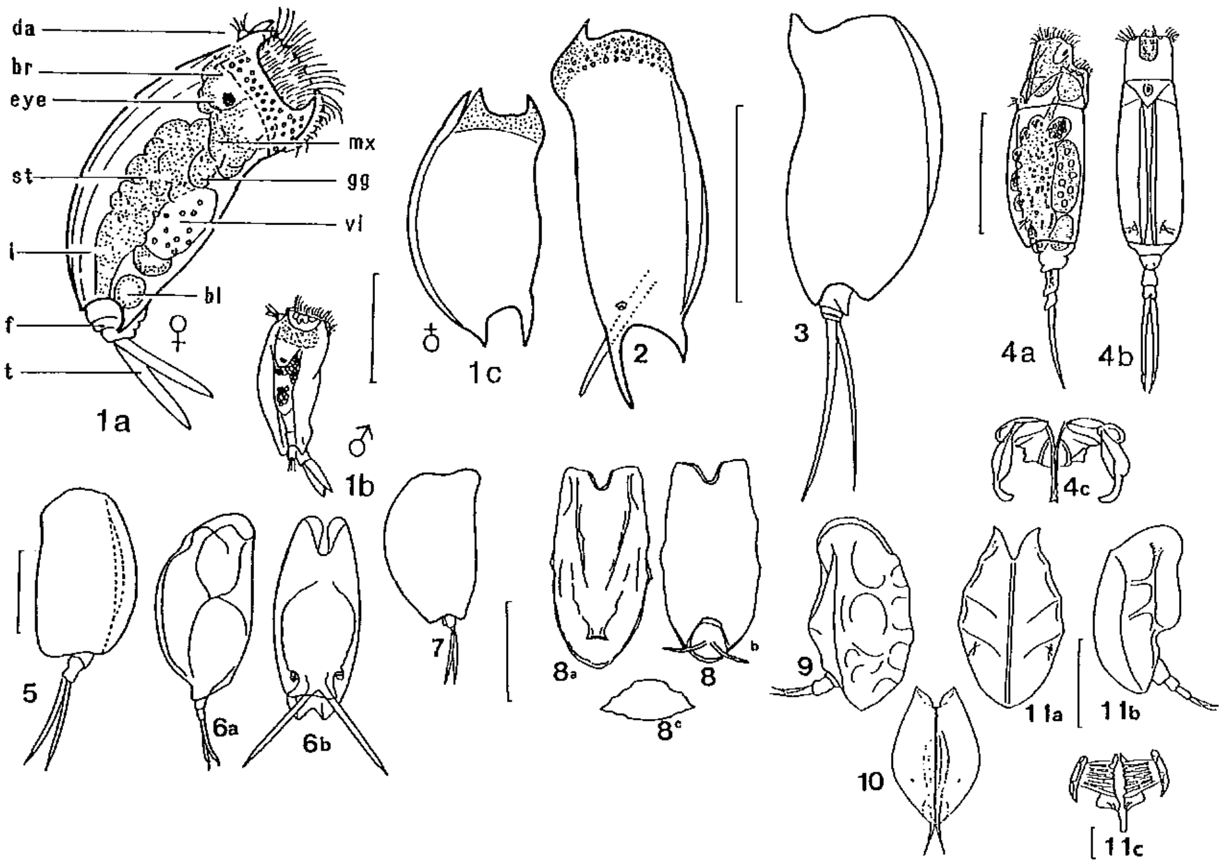


Fig. 44: 1, *Mytilina mucronata* (Müller): 1, lateral, swimming (*bl*=bladder, *br*=brain, *da*=dorsal antenna, *eye*=cerebral eye,*f*=foot, *gg*=gastric gland, *i*=intestine, *mx*=mastax, *st*=stomach, *t*=toe, *v*=vitellarium); b, male; c, lateral contracted; 2, *M. ventralis* (Ehrenberg); 3, *M. acanthophora* Hauer; 4, *M. crassipes* (Lucks): a, lateral; b, dorsal; c, trophi; 5, *M. unguipes* (Lucks); 6, *M. bisulcata* (Lucks): a, lateral; b, ventral; 7, *M. trigona* (Gosse); 8, *Lophocharis curvata* Berzins: a, dorsal; b, ventral; c, section; 9, *L. salpina* (Ehrenberg); 10, *L. naias* Wulfert; 11, .*L. oxysternon* (Gosse). Scale lines 100 µm. (Figs 1-7, 9-11 various authors, after Koste & Shiel (1989). Fig. 8 from Berzins (1982)).

Key to species of the genus Lophocharis known from Australian/N.Z. inland waters

1. Lorica >120 µm long with distinct dorsal keel producing triangular cross-section..**2**

\- Lorica <100 µm long, keel indistinct, cross-section more elliptical (Fig. 44:8)..*L. curvata* Berzins

2(1). Anterior margin of lorica strongly serrated, dorsal keel with transverse folds (Fig. 44:9)..*L. salpina* (Ehrenberg)

\- Anterior margin smooth or lightly serrated, dorsal keel without folds..........**3**

3(2). Lorica smooth; dorsal notch of head aperture V-shaped, ventral a broader U-shape; fine striae on both sides of dorsal keel (Fig. 44:10)....*L. naias* Wulfert

\- Lorica sculptured as *L. salpina*; head aperture notches V-shaped; no striae beside keel (Fig. 44:11)..*L. oxysternon* (Gosse)

Niche: Herbivorous

18. Fam. Euchlanidae Bartos, 1959

All five recorded euchlanid genera occur in Australia (16 spp.), three genera (15 spp.) in N.Z. With the exception of *Manfredium* the genera are characterized by a lorica with plates which are connected with sulci, a segmented foot, more or less elongated toes, a corona of the same type (*Euchlanis*-type, Fig. 9:8) and malleate trophi (Fig. 11:1).

Key to genera of the Family Euchlanidae

1. Lorica thin, without lateral sulci, long toes..*Manfredium* Gallagher (Fig. 45:1)
- Lorica rigid, with dorsal and sometimes ventral plates................................**2**

2(1). Lorica composed of three plates, dorsal divided, separated by sulci...*Diplois* Gosse (Fig. 45:2)
- Dorsal plate not divided...**3**

3(2). Dorsal plate arched, concave, narrower than arched ventral plate...*Dipleuchlanis* De Beauchamp (Fig. 45:3)
- Dorsal plate arched, convex or triangular..**4**

4(3). Dorsal and ventral plates nearly of same size, connected by a lateral double longitudinal membrane within a stiff projection..*Tripleuchlanis* Myers (Fig. 45:4)
- With and without lateral longitudinal sulci.......*Euchlanis* Ehrenberg (Fig. 46)

Manfredium Gallagher

The single species, *Manfredium eudactylotum* (Gosse, 1886) (Fig. 45:1) is known from both Australia and N.Z.

Niche: Herbivorous.

Diplois Gosse

Diplois daviesiae Gosse, 1886 (Fig. 45:2) is known from both Australia and New Zealand as a rare component of the littoral microfauna.

Niche: ?Herbivorous

Dipleuchlanis De Beauchamp

Two variants of a single species (*D. propatula*) are known from Australia, but not from New Zealand. Individuals can be discriminated by toe structure. *D. propatula* (Fig. 45:3a) has toes without a swelling before the points, whereas *D. propatula macrodactyla* (Fig. 45:3b) has toes with a swelling.

Niche: Bacterivorous/Herbivorous

Tripleuchlanis Myers

Tripleuchlanis plicata (Levander, 1894) (Fig. 45:4) is recorded from Australia, but not from N.Z. It is a rare littoral rotifer from billabongs and similar floodplain wetlands.

Niche: ?Herbivorous

Euchlanis Ehrenberg

Eleven species of *Euchlanis* are known from Australia, with eight of them also known from N.Z.. Five other species not recorded from Australia also occur in N.Z. (Shiel & Green 1995). The taxonomy of the different species is difficult; even within the same population lorica shape and cross-section is variable. The shape of the

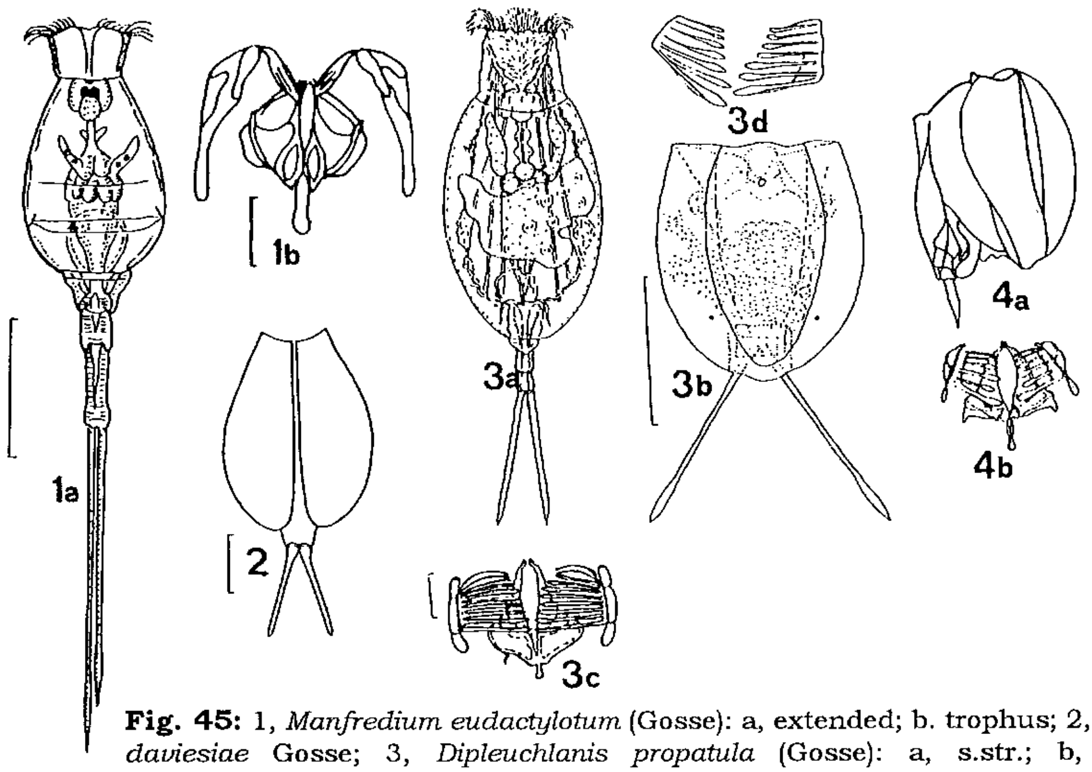


Fig. 45: 1, *Manfredium eudactylotum* (Gosse): a, extended; b. trophus; 2, *Diplois daviesiae* Gosse; 3, *Dipleuchlanis propatula* (Gosse): a, s.str.; b, *D. p. macrodactyla* (Hauer); c, trophus; d, unci teeth; *Tripleuchlanis plicata* (Levander). (Various authors, after Koste & Shiel (1989)).

anterior margin of both plates is of little value in the determination. Most useful is trophi structure, which is species-specific. *Euchlanis* should not be pressed by a coverslip. See for example *E. meneta* cross-sections and the different forms of *E. dilatata.*

Key to species of the genus Euchlanis known from Australian inland waters

1. Cross section of lorica more or less arched to semi-circular........................**2**
- Cross section of lorica triangular, dorsal plate with high keel...................**10**

2(1). Posterior edge of dorsal lorica with distinct notch or embayment (cf. Fig. 46:1)...**6**
- Notch absent, or only shallow emargination **3**

3(2) Ventral plate present...**4**
- Venter membraneous or rudimentary..**5**

4(3). Ventral plate ca. ½ dorsal plate width; wing-like lateral expansions of dorsal lorica margin (Fig. 46:2)...*E.alata* Voronkov
- Ventral plate ca. 2/3 dorsal plate width, constricted at posterior end; no expanded margins (Fig. 46:3)..*E. lyra* Hudson

5(3). Lateral constrictions in medial dorsal lorica; flanged lateral margins (Fig. 46:4)..*E. pyriformis* Gosse
- Dorsal lorica not constricted, lateral margin not flanged (Fig. 46:5)..*E. deflexa* Gosse

6(2). Cuticular shield-like process just below caudal part of dorsal plate (Fig. 46:6)..*E. meneta* Myers
- Shield-like process lacking...**7**

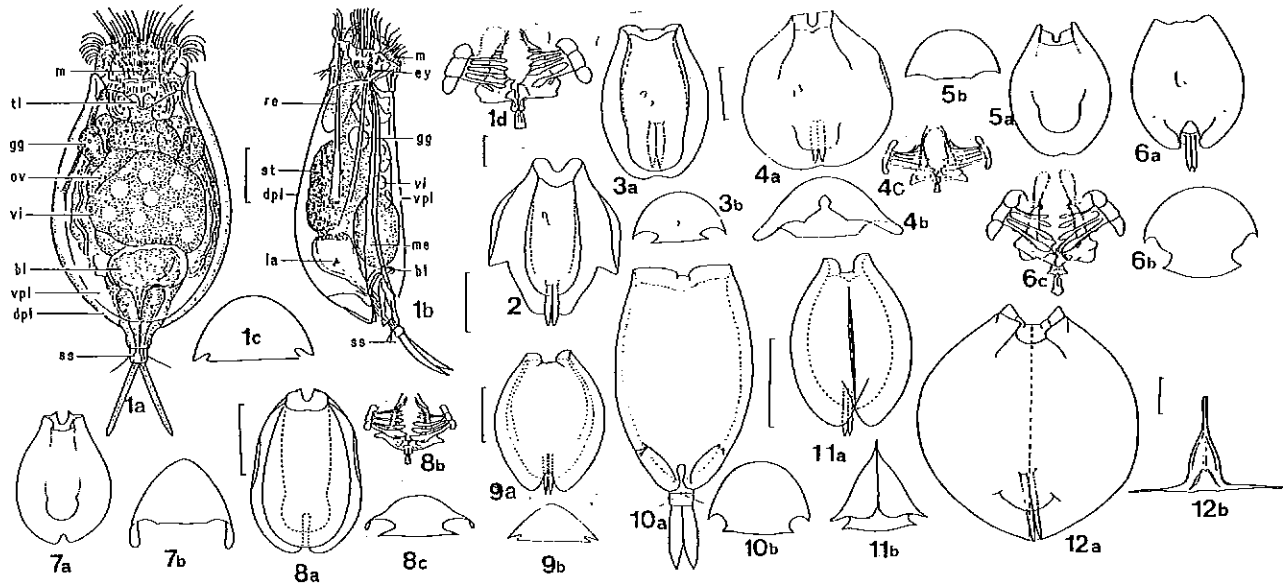


Fig. 46: 1, *Euchlanis dilatata* Ehrenberg: a morphology (*bl*=bladder, *dpl*=dorsal plate, *ey*=cerebral eye, *gg*=gastric glands, *la*=lateral antenna, *m*=mouth, *me*=membrane of sulcus, *ov*=ovary, *re*=retrocerebral sac, *st*=stomach, *ss*=sensillae, *ti*=trophi, *vi*=vitellarium, *vpl*=ventral plate); b, lateral; s, section, d, trophus; 2, *E. alata* Voronkov; 3, *E. lyra* Hudson: a, ventral; b, section; 4, *E. pyriformis* Gosse: a, ventral; b, section; c, trophus; 5, *E. deflexa* Gosse: a, ventral; b. section; c, trophus; 6, *E. meneta* Myers: a, ventral; b, section; 7, *E. calpidia* Myers: a, dorsal; b, section; 8, .*E. phryne* Myers: a, ventral; b. trophus; c, section; 9, *E. dilatata* Ehrenberg: a, dorsal; b, section; 10, *E. oropha* Gosse: a, dorsal; b, section; 11, *E. incisa* Carlin: a, dorsal, b, section; 12, *E. triquetra* Ehrenberg: a, ventral; b, section. Scale lines 100 µm. (Various authors, after Koste & Shiel 1989)).

7(6). Ventral plate rudimentary; longitudinal sulci absent; toes very long (>100 µm), slender (Fig. 46:7).. *E. calpidia* Myers
- Ventral plate well developed...**8**

8(7). Dorsal lorica with winglike lateral extensions deflected ventrally at tips (Fig. 46:8)..*E. phryne* Myers
- No lateral extensions of dorsal lorica..**9**

9(8). Foot and toes slender; toes 1/3 length of dorsal plate, blade-like, fusiform (Fig. 46:1, 9)..*E. dilatata* Ehrenberg
- Foot and toes stout; toes ¼ length of dorsal plate toes dilated distally for 2/3 length and constrict to acute points (Fig. 46:10)...................*E. oropha* Gosse

10(1). Ventral plate completely developed, lateral sulci present (Fig. 46:11)...*E. incisa* Carlin
- Ventral plate reduced to thin hyaline membrane; wide dorsal plate flanges (Fig. 46:12)..*E. triquetra* Ehrenberg

Niche: *Euchlanis* species are littoral rotifers living among aquatic plants, but in the pelagial of eutrophic lakes and ponds in the northern hemisphere they occur at cyanobacterial maxima, especially of *Gloeotrichia*, the main food of *Euchlanis dilatata* (Ruttner-Kolisko 1974). Other food consists of diatoms, desmids, other algae and detritus.

19. **Fam. Lecanidae** Bartos, 1959

Characteristic shield-shaped small loricate rotifers with one or two long toes. Mostly epiphytic or littoral, lecanids occasionally occur in plankton. The family was revised for Australia by Koste & Shiel (1990), and globally by Segers (1995), who argued for fusion of the three subgenera/genera into a single genus, *Lecane*. For convenience, the keys below are separate for the two morphological groups, however the unified status is followed. . Eighty-two taxa of lecanids were listed from Australia (Koste & Shiel 1990), and 38 from N.Z. (Shiel & Green 1995), with 29 spp. shared. These totals will have to be amended in view of the synonymies proposed by Segers (1995), and undoubtedly more lecanids are to be expected in both regions. The keys to the Australian species below (from Koste & Shiel 1987) are annotated in bold in the light of the recent global revision. Identification is based on lorica morphology, although Segers (1995) made use of SEM ultrastructure of trophi for the first time.

Key to subgenera of the family Lecanidae

1. Two toes, separated along their full length cf. Fig. 49)......*Lecane* (s.str.) Nitzsch, 1827 (p. 86)
\- Single toe or toes partly fused......**2**

2(1). Distal half of toes separated (Fig. 47:1)......*L. Hemimonostyla* Bartos, 1959
\- Single toe (Fig. 47:2)......*L...Monostyla* Ehrenberg, 1830

One species of *Lecane* (*Hemimonostyla*) is known from both Australia & N.Z.Australia. *L.* (*H.*) *inopinata* (Harring & Myers, 1926) (Fig. 47:1) is recognized by its partly fused toes. Species of the other two subgenera are keyed separately for convenience.

Key to species of the subgenus L. (Monostyla) known from Australian inland waters

1. Toe with two claws or a single fused claw......**2**
\- Toe without claw......**20**

2(1). Dorsal lorica anterior margin with median curved spines (Fig. 47:2)......*L. quadridentata* Ehrenberg
\- Dorsal lorica margin without median spines......**3**

3(2). Lorica anterior margin(s) more or less deeply sinuate......**12**
\- Lorica margin(s) relatively straight......**4**

4(3). Claws held tightly together, or fused with only a median groove......**6**
\- Claws diverging, immobile (Fig. 47:3)......**5**

5(4). Ventral lorica with paired posterolateral spines ("hip spurs") (Fig. 47:3)......*L. bifurca* Bryce
\- Ventral lorica without hip spurs (Fig. 47:4)......*L. furcata* Murray

6(4). Toe with only one claw, or indistict dividing line......**7**
\- Claws separate (Fig. 47:5)......*L. obtusa* Murray

7(6). Dorsal lorica with distinct striations/patterning/ornamentation......**8**
\- Dorsal lorica smooth......**10**

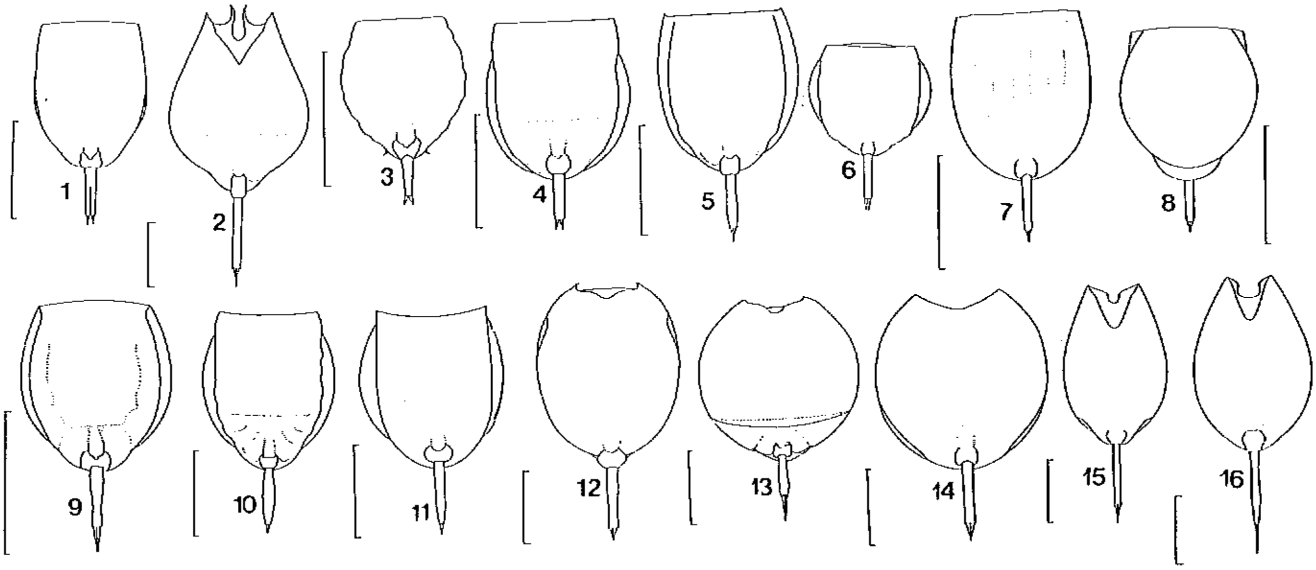


Fig. 47: 1, Lecane (Hemimonostyla) inopinata (Harring & Myers), ventral; 2, *L. quadridentata* Ehrenberg; 3, *L. bifurca* Bryce; 4, *L. furcata* Murray; 5, *L. obtusa* Murray; 6, *L. rugosa* Harring; 7, *L. tethis* Harring & Myers; 8, *L. elachis* Harring & Myers; 9, *L. subulata* Harring & Myers; 10, *L. copeis* Harring & Myers; 11, *L. scutata* Harring & Myers; 12, *L. stenroosi* (Meissner); 13, *L. unguitata* Fadeev 14, *L. cornuta* (Müller); 15, *L. bulla* Gosse; 16, *L. styrax* Harring & Myers. Scale lines 50 µm. (Various authors, after Koste & Shiel (1990)).

8(7). Dorsal and ventral surfaces heavily wrinkled and folded; total length <85 µm (Fig. 47:6)....................*L. rugosa* Harring
- Regular facettation, less distinct; lorica >90 µm....................**9**

9(8). Dorsal facettation regular, each facet bounded by double longitudinal lines; ventral lorica patterned (Fig 47:7)....................*L. tethis* Harring & Myers
- Only anterior facet row regular, no double boundaries; no ventral pattern (single transverse fold in front of foot) (Fig. 47:8)...*L. elachis* Harring & Myers

Both taxa synonymized with *L. furcata* Murray 1913 by Segers (1995) in view of the variability of the lorica ornamentation on the which the discrimination was based.

10(7). Ventral plate constricted just behind anterior margin....................*L. subulata* Harring & Myers (Fig. 47:9)
- Ventral plate not constricted....................**11**

11(10). Toe spindle-shaped, widest in the middle (Fig. 47:10)....................*L. copeis* Harring & Myers
- Toe tapers evenly (Fig. 47:11)....................*L. scutata* Harring & Myers

12(3). Dorsal and ventral anterior margins concave....................**14**
- Dorsal margin straight, ventral with sinus....................**13**

13(12). Ventral sinus shallow, with strongly convex sides, externally with two short,stout, incurved hooklike frontal spines (Fig. 47:12)....................*L. stenroosi* (Meissner)
- U-shaped shallow sinus flaring anteriorly, sides not convex; frontal spines absent (Fig. 47:13)....................*L. unguitata* Fadeev

14(12). Lorica outline nearly circular (Fig. 47:14)....................*L. cornuta* (Müller)
- Lorica outline oval to geoid....................**15**

15(14). Lorica ovoid, tapers to narrow head aperture (<½ body width) (Fig. 47:15)..**16**

- Lorica subcircular to elongate oval, taper less acute, head aperture wider (>½ body width) (Fig. 47:17)..**17**

16(15). Toe long, slender, ca. 1/3 body length; claw ¼ toe length (Fig. 47:15)..*L. bulla* Gosse

- Toe >1/3 body length claw extremely long, >1/3 toe length (Fig. 47:16)...*L. styrax* Harring & Myers

  These two taxa synonymised by Segers (1995) on the basis of variable morphology of *L. bulla*

17(15). Lorica <120 μm; toe >½ body length, long, thin, parallel-sided................**18**

- Lorica >200 μm; toe <½ body length, stout with medial bulge (Fig. 48:1)...*L. thalera* (Harring & Myers)

18(17). Dorsal and ventral anterior sinuses deep...**19**

- Dorsal margin only slightly concave; ventral margin with deep U-shaped sinus with convex sides (Fig. 48:2)...................................*L. crenata* Harring

19(18). Identical broadly V-shaped sinus in both dorsal and ventral margins, latter projects slightly beyond dorsal margin (Fig. 48:3)..................*L. acus* Harring

- Ventral sinus deeper than dorsal, rounded at posterior margin (Fig. 48:4)...*L. lunaris* (Ehrenberg)

  These last three taxa were synonymized as *L. lunaris* by Segers (1995) on the basis of intergrades between a wide variety of morphotypes of that species.

20(1). Lorica with lateral curved spine-like processes (Fig. 48:5)..*L. monostyla* (Daday)

- Lateral processes absent...**21**

21(20). Lorica anterior margin with more or less large frontal corner cusps/spines...**23**

- Front corner cusps absent..**22**

22(21). Ventral lorica margin somewhat concave...**24**

- Ventral lorica margin straight (Fig. 48:6).........................*L. pyriformis* Daday

23(22). Ventral lorica plate in upper third bilaterally constricted (Fig. 48:7)..*L. arcuata* Bryce

- Ventral lorica plate not constricted (Fig. 48:8)........*L. closterocerca* Schmarda

24(22). Head aperture margins straight, coincident; corner spines small (Fig. 48:9)...*L. opias* Harring & Myers

- Head aperture with dorsal and ventral sinuses of different size; corner spines large..**25**

25(24). Posterior segment of ventral lorica with sinuate margin and two lateral acute triangular cusps (Fig. 48:10)..................................*L. batillifer* Murray

- Posterior margin smoothly oval or elliptical..**26**

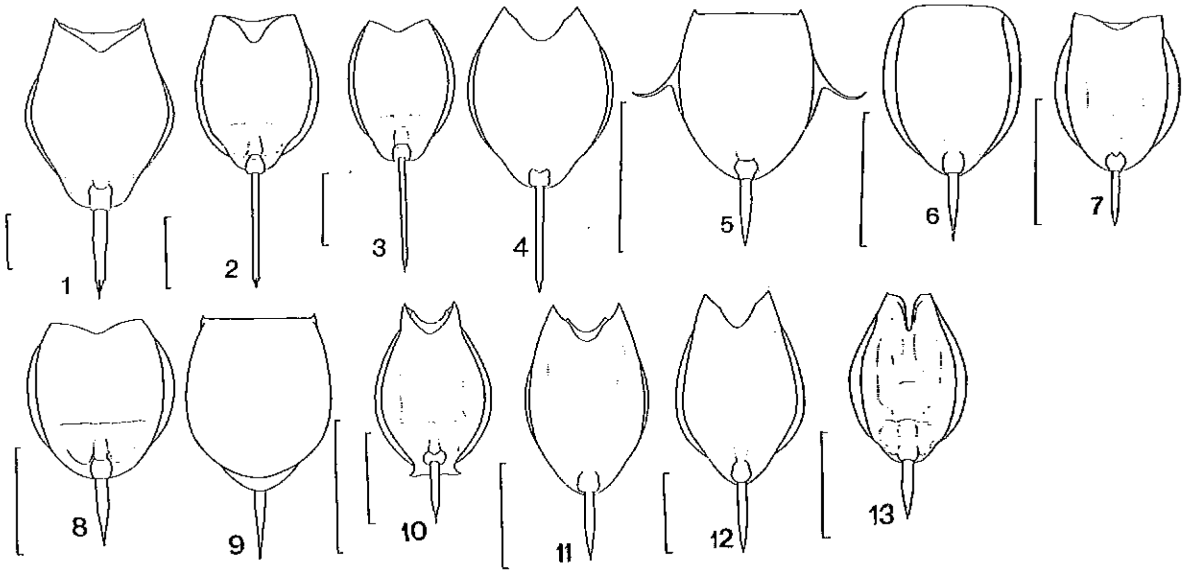


Fig. 48: 1, *L. thalera* (Harring & Myers); 2, *L. crenata* Harring; 3, *L. acus* Harring; 4, *L. lunaris* (Ehrenberg); 5, *L. monostyla* (Daday); 6, *L. pyriformis* Daday; 7, *L. arcuata* Bryce; 8, *L. closterocerca* Schmarda; 9, *L. opias* Harring & Myers; 10 *L. batillifer* Murray; 11, *L. hamata* Stokes; 12, *L. decipiens* Murray; 13, *L. sinuata* Hauer. Scale lines 50 µm (Various authors, after Koste & Shiel (1990))

26(25). Dorsal lorica surface smooth, unornamented..**27**
- Dorsal lorica with regular well-marked facets (Fig. 48:11)....*L. hamata* Stokes

27(26). Head aperture with deep, coincident dorsal and ventral margins, flanked by pointed cusps (extensions of ventral lorica) (Fig. 48:12)...*L. decipiens* Murray
- Dorsal anterior sinus shallow, rounded posteriorly with convex edges; ventral sinus a much deeper, narrow cleft (Fig. 48:13); truncate rather than pointed anterior corners of ventral plate.............................*L. sinuata* Hauer

L. *sinuata* synonymized with *L. hamata* by Segers (1995) on the basis of high variability in the head aperture margins

Key to species of the subgenus Lecane (s.str.)

1. Lorica with acute cusps or rounded projections at anterior external angles..**3**
- Lorica without spines or projections at anterior angles...............................**2**

2(1). Toes with claws or pseudoclaws..**8**
- Toes without claws or pseudoclaws..**4**

3(1). Toes with claws or pseudoclaws..**26**
- Toes without claws or pseudoclaws...**17**

4(2). Dorsal plate at least as long or longer than ventral plate (Fig. 49:1)...*L. clara* (Bryce)
- Dorsal plate noticeably shorter than ventral...**5**

5(4). Anterior margin almost straight or lightly convex..**6**
- Anterior margin (dorsal) with regular undulating lines (Fig. 49:2)..*L. nodosa* Hauer

A synonym of *L. hornemanni* (Ehrenberg) after Segers (1995)

6(5). Toes ~½ body length; dorsal and ventral surfaces with complex pattern (Fig. 49:3)..*L. venusta* Harring & Myers
- Toes ~¼-1/3 body length; dorsal surface smooth or sparsely lined, ventral plate with single transverse fold and some longitudinal folds......................**7**

7(6). Lorica wider than long; 2nd foot segment projects well beyond posterior margin (Fig. 49:4)...*L. hornemanni* (Ehrenberg)
- Lorica longer than wide; 2nd foot segment beneath lorica margin (Fig. 49:5)..*L. nana* (Murray)

8(2). Lorica 180-200 µm; toes >70 µm...**9**
- Lorica <180 µm; toes <50 µm...**10**

9(8). Barrel-shaped lorica (L:W ratio 1.25); broad footplate without marked constriction of lorica margin (Fig. 49:6)..............*L. grandis* (Murray)
- Lorica more elongate (L:W ratio 1.5), with anterior constriction behind head aperture and marked constriction of margins at footplate (Fig. 49:7)...*L. boorali* Koste & Shiel

10(8). Toes long (¼-½ body length) clearly visible beyond footplate......................**11**
- Toes remarkable short (<1/10 body length) barely protruding beyond footplate in dorsal view (Fig. 49:8)................................*L. pumila* Rousselet

11(10). Lorica elongated (L:W ratio 1.8) (Fig. 49:9).........................*L. inermis* (Bryce)
- Lorica broadly ovate (L:W <1.5)..**12**

12(11). Dorsal and ventral plates distinctly patterned..**15**
- Dorsal plate smooth, ventral with single transverse fold or light ornamentation...**13**

13(12). Claws short (claw:toe ratio <3.0)...**14**
- Claws long (ratio >3.0) (Fig. 49:10)...............................*L. tenuiseta* Harring

14(13). Ventral plate with posterolateral corners anterior to footplate producing rectangular appearance (Fig. 49:11)..................................*L. ruttneri* Hauer
- Ventral plate posterior margins smoothly curved, without corners (Fig. 49:12)...*L. formosa* Harring & Myers

15(12). Claws short (<10 µm)...**16**
- Claws long (13-18 µm). (Fig. 49:13)................................*L. doryssa* Harring

16(15). Dorsal plate subcircular; footplate projects beyond dorsal plate to cover 2nd foot segment (Fig. 49:14)...*L. pusilla* Harring
- Dorsal plate parallel-sided; 2nd foot segment projects beyond footplate (Fig. 49:15)...*L. subtilis* Harring & Myers

17(3). Caudal margin of lorica broadly truncate or rounded..............................**18**
- Caudal margin tapering to point, bilaterally constricted tongue or 'fishtail'...**25**

18(17). Caudal margin straight, with obtuse angled corners..............................**19**
- Caudal margin smoothly oval/elliptical..**20**

19(18). Toe <30 µm, short and stout. (Fig. 49:16)............*L. brachydactyla (Stenroos)*
- Toe >30 µm, thin, with finer taper. (Fig. 49:17)....*L. tudicola* Harring & Myers
Both synonyms of *L. depressa* (Bryce, 1891) in view of variability of toe morphology (Segers, 1995)

20(18). Second foot segment protrudes at least ½ its length beyond caudal margin..**21**
- Second foot segment not protruding..**22**

21(20). Toes >50 µm; ventral lorica >150 µm. (Fig. 49:18)...*L. pertica* Harring & Myers
- Toes <40 µm; lorica <100 µm (Fig. 49:19)............*L. rhytida* Harring & Myers

22(20). Lorica surfaces smooth...**23**
- Surfaces (particularly dorsal) clearly ornamented (Fig. 49:20)...*L. signifera* (Jennings)

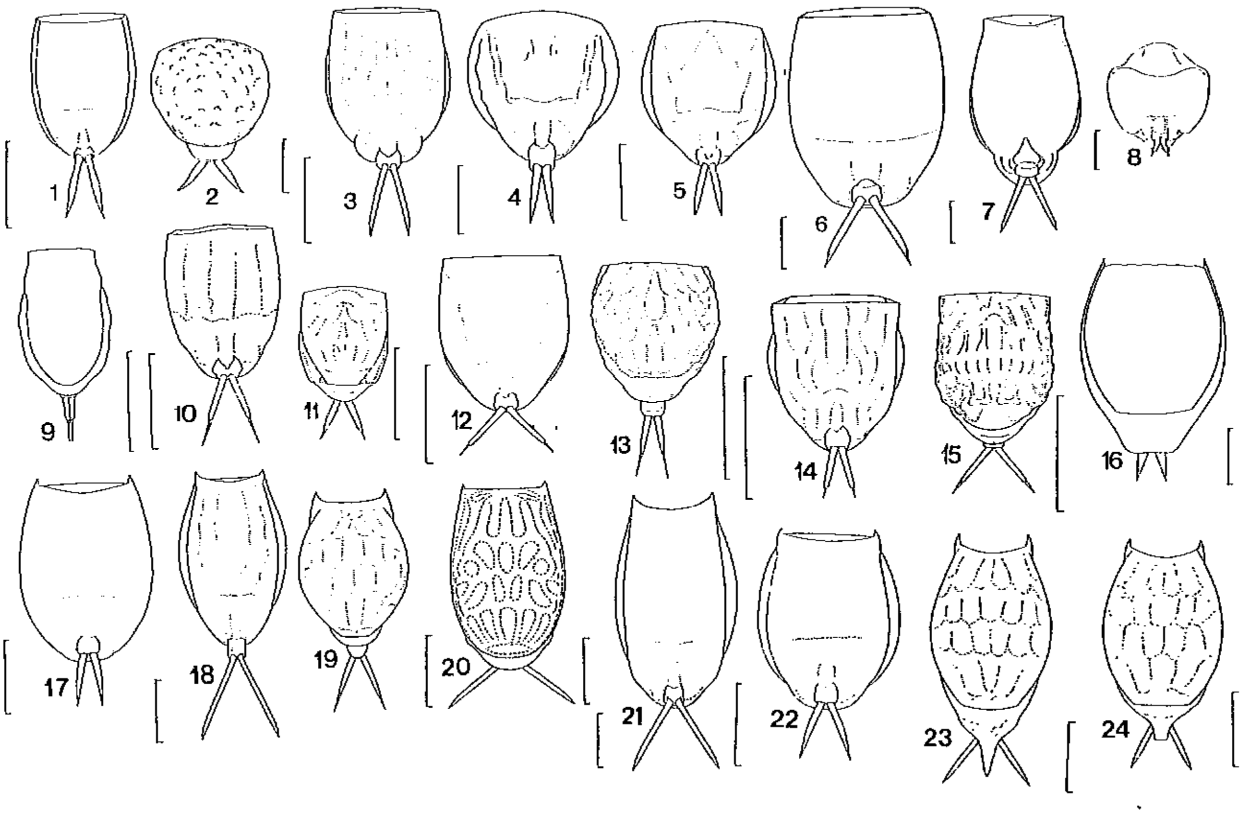


Fig. 49:1, *L. clara* (Bryce); 2, *L. nodosa* Hauer; 3, *L. venusta* Harring & Myers; 4, *L. hornemanni* (Ehrenberg); 5, *L. nana* (Murray); 6, *L. grandis* (Murray); 7, *L. boorali* Koste & Shiel; 8, *L. pumila* Rousselet; 9, *L. inermis* (Bryce); 10, *L. tenuiseta* Harring; 11, *L. ruttneri* Hauer ; 12, *L. formosa* Harring & Myers; 13, *L. doryssa* Harring; 14, *L. pusilla* Harring; 15, *L. subtilis* Harring & Myers; 16, *L. brachydactyla* (Stenroos); 17, *L. tudicola* Harring & Myers; 18, *L. pertica* Harring & Myers; 19, *L. rhytida* Harring & Myers; 20, *L. signifera* (Jennings); 21, *L. pyrrha* Harring & Myers; 22, *L. levistyla* (Olofsson); 23, *L. ludwigi* (Eckstein); 24, *L. ohioensis* (Merrick). Scale lines 50 µm. (Various authors, after Koste & Shiel (1990)).

23(22). Frontal margins straight or slightly concave; caudal margin smoothly rounded..**24**
- Margins deep V-shaped sinuses; caudal margin lobate (Fig. 50:19)...*L. herzigi* Koste & Shiel

24(23). Lorica elongated, ~200 µm; toes ~75 µm. (Fig. 49:21)...*L. pyrrha* Harring & Myers
- Lorica <150 µm; toes <20 µm (Fig. 49:22)....................*L. levistyla* (Olofsson)

25(17). Posterior lorica tapers to point (Fig. 49:23)...................*L. ludwigi* (Eckstein)
- Posterior lorica a bilaterally constricted blunt tongue, or 'fishtail'. (Fig. 49:24)...*L. ohioensis* (Merrick)

Both synonymized as *L. ohioensis* by Segers (1995)

26(3). Frontal corners of lorica with acute spines or cusps (Fig. 40:2)..................**27**
- Frontal corner projections rounded rather than acute (Fig. 50:1)...*L. papuana* (Murray)

27(26). Claws with knoblike swelling. (Fig. 50:2)........................*L. hastata* (Murray)
- Claws without swelling...**28**

28(27).Ventral plate with elongated footplate (Fig. 50:3).............*L. leontina* (Turner)
- Ventral caudal margin symmetrically rounded..**29**

29(28). Lorica ventral margin projects beyond dorsal footplate (Fig. 50:4)...*L. elsa* Hauer
- Margins coincident or dorsal projects beyond ventral..............................**30**

30(29). Dorsal anterior margin straight or lightly convex....................................**34**
- Dorsal anterior margin concave...**31**

31(30). Head aperture margins coincident V-shaped sinuses..............................**32**
- Both margins broad lunate sinuses..**33**

32(31). Smooth or weakly ornamented lorica; head aperture margins smooth footplate (Fig. 50:5)..*L. curvicornis* (Murray)
- Both surfaces distinctly ornamented; head aperture margin undulate footplate (Fig. 50:6)...*L. nitida* (Murray)

Both synonymized as *L. curvicornis* (Murray, 1913) by Segers (1995)

33(31). Dorsal surface unornamented; no noticeable constriction of posterolateral margins at footplate (Fig. 50:7).......................*L. luna* (Müller)
- Dorsal surface stippled; footplate elongated, with distinct bilateral constriction of posterolateral margins (Fig. 50:8)........*L. spenceri* (Shephard)

34(30). Dorsal margin straight between cusps, ventral margin coincident or lightly concave...**35**
- Dorsal margin convex between cusps, ventral margin coincident, straight or concave...**38**

35(34). Distal foot segment not visible beyond lorica margin..............................**36**
- Distal foot segment visible beyond lorica margin (Fig. 50:9).*L. mira* (Murray)

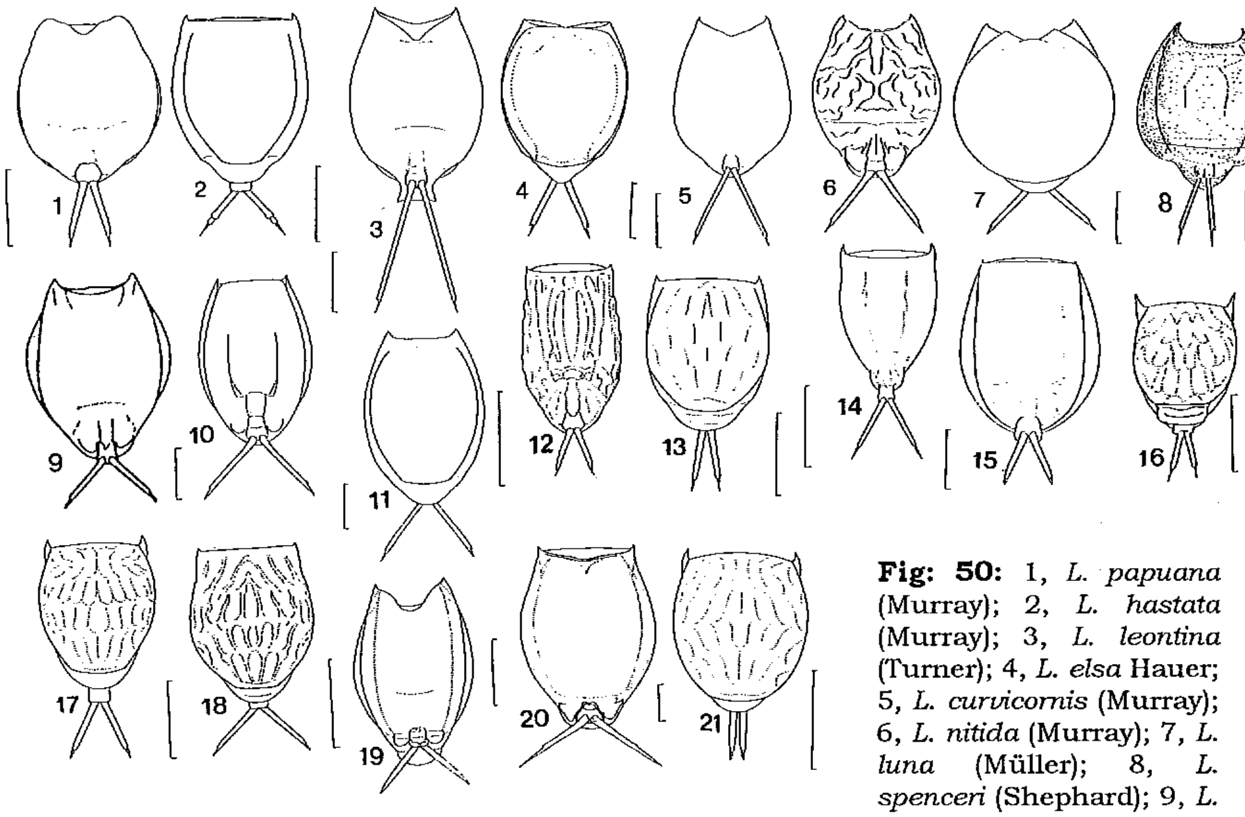


Fig: 50: 1, *L. papuana* (Murray); 2, *L. hastata* (Murray); 3, *L. leontina* (Turner); 4, *L. elsa* Hauer; 5, *L. curvicornis* (Murray); 6, *L. nitida* (Murray); 7, *L. luna* (Müller); 8, *L. spenceri* (Shephard); 9, *L. mira* (Murray); 10, *L. eylesi* Russell; 11, *L. acronycha* (Harring & Myers); 12, *L. glypta* Harring & Myers;13, *L. aspasia* Myers; 14, *L. crepida* Harring; 15, *L. mylacris* Harring & Myers; 16, *L. aculeata* (Jakubski); 17, *L. stichaea* Harring; 18, *L. haliclysta* Harring & Myers; 19, *L. herzigi* Koste & Shiel; 20, *L. ungulata* (Gosse); 21, *L. flexilis* (Gosse). Scales lines 50 µm. (Various authors, after Koste & Shiel (1990)).

36(35).Ventral margin concave; dorsal plate smaller than ventral plate; toes >60 µm long..**37**

- Margins coincident; dorsal plate larger than ventral; toes <60 µm long (Fig. 50:10)..*L. eylesi* Russell
  Senior synonym of *L. tasmaniensis* Shiel & Koste, 1985 (Segers 1995).

37(36). Claws short (claw:toe ratio >5) (Fig. 50:11)...*L. acronycha* (Harring & Myers)
  A synonym of *L. curvicornis* after Segers (1995)

- Claws long (ratio <3.5) (Fig. 50:20)..................................*L. ungulata* (Gosse)

38(34). Last foot segment visible beyond dorsal margin......................................**41**

- Last foot segment not visible beyond margin..**39**

39(38). Head aperture margins coincident, convex; lorica not noticeably elongated...**40**

- Dorsal margin convex, ventral concave; lorica elongated (Fig. 50:12)...*L. glypta* Harring & Myers
  A synonym of *L.flexilis* (Gosse, 1886) after Segers (1995)

40(39). Lorica <80 µm long; ventral plate constricted anteriorly; small semicircular footplate projects slightly beyond posterior lorica (Fig. 50:21)..*L. flexilis* (Gosse)

- Lorica >100 µm long; ventral plate not constricted; footplate broad, extends well beyond posterior margin of dorsal plate (Fig. 50:13)......*L. aspasia* Myers

41(38). Ventral plate strongly constricted in 'hip' region (Fig. 50:14)..*L. crepida* Harring
- Ventral plate not constricted..**42**

42(41). Dorsal plate covers all ventral plate and footplate (Fig. 50:15)..*L. mylacris* Harring & Myers
A synonym of *L. instrasinuata* (Olofsson, 1917) (Segers 1995)
- Footplate visible posterior to dorsal plate..**43**

43(42). Cusps large, outer margins convex, pointing outwards (Fig. 50:16)..*L. aculeata* (Jakubski)
- Cusps small, outer margins concave, point ahead or inwards...................**44**

44(43). Toe points short with distinct step on inside distinguishing claw (Fig. 50:17)..*L. stichaea* Harring
- Toe points elongated, claws indistinct (Fig. 50:18)..*L. haliclysta* Harring & Myers

Niche: bacterivorous/herbivorous

20. Fam. Trichocercidae Remane, 1933

Forty-five species in three genera (*Ascomorphella, Elosa, Trichocerca*) were reviewed from Australia by Shiel & Koste (1992). *Ascomorphella volvocicola,* which is an obligate parasite (specialized grazer?) of *Volvox*, may be found in *Volvox* colonies during seasonal blooms. *Elosa woralli* is known from a single record (Murray 1913). *Trichocerca* is common, predominantly littoral in habit, although three or four species may venture into the plankton, e.g. *T. pusilla* and *T. similis, T. longiseta* and *T. rattus* less commonly. The New Zealand fauna includes *Ascomorphella* and 36 spp. of *Trichocerca* (26 in common) (Shiel & Green 1995). Species discrimination is by dimensions and trophi structure.

Key to genera of Trichocercidae

1. Foot present, toes bristle-like, often of considerable length..*Trichocera* Lamarck
Foot absent..2

2(1). Cuticle soft; toes minute; single cerebral eyespot..*Ascomorphella* Wiszniewski
Cuticle stiff, toes rudimentary or absent; cerebral and apical eyespots ....*Elosa* Lord

Ascomorphella Wiszniewski

A single species is known, *Ascomorphella volvocicola* (Plate, 1886) (Fig. 51:1). It is a very specialized herbivore, living and feeding within spherical colonies of *Volvox*.

Elosa Lord

Elosa woralli Lord, 1891 (Fig. 51:2), an inhabitant of wet *Sphagnum*, was reported by Murray (1913b) from N.S.W. and has not been seen since. The record needs verification.

Trichocerca Lamarck

Body more or less curved, in many species somewhat spiraled, or bent from left, anterior end of lorica with multiple spines, denticles or folds. Posterior to these may be striated area associated with torsion of body, followed by a keel or two ridges; caudally, abdomen projects further on left than right, foot is inserted obliquely; may be two well-developed or only one obvious toe, the basis of separation into two subgenera. Trophi important in species discrimination.

Key to species of Trichocerca known from Australian inland waters

1. Toes of similar length, or RT at least 1/3 length of LT..............*T.* (*Diurella*)..**2**
\- RT considerably reduced, always <1/3 length of LT..................*T.* (s. str)...**22**

2(1). Lorica anterior margin without projections..**3**
Cusps, spines or other projections present..**4**

3(2). Anterior lateral tongue-shaped plate present.......*T. vernalis* Hauer (Fig. 51:3)
\- Lateral plate absent....................................*T. collaris* (Rousselet) (Fig. 51:4)

4(2). Anterior margin with lateral tongue-shaped plate.......................................**5**
\- Lateral plate absent..**6**

5(4). Margin with stubby projections, no spine(s).....*T. sulcata* Jennings (Fig. 51:5)
\- Margin with one long spine..............................*T. weberi* Jennings (Fig. 51:6)

6(4). Margin with blunt projections, or blunt projections with two dissimilar length spines..**7**
\- No blunt projections; one or two spines or cusps......................................**12**

7(6). Margin with blunt projections only...**8**
\- Blunt projections, 2 dissimilar length spines, 8-9 serrations...*T. rousseleti* (Voigt) (Fig. 51:7)

8(7). Dorsal keel present..**10**
\- No dorsal keel..**9**

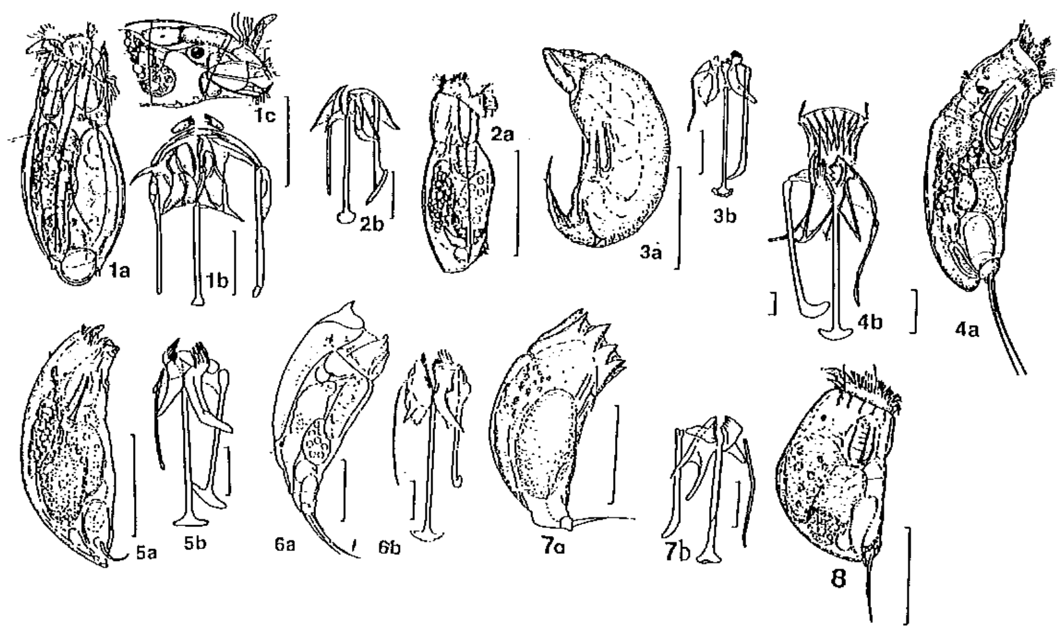


Fig. 51: 1, *Ascomorphella volvocicola* (Plate); 2, *Elosa woralli* Lord; 3, *Trichocerca vernalis* Hauer; 4, *T. collaris* (Rousselet); 5, *T. sulcata* Jennings; 6, *T. weberi* Jennings; 7, *T. rousseleti* (Voigt); 8, *T. inermis* (Linder). Scale lines: adult 50 µm, trophi 10µm. (Various authors, after Shiel & Koste (1993)).

9(8). Toes curved ventrally; LM with distinct single bend..*T. inermis* (Linder) (Fig. 51:8)
- Toes not curved ventrally; LM weakly curved terminally..*T. ruttneri* (Donner) (Fig. 52:1)

10(8). Toes curved ventrally; LM with double crook..**11**
- Toes follow body axis (occasionally lightly curved terminally); LM only weakly bent..*T. dixon-nuttalli* Jennings (Fig. 52:2)

11(10). Lower third of body conspicuously narrower; left uncus with several teeth..*T. brachyura* (Gosse) (Fig. 52:3)
- Body not conspicuously narrower; left uncus with single tooth..*T. cavia* (Gosse) (Fig. 52:4)

12(6). Lorica anterior margin with single spine..**13**
- Lorica anterior margin with two spines..**17**

13(12). Spine short (<14 μm)..**14**
- Spine long (14-26 μm)..*T. uncinata* (Voigt) (Fig. 52:5)

14(13). Body long and slender, conspicuously narrower in lower third; LM with single or double bend..**15**
- Body not constricted posteriorly; LM weakly bent..*T. tenuior* (Gosse) (Fig. 52:6)

15(14). BL > 130 μm; toes > 50 μm..*T. tigris* (Müller) (Fig. 52:7)

NB: A single specimen of a species closely resembling *T. tigris*, *T. kostei* Segers, 1993 (Fig. 52:8), was collected recently near Wodonga, Vic.

- BL 90-106 μm; toes < 35 μm..**16**

16(15). LM with double bend; left uncus single toothed..*T. intermedia* (Stenroos) (Fig. 52:9)
- LM weakly bent; left uncus with several teeth. *T. insulana* (Hauer) (Fig. 52:10)

17(12). Two dissimilar length spines/cusps..**18**
- Two similar length spines/cusps..**21**

18(17). Body squat; posterior lorica overhangs foot..**19**
- Body long; posterior lorica does not overhang foot..**20**

19(18). LT 43-60 μm; RT 36-45 μm; TR > 50 μm.......*T. porcellus* (Gosse) (Fig. 52:11)
- LT < 43 μm; RT < 35 μm; TR < 50 μm............*T. musculus* Hauer (Fig. 52:12)

20(18). Body conspicuously constricted in lower 1/3; anterior spines different length..*T. myersi* (Hauer) (Fig. 52:13)
- Body not constricted; spines similar length....*T. insignis* (Herrick) (Fig. 52:14)

21(17). Single dorsal keel; posterior lorica projects over foot..*T. bidens* (Lucks) (Fig. 52:15)
- Double keel; posterior margin does not project over foot..*T. similis* (Wierzejski) (Fig. 52:16)

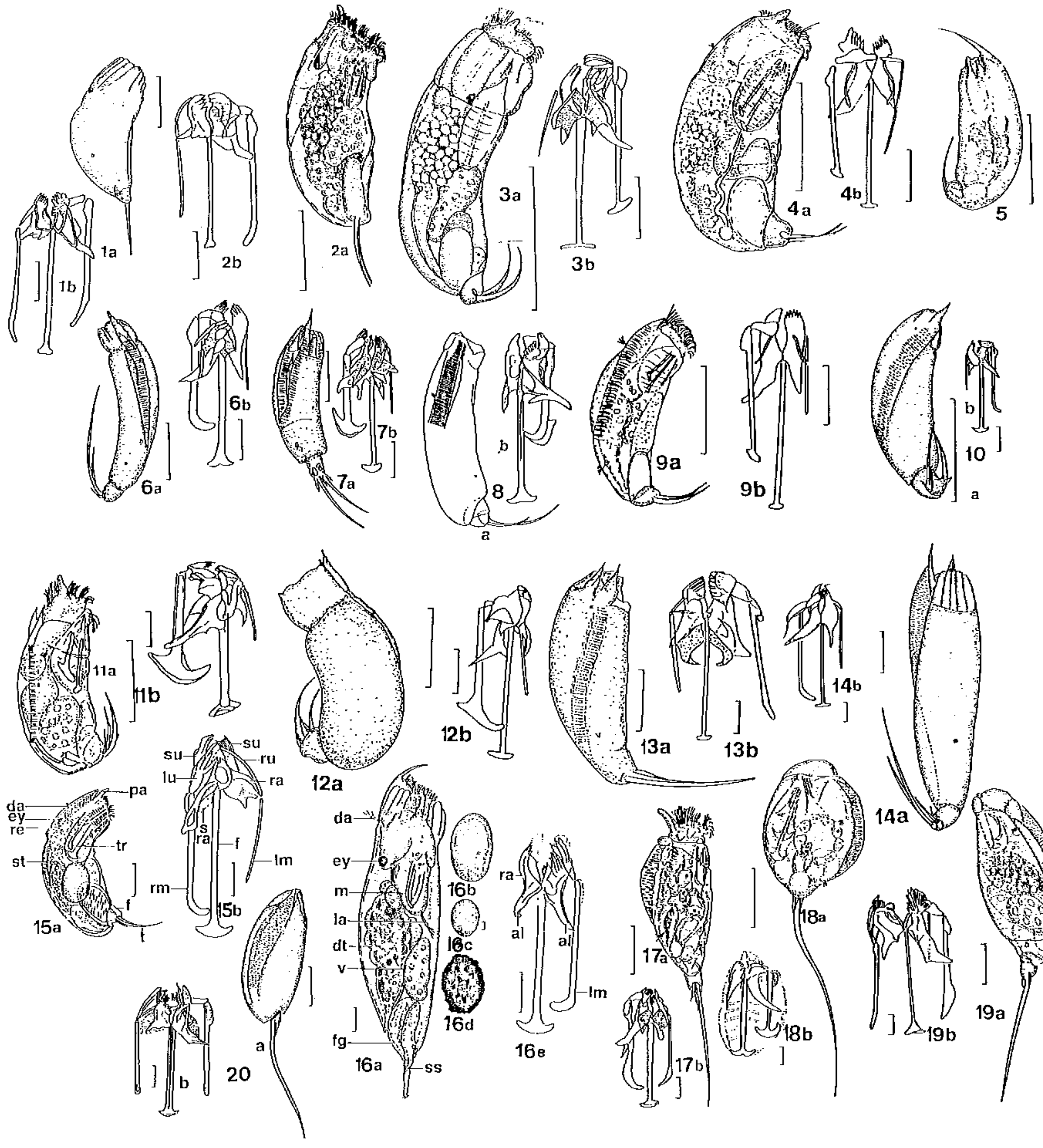


Fig. 52: 1, *T. ruttneri* (Donner); 2, *T. dixon-nuttalli* Jennings; 3, *T. brachyura* (Gosse); 4, *T. cavia* (Gosse); 5, *T. uncinata* (Voigt), 6, *T. tenuior* (Gosse); 7, *T. tigris* (Müller); 8, *T. kostei* Segers, 1993; 9, *T. intermedia* (Stenroos); 10, *T. insulana* (Hauer); 11, *T. porcellus* (Gosse); 12, *T. musculus* Hauer; 13, *T. myersi* (Hauer); 14, *T. insignis* (Herrick); 15, *T. bidens* (Lucks): a, lateral (pa=palpar organ; da=dorsal antenna; ey=eye; re=retrocerebral organ; tr=trophus; st=striated field; f=foot; t=toe); b, trophus (su=subuncus; lu=left uncus; ru=right uncus; ra=right ramus; sra=supraramus; fu=fulcrum; lm=left manubrium; rm=right manubrium; al=alula) 16, *T. cylindrica* (Imhof): a, lateral (la=lateral antenna; m=mastax; dt=digestive tract; v=vitellarium; fg=foot glands; ss=substyli); 17, *T. rattus* (Müller); 18, *T. flagellata* Hauer; 19, *T. bicristata* (Gosse); 20, *T. mucosa* (Stokes). Scale lines: adult 50 µm; trophi & eggs 10 µm. (Various authors after Shiel & Koste (1992))

22(1). Lorica anterior margin without projections..**23**
- Anterior margin with blunt projections, spines or cusps............................**28**

23(22). Single dorsal keel present..**24**
- Double dorsal keel..**25**

24(23). LM with single crook; alula of LR angled about 45^{0} from TR axis..*T. rattus* (Muller) (Fig. 52:17)
- LM with double crook; alula of LR angled > 45^{0} from TR axis...*T. flagellata* Hauer (Fig. 52:18)

25(23). Body tapers in posterior 1/3; toes curved ventrally................................**26**
- Body slender or squat, not constricted posteriorly; toes follow body axis....**27**

26(25). BL >190 µm; LT >200 µm..........................*T. bicristata* (Gosse) (Fig. 52:19)
- BL <190 µm; LT <150 µm.............................*T. mucosa* (Stokes) (Fig. 52:20)

27(25). BL >300 µm; LT >160 µm.............................*T. elongata* (Gosse) (Fig. 53:2)
- BL <130 µm; LT >150 µm (exceeds BL).......*T. braziliensis* (Murray) (Fig. 53:3)

28(22). Lorica anterior margin with spine(s)..**33**
- Lorica margin with blunt projections, no spines......................................**29**

29(28). Dorsal keel present..*T. gracilis* (Tessin) (Fig. 53:4)
- Dorsal keel absent..**30**

30(29). TL >180 µm; BL >135 µm..**31**
- TL <180 µm; BL <135 µm...**32**

31(30). Posterior lorica overhangs foot; LT >70 µm........*T. agnata* Wulfert (Fig. 53:5)
- Posterior lorica without overhang; LT <70 µm......*T. stylata* (Gosse) (Fig. 53:6)

32(30). LT > BL (ratio 0.72-0.83).......................................*T. mus* Hauer (Fig. 53:7)
- LT < BL (ratio 1.8)..*T. pusilla* Jennings (Fig. 53:8)

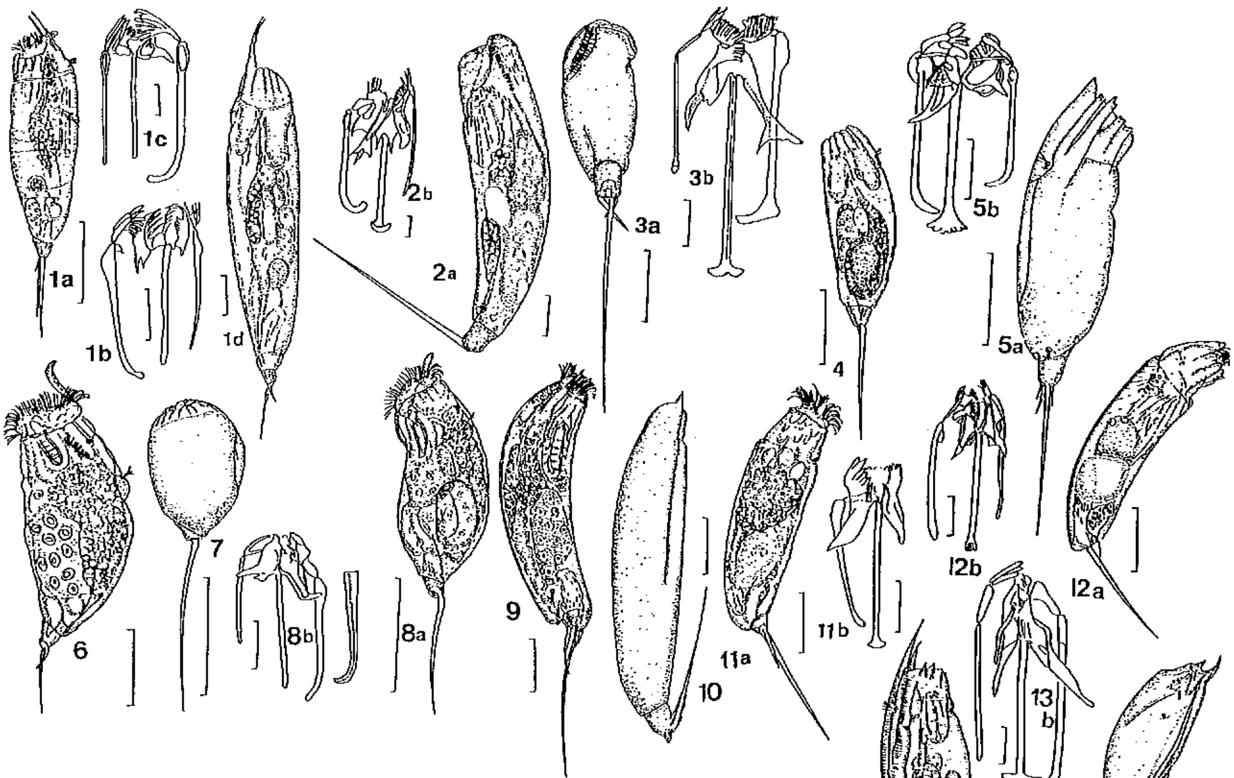
33(28). Anterior margin with single spine..**34**
- Anterior margin with two spines...**37**

34(33). TL >450 µm; anterior spine long.................*T. cylindrica* (Imhof) (Fig. 52:16)
- TL <450 µm; anterior spine short..**35**

35(34). Dorsal posterior lorica projects over foot; RT >30 µm (right:LT ratio <5.5)..*T. jenningsi* Voigt (Fig. 53:9)
- Posterior lorica does not overhang foot; RT < 30 µm (ratio >5.5)................**36**

36(35). TL >300 µm; BL >200 µm; LT > 100 µm.........*T. macera* (Gosse) (Fig. 53:10)
- TL <300 µm; BL <200 µm; LT <100 µm..............*T. iernis* (Gosse) (Fig. 53:11)

37(33). Two dissimilar length spines...**38**
- Two spines and dorsal cowl-like structure ....*T. capucina* Wierzejski & Zacharias (Fig. 53:12)



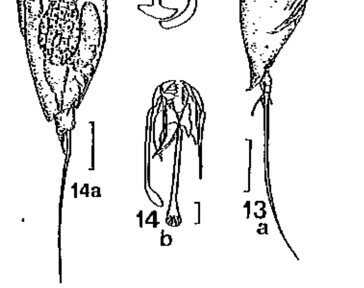


Fig. 53: 1, *T. similis* (Wierzejski): a, s.str., lateral; b. trophus; c. *T. similis grandis* trophus; d. *T. similis grandis* Hauer; 2, *T. elongata* (Gosse): a, lateral; b, trophus ; 3, *T. braziliensis* (Murray): a, lateral; b, trophus; 4, *T. gracilis* (Tessin), lateral; 5, *T. agnata* Wulfert: a, lateral; b, trophus; 6, *T. stylata* (Gosse), lateral; 7, *T. mus* Hauer, lateral; 8, *T. pusilla* (Jennings): a, lateral; b, trophus; c, fulcrum, lateral; 9, *T. jenningsi;* 10, *T. macera* (Gosse); 11, *T. iernis* (Gosse): a, lateral; b, trophus; 12, *T. capucina* Wierzejski & Zacharias: a, lateral; b, trophus; 13, *T. rosea* (Stenroos), a, lateral; b, trophus; 14, *T. longiseta* (Schrank): a, lateral; b, trophus. Scale lines: adults 50 µm, trophi 10 µm. (Various authors, after Shiel & Koste, (1992)).

38(37). Body constricted in posterior 1/3; posterior overhangs foot; LM weakly curved terminally..*T. rosea* (Stenroos) (Fig. 53:13)
Body not constricted; no overhang; LM with single crook..*T. longiseta* (Schrank) (Fig. 53:14)

Niche: There is little available information on biology of the different species. They appear to be adapted to specialized niches or their preferred habitat. Planktonic species *T. capucina* and *T. cylindrica* suck out the contents of eggs of planktonic rotifers, e.g. *Brachionus* and *Keratella.* Littoral taxa extract contents from algal cells, e.g. *T. longiseta*, common in billabongs, breaks filaments of chlorophyceae (e.g. *Mougeotia*) using its dorsal spine, rasps a hole in the cell wall, and sucks out cytoplasm contents; *T. similis grandis* takes whole coccoid chlorophytes, e.g. *Gloeocystis*; *T. bidens* has developed a specialized pharyngeal basket to suck contents from desmids (see Pourriot 1970 for other feeding specialties).

21. Fam. Notommatidae Remane, 1933

The characteristics of the family were described by, *inter alia*, Harring & Myers (1924), Remane (1933) and Koste (1978). The family was revised for Australia by Koste & Shiel (1991). The genus *Itura* was relocated into a new family, Ituridae by Segers et al. (1994). The modified key below separates out the Ituridae but otherwise follows Koste & Shiel (1991). The notommatids are a diverse assemblage of illoricate or partly loricate taxa comprising two subfamilies: Tetrasiphoninae (two genera) and Notommatinae (18 genera) separated on the basis of presence (Tetrasiphonae) or absence (Notommatinae) of a whorl of bulbous glands between the stomach and intestine.

Subfamily Tetrasiphoninae

Of two described genera, *Repaulina* and *Tetrasiphon*, only *Tetrasiphon hydrocora* Ehrenberg, 1840 (Fig. 54) is known from Australia, at present only from vegetated margins of Murray-Darling billabongs. It is not known from N.Z.

Niche: Herbivore. *Tetrasiphon hydrocora* is specialized for large algae, e.g. *Staurastrum, Cosmarium, Micrasterias, Pleurotaenium* (Pourriot 1965; Koste & Shiel 1991).

Subfamily Notommatinae

Twelve of 18 known genera are known from Australia. *Metadiaschiza* Fadeev, *Pleurotrochopsis* Berzins, *Pseudoharringia* Fadeev, *Rousseletia* Harring, *Sphyrias* Harring and *Tylotrocha* Harring & Myers are not presently recorded here. If found, they may be identified to genus from the following key, but not further. For more detailed information on them, see Koste (1978).

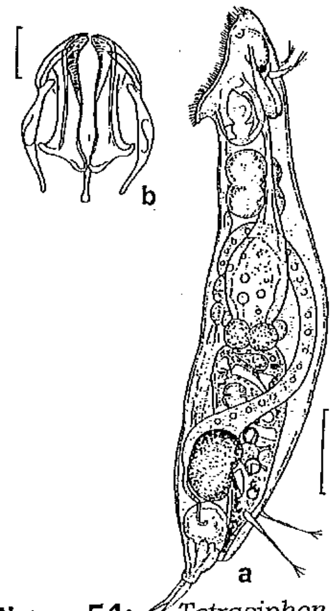


Fig. 54: *Tetrasiphon hydrocora* Ehrenberg: a, lateral; b, trophus. Scale lines: a, 100 µm; b, 20 µm. (After Koste (1978)).

Key to genera of the subfamily Notommatinae

1. Corona on cylindrical extrusion/evagination, with circumapical ciliation; annular adhesive organ present; no lateral ciliary auricles; mouth deeply invaginated........*Drilophaga* Vejdovsky (p. 103)

\- Corona not extruded, may be frontal, oblique or extending ventrally; no adhesive organ; ciliary auricles may be present; mouth not deeply invaginated........**2**

2. Vitellarium band- or ribbon-shaped........**3**

\- Vitellarium oval or kidney-shaped........**5**

3(2). Nuclei arranged linearly........**4**

\- Nuclei irregularly distributed........*Enteroplea* Ehrenberg (p. 103)

4(3). Eyeless; foot two to three-segmented........*Pseudoharringia* Fadeev

\- Two frontal eyes on papillae; foot one-segmented with annuli........*Sphyrias* Harring

5(2). Foot and toes longer than body........**6**

\- Foot and toes shorter than body........**7**

6(5). Toes of dissimilar length; foot short, mostly 2-, rarely three-segmented........*Monommata* Bartsch (p. 103)

\- Toes of similar length; foot 3-segmented and very long........*Scaridium* Ehrenberg (p. 107)

7(5). Foot with single toe..*Tylotrocha* Harring & Myers
- Foot with two toes..**8**

8(7). Rump or last foot segment with spine...**9**
- Rump or last foot segment without spine..**10**

9(8). Rump with curved spine.......................*Dorystoma* Harring & Myers (p. 102)
- Foot-end with short spine..*Rousseletia* Harring

10(8). Trunk loricate with 3-5 species-specific cuticular plates...........................**11**
- Trunk illoricate..**12**

11(10). 2 dorsolateral plates; 1 granulated ventral plate.. *Metadiaschiza*. Fadeev
- 2 dorsoventral, 2 (or 5) ventrolateral plates, also 3 smooth trunk plates present...*Cephalodella* Bory de St Vincent (p. 98)

12(10). Cuticle with rows of tiny hooks..............................*Pleurotrochopsis* Berzins
- Cuticle lacking hooks **13**

13(12). Trunk with conspicuous annuli......................*Taphrocampa* Gosse (p. 107)
- Annuli absent...**14**

14(13). One cerebral eye and two widely-separated frontal eyes..........................**15**
- Cerebral eye absent (or if present, no frontal eyes as above)......................**17**

15(14). Stomach with blind sacs..*Itura* Harring & Myers
(relocated to Fam. Ituridae, p. 108)
- Stomach without blind sacs..**16**

16(15). Mastax with single salivary gland............*Eothinia* Harring & Myers (p. 103)
- Mastax with paired salivary glands..................*Eosphora* Ehrenberg (p. 103)

17(15). Corona displaced ventrally; ciliary auricles generally present...*Notommata* Ehrenberg (p. 105)
- Corona anterior, no auricles present...**18**

18(17). Salivary glands symmetrical.......................*Pleurotrocha* Ehrenberg (p. 107)
- Salivary glands asymmetrical or rudimentary..*Resticula* Harring & Myers (p. 107)

Cephalodella Bory de St Vincent

Fusiform notommatid rotifers of various shapes, from elongate to short and stumpy; occasionally illoricate; trophi probably species-specific in 3-dimensional structure. Twenty-six species are known from Australia, 22 from N.Z. (15 shared). Other taxa (especially *nomina dubia*) are given by Harring & Myers (1924), who also discuss the confused generic nomenclature.

Trophi morphology: The key gives a trophus type for each species according to the six trophi types described by Wulfert (1937). These are as follows:
Type A (Fig. 55:1): fulcrum spatulate distally; rami single, without teeth on inner margin; manubria slender, rodlike, curving inwards in top view, from straight

shaft; no basal lamellae or distal dilation of manubria, which form characteristic crescentic shape when closed.

Type B (Fig. 55:2): fulcrum as Type A; inner margin of rami toothed or striated, at times with alulae; manubria with single or bilateral basal lamellae, distally T-shaped (termed 'double-crooked' by Wulfert, referring to a curved shepherd's 'crook'. This implement, and the term, no longer seem to be in common usage). Several species (e.g. *C. eva*) have a spatulate dilation of the manubria ends rather than a free-standing T, but in all other features conform to Type B trophi.

Type C (Fig. 55:3): features distinctive ringlike fenestrations at distal ends of manubria, considered by Wulfert to be derived from double-crooked Type B trophi.

Type D (Fig. 55:4): is most complex, with trophi parts not found in other types. Fulcrum short, dilated distally (also in lateral view), narrower in middle; rami from above widely separated, with comblike teeth on forcipate tips (absent in *stenroosi*); manubria proximally with wide bilateral lamellae, distally with single abrupt inward curve or crook; behind basal expansions, branched structures (subunci) occur; unci single, often with dorsal plate. In some species (*forficula, gigantea, tenuiseta*), a large delicate frontal plate with denticulate margin occurs above rami.

Type E (Fig. 55:5): known only in *C. megalocephala*. Fulcrum not dilated; rami right-angled dorsally (visible in lateral view), closed distally (at fulcrum) and separating proximally; basal lamellae of thin, S-shaped manubria apparently separate.

Type F (Fig. 55:6): recorded only in *C. mira*, which is not known from Australia. This trophus is comprised entirely of delicate rods.

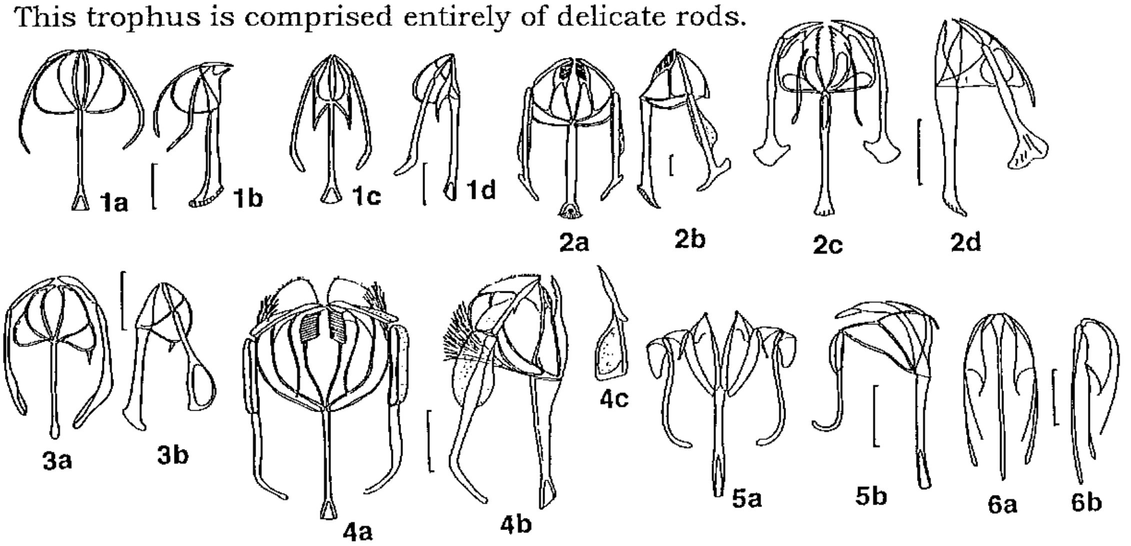


Fig. 55: Trophi types recognized in *Cephalodella* species: 1, Type A; 2, Type B; 3, Type C; 4, Type D; 5; Type E; 6, Type F. Scale lines 10 μm (After Wulfert 1937).

Key to species of Cephalodella known from Australian inland waters

Abbreviation: TR=trophus/trophi

1. Ratio total length/toe length <3 .... **2**

\- Ratio total length/toe length >3 .... **5**

2(1). With single or double cerebral eye..**3**
Eyeless...**4**

3(2). Toes curved dorsally, distinctly segmented; TR:A..*C. tantilloides* Hauer (Fig. 56:1)
Toes sigmoid in lateral view, not segmented; TR:A...*C. nana* Myers (Fig. 56:2)

4(2). Abdomen with hooked caudal projection; TR B...*C. mucronata* Myers (Fig. 56:3)
Without hooked caudal projection; TR:B.......*C. biungulata* Wulfert (Fig. 56:4)

5(1). Ratio total length/toe length 3-5..**6**
Ratio total length/toe length >5..**21**

6(2). Toe tips with longitudinal denticle row (2-4) on functionally ventral side; TR:B.......................................*C. lindamaya* Koste & Shiel (Fig. 56:5)
Toe tips without ventral denticles, but may have median dorsal denticles....**7**

7(6). Body >300 µm...**18**
Body <300 µm...**8**

8(7). Body >90 µm, toes >20 µm..**9**
Body <90 µm, toes =<20 µm; TR: intermediate A/B...*C. gisleni* Berzins (Fig. 56:6)

9(8). Toes (straight or curved) taper evenly from base to tip..............................**11**
Toes with recurved bristle-like tip or obvious segmentation......................**10**

10(9). Tips of toes sickle-shaped, recurved; TR:A..........*C. apocolea* Myers (Fig. 56:7)
Distal 1/4 of toes demarcated by transverse septum into segmented tip; TR:B..*C. intuta* Myers (Fig. 56:8)

11(9). Toes >60 µm...**12**
Toes <60 µ...**13**

12(11). Trophi >70 µm; TR:B...................................*C. gibba* (Ehrenberg) (Fig. 56:9)
Trophi ca. 30 µm: TR:D......................................*C. tinca* Wulfert (Fig. 56:10)

13(11). Toes 30-60 µm...**15**
Toes <30 µm...**14**

14(13). Body <125 µm; toes 20-26 µm; trophi <30 µm; TR:C...*C. exigua* (Gosse) (Fig. 56:11)
Body >125 µm; toes 25-28 µm; trophi 30-34 µm; TR:A..*C. ventripes* Dixon-Nuttall (Fig. 56:12)

15(13). Trophi <30 µm...**16**
Trophi >30 µm...**17**

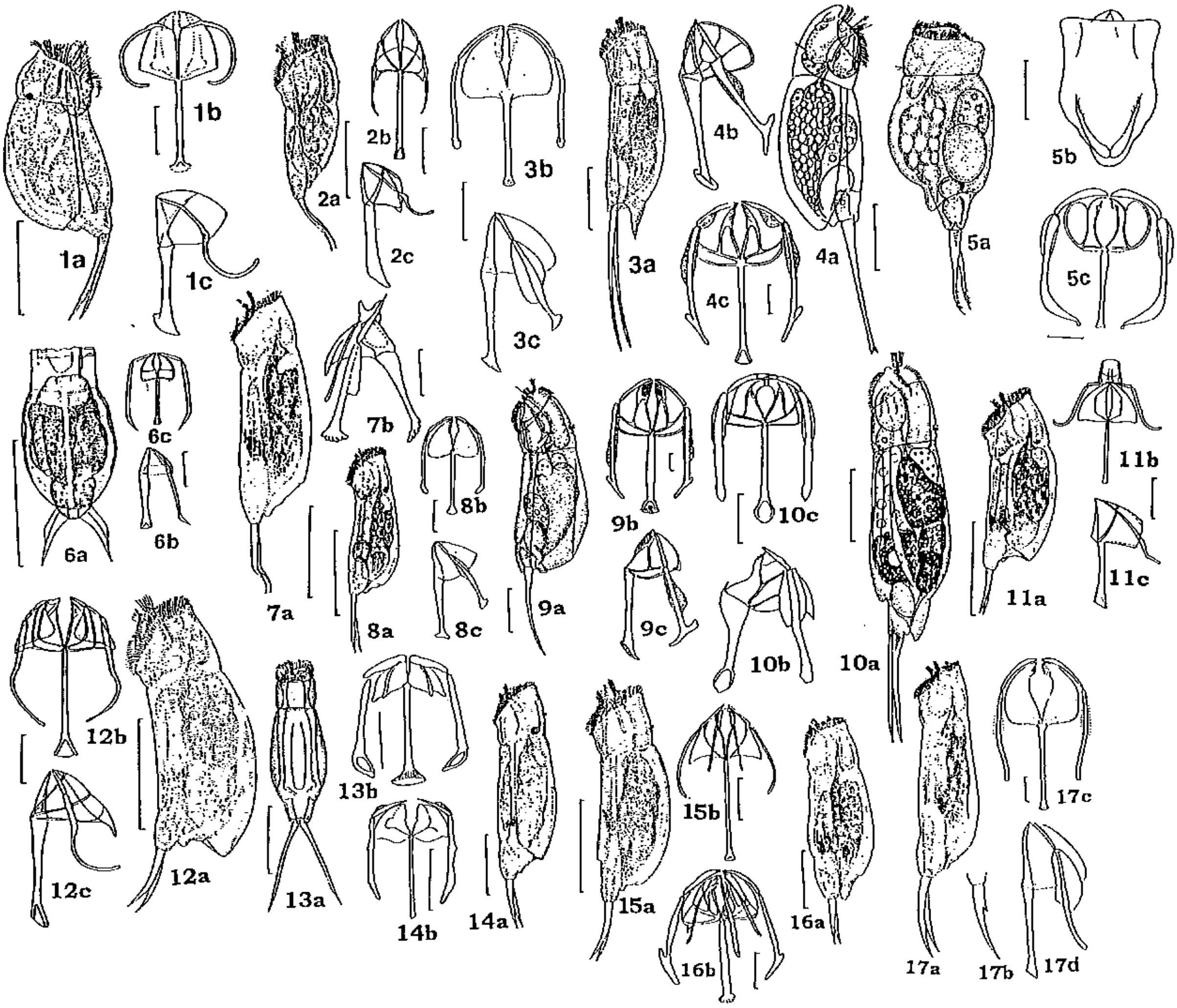


Fig. 56: 1, *C. tantilloides* Hauer: a, lateral; b, TR ventral,; c, TR lateral; 2, *C. nana* Myers; 3, *C. mucronata* Myers; 4, *C. biungulata* Wulfert; 5, *C. lindamaya* Koste & Shiel; 6, *C. gisleni* Berzins; 7, *C. apocolea* Myers; 8, *C. intuta* Myers; 9, *C. gibba* (Ehrenberg); 10, *C. tinca* Wulfert; 11, *C. exigua* (Gosse); 12, *C. ventripes* Dixon-Nuttall; 13, *C. misgurnus* Wulfert; 14, *C. forficata* (Ehrenberg); 15, *C. hoodi* (Gosse); 16, *C. sterea* (Gosse); 17, *C. panarista* Myers. Scale lines: adults 50 µm; trophi 10 µm. (Various authors, after Koste & Shiel (1991)).

16(15). Paired eyespots with crystalline lens; toes > 1/3 body length..*C. misgurnus* Wulfert (Fig. 56:13)
No eyespots; toes <1/3 body length..........*C. forficata* (Ehrenberg) (Fig. 56:14)

17(15). Single eyespot at posterior end of ganglion; corona with prominent lips; manubria not crutched..............................*C. hoodi* (Gosse) (Fig. 56:15)
Paired frontal eyespots in single capsule; corona without prominent lips; manubria crutched................................*C. sterea* (Gosse) (Fig. 56:16)

18(7). Toes >100 µm..**19**
Toes <100 µm..**20**

19(18). Toes ca. 1/3 body length; trophi >70 µm......*C. gibba* (Ehrenberg) (Fig. 56:9)
Toes 1/6 body length; trophi <70 µm.............*C. panarista* Myers (Fig. 56:17)

20(18). Distinct eyespot; toes 1/5 body length.....*C. forficula* (Ehrenberg) (Fig. 57:1)
No eyespot; toes 1/2 body length.....................*C. tenuiseta* (Burn) (Fig. 57:2)

21(2). Toes> 20 µm...**22**
- Toes <20 µm...*C. catellina* (Müller) (Figs 57:3)

22(21). Body >190 µm..**23**
- Body <190 µm..**24**

(NB: Occasionally individuals of *C. parasitica* may exceed 190 µm

23(22). Toes >50 µm (at least 1/3 body length)..................*C. eva* (Gosse) (Fig. 57:4)
- Toes <50 µm, 1/6 body length...........*C. megalocephala* (Glasscott) (Fig. 57:5)

24(22). Eyespot(s) visible, coloured or colourless...25
- No eyespot...*C. parasitica* (Jennings) (Fig. 57:6)

25(24). Two cerebral eyespots; lorica keeled in dorsal 1/3...*C. euderbyi* Wulfert (Fig. 57:7)
- Single eyespot, colourless or coloured; no dorsal keel on posterior lorica...**26**

26(25). Eyespot reddish; trophi >30 µm....*C. auriculata* (Müller) (Fig. 55:1a, b, 57:8)
- Eyespot colourless; trophi <30 µm...............*C. gracilis* (Ehrenberg) (Fig. 57:9)

Niche: herbivorous/omnivorous/carnivorous.

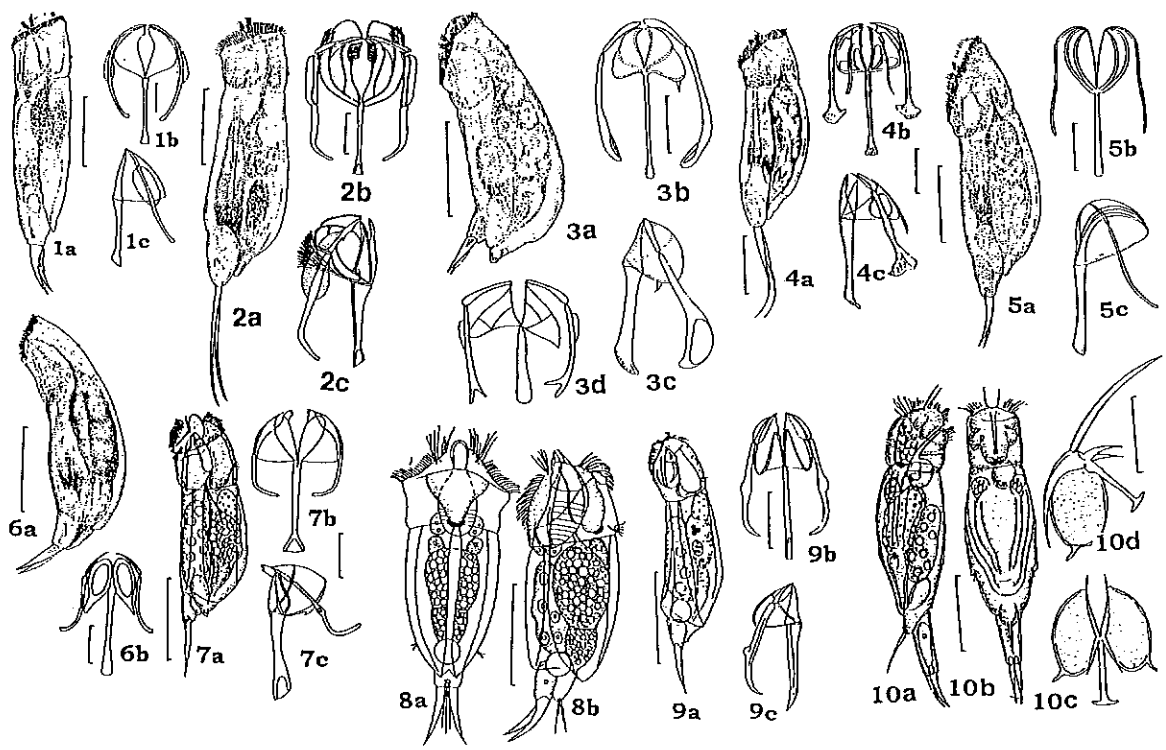


Fig. 57: 1, *C. forficula* (Ehrenberg); 2, *C. tenuiseta* (Burn); 3, *C. catellina* (Müller); 4, *C. eva* (Gosse); 5, *C. megalocephala* (Glasscott); 6, *C. parasitica* (Jennings); 7, *C. euderbyi* Wulfert; 8, *C. auriculata* (Müller); 9, *C. gracilis* (Ehrenberg); 10, *Dorystoma caudata* (Bilfinger). Scale lines: adults 50 µm; trophi 10 µm. (Various authors, after Koste & Shiel (1991)).

Dorystoma Harring & Myers

A monotypic genus, with *Dorystoma caudata* (Bilfinger, 1894) (Fig. 57:10) recorded from Yarnup Swamp (Koste et al. 1983).
Niche: Herbivorous, eats algae.

Drilophaga Vejdovsky

A single free-swimming animal identified as *Drilophaga* (W. Koste, pers. comm) was collected from Ryan's 2 billabong at Wodonga on Sept. 27, 1990. The genus is parasitic on oligochaetes and leeches. No species determination (cf. Koste & Shiel 1991) (cf. Fig. 58:1).

Enteroplea Ehrenberg

A monotypic genus, with *Entroplea lacustris* Ehrenberg, 1830 (Fig. 58:2) recorded occasionally in collections from billabongs and floodplain wetlands.

Niche: Carnivorous on other rotifers.

Eosphora Ehrenberg

Five species are known from Australia, three of them also from N.Z.

Key to species of Eosphora recorded from Australian inland waters

1. Foot segmented....................2
- Foot unsegmented....................3

2(1). Papilla at base of toes....................*E. najas* Ehrenberg (Fig. 58:3)
No papilla at base of toes....................*E. ehrenbergi* Weber (Fig. 58:4)

3(1). Obvious cerebral eye present....................4
Cerebral eye absent....................*E. anthadis* Harring & Myers (Fig. 58:5)

4(3). Trophi length <40 μm....................*E. thoides* Wulfert (Fig. 58:6)
Trophi length 50 μm....................*E. thoa* Harring & Myers (Fig. 58:7)

Niche: Predatory on other rotifers.

Eothinia Harring & Myers

A single species, *Eothinia elongata* (Ehrenberg, 1832) (Fig. 58:8) is known from Ryan's billabongs at Wodonga, Vic. It is not yet recorded from N.Z.

Niche: Carnivore of other rotifers, particularly bdelloids

Monommata Bartsch

Body cylindrical or fusiform; toes extremely long, almost twice body length, right longer than left (with exception of *M. aequalis*); trophi variable, from simple virgate to intermediate between virgate and forcipate. Eleven species have been recorded from Australia, five from N.Z. (one shared).

Key to species of Monommata known from Australian inland waters

1. Toes of similar length....................*M. aequalis* Ehrenberg (Fig. 58:9)
- Toes of dissimilar length....................**2**

2(1). Stomach with sacs....................*M. viridis* Myers (Fig. 58:10)
- Stomach without sacs....................3

3(2). Dorsal antenna single....................**5**
- Dorsal antennae paired....................**4**

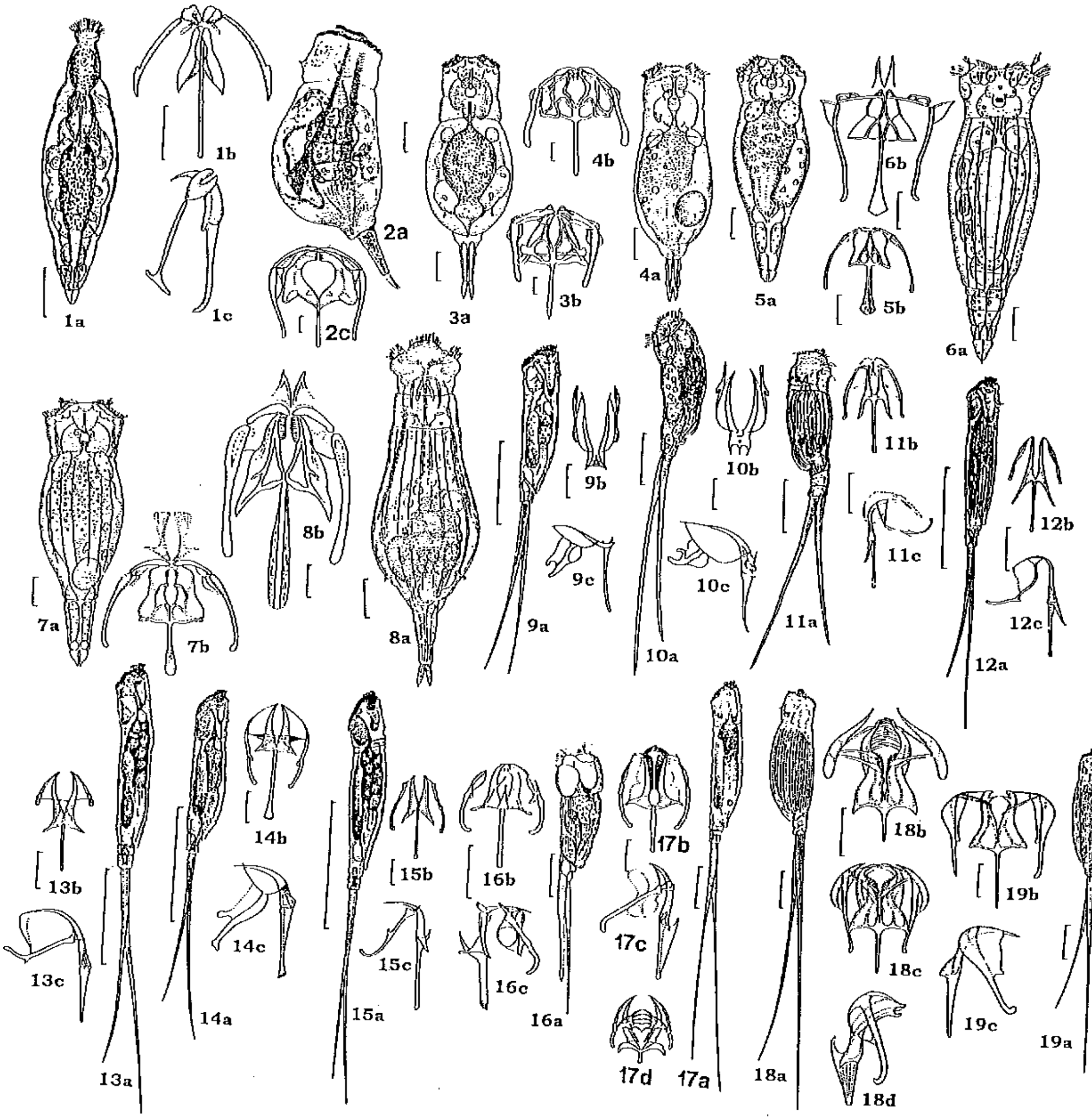


Fig. 58: 1, *Drilophaga bucephalus* Vejdovsky: a, dorsal; b, trophus ventral; c, trophus lateral; 2, *Entroplea lacustris* Ehrenberg; 3, *E. najas* Ehrenberg; 4, *E. ehrenbergi* Weber; 5, *E. anthadis* Harring & Myers; 6, *E. thoides* Wulfert; 7, *E. thoa* Harring & Myers; 8, *Eothinia elongata* (Ehrenberg, 1832); 9, *Monommata aequalis* Ehrenberg 10, *M. viridis* Myers; 11, *M. arndti* Remane; 12, *M. actices* Myers; 13, *M. diaphora* Myers; 14, *M. phoxa* Myers; 15, *M. aeschyna* Myers; 16, *M. dentata* Wulfert; 17, *M. grandis* Tessin; 18, *M. maculata* Harring & Myers; 19, *M longiseta* (Müller). Scale lines: adult 50 µm; trophi 10 µm. (Various authors, after Koste & Shiel (1991)).

4(3). Body >200 µm; right:left toe ratio <1.2.............*M. arndti* Remane (Fig. 58:11)
\- Body <200 µm; right:left toe ratio >1.2..............*M. actices* Myers (Fig. 58:12)

5(3). Rami with teeth on inner margin..8
\- Rami without teeth on inner margin...6

6(5). Toes <200 µm; trophi 25-35 µm...7
\- Toes >200 µm; trophi <25 µm........................*M. diaphora* Myers (Fig. 58:13)

7(6). Right toe >165 µm; rami lyrate; unci with 5-6 linear teeth..*M. phoxa* Myers (Fig. 58:14)
- Right toe <165 µm; rami triangular; unci single-toothed..*M. aeschyna* Myers (Fig. 58:15)

8(5). Rami with 1-5 inner margin tooth pairs..9
- Rami with 1 or 2 occasionally unpaired inner margin teeth..*M. dentata* Wulfert (Fig. 58:16)

9(8). Unci with plate-like teeth terminally with finger-like extensions..*M. grandis* Tessin (Fig. 58:17)
- Unci only with long dagger-like teeth..10

10(9). Unci teeth paired...........................*M. maculata* Harring & Myers (Fig. 58:18)
- Unci teeth single.. *M longiseta* (Müller) (Fig. 58:19)

Niche: Eat phytoflagellates, e.g. *Synura*, by holding colonies in the corona and sucking cell contents

Notommata Ehrenberg

Body cylindrical, spindle-shaped; corona broadly triangular, displaced ventrally ("*Notommata* type") (Fig. 9:1, 2), in some species extending into pronounced "chin"; auricles generally large; mastax virgate; trophi asymmetric. Fourteen species are known from Australia, four from N.Z. (two shared). In view of gross morphological similarities between some taxa, and ready confusion of juveniles of large species with adults of smaller forms, the key can be used reliably only with living adults. For preserved material, and doubtful live material, trophi differences as described and figured enable accurate specific identification.

Key to species of Notommata recorded from Australian inland waters

1. Cylindrical, fusiform or conical body, without lateral extensions (alae).........**2**
- Body with pronounced alae.....................*N. spinata* Koste & Shiel (Fig. 59:1)

2(1). Rump with projecting digitiform process (Fig. 59:2)..................................**3**
- Rump without obvious appendage..**4**

3(2). Body >500 µm; trophi >80 µm; caudal process with articulated tip, does not reach base of toes....................................*N. copeus* (Ehrenberg) (Fig. 59:2)
- Body <200 µm; trophi <30 µm; caudal process not articulated, extends past base of toes..*N. tripus* Ehrenberg (Fig. 59:3)

4(2). Caudal 'tail' more or less covering base of foot..**5**
- Rump rounded, with no obvious tail..**12**

5(4). Toes <10 µm; body vermiform; auricles indistinct..*N. contorta* (Stokes) (Fig. 59:4)
- Toes >10 µm; body fusiform or gibbous; auricles distinct............................**6**

6(5). Toes >35 µm...**7**
- Toes <35 µm...**8**

7(6). Toes 40-42 µm; body <310 µm; TR 40-45 µm..*N. doneta* Harring & Myers (Fig. 59:5)
- Toes 35-75 µm; body 300-800 µm; TR >75 µm..*N. pachyura* (Gosse) (Fig. 59:6)

8(6). TR <40 µm; toes 16-20 µm; body <350 µm..........*N. aurita* (Müller) (Fig. 59:7)
- Trophi >40 µm; toes 15-35 µm; body 300-750 µm..**9**

9(8). TR >100 µm; body 500-750 µm..................*N. collaris* (Ehrenberg) (Fig. 59:8)
- Mastax smaller, trophi <70 µm; body 300-680 µm....................................**10**

10(9). Tail with median lobe and two lateral lobes; trophi 45-60 µm...................**11**
- Tail rounded; trophi 60-70 µm.......................*N. glyphura* Wulfert (Fig. 59:9)

11(10). Toes 30-35 µm; TR symmetric, unci single-toothed
....*N. pseudocerberus* De Beauchamp (Fig. 59:10)
- Toes 15-35 µm; TR asymmetric, unci 3-5-toothed...*N. cerberus* (Gosse) (Fig. 59:11)

12(4). Toes 20-30 µm; trophi 30-35 µm.....................*N. cyrtopus* Gosse (Fig. 59:12)
- Toes <20 µm; trophi <25 µm..**13**

13(12). Body 160-200 µm; toes 8-10 µm, TR 24 µm.....*N. silpha* (Gosse) (Fig. 59:13)
- Body <140 µm, toes 12-16 µm, trophi 20 µm.*N. tyleri* Koste *et al.* (Fig. 59:14)

Niche: herbivorous (desmids, diatoms, flagellates)/carnivorous (bdelloids and other rotifers) in littoral. Evidence of resource partitioning by different species in the same habitat.

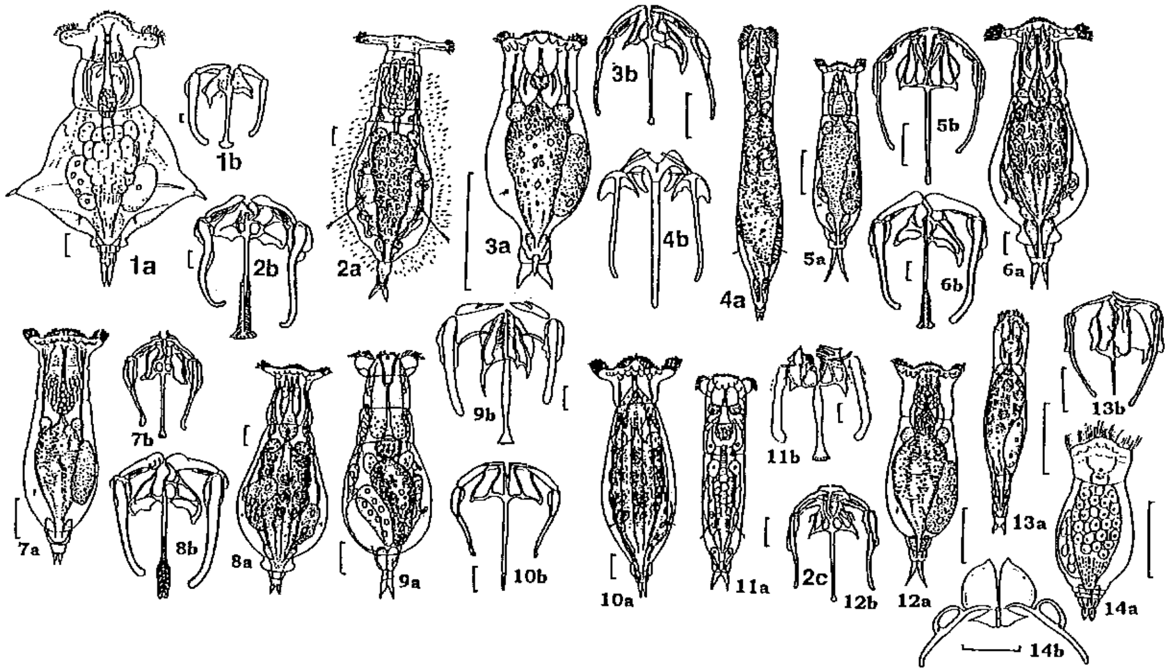


Fig. 59: .*Notommata. spinata* Koste & Shiel: a, dorsal; b, TR ventral; 2, *N. copeus* (Ehrenberg); 3, *N. tripus* Ehrenberg; 4, *N. contorta* (Stokes); 5, *N. doneta* Harring & Myers; 6, *N. pachyura* (Gosse); 7, *N. aurita* (Müller); 8, *N. collaris* (Ehrenberg); 9, *N. glyphura* Wulfert; 10, *N. pseudocerberus* De Beauchamp; 11, *N. cerberus* (Gosse); 12, *N. cyrtopus* Gosse; 13, *N. silpha* (Gosse); 14, .*N. tyleri* Koste *et al.* Scale lines: adult 50 µm; trophi 10 µm. (Various authors, after Koste & Shiel (1991)).

Pleurotrocha Ehrenberg

Short, stout illoricate body; corona slightly oblique with ciliated circumapical band and lateral auricle-like tufts of long cilia for swimming; mastax virgate, trophi simple. Only *P. petromyzon* Ehrenberg, 1830 (Fig. 60:1) known from Australia. Not known from N.Z.

Niche: Necrophage - cleans out carapaces of dead mites and microcrustacea, also eats sessile ciliates.

Resticula Harring & Myers

Very slender, fusiform illoricate body; mastax virgate; fulcrum long, slender; rami triangular, symmetrical with right-angled median bend; unci with single well-developed tooth. Three species known from Australia, none from N.Z.

Key to species of Resticula recorded from Australian inland waters

1. Foot from end of abdomen to base of toes long (ca. 1/4 total length)..*R. gelida* (Harring & Myers) (Fig. 60:2)

\- Foot short and indistinct, less than length of toes.......................................2

2(1). Eyespot a mass of red pigment granules ....*R. nyssa* Harring & Myers (Fig. 60:3)

\- No eyespot discernible.................... *R. melandocus* (Gosse, 1887) (Fig. 60:4)

Niche: Carnivorous on rotifers (particularly bdelloids) in littoral.

Scaridium Ehrenberg

Body cylindrical or fusiform, partially loricate both dorsally and ventrally; neck behind dorsal antennae also with stiffened cuticle; foot very long, three-segmented, not retractable, with short basal-, long distal-segment; complex internal foot musculature to move very long, straight toes. Two species recorded from Australia, one of them also from N.Z. The species can be separated on size and characteristics of their trophi. The genus is poorly known; it is likely that other species remain to be described from both regions.

Key to species of Scaridium known from Australian inland waters

1. BL >300 µm; TR as Fig. 60:5...................................*S. longicaudum* (Müller)

TR <300 µm; TR as Fig. 60:6............................*S. bostjani* Daems & Dumont

Niche: Herbivorous.

Taphrocampa Gosse

Characteristic fusiform body with more or less distinct transverse plicae. Two species are known from Australia, both also from N.Z..

Key to species of Taphrocampa recorded from Australian/N.Z. inland waters

1. Body generally <220 µm; toes <15 µm..............*T. annulosa* Gosse (Fig. 60:7)

Body >220 µm: toes >25 µm.............................*T. selenura* Gosse (Fig. 60:8)

Niche: ?Detritivorous/herbivorous.

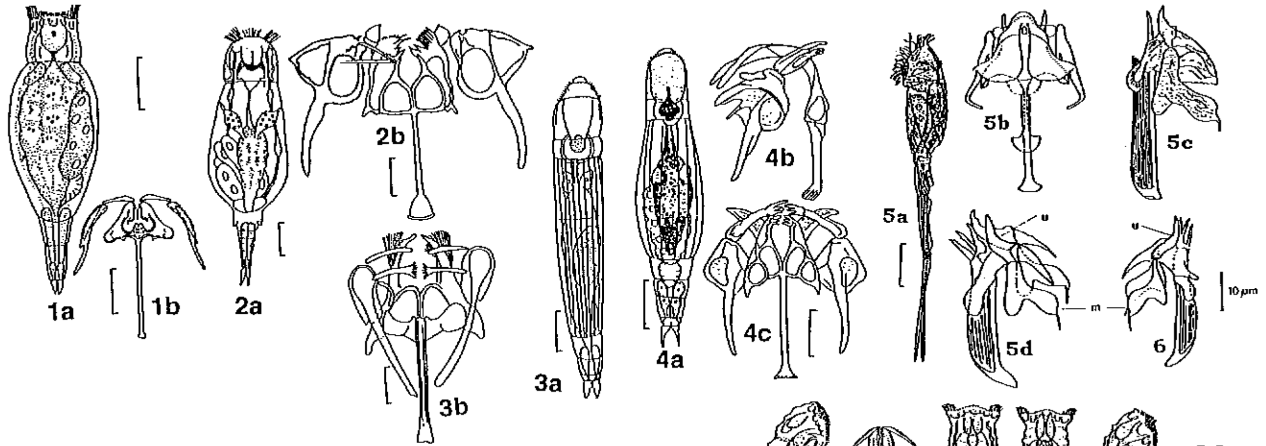
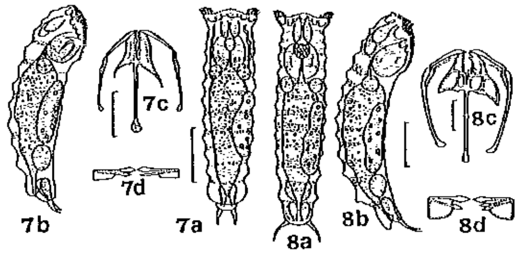



Fig. 60: 1, *Pleurotrocha petromyzon* Ehrenberg; 2, *Resticula gelida* (Harring & Myers); 3, *R. nyssa* Harring & Myers; 4, *R. melandocus* (Gosse); 5, *Scaridium longicaudum* (Müller); 6, *S. bostjani* Daems & Dumont; 7, *Taphrocampa annulosa* Gosse; 8, *T. selenura* Gosse. Scale lines: adult 50 µm; trophi 10 µm. (Various authors, after Koste & Shiel (1991)).

22. Fam. **Ituridae** Markevich, 1990

The family was erected by Markevich to separate the genus *Itura* Harring & Myers from the Notommatidae. Segers *et al.* (1994) reviewed the characteristics of the known *Itura* species. Body elongate, fusiform, may be green due to symbiotic zoochlorellae. Three species are known from Australia, none from N.Z.

Key to species of Itura known from Australian inland waters

1.	Rami with asymmetric lamellae on outer border...	*I. aurita* (Ehrenberg) (Fig. 61:1)
-	Rami without lamellary ribs on outer border...	**2**
2(1).	Subcerebral glands very long..............................	*I. myersi* Wulfert (Fig. 61:2)
-	Subcerebral glands missing or poorly developed..	*I. viridis* (Stenroos) (Fig. 61:3)

Niche: Herbivorous.

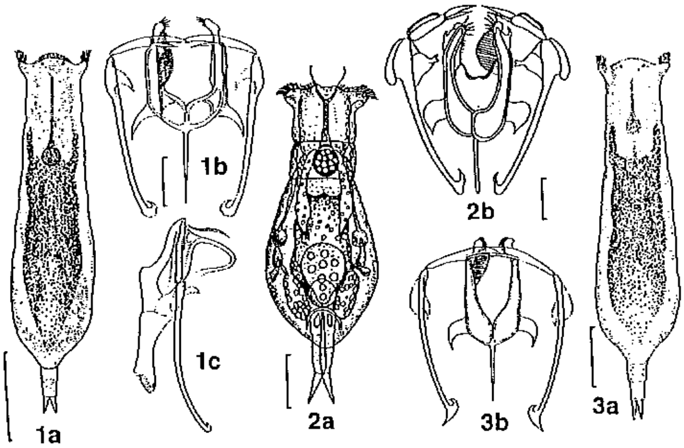


Fig. 61: 1, *Itura aurita* (Ehrenberg); 2, *I. myersi* Wulfert; 3, *I. viridis* (Stenroos). Scale lines: adult 50 µm; trophi 10 µm. (Various authors, after Koste & Shiel (1991)).

23. Fam. **Gastropodidae** Remane, 1933

These are small, fast, spherical rotifers perennial in the plankton of ponds and billabongs. The two genera have distinctive colour differences, although *Gastropus* has a foot and *Ascomorpha* does not, it is usually withdrawn and not clearly seen. Three species in each genus are known from Australia, with all three *Ascomorpha* species and two of the *Gastropus* also known from N.Z.

Key to genera and species of Gastropodidae known from Australia/N.Z.

1. 1-4 dark to black inclusions, foot absent (Fig. 62:1-3)............*Ascomorpha*..**2**
- No dark inclusions, gut usually bright green, foot present (Fig. 62:4-6)............*Gastropus*..**4**

2(1) Corona with fingerlike palpar organ used to grasp prey (Fig. 62:1)............*Ascomorpha ecaudis* Perty
- No palpar organ............**3**

3(2) Lorica formed by a dorsal and a shield-like ventral plate (Fig. 62:2)............*A. ovalis* (Bergendal)
- No plates, cuticle one-piece (Fig. 62:3)............*A. saltans* Bartsch

4(1) Foot medioventral with a single toe (Fig. 62:4)..........*Gastropus stylifer* Imhof
- Foot posteroventral with two toes............**5**

5(4) BL < 140 µm (Fig. 62:5)............*G. minor* (Rousselet)
- BL > 150 µm (Fig. 62:6)............*G. hyptopus* (Ehrenberg)

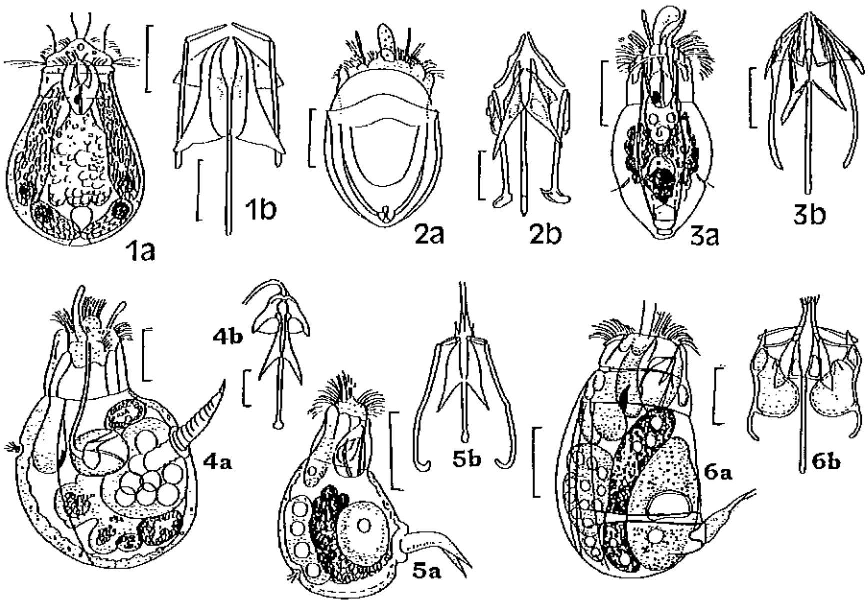


Fig 62: 1, *Ascomorpha ecaudis* Perty; 2, *A. ovalis* (Bergendal); 3, *A. saltans* Bartsch; 4, *Gastropus stylifer* Imhof; 5, *G. minor* (Rousselet); 6, *G. hyptopus* (Ehrenberg). Scale lines: adult 50 µm; trophi 10 µm. (Various authors, after Shiel & Koste (1993)).

24. Fam. Synchaetidae Remane, 1933

Three genera, of which *Polyarthra* and *Synchaeta* are most common in the plankton, often in high densities (>25,000 l^{-1}). Co-occurring species in each genus are common, and seasonal succession of congeners with up to five species occurring over a year also is known. Soft cuticled to more or less loricate; body conical, pyriform, cup-, bell-shaped, vasiform or saccate; mastax virgate with complex paired hypopharynx muscles. Of four described genera, *Ploesoma, Polyarthra* and *Synchaeta* are known from Australia; *Pseudoploesoma* is not. Synchaetids can be identified to genus on gross morphology, and to species by trophi structure

Key to genera of Synchaetidae known from Australia

1. Illoricate body, cuticle thin but maintains shape; corona with lateral ciliary auricles; foot more or less distinct with two short toes, occasionally one........*Synchaeta* Ehrenberg

\- Auricles absent........**2**

2(1). Body illoricate, saccate-cuboidal; cuticle thin but rigid; foot absent; lateral bundles of rigid serrated fins........*Polyarthra* Ehrenberg

\- Body loricate, generally with ornamented surfaces (ridges, fillets, etc); foot-opening or ventral aperture present; foot annular and distinct, two toes........*Ploesoma* Herrick

Ploesoma Herrick

Body bean-shaped/saccate, distinctly loricate, ornamented (Fig. 63) Two species are recorded from Australia, none from N.Z.

Key to species of Ploesoma recorded from Australia

1. Anterior margin of headshield smooth, straight to undulate (Fig. 63:1)........*P. truncata* (Levander)

\- Headshield margin with median, short, triangular toothlike extension (Fig. 63:2)........*P. lenticulare* Herrick

Niche: All known species are planktonic or semiplanktonic carnivores, eating pelagic and benthic rotifers. Cannibalism is noted (Koste 1982).

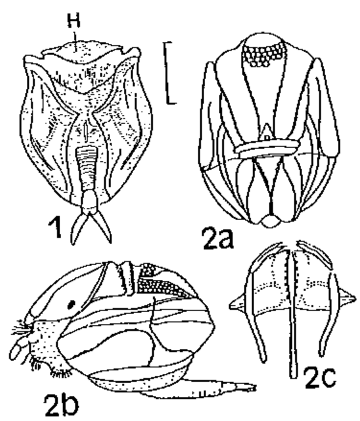


Fig. 63: 1, *Ploesoma truncata* (Levander); 2, *P. lenticulare* Herrick. Scale bar: adult 50 µm. (Various authors, after Shiel & Koste (1993)).

Polyarthra Ehrenberg

Body cylindrical, conical, saccate or cuboidal, with characteristic dorsal and ventral, in two groups of three, blade- or sword-shaped serrated finlike processes. At present, six taxa have been recorded from Australia, four of them also from N.Z. The difficulty of specific determination from preserved contracted material was noted by Koste (1978). He recommended calculation of indices of body:fin length and fin length:width, carmine staining of vitellaria, NaOCl-clearing for trophi analysis, etc. Comparative indices were used successfully by Guiset (1977) to separate *Polyarthra* species in Spanish reservoirs. Some intergrades of body and fin-lengths have been reported, so collection of all the relevant morphometric information for a particular population may not ensure specific placement. It is likely that trophi are species-specific, and will enable accurate species recognition.

Key to species of Polyarthra known from Australian/N.Z. inland waters

Abbreviations: BL=body length; FW=fin width; TR=trophi.

1. ventral fins present (Fig. 64:1c)..**2**
\- ventral fins absent **3**

2(1). FW <15 µm; TR as Fig. 64:1b........................*P. dolichoptera* Idelson
\- FW >15 µm; TR as Fig. 64:2b........................*P. vulgaris* Carlin

3(1). BL >120 µm; vitellarium with 8 nucleii; TR as Fig. 64:3b or 64:4b..............**4**
\- BL <120 µm; vitellarium with 4 nucleii; TR as Fig. 64:5b or 64:6b..............**5**

4(3). FW 8-11 µm, TR as Fig. 64:3b........................*P. longiremis* Carlin
\- FW 20-62 µm; TR as Fig. 64:4b........................*P.major* Burckhardt

5(3). BL <70 µm; FW <5 µm; left dorsal fins notably longer than others; trophi as Fig. 64:5b........................*P. minor* Voigt
\- BL >80 µm; FW >5 µm; all fins similar length; trophi as Fig. 64:6b........................*P. remata* (Skorikov)

Niche: Herbivore, particularly monads and dinoflagellates.

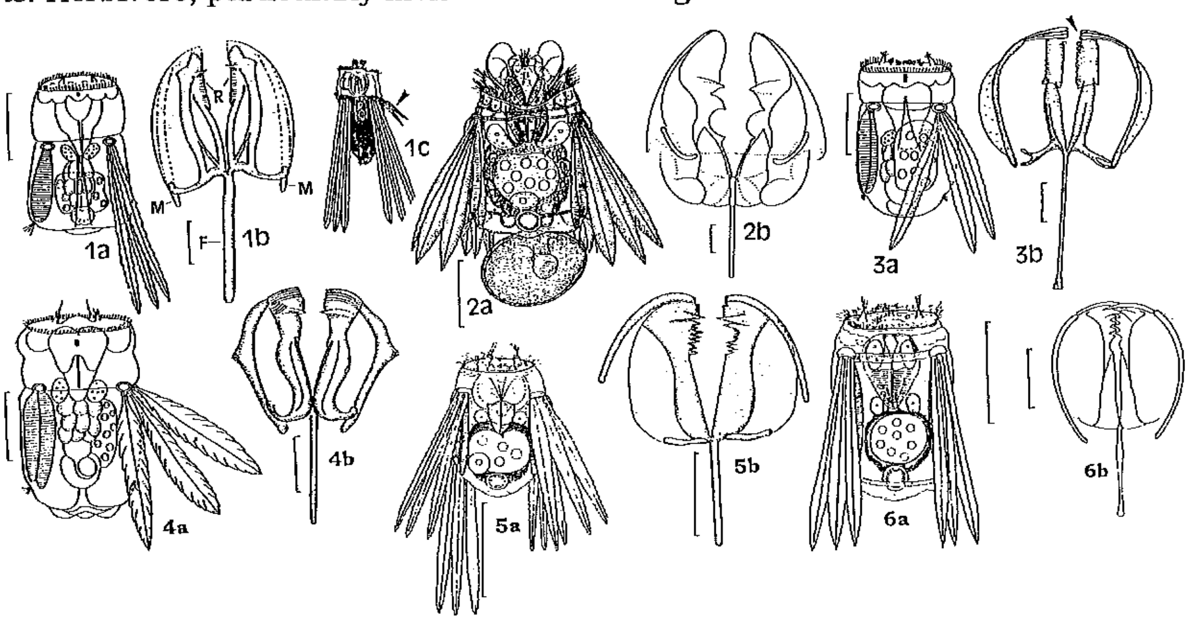


Fig. 64: 1, *P. dolichoptera* Idelson: a, lateral; b, trophus, dorsal; 2, *P. vulgaris* Carlin; 3, *P. longiremis* Carlin; 4, *P.major* Burckhardt; 5, *P. minor* Voigt; 6, *P. remata* (Skorikov). Scale lines: adults 50 µm; trophi 10 µm. (Various authors, after Shiel & Koste (1993)).

Synchaeta Ehrenberg

Common in the plankton, *Synchaeta* species are transparent, conical-vasiform; gut may be coloured by ingested food. Ten *Synchaeta* species have been reported from Australian inland waters, five shared with N.Z., which has five additional *Synchaeta* not known from Australia (*S. cecilia* Rousselet, *S. ?curvata* Lie-Petersen, *S. ?fennica* Rousellet, *S. monopus* Plate and *S. triophthalma* Lauterborn) (Shiel & Green (1995)). *S. baltica* Ehrenberg is known from estuarine/marine waters off coastal Australia. It is a widespread marine species, not considered further here. Discrimination of Synchaeta species is difficult without examination of trophi

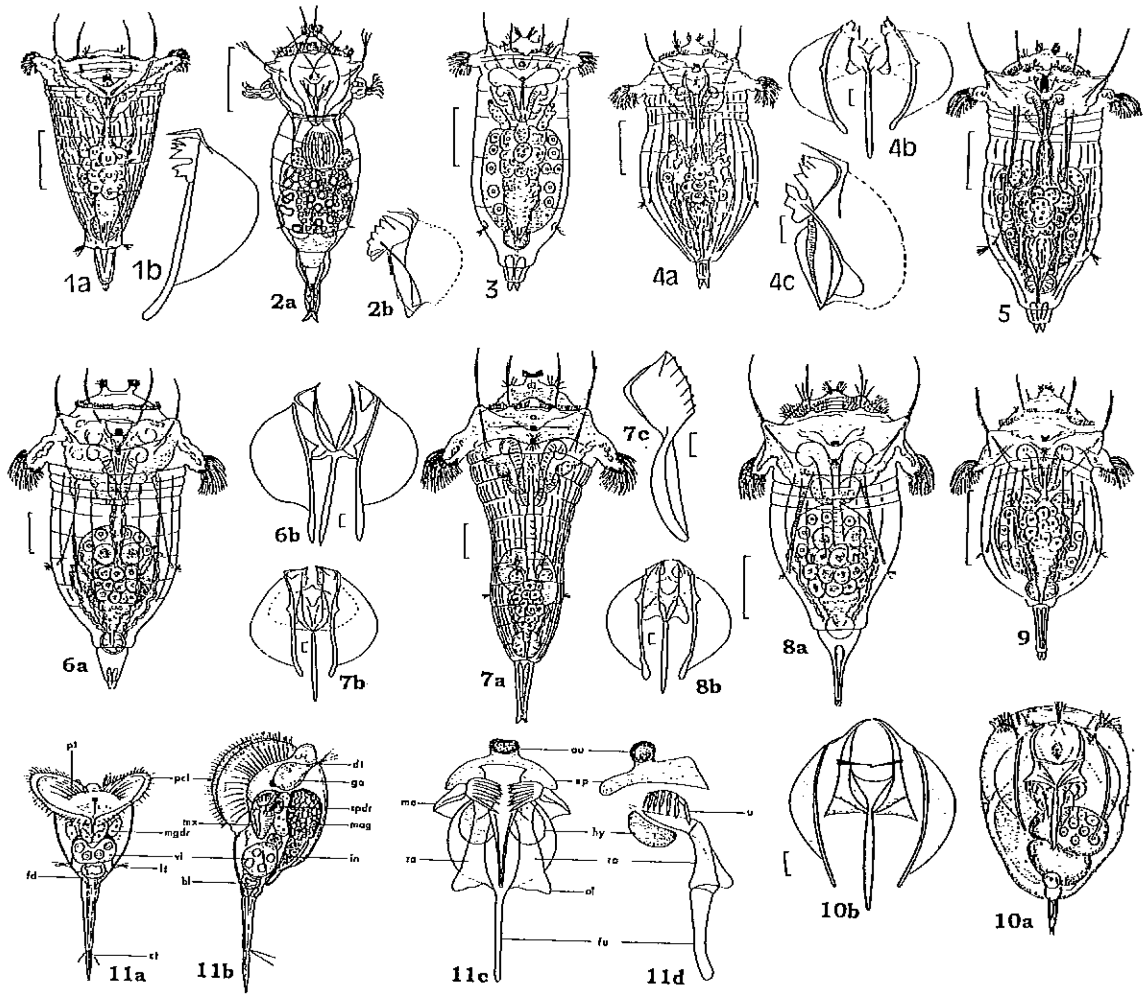


Fig. 65: *S. tremula* (Müller): a, dorsal; b. uncus, ramus and manubrium of trophus; 2, *S. lakowitziana* Lucks; 3, *S. tavina* Hood; 4, *S. oblonga* Ehenberg; 5, *S. litoralis* Rousselet; 6, *S. pectinata* Ehrenberg; 7, *S. grandis* Zachiarias; 8, *S. stylata* Wierzejski; 9, *S. longipes* Gosse; 10, *S. jollyi* Shiel & Koste; 11, *Microcodon clavus* Ehrenberg. Scale lines: adult 50 µm; trophi 10 µm. (Fig. 11 after Koste (1978), others various authors after Shiel & Koste (1993).

structure. The trophi are relatively light and membranous compared to those of other rotifers, so care has to be taken during the clearing process to ensure that they are not completely eroded or lost.

Key to species of Synchaeta known from Australian inland waters

1. Uncus of trophus with one main tooth, no accessory teeth.......................... **6**
\- Uncus with main and accessory teeth... **2**

2(1). Lateral antennae in posterior third of body.. **3**
\- Lateral antennae near base of foot.................... *S. tremula* (Müller) (Fig. 65:1)

3(2). Marked constriction below ciliary auricles (Fig. 65:2a)..*S. lakowitziana* Lucks
\- No obvious constriction.. **4**

4(3). Body cylindrical; auricles small; toes 9-10 µm; unci with 4-5 robust teeth... *S. tavina* Hood (Fig. 65:3)
\- Body coniform; auricles not small; toes <=5 µm; unci with 5-8 teeth............ **5**

5(4). Apical field flat; uncus 6-8 toothed................*S. oblonga* Ehenberg (Fig. 65:4)
- Apical field domed; uncus 5-6 toothed...........*S. litoralis* Rousselet (Fig. 65:5)

6(1). Two large ciliated tentacles in apical field....*S. pectinata* Ehrenberg (Fig. 65:6)
- Apical field smooth or with ciliated humps..**7**

7(6). Trunk medially constricted, elongated (Fig. 8:2a); BL >400 µm...*S. grandis* Zachiarias (Fig. 65:7)
- No obvious constriction, trunk convex at sides; BL to 320 µm....................**8**

8(7). BL <200 µm; foot elongated...**9**
- BL 200-313 µm; foot not elongated................*S. stylata* Wierzejski (Fig. 65:8)

9(8). BL >150 µm; foot and toes as Fig. 65:9..............................*S. longipes* Gosse
- BL <150 µm; foot and toes as Fig. 65:10......................*S. jollyi* Shiel & Koste

Niche: Planktonic herbivore, e.g. eats monads.

25. Fam. Microcodonidae Remane, 1933

A single species of the genus *Microcodon*, *M. clavus* Ehrenberg, 1830 (Fig. 65:11) has been recorded from both Australia and N.Z.

Niche: Rare littoral ?herbivore.

Zoogeography of rotifers

Despite observations in earlier general works that rotifers are 'cosmopolitan', there is increasing evidence that this is not so - each continent has an endemic rotifer assemblage. Australia is no exception, with 30-50% of species in some genera at present known only from the continent. Recent reports of 'Australian' endemics from Papua-New Guinea, New Zealand and Thailand suggest that 'Australasian' may be a more appropriate term for these regionally restricted taxa. Within Australia and New Zealand there are latitudinal differences in rotifer species composition, summarized by Shiel & Koste (1986) and Shiel *et al.* (in press), and also limited evidence for longitudinal differences, between long-separated western and eastern Australian assemblages (Storey *et al.* 1993). Northern Australia has an Indo-Malaysian component in its rotifer assemblages, with poor representation of Brachionidae, among others. Further south Brachionidae are more significant (but not in Tasmania or N.Z., where Lecanidae have diversified). Because of generally poor coverage in sampling, no distributions on a continental basis are yet realistic.

The keys presented here are the known or named species, which probably represent half or less of the possible rotifer species to be found here. Some of these may be incorrect, determined by comparison with the 'nearest' figure in an authoritative (northern hemisphere) reference. Perhaps the succinct advice provided by an anonymous sage to the adventurous taxonomist..."When you hear hoofbeats, think horses, not zebras" could equally be applied to kangaroos (and rotifers) in the Australian environment....there are cosmopolitan or widely distributed species here, but there are 'others'. If something you find doesn't 'fit' any of the keys, or differs from the figured taxa, it is probably a new record or a new species.

PHYLUM ARTHROPODA: SUBPHYLUM CRUSTACEA: CLASS BRANCHIOPODA: ORDERS ANOMOPODA & CTENOPODA

(CLADOCERA)

This is the general, albeit non-taxonomic, term applied to the small branchiopod crustaceans sometimes referred to as "water fleas". Cladocerans are a significant component of microfaunal food webs, e.g. as grazers of phytoplankton, as dietary items for macroinvertebrates or juvenile fish. They range in size from <250 μm in the chydorid genus *Alonella* to 4-6 mm in the daphniid genera *Daphnia* and *Simocephalus*. All are herbivorous or detritivorous in Australia. A brief review, including a key to Australian cladoceran families, was given by Williams (1980). The first taxonomic revision of the group by Smirnov & Timms (1983) provided keys and distribution information to the then known species. Subsequently, several families have been revised, and new taxa have been identified (see Table 2 and systematic section below). To date, ca. 150 spp. of cladocerans have been recorded from Australia, with most of these littoral or epiphytic/epibenthic in habit, rarely collected in open water. Littoral cladoceran assemblages commonly are dominated by Chydoridae, Macrothricidae, and occasionally Daphniidae and Ilyocryptidae. Planktonic cladocerans are dominated by four families: Bosminidae, Daphniidae, Moinidae, and Sidiidae, although some taxa from other families may be collected seasonally.

NB: Useful references, albeit northern hemisphere in origin, and to be used with caution below family level for taxonomy of Australian cladocerans, include Flößner (1972), Negrea (1983) (Europe), Smirnov (1971, 1976) (Russia) and North American works of Pennak (1989) and Dodson & Frey (1991).

Methods of collection

Similar methods as for collection of rotifers, although nets do not need to be so fine - 90-150 μm is common. A pole net as used by the late D.G. Frey (Indiana University) is a useful alternative to a plankton net - it consists of 3 brass tank aerial sections which can be threaded together to extend to >3m, with a small cone net on the end. It was meant for sampling vegetated habitats, using a stainless steel mesh over the net opening to keep out larger debris, but is just as useful when extended and used from the margin of a hatchery pond. Aluminium tubing can be substituted for the original Frey model's tank aerial! Collections made with the pole-net or plankton net can be examined live, or preserved immediately in the field. Alcohol preservation (75-95%) generally is adequate, although sugar-formalin is often recommended to minimise distortion and loss of eggs from from the brood pouch (add 40 g sucrose l-1 of 37% formalin, diluted to 3-5% final concentration). For long-term preservation add glycerol (ca. 1-2% final concentration) to minimise accidental desiccation.

Morphology: external anatomy and internal organization

For details of cladoceran anatomy, refer to any of the above authors. In summary, all Australian/N.Z. cladocerans found in inland waters are encased in a bivalved 'shell' (carapace) which covers their trunk limbs. Fig. 66 shows a daphniid and a chydorid respectively, with major anatomical features labelled. The following anatomical terms refer to the figures.

Table 2: Updated taxonomic summary of Cladocera in Australian inland waters, including estuarine taxa. Marine Podonidae are not included. (Williams (1980) species numbers in parentheses) (compiled from Shiel & Dickson (in press)).

Family/genus	Number of species
Sidiidae	
Diaphanosoma	5 (2)
Latonopsis	2 (2)
Penilia	1 (-)
Pseudosida	2 (-)
Sarsilatona	1 (-)
Bosminidae	
Bosmina	?1 (2)
Bosminopsis	1 (1)
Chydoridae	
Acroperus	4 (4)
Alona	21 (10)
Alonella	3 (3)
Archepleuroxus	1 (-)
Australochydorus	1 (-)
Biapertura	14 (10)
Camptocercus	1 (1)
Celsinotum	3 (-)
Chydorus	10 (6)
Dadaya	1 (1)
Disparalona	1 (-)
Dunhevedia	1 (1)
Ephemeroporus	1 (-)
Euryalona	1 (1)
Graptoleberis	1 (1)
Kurzia	2 (2)
Leberis	1 (-)
Leydigia	5 (5)
Monope	1 (1)
Monospilus s.l.	2 (-)
Notoalona	1 (-)
Oxyurella	2 (2)
Planicirclus	1 (-)
Plurispina	2 (-)
Pleuroxus	8 (5)
Pseudochydorus	1 (1)
Rak	2 (-)
Rynchochydorus	1 (-)
Saycia	1 (1)
Daphniidae	
Ceriodaphnia	5 (4)
Daphnia	6 (10)
Daphniopsis	3 (1)
Scapholeberis	1 (2)
Simocephalus	5 (2)
Ilyocryptidae	
Ilyocryptus	4 (2)
Macrothricidae	
Grimaldina	1 (-)
Macrothrix	18 (13)
Neothrix	3 (1)
Pseudomoina	1 (1)
Streblocerus	1 (1)
Moinidae	
Moina	5 (5)
Moinadaphnia	1 (1)

Definitions of specialised terms used in following sections

antennae, 1st and 2nd: the 1st antennae or antennules are found at the front of the head, at the base of the rostrum (Fig. 66a). They are tipped with a tuft of sensillae and are sensory. The 2nd antennae are the large swimming appendages on each side of the head by which all cladocerans move. Only in the chydorids can the 2nd antennae be withdrawn into the carapace. The structure of the 2nd antennae is taxonomically significant;

brood pouch: in female cladocerans, eggs are deposited into and develop in the space between the body and the carapace, which is termed the brood pouch or chamber;

carapace: the bivalved body covering behind the head. The carapace may be smooth or ornamented with striae, hexagons, punctations;

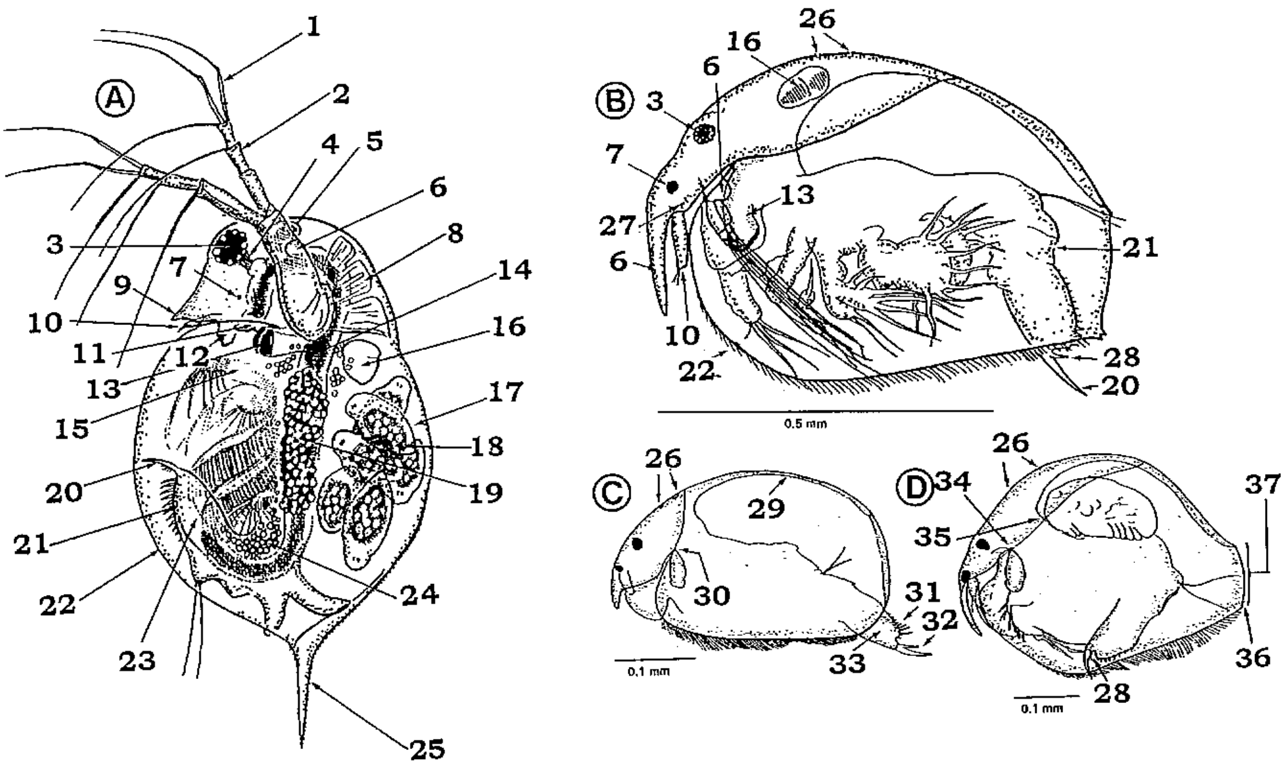


Fig. 66: **A**, anatomy of a daphniid (*Daphnia*); **B**, anatomy of a chydorid (*Pleuroxus*); **C**, points of difference between the chydorid subfamily Aloninae (*Oxyurella*) and **D**, subfamily Chydorinae (*Pleuroxus*). **1**, swimming setae of 2nd antennae (AII); **2**, dorsal (4-segmented) branch of AII; **3**, compound eye; **4**, oculomotor muscle; **5**, hepatic caecum; **6**, AII; **7**, ocellus; **8**, antennal muscles; **9**, rostrum; **10**, 1st antenna (AI) with sensillae; **11**, mouth; **12**, labrum; **13**, mandible (jaw); **14**, midgut; **15**, 1st trunk limb; **16**, heart; **17**, brood chamber; **18**, embryo; **19**, ovary; **20**, postabdominal (PA) claw; **21**, anus; **22**, carapace; **23**, hindgut; **24**, fat globules; **25**, tail spine; **26**, head pores; **27**, flange of rostrum; **28**, basal spine on claw (2 on Chydorinae); **29**, sclerotized ridge; **30**, point of articulation of mandible, junction of headshield and shell; **31**, marginal denticles; **32**, single basal spine on PA claw; **33**, lateral fascicles; **34**, mandible articulation in special pocket (cf. 30); **35**, junction of headshield and shell; **36**, teeth at posterior-ventral angle of shell; **37**, free posterior margin of shell. (B after Smirnov (1971); A, C, D after Dodson & Frey (1991)).

ephippium: a (usually) melanised container formed during sexual reproduction around "resting eggs" in the brood pouch. The ephippium protects one or two early embryos from environmental extremes after the the ephippium is cast off with the carapace during moulting;
exuvium: as cladocerans grow they cast off their old exoskeleton and grow a new, larger one. The cast off transparent shells (exuviae) may persist in sediments and provide a useful measure of morphology, growth, etc.;
headshield: particularly important in identification of chydorids, the headshield covers the head anterior to the carapace. In most chydorid genera the headshield has characteristic median and/or lateral pores which can be seen only withdifficulty when the animal is viewed laterally on the compound microscope. Cast off headshields found with exuviae are more readily observed. SEM preparation enables the best resolution;
postabdominal claw: a double claw at the distal end of the abdomen which is used for cleaning the feeding "chamber" inside the carapace, e.g. removing excessive clumps of algae/detritus which may be collected. Kicking motions of the postabdomen also provide leverage for motion in benthic cladocerans.

rostrum: the acute apex or "beak" at the front of the head (the anterior tip of the headshield in chydorids).
s.l.: *sensu lato*, "in the broad sense", i.e. more than one species is involved (vs *s.str.* - *sensu stricto* - "in the strict sense", the nominate species).

The internal organization of most cladocerans can usually be seen through the carapace under light microscopy, except in those taxa which may be highly coloured, e.g. *Daphniopsis*, and some chydorids. In the living animal, the trunk limbs, which create currents necessary for food capture and respiratory oxygen supply, can be seen beating rapidly inside the carpace valves. There are 5-6 pairs of trunk limbs, depending on family. The postabdomen can be seen 'flicking' material from between the limbs occasionally - the postabdominal claw ejects congested algae or debris from the feeding chamber, cleaning the setae of the trunk limbs in the process. Behind the rostrum are the mandibles and mouth, followed by the foregut, midgut and hindgut, leading to the anus opening on the end of the postabdomen. The gut will be visible if the animal has been feeding. Gut contents can be identified by dissecting out the gut with fine tungsten needles. The contents can be expressed by light pressure on a coverslip.

Sensory organs visible at the head end are the compound eye, ocellus, and antennules or first antennae (AI). The AI have a clump of sensillae at their tips. The obvious AII are used for swimming (or crawling in the epiphytic/epibenthic taxa). Other features shown in Fig. 66 will be discussed further in the systematic section.

Identification

Depending on taxon and size, individuals for identification may be picked out of the bulk sample with a tungsten wire loop, pipette or (carefully) with fine forceps. The specimen is then placed in a drop of 10% glycerol/H_2O on a slide. Required records should be made before addition of a coverslip, i.e. uncompressed. A microcompressor (Fig. 3) also may be used to impede living specimens. Measurements, drawings, photographs generally should be made on a compound microscope. Larger species (>1 mm) may be identifiable without mounting or use of a compound microscope, but smaller taxa require higher magnification. If dissection is necessary, e.g. removing post-abdomen from within the carapace for examination of fine detail, fine needles mounted in pin vises can be used on the dissecting microscope stage. Most of the taxonomically significant features of planktonic taxa are outside the carapace, and do not require dissection, whereas those of chydorids are mostly within the carapace. Disarticulation of chydorids is necessary if unimpeded view of headshield, postabdomen, etc. is required. Steady hands, with practice, can dissect chydorids or exuviae with fine needles. If exuviae are not available. sodium hypochlorite (NaOCl) can be used to clear the cytoplasmic contents from the exoskeleton and enable headshield-carapace junctions to be seen. Lactic acid achieves the same clearing over a longer period, e.g. overnight. Chemical disarticulation as described by Megard (1964) can be used for chydorids. In this method, whole chydorids are placed in a pyrex well-block or deep well slide, 1 ml of conc. HCl added, and the block/slide heated on a hotplate until the acid fumes. It may take less than 5 min for hydrolysis to separate the headshield and other chitinous structures from the shell, however progress should be monitored on a binocular microscope once the acid cools. The various parts can then be washed, teased apart if necessary, and mounted in glycerol/H_2O for examination.

Permanent mounts
Equilibration to glycerol through serial dilutions and mounting in glycerine-gelatine (as for rotifers) or polyvinyl lactophenol (PVL) with a few grains of lignin pink or chlorazol black (which stain exoskeletal material) are useful mountants. Some care in mounting in PVL is required - leaving the fresh mounts stand for several days or drying more rapidly on a warm heating element, then 'topping up' the mountant. This is allowed to dry before sealing the coverslip edge with lacquer (nail varninsh). PVL-mounted specimens not so treated form bubbles under the coverslip as the mountant desiccates, possibly rendering the preparation useless if bubbles form around the specimen. Canada Balsam is regarded as the best mountant for museum specimens (Dodson & Frey 1991), although dehydration through an alcohol series is required.

Systematics

A key to the six families of Cladocera then known from Australia was provided by Williams (1980): Bosminidae, Chydoridae, Daphniidae, Macrothricidae, Moinidae and Sididae. The key to families in Smirnov & Timms (1983), included the marine/estuarine family, Podonidae. Three northern hemisphere families (Holopedidae, Leptodoridae and Polyphemidae), which include predaceous cladocerans, have not been recorded in Australia (for their details see Dodson & Frey 1991). 125 species in 40 genera were listed in Smirnov & Timms (1983). Subsequent workers refined discrimination and added a family, several new genera and 22 new species, e.g. Benzie (1988) on *Daphnia*, Frey (1991a, b) on several genera of Chydoridae, Korovchinsky (1992) on Sidiidae, and Smirnov (1989a, b, 1992 on Chydoridae, Macrothricidae, Moinidae and erection of Ilyocryptidae). Some taxa have been synonymized, however the cumulative total of *described* freshwater cladocerans for Australia stands at 166 species in 53 genera (Shiel & Dickson 1995). New or redescriptions in preparation (Frey & Shiel, unpubl.) will bring the total to ca. 160 spp. Undoubtedly, more will be added as the microfauna of the continent's freshwaters is surveyed (Frey 1991b).

Keys to families

The key to cladoceran families in Smirnov & Timms (1983:4) enables family placement for all except the Ilyocryptidae, which was separated from the Macrothricidae by Smirnov (1992). The dichotomous key below enables placement of cladocerans to family. Fig. 67 gives a 'flow-diagram' treatment to the same end, discriminating between the various families using readily observable morphological features. Intrafamilial keys vary - the following comments lead to the most likely taxonomic reference or authority for generic and specific diagnoses:

Key to the families of cladocerans known from Australian inland waters

1. Viewed laterally, small hemispherical animals (usually <0.5 mm) (Fig. 67:1, 2), may have long fused antennae resembling elephant tusks (Fig. Fig. 67:1)..**2**
\- Not as above..**3**

2(1). First antennae long, curving, fused to head (Fig. 67:1)...**Bosminidae** (p. 120)
\- First antennae partly or completetly hidden by rostrum (Fig. 67:2)..**Chydoridae** (p. 120)

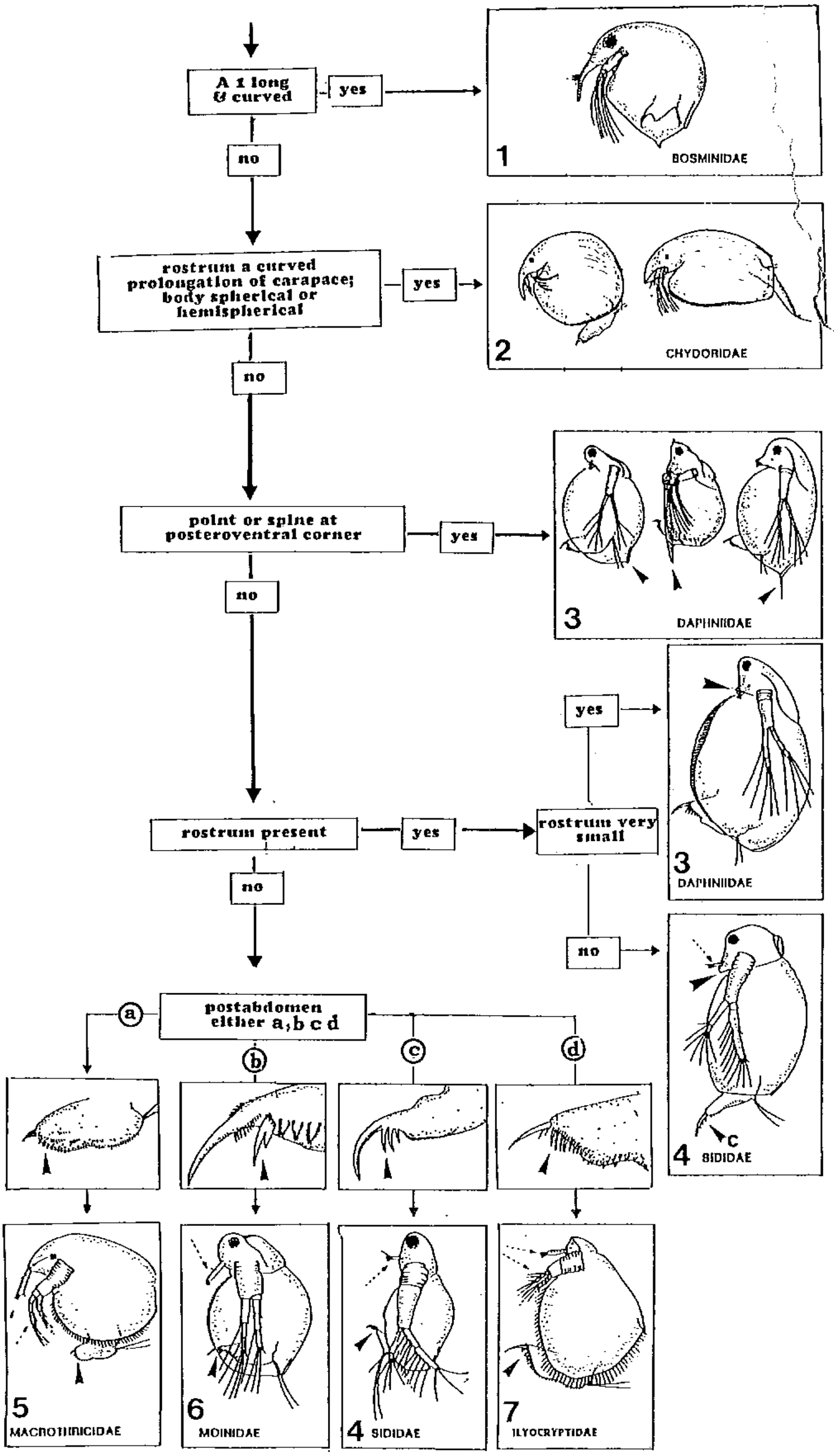


Fig. 67: Key to families of cladocerans known from Australian inland waters: start at the top, follow the arrows. Numbers in each box refer to dichotomous key opposite. (Modified from Amoros (1984)).

3(2) Acute angle or spine at the posteroventral corner of carapace.(Fig. 67:3)..**Daphniidae** (p. 124)
\- Posteroventral corner rounded..**4**

4(3) Distinct rostrum present..**5**
\- No obvious rostrum..**6**

5(4) Rostrum very small..**Daphniidae**
Rostrum pronounced..**Sididae** (p. 128)

6(5) Postabdomen without basal spine(s) just behind claw (Fig. 67:5)..**Macrothricidae** (p. 126)
Postabdomen with bifurcate tooth or pronounced spines................................**7**

7(6) Bifurcate tooth behind claw (Fig. 67:6)................................**Moinidae** (p. 127)
Postabdomen as Figs 67:4 or 67:7..**8**

8(7) Morphology of animal and postabdomen as Figs 67:4........................**Sididae**
Morphology and postabdomen as Fig. 67:7................**Ilyocryptidae** (p. 126)

Bosminidae Baird, 1845

Only two genera are recognised in the family, *Bosmina* and *Bosminopsis*. Only one species from each genus is known from Australia, although it is likely that more occur here. No key is necessary - the two taxa are figured. They are easily separated - *Bosminopsis dietersi* (Fig 68:2) has a Y-shaped first antenna, in *Bosmina meridionalis* the 1st antennae are separate and parallel (Fig. 68:1). *B. dietersi* reportedly is tropical in distribution, although it has been recorded as far south as Sydney. *B. meridonalis* is the common species in S.E. Australia.

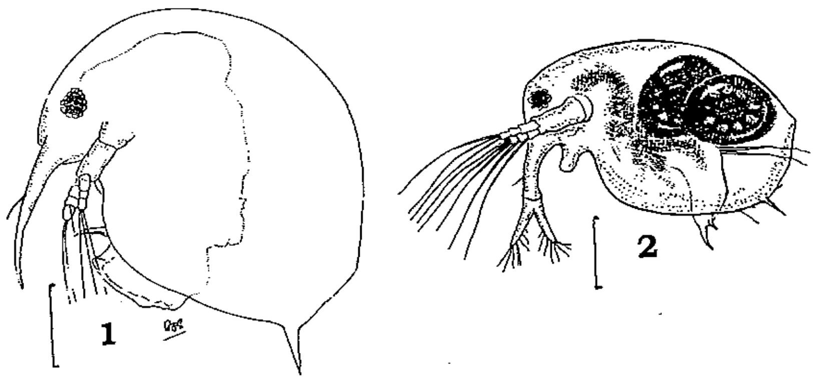


Fig. 68: 1, *Bosmina meridionalis* Sars, 2, *Bosminopsis dietersi* Richard. (1, orig., 2, after Dodson & Frey, (1991)). Scale lines: 100 µm.

Chydoridae Stebbing, 1902

This family of small cladocerans occurs predominantly in the littoral of vegetated ponds, however adaptive radiation appears to have occurred in Australia, and there are species which occur frequently in the limnoplankton of lakes and billabongs, and in non-vegetated or saline habitats. Many species have "cosmopolitan" names, e.g. *Chydorus sphaericus*, although work by Frey (1991a, b) suggests that "cosmopolitan" taxa are in reality more restricted.

In addition to the chydorids described and listed in Smirnov & Timms (1983), new taxa were described by Frey (1991a, b), Rajapaksa & Fernando (1987), and Smirnov (1989a, b). With 82 identified species in 28 genera, the chydorids are

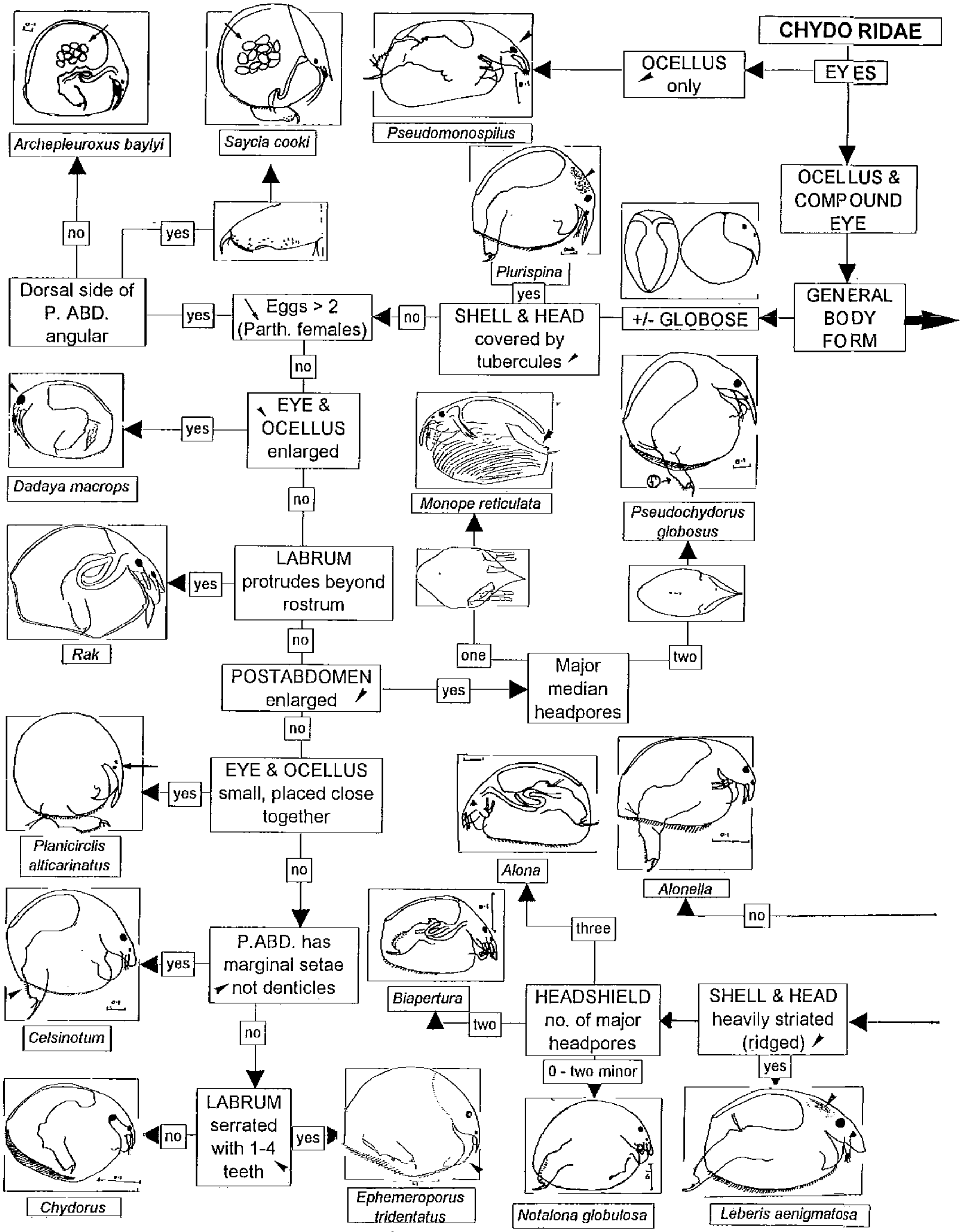
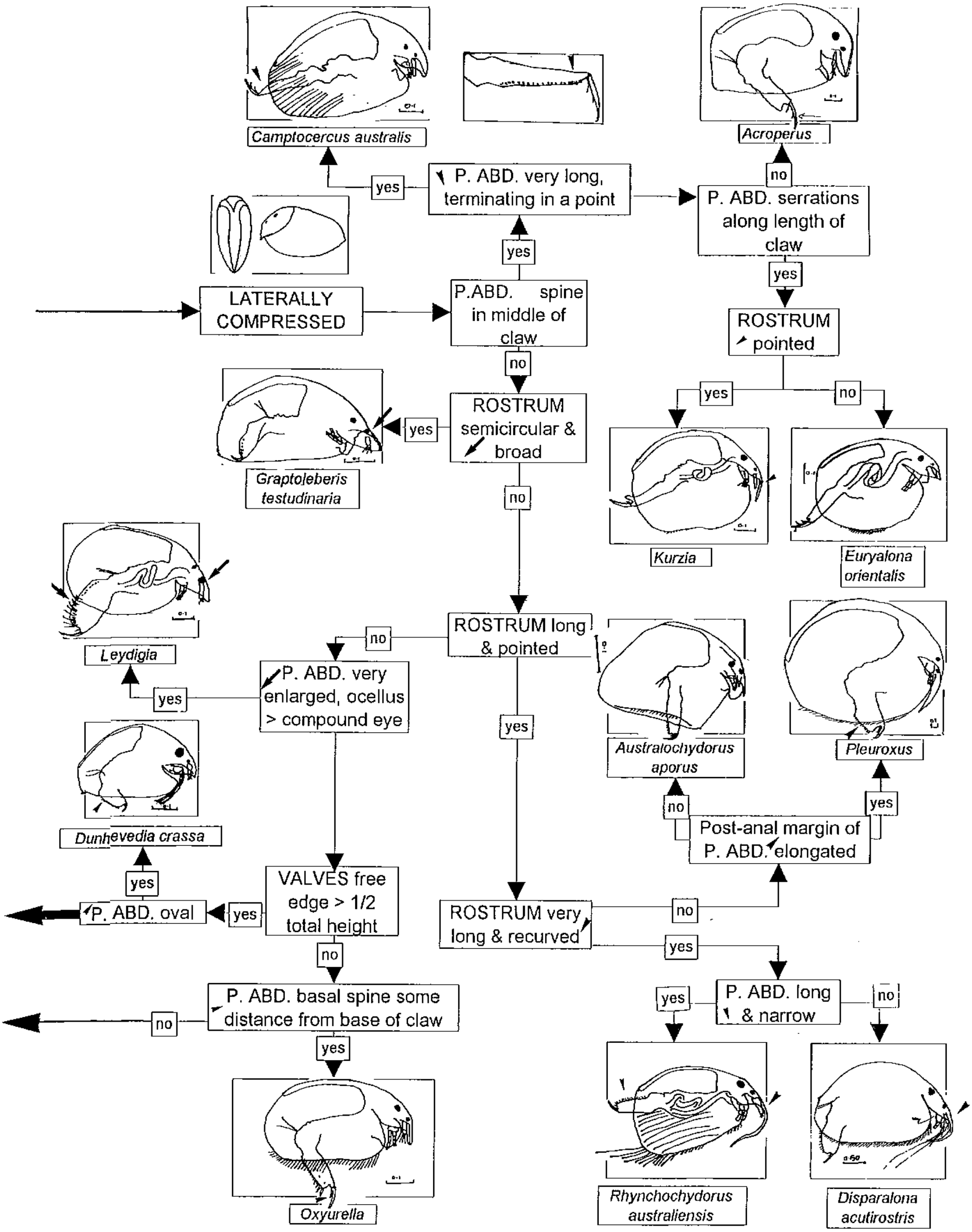


Fig. 69: Preliminary key to genera of Chydoridae known from Australian inland waters. Characters used are visible using light microscopy, however head pore detail may require disarticulation of headshield and shell (p. 117). (Figure by J. Dickson, MDFRC, from published figures, various authors.)



Camptocercus australis
Acroperus
P. ABD. very long, terminating in a point
yes
no
P. ABD. serrations along length of claw
yes
P.ABD. spine in middle of claw
LATERALLY COMPRESSED
ROSTRUM pointed
yes
no
ROSTRUM semicircular & broad
yes
Graptoleberis testudinaria
Kurzia
Euryalona orientalis
Leydigia
ROSTRUM long & pointed
no
P. ABD. very enlarged, ocellus > compound eye
yes
Australochydorus aporus
Pleuroxus
Dunhevedia crassa
Post-anal margin of P. ABD. elongated
P. ABD. oval
VALVES free edge > 1/2 total height
ROSTRUM very long & recurved
P. ABD. basal spine some distance from base of claw
P. ABD. long & narrow
Oxyurella
Rhynchochydorus australiensis
Disparalona acutirostris

the most diverse cladoceran family in Australia, and the most in need of revision. Evidence from Frey's published papers (1991a, b), and also his incomple work on Gondwanan radiation of the Chydoridae, suggests that many chydorids remain to be described from Australia. At least some of those named from the continent were misidentified by earlier workers, possibly as a response to the then prevailing view of cosmopolitanism in the group.

In order to resolve the taxonomic confusion in the Australasian Chydoridae it will be necessary to reach an equivalent standard of description, using SEM and detailed morphological analysis, to that of Frey (1991b) for the genera *Archepleuroxus, Planicirclus, Pleuroxus* and *Plurispina.* Until the family can be revised, accept as valid any taxon in Smirnov & Timms (or later publication) which was described from Australia or New Zealand. If it was described from somewhere else, particularly the northern hemisphere, treat the record with caution.

The key to chydorid genera in Smirnov & Timms (1983) can be used for the then known taxa - anything which cannot be placed in a genus using their key should be checked against the later described species, or referred for specialist attention. Until the generic key can be revised, and for the purposes of this workshop, Jackie Dickson (MDFRC) and I searched the literature for all recorded chydorid taxa from Australia, and Jackie compiled a draft identification guide (Fig. 69). We stress that this is a working draft, yet to be finalized, but it should allow recognition of the known chydorid genera. We welcome comments or suggestions on the success (or otherwise!) of using the key.

Species keys within each genus are on our 'want list', but will take time to produce in view of the need to characterize the named taxa to the 'Frey standard'. For example, the following draft key to the difficult genus *Chydorus* was compiled by Jackie from the published literature. D.G. Frey was of the opinion *that Chydorus sphaericus* s.str. probably did not occur in Australia - yet another chore of resolution which awaits us.....

Key to species Chydorus known from Australian inland waters

Source: Hann (1975) & Smirnov & Timms (1983) & Frey (1987).

1. Valves with deep polygonal cells..**2**
- Valves without deep polygonal cells...**3**

2(1). Free edge of rostrum bordered by meshed with high walls, which overlap and obscure marginal strip. Apex of rostrum conspicuously bifid, with tips blunt and dark; meshes relatively few in number (about 120 per half shell), large and with high walls..*C. obscurirostris* Frey, 1987
- Free edge of rostrum bordered by meshes with low walls, even no walls at all, leaving marginal strip not overhung, and freely visible from any direction. 24-27 setae in duplicature, all attached to prominent solid line; postabdominal claw with roughly seven short setules proximally and about 14 longer setules distally; surface pattern within meshes consisting of several overlapping layers of fine, curved, anastomising striae, making head and shell opaque...*C. opacus* Frey, 1987

3(1). Surface of valves pubescent (covered with soft hair or down)..*C. pubescens* Sars, 1901
- Surface of valves smooth...**4**

4(3). Inner surface of anterior margin of valves with chitinous knobs..*C. parvus* Daday, 1898
- Inner surface of anterior margin of valves without chitinous knobs.................**5**

5(4). Labrum rounded at apex..**6**
- Labrum pointed (acute) at apex..**7**

6(5). Shell lacking reticulation...*C. eurynotus* Sars, 1901
- Shell with wavy-margined polygonal reticulation.......*C. kallipygos* Brehm, 1934

7(5). Apex of labrum not elongated, but with an angular point. The post-anal edge of the postabdomen is somewhat convex and possesses rather thin anal teeth...*C. clelandi* Henry, 1919
- Apex of labrum elongated **8**

8(7). Headshield with v-shaped notch at apex of rostrum...*C. sphaericus* (Müller, 1785)
- Headshield lacking v-shaped notch.........................*C. herrmanni* Brehm, 1933

Daphniidae Straus, 1820

Widespread in the plankton and littoral of ponds, lakes and reservoirs, daphniids include the most familiar of the "water fleas" - species of the genus *Daphnia*, which are often the largest microcrustaceans in the plankton. Daphniids are significant grazers of bacteria (the smaller species) and phytoplankton, and provide important food items for both juvenile and adult fish. The most recent or most acceptable taxonomic references for the respective genera are: *Ceriodaphnia* - Smirnov & Timms (1983:106) [genus requires revision - at least some of the *Ceriodaphnia* species named from Australia probably are not the nominate taxa]; *Daphnia* - Benzie (1988); *Daphniopsis* - Smirnov & Timms (1983), Sergeev & Williams (1983, 1985), Sergeev (1990) [more species are likely to occur here, cf. Kokkin & Williams (1987); *Scapholeberis* - Dumont in Smirnov & Timms (1983); *Simocephalus* - Dumont in Smirnov & Timms (1983).

Key to genera Daphniidae known from Australian inland waters

1. Ventral margin of carapace rounded, not melanized....................................**2**
Ventral margin straight, heavily melanized................*Scapholeberis* Schoedler

2(1). Front of head rounded, lacks obvious rostrum.................*Ceriodaphnia* Dana
[*Ceriodaphnia cornuta s.l.*is the only exception - this small(<0.5 mm) species (or species complex in Australia) has an acute 'beak')
- Rostrum, small or large, ± acute, present, adults > 1 mm............................**3**

3(3). Head large, rostrum large, anal margin of postabdomen straight...**4**
- Head small (in proportion to body), rostrum small, anal margin of postabdomen embayed..........................*Simocephalus* Schoedler

4(3). Dorsal keel on shell..*Daphnia* Müller
- Dorsal keel present; postabdomen tapers; may be heavily melanized...*Daphniopsis* Sars

Scapholeberis Schoedler

Only one species known, *S. kingi* Sars, 1903 (Fig. 70:1). This rare littoral cladoceran may be collected hanging upside down from the surface film in billabongs and other vegetated wetlands. It is not readily confused with anything else, although less melanized individuals superficially resemble small *Ceriodaphnia*.

Ceriodaphnia *Dana*

Ceriodaphnia species are common in a wide range of inland waters. Species determination is based on head and postabdomen morphology, however the genus represents another example of widespread proliferation of northern hemisphere names. It is not yet clear if the species recorded from Australia are indeed the nominate species, and a thorough revision is required. The existing key in Smirnov & Timms (1983) should be used until a comprehensive revision of the genus. *C. pulchella* Sars has subsequently been recorded from Goulburn R. billabongs and is included in the key. Fig. 70 shows details of some of the taxa named from the continent.

Key to species of Ceriodaphnia known from Australian inland waters
(Modified after Smirnov & Timms (1983))

1. Small species as adult, (<0.5 mm); head with an acute rostrum.......................*C. cornuta* Sars
- Larger as adult (>0.5 mm), head without acute rostrum.......................**2**

2(1). Head with frontal denticles (Fig. 70:3b, 70:4).......................**3**
- No frontal denticles.......................**4**

3(2). Head and postabdomen as Fig. 70:3.......................*C. pulchella* Sars
- Head and postabdomen as Fig. 70:4.......................*C. rotunda* Sars

4(2). Postabdomen clearly dilated medially (Fig. 70:4c).........*C. laticaudata* Mueller
- Not as above.......................**5**

5(4). Fine setules along concave side of PA claw (Fig. 70:6).......................*C. quadrangula* (Müller) s.l.
- Small denticles on proximal half of PA claw, but no setule row (Fig. 70:7).......................*C. dubia* Richard

Niche: Planktonic bacteriovores/herivores.

Daphnia Müller

Often the largest cladoceran in plankton assemblages, six species are recognized by Benzie (1986). The most common of these are *D. carinata* (Fig. 71:1), *D. cephalata* (Fig. 71:2) and *D. lumholtzi* (Fig. 71:3), each recognizable by its characteristic morphology. For full species descriptions and keys, refer to Benzie (1988).

Daphniopsis Sars (1903)

Three species of *Daphniopsis* are recognized from saline waters in Australia, and more are likely (Kokkin & Williams 1987). To discriminate the species refer to the papers cited in the first paragraph of the Daphniidae section.

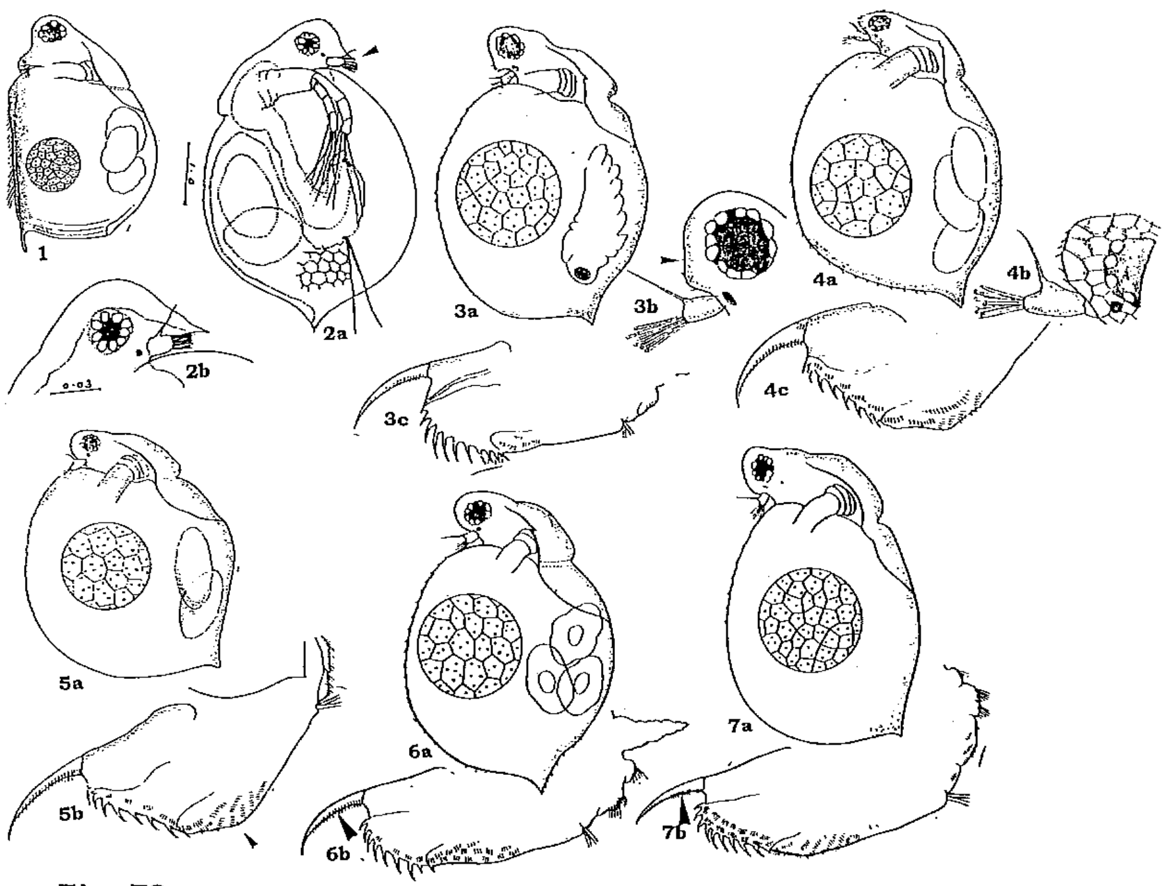


Fig. 70: 1, *Scapholeberis kingi* Sars; 2, *Ceriodaphnia cornuta* Sars: a, lateral; b, rostrum detail; 3, *C. pulchella* Sars: a lateral; b, head detail; c, postabdominal claw; 4, *C. rotunda* Sars; 5, *C. laticaudata* Mueller; 6, *C. quadrangula* (Müller) s.l.; 7, *C. dubia* Richard. (After Negrea (1983)).

Simocephalus Schoedler

Five species are known from Australian inland waters, where they are generally littoral in habit. They may be identified readily using the key by Dumont in Smirnov & Timms (1983).

Ilyocryptidae Smirnov, 1992

The family was erected by Smirnov (1992) to accommodate *Ilyocryptus* and remove the genus from the Macrothricidae. *Ilyocryptus* species (Fig. 71:4) are distinctive and unlikely to be confused with any other benthic cladocerans. Three species are listed by Smirnov & Timms (1983), however the Australian species of *Ilyocryptus* require revision - it is likely that at least some of the species are incorrectly named, and that there are more taxa here (P. Stifter, pers. comm.). *Ilyocryptus* species are very distinctive benthic dwellers which may occasionally be found in plankton tows.

Macrothricidae Norman & Brady, 1867

The most recent revision, a global guide by Smirnov (1992) includes a number of new species for Australia and synonymizes *Echinisca* Liévin with *Macrothrix* Baird. While some of the descriptions will need to be expanded for satisfactory discrimination at a later date, this is the most comprehensive work to date. Some 24 taxa of Macrothricidae are known from Australian inland waters (Table 2), generally littoral epiphytic or epibenthic in habit, and unlikely to be recorded in plankton collections. Of the four genera, *Macrothrix, Neothrix, Pseudomoina* and *Streblocerus*, only one or two species may be seen as incursions in billabongs.

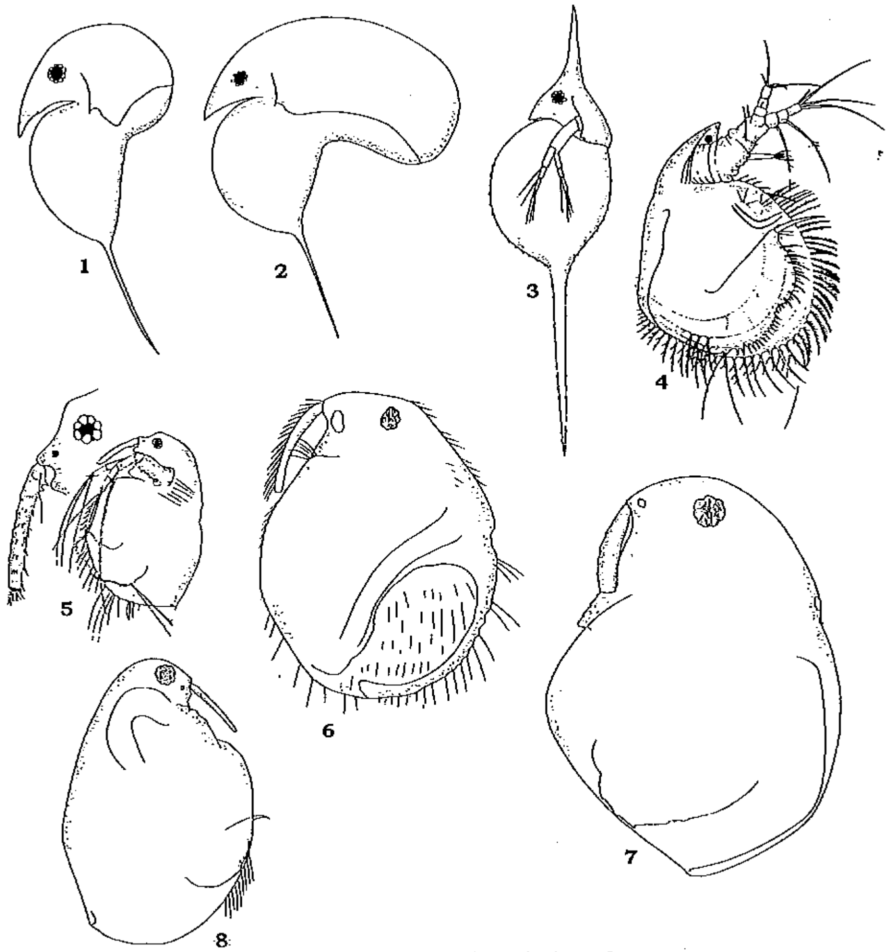


Fig: 71: 1, *Daphnia carinata* King; 2, *D. cephalata* King; 3, *D. lumholtzi* Sars (Daphniidae); 4, *Ilyocryptus* (Ilyocryptidae); 5, *Macrothrix*; 6, *Neothrix*; 7, *Streblocerus*; 8, *Pseudomoina* (Macrothricidae). (1-3 after Benzie (1988); 4 after Dodson & Frey (1991); 5-8 after Smirnov (1992)).

Key to genera of Macrothricidae known from Australina inland waters

1 Valves 'hairy' , with long bristles, no claw on postabdomen............*Neothrix* (Fig. 71:6)
Valves smooth or with sparse/short bristles............2

2(1) Intestine convoluted............*Streblocerus* (Fig. 71:7)
Intestine not convoluted............3

3(2) Postabdomen tapers, claw without basal spine.........*Pseudomoina* (Fig. 71: 8)
(Only one species, *P. lemnae*, is described)
PA not tapered, claw with basal spine............*Macrothrix* (Fig. 71:5)

Moinidae Goulden, 1968

Two genera are known: *Moinodaphnia* and *Moina*, with one and five species respectively. An additional *Moina* species to those listed in Smirnov & Timms (1983) was described by Forro (1985). A thorough revision of the family to modern standards is required to clarify the species assemblage occurring in Australia. Moinids are common seasonally in pond plankton*Moinodaphnia macleayi* is more northern in distribution. Two species of *Moina*, *M. micrura* and *M. tenuicornis* are readily recognised in southeastern Australian plankton (see Smirnov & Timms (1983) for figures)..

Key to genera and common species of Moinidae form Australian inland waters

1 Compound eye and ocellus............*Moinodaphnia*
(Only one species known, *M. macleayi*)
Compound eye only, no ocellus............*Moina*...**2**

2(1). Antennule long and thin, length 10-12X width..................*M. tenuicornis* Sars
Antennule short and broad, length <10X width......................*M. micrura* Kurz

Sididae Baird, 1860

Sidids are diaphanous cladocerans generally recognized by their large head, feathery antennae, and setae along all or part of the valve margin. In freshwaters, *Latonopsis* and *Pseudosida* are likely to be littoral in habit. Only *Diaphanosoma* is common in the plankton. The most recent revision is a global guide by Korovchinsky (1992), whose figures and descriptions enable species discrimination of all known Australian sidids.

Zoogeography of cladocerans

On present evidence, Australia has more cladoceran species and a higher degree of endemism in its cladoceran fauna than that of comparable areas (166 spp, vs 120 for Europe and 140 for U.S.A., 43 % endemicity overall (Shiel & Dickson (1995)). Endemic genera now include *Archepleuroxus, Australochydorus, Monope, Neothrix* and *Pseudomoina*. It is the Chydoridae which appear to have radiated most, with nearly 50% endemicity, and this is likely to increase with improved taxonomic resolution of extant 'cosmopolitan' species and more intensive collecting. Succinct comments on the east-west zoogeography of Australian chydorids were given by Frey (1991b).

PHYLUM ARTHROPODA: SUBPHYLUM CRUSTACEA: CLASS MAXILLIOIDA: SUBCLASS COPEPODA: ORDERS CALANOIDA, CYCLOPOIDA, HARPACTICOIDA
(COPEPODS)

The subclass Copepoda is the largest class of the Crustacea, and is predominantly marine in affinity, with a large group of species parasitic on fishes. In fresh waters, two orders, Caligoida and Lernaeopodida are primarily parasitic. There are three free-living orders, all which have freshwater representatives: Calanoida (Fig. 72:1), Cyclopoida (Fig. 72:2) and Harpacticoida (Fig. 72:3). In large lakes and reservoirs of SE Australia, the Calanoida are numerically important, with the Cyclopoida infrequent or seasonal. Both are common in small ponds, although different species to those occurring in reservoirs usually are found. Harpacticoids are benthic in habit, and rarely collected in open water. Copepods are important in aquatic food webs - juvenile stages (naupli or copepodites) in particular may be a major food supply for young fish. Calanoids are best-known taxonomically (Bayly 1991). Cyclopoids and harpacticoids are in the early stages of revision (Morton 1985, 1990; Hamond 1987). The general review of copepods in Williams (1980) is still relevant. For a recent review of collecting, rearing, and identification techniques applicable to Australian copepods, see the revision of Northern Hemisphere freshwater Copepoda by Williamson (1991).

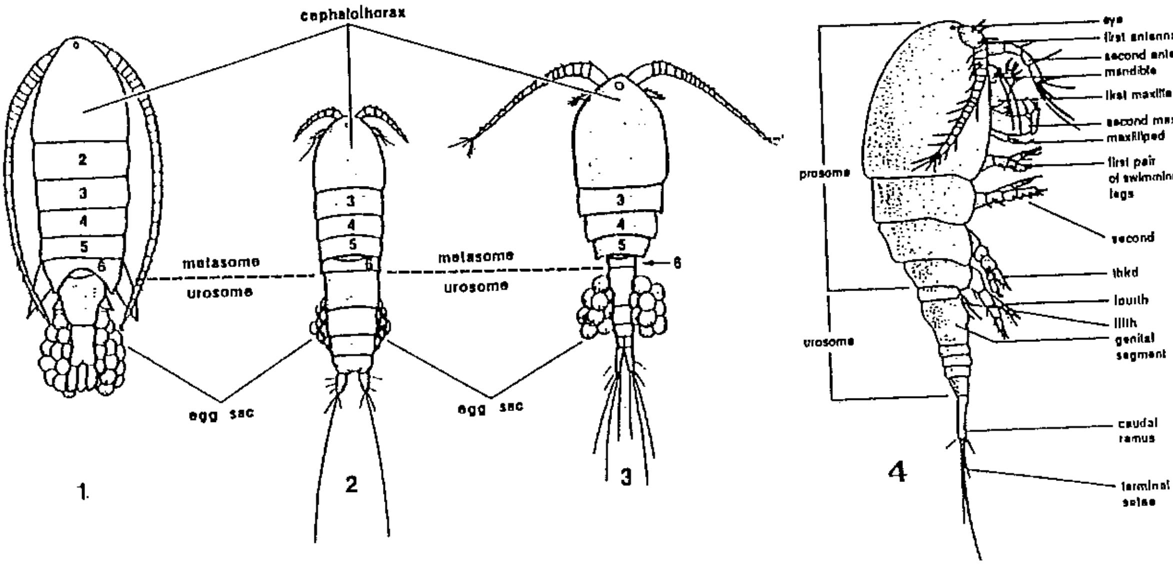


Fig. 72: General morphology of copepods: 1, Calanoida, 2, Harpacticoida, 3, Cyclopoida; 4, structures of a cyclopoid. (1-3 after Williams (1980); 4 after Williamson (1991)).

Definitions of specialised terms used in following sections

Refer to Fig. 72, which shows general morphology of a calanoid, cyclopoid and harpacticoid copepod respectively, with structural details shown in Fig. 72:4.

A1: 1st antennae
A2: 2nd antennae
cephalothorax: fused head and first thoracic segment
caudal ramus: bifurcate termination of abdomen
exopodite/endopodite: outer and inner branches respectively of a typically biramous crustacean limb
P1-5: 1st to 5th pair of swimming legs

ramus/rami: (sing./pl.) crustaceans typically have paired limbs. Each branch is a ramus

urosome: posterior end of copepod

Key to orders of copepods from Australian inland waters

1. A1 very short (<10 segments), do not reach past end of cephalothorax; body cyclindrical (Fig. 72:2)..**Harpacticoida**
- A1 up to 18 segments, may reach past the posterior end of the cephalothorax; body widest behind the head, tapers to urosome (Fig. 72:3, 4)..**Cyclopoida**
- A1 long, >20 segments, extend to urosome or past end; body torpedo-like (Fig. 72:1)..**Calanoida**

ORDER CALANOIDA

Two families of Calanoida, Centropagidae and Diaptomidae, are known from inland waters. The Diaptomidae (2 spp. of *Diaptomus*) are confined to northern Australia (Bayly, 1966). Most common calanoids in S.E. Australia are from one or two genera of centropagids, *Boeckella* and *Calamoecia*. *Hemiboeckella* tends to be associated with shallow vegetated waters. Taxonomic features of all species in the family were reviewed by Bayly (1992).

PRACTICAL ASPECTS OF PREPARING CALANOIDA (CRUSTACEA:COPEPODA) FOR IDENTIFICATION

[Prepared especially for the Seventh Taxonomic Workshop, Albury,
8-10 February 1995
by Ian A.E. Bayly]

Ecology: Calanoid copepods are commonly dominant components of the zooplankton in the limnetic region of standing bodies of inland water, both fresh and saline. There is good evidence that Australian calanoids of the genera *Boeckella* and *Calamoecia* consume a wide variety of phytoplankton species (see e.g. several recent papers by T. Kobayashi). In the past it has been usual to regard these calanoids as being purely herbivorous or detritivorous. However, it is now clear (Green and Shiel (1992) and J.D. Green, unpublished) that some of our larger calanoids, such as *Boeckella major*, are partly carnivorous, and capable of feeding on copepod nauplii, rotifers and small cladocerans. It is likely to prove the case that most of the Australian calanoids are omnivorous rather than purely herbivorous.

Life cycle: Calanoid eggs hatch into a nauplius larva (nauplius stage I) - a small unsegmented, ovoid organism with only three pairs of appendages : antennules (first antennae), antennae (second antennae) and mandibles. A calanoid and cyclopoid nauplius are shown in Fig. 73. Development proceeds through a total of six naupliar instars (nauplius stages I-VI). The last nauplius stage develops into the first copepodid stage which basically exhibits the adult features, except for the small size and the lack of a full complement of biramous swimming legs (ultimately there are five of these) posterior to the last of the mouth-parts (the maxillipeds). Development then proceeds through five copepodid stages before the adult (or sixth copepodid) stage is reached. The sexes are always separate, and most of the sexual dimorphism is achieved during the final moult from copepodid stage V to copepodid stage VI.

Taxonomy: A typical collection of zooplankton from inland waters made with a fine net (mesh size 100 μm or less) is likely to contain up to eleven (stages NI-VI plus CI-V) immature stages of the same species of calanoid copepod. Generally speaking, all of these immature stages are useless from the taxonomic viewpoint; with ourpresent knowledge it is difficult, if not impossible, to make a species-level identification on the basis of an immature calanoid. It follows that the first task for a would-be identifier of calanoids is to be able to recognize with confidence mature male and female calanoids.

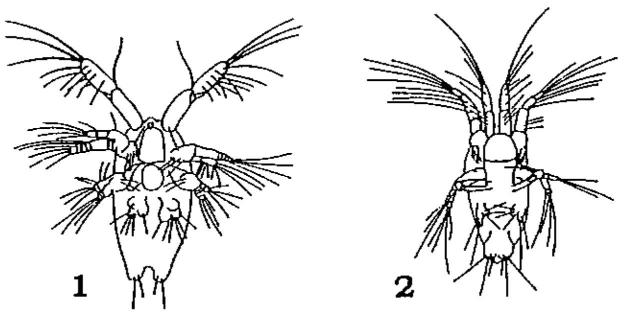


Fig. 73: Copepod nauplii: 1. a calanoid nauplius; 2, cyclopoid nauplius. Note difference in body shape and setation at the posterior end. (After Green 1969).

Examine a collection of zooplankton containing calanoids under a stereo-microscope using a magnification in the range 10-20 X. Bearing in mind that the bulk of the material consists of immature stages, concentrate on the larger specimens. Specimens carrying egg sacs stand out and must be adult females. However, adult females lacking an egg sac are nearly always present as well. With practice these can be recognized by looking at specimens the same size as egg-bearing females, and which have symmetrical antennules (the longest of all the appendages attached near the anterior extremity to the body). Typically these non-egg-bearing adult females can be recognized by having a lobe or outgrowth developed on the last segment of the prosome (i.e. on the posterior extremity of the wide part of the body). Mastering the recognition of adult females is worthwhile but, unfortunately, with existing keys females are much less valuable than males for species- level determination. However, the shape of the genital segment of the female (the first segment of the urosome or narrow part of the body) may assist in identification, especially if only a few specimens are available and mature males are entirely lacking.

Recognition of adult males is practically essential. Look for specimens that are slightly smaller than the adult females that you have already recognized. Further, look for individuals that have asymmetrical antennules; the right antennule of adult males of all calanoids occurring in Australian inland waters is geniculate - it has a knee-like hinge about one-quarter of the total length from the distal extremity of the antennule. Sometimes the antennule is turned back on itself at this hinge-point, in which case the geniculate state is obvious. However, often the distal extremity of the antennule lies in the same straight line as the more proximal region. In this case the geniculate state can still be determined by carefully observing the thickening in the immediate vicinity of the hinged joint.

Take two or three adult male calanoids and place in a medium-sized drop of polyvinyl lactophenol (P.V.A.) mountant on a microslide. Observe these specimens under a stereo-microscope using a magnification of about 25X. Using a pair of finely sharpened tungsten needles mounted on needle-holders, dissect off the fifth pair of swimming legs (the last pair of appendages attached ventrally to the last segment of the prosome or wide portion of the body). For a right-handed person it is usually convenient to orientate the specimen ventral surface uppermost and with the head facing you, and to spear the central portion of the prosome with the left needle and anchor the specimen with this needle. The fifth legs are then dissected off with a shearing, left-to-right movement of the right needle. When dissecting off this last pair of legs try to keep them as a pair. When the fifth (last) legs have been dissected off all specimens, remove all body parts other than the fifth legs to the edge of the drop of mountant and centre the fifth legs within the drop of mountant (use ca 10X magnification for this operation). The preparation should now be covered with a coverslip while continuing to observe with the stereo-microscope at ca 10X. It is best to use a square coverslip (ca 20 mm). With the left hand, place the left edge (for right- handed person) of the coverslip on the slide close to the drop of mountant while the right edge is held up by the right needle placed beneath the coverslip. The right needle should then be slowly withdrawn to the right. As the mountant flows under the coverslip, centring of the fifth legs can be maintained by continuing observation under the stereo- microscope and pressing down on the appropriate edge of the coverslip. The preparation should now be left to stand for at least ten minutes.

Species-level identification should now be made by studying the structure of the male fifth legs under a compound microscope (magnifications of up to about 400X may be necessary) and using the keys found in Bayly (1964) [for *Boeckella*] or Bayly (1992) [for *Boeckella*, *Hemiboeckella* and *Calamoecia*] Representative P5's of these three genera are shown in Fig. 74. Generic level identification may be achieved using the key provided in Williams (1980).

Fine tungsten points are best made by the electrolytic sharpening method described by Brady (see reference in Green and Shiel (1992)).

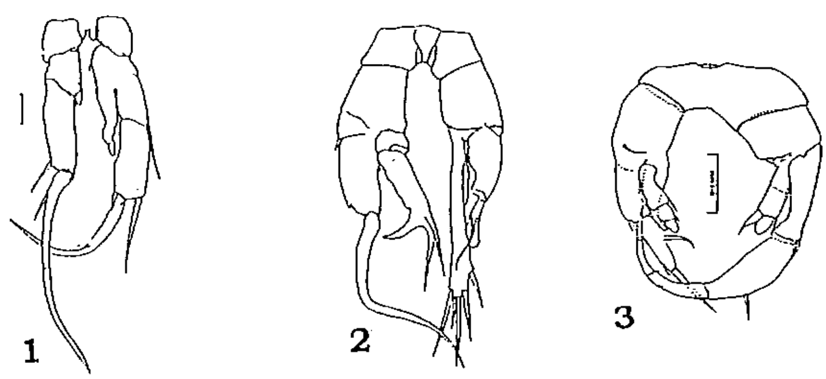


Fig. 74: Male P5's of 1. *Boeckella*; 2, *Calamoecia*; 3, *Hemiboeckella*

Order Cyclopoida

Cyclopoids have been less intensively studied in Australia than have calanoids. As for other microfauna, they have suffered the indignity of being lumped with northern hemisphere identities, when many taxa are good endemic species. The generic key in Williams (1980) is useful for the then known genera. Two revision papers have been published (Morton 1985, 1990) on the genera *Acanthocyclops*, *Diacyclops*, *Australocyclops*, *Eucyclops* and *Ectocyclops*. Cyclopoid generic identification requires dissection of the adult female P5, and species identification may require P4, P1, A1 and/or A2. Females are recognized by egg sacs or by both antennae straight, whereas male cyclopids have both A1 geniculate.

Cyclopoids, particularly the smaller genera are a little more difficult to dissect for identification than are calanoids. A line, rather than a drop of glycerol or PVL, is placed across a slide, the specimen placed at one end of the drop, and the relevant segments dissected off sequentially (cf. Hamond 1969). Permanent mounts may be made in PVL, Canada Balsam or similar as for cladocerans. The same cautions are required to minimise bubbles forming in the mountant.

Details of dissection and generic identification will be provided in the Workshop.

Order Harpacticoida

Harpacticoids are rare epiphytic/epibenthic taxa, not well-known taxonomically for Australia. A note on them was given by Williams (1980), with the first part of a continental revision by Hamond (1987). For more detailed information, and other works on Australian harpacticoids, refer to this paper.

Glossary

Specialist terms or those not in general use which may not be defined in the text

allometry: change in relative growth rate

alula/alulae: membraneous extensions of trophi elements, usually at ends, in rotifer teeth

amictic: reproductive phase without males in rotifers (vs *mictic*)

apopyhsis/apophyses: projecting process from bone, or in this case trophi element of rotifers, for muscle attachment

cerebral ganglion: mass of neurones generally called the "brain" in rotifers

cloaca: common opening of intestine/bladder

corona: cilia disc at the head of a rotifer, beats metachronally, gives impression of a revolving wheel

denticulate: bearing small teeth, i.e. denticles (vs. *spinulate*)

ephippium: resistant, usually pigmented case formed around cladoceran resting eggs

epipharynx: supporting structure anterior to trophi around oesophagus in rotifers

eutely: constancy of cell numbers, fixed during development, does not change

fusiform: spindle-shaped

incus: term used for combination of fulcrum and rami in rotifer trophi

labrum: top or anterior lip (vs. *labium*)

malleus: combination of unci and manubria in rotifer trophi

manubrium/manubria: outer levers to which mastax musculate attaches to facilitate tooth movement in rotifers

mictic: reproductive phase of rotifers with males present (vs. *amictic*)

ocellus/ocelli: light sensitive organelles

ovipary: producing eggs which hatch externally

ovovivipary: eggs produced with a membrane, but hatch internally, e.g. in oviduct (e.g. *Asplanchna*)

palp: fingerlike sensory organ on head of some rotifers

parthenogenetic: mode of reproduction without male gametes

pharyngeal basket: complex reinforcing structure in some trichocercid rotifers (cf. *epipharynx*)

protonephridia: simple ducted excretory system with flagellated cells (flame cells) at the closed end, the motion of which gives a flickering appearance

punctiform: appears stippled by light microscopy, but by SEM may have tiny anemone-shaped protrusions or small 'pimples' (=pustulate)

pyriform: pear-shaped

ramus/rami: central component of rotifer teeth, move like forceps, hinged on the *fulcrum*

rostrum: projection or snout at the front of bdelloid (and other) rotifer head

spinulate: surface bearing small spines

sulcus: groove between, for example dorsal and ventral plates of lecanid or euchlanid rotifers, or applied to an embayment.

syncitium: multinucleated 'tissue' formed by post-embyonic loss of cell memranes in some rotifer organs

trochus/trochal discs: retractable stumpy/papillate coronae of bdelloid rotifers

uncus/unci: tooth/teeth (of rotifer)

vivipary: produce living young

vitellarium: yolk-producing component of female rotifer reproductive system

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NOTES

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APPENDIX 1

Rotifer families and genera (# spp) recorded from (N.Z.) and [Australia]

Bdelloidea

Adinetidae

Adineta (9 spp.)	[6]
Bradyscela (1 sp.)	[-]

Habrotrochidae

Habrotrocha (30 spp.)	[18]
Otostephanus (3 spp.)	[1]
Scepanotrocha (4 sp.)	[1]

Philodinavidae

Philodinavus (1 sp.)	[-]

Philodinidae

Ceratotrocha (2 spp.)	[1]
Didymodactylus (1 sp.)	[-]
Dissotrocha (3 spp.)	[3]
Embata (- .)	[1]
Macrotrachela (22 spp.)	[22]
Mniobia (15 spp.)	[9]
Philodina (16 spp.)	[10]
Pleuretra (4 spp.)	[3]
Rotaria (9 spp.)	[10]
n = (120)	[85]

Monogononta

Collothecacea

Atrochidae

Cupelopagis (1 sp.)	[1]

Collothecidae

Collotheca (5 spp.)	[13]
Stephanoceros (-)	[2]

Flosculariacea

Conochilidae

Conochilus (4 spp.)	[5]

Filiniidae

Filinia (8 spp.)	[10]

Flosculariidae

Beauchampia (-)	[1]
Floscularia (2 spp.)	[4]
Lacinularia (-)	[8]
Limnias (1 sp.)	[2]
Octotrocha (-)	[1]
Ptygura (3 spp.)	[13]
Sinantherina (-)	[5]

Hexarthridae

Hexarthra (4 spp.)	[6]

Testudinellidae

Pompholyx (2 spp.)	[2]
Testudinella (5 spp.)	[22]

Trochosphaeridae

Trochosphaera (-)	[1]
Horaëlla (-)	[1]

Ploimida

Asplanchnidae

Asplanchna (6 spp.)	[7]
Asplanchnopus (1 sp.)	[2]

Brachionidae

Anuraeopsis (1 sp.)	[3]
Brachionus (11 spp.)	[26]
Keratella (13 spp.)	[13]
Notholca (4 spp.)	[2]
Plationus (1 sp.)	[2]
Platyias (1 sp)	[1]

Colurellidae

Colurella (7 spp.)	[6]
Lepadella (12 spp.)	[35]
Squatinella (3 spp.)	[5]

Dicranophoridae

Albertia (-)	[1]
Aspelta (1 sp.)	[6]
Balatro (-)	[1]
Dicranophorus (3 spp.)	[14]
Encentrum (2 sp.)	[8]
Erignatha (-)	[1]
Paradicranophorus (1 sp.)	[-]
Wierzejskiella (-)	[1]

Epiphanidae

Cyrtonia (-)	[1]
Epiphanes (2 spp.)	[4]
Liliferotrocha (-)	[1]
Microcodides (-)	[2]

Proalides (1 sp.)	[2]
Rhinoglena (1 sp.)	[1]
Euchlanidae	
Dipleuchlanis (-)	[2]
Diplois (1 sp.)	[1]
Euchlanis (13 spp.)	[11]
Manfredium (1 sp.)	[1]
Tripleuchlanis (-)	[1]
Gastropodidae	
Ascomorpha (3 spp.)	[4]
Gastropus (2 spp.)	[3]
Ituridae	
Itura (1 sp.)	[3]
Lecanidae	
Lecane (38 spp.)	[82]
Lindiidae	
Lindia (4 spp.)	[5]
Microcodonidae	
Microcodon (1 sp.)	[1]
Mytilinidae	
Lophocharis (1 sp.)	[3]
Mytilina (4 spp.)	[7]
Notommatidae	
Cephalodella (22 spp.)	[25]
Dorystoma (-)	[1]
Drilophaga (-)	[?1]
Enteroplea (-)	[1]
Eospora (3 spp.)	[5]
Eothinia (-)	[1]
Monommata (5 spp.)	[11]
Notommata (4 spp.)	[14]
Pleurotrocha (-)	[1]
Resticula (-)	[4]
Scaridium (1 sp.)	[2]
Taphrocampa (2 spp.)	[2]
Tetrasiphon (-)	[1]
Proalidae	
Bryceella (1 sp.)	[1]
Proales (7 spp.)	[9]
Proalinopsis (-)	[2]
Synchaetidae	
Ploesoma (-)	[2]
Polyarthra (4 spp.)	[6]
Synchaeta (10 spp.)	[12]
Trichocercidae	
Ascomorphella (1 sp.)	[1]
Elosa (1 sp.)	[1]
Trichocerca (36 spp.)	[46]
Trichotriidae	
Macrochaetus (1 sp.)	[4]
Trichotria (2 spp.)	[5]
Wolga (-)	[1]
n =(277)	[525]

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