MEIOFAUNA MARINA

Biodiversity, morphology and ecology
of small benthic organisms

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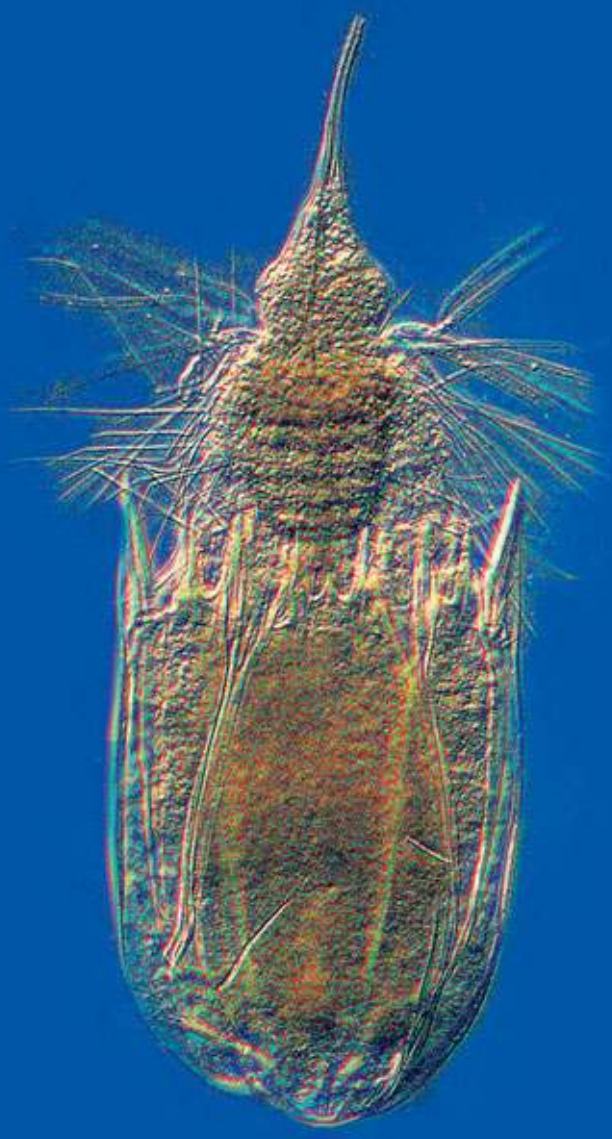

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Biodiversity, morphology and ecology of small benthic organisms

Volume 16 • March 2008
pages 1-200, 190 figs., 14 tabs.

Meiofauna marina is published annually

Subscriptions should be addressed to the Publisher:
Verlag Dr. Friedrich Pfeil, Wolfratshauser Str. 27, D–81379 München, Germany
PERSONAL SUBSCRIPTION: 48.– Euro
INSTITUTIONAL SUBSCRIPTION: 96.– Euro
Fees for mailing will be added

Manuscripts should be addressed to the editors

Bibliografische Information Der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.ddb.de abrufbar.

Printed by Advantage Printpool, Gilching

ISSN 1611-7557
Printed in the European Union

Verlag Dr. Friedrich Pfeil, Wolfratshauser Str. 27, D–81379 München, Germany
Phone: + 49 (0)89 742827-0 • Fax: + 49 (0)89 7242772 • E-mail: info@pfeil-verlag.de • www.pfeil-verlag.de

Meiofauna Marina, Vol. 16, pp. 75-99, 109 figs., March 2008

Identification key to the genera of marine rotifers worldwide

Diego Fontaneto*, **, Willem H. De Smet* and Giulio Melone****

Abstract

A dichotomous key to rotifers is presented for the 28 Families and 66 Genera that have been reported from saline systems of both marine and inland waters. Information is provided on general identification and papers dealing more particularly with certain Families and Genera. A succinct overview of the species found in saline habitats is given for each genus.

Keywords: Rotifera, saltwater, brackish water, dichotomous key

Introduction

Rotifers (phylum Rotifera) are transparent microscopic eutelic metazoans (50-2000 µm), with three main body regions: head, trunk, and foot (Figs. 1-2). The head is characterized by the presence of a typical anterior ciliated field named corona, with different ciliated areas located anteriorly and around the mouth. The body wall may be thickened in a lorica, and may bear variable appendages. The foot usually ends with movable toe-like extensions named spurs and toes; some species lack toes and possess one or more adhesive disks. While many rotifers may lack the above features, all of them possess a specialized masticatory organ, the muscular pharynx or mastax, containing a set of hard sclerotised jaws or trophi, the shape of which is very important in rotifer taxonomy (Wallace et al. 2006). Trophi elements are a single median fulcrum, and 3 paired elements: rami, unci, and manubria (Fig. 3). The fulcrum (absent in bdelloids) is mostly rectangular in lateral view, but may be variable in shape. The rami are hollow, roughly triangular structures. Their inner margin is provided with numerous elongate elements, the rami scleropili, which may be fused in a ridge and/or a series of tooth-like projections. Commonly in monogononts, the rami are provided with lateral projections, the alulae. The unci are plates formed by connection of a variable number of teeth into one rigid structure. The teeth are mostly unequal. Minute subuncinal teeth are mostly present, and are situated under the unci plate. The manubria are more-or-less triangular to crescent-shaped, or rod-shaped supports of the unci. A variable number of diverse accessory sclerites occurs in monogononts. Nine main types of trophi are recognized (malleate, malleoramate,

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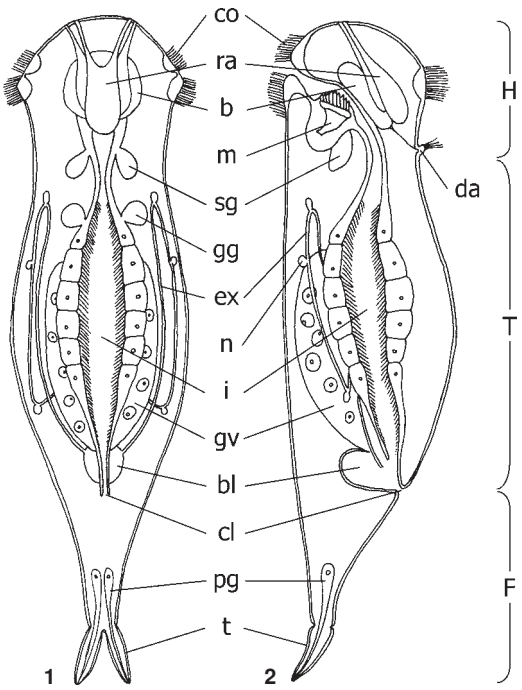


Figs. 1, 2. Scheme of the anatomy of a generic rotifer in dorsal (**1**) and lateral (**2**) view. **H**, head; **T**, trunk; **F**, foot; **b**, brain; **bl**, bladder; **cl**, cloaca; **co**, corona; **da**, dorsal antenna; **ex**, excretory apparatus; **gg**, gastric glands; **gv**, germo-vitellarium; **i**, intestine; **m**, mastax with trophi; **n**, nephridium; **pg**, pedal glands; **ra**, retrocerebral apparatus; **sg**, salivary glands; **t**, toe. Modified from Wallace & Ricci (2002).

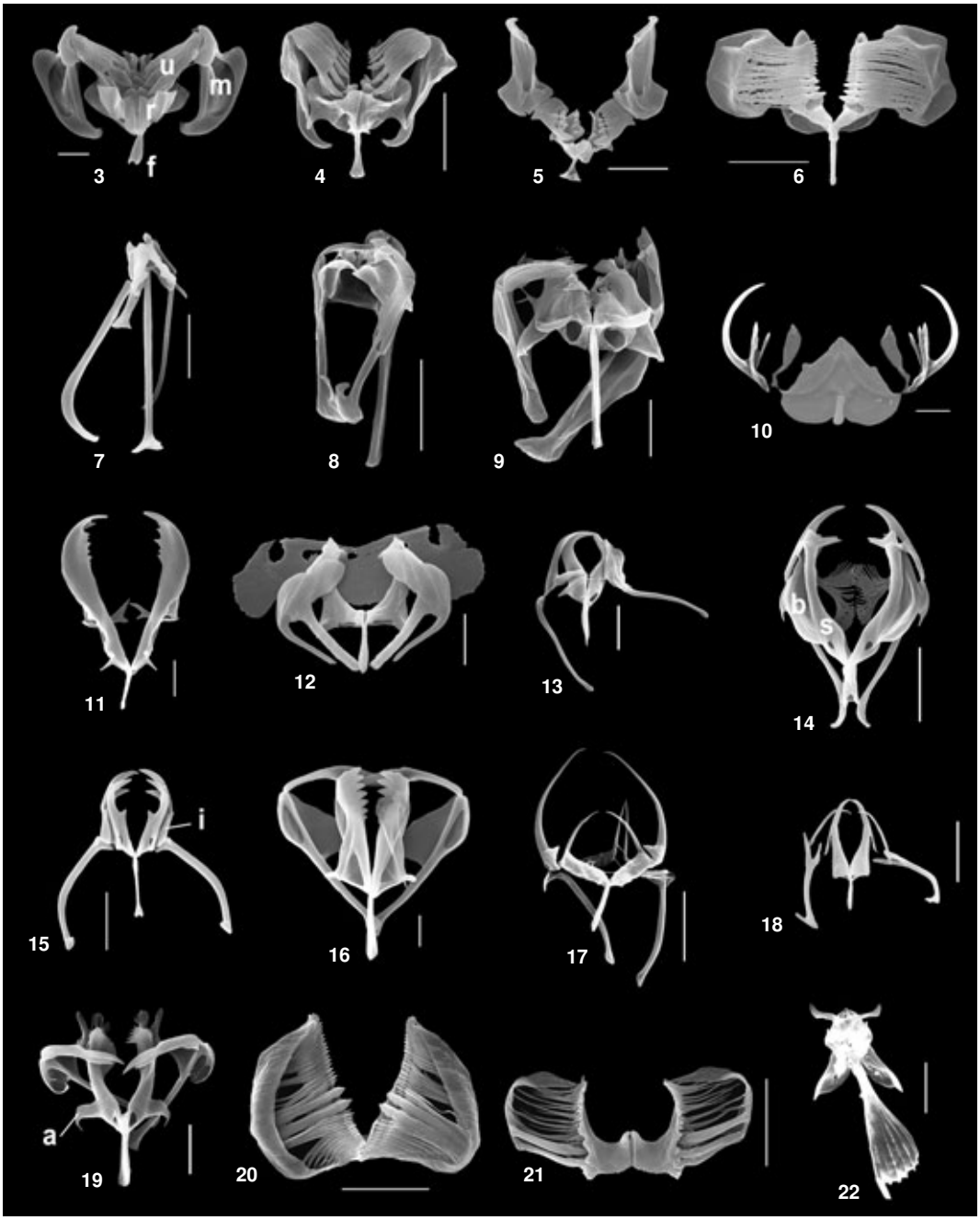
uncinate, incudate, virgate, cardate, forcipate, ramate, and fulcrate), characterized by the shape and size of the elements, the presence of accessory parts, and the way they operate (Figs. 3-22).

1) Malleate (Fig. 3-5): fulcrum short, rami more or less triangular and flat. Unci with several (4-12) firmly connected teeth. The manubria are provided with a shaft, which is typically fairly short, but this structure is more elongate in the submalleate trophi of Lecanidae and some Proalidae. The malleate trophi are adapted for gripping, grinding and pumping.
2) Malleoramate (Fig. 6): fulcrum short, rami more-or-less triangular, flat; similar to malleate type, but unci teeth more numerous, with weaker connections, occasionally resembling striated plate; manubria crescent-shaped, without shaft. Only grinding.
3) Virgate (Fig. 7-9): fulcrum long, rami recurved dorsally, unci with few teeth or reduced, manubria mostly with elongate shafts; often asymmetrical (e.g., *Trichocerca*). The virgate trophi type is the most variable of all. Used for piercing and sucking, or swallowing food by pumping without crushing.
4) Uncinate (Fig. 10): similar to the malleoramate type, but all trophi elements except the unci strongly reduced. Unci teeth few (2-5 teeth per uncus), elongate and curved, forming supporting rods for the mastax; not important, the food is already predigested. Only in Collothecidae.
5) Incudate (Fig. 11): fulcrum short, rami elongate, pincer-shaped. Manubria and unci strongly reduced. Specialized for seizing. Only in Asplanchnidae.
6) Cardate (Fig. 12): fulcrum short, rami lyriform, manubria with a shaft and a characteristic, additional ventral projection. Species-specific accessory trophi elements are present, and often numerous. The cardate type is adapted for pumping. Restricted to Lindiidae.
7) Forcipate (Figs. 13-19): fulcrum mostly short; rami elongate long pincers, usually with sharp tips and often armed with teeth along medial margin. Unci are strong, but with a single or few teeth only. Manubria are long and thin; often with intramalleus between uncus and manubrium. The trophi work by gripping (rami and unci can be extruded in Dicranophoridae). In Dicranophoridae and Ituridae.
8) Ramate (Figs. 20, 21): fulcrum absent, rami semicircular, flat; unci teeth numerous, occasionally resembling striations; manubria as lateral bands. Grinding. In Subclass Bdelloidea.
9) Fulcrate (Fig. 22): fulcrum long, manubria absent; the pumping action is performed by the hypopharynx muscle. In *Seison*.

For a recent, comprehensive introduction to the morphology, biology and ecology of the taxon see Wallace & Ricci (2002) and Wallace et al. (2006).

Classification and systematics

Classically, three groups are recognized within Phylum Rotifera: Seisonacea, Bdelloidea and Monogononta, while molecular studies indicate that the exclusively endoparasitic Acanthocephala actually are rotifers (Mark Welch 2000, Sørensen



Figs. 3-22. SEM pictures of the nine trophi types. **3-5.** malleate: **3,** *Brachionus plicatilis*; **4,** *Proales similis*; **5,** *Colurella colurus*; **6,** malleoramate, *Testudinella clypeata*. **7-9.** virgate: **7,** *Trichocerca pediculus*; **8,** *Cephalodella* sp.; **9,** *Pleurotrocha atlantica*. **10,** uncinate, *Cupelopagis vorax* (freshwater species); **11,** incudate, *Asplanchna priodonta*; **12,** cardate, *Lindia tecusa*; **13-19,** forcipate: **13,** *Aspelta europaea*; **14,** *Dicranophoroides caudatus*; **15,** *Encentrum algente*; **16,** *Dicranophorus forcipatus*; **17,** *Erignatha clastopis*; **18,** *Myersinella uncodonta*; **19,** *Itura myersi*. **20-21.** ramate: **20,** *Zelinkiella synaptae*; **21,** *Philodinavus paradoxus*. **22,** fulcrate, *Seison annulatus*. Scale bars = 10 µm; **a**, alula; **b**, basal chamber; **f**, fulcrum; **i**, intramalleus; **m**, manubrium; **r**, ramus; **s**, subbasal chamber; **u**, uncus.

& Giribet 2006). Nevertheless, only the three classical groups will be considered in this key. The most recent and comprehensive checklist of all rotifer species, excluding acanthocephalans, is by Segers (2007).

Seisonacea, with only three species, are exclusively marine and live epizootically on leptostracan crustacea. Males and females are usually present at a 1 : 1 sex ratio, and reproduction is by obligate amphimixis (Ricci et al. 1993).

Monogononta contains 1570 species-level taxa, and the vast majority of them (1488) are free-living fresh or inland water taxa (Segers 2007, 2008). Monogononts occur in all types of water bodies worldwide; they are particularly abundant and diverse in lentic freshwater habitats, although many species also occur in haline habitats (Fontaneto et al. 2006a). This group is characterized by a single gonad and cyclic parthenogenetic reproduction: parthenogenesis dominates, but sexual reproduction also occurs occasionally. Eggs produced by sexual reproduction are known as resting eggs undergoing obligatory diapause. They are able to survive desiccation and other adverse environmental conditions for long periods, and often form large resting egg banks. These resting stages may be dispersed by wind, waterfowl, insects etc. (e.g. Cáceres 1997).

Bdelloidea contains 461 species, only one of which is known as strictly marine (Segers 2007). Bdelloids reproduce exclusively by apomictic thelytoky, a kind of parthenogenesis producing females only, without meiosis. Biological species concepts cannot apply to these organisms that do not reproduce sexually; nevertheless, bdelloid species have been demonstrated to be distinct entities, at least equivalent to species in sexual groups (Fontaneto et al. 2007b). Many bdelloids produce resting stages as well, but they do not enter dormancy in a fixed period of their life as monogononts: they may enter dormancy in every stage of their lives, becoming dormant resting propagules (e.g. Cáceres 1997).

Biogeography

Rotifers have always been considered non-interesting biogeographically, due to their capacity to produce resting stages, and their considerable abilities for passive dispersal (but see e.g. Dumont 1983, Fontaneto et al. 2006b). On the contrary, recent studies from continental habitats show a different scenario, with areas of high numbers of endemic taxa. The rotifer record is highest in the Northern hemisphere, but this may be due to the higher number of studies in those regions. Diversity hotspots are northeast North America, tropical South America, Southeast Asia, Australia, and Lake Baikal. Endemicity is low in Africa (including Madagascar), Europe, the Indian subcontinent and Antarctica (Segers 2008). Data for marine rotifers are still too scarce to allow sound conclusions about their biogeography (Fontaneto et al. 2006a).

Collection and specimen handling and preparation

Rotifers may be found in the plankton and periphyton, and as interstitial fauna or psammon. Planktonic and littoral rotifers are collected by dragging a plankton net (mesh size: 25-50 µm) through the open water, submerged vegetation, littoral macrophytes or algae. Rotifers inhabiting periphyton may be collected using a flexible collecting tube attached to a large syringe. Alternatively, plant material, debris and algae can be squeezed over a plankton net. Creeping animals can be collected by scraping various substrata, while sessile rotifers can be found by careful examination of plant material or other substrates. Psammon is collected with coring devices, dredges etc., or simply by scraping the uppermost centimetres of sand with a vial. The sand is consequently mixed with water, and after momentary settling the water is decanted through a plankton net. However, some psammic species can cling to the sand grains and their number is often underestimated. At the shore, samples taken below the mean water level, and especially in the intertidal zone, will yield rotifers. Quantitative sampling is possible, although difficult, and we suggest following the recommendations by Wallace & Ricci (2002). Higgins & Thiel (1988) and Giere (1993) can be consulted also, as methods developed for other microscopic or small organisms can be applied to rotifers as well.

After collection, samples can be fixed directly in the field or quickly transferred unaltered to the laboratory for examination. In the first case, anaesthesia with a solution of marcaine 0.5 % for a few minutes before fixation, may help identification of illoricate rotifers. The second alternative yields living specimens, which is often mandatory

for the identification of many illoricate species (Wallace & Ricci 2002, Wallace et al. 2006).

Once in the lab, animals can be sorted using micropipettes and embryo or Petri dishes under a stereomicroscope at 5-50× magnification. To avoid excessive heating when sorting living animals, it is recommended to use optical fibers, instead of direct light from a light bulb. For proper identification, animals need to be transferred on a slide in a small drop of water, and gently covering it with a coverslide. Observation at magnifications up to 400-1000× is needed to observe minute details, especially for the trophi.

Trophi can be observed by microscope at high magnification, squeezing the animals under a coverglass. Unfortunately, during the squeezing process, the animal itself can be lost for subsequent analysis. However, with some experience it will be easy to recognize Families without squeezing the animal too much, but for beginners it will be helpful to draw the animal and its body features before squeezing it. For a more detailed examination, proper preparation of trophi is necessary. This can be done by adding a small drop of NaOCl, which will dissolve soft tissues and enhance recognizability of trophi features. For details on SEM preparation follow De Smet (1998) and Segers (2004), or consult the rotifer trophi web page (http://users.unimi.it/melone/trophi).

Marine rotifers

Most known rotifer species live in freshwater and limnoterrestrial habitats, while marine habitats, both brackish and seawater, are considered to possess a few species (see for instance de Beauchamp 1965, Wulfert 1969, Smith 2001, Segers 2004, Wallace et al. 2006). Although marine rotifer species richness is probably lower indeed, it is unquestionably underestimated due to e.g. the few taxonomists studying them and insufficient sampling efforts. Remane (1929), Myers (1936), Bērziņš (1952) and Rudescu (1961) were the first to present and discuss an estimate of the number of marine and brackish water species, and more recently Ahlrichs (2003), Ricci & Fontaneto (2003) and Fontaneto et al. (2006a) reviewed available data on marine rotifers.

To date about 396 rotifer species, belonging to 66 genera, have been reported worldwide from saline waters, either marine, brackish, or inland saline. Species found in saline waters may be strictly haline, i.e. never reported from freshwaters, euryhaline or found in both freshwater and saltwater, as well as haloxenous, i.e. inhabitants of freshwater occurring in saltwater accidently. Detailed references for all species of each genus reported from saline waters (marine, brackish, inland saline), are to be found in Fontaneto et al. (2006a). Here we add new or overlooked data, together with taxonomic references useful for species identification.

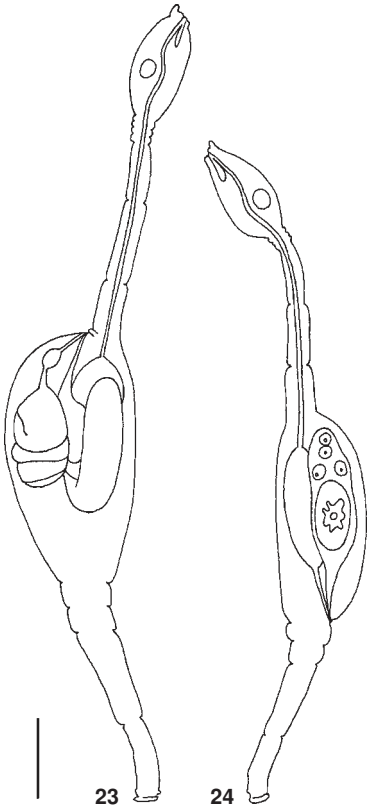
Dichotomous keys to the marine rotifers

Interpreting some of the dichotomies, especially the higher rank ones, can be problematic. However, with some experience it will be possible to identify Families and Genera without starting from the beginning of the key, and, of course, all pictures and drawings referred in the key may be of help to recognize some peculiar groups immediately.

Trophi type is one of the most useful taxonomic features in rotifers, but only careful and detailed observations allow proper identification. Figures 3-22 show SEM pictures of all types of trophi.

Seisonacea are usually known as epibionts on *Nebalia* only; therefore, their identification is easy. Identifying single or paired ovaries to recognize bdelloid or monogonont rotifers can be difficult, but only bdelloids have paired ones, and their body shape is quite characteristic and homogeneous (Figs. 25-33); therefore, even for beginners there is no really need to find ovaries.

Another painstaking but often misleading task is the distinction between loricate and illoricate species, as some semiloricate taxa exist. Loricate rotifers will retain their shape when preserved, while illoricate ones usually will not. When observing live animals, a gentle pressure applied to the coverglass may help: in illoricate rotifers the body bulges under the pressure but its shape will return when pressure is released, whereas in loricates it is not or hardly deformed. Segers (2004) also recommends the examination for presence of lorica projections, which are always absent in illoricate taxa and often present in loricates. By rotating the animal one may get an impression of its body shape in cross sectional view. Some genera that are often described as typically loricate (e.g. *Brachionus*, *Lecane*) possess species that are



Figs. 23, 24. Scheme of the morphology of *Seison nebaliae*: **23,** male; **24,** female. Scale bar = 100 µm.

illoricate, and just the opposite holds for others (e.g. *Cephalodella*).

1 Trophi fulcrate (Fig. 22). Corona rudimentary. Epizoic on marine crustaceans of the genus *Nebalia*. Males and females in equal numbers (Figs. 23, 24). ..... Class Pararotatoria, Order Seisonacea
– Trophi not fulcrate. Corona well developed. Not epizoic on *Nebalia*. Mostly or only females (Class Eurotatoria). 2

2 Paired ovaries (Figs. 26-28). Trophi ramate (Figs. 20, 21). .....Subclass Bdelloidea
– Single ovary. Trophi not ramate (Figs. 3-19) (Subclass Monogononta). 3

3 Trophi malleoramate (Fig. 6). Corona elliptical to round, heart-shaped, horseshoe-shaped or four-lobed, without long setae (Figs. 34-43). Free-swimming or sessile. ..... Order Floscullariaceae
– Trophi uncinate (Fig. 10). Corona funnel like with tentacles, lobes or knobs bearing long setae (setae always present in the genus and species concerned (Fig. 44); there may be cilia between the tentacles, lobes etc). Usually sessile, a few planktonic species..... .....Order Collothecaceae
– Trophi otherwise: cardate, forcipate, incudate, malleate, or virgate (Figs. 3-5, 7-9, 11-19). ....Order Ploima

Class Pararotatoria, Order Seisonacea
Family Seisonidae

Genus *Seison* (Figs. 22-24)

To date, three species of this genus are known, two of them *(S. annulatus* and *S. nebaliae)* epibiotic on leptostracan crustaceans of the genus *Nebalia* (the habitat is still unknown for *S. africanus*). Seisonacea is the only exclusively marine order among rotifers. A detailed morphological revision of *S. annulatus* and *S. nebaliae* is presented in Ricci et al. (1993), and minute details of their trophi morphology are described in Segers & Melone (1998). All that is known about *S. africanus* can be found in the original description by Sørensen et al. (2005).

Sørensen et al. (2005) and Segers (2007) re-established the genus *Paraseison* for *S. annulatus*; nevertheless, for the scope of this key, we will consider it a synonym of *Seison*.

The body of *Seison* is divided into four parts (Figs. 23, 24): head, neck, trunk, and foot. Neck and foot are pseudosegmented and telescopically retractable. The head is ovate and laterally flattened, and distinctly offset from the neck. The ovate trunk is smooth, without annulations. Body length: 300-2500 µm. Trophi fulcrate (Fig. 22).

Class Eurotatoria, Subclass Bdelloidea

Bdelloidea are composed of four Families in three Orders; collective these comprise 20 genera as follows: Order Adinetida with Family Adinetidae (1 genus), Order Philodinida with Families Habrotrochidae (3 genera) and Philodinidae (13 genera), and Order Philodinavida with Family Philodinavidae (3 genera). Koste & Shiel (1986), Turner (1999) and Ricci & Melone (2000) published keys to bdelloid genera, both marine and freshwater ones. Another key to genera is that of Fontaneto & Ricci (2004), but only for those occurring in freshwater (that is all except *Zelinkiella*). Bartoš (1951) and especially Donner (1965) are still

the most recent and reliable taxonomic keys for identification to the species level. Very few new species have been described since the publication of these two monographies, and none from marine habitats. The following key refers to all 8 genera that have been reported from saltwater.

One difficult task is to check for the number of toes. While spurs are always extended, and cannot be retracted, identifying toes may be tricky, as they are usually retracted in the foot. The only moment they can be seen, even if for very short periods, is when the animal extends the foot while creeping on the surface of the glass slide. Moreover, toes and spurs are not homologous structures in bdelloids and monogononts.

1 Trophi close to mouth opening, extruded when animal is feeding; proximal minor teeth of uncus plate reduced or absent (Fig. 21) (Family Philodinavidae). Corona reduced to small ciliated field, trochi absent. Foot with 4 toes and 2 short spurs (Fig. 25)..... ..... *Philodinavus*

– Trophi deep in the oesophagus, never extruded; proximal and distal minor teeth of uncus plate always present (Fig. 20). Corona otherwise, trochi absent or present. Foot with two spurs of variable length. Toes present (2, 3 or 4) or absent.....2

2 Corona modified to a ventral ciliated field, no trochi (Family Adinetidae). Foot long and extensible, with 3 toes and 2 spurs (Fig. 26). Move by scraping and browsing the substratum. ..... *Adineta*

– Corona with trochi, mostly elevated on pedicels. Foot with two spurs of variable length. Toes present (2, 3 or 4) or absent (Figs. 27-33). 3

3 Stomach without recognizable lumen, with round pellets in its wall (Family Habrotrochidae). Upper lip developed normally, trochi visible, cilia whirls of trochi often very close to each other (Fig. 27)..... *Habrotrocha*

– Stomach with thick wall and visible lumen, not filled with round pellets (Family Philodinidae) (Figs. 29-33).....4

4 Foot without toes (Figs. 28-31).....5

– Foot with toes (Figs. 32, 33).....7

5 Foot longer than one half of trunk length (Fig. 28). Epizoic in gill chamber of crabs..... ..... *Anomopus*

– Foot shorter than one half of trunk length (Fig. 29). Free-living or epizoic. 6

6 Viviparous, with developing animals visible within the trunk (Fig. 29). Trophi with 2 major teeth (Fig. 20). Epizoic on holoturians and annelids. ..... *Zelinkiella*

– Oviparous. Trophi with 3 or more major teeth (Fig. 30). Free-living. ..... *Mniobia*

7 Foot with 3 toes. Viviparous. Often eye-spots visible on rostrum (Fig. 32); rostrum extended also when swimming. ..... *Rotaria*

– Foot with 4 toes. Oviparous. Eye-spots on brain, when visible (Fig. 33)..... *Philodina*

Genus *Adineta* (Fig. 26)

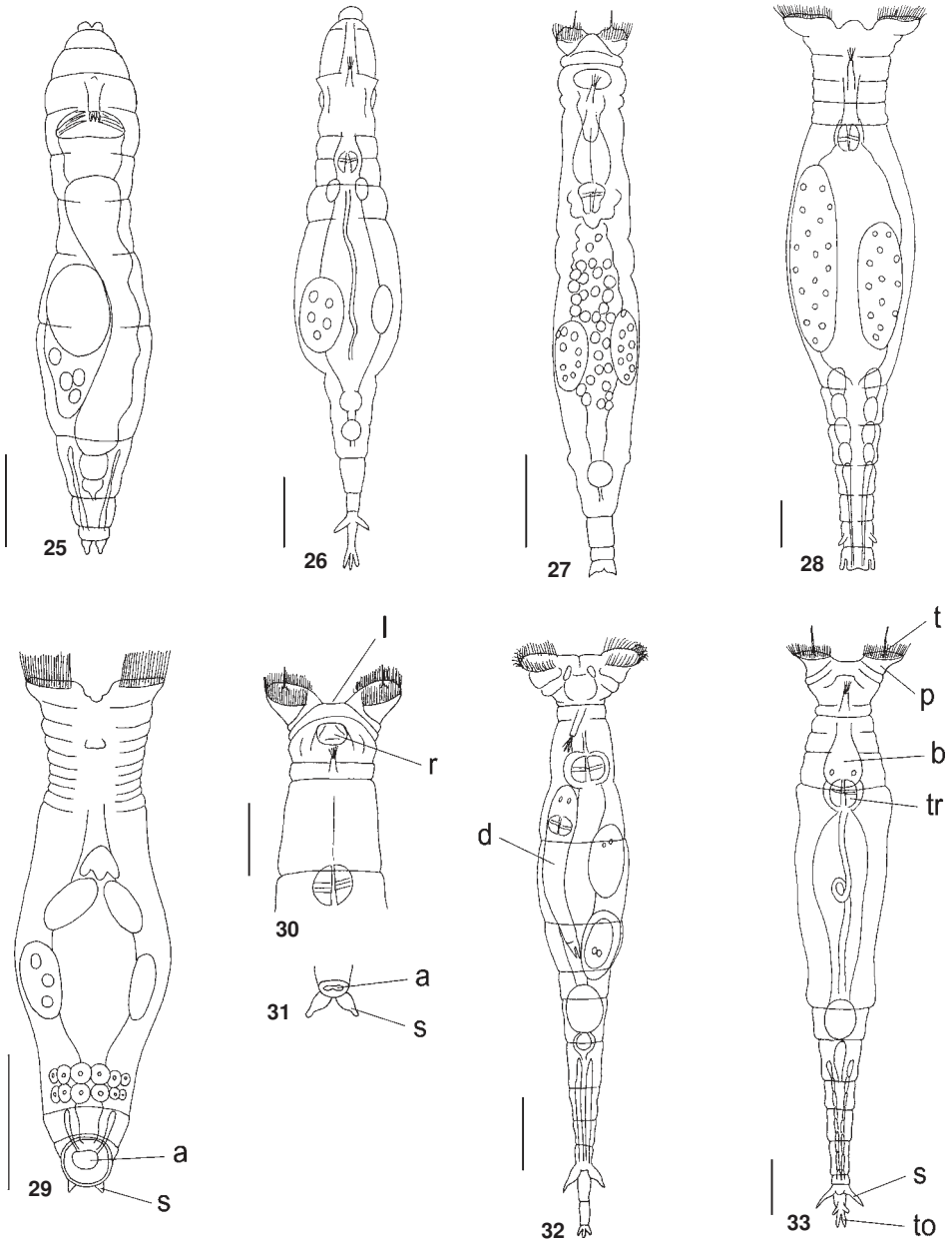
Three haloxenous species out of the 14 known members of the genus have been reported so far from inland saltwaters, whereas never from true marine environments. This genus is quite easy to identify: they are dorso-ventrally compressed, with a well developed foot; they move by gliding on the surface, repeatedly protruding and retracting the foot, while the cilia of the head convey food particles to a rake close to the mouth opening. Body length: 200-700 µm. Trophi are very small and each uncus has 2 major teeth.

Genus *Anomopus* (Fig. 28)

Two species are known of this genus, both epizoic in the gill chambers of freshwater crabs. *Anomopus chasmagnati*, epibiont of the freshwater crab *Chasmagnathus granulata,* has been reported also from crabs collected in the brackish waters of Mar de la Plata in Uruguay (Mañé-Garzón & Montero 1973). The genus shows a characteristic very long foot, ending with short spurs and an adhesive disc. The trochi of the corona are wide. Body length: 600-1000 µm. Each uncus in *A. chasmagnathi* has 2 major teeth.

Genus *Habrotrocha* (Fig. 27)

Only one species, *H. constricta*, has been reported from inland saltwater, out of more than 100 species known from freshwater. Pellets inside the stomach may be recognized only on careful inspection. Animals of this genus have a short foot and quite long oesophagus. Commonly they creep and the trochi, seldomly extended, are rather narrow. Body length: 150-400 µm. On each uncus there are from 2 to 10 major teeth of different width. The only species reported from saltwater has 6-8 major teeth on each uncus.



Figs. 25-33. Bdelloid rotifers: **25,** *Philodinavus paradoxus*; **26,** *Adineta gracilis*; **27,** *Habrotrocha constricta*; **28,** *Anomopus chasmagnathi*; **29,** *Zelinkiella synaptae*; **30,** *Mniobia symbiotica*, head; **31,** *M. symbiotica*, foot; **32,** *Rotaria laticeps*; **33,** *Philodina roseola*. Scale bars = 50 µm. **a**, adhesive disk; **b**, brain; **d**, developing embryo; **l**, lip; **p**, pedicel; **r**, rostrum; **s**, spur; **t**, trochus; **to**, toe; **tr**, trophi.

Genus *Mniobia* (Figs. 30, 31)

The genus is quite diverse, with more than 45 species known to date. Only one, possibly euryhaline species, *M. symbiotica*, is reported from lichens and cyanobacteria growing on rocks at the seashore (Kronberg 1988, Egborge 1994). This species is very polymorphic, and it is likely that the halophilous populations belong to a new species. The

genus is characterized by the absence of toes, and the adhesive disc is hardly visible and always hidden in the foot. Body length: 300-800 µm. Trophi with seldom 2, mostly 3, up to 10 major teeth on each uncus; *M. symbiotica* has 2-4 ones.

Genus *Philodina* (Fig. 33)
Seven (6 haloxenous and 1 euryhaline) species reported from inland and marine habitats, out of about 50 species. The bright eyes present on the brain are easy to spot, although not all species have visible eyes. The body is tapered, foot longish, with the 4 toes easily visible. Trochi are wide and well separated. Body length: 100-800 µm. Each uncus has usually 2 major teeth, but up to 5 major teeth may occur.

Genus *Philodinavus* (Figs. 21, 25)
Two species are known in the genus, and one, *P. paradoxus*, has been reported only once from inland saltwater. It lacks the corona (Fig. 25) and has only a few cilia around the mouth. The trophi lie close to the mouth. Rostrum and antenna are evident. The foot is short, with very small parallel spurs and 4 strong toes easily visible. Body length: 200-300 µm. The trophi are rather peculiar, lacking proximal minor teeth (Fig. 21).

Genus *Rotaria* (Fig. 32)
Out of 26 species in the genus, 6 have been recorded from inland saline and marine habitats. Five of them may be haloxenous, but one, *R. laticeps*, is strictly haline and commonly found at least in the Mediterranean, among algae, detritus, and in rock pools (personal observation). All are viviparous. They usually swim showing a wide corona. The rostrum, often with dark eyes, is commonly visible between the trochi. The foot is long and slender, with long spurs and 3 toes that are long and easily visible. Body length: 400-1300 µm long. Each uncus has 2 major teeth.

Genus *Zelinkiella* (Figs. 20, 29)
This monospecific genus is strictly haline, with *Z. synaptae* living epizoic on holothurians and annelids. The foot is very short, with small spurs and adhesive disc (Fig. 29). Body length: 200 µm. Each uncus has 2 major teeth (Fig. 20).

Class Eurotatoria, Subclass Monogononta

Superorder Pseudotrocha, Order Floscullariaceae

The most useful work to identify species is still Koste (1978); for more details consult Edmondson (1959), Ruttner-Kolisko (1974), Pennak (1978, 1989), Stemberger (1979), Shiel (1995), Smith (2001), Wallace & Snell (2001), Segers (2004), Wallace et al. (2006). No recent taxonomic revision is currently available for Floscullariaceae, except for some genera (details in genus descriptions).

1 Body loricate (Figs. 34, 35) (Family Testudinellidae). 2
– Body illoricate, although possibly hidden in tubes. 3

2 Lorica egg-shaped. Foot absent (Fig. 35). ..... *Pompholyx*
– Lorica more or less dorso-ventrally compressed. Foot wrinkled, ventral, retractile (Fig. 34). ..... *Testudinella*

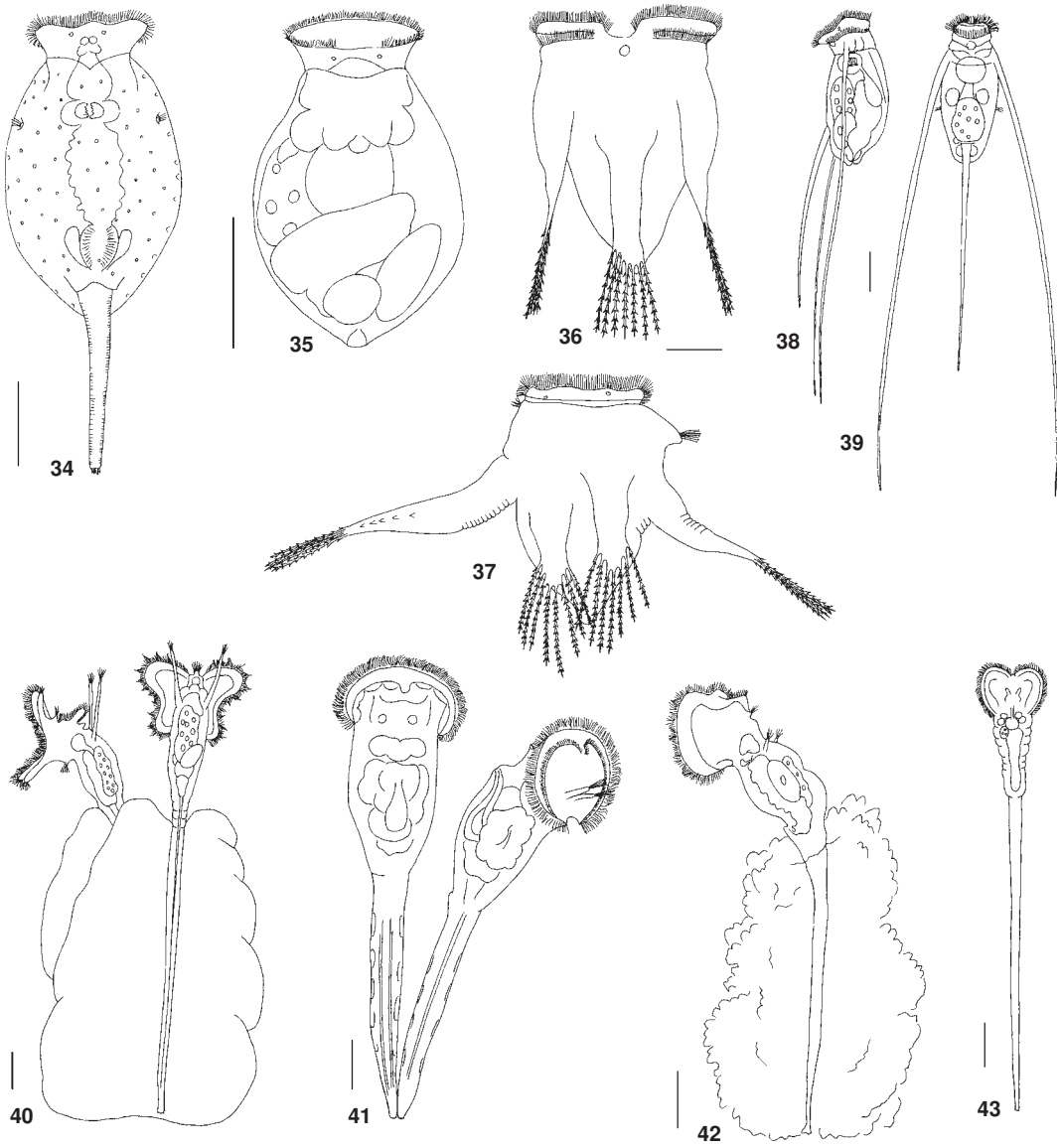
3 Six arm-like appendages with setae arranged fanwise (Family Hexarthridae) (Figs. 36, 37). ..... *Hexarthra*
– Arm-like appendages absent. 4

4 Foot absent. Apical field dome-shaped. Body with 2 long lateral movable setae and 1 caudal seta. Trophi modified malleoramate with pseudoalulae (Family Trochosphaeridae) (Figs. 38, 39). ..... *Filinia*
– Foot present. Apical field not dome-shaped. Movable setae absent. Trophi not as above... 5

5 Corona horseshoe to U-shaped. Teeth of left uncus longer than those of right one (Family Conochilidae). Transparent gelatinous case. Adult females free-swimming, solitary, or in small to large spherical colonies (Fig. 41). ..... *Conochilus*
– Corona not horseshoe to U-shaped. Teeth of left and right uncus equally long (Family Floscullariidae). 6

6 Corona with 4 lobes. Sessile. Solitary or in tree-like colonies (Fig. 40). ..... *Floscularia*
– Corona round to elliptical or heart-shaped. Sessile or free-swimming. In tubes of mucus, often supplemented with detritus, or with mucus only covering extremity of foot. Solitary or in colonies. 7

7 Corona round to elliptical. Sessile. Tubes mucous, often with detritus. Solitary or in colonies (Fig. 42). ..... *Ptygura*
– Corona heart-shaped. Sessile or free-swimming. Mucus only covering extremity of foot. Colonies spherical (Fig. 43). ..... *Sinantherina*



Figs. 34-43. Floscullariacean rotifers: **34,** *Testudinella clypeata*; **35,** *Pompholyx sulcata*; **36,** *Hexarthra fennica*, ventral; **37,** *H. fennica*, lateral; **38,** *Filinia longiseta*, lateral; **39,** *F. longiseta*, ventral; **40,** *Floscularia melicerta*; **41,** *Conochilus hippocrepis*; **42,** *Ptygura crystallina*; **43,** *Sinantherina socialis*. Scale bars = 50 µm.

Genus *Conochilus* (Fig. 41)
Two freshwater species, *C. hippocrepis* and *C. unicornis*, are known from marine plankton out of 7. For a recent taxonomic revision, see Segers & Wallace (2001).

Genus *Filinia* (Figs. 38, 39)
Six species have been found in saltwater habitats (4 of them in the sea) out of 15. All of them are planktonic and haloxenous *(Filinia brachiata, F. cornuta, F. passa)* or euryhaline *(F. limnetica, F. longiseta, F. terminalis)*. The most recent taxonomic revision of the genus with dichotomous keys can be found in Sanoamuang (2002); Sanoamuang (1993) gives nice SEM pictures of the trophi. See Segers (2002b) for the inclusion of this genus in Family Trochosphaeridae.

Genus *Floscularia* (Fig. 40)
Only one species out of 10, *F. melicerta*, has been found in marine plankton.

Genus *Hexarthra* (Figs. 36, 37)
Ten taxa belonging to 7 species *(H. fennica*, *H. intermedia*, *H. jenkinae*, *H. libica*, *H. mira*, *H. oxyuris*, and *H. polyodonta)*, out of 13 total species, are haline, and all of them are planktonic.

Genus *Pompholyx* (Fig. 35)
Two species out of 3, *P. complanata* and *P. sulcata*, have been recorded in saltwater, the former in the benthos as haloxenous, the latter in the plankton as euryhaline.

Genus *Ptygura* (Fig. 42)
Three taxa out of 29 have been found in the sea: two, *P. crystallina* and *P. melicerta*, can be considered euryhaline, while *P. melicerta agassizi* is strictly haline.

Genus *Sinantherina* (Fig. 43)
One freshwater species, *S. socialis*, out of the 6 described taxa has been reported from marine plankton.

Genus *Testudinella* (Figs. 6, 34)
Eight species out of 46 have been cited in haline waters. Only *Testudinella clypeata*, *T. dentata* and *T. obscura* are strictly haline, living in marine and/or brackish waters; the others are haloxenous *(T. elliptica*, *T. truncata)* or euryhaline *(T. incisa*, *T. patina*, *T. reflexa)*. *Testudinella dentata* described from brackish waters in Wisconsin and New Jersey, USA (Myers, 1934), is not mentioned in the list by Fontaneto et al. (2006a). For details on trophi morphology, consult De Smet (2005b).

Class Eurotatoria, Subclass Monogononta

Order Collothecaceae

No recent revision is available for Collothecaceae, and the only comprehensive key is still that of Koste (1978); more information is to be found in Edmondson (1959), Pennak (1978, 1989), Shiel (1995), Smith (2001), Wallace & Snell (2001), Segers (2004), and Wallace et al. (2006).

Family Collothecidae is characterized by a corona with lobes, tentacles or knobs bearing long setae. Only the genus *Collotheca,* out of the 2 genera in the Family, has been reported from saline waters.

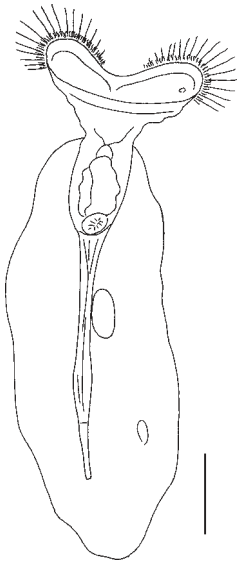


Fig. 44. Collothecacean rotifer: *Collotheca mutabilis*. Scale bar = 50 µm.

Collotheca (Fig. 44)
Seven taxa out of 46 are known to occur in saltwater habitats, mostly in truly marine environments. *Collotheca campanulata*, *C. cornuta*, *C. coronetta*, and *C. ornata* are found in the benthic habitat, while *C. mutabilis*, *C. ornata natans*, and *C. pelagica* are plankton-dwellers.

Class Eurotatoria, Subclass Monogononta

Order Ploima

The works of Edmondson (1959), Ruttner-Kolisko (1974), Koste (1978), Stemberger (1979), Koste & Shiel (1986, 1987, 1989a,b, 1990a,b, 1991, 1992, 1993), Pennak (1989), Shiel (1995), Kutikova (2002), Wallace & Snell (2001), Segers (2004) and Wallace et al. (2006) may prove useful for Ploima in general.

1 Trophi cardate (Fig. 12). Illoricate (Figs. 86, 87).....Lindiidae
– Trophi not cardate. Loricate or illoricate. 2

2 Trophi forcipate (Figs. 13-19). Illoricate. 3
– Trophi not forcipate. Loricate or illoricate...4

3 Trophi with hook-shaped alulae, not protrusible (Fig. 19). Stomach and intestine mostly greenish, filled with zoochlorellae (Fig. 79). . .....Ituridae

– Trophi without alulae or with differently shaped alulae, protrusible (Figs. 13-18). Stomach and intestine rarely with zoochlorellae (Figs. 56-69). ..... Dicranophoridae

4 Trophi incudate (Fig. 11). Illoricate. (Figs. 45, 46). ..... Asplanchnidae
– Trophi otherwise. Loricate or illoricate. 5

5 Trophi virgate (Figs. 7-9). 6
– Trophi malleate (Figs. 3-5) 10

6 Foot and toes very long, combined longer than body (Fig. 101). ..... Scaridiidae
– Foot shorter, toes variable, combined shorter than or as long as body 7

7 Body more or less strongly asymmetrical. Trophi very asymmetrical, asymmetry concerns all trophi elements (Fig. 7). Foot terminally, a short single pseudosegment bearing several bristles (substyli) and elongate spine-like toe(s) of unequal length. Trunk usually cylindrical with dorsal crest (usually asymmetrical); ventral fissure absent (Fig. 109). ..... Trichocercidae
– Body symmetrical. Trophi usually symmetrical, sometimes weakly asymmetrical (asymmetry most pronounced in rami and unci: Fig. 8, 9). Toes absent, or present and of equal length, never substyli; occasionally a single toe. Body sacciform, fusiform, conical, etc., never with dorsal crest, or if indication of dorsal crest lorica with ventral fissure. 8

8 Stomach coloured yellowish or brownish, with blind sacs. Body saccate to ovate, weakly loricate (Figs. 80, 81). ..... Gastropodidae
– Stomach without blind sacs. Trunk fusiform, conical, vasiform or cylindrical and illoricate, or ovate to bean-shaped and distinctly loricate. 9

9 Corona with stiff setae and sensory palps. Strongly developed V-shaped hypopharynx muscles. Illoricate or loricate (Figs. 105-108). ..... Synchaetidae
– Not as above (Figs. 93-100). ..... Notommatidae

10 Number of unci teeth reduced, usually composed of 3 stout subequal fused teeth. Foot short, a single pseudosegment, inserted ventrally on ventral plate. Toes 2 or fused (partly or completely) to 1. Usually loricate with dorsal and ventral plate separated by lateral furrows (sulci); dorsal and ventral plate not distinguishable in illoricate species (Fig. 88). ..... Lecanidae
– Unci with many teeth, gradually decreasing in length; when number of teeth reduced, foot absent or composed of 2–5 pseudosegments in line with trunk. Loricate or illoricate. Dorsal, ventral and/or lateral sulci present or absent. 11

11 Head shield present, retractile or non-retractile (Figs. 82-85). ..... Lepadellidae
– Head shield absent. 12

12 Loricate, lorica of one piece with longitudinal dorsal sulcus or dorsal keel (not part of polygonal facets). Foot present. (Figs. 89-92). ..... Mytilinidae
– Loricate or illoricate, without dorsal sulcus or keel (if present part of polygonal facets). Foot absent or present. 13

13 Illoricate or very weakly loricate 14
– Distinctly loricate. 15

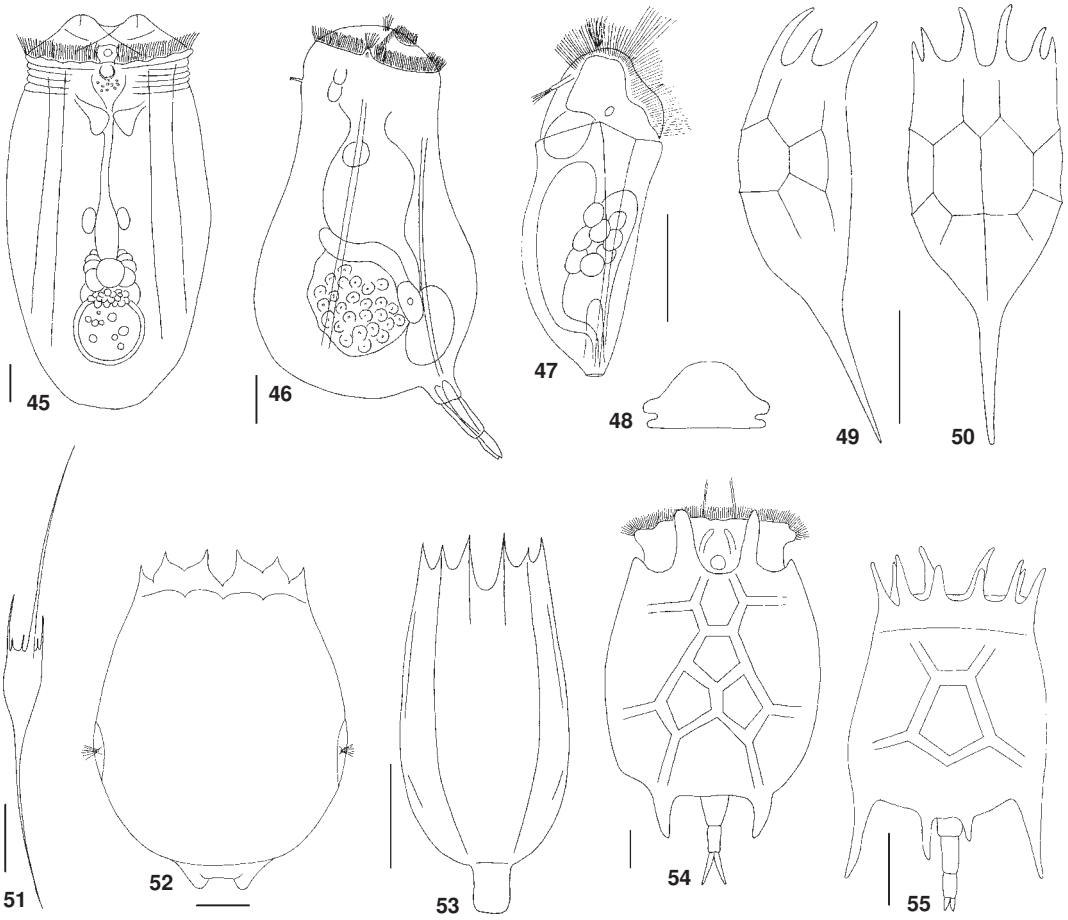
14 Mouth set at end of shallow or deep, large funnel-shaped buccal field. Corona usually with conspicuous series of tufts of long cirri. Foot distinct with one or 2 toes, or rudimentary and toes lacking. Trunk occasionally with several protruding transversal folds; without lateral sulci (Figs. 70-72). ..... Epiphanidae
[illoricate Brachionidae may key out here]
– Mouth superficial, no large funnel-shaped buccal field. Corona usually without tufts of long cirri [except in *Bryceella*]. Foot distinct with one or 2 toes. Trunk without protruding transversal folds; usually without lateral sulci [shallow ones in *Bryceella*]. (Fig. 102). ... Proalidae

15 Conspicuous lateral sulci present. Foot with 2 stout toes. (Figs. 73-78) ..... Euchlanidae
– Lateral sulci absent, shallow or inconspicuous. Foot absent or present; toes absent or present. 16

16 Lorica covering clearly defined head, trunk and foot. (Figs. 103, 104). ..... Trichotriidae
– Lorica only covering trunk and occasionally foot. Foot absent or present. (Figs. 47-55). ..... Brachionidae

Family Asplanchnidae

The most recent taxonomic treatment, with useful keys to all species is José de Paggi (2002).



Figs. 45-55. Ploima rotifers: **45,** *Asplanchna priodonta*; **46,** *Asplanchnopus hyalinus*; **47,** *Anuraeopsis fissa*, lateral; **48,** *A. fissa*, cross-section; **49,** *Keratella cochlearis*, lateral; **50,** *K. cochlearis*, dorsal; **51,** *Kellicottia longispina*; **52,** *Brachionus plicatilis*; **53,** *Notholca labis*; **54,** *Platyias quadricornis*; **55,** *Plationus patulus*. Scale bars = 50 µm.

1 Foot and toes present (Fig. 46)..... .....*Asplanchnopus*
– Foot and toes absent (Fig. 45). .....*Asplanchna*

Genus *Asplanchna* (Figs. 11, 45)
Five freshwater taxa out of 9 have been found in the sea: *Asplanchna brightwellii, A. girodi, A. herrickii*, *A. priodonta* and *A. sieboldii*.

Genus *Asplanchnopus* (Fig. 46)
Four freshwater species are known in the genus, and one, *A. hyalinus*, has been reported from brackish water. A species inquirenda, *A. syrinx*, has been reported from inland saline waters.

Family Brachionidae

No recent revision available. For a more comprehensive review one should consult Koste (1978) and Koste & Shiel (1987).

1 Foot present. 2
– Foot absent. 4

2 Foot tubular, wrinkled, completely retractile in trunk (often indistinct in contracted specimens) (Fig. 52). .....*Brachionus*
– Foot pseudosegmented, not or only partly retractile.....3

3 Lorica dorso-ventrally flattened, foot opening ventral (Fig. 54). .....*Platyias*
– Lorica high in cross-section, foot opening terminal (Fig. 55). ..... *Plationus*

4 Lorica without spines, composed of dorsal and ventral plate joined by shallow lateral sulci (Figs. 47, 48).....*Anuraeopsis*
– Lorica with spines, lateral sulci absent or indistinct. 5

5 Anterior margin of lorica with 4-6 strongly asymmetrical spines, unequal in length; single posterior spine (Fig. 51). ..... *Kellicottia*
– Anterior margin of lorica with 6 spines symmetrical in length (not necessarily equal); posterior projection(s) 1, 2, or absent. 6

6 Dorsal plate with pattern of polygonal facets, sometimes indistinct (Figs. 49, 50). .. *Keratella*
– Dorsal plate with longitudinal striae, smooth or with fossettes (Fig. 53)..... *Notholca*

Genus *Anuraeopsis* (Figs. 47, 48)
The euryhaline *Anuraeopsis fissa*, and the haloxenous *A. navicula* are the only species out of 10 of the genus, reported from marine habitats.

Genus *Brachionus* (Figs. 3, 52)
Out of 56 species of the genus, 21 (and several infrasubspecific taxa) have been reported from saltwater. Five species are strictly haline: *Brachionus asplanchnoides*, *B. manjavacas* (new addition by Fontaneto et al. (2007a), not listed in Fontaneto et al. (2006a)) and *B. plicatilis* occur in inland saline waters, whereas *B. ibericus* and *B. rotundiformis* are restricted to the marine environment. The other species are euryhaline *(B. angularis, B. calyciflorus*, *B. dimidiatus*, *B. leydigii*, *B. novaezelandiae*, *B. quadridentatus*, *B. rubens*, *B. urceolaris)* or haloxenous *(B. bennini*, *B. caudatus*, *B.* cf *nilsoni*, *B. diversicornis*, *B. falcatus*, *B. forficula*, *B. sessilis)*.

Genus *Kellicottia* (Fig. 51)
The genus contains 2 species, with the euryhaline *Kellicottia longispina* only reported from both inland saline and marine plankton.

Genus *Keratella* (Figs. 49, 50)
Nine species (and several infrasubspecific taxa), out of 44 recognized in the genus have been reported from saltwaters. *Keratella cochlearis baltica*, *K. c. recurvispina*, *K. cruciformis* and *K. eichwaldi* are found in marine habitats only. Six other species *(K. americana*, *K. cochlearis*, *K. crassa*, *K. quadrata*, *K. tropica*, *K. valga)* are euryhaline and one *(K. testudo)* is haloxenous.

Genus *Notholca* (Fig. 53)
Fifteen species out of 37 recognized in the genus have been mentioned from saltwaters, with 10 strictly marine (*N. angakkoq*, *N. bipalium*, *N. ikaitophila*, *N. japonica*, *N. j. kisselevi*, *N. liepetterseni*, *N. marina*, *N. pacifica*, *N. psammarina*, *N. squamula salina*). The other species are euryhaline (*N. acuminata*, *N. caudata*, *N. foliacea*, *N. labis*, *N. striata*, *N. s. squamula*, *N. verae*). For the marine *Notholca angakkoq* and *N. ikaitophila*, not included in the keys by Koste (1978) and Koste & Shiel (1987), see Sørensen (1998) and Sørensen & Kristensen (2000).

Genus *Plationus* (Fig. 55)
Of the genus *Plationus* (3 spp.), the haloxenous *P. patulus* only has been met with in marine habitats.

Genus *Platyias* (Fig. 54)
The euryhaline *Platyias quadricornis* is the only member of the genus (3 spp.) known from marine habitats.

Family Dicranophoridae

De Smet & Pourriot (1997) is the most recent and useful key to all genera and species; recently described marine species not included in the key are mentioned with the genus. Differences between genera in this Family are not easily appreciable, as they are mostly based on trophi shape.

1 Trophi asymmetrical, with unci dissimilar in shape; shafts of unci expanded basally or bifid (Figs. 13, 57). .....*Aspelta*
– Trophi symmetrical (at most teeth on inner margin of rami often unpaired); unci composed of tooth and shaft, never as above. ...2

2 Axis of each ramus composed of subbasal chamber only; basal chambers laterally, appearing lamellar; fulcrum triangular or elongate-triangular in dorsal view (Figs. 14, 59, 60). ..... *Dicranophoroides*
– Axis of each ramus composed of a basal and subbasal chamber; basal chamber fused to subbasal, not appearing lamellar; basal chambers extended apically, longer than subbasal ones; fulcrum plate-shaped in lateral view, rod-like in dorsal view.....3

3 Each uncus hinged at its posterior to ramus as well as to manubrium, forming a triple joint. 4
– Each uncus hinged near its tip or middle, to the tip or middle of ramus; manubrium hinged to uncus or intramalleus, occasionally grasping outer margin of ramus. 5

4 Outer margin of rami with posteriorly directed projection, at the end of which is a joint uniting uncus and manubrium to ramus (Figs. 18, 58). .....*Myersinella*
– Outer margin of rami without posteriorly directed projection; uncus and manubrium hinged to postero-lateral corners of rami (Figs. 17, 65, 66). .....*Erignatha*

5 A well developed intramalleus between uncus and manubrium. 6
– Intramalleus absent and manubrium attached directly to uncus, or intramalleus very thin and inconspicuous. 8

6 Body broadly ovate, strongly flattened dorsoventrally (Fig. 69). ..... *Wigrella*
– Body otherwise. 7

7 Foot long, usually ¼-⅓ total length; toes rod-shaped, tips rounded (Fig. 68).. *Wierzejskiella*
– Foot equal or shorter than ⅕ total length; toes tapering to ± acute tips (Figs. 15, 63, 64)..... .....*Encentrum*

8 Body very stout, pyriform, distally rounded; body with deep transverse and longitudinal furrows; integument sticky, usually covered with detritus. Foot rudimentary, usually displaced ventrally. Toes short, slender, acutely pointed. Preuncinal teeth or subunci present (Fig. 67). ..... *Paradicranophorus*
– Body fusiform or cylindrical, without deep furrows; integument not sticky. Foot usually in line with trunk. Toes variable, from lacking to very long. Preuncinal teeth and subunci absent. 9

9 Corona large, usually ventral or strongly oblique; rostrum conspicuous; usually 2 frontal eyespots. Toes long to very long. Inner margin of rami usually with teeth (Figs. 16, 61, 62). .....*Dicranophorus*
– Corona small, oblique; rostrum minute or absent; eyespots lacking. Toes lacking to minute (Fig. 56). Inner margin of rami without teeth. Endoparasite of brackish water oligochetes. .....*Albertia*

Genus *Albertia* (Fig. 56)
One species, *A. crystallina*, out of 7 is strictly haline and lives as endoparasite in the intestine of the brackish water oligochaete *Paranais litoralis*.

Genus *Aspelta* (Figs. 13, 57)
The 5 strictly haline species, *Aspelta clydona*, *A. europaea*, *A. harringi*, *A. pachida* and *A. reibischi*, out of the about 21 species contained in the genus, are inhabitants of the marine littoral.

Genus *Dicranophoroides* (Figs. 14, 59, 60)
One euryhaline species, *Dicranophoroides caudatus*, out of 4 has been found in inland saline waters.

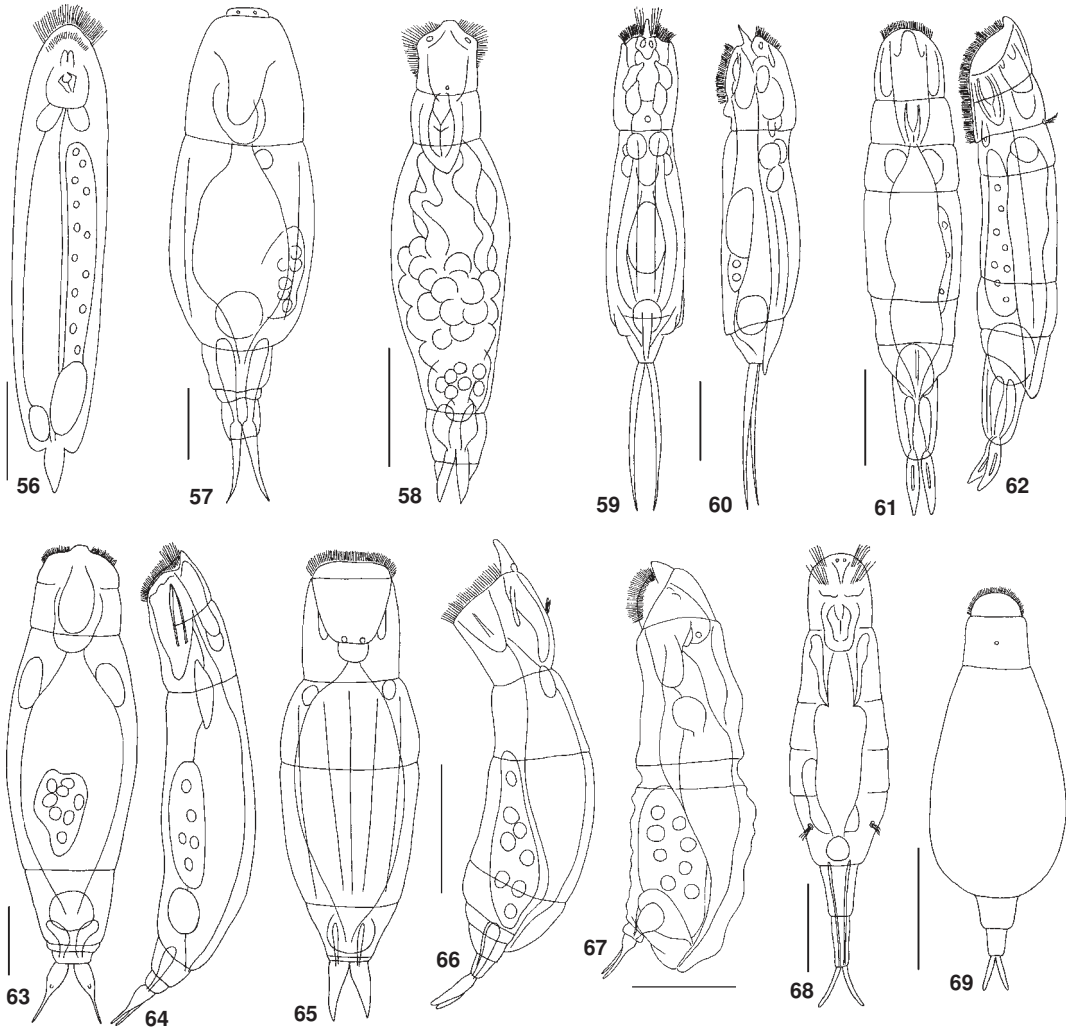
Genus *Dicranophorus* (Figs. 16, 61, 62)
Three species, *D. bulgaricus*, *D. forcipatus* and *D. proclestes,* out of about 50 have been reported from saltwaters; only *D. bulgaricus* is strictly marine.

Genus *Encentrum* (Figs. 15, 63, 64)
This genus is very species-rich, and actually contains about 100, mostly benthic-periphytic and psammophilous species. It is the most species rich marine rotifer genus, with 39 species reported from marine habitats *(Encentrum algente, E. arenarium, E. astridae, E. axi, E. barti, E. bidentatum, E. boddensis, E. cruentum, E. dieteri, E. enteromorphae, E. eristes, E. eulitorale, E. flexile, E. frenoti, E. graingeri, E. incertum, E. kostei, E. lacidum, E. limicola, E. listense, E. listensoides, E. longirostrum, E. matthesi, E. myersi, E. obesum, E. permutandum, E. porsildi, E. psammophilum, E. remanei, E. rousseleti, E. sacculiforme, E. salsum, E. simillimum, E. striatum, E. tectipes, E. tenuidigitatum, E. valkanovi, E. villosum*), and 2 strictly halines from inland saline waters *(E. pachypus, E. salinum)*. Another 7 euryhaline species *(E. glaucum, E. gulo, E. marinum, E. nesites, E. oculatum, E. putorius, E. spatiatum)* and a haloxenous one *(E. mustela)* have been found in inland saline and/or marine waters.

Recent marine species additions not in the key by De Smet & Pourriot (1997): *E. barti*, *E. listensoides*, *E. tenuidigitatum*, *E. frenoti* (De Smet 2000, 2002); *E. kutikovae*, *E. ussuriensis* (De Smet & Chernyshev 2006); *E. porsildi*, *E. astridae* (Sørensen 1998, 2001b).

Genus *Erignatha* (Figs. 17, 65, 66)
Six species are known in the genus, and 2 of them, *E. longidentata* and *E. sagitta*, are strictly marine; another species inquirenda, *E. thienemanni*, has been reported from shore-pools. For the description of *E. longidentata* see Sørensen (2001a).

Genus *Myersinella* (Figs. 18, 58)
The genus is represented by 4 species, 2 of which, *Myersinella uncodonta* and *M. longiforceps*, have been described from Mediterranean psammon (De Smet 2007).



Figs. 56-69. Ploima rotifers, family Dicranophoridae: **56,** *Albertia crystallina*; **57,** *Aspelta europaea*; **58,** *Myersinella uncodonta*; **59,** *Dicranophoroides caudatus*, dorsal; **60,** *D. caudatus*, lateral; **61,** *Dicranophorus bulgaricus*, dorsal; **62,** *D. bulgaricus*, lateral; **63,** *Encentrum algente*, dorsal; **64,** *E. algente*, lateral; **65,** *Erignatha longidentata*, dorsal; **66,** *E. longidentata*, lateral; **67,** *Paradicranophorus sinus*; **68,** *Wierzejskiella marina*; **69,** *Wigrella amphora*. Scale bars = 50 μm.

Genus *Paradicranophorus* (Fig. 67)
Four species, *P. hudsoni*, *P. sinus*, *P. sordidus*, and *P. wesenberglundi*, out of 7 are reported from saltwaters. Of them only *P. sinus* and *P. wesenberglundi* are strictly haline and marine. For descriptions of *P. sinus* and *P. wesenberglundi*, see De Smet (2003) and Sørensen (2001a) respectively.

Genus *Wierzejskiella* (Fig. 68)
Four species out of 8, the strictly haline *Wierzejskiella ambigua*, *W. marina* and *W. subterranea*, and the haloxenous *W. elongata*, are reported from marine habitats.

Genus *Wigrella* (Fig. 69)
One species, *W. amphora*, out of 2 is strictly haline, living in the marine littoral psammon.

Family Epiphanidae

For more information see Ruttner-Kolisko (1974), Koste (1978) and Koste & Shiel (1987).

1 Foot rudimentary, toes lacking. Body elongate cylindrical, with protruding transversal folds (Fig. 72). ..... *Proalides*
– Foot present, toes one or 2. Body conical to sacciform, without protruding transversal folds. 2

2 Corona with large dorsal proboscis bearing 2 eyespots (Fig. 71). ..... *Rhinoglena*
– Dorsal proboscis absent (Fig. 70); single cerebral eyespot..... *Epiphanes*

Genus *Epiphanes* (Fig. 70)
Of this genus (6 spp.), the haloxenous *Epiphanes senta* and the euryhaline *E. macroura* have been reported from inland saline and marine waters respectively.

Genus *Proalides* (Fig. 72)
One species only, *P. tentaculatus*, out of 3 has been reported in brackish water.

Genus *Rhinoglena* (Fig. 71)
Two members of this genus (3 spp.), the strictly haline *Rhinoglena fertoeensis* and the haloxenous *R. frontalis*, have been reported from inland saline waters only.

Family Euchlanidae

For more information see Koste (1978) and Koste & Shiel (1989a).

1 Dorsal and ventral plate connected by a pair of lateral sulci, with stiff flange between (Figs. 77, 78). ..... *Tripleuchlanis*
– Dorsal and ventral plate connected by single lateral sulci. 2
2 Dorsal plate narrower than ventral plate (Figs. 73, 74). ..... *Dipleuchlanis*
– Dorsal plate similar in size or wider than ventral plate (Figs. 75, 76)..... *Euchlanis*

Genus *Dipleuchlanis* (Figs. 73, 74)
The genus contains 3 species inhabiting freshwaters, with *Dipleuchlanis propatula* once found in brackish water.

Genus *Euchlanis* (Figs. 75, 76)
Of this genus containing about 24 species, 2 haloxenous (*Euchlanis deflexa*, *E. incisa*) and 3 euryhaline (*E. dilatata*, *E. lyra*, *E. parva*) species have been found in inland saline and/or marine waters.

Genus *Tripleuchlanis* (Figs. 77, 78)
The sole member of this genus, *Tripleuchlanis plicata*, is an euryhaline element, occurring in both inland saline and marine habitats.

Family Gastropodidae

Radwan & Bielanska-Grajner (2002) give pictures and keys for all species in the two genera.

1 Foot present, ventral, with one or two toes. Trunk weakly compressed laterally (Fig. 81). ..... *Gastropus*
– Foot absent (Fig. 80). Body weakly flattened dorso-ventrally, 1-4 dark brown defecation reservoirs..... *Ascomorpha*

Genus *Ascomorpha* (Fig. 80)
Three euryhaline species, *A. ecaudis*, *A. ovalis* and *A. saltans*, out of 8 in the genus have been reported in marine and inland saline waters.

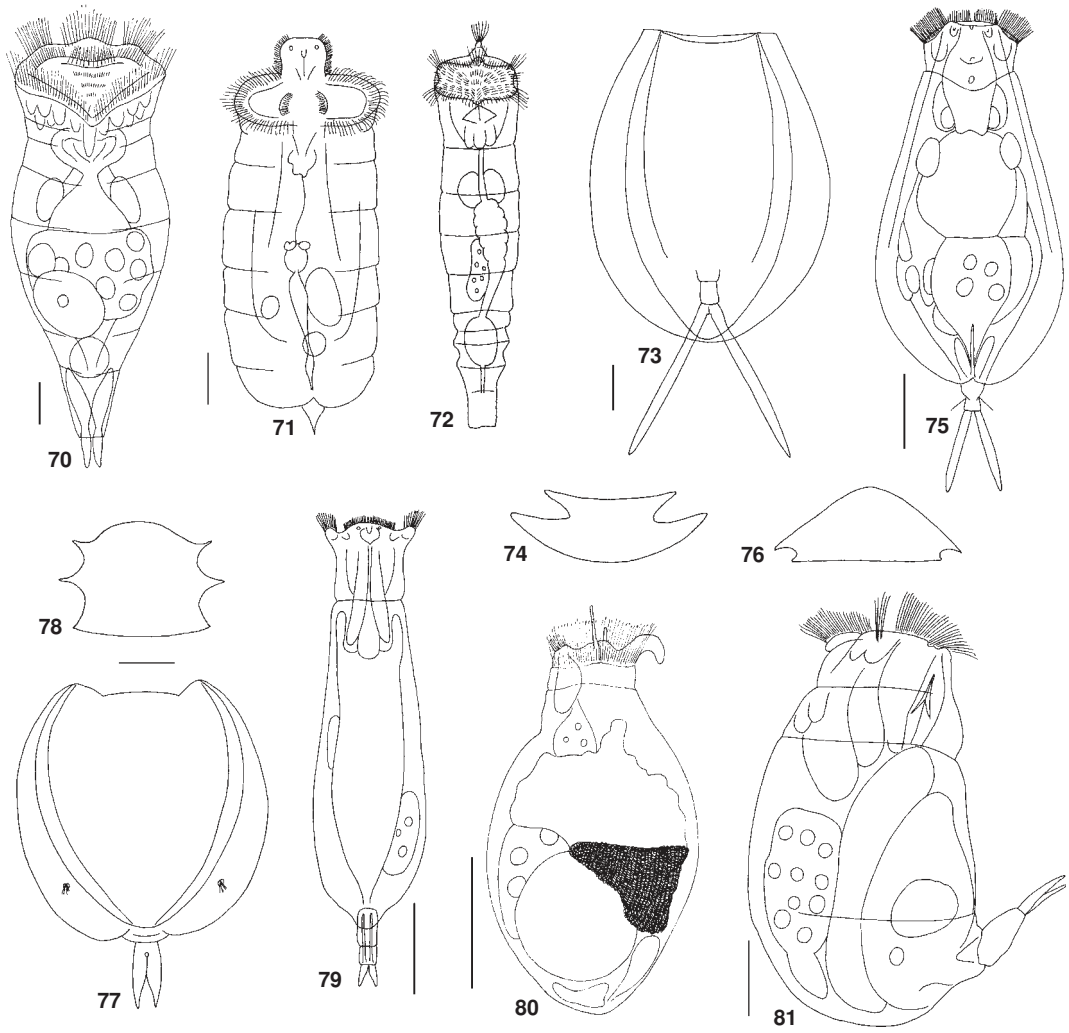
Genus *Gastropus* (Fig. 81)
Two freshwater species, *G. hyptopus* and *G. stylifer*, have been reported from inland saltwaters.

Family Ituridae

One genus only, *Itura* (Figs. 19, 79), with 2 freshwater species mentioned from saltwaters: *I. aurita* and *I. myersi*; the former more euryhaline, found also in the sea, while the latter only in inland saltwater. Consult De Smet & Pourriot (1997) for more information and keys to species.

Family Lecanidae

Lecane (Fig. 88) is the only genus in the Family, although very diverse, as more than 200 species are known (Segers, 2007), mostly from benthic-periphytic and interstitial habitats. About 40 of them have been found in saltwaters, and at least 7 (*L. abanica*, *L. althausi*, *L. grandis*, *L. inconspicua*, *L. lamellata*, *L. sinuosa*, and *L. insulaconae* as a new addition (Fontaneto et al., in press)) have been reported as strictly haline, occurring in inland saline and/or marine habitats. Euryhalines: *L. arcuata*, *L. arcula*, *L. bulla*, *L. closterocerca*, *L. cornuta*, *L. flexilis*, *L. galeata*, *L. hastata*, *L. inermis*, *L. intrasinuata*, *L. ligona*, *L. ludwigii*, *L. luna*, *L. lunaris*, *L. nana*, *L. papuana*, *L. paradoxa*, *L. punctata*, *L. quadridentata*, *L. stenroosi*, *L. thalera*; haloxenous species: *L. aspia*, *L. bifurca*, *L. difficilis*, *L. eutarsa*, *L. furcata*, *L. hamata*, *L. muscicola*, *L. paxiana*, *L. psammophila*, *L. pyriformis*, *L. rhytida*, *L. tenuiseta*, *L. ungulata*.



Figs. 70-81. Ploima rotifers: **70,** *Epiphanes senta*; **71,** *Rhinoglena fertoeensis*; **72,** *Proalides tentaculatus*; **73,** *Dipleuchlanis propatula*; **74,** *D. propatula*, cross-section; **75,** *Euchlanis dilatata*; **76,** *E. dilatata*, cross-section; **77,** *Tripleuchlanis plicata*; **78,** *T. plicata*, cross-section; **79,** *Itura aurita*; **80,** *Ascomorpha saltans*; **81,** *Gastropus hyptopus*. Scale bars = 50 µm.

The most comprehensive and recent taxonomic revision of the genus with dichotomous keys and general information is by Segers (1995b).

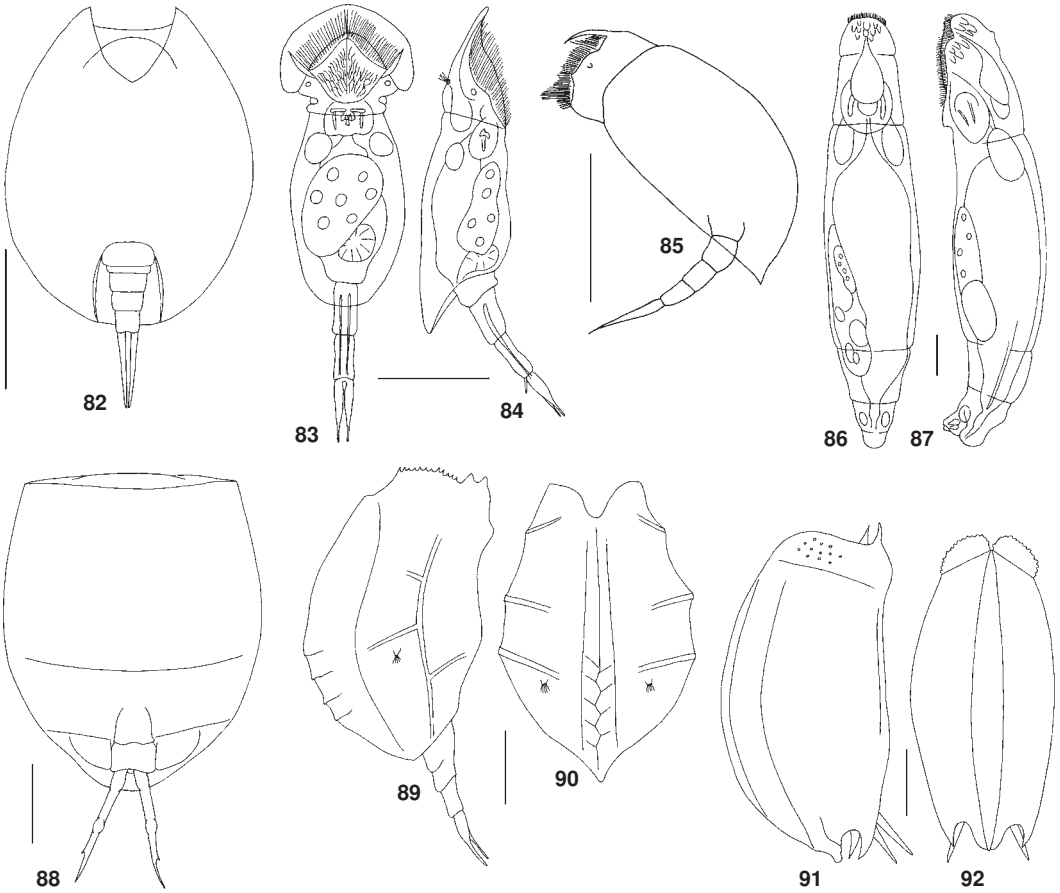
Family Lepadellidae

No recent revision of Lepadellidae available; for more information consult Koste (1978) and Koste & Shiel (1989b).

1 Head covered by non-retractile shield (Figs. 83, 84). ..... *Squatinella*
– Head shield retractile. 2
2 Lorica flattened dorso-ventrally, with anterior head opening and postero-ventral foot opening; sulci absent (Fig. 82). ..... *Lepadella*
– Lorica strongly compressed laterally, continuous dorsally, with sulcus along anterior, ventral and posterior margin; foot emerging from ventral sulcus (Fig. 85). ..... *Colurella*

Genus *Colurella* (Figs. 5, 85)

Fourteen species out of 23 have been found in saltwater. Strictly marine species are *Colurella halophila*, *C. marinovi* and *C. unicauda*; strictly



Figs. 82-92. Ploima rotifers: **82,** *Lepadella patella*; **83,** *Squatinella rostrum*, ventral; **84,** *S. rostrum*, lateral; **85,** *Colurella adriatica*; **86,** *Lindia tecusa*, dorsal; **87,** *L. tecusa*, lateral; **88,** *Lecane grandis*; **89,** *Lophocharis salpina*, lateral; **90,** *L. salpina*, dorsal; **91,** *Mytilina ventralis*, lateral; **92,** *M. ventralis*, dorsal. Scale bars = 50 µm.

halines from inland waters are *C. geophila hallensis*, *C. g. limnetica* and *C. subtilis*. Three species, the euryhaline *C. adriatica* and *C. colurus*, and the strictly haline *C. salina*, are among the most common *Colurella* spp. in both marine and inland saline habitats. The remaining species are euryhaline *(C. dicentra*, *C. obtusa*, *C. uncinata*, *C. anodonta)* occurring in both saltwater types, or haloxenous *(C. ornata)*.

Genus *Lepadella* (Fig. 82)
Fourteen species, out of about 116 species recognized valid, have been reported from saltwater. Two species, *Lepadella pontica* and *L. psammophila*, are strictly marine; *L. duvigneaudi* is a strictly haline from inland waters. The remainder of the species is euryhaline *(L. acuminata*, *L. arabica*, *L. oblonga*, *L. ovalis*, *L. patella*, *L. quadridentata*, *L. triptera)* or haloxenous *(L. amphitropis*, *L. minuta*, *L. rhomboides*, *L. rhomboidula)*.

Genus *Squatinella* (Figs. 83, 84)
A single species, *Squatinella rostrum*, of this freshwater genus (10 spp.) has occasionally been found in saltwaters.

Family Lindiidae

The Family contains one genus only, *Lindia* (Figs. 12, 86, 87), with 16 species. Five of them have been recorded in marine habitats. *Lindia annecta* may be considered haloxenous, *L. torulosa* is euryhaline, and all the others, *L. elsae*, *L. gravitata* and *L. tecusa*, are strictly marine. Consult Segers (2002a) for a revision, taxonomic keys and general information; De Smet (2005a, 2006) added new

species and detailed morphological and ecological information.

Family Mytilinidae

For keys and descriptions see Koste (1978) and Koste & Shiel (1989a).

1 Lorica with longitudinal dorsal sulcus (Figs. 91, 92). ..... *Mytilina*
– Lorica with longitudinal dorsal keel (Figs. 89, 90). ..... *Lophocharis*

Genus *Lophocharis* (Figs. 89, 90)
Four species of *Lophocharis*, out of the 11, have been recorded in saltwater; *Lophocharis ambidentata* is strictly marine, whereas the others *(L. najas*, *L. oxysternon*, *L. salpina)* are euryhaline.

Genus *Mytilina* (Figs. 91, 92)
Four euryhaline taxa, *M. mucronata*, *M. ventralis*, *M. v. brevispina*, and *M. videns*, out of the 14 in the genus, have been reported from benthic-periphytic saltwater habitats.

Family Notommatidae

Out of 19 genera in the Family, 6 may occur in saltwater. Only *Pleurotrocha atlantica* and three species of *Cephalodella* are considered strictly haline; all other species reported are euryhaline. The most comprehensive and recent taxonomic revision of the Family is by Nogrady et al. (1995), from which we modified the following dichotomous key to the genera found in saltwater, and the consultation of which we recommend for species identification.

1 Toes much longer than trunk, of unequal length (Figs. 93, 94). ..... *Monommata*
– Toes shorter or as long as trunk, of equal length. 2

2 Trunk usually weakly loricate, 3–5 more or less distinct plates separated by shallow sulci (Fig. 95). ..... *Cephalodella*
– Trunk illoricate. 3

3 Two frontal eyes and one cervical eye (Fig. 100). ..... *Eosphora*
– No frontal eyes, cervical eye present or absent. 4

4 Ciliated auricles present; corona ventral (Fig. 96). ..... *Notommata*
– No auricles, in place often a ciliary tuft; corona frontal or oblique frontal. 5

5 Salivary glands symmetrical (Figs. 97, 98). ..... *Pleurotrocha*
– Salivary glands usually asymmetrical or rudimentary (Fig. 99). ..... *Resticula*

Genus *Cephalodella* (Figs. 8, 95)
More than 20 species out of about 200 have been reported from saltwater; three of them are considered strictly haline, with *C. marina* living in marine habitats, and *C. gisleni* and *C. mineri* only known from inland saline waters. All other species are euryhaline (*C. auriculata, C. catellina, C. delicata, C. fluviatilis, C. gibba, C. globata, C. gracilis, C. hoodi, C. megalocephala, C. obvia, C. pentaplax, C. stenroosi*) or haloxenous (*C. forficata, C. forficula, C. pachydactyla, C. sterea, C. tenuiseta, C. ventripes)*.

Genus *Eosphora* (Fig. 100)
Two euryhaline species, *E. ehrenbergi* and *E. najas*, out of 7 in the genus, have been repeatedly reported from saltwaters.

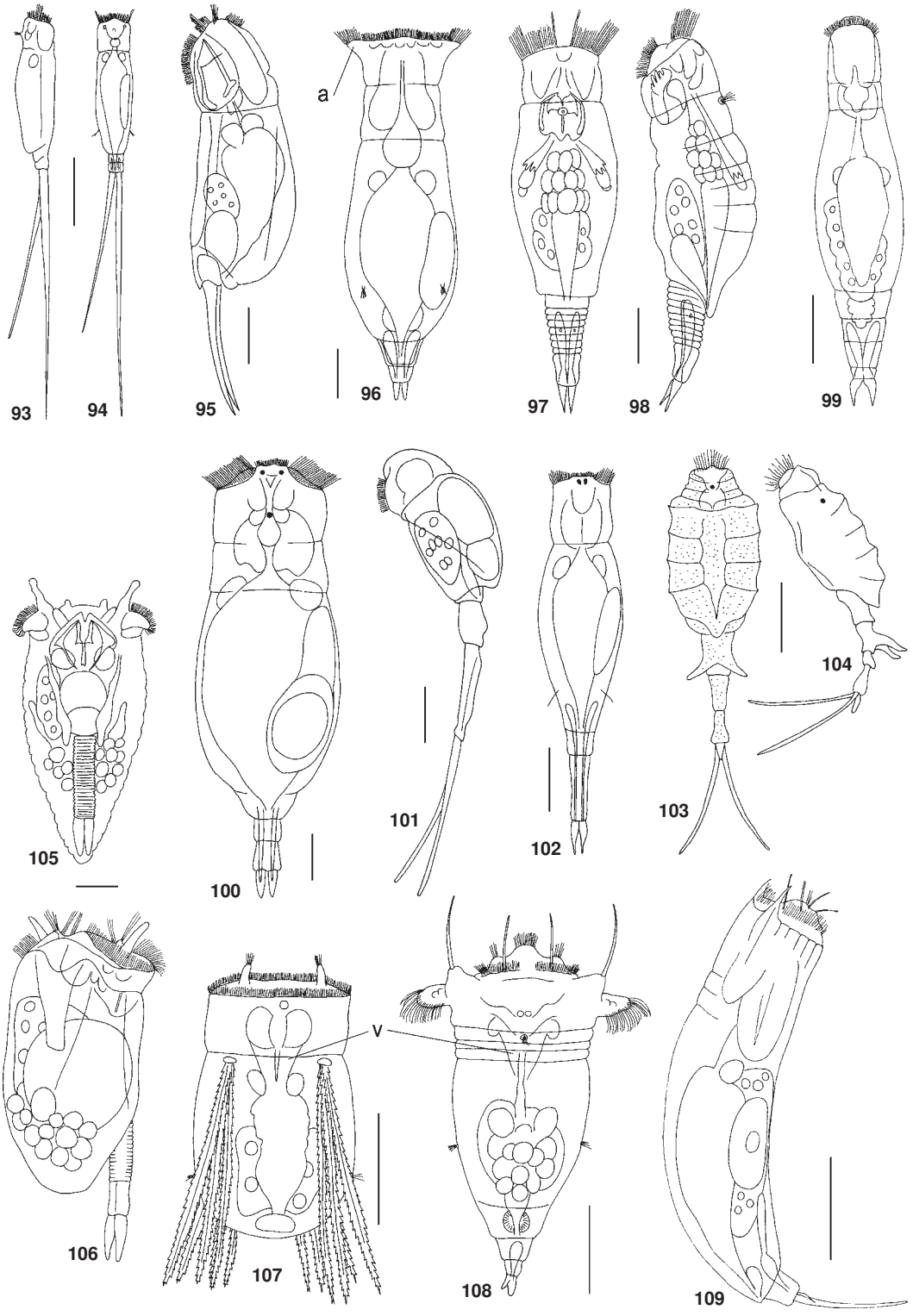
Genus *Monommata* (Figs. 93, 94)
Three freshwater species, *M. dentata*, *M. grandis* and *M. longiseta*, out of 18 in the genus, have been occasionally found in inland saltwater.

Genus *Notommata* (Fig. 96)
Three freshwater species, *N. aurita*, *N. cyrtopus* and *N. glyphura*, out of 45, have been occasionally found in saltwaters.

Genus *Pleurotrocha* (Figs. 9, 97, 98)
Two species out of 9 are known to occur in saltwater: *P. atlantica* is strictly haline and reported from marine habitats only, whereas *P. petromyzon* is an euryhaline inhabitant of inland saltwaters.

Genus *Resticula* (Fig. 99)
Only one freshwater species, *R. melandocus*, out of 7 has been occasionally found in inland saltwater.

Figs. 93-109. Ploima rotifers: **93,** *Monommata longiseta*, lateral; **94,** *M. longiseta,* dorsal; **95,** *Cephalodella gibba*; ▷ **96,** *Notommata aurita*; **97,** *Pleurotrocha atlantica*, dorsal; **98,** *P. atlantica*, lateral; **99,** *Resticula melandocus*; **100,** *Eosphora ehrenbergi*; **101,** *Scaridium longicaudum*; **102,** *Proales reinhardti*; **103,** *Trichotria pocillum*, dorsal; **104,** *T. pocillum*, lateral; **105,** *Ploesoma hudsoni*, ventral; **106,** *P. hudsoni*, lateral; **107,** *Polyarthra remata*; **108,** *Synchaeta neapolitana*; **109,** *Trichocerca marina*. Scale bars = 50 µm. **a**, auricle; **v**, V-shaped hypopharynx muscle.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Family Proalidae

Out of the 4 genera in the Family, only *Proales* (Figs. 4, 102) has representatives in saltwater. Seventeen valid species (out of 43) are known to live in saltwater habitats. *Proales commutata*, *P. germanica*, *P. halophila*, *P. litoralis*, *P. oculata*, *P. reinhardti*, *P. similis* are strictly marine and often common in marine benthos and psammon, and among periphyton; *P. paguri* lives on the marine hermit crab *Pagurus bernhardus* and feeds on the epithelial cells of the gills; *P. christinae* and *P. gonothyraeae* are commensal/ectoparasitic epizoics of marine hydroids. Some haloxenous *(P. decipiens*, *P. fallaciosa*, *P. werneckii)* and euryhaline species *(P. globulifera*, *P. minima*, *P. theodora)* have also been reported from saltwaters. The most recent taxonomic revision with keys to the species and general information is De Smet (1996a); for the benthic-periphytic *P. litoralis* not included in the key, see De Smet (1996b).

Family Scaridiidae

One genus only, *Scaridium*, with 7 species, one of which, *S. longicaudum* (Fig. 101), has been reported as haloxenous element in inland saltwater. For a taxonomic revision of the Family, with dichotomous keys and general information consult Nogrady et al. (1995) and Segers (1995a).

Family Synchaetidae

For a recent review of the Family, and keys to genera and species, see Hollowday (2002).

1 Body loricate. Foot ventral (Figs. 105, 106)..... *Ploesoma*
– Body illoricate. Foot caudal, or absent. 2

2 Body conical, bell- or vase-shaped; head usually wider than trunk, with lateral auricles and sensory setae. Foot rudimentary to long and slender, with one or two small toes (Fig. 108)..... *Synchaeta*
– Body squared or rectangular in dorsal view, dorsoventrally compressed, with 4 bundles of blade-shaped appendages. Foot absent (Fig. 107)..... *Polyarthra*

Genus *Ploesoma* (Figs. 105, 106)
Three euryhaline species *(Ploesoma hudsoni*, *P. lenticulare*, *P. truncatum)* out of 8 are known to occur in saltwater.

Genus *Polyarthra* (Fig. 107)
Three freshwater species of this genus *(Polyarthra dolichoptera*, *P. remata*, *P. vulgaris)*, out of 17, have been recorded frequently also in saltwater.

Genus *Synchaeta* (Fig. 108)
This is one of the most diverse rotifer genera of the saltwater plankton: 31 taxa out of about 41 are strictly haline or euryhaline. The huge majority (22 spp.) of the strictly halines is marine *(Synchaeta arcifera*, *S. atlantica*, *S. bacillifera*, *S. baltica*, *S. bicornis*, *S. cecilia*, *S. curvata*, *S. fennica*, *S. glacialis*, *S. grimpei*, *S. gyrina*, *S. hutchingsi*, *S. hyperborea*, *S. johanseni*, *S. monopus*, *S. neapolitana*, *S. pontica*, *S. rousseleti*, *S. squamadigitata*, *S. tamara*, *S. triophthalma*, *S. vorax)*, or inland saline *(S. cylindrica)* and as well as marine *(S. elsteri)*. Seven more euryhalines were reported from marine habitats, and to a lesser extent also from inland saline waters *(S. kitina*, *S. littoralis*, *S. oblonga*, *S. pectinata*, *S. stylata*, *S. tavina*, *S. tremula)*.

For a recent taxonomic review of the genus and useful keys, consult Hollowday (2002); Rougier et al. (2000) and De Smet (2006) provide aditional details and a new species *(S. squamadigitata)*.

Family Trichocercidae

Only one of the 3 genera of the Family, *Trichocerca* (Figs. 7, 109), occurs in saltwater, with 20 species out of about 105. Almost half of them are plankonic and half are benthic. *Trichocerca marina* (and the maybe synonymous sp. inq. *T. curvata* and *T. henseni*), *T. pediculus* and sp. inq. *T. artmanni* and *T. heterodactyla* are the only strictly marine members. *Trichocerca capucina*, *T. longiseta*, *T. pusilla*, *T. rattus*, *T. ruttneri* and *T. taurocephala* are euryhaline, and *T. brachyura*, *T. cavia*, *T. insignis*, *T. obtusidens*, *T. porcellus*, *T. rousseleti*, *T. stylata* and *T. tenuior* are freshwater representatives, occasionally found in saltwaters.

The most useful taxonomic revision is still Koste (1978), although Segers (2003) has to be considered.

Family Trichotriidae

Only one of the 3 genera in the Family, *Trichotria* containing 12 species (Figs. 103, 104), has haline records, with 2 freshwater species *(T. pocillum*, *T. tetractis)* reported in saltwater as haloxenous. Koste (1978) and Koste & Shiel (1989a) provide keys and species descriptions.

Acknowledgements

We wish to thank Antonio Todaro for inviting us to write this key. Many thanks to two anonymous reviewers for their helpful comments.

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Biodiversity, morphology and ecology of small benthic organisms

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Volume 16

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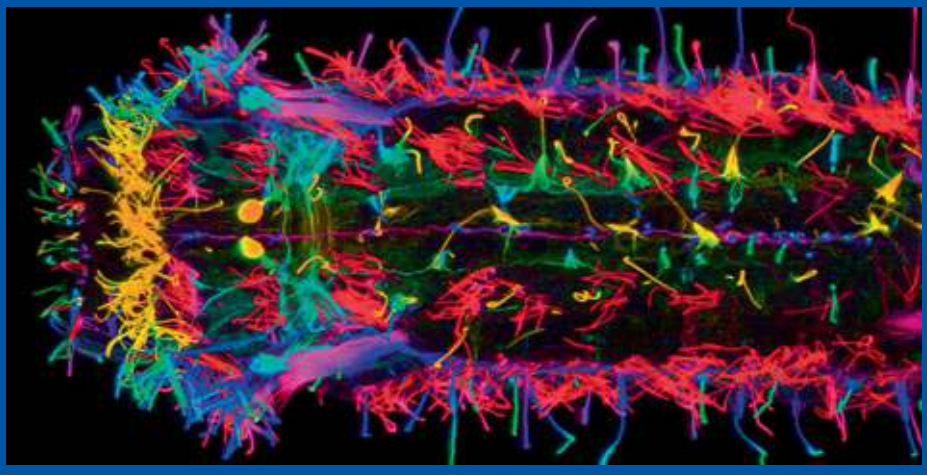

ISSN 1611-7557