

Mediterranean Rotifers: a very inconspicuous taxon

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SUMMARY

Occurrence of rotifer species in the sea is here reviewed, with emphasis on the Mediterranean Sea. Most of the few investigations dealt with rotifer species in Arctic and Antarctic Seas and along Northern European coasts, while Mediterranean area has received very little attention. Despite the few studies, one hundred five rotifers are reported as strictly marine, of these only 20 are signaled in the Mediterranean Sea. The species number is doubled if the freshwater rotifers that are occasionally found in the sea are added. Reasonably, the short list of rotifers from the Mediterranean is to be ascribed to the very few studies carried out and not to absence of rotifers in the area.

ROTIFERS

Phylum Rotifera comprises 1800 species of microscopic metazoans (80-2000µm in length) divided into three major groups: Monogononta (~1450 species), Bdelloidea (~350) and Seisonidea (2) (Segers, 2002). They are characterized by short life cycle and direct development, most are filter-feeders, some are predators and few live as parasites. The three groups differ because of their reproduction. Seisonids are always amphimictic, with sex ratio 1:1, and monogononts punctuate thelytokous parthenogenesis (producing females) with arrhenotokous parthenogenesis (producing males) and subsequent sexual reproduction. Mating produces a diploid egg with delayed development, called resting egg; however, among most monogonont species only females are known so far. Bdelloids consist of parthenogenetic females only (Mark Welch and Meselson, 2000).

Monogononts live in aquatic habitats like rivers, lakes, ponds, temporary and permanent pools, lagoons and seas, and very few can live in the water films around soil particles (Nogrady et al., 1993). Bdelloids are commonly part of the meiofauna of any habitat where water is occasionally present, thus they can be found in rivers, lakes, ponds, but also among soil particles, and in mosses and lichens (Donner,

1965), and almost all of them can escape unfavorable periods entering anhydrobiosis (Ricci, 2001). Seisonids are exclusively marine (Ricci et al., 1993).

MARINE ROTIFERS

Only 105 rotifer species, belonging to 22 genera, are exclusively marine. Ninety species more, that are used to dwell in freshwaters, have been found in marine habitat too, near river estuaries or in brackish waters.

Among the strictly marine species we can list the two seisonids, *Seison annulatus* and *S. nebaliae*, epizoic on the leptostracan crustaceans *Nebalia* (Ricci et al., 1993), and one bdelloid, *Zelinkiella synaptae*, epibiont on olothuroids (*Leptosynapta* sp.pl.) and on the polychete *Amphitrite gracilis* (di Milia, 1962). The large majority of species, as many as 102, belong to the Monogononta group. Among them, 35 species belong to genus *Encentrum* (Dicranophoridae) and 11 to *Proales* (Proalidae); both genera include benthic and interstitial species. Planktonic are the 18 species of genus *Synchaeta* (Synchaetidae) and 7 of *Notholca* (Brachionidae) (Tab. I).

Tab. I - Number of marine rotifer species distinguished into genera. The total number of species of each genus is given, as well as the percentage of the marine species.

Genus	family	marine species	species total	%
Monogononta				
<i>Brachionus</i> Pallas, 1766	Brachionidae	1	55	1,8
<i>Keratella</i> Bory de St. Vincent, 1822	Brachionidae	3	45	6,7
<i>Notholca</i> Gosse, 1886	Brachionidae	7	40	17,5
<i>Albertia</i> Dujardin, 1838	Dicranophoridae	1	7	14,3
<i>Aspelta</i> Harring & Myers, 1928	Dicranophoridae	5	21	23,8
<i>Dicranophorus</i> Nitzsch, 1827	Dicranophoridae	1	50	2,0
<i>Encentrum</i> Ehrenberg, 1838	Dicranophoridae	35	100	35,0
<i>Erignatha</i> Harring & Myers, 1928	Dicranophoridae	2	5	40,0
<i>Paradicranophorus</i> Wiszniewski, 1929	Dicranophoridae	1	5	20,0
<i>Wierzejskiella</i> Wiszniewski, 1934	Dicranophoridae	2	8	25,0
<i>Wigrella</i> Wiszniewski, 1932	Dicranophoridae	1	2	50,0
<i>Lecane</i> Nitzsch, 1827	Lecanidae	4	170	2,4
<i>Colurella</i> Bory de St. Vincent, 1824	Lepadellidae	2	20	10,0
<i>Lindia</i> Dujardin, 1841	Lindiidae	1	14	7,1
<i>Cephalodella</i> Bory de St. Vincent, 1826	Notommatidae	4	190	2,1
<i>Pleurotrocha</i> Ehrenberg, 1830	Notommatidae	1	6	16,7
<i>Proales</i> Gosse, 1886	Proalidae	11	42	26,2
<i>Synchaeta</i> Ehrenberg, 1832	Synchaetidae	18	38	47,4
<i>Testudinella</i> Bory de St. Vincent, 1826	Testudinellidae	1	40	2,5
<i>Trichocerca</i> Lamarck, 1801	Trichocercidae	1	75	1,3
Bdelloidea				
<i>Zelinkiella</i> Harring, 1913	Philodinidae	1	1	100,0
Seisonidea				
<i>Seison</i> Grube, 1859	Seisonidae	2	2	100,0

Marine, but mainly from brackish water, is *Brachionus plicatilis*, a complex species that is possibly made of 9 different taxa (Gomez et al., 2002).

On the whole, only 6% of rotifer species are strictly marine; so far 17% of the genera and 35% of the families have representatives in the sea. These percentages can be increased if we add the number of euryhaline species (Fig. 1). These figures are high if related to the very few studies carried out on marine rotifers, and to the few rotifer students who have sampled few areas. Only the seas in the Arctic and Antarctica, the North and Baltic Sea, the coasts along Scandinavia,

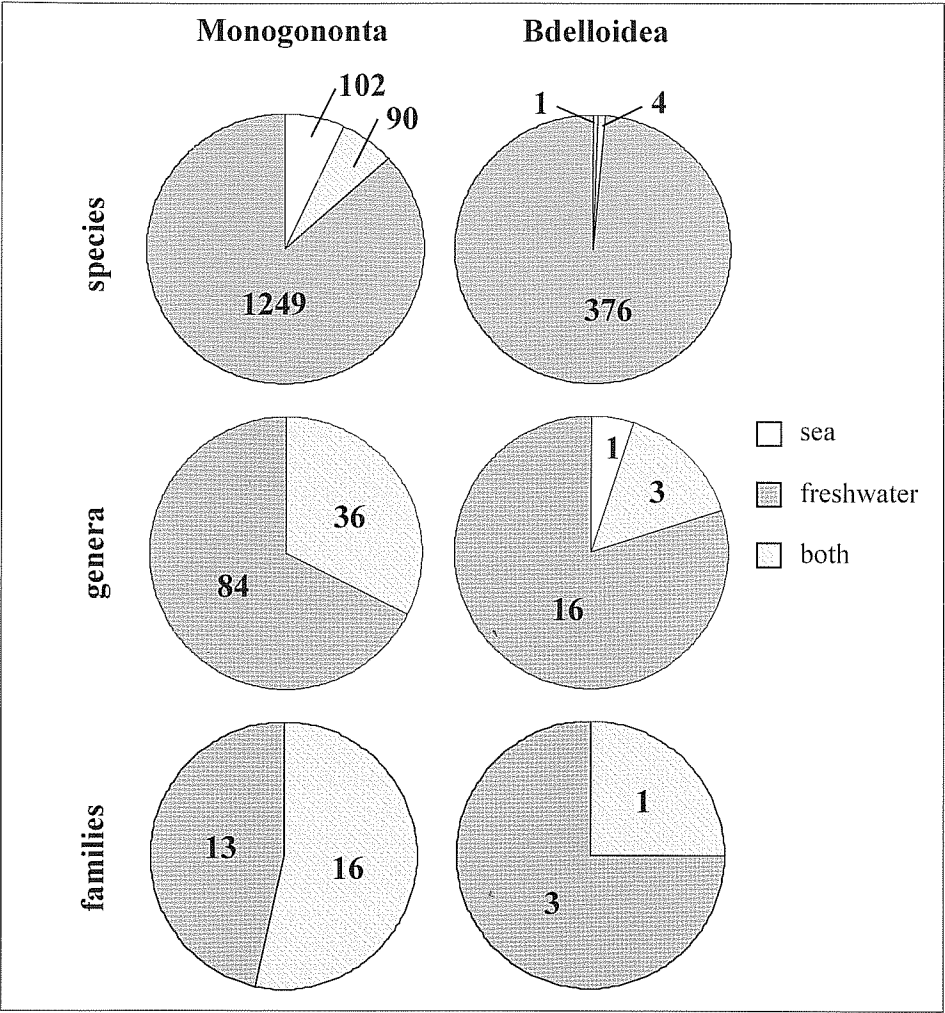


Fig. 1 - Number of species, genera and families of monogonont and bdelloid rotifers occurring exclusively in the sea, exclusively in the freshwater, and in both habitats.

Greenland, Florida and, to a lesser extent, some Mediterranean areas were sampled (Remane, 1929; Turner, 1993; Nogrady et al., 1995; Segers, 1995; De Smet, 1996; de Ridder and Segers, 1997; De Smet and Pourriot, 1997; Saunder-Davies, 1998; Funch and Sørensen, 2001; De Smet, 2002).

MEDITERRANEAN ROTIFERS

Few areas of the Mediterranean sea were sampled in order to studying the rotifers: the shores of Balearic Islands (de Manuel et al., 1992), along Spain (Velasco, 1990), and along Italy (di Milia, 1962; Donner, 1965; Riedl, 1970; Bērziņš, 1978; Ricci et al., 1993; Pati et al., 1999; Rubino et al., 2000). Twenty true marine species were found that belong to 11 genera, scattered among 10 families (Tab. II); twenty additional species can be added that are euryhaline (Tab. III).

DISCUSSION

On the whole, it is evident that marine rotifers are very little known. The very few sampling efforts in the Mediterranean area produced the collection of two

Tab. II - Marine rotifers reported from the Mediterranean.

Species	family
Monogononta	
<i>Brachionus plicatilis</i> O.F. Müller, 1786	Brachionidae
<i>Keratella cruciformis</i> (Thompson, 1892)	Brachionidae
<i>Encentrum villosum</i> Harring & Myers, 1928	Dicranophoridae
<i>Lecane lamellata</i> (Daday, 1893)	Lecanidae
<i>Lecane punctata</i> (Murray, 1913)	Lecanidae
<i>Colurella salina</i> Althaus, 1957	Lepadellidae
<i>Colurella unicauda</i> Eriksen, 1968	Lepadellidae
<i>Pleurotracha atlantica</i> Myers, 1936	Notommatidae
<i>Proales similis</i> de Beauchamp, 1907	Proalidae
<i>Synchaeta fennica</i> Rousselet, 1909	Synchaetidae
<i>Synchaeta grimpei</i> Remane, 1929	Synchaetidae
<i>Synchaeta littoralis</i> Rousselet, 1902	Synchaetidae
<i>Synchaeta monopus</i> Plate, 1889	Synchaetidae
<i>Synchaeta neapolitana</i> Rousselet, 1902	Synchaetidae
<i>Synchaeta triophthalma</i> Lauterborn, 1894	Synchaetidae
<i>Synchaeta vorax</i> Rousselet, 1902	Synchaetidae
<i>Testudinella obscura</i> Althaus, 1957	Testudinellidae
Bdelloidea	
<i>Zelinkyella synaptae</i> (Zelinka, 1887)	Philodinidae
Seisonidea	
<i>Seison annulatus</i> Claus, 1876	Seisonidae
<i>Seison nebaliae</i> Grube, 1861	Seisonidae

Tab. III - Euryhaline rotifers reported from the Mediterranean.

Species	family
Monogononta	
<i>Brachionus calyciflorus</i> Pallas, 1766	Brachionidae
<i>Notholca bipalium</i> (O.F. Müller, 1786)	Brachionidae
<i>Notholca squamula</i> (O.F. Müller, 1786)	Brachionidae
<i>Notholca striata</i> (O.F. Müller, 1786)	Brachionidae
<i>Colurella adriatica</i> Ehrenberg, 1831	Colurellidae
<i>Colurella colurus</i> (Ehrenberg, 1830)	Colurellidae
<i>Enicentrum marinum</i> (Dujardin, 1841)	Dicranophoridae
<i>Hexarthra fennica</i> (Levander, 1892)	Hexarthridae
<i>Lecane ludwigii</i> (Eckstein, 1883)	Lecanidae
<i>Lecane nana</i> (Murray, 1913)	Lecanidae
<i>Lecane paradoxa</i> (Steinecke, 1916)	Lecanidae
<i>Lecane quadridentata</i> (Ehrenberg, 1832)	Lecanidae
<i>Lecane thalera</i> (Harring & Myers, 1926)	Lecanidae
<i>Cephalodella catellina</i> (O.F. Müller, 1786)	Notommatidae
<i>Eosphora ehrenbergi</i> Weber, 1918	Notommatidae
<i>Eosphora najas</i> Ehrenberg, 1830	Notommatidae
<i>Synchaeta kitina</i> Rousselot, 1902	Synchaetidae
<i>Testudinella clypeata</i> (O.F. Müller, 1786)	Testudinellidae
<i>Trichotria pocillum</i> (O.F. Müller, 1776)	Trichotriidae
Bdelloidea	
<i>Rotaria citrina</i> (Ehrenberg, 1838)	Philodinidae

seasonids and one bdelloid, and the scarce records of monogononts are sometime taxonomically uncertain. The only study that explored the rotifer communities was run by de Manuel et al. (1992) and focused to the Balearic archipelago.

In the Mediterranean, the genus *Enicentrum*, that counts 35 marine species worldwide, is represented by one species only, and the genus *Proales*, with 11 marine species, is signaled with one species. Both genera are from benthos and include interstitial animals. In freshwater, the planktonic rotifer species are much better known than the benthic ones and the same can be true for marine rotifers as well. Actually, out of 18 marine species of genus *Synchaeta* as many as 7 are reported in the Mediterranean, and the genus is planktonic.

Due to the problems of rotifer taxonomy, that is based on morphological traits only, it can be argued that the rotifers found in both freshwater and brackish waters, that are attributed to some cosmopolitan taxon, can really belong to cryptic species (Gomez et al., 2002). And the records of freshwater rotifers in salt waters might be due to misidentification, or alternatively to unidentified taxon. Of course we cannot offer any answer, but more detailed investigation could provide some result on this point.

Finally, in contrast with freshwater rotifer biology, nothing is known about rotifer reproductive cycles, dispersal mechanisms, and resting stages in the seas.

Marine resting eggs do exist because *Synchaeta* eggs were sampled in Adriatic benthos (Pati et al., 1999; Rubino et al., 2000). However, cosmopolitism or endemism and dispersal modalities of marine rotifers are still open to speculation.

CONCLUSION

For sure, more focused sampling in the Mediterranean area could greatly improve the poor list of rotifer species we reported. To stress the importance of the contribution of experts, a rotifer investigator (Willem De Smet) collected a small sample of sand during winter 2001-2002 at -51 m, 4 km off Marseille, and found 5 rotifer species, one of them new to science and awaiting for description (De Smet, pers. com.). In contrast, samples of marine benthos collected for extracting other taxa seldom contained rotifers (Curini Galletti, pers. com.; Todaro, pers. com.). This could be due to extraction methods, maybe not appropriate for the rotifers, evidencing that the geographic distribution of 'inconspicuous' taxa reflects the distribution of their students, more than the distribution of the animals!

REFERENCES

- BRZIŃSKI, B. 1978 - Rotatoria. In: J. Illies (ed.), *Limnofauna Europaea*. G. Fischer Verlag, Stuttgart & New York: 54-91.
- DE MANUEL J., PRETUS J.L.L., JAUME D. 1992 - Rotifers from the Balearic Archipelago. *Hydrobiologia*, 239: 33-41.
- DE RIDDER M., SEGERS H. 1997 - Monogonont Rotifera recorded in the World literature (except Africa) from 1960 to 1992. *Studiedocumenten van het Koninklijk Belgisch Instituut voor Natuurwetenschappen*, Bruxelles, 481 pp.
- DE SMET W.H. 1996 - Rotifera. Vol. 4: The Proalidae (Monogononta). In: H.J.F. Dumont (ed.), *Guides to the identification of the microinvertebrates of the continental waters of the world 9*. SPB Academic Publishing bv, The Hague, The Netherlands, 102 pp.
- DE SMET W.H. 2002 - Marine Rotifera from the Crozet and Kerguelen Islands (Subantarctica), with the description of a new Enicentrum (Monogononta: Dicranophoridae). *Int. Rev. Hydrobiol.*, 87: 411-422.
- DE SMET W.H., POURRIOT R. 1997 - Rotifera. Vol. 5: The Dicranophoridae and the Ituridae (Monogononta). In: H.J.F. Dumont (ed.), *Guides to the identification of the microinvertebrates of the continental waters of the world 9*. SPB Academic Publishing bv, The Hague, The Netherlands, 325 pp.
- DI MILIA A. 1962 - Il rotifero *Zelinkella synaptae* (Zelinka) sopra un nuovo ospite nelle acque livornesi. *Arti Soc. Tosc. Sc. Nat. serie B*, 69: 106-110.
- DONNER J. 1965 - Ordnung Bdelloidea (Rotifera, Rädertiere). *Akademie Verlag*, Berlin, 297 pp.
- FUNCH P., SØRENSEN M.V. 2001 - Rotifers in saline waters from Disko Island, West Greenland. *Hydrobiologia*, 446/447: 273-282.
- GOMEZ A., SERRA M., CARVALHO G.R., LUNT D.H. 2002 - Speciation in ancient cryptic species complexes: Evidence from the molecular phylogeny of *Brachionus plicatilis* (Rotifera). *Evolution*, 56: 1431-1444.
- MARK WELCH D., MESELMAN M. 2000 - Evidence for the evolution of bdelloid rotifers without sexual reproduction or genetic exchange. *Science*, 288: 1211-1215.
- NOGRADY T., POURRIOT R., SEGERS H. 1995 - Rotifera. Vol 3: The Notommatidae and the Scardiidae. In: H.J.F. Dumont (ed.), *Guides to the identification of the microinvertebrates of the continental waters of the world. Vol 8*. SPB Academic Publishing, The Hague, 248 pp.
- NOGRADY T., WALLACE R.L., SNELL T.W., 1993. Rotifera. Vol I: Biology, Ecology and Systematics. In: H.J.F. Dumont (ed.), *Guides to the identification of the microinvertebrates of the continental waters of the world, 4*. SPB Academic Publishers, The Hague, 142 pp.
- PATI A.C., BELMONTE G., CECCHERELLI V.U., BOERO F. 1999 - The inactive temporary component: an unexplored fraction of meiobenthos. *Mar.Biol.*, 134: 419-427.

- REMANE A. 1929 - Rotatoria. In: G. Grimpe and E. Wagler (eds.), *Die Tierwelt der Nord- und Ostsee*, Leipzig, Akademische Verlagsgesellschaft, vol. 16: 156 pp.
- RICCI C. 2001 - Dormancy patterns in rotifers. *Hydrobiologia*, **446**: 1-11.
- RICCI C., MELONE G., SOTGIA C. 1993 - Old and new data on Seisonidea (Rotifera). *Hydrobiologia*, **255**: 495-511.
- RIEDL R. 1970 - Rotatoria. In: *Fauna und Flora der Adria*. Parey Ed., Hamburg: 220-222.
- RUBINO F., BELMONTE G., MIGLIETTA A.M., GERACI S., BOERO F. 2000 - Resting stages of plankton in recent North Adriatic sediments. *Marine Ecol.*, **21**: 263-286.
- SAUNDERS-DAVIES A. 1998 - Differences in rotifer populations of the littoral and sub-littoral pools of a large marine lagoon. *Hydrobiologia*, **387/388**: 225-230.
- SEGBERD H. 1995 - Rotifera. Vol 2: The Lecanidae (Monogononta). In: H.J.F. Dumont (ed.). *Guides to the identification of the microinvertebrates of the continental waters of the world*. Vol 6. SPB Academic Publishing, The Hague, 226 pp.
- SEGBERD H. 2002 - The nomenclature of the Rotifera: annotated checklist of valid family and genus-group names. *J. Nat. Hist.*, **36**: 631-640.
- TURNER P.N. 1993 - Distribution of rotifers in a Floridian saltwater beach, with a note on rotifer dispersal. *Hydrobiologia*, **255**: 435-439.
- VELASCO J.L. 1990 - Lista faunística y bibliographia de los Rotíferos (Rotatoria) de la Peninsula Iberica e Islas Baleares y Canarias, AEL, Publ., Madrid, vol. 8, 195 pp.
- WALLACE R.L., RICCI C. 2002 - Rotifera. In: S.D. Rundle, A.L. Robertson, J.M. Schmid-Araya (eds.). *Freshwater Meiofauna: Biology and Ecology*. Backhuys Publishers, Leiden, The Netherlands: 15-44.