Hydrobiologia **239**: 33–41, 1992.

Rotifers from the Balearic archipelago

J. De Manuel, J. LL. Pretus & D. Jaume
Departament d'Ecologia. Facultat de Biologia. Universitat de Barcelona. Avg. Diagonal 645, 08028, Barcelona, Spain

Received 25 June 1991; in revised form 20 September 1991; accepted 16 October 1991

Key words: Balearic Islands, zoogeography, community type, checklist, pantropical rotifers

Abstract

Ecological and historical factors of the Balearic archipelago (Western Mediterranean Sea) result is some peculiarities to its rotifer fauna. A group of warm-stenothermous species are frequent seasonally in the islands. Among them the occurrence of *Keratella procurva* (Thorpe, 1912), a pantropical species, is remarkable, and this is found more or less abundantly on each island. We briefly describe the different habitat categories of the archipelago. Clustering the collected species we relate each community type to its habitat; in this sense we distinguish 4 community type in the islands corresponding to different environments. This work also summarizes all the obtainable data on the rotifer fauna of the Balearic archipelago, adding the results of the investigations done in the last survey (spring, 1989); a checklist, including 100 species from the archipelago, is shown (69 Majorca, 72 Minorca, 24 Ibiza, 25 Formentera). Some examples of pantropical distribution are given, and the biotic and abiotic factors which determine the colonization of the islands by these species are discussed.

Introduction

The rotifer fauna from the Mediterranean islands is not well known, in spite of the fact that these islands constitute a transition between the subtropical and the northern areas. The features of the mediterranean climate, the relative isolation from the mainland, and the diversity of habitats, make any investigations on freshwater organisms from the islands fascinating. Zoogeography of rotifers was discussed by (De Ridder, 1981; Dumont, 1983; Shiel *et al.*, 1989); their great passive dispersal potential leads to cosmopolitanism for many species. However, historical and ecological factors restrict the distribution of some rotifers, particularly of the family Brachionidae (Pejler, 1977; Pejler & Berzins, 1989).

This paper summarizes all data obtainable on rotifers from the Balearic islands and adds the results of a survey on Majorca and Minorca in spring 1990. It provides a checklist of the monogonont rotifers of the Balearic archipelago, and describes the assemblages and community types from the different habitat categories of the islands. All the processed data are derived from monographic papers on rotifers (De Manuel, 1990, in press, a, b, c; De Ridder, 1967), and from general or specific works on limnology and hydrobiology (Margalef, 1951, 1952, 1953; Pretus, 1989; Pretus *et al.*, 1990).

The islands and habitat heterogeneity

Figure 1 shows the Balearic archipelago. It is located in the Western Mediterranean Sea, at 40° N, relatively close to the mainland. Geological features are updated in Pomar (1982). In Table 3 some physical parameters of each island are indicated.

Majorca is the largest island of the archipelago. Most of the land is formed by Mesozoic and Cenozoic calcareous rocks, and karstic phenomena are frequent.

Minorca is located in the NE of the archipelago. It is characterized by the heterogeneity of its geological substrata. The South and the Northwestern part are mainly Cenozoic calcareous, and the rest of the island is constituted of Palaeozoic and Mesozoic strata, dominated by slates and sandstones.

Ibiza and Formentera are small islands in the Southwestern Balearic archipelago, relatively closer to the Iberian shores (approximately 100 kms) than the other islands. Their geological substrata, similar to Majorca, are mainly calcareous.

The climate of the archipelago, typically mediterranean, is distinguished by low and irregular rainfalls, following a latitudinal gradient. This fact determines the distribution of the wetlands. On all the islands, the following limnetic environments are relatively abundant:

1. A littoral strip where lagoons are common and the waterbodies usually are brackish and permanent. S'Albufera d'Alcúdia, S'Albufereta

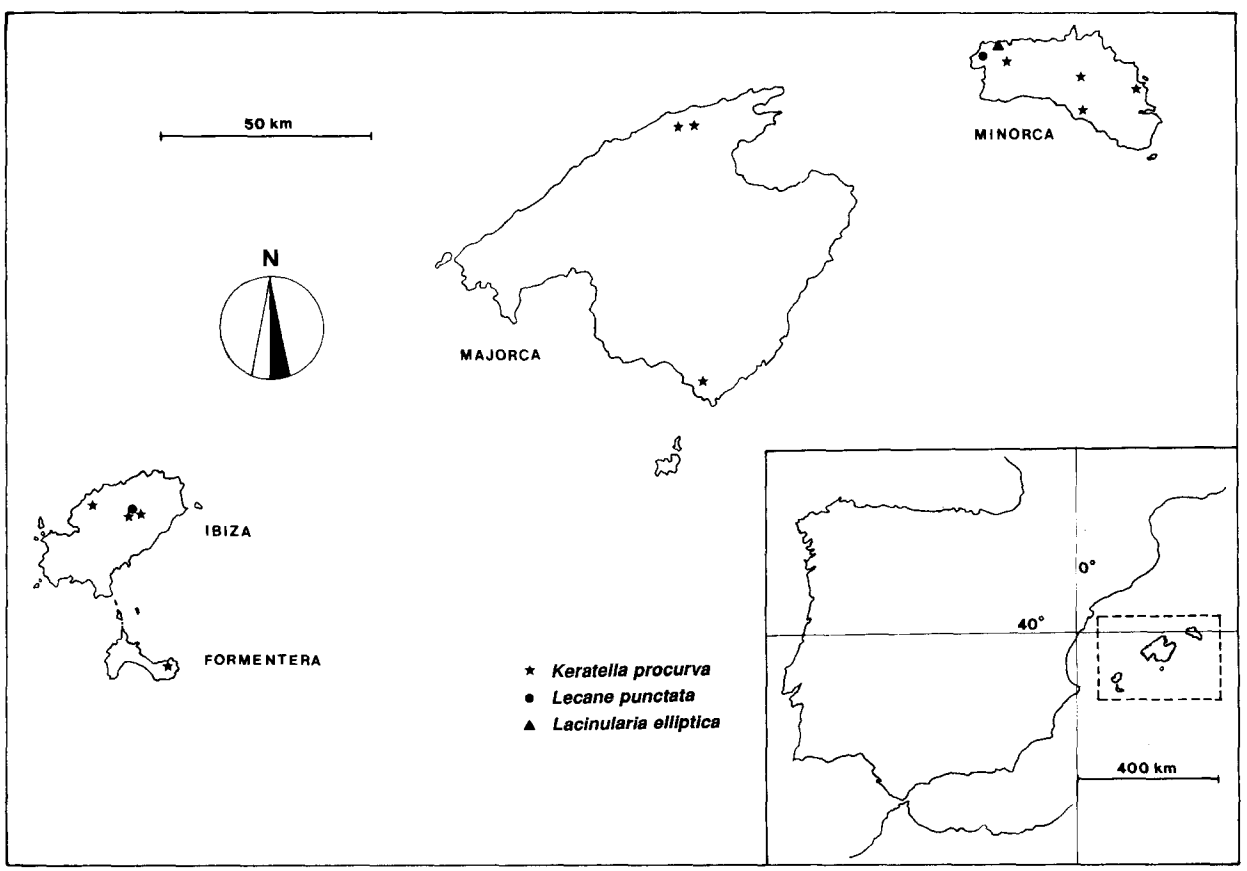

Fig. 1. Map of the Balearic archipelago. The distribution of the pantropical species: *Keratella procurva*, *Lecane punctata* and *Lacinularia elliptica* is shown.

de Pollença are examples from Majorca. S'Albufera des Grau, and Aiguamolls de Son Bou, in Minorca. Ses Salines in Ibiza and S'Estany Pudent in Formentera.

2. Ephemeral ponds. Waterbodies created by precipitation in small endorheic basins. They are common in the islands because of the calcareous substrata. In this sense, the system of pools of Marina de Llucmajor in Majorca and the temporary ponds that settle over red sandstones in the North of Minorca are remarkable.
3. Waterbodies originated by temporary or permanent streams.
4. Man-made waterbodies. Farm-ponds, drinking troughs, little reservoirs and other artificial waters are very common in all the islands.

The mineralization of the water derives from the geological substrata and wind contributions. The latter is responsible for the relatively high level of mineralization by chloride in Minorca (300–400 mg l^{-1} is a common range) whereas in the rest of the islands alkalinity is the main contributor (Pretus, 1991).

Methods

209 samples were studied (76 of Majorca, 91 of Minorca, 20 of Ibiza and 31 of Formentera) from 120 localities (43 of Majorca, 45 of Minorca, 16 of Ibiza and 17 of Formentera). Most of them were collected between April 1986 and May 1990. All the samples were collected with a 45 μm mesh plankton net, and immediately preserved in 4% formaldehyde. Temperature, pH and conductivity were measured. Slides of subsamples were made for observation under HP microscope. Species identifications were done following the taxonomic keys of Koste (1978) and the works of Harring & Myers (1924, 1926).

Cluster analysis for the characterization of community types was performed following Jongman *et al.* (1987), expressing the linkage dendrogram resulting from the Ward's method using the squared euclidean distance (rescaled in the dendrogram of Fig. 2). Data were processed by SPSS (v. 4.0) statistic package.

Results

Assemblages and communities

Table 1 shows all the recorded species from the archipelago. 21 taxa were new records for the Balearic islands. The families Brachionidae (16 spp), Colurellidae (10 spp), Lecanidae (19 spp) and Notommatidae (14 spp) were widely represented and distributed through the archipelago.

Table 1. Rotifers identified in the Balearic islands (M, Majorca; Mi; Minorca; I, Ibiza; F, Formentera). * new records for the Balearic archipelago.

Species	M	Mi	I	F
Anuraeopsis fissa Gosse, 1851	+	+	+	
Ascomorpha saltans Bartsch, 1870	+			
Brachionus angularis Gosse, 1851	+	+		+
B. bidentatus f. testudinarius (Jakubski, 1912)	+	+		
B. calyciflorus Pallas, 1776	+	+		
B. nilsoni Ahlstrom, 1940		+		
B. plicatilis Müller, 1786	+	+		+
B. quadridentatus Hermann, 1873	+	+		+
B. rubens Ehrenberg, 1838	+			
B. urceolaris (Müller, 1773)	+	+	+	+
Cephalodella auriculata (Müller, 1773)	+	+		
C. catellina (Müller, 1776)	+	+		+
C. forficata Ehrenberg, 1832*	+			
C. forficula (Ehrenberg, 1838)	+	+		
C. gibba (Ehrenberg, 1838)	+	+	+	+
C. gracilis (Ehrenberg, 1831)			+	+
C. innesi Myers, 1924				+
C. intuta Myers, 1924*	+			
C. megalocephala (Glasscott, 1893)	+			
C. stenroosi (Wulfert, 1937)	+			
C. sterea (Gosse, 1887)*	+			
C. ventripes Dixon-Nuttall, 1901		+		
Collotheca pelagica (Rousselet, 1893)	+			
Colurella adriatica Ehrenberg, 1831	+	+	+	+
C. colurus (Ehrenberg, 1830)	+	+	+	
C. halophila Wulfert, 1942	+			
C. obtusa (Gosse, 1886)	+	+	+	
C. uncinata Müller, 1773		+		
Dicranophorus epicharis (Harring & Myers, 1928)	+			
Encentrum marinum Dujardin, 1841		+		
Eosphora najas Ehrenberg, 1830	+	+		
E. ehrenbergi Weber, 1918	+			
Epiphanes clavulata (Ehrenberg, 1832)*	+			
E. macrourus (Barrois & Daday, 1894)	+			

Table 1. (Continued)

Species	M	Mi	I	F
E. senta (Müller, 1773)*	+	+		
Euchlanis dilatata (Ehrenberg, 1832)	+	+		
Filinia longiseta (Ehrenberg, 1824)	+	+		
Hexarthra fennica Levander, 1892	+	+	+	+
H. mira (Hudson, 1871)	+	+		+
Hexarthra oxyuris (Sernov, 1903)		+		
Keratella procurva (Thorpe, 1912)	+	+	+	+
K. quadrata (Müller, 1786)	+	+		
Lacinularia elliptica Shephard, 1879		+		
Lecane (M.) bifurca (Bryce, 1892)		+		
L. (M.) bulla (Gosse, 1886)	+	+	+	
L. (M.) closterocerca Schmarda, 1859	+	+	+	+
L. (L.) flexilis (Gosse, 1886)*		+		
L. (M.) furcata Murray, 1913	+	+		
L. (M.) hamata Stokes, 1896	+	+	+	
L. (L.) hastata (Murray, 1913)	+	+		
L. (M.) inopinata (Harring & Myers, 1926)	+		+	
L. (M.) lamellata Daday, 1893	+			+
L. (L.) luna (Müller, 1776)	+	+	+	
L. (M.) lunaris Ehrenberg, 1832	+	+	+	
L. (L.) margalefi De Manuel, in prep.*	+			
L. (L.) nana (Murray, 1913)		+	+	+
L. (L.) ohioensis (Herrick, 1885		+		
L. (M.) punctata (Murray, 1913)		+	+	
L. (M.) pyriformis Daday, 1905		+		
L. (M.) quadridentata (Ehrenbertg, 1832)	+	+		
L. (L.) rotundata (Oloffson, 1918)*	+			
L. (L.) tenuiseta Harring, 1914*		+		
Lepadella patella (Müller, 1786)	+	+	+	+
L. ovalis (Müller, 1786)	+	+		
L. rhomboides (Gosse, 1886)	+	+		+
L. triptera (Ehrenberg, 1830)	+	+	+	+
Lophocharis salpina Ehrenberg, 1834	+	+		
Monommata dentata Wulfert, 1940*		+		
Mytilina ventralis (Ehrenberg, 1832)		+		
Notholca acuminata Ehrenberg, 1832*	+			
N. bipalium (Müller, 1786)		+		
N. salina (Focke, 1961)*	+			
N. squamula (Müller, 1786)	+	+		+
N. striata (Müller, 1786)	+			
Pleurotrocha petromyzon Ehrenberg, 1830*	+			
Polyarthra dolichoptera Idelson, 1925	+	+		
P. remata (Skorikov, 1846)		+		
P. vulgaris Carlin, 1943	+			+
Proales decipiens Ehrenberg, 1831*		+		
P. fallaciosa Wulfert, 1937*		+		
P. reinhardti (Ehrenberg, 1834)		+		
P. sigmoidea (Skorikov, 1896)		+		
P. similis De Beauchamp, 1908*		+		
Rhinoglena frontalis Ehrenberg, 1853*		+		
Squatinella mutica Ehrenberg, 1832*		+		

Table 1. (Continued)

Species	M	Mi	I	F
Synchaeta kitina Rousselet, 1902		+		
S. oblonga Ehrenberg, 1831	+	+	+	+
S. pectinata Ehrenberg, 1832	+			
Testudinella clypeata (Müller, 1786)	+	+	+	
T. patina (Hermann, 1783)	+	+	+	+
Trichocerca intermedia (Stenroos, 1898)		+	+	
T. musculus Hauer, 1935		+		
T. pusilla (Lauterborn, 1898)	+	+	+	
T. rattus (Müller, 1776)	+	+		+
T. similis (Wierzejsky, 1893)*	+			
T. stylata (Gosse, 1851)*		+		
T. weberi Jennings, 1903	+			+
Trichotria pocillum (Müller, 1776)	+	+		
T. tetractis Ehrenberg, 1830	+			
Tripleuchlanis plicata (Levander, 1894)*		+		

We clustered 100 samples belonging to different localities of the studied islands. Figure 2 shows a fraction of the data set. We differentiated 4 rotifer communities in the archipelago, associated with the habitat categories mentioned above:

1. A well-defined community from the coastal strips, comprising *Brachionus plicatilis Hexarthra fennica, Synchaeta kitina, Colurella colurus* and *Colurella adriatica* in pelagic environments, and *Testudinella clypeata, Cephalodella catellina, Lecane ohioensis, Testudinella patina* and *Notholca squamula* in the littoral edges among macrophytes. Some uncommon species were collected occasionally in abundance, *Hexarthra oxyuris* or *Lecane lamellata* in plankton; others were rare and scanty: *Notholca bipalium, N. salina, Proales reinhardti, Encentrum marinum, Eosphora najas* and *E. ehrenbergi*. Figure 2 shows some rotifers from the Albufera *des* Grau (Minorca).

In this community type, salinity (from marine origin), was the principal determinant of the rotifer populations. In the dendrogram (Fig. 4), localities belonging to coastal lagoons (CL) and littoral strip ponds (LP), were segregated according to their rotifer communities.

2. Another community type was defined by the rotifers from the ephemeral ponds. The ponds were all small and shallow. A large heteroge-

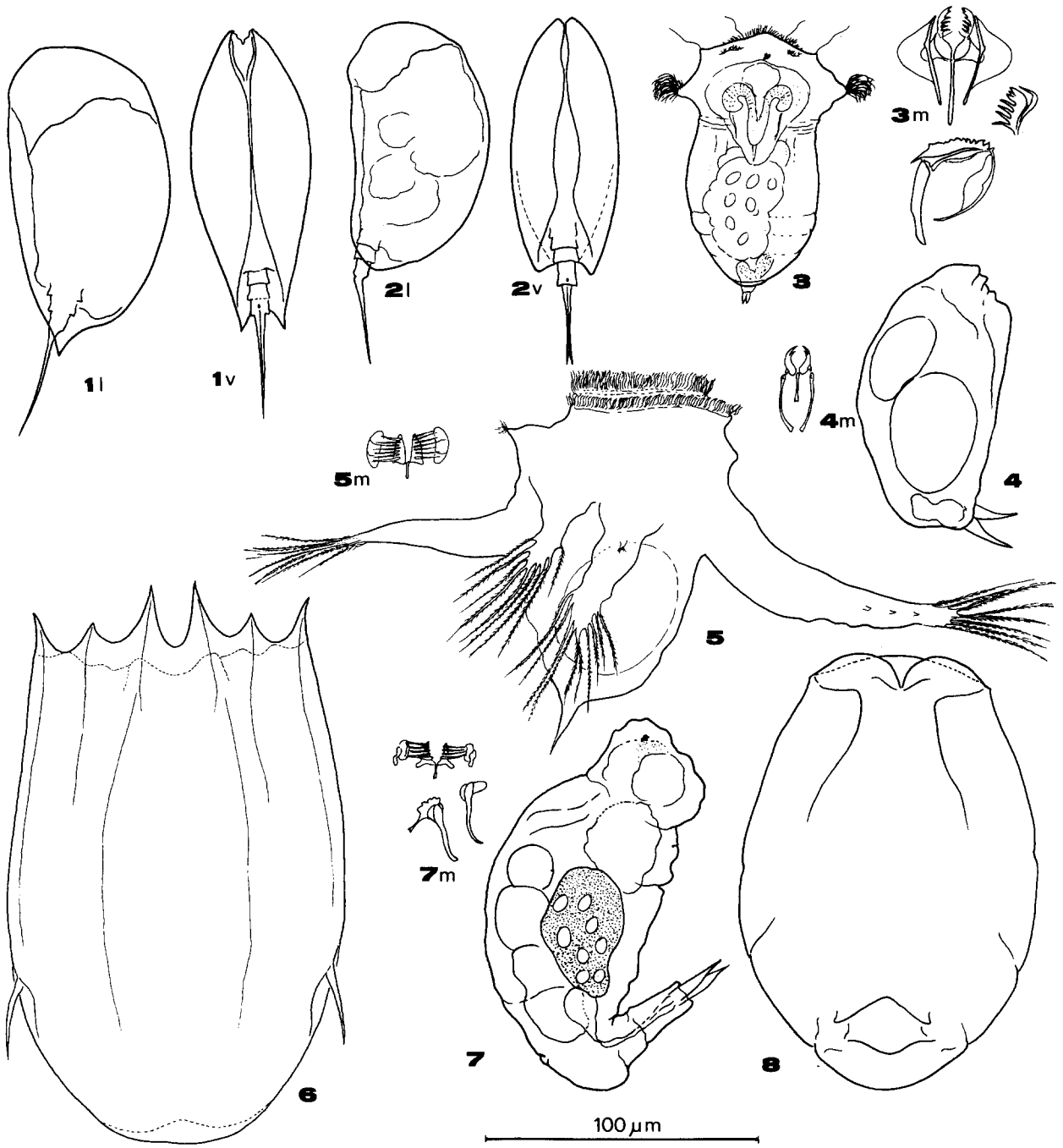

Fig. 2. Some rotifers from the Albufera of Minorca: 1. *Colurella adriatica* (l, lateral, v, ventral); 2. *Colurella colurus* (l, lateral, v, ventral); 4. *Encentrum marinum* (m, mastax); 5. *Hexarthra oxyuris* (m, mastax); 6. *Notholca bipalium*; 7. *Proales reinhardti* (m, mastax); 8. *Testudinella clypeata.*

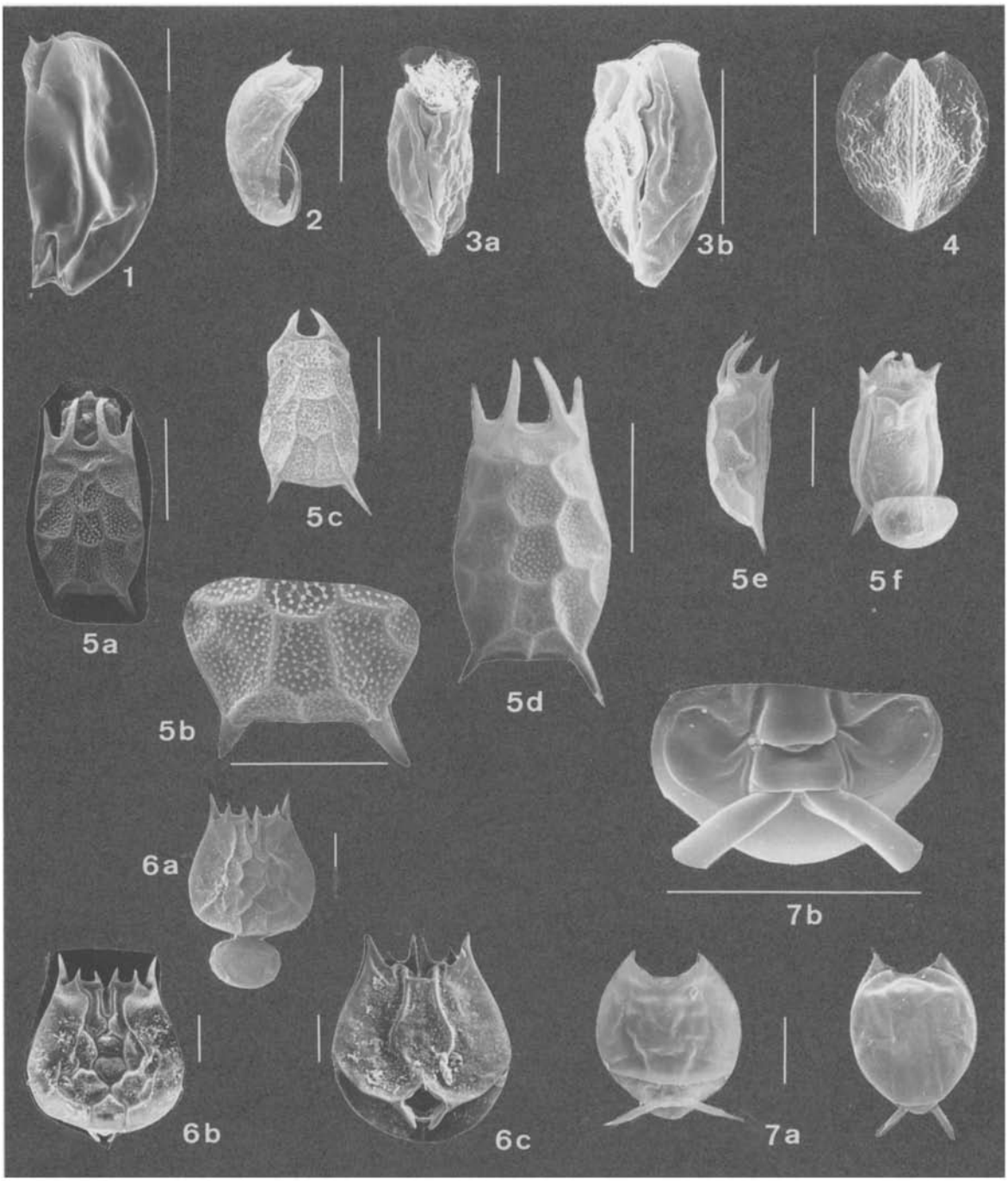

Fig. 3. Photographies of scanning electron microscope of some frequent species collected in ephemeral ponds of the Balearic archipelago: 1. *Mytilina ventralis* (from Minorca); 2. *Trichocerca weberi* (from Majorca); 3. a,b. *Anuraeopsis fissa* (from Minorca); 4. *Lepadella triptera* (from Majorca); 5. a–f, *Keratella procurva* (a,b, from Minorca; c, from Majorca; d,e,f, from Ibiza); 6. a–c, *Brachionus bidentatus f. testudinarius* (from Minorca); *Lecane luna* (from Minorca).

neity was observed in these habitats, but Llucmajor ponds in Majorca and the waterbodies from the North of Formentera had a distinct rotifer community, constituted by *Lepadella patella*, *L. rhomboides*, *L. triptera*, *Lecane closterocerca*, *B. quadridentatus*, *Euchlanis dilatata*, *Cephalodella megalocephala* and *Trichocerca weberi*. Less common species were *Lecane furcata*, *L. hastata*, *L. bifurca*, *L. margalefi* (De Manuel, in prep.), *Lophocharis salpina* and *Brachionus bidentatus f. testudinarius*.

3. The temporary ponds of Minorca show great diversity in their rotifer communities (De Manuel, 1990), corresponding to the heterogeneity of their substrata. *Lecane luna*, *L. bulla*, *L. closterocerca*, *L. nana*, *Lepadella patella*, *Lophocharis salpina*, *Trichocerca pusilla* and *T. rattus* were common meiobenthic species; *Keratella procurva*, *Filinia longiseta*, *Brachionus urceolaris*, *B. angularis*, *B. quadridentatus* and *Anuraeopsis fissa* were frequent species collected in open waters of ephemeral waterbodies of Minorca. Some common rotifers collected in balearic ephemeral ponds are shown in Fig. 3.
4. The last community type was not well-defined. It was constituted by a series of assemblages frequently observed in artificial waters of the islands (washing places, drinking troughs, little pools...). *Keratella procurva* and *Lecane punctata* were the most remarkable records, while *Brachionus angularis*, *Anuraeopsis fissa*, *Lecane closterocerca* and *Lecane luna* were common. The instability and diversity of these environments divided and mixed them with other localities in the clustering.

Zoogeography

In spite of the fact that the archipelago is relatively close to both European and African continents, it presents some remarkable cases for discussing zoogeography of rotifers. The brachionid *Keratella procurva*, pantropical and warm-stenothermous, was collected on all the islands (Fig. 1).

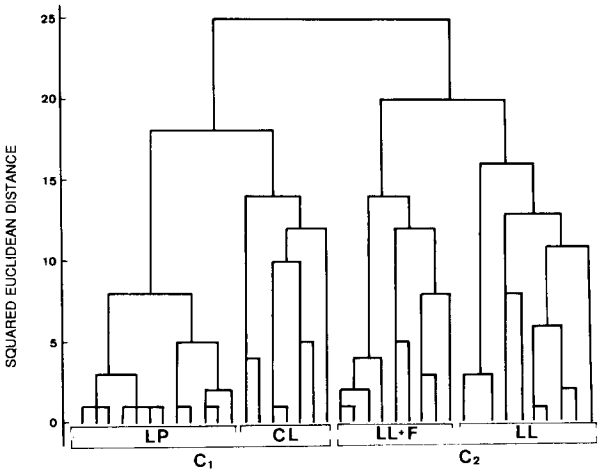

Fig. 4. Average linkage dendrogram, expressed in rescaled squared euclidean distance, for littoral strip waterbodies (C_1) and ephemeral ponds (C_2) of the Balearic islands. CL: coastal lagoons; LP: littoral ponds; LL + F: ephemeral ponds from Marina de Llucmajor (Majorca) and Formentera.

The most northern record was in the Northeast of the Iberian peninsula (Catalán, 1986), but it is a common species in Northwest Africa (Coussement & Dumont, 1980). In our opinion, this species colonized the islands from Africa. Why has *Keratella procurva* not successfully colonized peninsular freshwaters? Actually we don't know if that species occurs in the Southeast of the Iberian peninsula; till now it has not been recorded, in spite of important efforts. On the other hand, *Keratella cochlearis* and *K. quadrata* are very common species in the peninsula (Guiset, 1977; De Manuel, 1991); the first was not found in the Balearic islands, the latter, morphologically related to *K. procurva*, is scarce in the archipelago. In our opinion, *K. procurva* and *K. quadrata* occupy closely ecological niches in freshwaters, and one is probably excluding the other by competition. This explanation applies only to ecological factors, but some historical factors could be involved.

Lecane punctata, *L. inopinata* and the colonial rotifer *Lacinularia elliptica*, are also southern colonizers. The first was found in Minorca and Ibiza, it was considered as a Neotropical species (De Ridder, 1981), often confused with the species *Lecane harringi* described by Ahlstrom (1934).

According to recent taxonomy both species are synonymous, and have a pantropical-pansubtropical distribution (De Ridder & Segers, personal communication). The presence of these southern organisms is shown in Fig. 1.

A new species of rotifer, *Lecane margalefi* (De Manuel, in prep.), was found in some ephemeral ponds in Marina de Llucmajor (Majorca), where also was found the undescribed male of *Brachionus bidentatus f. testudinarius*.

The introduction of rotifers in the archipelago could be a consequence of dust rains, which are frequent phenomena in the archipelago (Colom, 1948; Fiol, 1985; Jansà, 1985). Migrating birds could also be responsible for the introduction of southern species, if we take into account the importance of the Balearic islands as a migration pathway (Araujo *et al.*, 1977). Dust rain and migrating birds are able to transport resting eggs, and parthenogenetic females hatching from sexual eggs may found new populations in a suitable habitat. A similar colonization of the islands by some African crustaceans is discussed by Jaume (1989).

Table 2 compares the number of species of some studied crustaceans (*Branchiopoda*) with that of rotifers (not including *Bdelloidea*), recorded till now in each island of the archipelago. An increase of the number of rotifers is probably if additional investigations are carried out (especially if the surveys are conducted seasonally). In Table 3 some data of the islands, that are important for the aquatic organism colonization, are given. Minorca has a number of species which is relative high to its size, a probable consequence of the relatively high rainfall and the diversity of habitats – which result from the heterogeneity of the geological substrata.

Table 2. Comparison of the number of species of Branchiopoda (from Jaume, submitted, and Pretus, 1990) and Rotifera found in the Balearic archipelago.

	Majorca	Minorca	Ibiza	Formentera	Total
Branchiopoda	33	37	12	8	44
Rotifera	69	72	24	25	100

Table 3. Features of the islands of the archipelago with relevance to the aquatic colonization. Area and altitude maximum could be an estimation of the habitat heterogeneity.

	Majorca	Minorca	Ibiza	Formentera
Rainfall (mm)	550	600	450	450
Extension (km^2)	3640.16	701.84	541.22	82
Max. altitude (m)	1443	358	475	192
Distance to the mainland (km)	167	210	92	115

References

Ahlstrom, E. H., 1934. Rotatoria of Florida. Trans. Am. Microsc. Soc. 53: 51–266.

Araujo, J., L. Muñoz-Cobo & F. J. Purroy, 1977. Las rapaces y aves marinas del archipiélago de Cabrera. Nat. Hisp. 12, 94 pp.

Catalán, J., 1986. Aproximación a la composición y organización del Neuston. Oecol. Aquat. 8: 25–38.

Colom, G., 1948. Las lluvias de barro en las Baleares, bajo el punto de vista geológico. Rev. Geofis. (año VII). 26: 194–21.

Coussement, M. & H. J. Dumont, 1980. Some peculiar elements in the rotifer fauna of the Atlantic Sahara and of the Atlas Mountains. Hydrobiologia 73: 249–254.

De Manuel, J., 1990. Contribution to the knowledge of rotifer fauna (Rotifera: Monogononta) from Minorcan inland waters (Balearic Isles: Spain). Limnética 6: 119–130.

De Manuel, J. Distribution of the Brachionidae (Rotifera: Monogononta) in Spanish reservoirs. Verh. int. Ver. Limnol. (in press a).

De Manuel, J. Some rotifers (Rotifera: Monogononta) from Majorca (Balearic archipelago: Spain). Boll. Hist. Nat. Balears. (in press b).

De Manuel, J. Some rotifers (Rotifera: Monogononta) from the islands of Ibiza and Formertera. (Balearic archipelago: Spain). Limnética. (in press c).

De Ridder, M., 1967. Quelques rotiferes de Majorque. Bull. Nat. Belg. 48: 409–418.

De Ridder, M., 1981. Some considerations on the global distribution of rotifers. Hydrobiologia 85: 209–225.

Dumont, H. J., 1983. Biogeography of Rotifers. Hydrobiologia 104: 19–30.

Fiol, LL. A., 1985. Estudi d'una formació microedàfica a l'habitació urbana de Palma de Mallorca. Boll. Soc. His. Nat. Balears 29: 37–62.

Guiset, A., 1977. General distribution of planktonic rotifers in Spanish reservoirs. Ergebn. Limnol. 8: 222–225.

Jansá, A., 1985. Condiciones climáticas. In: Baleares, Macromagnitudes del sector agrario. El Campo. Boletín de información agraria, 100. Banco de Bilbao.

Jaume, D., 1989. *Metadiaptomus chevreuxi* (Copepoda: Calanoida: Diaptomidae) and *Leptestheria mayeti* (Branchiopoda: Conchostraca: Leptestheriidae), two African freshwater crustaceans recorded in Majora. Limnética 5: 101–109.

Jongman, R. H., C. J. F. Ter Braak, & O. F. R. Van Tongeren, 1987. Data analysi in community and landscape ecology. Pudoc Wageningen. 297 pp.

Harring, H. K. & F. J. Myers, 1924. The rotifer fauna of Wisconsin. II. A revision of the Notommatid Rotifers. Exclusive the Dicranophoridae. Trans. Wis. Acad. Sci. Arts. Lett. 21: 415–549.

Harring, H. L. & F. J. Myers, 1926. The rotifer fauna of Wisconsin. III. A revision of the genera *Lecane* and *Monostyla*. Trans. Wis. Acad. Sci. Arts. Lett. 22: 315–423.

Koste, W., 1978. Rotatoria. Die Radërtiere Mitteleuropas. Bestimmungswerk begründet von Max Voigt. 2 vols. (Borntraeger: Stuttgart).

Margalef, R., 1951. Materiales para la hidrobiología de la isla de Ibiza. P. Inst. Biol. Apl. 8. 9–70.

Margalef, R., 1952. Materiales para la hidrobiología de la isla de Menorca. P. Inst. Biol. Apl. 11. 5–112.

Margalef, R., 1953. Materiales para la hidrobiología de la isla de Mallorca. P. Inst. Biol. Apl. 15. 5–111.

Pejler, B., 1977. On the global distribution of the family Brachionidae (Rotatoria). Arch. Hydrobiol. Suppl. 53: 255–306.

Pejler, B. & B. Berzins, 1989. On choice of substrate and habitat in brachionid rotifers. Hydrobiologia 186/187: 137–144.

Pomar, L., 1982. la evolución tectonosedimentaria de las Baleares: Análisis crítico. Acta Geol. Hisp. 14: 293–310.

Pretus, J. LL., 1989. Limnología de la Albufera de Menorca. Limnética, 5: 69–81.

Pretus, J. LL., 1990. A commented check-list of the Balearic branchipoda (Crustacea). Limnética, 6: 157–164.

Pretus, J. LL., 1991. Estudio taxonómico, biogeográfico y ecológico de los crustáceos epigeos e hipogeos de las Baleares. Tesis Universitat Barcelona: 513 pp.

Pretus, J. LL., J. De Manuel & LL. Cardona, 1990. Temporal heterogeneity, zooplankton composition and fish food supply in the Albufera o Minorca, a highly fluctuant environment. Rapp. Comm. Int. Mer. Medit. 32: 76.

Shiel, R. J., W. Koste & L. W. Tan, 1989. Tasmania revisited: rotifer communities and habitat heterogeneity. Hydrobiologia 186/187: 239–245.