Limnetica, 24(3-4): 275-294 (2005). DOI: 10.23818/limn.24.28
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The zooplankton community in a small, hypertrophic mediterranean reservoir (Foix reservoir, NE Spain)

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ABSTRACT

A small hypertrophic reservoir (Foix Reservoir, Spain) was sampled from March 1997 to January 2000 to document the composition and spatial and temporal variability of the zooplankton assemblage. Twenty five species of Rotifera, 10 of Cladocera, and one species of copepod (*Acanthocyclops robustus* (Sars)) were collected. The most abundant rotifer species were *Brachionus angularis* (Gosse) and *Polyarthra spp*. *Daphnia galeata* Sars, *Ceriodaphnia quadrangula* (Müller), and *Chydorus sphaericus* (Müller) were the main cladocerans. For each species, brief information is given on ecology, distribution, and occurrence in Spain and in the Foix Reservoir. The zooplankton community of the Foix Reservoir was characterized by the abundance of heleoplanktonic species, which accounted for 50 % of the taxa. Remarkable changes over time in species' composition and occurrence were found for Rotifera and Cladocera during the study period. *A. robustus* showed high density and biomass values throughout the sampling period. In the summer of 1999, copepods avoided deep layers, whereas some Rotifera (*Polyarthra* spp,, *Filinia* spp,, *Brachionus angularis*) and *Chydorus sphaericus* were found near the anoxic bottom. A rare rotifer in the Iberian Peninsula, *Itura aurita aurita* (Ehrenberg), was also found in lotic sections of the reservoir.

Keywords: *Itura aurita*, *Acanthocyclops robustus*, *Brachionus angularis*, *Chydorus sphaericus,* vertical distribution, colonization

RESUMEN

*Un embalse pequeño e hipereutrófico (Embalse de Foix, España) fue muestreado desde Marzo de 1997 a Enero de 2000, con el fin de documentar la composición y variabilidad espacial y temporal de la comunidad zooplantónica. Veinticinco especies de rotíferos, 10 de cladóceros y una especie de copépodo (*Acanthocyclops robustus *(Sars)) fueron recogidos. Las especies de rotíferos más abundantes fueron* Brachionus angularis *(Gosse) y* Polyarthra *spp.* Daphnia galeata *Sars,* Ceriodaphnia quadrangula *(Müller) y* Chydorus sphaericus *(Müller) fueron los principales cladóceros. Para cada especie se da breve información sobre su ecología, distribución y ocurrencia en España y en el Embalse de Foix. La comunidad zooplantónica del embalse se caracterizó por una fuerte presencia de especies heleoplantónicas, que supusieron un 50 % de los taxones. Se constataron cambios remarcables en la composición específica y densidades de rotíferos y cladóceros a lo largo del periodo estudiado. Por el contrario, A. robustus mostró densidades y biomasas altas durante todo el periodo. En el verano de 1999 los copépodos evitaron las capas profundas, mientras que algunos rotíferos (*Polyarthra *spp,* Filinia *spp,* Brachionus angularis*) y* Chydorus sphaericus *fueron encontrados cerca del fondo anóxico. Un rotífero raro en la Península Ibérica,* Itura aurita aurita *(Erhenberg), fue encontrado en la sección lótica del embalse.*

***Palabras clave**:* Itura aurita, Acanthocyclops robustus, Brachionus angularis, Chydorus sphaericus*, distribución vertical, colonización*

INTRODUCTION

More than 1000 reservoirs were built during the past century (MOPU, 1988), as sources of water to alleviate the shortages suffered regularly by Spain. Reservoirs are often found in areas of water scarcity, or where controlled water facilities are necessary. Large natural water bodies in the South of Europe are scarce, and reservoirs can be effectively regarded as regional-scale experiments, particularly with regard to plankters' dispersion (Margalef, 1983).

Limnology and planktonic communities of large Spanish reservoirs are well known (Margalef *et al*., 1976; Morguí *et al.*, 1990; Armengol *et al.*, 1991; Riera *et al.*, 1991; Sabater & Nolla, 1991; Riera *et al.*, 1992; Riera, 1993; Armengol *et al.*, 1994). However, no data are available for over 600 small reservoirs (i.e. <10 hm^3) located in Spain and Portugal.

The Foix Reservoir belonged to this limnologically unknown group until the work carried out by Marcé *et al*. (2000) and Gomà (2001). Prior to this, only a description of benthic protozoans was available (Salvadó & Gracia, 1991). However, no data concerning the composition of its zooplankton community is available. The aim of the present paper is to examine the zooplankton community of a small man-made lake (Foix Reservoir, Barcelona, Spain), and to discuss the reasons for its composition and distribution in the water column.

SITE DESCRIPTION

Located in NE Spain (E 1º38'53", N 41º15'21"), at 61 m above sea level, the Foix Reservoir results from the damming of the Foix River, and is the closest reservoir to the city of Barcelona (Fig. 1). The river was dammed in 1928 to supply different villages and agricultural fields. Today, is unprofitable because the low quality of its water. The reservoir is small and shallow (Table 1), and the predominant geology of the area is calcareous.

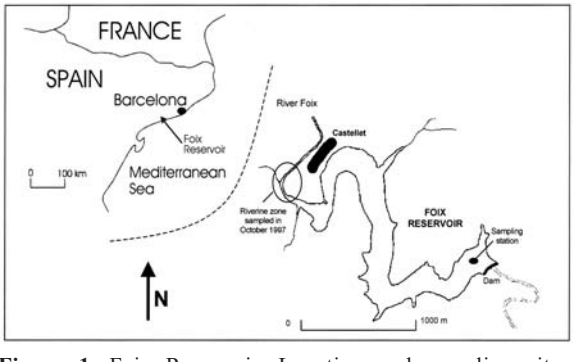

Figure 1. Foix Reservoir. Location and sampling sites. *Embalse de Foix. Situación y estaciones de muestreo.*

Table 1. Morphometric features of the Foix Reservoir. *Características morfométricas del embalse de Foix.*

Feature	Value
Bottom elevation	61 m
Catchment area	3.12×10^6 m^2
Surface area	7.2×10^5 m^2
Max. volume	3.7×10^6 m^3
Max. depth	10.7 m
Mean depth	7 m

Vegetation around the reservoir is mainly constituted by *Pinus halepensis* Miller woodland with a sparse population of *Quercus ilex* L.

The Foix Reservoir is monomictic, with a non-well developed hypolimnetic layer during summer, when the bottom is usually anoxic. Main features of the reservoir are its extreme hypertrophy and strong seasonal variability of water residence times. Main algal groups are Cryptophyta, Chlorophyta, Cyanobacteria and diatoms (Gomà, 2001). For a detailed description of the reservoir limnology see Marcé *et al*. (2000).

MATERIAL AND METHODS

The reservoir was sampled at a station near the dam from March 1997 to January 2000, with irregular periodicity. Between March 1997 and October 1998, samples were taken approximately every three months. From June 1999 to January 2000 sampling frequency was monthly. A qualitative sample was taken in the riverine zone of the reservoir in October 1997 (Fig. 1).

In addition to several physical and chemical variables (see Marcé *et al*., 2000), vertical hauls were taken by means of an Apstein plankton net of 53 μm mesh size from March 1997 to June 1999. Samples were preserved in 4% formalin. After sieving the fixed samples with 710, 500, 250, 150, 100 and 53 μm mesh, Rotifera, Cladocera, and Copepoda were counted and identified using Utermolhl chambers under an inverted microscope (McCauley, 1984). In order to identify the vertical distribution of different groups during stratification, discrete water sam-

ples were taken at 0, 2, 5 and 10 m depth with a 5 L capacity Schindler-Patalas hydrographic bottle, from June 1999 to January 2000. The content of each bottle was filtered through a 53 µm mesh, preserved and size-fractions counted.

Specific biomass was calculated from measurements of several individuals of each species at the appropriate magnification, using an ocular micrometer. Equations from Botrell *et al*. (1976), Malley *et al*. (1989) and Dumont *et al.* (1975) were applied for Cladocera, from Malley *et al*. (1989) for Copepoda, and the Ruttner-Kolisko's approximation for Rotifera (Botrell *et al*., 1976; Ruttner-Kolisko, 1977).

In order to test if any zooplankton group was significantly concentrated in the surface or deep layers during stratification in 1999 (June to October), mean biomass for different groups (Rotifera, Cladocera, and Copepoda) below and above the thermocline and below and above the oxycline were compared by means of a two-tailed t-student test.

The work includes original drawings and pictures taken by means of a Leica D100 digital camera.

RESULTS

A total of 25 species of Rotifera, 10 species of Cladocera, and one species of Copepoda were found in the Foix Reservoir during the studied period. Among them, 19 species of Rotifera, 9 species of Cladocera, and one copepod species were collected at a sampling station near the dam

Table 2. Densities (ind/L) for each taxa found in the station near the dam at every sampling date. Densities in 1999 were calculated integrating data for the whole water column. *Densidades (ind/L) para cada taxon encontrado en la estación próxima a la presa en cada muestreo. Las densidades en 1999 se calcularon integrando los datos de toda la columna de agua.*

	3-97	6-97	9-97	10-97	12-97	3-98	5-98	7-98	10-98	6-99	7-99	8-99	9-99	10-99	11-99	12-99	1-00
Rotifera																	
A. brightwelli				0.2													
B. angularis	326	92.8	18.4	618	10.2	120		2,476	31.2	10.9	28.6	17.6	1,000	57.4	667	4.5	
B. calicyflorus	16.2	0.02	0.05	15.0						0.5	9.8	0.7					
B. urceolaris	15.9	13.7	0.1	0.9	0.06		2.0		0.3	0.5		1.0	2.3	1.2			
Filinia sps	216	0.5		0.5	0.05	1.0			0.1	6.3		2.0	1.8	0.3			
H. mira		0.2	0.03		0.1										0.5		
K. cochlearis	0.3		0.5		1.9	1.2				0.2							2.7
K. cochlearis f. *tecta*	11.6	1.0	0.1		7.7												
K. quadrata	1.1	0.5	1.0		0.2	3.2											
K. cf *testudo*	2.7										0.03						
K. tropica															51.9	18.5	7.8
L. closterocerca											0.7						
L. hamata													0.7				
P. sulcata		0.2													5.6	85.0	2,115
Polyartrha sps	93.8	12.6	1.5	1.7	2.3	24.2	12.8	26.6	5.2	460	131	178	49.7	110	23.1	19.6	125
R. neptunia	39.5	0.01									1.4			0.1			
S. pectinata	6.2	0.2															11.2
T. patina	0.6																
Copepoda (*A. robustus*)																	
Adults	0.1	53.5	24.9	3.6	70.4	15.0	13.6	91.4	5.2	41.3	98.5	90.0	74.2	44.5	26.3	45.0	12.1
Copepodites	6.6	62.7	15.8	24.4	164	16.5	173	206	24.4	101	373	125	175	228	69.9	598	27.2
Nauplii	1.0	123	12.6	27.0		127	376	120	14.5	47.7	457	142	771	132	209	37.8	1.9
Cladocera																	
C. sphaericus										0.8	0.5	27.6	213	24.9	116	2.8	23.4
A. rectangula				0.4			1.0								0.5		
B. longirostris	0.01	0.2			0.4						1.8						
C. quadrangula					0.06	1.7	2.7	12.8		16.9	6.6	7.8	0.9	1.8	1.4		2.4
D. galeata	0.01	2.6	0.06				3.3	2.5		2.0		0.7	0.3	0.6	15.2	21.3	16.6
D. magna						0.06											
D. pulicaria						0.1											
D. longispina																	1.3
M. micrura			0.2	0.5													

(Table 2). The rest were found in the riverine zone in October 1997 (Fig. 1). The following text gives a brief bibliographical revision for each taxon, giving notes on occurrence in the Foix Reservoir.

Rotifera

Class Eurotatoria De Ridder, 1957

Subclass Bdelloidea Hudson, 1884
Family Philodinidae
Rotaria neptunia (Ehrenberg, 1832)

Ecology: Benthic rotifer is frequently found in planktonic environments (Koste & Shiel, 1986). Typical of alkaline and eutrophic waters, it tolerates low oxygen concentrations (de Manuel, 2000).

Distribution: Cosmopolitan. In the Iberian Peninsula it is mainly found in the north, although it has also been recorded in more southern latitudes (de Manuel, 2000). It is infrequent in reservoirs. It is cited on four occasions in the extensive study by de Manuel (2000).

In Foix: Bdelloid Rotifera were never abundant, except in May 1997, when a maximum density of 39 ind/L was achieved (Table 2). *R. neptunia* also appeared in June 1997 (0.01 ind/L) and in surface layers during summer 1999.

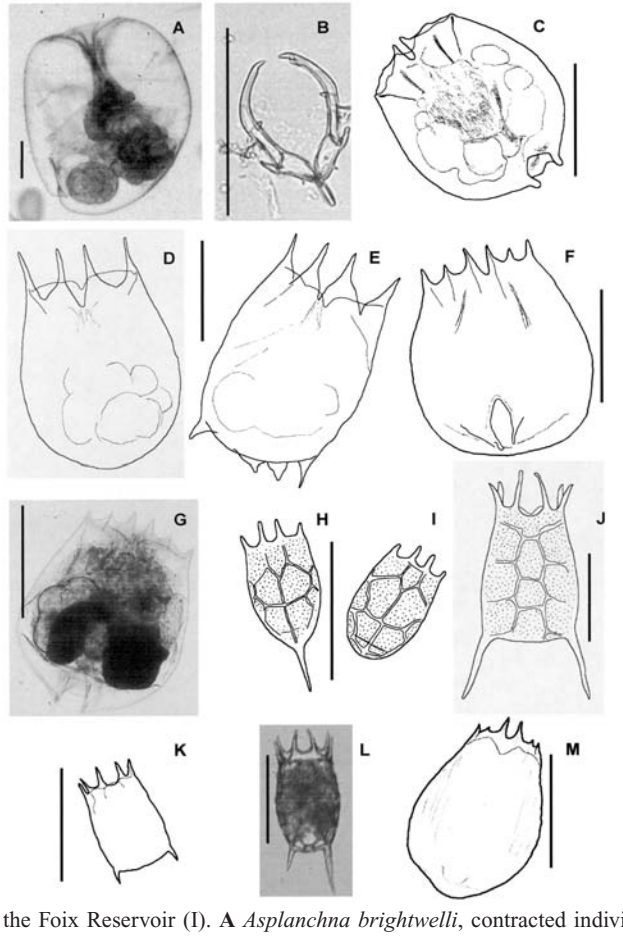

Figure 2. Rotifers species from the Foix Reservoir (I). **A** *Asplanchna brightwelli*, contracted individual. **B** *A. brightwelli*, mastax. **C** *Brachionus angularis*. **D** *B. calicyflorus* f. *typica*. **E** *B. calicyflorus* f. *amphiceros*. **F** *B. quadridentatus*. **G** *B. urceolaris*. **H** *Keratella cochlearis* f. *typica*. **I** *K. cochlearis* f. *tecta*. **J** *K. quadrata*. **K** *K.* cf. *testudo*. **L** *K. tropica*. **M** *Notholca squammula*. Bars: 100 µm. *Rotíferos del embalse de Foix (I)*. ***A*** Asplanchna brightwelli*, individuo contraído.* ***B*** A. brightwelli, mastax. ***C*** Brachionus angularis*.* ***D*** B. calicyflorus f. typica*.* ***E*** B. calicyflorus f. amphiceros*.* ***F*** B. quadridentatus*.* ***G*** B. urceolaris*.* ***H*** Keratella cochlearis f. typica*.* ***I*** K. cochlearis f. tecta*.* ***J*** K. quadrata*.* ***K*** K. cf. testudo*.* ***L*** K. tropica*.* ***M*** Notholca squammula*. Barras: 100 µm.*

Subclass Monogononta Plate, 1889
Family Asplanchnidae

Asplanchna brightwellii Gosse, 1850 (Fig. 2)

Ecology: Euplanktonic rotifer (de Manuel, 2000). This species prefers warm eutrophic and acidic waters (Margalef *et al*., 1976). It preys on Rotifera, crustacean nauplii, ciliates, and a great range of algae (Braioni & Gelmini, 1983). *A. brightwellii* may be easily confused with *A. sieboldii*. These two species may be distinguished by the number of flame bulbs of the protonephridia and nucleii in the vitellarium (Gilbert *et al.* 1979).

Distribution: Cosmopolitan. It is the most frequent species of the genus *Asplanchna* in the Spanish reservoirs (de Manuel, 2000).

In Foix: Rotifer rare in the Foix Reservoir. It was collected in October 1997 at low densities (0.2 ind/L) (Table 2).

Family Brachionidae

Brachionus angularis (Gosse, 1851) (Fig. 2)

Ecology: Planktonic rotifer from shallow waters frequently associated with macrophytes (Braioni & Gelmini, 1983; de Manuel, 2000). Braioni & Gelmini (1983) relate this rotifer to organic-rich eutrophic waters. *B. angularis* eats bacteria, detritus and a wide range of algae (Pourriot, 1977; Braioni & Gelmini, 1983; Boon & Shiel, 1990; de Manuel, 2000).

Distribution: Cosmopolitan. It is not abundant in Iberian reservoirs (Margalef *et al*., 1976). De Manuel (1997) found it mainly in the watershed of the Guadalquivir River.

In Foix: B. angularis was the most abundant rotifer. Densities were high throughout the sampling period, reaching peak values of around 2500 ind/L in July 1998 (Table 2). During September 1999, *B. angularis* density achieved a maximum, located in surface layers. Maxima were found in bottom layers after mixing (Fig. 6). A remarkable aspect of *B. angularis* shown during this study was its morphological plasticity, as exemplified by the range of morphs and sizes observed (Fig. 3). Some authors have described different morphs of this species, although their taxonomic value is dubious. Hutchinson (1967) for instance, realized that *B. angularis* is a cyclomorphic species. The pattern of shapes and lengths of *B. angularis* in Foix suggest cyclomorphosis occurs, if we consider only one genotype present in the reservoir.

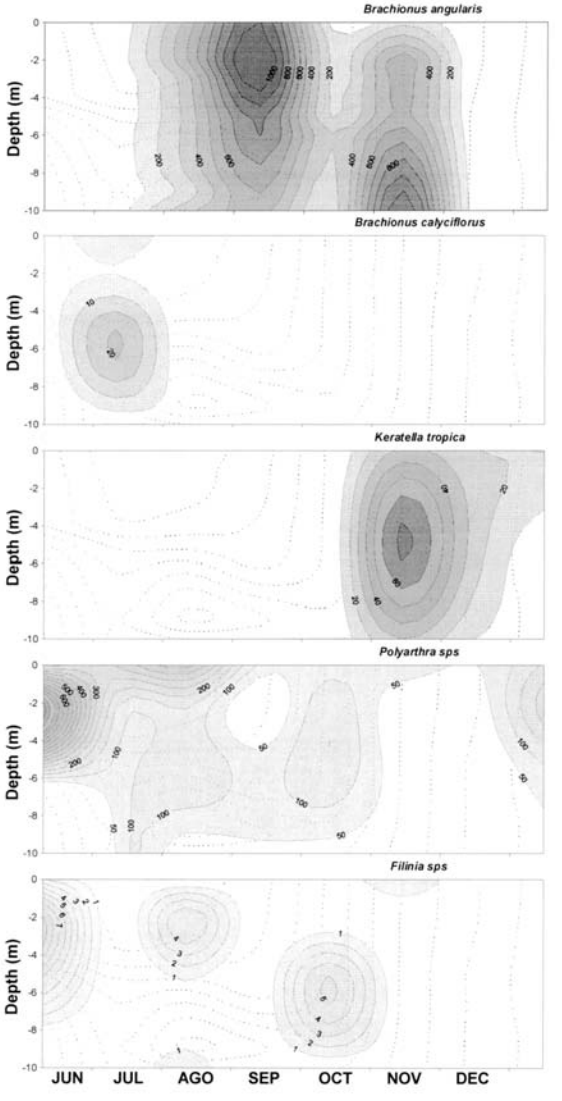

Figure 6. Density (ind l^{-1}) depth-time plots for some rotifera species during 1999. The dotted line shows temperature profiles. *Gráficos profundidad-tiempo para la densidad (ind l^{-1}) para algunos rotíferos durante 1999. La línea punteada muestra el perfil de temperatura.*

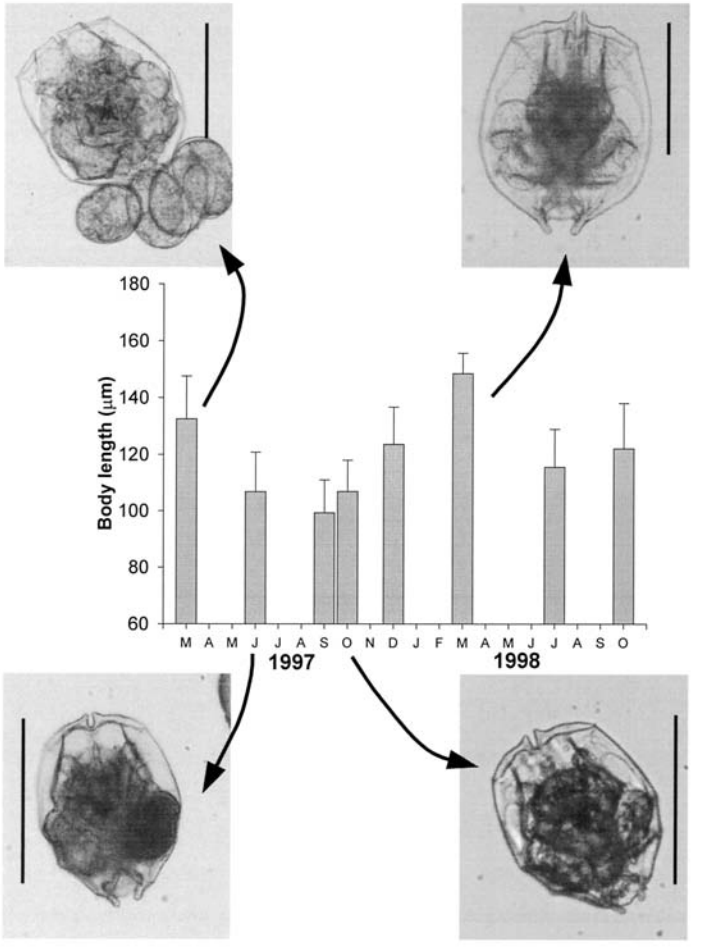

Figure 3. Medium body length (µm) for *Brachionus angularis* in 1997 and 1998 sampling dates. Pictures show a typical individual from each sample. Bars: 100 µm. *Longitud media del cuerpo (µm) de* Brachionus angularis *en muestreos correspondientes a 1997 y 1998. Las fotografías muestran la forma típica para cada muestra. Barras: 100 µm.*

Brachionus calicyflorus Pallas, 1766 (Fig. 2)

Ecology: Planktonic taxon, occasionally found in running waters (de Manuel, 2000). It is associated to alkaline, shallow, eutrophic environments (Margalef *et al*., 1976; Braioni & Gelmini, 1983; Koste & Shiel, 1987; de Manuel, 2000). Chloride tolerant. It feeds on bacteria, detritus and Chlorocoocales, Volvocales, and Euglenoid algae (Pourriot, 1977; de Manuel, 2000). Highly polymorphic (Gilbert, 1967; Hutchinson, 1967).

Distribution: Cosmopolitan, found in many Spanish reservoirs, mainly in alkaline, polluted waters (Margalef *et al*., 1976; de Manuel, 2000). *In Foix*: It achieved high densities during mixing in 1997 (i.e. 15 ind/L) (Table 2). A metalimnetic maximum during summer 1999 was apparent (Fig. 6). This species co-occurred with *Asplanchna brightwellii* in October 1997 (Table 2). Also, the latter species is known to be positively associated with *B. calicyflorus* (Braioni & Gelmini, 1983).

Brachionus quadridentatus Hermann, 1783 (Fig. 2)

Ecology: Common taxon in warm, small water bodies. It is also found in running waters (Ruttner-Kolisko, 1974; de Manuel, 2000). Ruttner-Kolisko (1974) considered this rotifer

was rare in open waters, and Braioni & Gelmini (1983) considered it typical for this habitat in Italy. Good indicator for eutrophic conditions (Koste & Shiel, 1987; Braioni & Gelmini, 1983; Margalef *et al*., 1976). It eats nanoplankton and detritus (Braioni & Gelmini, 1983).

Distribution: Cosmopolitan. It is the main species from the genus in Spanish reservoirs (Margalef *et al*., 1976; de Manuel, 2000).

In Foix: *B. quadridentatus* f. *cluniorbicularis* was only found once in the Foix Reservoir, in October 1997, at the riverine section of the reservoir (Fig. 1).

Brachionus urceolaris Müller, 1773 (Fig. 2)

Ecology: Heleoplanktonic species living in alkaline, small water bodies (de Manuel, 2000). Many authors consider *B. urceolaris* mainly as a benthic rotifer (Ruttner-Kolisko, 1974; Margalef *et al*., 1976; Braioni & Gelmini, 1983). It feeds on unicellular algae (Braioni & Gelmini, 1983). It is highly polymorphic, as it is usual in this genus.

Distribution: Margalef *et al*. (1976) found it in reservoirs within the watershed of the Duero River. De Manuel (2000) however, collected individuals throughout Spain, suggesting the species might have colonized other reservoirs, as predicted by Margalef *et al*. (1976).

In Foix: Frequent in the reservoir, with maximum densities in excess of 15 ind/L (Table 2). The mean density for the whole sampling period was 3.4 ind/L. *B. urceolaris* was often more abundant in surface layers during 1999.

Keratella cochlearis (Gosse, 1851) (Fig. 2)

Ecology: Euplanktonic rotifer, very common in lakes and reservoirs. It feeds on algae and bacteria (Pourriot, 1965; 1977; Boon & Shiel, 1990). It is prey to *Asplanchna* (Guiset, 1977). Its presence has been related to pollution (Braioni & Gelmini, 1983; Koste & Shiel, 1987), but this link seems to depend on mineralization (Margalef *et al*., 1976).

Distribution: Cosmopolitan species, common in Spain. It can be found in all Spanish reservoirs, especially those with acidic waters (Margalef *et al*., 1976), and more frequently during stratification (de Manuel, 2000).

In Foix: Two forms of this species were observed, f. *typica* and *tecta* (Fig. 2). Both were frequent in 1997, especially during the mixing period, being less common the rest of the period (Table 2). No clear spatial patterns were apparent during 1999.

Keratella quadrata (Müller, 1786) (Fig. 2)

Ecology: Euplanktonic rotifer. It tolerates a wide range of temperature and mineralization conditions (de Manuel, 2000). Traditionally, this rotifer has been considered a good indicator for eutrophy (Hutchinson, 1967). However, it may be present in systems under any trophic state (Margalef *et al*., 1976; Braioni & Gelmini, 1983). *K. quadrata* densities usually rise during summer (Hutchinson, 1967; Margalef *et al*., 1976). It feeds on detritus, bacteria and algae (Pourriot, 1977). Highly polymorphic.

Distribution: Cosmopolitan. Rotifer frequent in Spain, although never at high densities. No distribution pattern of this species has been identified in Spanish reservoirs (Margalef *et al*., 1976).

In Foix: In 1997, *K. quadrata* was frequently found, albeit at low densities (i.e. maximum less than 3 ind/L). It was not observed after May 1998 (Table 2).

Keratella cf *testudo* (Ehrenberg, 1832) (Fig. 2)

Ecology: Euplanktonic species living in alkaline, small-sized water bodies (Braioni & Gelmini, 1983; de Manuel, 2000). It was defined by Ruttner-Kolisko (1974) as a reservoir species. It eats bacteria, detritus, and algae (Chlorococcales, Euglenoids, Cryptomonads and diatoms) (Sladecek, 1983).

Distribution: Cosmopolitan, rare in Spain. In surveys of a large number of Spanish reservoirs, Margalef *et al*. (1976) and de Manuel (2000) found *K. testudo*, at very low densities, in one and three reservoirs, respectively.

In Foix: Rare. It was collected twice, at low densities (i.e. <3 ind/L): in March 1997 and in July 1999 (Table 2), when it appeared in surface layers.

The record is not confirmed, since it was not possible to observe the presence of

a closed lateral facet at both sides of the central facet under optical microscope (see de Manuel, 2000).

Keratella tropica (Apstein, 1907) (Fig. 2)

Ecology: Euplanktonic rotifer, from warm and alkaline waters (de Manuel, 2000).

Distribution: Pantropical and pansubtropical, occasional in Europe (Koste & Shiel, 1987). Eight records of this species can be found in Margalef *et al*. (1976), an account of a survey of Spanish reservoirs. A second survey, reported in de Manuel (2000), records this species 17 times, clearly suggesting its expansion to new areas.

In Foix: Margalef *et al*. (1976) mention this rotifer as present in Foix, despite not explicitly including the reservoir in their study. Here, the species appeared in autumn 1999 (Fig. 6), with densities in excess of 70 ind/L.

Notholca squamula (Müller, 1786) (Fig. 2)

Ecology: Planktonic rotifer, often associated with littoral margins (de Manuel, 2000; Braioni & Gelmini, 1983). Cold stenotherm typical of alpine lakes (Ruttner-Kolisko, 1974). Koste & Shiel (1987) consider *N. squamula* a special case in the genus, because it is found in waters above 15 ºC. It feeds preferentially on diatoms (Braioni & Gelmini, 1983).

Distribution: It is the most frequent species of the genus in Spain. It is not rare in alkaline and eutrophic reservoirs (Margalef *et al*., 1976), where it can easily be found during winter. During summer it may be found in the hypolimnion (de Manuel, 2000).

In Foix: *N. squamula* was not collected in the main body of the reservoir. It was found once in the riverine section of the reservoir, in October 1997 (Fig. 1).

Family Lepadellidae

Lepadella patella (Müller, 1786) (Fig. 4)

Ecology: Littoral periphytic rotifer, occasionally reported in open and running waters (Ruttner-Kolisko, 1974; Margalef *et al*., 1976; Braioni & Gelmini, 1983; de Manuel, 2000).

Distribution: Cosmopolitan. It has been found in alkaline eutrophic reservoirs by Margalef *et al*. (1976), but its distribution appears to be considerably variable over time (de Manuel, 2000).

In Foix: Not collected in the main body of the reservoir. It was found on one occasion, in October 1997, in the riverine section of the reservoir (Fig. 1).

Family Lecanidae

Lecane bulla (Gosse, 1851) (Fig. 4)

Ecology: Periphytic species found in rivers and small water bodies, occasionally in the plankton. Hutchinson (1967) related its presence in the pelagial to storm events. It has been found in a wide range of trophic conditions (Segers, 1995).

Distribution: Cosmopolitan. Common in Spain. De Manuel (2000) found this species in Eastern reservoirs over calcareous watersheds.

In Foix: *L. bulla* was not collected in the main body of the reservoir. It was found once in the riverine section of the reservoir on one occasion, in October 1997 (Fig. 1)

Lecane closterocerca (Schmarda, 1859) (Fig. 4)

Ecology: Benthic rotifer, although it frequently migrates to the plankton (Ruttner-Kolisko, 1974). It is also found in running waters (Braioni & Gelmini, 1983; Koste & Shiel, 1990).

Distribution: Cosmopolitan. It is abundant in Spanish reservoirs, without a clear distribution pattern (Margalef *et al*., 1976; de Manuel, 2000).

In Foix: Rotifer rare in the reservoir. It was found on one sampling occasion (July 1999), at low densities in surface layers (Table 2).

Lecane hamata Stokes, 1896 (Fig. 4)

Ecology: Littoral rotifer, found in running or small-sized water bodies. It is occasionally found in the plankton (Braioni & Gelmini, 1983).

Distribution: Cosmopolitan rotifer. Frequent in the Balearic Islands, but rare in Spanish reservoirs (Margalef *et al*., 1976; de Manuel, 2000).

In Foix: Rare. It appeared at low densities (i.e. < 1 ind/L) below surface layers in September 1999 (Table 2).

Family Notommatidae

Cephalodella gibba Ehrenberg, 1832 (Fig. 4)

Ecology: Heleoplanktonic species. It has also been found in crustacean gills (Koste & Shiel, 1991; de Manuel, 2000). It feeds on unicellular algae, flagellates, and ciliates (Braioni & Gelmini, 1983; de Manuel, 2000).

Distribution: Cosmopolitan, spread throughout the Iberian Peninsula. It is frequent in both the plankton (de Manuel, 2000) and benthic habitats (Margalef *et al*., 1976).

In Foix: Rare. It was found on one sampling occasion, in October 1997, in the riverine section of the reservoir (Fig. 1).

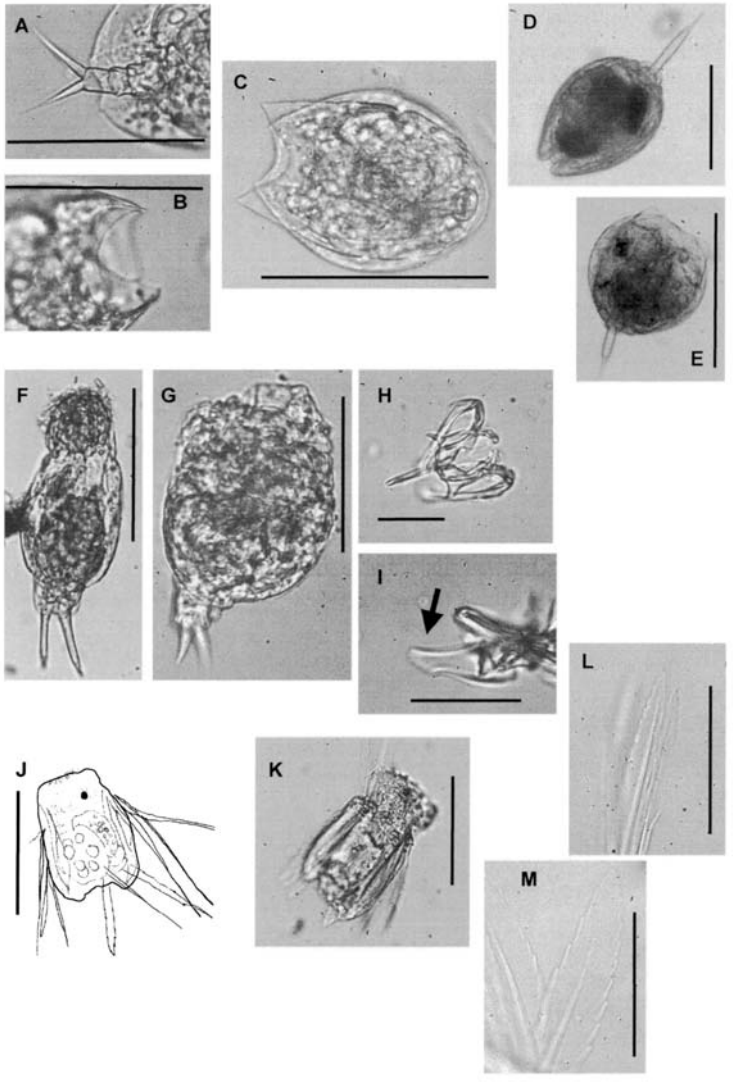

Figure 4. Rotifera species from the Foix Reservoir (II). **A** *Lepadella patella*, foot. **B** *L. patella*, food opening. **C** *Lecane hamata.* **D** *L. bulla.* **E** *L. closterocerca.* **F** *Cephalodella gibba*, contracted individual. **G** *Itura aurita aurita*, contracted individual. **H** *I. aurita aurita*, mastax. **I** *I. aurita aurita*, fulcrum. **J** *Polyarthra dolychoptera.* **K** *P. major.* **L** *P. dolychoptera*, blades. **M** *P.* major, blades. Bars: 100 µm, except **H-I**: 20 µm and **L-M**: 50 µm. *Rotiferos del embalse de Foix (II). **A*** Lepadella patella*, pie. **B*** L. patella*, abertura del pie. **C*** Lecane hamata. ***D*** L. bulla. ***E*** L. closterocerca. ***F*** Cephalodella gibba*, individuo contraído. **G*** Itura aurita aurita*, individuo contraído. **H*** I. aurita aurita*, mastax. **I*** I. aurita aurita*, fulcrum. **J*** Polyarthra dolychoptera. ***K*** P. major. ***L*** P. dolychoptera*, palas. **M*** P. major*, palas. Barras: 100 µm, excepto **H-I**: 20 µm y **L-M**: 50 µm.*

Itura aurita aurita (Ehrenberg, 1830) (Fig. 4)

Ecology: Littoral rotifer, it lives in still or slow-running waters (De Smet & Pourriot, 1997). It may associate with periphyton (Pourriot, 1997). It prefers eutrophic bodies (Braioni & Gelmini, 1983), and feeds on euglenoids and unicellular algae (De Smet & Pourriot, 1997).

Distribution: Cosmopolitan. This Rotifer is highly rare in the Iberian Peninsula. It has only been found in Tablas de Daimiel and in some karstic lakes in Cuenca, both in Central Spain (R.M. Miracle, University of Valencia, *pers. com.*). Neither Margalef *et al*. (1976) nor de Manuel (2000) collected this rotifer in their studies.

In Foix: Rare. *I. aurita* was not collected in the main body of the reservoir. It was found once, in October 1997, in the riverine section (Fig. 1).

Family Synchaetidae

Polyarthra dolichoptera (Idelson, 1925) (Fig. 4)

Ecology: Euplanktonic species from cold waters. It may survive in low oxygen concentrations (Ruttner-Kolisko, 1974; Braioni & Gelmini, 1983; de Manuel, 2000). *P. dolichoptera* feeds on Cryptomonads, Chrysomonads and central diatoms (Pourriot, 1977), and is prey to *Asplanchna*. Densities in the hypolimnion were significantly larger than those in surface layers during summer 1999. This rotifer shows a strong vertical distribution pattern during the summer, when it accumulates in the hypolimnion (Hutchinson, 1967; Margalef *et al*., 1976).

Distribution: Cosmopolitan. It is widespread in Spanish water bodies. It is frequent in alkaline, eutrophic reservoirs.

In Foix: (see *P. major*).

Polyarthra major (Burckhardt, 1900) (Fig. 4)

Ecology: Euplanktonic species from mesotrophic waters (de Manuel, 2000). It usually presents its population maxima during summer and autumn (Hutchinson, 1967; Ruttner-Kolisko, 1974; Braioni & Gelmini, 1983). It may be found in surface waters during the mixing, but as stratification develops, higher densities are generally found further below.

Distribution: Cosmopolitan. Rotifer frequent in the Iberian Peninsula. It is also frequent in SW Spanish reservoirs. It shows preference for eutrophic acidic waters (Margalef *et al*., 1976).

In Foix: It was not always possible to distinguish between species of the genus *Polyarthra*. The preservation method often collapsed individuals hindering identification.

The genus was perennial in the reservoir. It appeared at variable densities, ranging 1.5 - 460 ind/L (Table 2). Together with *B. angularis*, *B. calicyflorus,* and *Filinia spp*, it could be found in the anoxic layers during stratification (Fig. 6).

Synchaeta pectinata (Ehrenberg, 1832) (Fig. 5)

Ecology: Euplanktonic rotifer from cold waters (Ruttner-Kolisko, 1974). The species is equally found in lakes and reservoirs of varying trophy (Braioni & Gelmini, 1983). It feeds on Cryptomonads, Chrysophycean, and diatoms (Pourriot, 1970). It may also feed on the rotifer *Keratella* (Hutchinson, 1967)

Distribution: Cosmopolitan. It is found in many Spanish reservoirs, mainly in alkaline waters. Margalef *et al*. (1976) associated abundance of this rotifer to mixing conditions, but de Manuel (2000) did not find any remarkable spatial or temporal pattern.

In Foix: Rotifer occasionally found in the reservoir. It appeared during mixing periods, reaching maximum densities of 11 ind/L in January 2000. It was not recorded in 1998 (Table 2).

Family Testudinellidae

Pompholyx sulcata (Hudson, 1885) (Fig. 5)

Ecology: Euplanktonic species. It has also been found on macrophytes (Braioni & Gelmini, 1983). It feeds on detritus and bacteria (Braioni & Gelmini, 1983; de Manuel, 2000). Some authors consider it as an eutrophication state indicator species (Braioni & Gelmini, 1983).

Distribution: Cosmopolitan. It is abundant in the Iberian Peninsula. Most abundant in surface layers of eutrophic reservoirs (Margalef *et al*., 1976).

In Foix: Rotifer occasionally collected in the Foix Reservoir. It appeared at low densities in

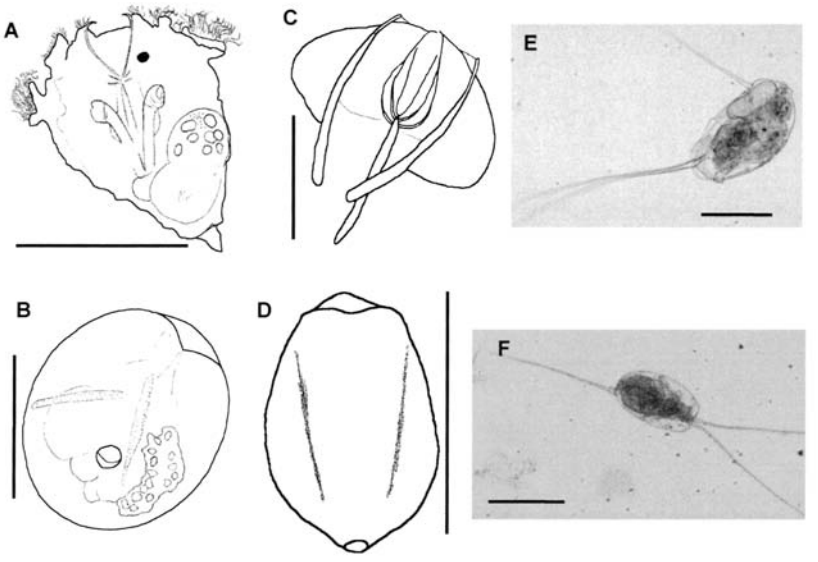

Figure 5. Rotifera species from the Foix Reservoir (III). **A** *Synchaeta pectinata*. **B** *Testudinella patina*. **C** *S. pectinata*, mastax. **D** *Pompholyx sulcata*. **E** *F. longiseta*. **F** *F. terminalis*. Bars: 100 µm, except **C**: 50 µm. *Rotíferos del embalse de Foix (III)*. ***A*** Synchaeta pectinata. ***B*** Testudinella patina. ***C*** S. pectinata*, mastax*. ***D*** Pompholyx sulcata. ***E*** F. longiseta. ***F*** F. terminalis*. Barras: 100 µm, excepto **C**: 50 µm.*

June 1997, but during the winter of 1999 it achieved densities of over 2000 ind/L (Table 2). This maximum coincided with the virtual absence of *B. angularis*, suggesting some kind of competition between both species.

Testudinella patina (Hermann, 1783) (Fig. 5)

Ecology: Heleoplanktonic and littoral species (Hutchinson, 1967; Ruttner-Kolisko, 1974; de Manuel, 2000). It is more frequent between spring and autumn. Salinity tolerant. It feeds mainly on *Chlorella* and diatoms (Braioni & Gelmini, 1983; de Manuel, 2000).

Distribution: Cosmopolitan. In Spain it has frequently been recorded in marshes and lagoons, but only in six reservoirs (de Manuel, 2000).

In Foix: Rare species. It was found on one sampling occasion, in October 1997, in the riverine section of the reservoir (Fig. 1).

Family Hexarthridae

Hexarthra mira (Hudson, 1871)

Ecology: Euplanktonic species from shallow waters (Ruttner-Kolisko, 1974), although it has been recorded in a wide range of habitats (Hutchinson, 1967; Margalef *et al*., 1976). It feeds on vegetable detritus and bacteria (Pourriot, 1977; Braioni & Gelmini, 1983).

Distribution: Cosmopolitan, common in the Iberian Peninsula. Most records in Spanish reservoirs are from western ones (de Manuel, 2000).

In Foix: Species occasionally collected in the reservoir, always at low densities, and without a clear temporal pattern (Table 2).

Family Filiniidae

Filinia longiseta (Ehrenberg, 1834) (Fig. 5)

Ecology: Euplanktonic species from warm eutrophic waters. Braioni & Gelmini (1983) recorded *F. longiseta* mainly in the epilimnion, but Margalef *et al*. (1976) found a rising trend in densities with depth. It feeds on detritus, bacteria, and algae (Pourriot, 1965).

Distribution: Cosmopolitan. Rotifer homogeneously distributed in the Iberian Peninsula, and common in reservoirs. It generally appears during the stratification period.

In Foix: (see *F. terminalis*)

Filinia terminalis (Plate, 1886) (Fig. 5)

Ecology: Euplanktonic cold-stenotherm rotifer (de Manuel, 2000). It is found at higher densities in hypolimnion of stratified lakes and reservoirs, and also in well-mixed water bodies (de Manuel, 2000). It tolerates low oxygen concentrations (Margalef *et al*., 1976).

Distribution: Cosmopolitan and common in the Iberian Peninsula. It is abundant in Spanish reservoirs.

In Foix: Despite their different morphological features, it was not always possible to distinguish between species from the genus *Filinia*, since preservation methods often collapsed individuals. So for quantitative considerations they are treated as *Filinia spp*.

Frequent, albeit at moderate densities (i.e. 0.05-6 ind/L). In March 1997, the genus reached 216 ind/L, and was relatively abundant (Table 2). Sporadic high densities may be related to hydrological conditions. March 1997 was the wettest period between the years 1997 and 2000 (Marcé *et al*., 2000). Individuals from this genus located at different depths in 1999 (Fig. 6), could be explained by segregation of the two species found, however this could not be confirmed.

Crustacea

Class Branchiopoda Latreille
Family Eurycercidae

Chydorus sphaericus (Müller, 1776) (Fig. 7)

Ecology: Species inhabiting preferentially littoral or shallow waters, often associated to algae or macrophytes. Frequent in the plankton (Korovchinsky, 2000), where it has been related to the presence of Cyanobacteria (Hutchinson, 1967; Armengol, 1978; Alonso, 1996). It tolerates a wide range of environmental conditions (Margaritora, 1985), but shows poor tolerance to high chloride concentrations (Margalef, 1953; Margalef *et al*., 1976; Alonso, 1985). It feeds on flagellates, diatoms, and detritus.

Distribution: Cosmopolitan. Widespread cladocerans in the Iberian Peninsula (Margalef *et al*., 1976). Frequent in Spanish eutrophic reservoirs, always at low densities.

In Foix: It appeared in 1999 (Table 2), concomitantly to *B. angularis* (Fig. 6 and 8). Despite being a benthic species, *C. sphaericus* achieved densities in excess of 200 ind/L (Table 2). High densities of this species were related to exceptional turbidity in 1999 (i.e. >40 Nephelometric Turbidity Units-NTU) (Marcé *et al*., 2000).

Alona rectangula G.O. Sars, 1862 (Fig. 7)

Ecology: Heleoplanktonic species frequently associated to macrophytes, although it can swim (Armengol, 1978). It is more frequently found in small water bodies (Alonso, 1996), but also appears in turbid, eutrophic, planktonic habitats (Margalef, 1953; Armengol, 1978).

Distribution: Holartic and Ethiopian species. It does not have a clear distribution pattern in the Iberian Peninsula (Armengol, 1978; Alonso, 1996). Rare in reservoirs.

In Foix: Isolated records, mainly during mixing and always at low densities (i.e. $\leqslant$ 1 ind/L) (Table 2). Appeared near the bottom in November 1999.

Family Moinidae

Moina micrura (Kurz, 1875) (Fig. 7)

Ecology: Stenotherm cladoceran from warm waters (Alonso, 1996). Heleoplanktonic species frequently recorded in eutrophic planktonic environments.

Distribution: Cosmopolitan (Margaritora, 1985), and frequent in the Iberian Peninsula, where it appears in low mineralised and turbid waters. Not frequent in reservoirs (Margalef *et al*., 1976).

In Foix: Rare. It appeared in the plankton during autumn 1997, always at densities less than 1 ind/L (Table 2).

Family Daphniidae

Daphnia (Daphnia) galeata G.O. Sars, 1863 (Fig. 7)

Ecology: Common species in lakes and small water bodies (Armengol, 1978; Alonso, 1996).

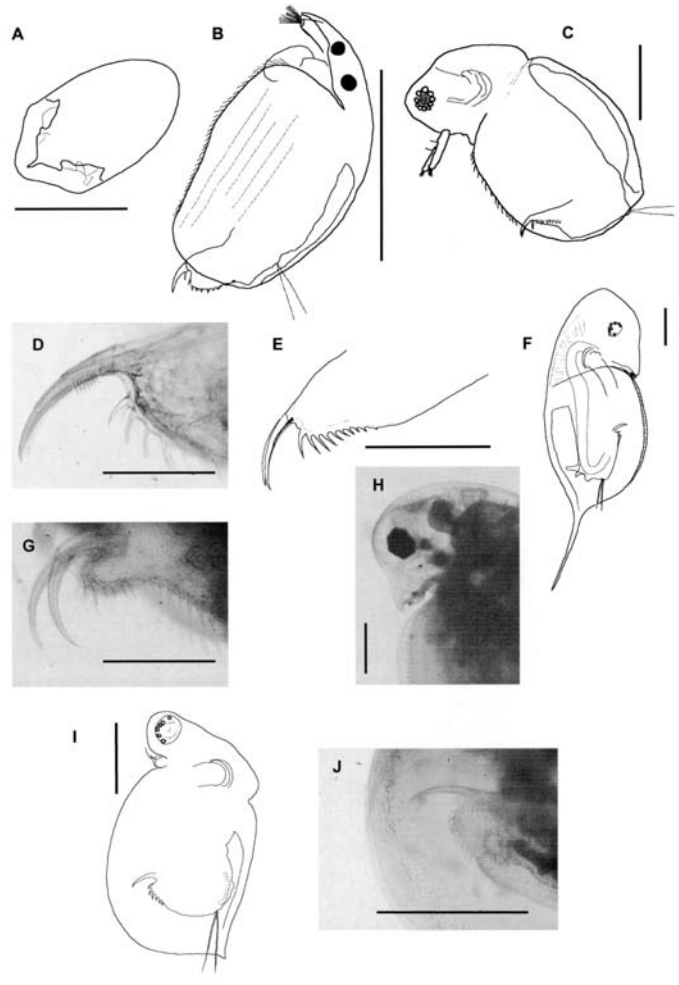

Figure 7. Cladocera species from the Foix Reservoir. **A** *Chydorus sphaericus*, cephalic capsule. **B** *Alona rectangula*. **C** *Moina micrura*. **D** *Daphnia pulicaria*, pecten. **E** *D. galeata*, pecten and postabdomen. **F** *D. galeata*, young individual. **G** *D. magna*, postabdomen. **H** *D. magna*. **I** *Ceriodaphnia quadrangula*. **J** *C. quadrangula*, postabdomen. Bars: 200 µm. *Cladóceros del embalse de Foix*. ***A*** Chydorus sphaericus*, cápsula cefálica*. ***B*** Alona rectangula. ***C*** Moina micrura. ***D*** Daphnia pulicaria*, pecten*. ***E*** D. galeata*, pecten y postabdomen*. ***F*** D. galeata*, juvenil*. ***G*** D. magna*, postabdomen*. ***H*** D. magna. ***I*** Ceriodaphnia quadrangula. ***J*** C. quadrangula*, postabdomen. Barras: 200 µm.*

It is recorded in systems with a wide range of trophic states. Alonso (1996), however, relates presence of this species to eutrophic conditions.

Distribution: Holartic and widespread in Spain. Very abundant in reservoirs (Alonso, 1996). It has been confused with *D. hyalina* (Margalef *et al*., 1976; Armengol, 1978).

In Foix: Frequent. It presented densities between 0.01 and 17 ind/L. It was found during both mixing and stratified conditions (Table 2), without a clear temporal pattern. During autumn 1999, it was the only cladoceran present in the surface layers of the reservoir (Fig. 8).

Daphnia (Daphnia) longispina (Müller, 1776)

Ecology: Species inhabiting still or slow running waters, often associated to submerged macrophytes (Alonso, 1996). It is not frequent in eutrophic environments.

Distribution: Paleartic species. Widespread in the Iberian Peninsula, especially in the Pyrenees and in Spanish reservoirs (Armengol, 1978).

In Foix: Very rare. It was collected only on one single occasion, near the bottom, in January 2000 (Table 2).

Daphnia (Daphnia) pulicaria Forbes, 1893 (Fig. 7)

Ecology: Planktonic species found in permanent, clear, and low mineralised waters (Alonso, 1996).

Distribution: Holartic cladoceran. Its taxonomic position is still controversial (Margaritora, 1985). It has been collected in Western Spanish reservoirs (Margalef *et al*., 1976). It is easily excluded when other cladocerans from the genus *Daphnia* are present. It is often found with *D. magna* (Margalef *et al*., 1976).

In Foix: Very rare. It was collected on one single occasion, in March 1998 (Table 2), coinciding with the only record of *D. magna.*

Daphnia (Ctenodaphnia) magna Straus, 1820 (Fig. 7)

Ecology: Cladoceran often found in temporary waters (Margalef, 1953; Armengol, 1978). It is often associated with vegetation in windless, shallow, and warm locations (Armengol, 1978). Margaritora (1985) considers this species as an indicator of eutrophic conditions. Alonso (1996) defines this cladoceran as pollution-tolerant.

Distribution: Holartic. In Spain it is mainly found in the eastern eutrophic reservoirs (Margalef *et al*., 1976).

In Foix: Highly rare species in the reservoir, where it was collected once in March 1998 (Table 2), coinciding with the only record of *D. pulicaria*.

Ceriodaphnia quadrangula (Müller, 1785) (Fig. 7)

Ecology: This cladoceran inhabits any kind of water bodies, even temporary ones, where it is often found in plant beds (Margalef, 1953; Armengol, 1978; Alonso, 1985). As Armengol (1978) pointed out, Alonso (1996) considers that a poor developed taxonomy of the genus may explain the wide ecological distribution of *C. quadrangula*.

Distribution: Holartic and Neotropical. Widespread. It is often recorded in reservoirs (Hutchinson, 1967; Armengol, 1978; Alonso, 1996). It is frequent in eutrophic Spanish reservoirs. Its distribution does not follow any clear pattern (Margalef *et al*., 1976).

In Foix: Frequent. Densities ranged 0.06-17 ind/L (Table 2). Densities during summer were marginally higher. In 1999, it peaked during stratification (Fig. 8). Maximum densities were found at larger depths after mixing. Similar patterns were found for *C. sphaericus* and *B. angularis*.

Ceriodaphnia reticulata (Jurine, 1820)

Ecology: Littoral species associated with macrophytes (Armengol, 1978; Alonso, 1996). It is often found in eutrophic conditions (Margaritora, 1985), and cannot survive in turbid systems (Alonso, 1996).

Distribution: Holartic, Neotropical, and Ethiop. Rare in Spanish reservoirs, it has been collected in mineralized waters poor in chloride (Margalef *et al*, 1976).

In Foix: It was found on one occasion in October 1997, in the riverine section of the reservoir (Fig. 1).

Family Bosminidae

Bosmina longirostris (Müller, 1776)

Ecology: Euplanktonic species from lakes and reservoirs. It is also frequent in littoral margins, but is seldom found in plant beds. It has often been recorded in low mineralized and eutrophic systems (Armengol, 1978; Margaritora, 1985; Alonso, 1996).

Distribution: Cosmopolitan. Widespread in the Iberian Peninsula and very frequent in Spanish reservoirs, although at low densities (Armengol, 1978; Alonso, 1996). It is not often collected in hypolimnetic layers (Margaritora, 1985).

In Foix: Occasional. Densities ranged 0.01-1.8 ind/L (Table 2). The scarcity of records does not allow us to define a seasonal or spatial pattern.

Class Copepoda
Family Cyclopidae

Acanthocyclops robustus (Sars, 1863) (Fig. 9)

Ecology: This species inhabits the plankton of lakes, marshes, and small water bodies. However,

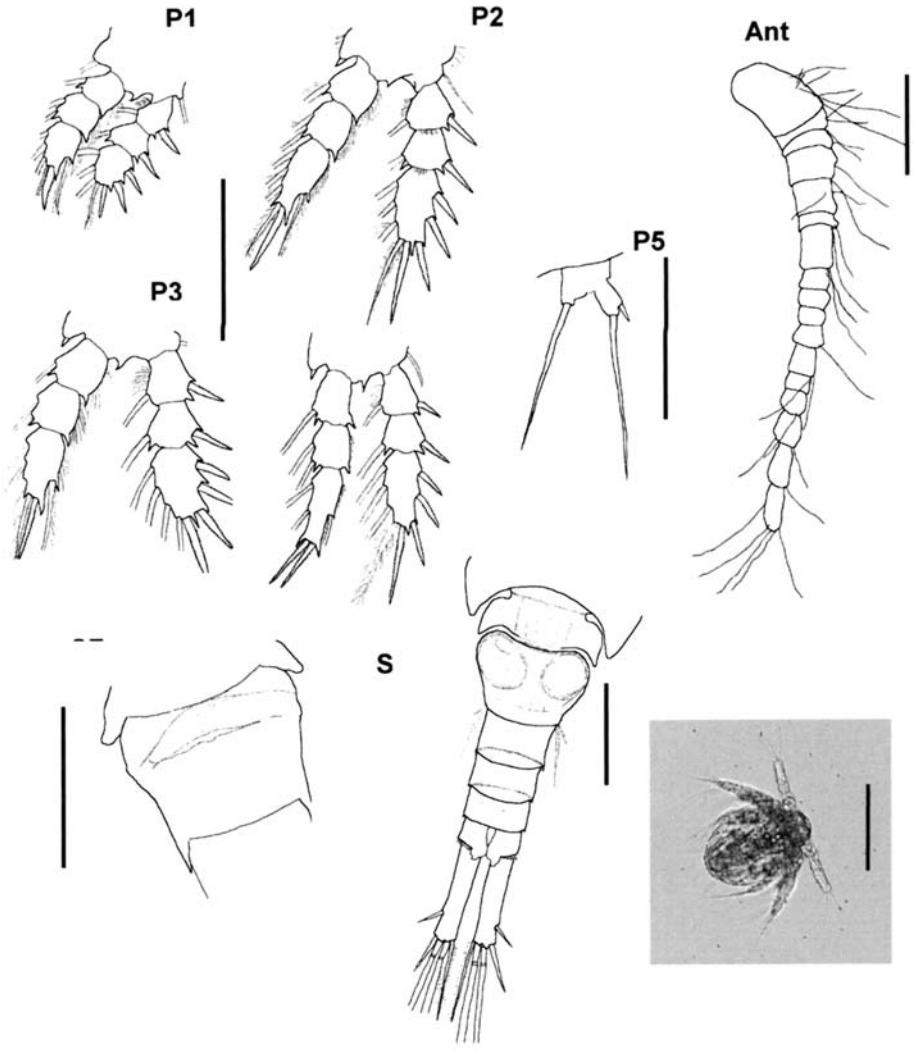

Figure 9. *Acanthocyclops robustus* from the Foix Reservoir. **P1-P5** Pairs of swimming legs. **Ant** Antennula. **SF** Female genital segment. **SM** Male abdomen and furca. **N** Nauplius instar. Bars: 200 µm, except **P5**: 100 µm. Acanthocyclops robustus *en el embalse de Foix. **P1-P5** Pares de patas nadadoras. **Ant** Anténula. **SF** Segmento genital femenino. **SM** Abdomen y furca masculino. **N** Nauplius. Barras: 200 µm, excepto **P5**: 100 µm.*

it is considered as a littoral copepod, and records of this species in the plankton are available only since the 1970's (Maier, 1996; Caramujo & Boavida, 1998). It is found in all kinds of waters (Alonso, 1985), but it prefers warm temperatures (Dussart, 1969). It is only abundant in the plankton in eutrophic conditions (Caramujo & Boavida, 1998). *A. robustus* is a predatory copepod (Armengol, 1978; Gliwicz & Umana, 1994; Hopp *et al*., 1997), but it also eats algae (Hopp *et al*., 1997). A surprising predatory behaviour on *Daphnia* eggs inside the brood pouch was described by Gliwicz & Stibor (1993).

Distribution: Cosmopolitan. *Acanthocyclops* is the most abundant genus in Spanish reservoirs after the genus *Cyclops* (Armengol, 1978). It is more abundant in eutrophic waters, and can be found in waters of varied mineralisation. Taxonomy of the group *robustus-vernalis* is controversial (Fryer, 1985; Reed, 1986; Einsle,

1993; Dodson, 1994; Einsle, 1996; Lescher-Moutué, 1996; Caramujo & Boavida, 1998), and *A. robustus* & *A. vernalis* are often confused.

In Foix: It was the only copepod species found in the Foix Reservoir during the period of study. Adult densities ranged between 0.1 and 98 ind/L (Table 2), with a peak approximately every six months (i.e. one during summer and another during winter). Copepodite densities of *A. robustus* almost matched adult dynamics (Table 2). Nauplii did not follow any clear temporal pattern. Both females and males avoided deep layers during mid-summer, and the temporal segregation during autumn is remarkable (Fig. 8). Densities of males and females were remarkably different throughout the whole period too. This sex-ratio could be explained by high temperatures in the reservoir (see Marcé *et al*., 2000), which favour male development (Dussart, 1969), helped by preferential accumulation of female individuals on the shores, as it has been found in some reservoirs (Fernández, 1996). Unfortunately, our data do not allow us to test these hypotheses.

DISCUSSION

The zooplankton community of the Foix Reservoir is characterized by a diversity of heleoplanktonic species, accounting for 50% of the taxa found. De Manuel (2000) found that heleoplanktonic Rotifera were very abundant in a survey of over one hundred Spanish reservoirs, so Foix does not have an unusual rotifer community. Low crustacean richness, and especially the presence of only one copepod species, characterise the zooplankton of Foix. A survey of over 100 reservoirs (Margalef *et al*., 1976) recorded this situation in only four locations (Margalef & Armengol, 1980). However, their sampling was only carried out once per season. A more intensive sampling programme would probably have collected more copepod taxa in these reservoirs. According to Margalef (1983), the presence of two or more copepod species in plankton of reservoirs is the most frequent situation.

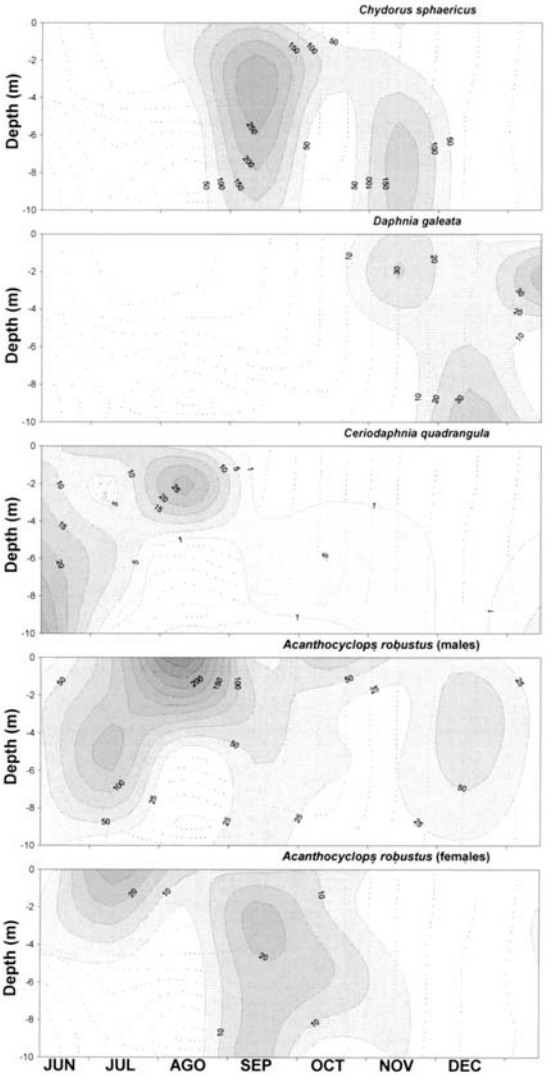

Figure 8. Density (ind l^{-1}) depth-time plots for some cladocera and copepod species during 1999. The dotted line shows temperature profiles. *Gráficos profundidad-tiempo para la densidad (ind l^{-1}) para algunos cladóceros y copépodos durante 1999. La línea punteada muestra el perfil de temperatura.*

Low crustacean diversity could be a common feature of small reservoirs or the product of the extreme limnological characteristics of the Foix Reservoir (see Marcé *et al*., 2000). Dodson (1991; 1992) related crustacean richness in European lakes to basin morphology, finding a positive relationship between lake size and amount of crustacean species. However, no data

Table 3. Biomass (µg/L) for rotifera (Rotif.), copepoda (Copep.), and cladocera (Cladc.) in the station near the dam at each sampling date (month above, year below). Biomasses in 1999 were calculated integrating data for the whole water column. The percentage of total zooplankton biomass accounted for each group is also shown. *Biomasa (µg/L) para rotíferos (Rotif.), copépodos (Copep.) y cladóceros (Cladc.) en la estación cercana a la presa en cada muestreo (mes arriba, año debajo). Las biomasas en 1999 se calcularon integrando los datos de toda la columna de agua. Se muestra también el porcentaje de la biomasa total de zooplánkton debida a cada grupo.*

	3 97	**6 97**	**9 97**	**10 97**	**12 97**	**3 98**	**5 98**	**7 98**	**10 98**	**6 99**	**7 99**	**8 99**	**9 99**	**10 99**	**11 99**	**12 99**	**1 00**
Rotif.	36	3.1	0.4	14	0.4	6.6	0.6	53	1.1	11	6.6	6.0	22	4.8	17	3.0	49
%	74	1.7	0.8	38	0.1	5.7	0.3	18	2.8	6.9	2.2	2.3	3.4	1.5	2.9	0.3	15
Copep.	13	143	54	21	519	100	163	188	37	124	287	173	226	249	134	876	74
%	26	77	95	58	99	86	67	66	97	76	95	67	35	81	23	77	23
Cladc.	0.0	39	2.2	1.6	0.1	10	79	44	0.0	28	9.9	80	401	55	435	256	195
%	0.0	21	3.9	4.4	0.0	8.8	32	16	0.0	17	3.3	31	62	18	74	22	61

are available comparing both large and very small reservoirs. Dodson *et al*. (2000) postulated that crustacean richness varies with trophy, decreasing at high productivity (see also Jeppesen *et al*., 2000). Thus, low crustacean richness in the Foix Reservoir could be due both to its small size and extreme hypertrophy.

Changes over time in species' composition are also remarkable, except for copepods. *Keratella cochlearis* f. *tecta* and *K. quadrata* did not reappear after March 1998, whereas *K. tropica* and *Lecane closterocerca* appeared again in 1999. Benthic species were occasionally collected, such as *Rotaria neptunia* or *Testudinella patina* (Table 2). These species were abundant during high inflow periods, such as those occurred in March and June 1997 (Marcé *et al*., 2000). Rotifera richness was clearly higher during low residence time periods. For instance, in March 1997 12 rotifera taxa accounted for 74 % of total zooplankton biomass (Table 3).

Chydorus sphaericus appeared in 1999, and increased cladoceran biomass, reaching the higher values for the whole period (Table 3). Regarding physical and chemical variables in the reservoir (Marcé *et al*., 2000), only turbidity was strongly different in 1999 compared to other years. Marzolf (1990) postulated turbidity as a key factor controlling zooplankton communities.

T-student tests for biomass of different groups in thermocline and oxycline-defined layers gave similar results, so only results from tests for thermocline will be given. Copepods were significantly more abundant (p=0.04, n=5) above both thermocline and oxycline during stratification in 1999. Test for cladoceran distribution (p=0.51, n=5) was strongly influenced by *Chydorus* biomass near the bottom in September. Rotifera did not show significant differences (p=0.22, n=5) due to high biomass in deep layers, mainly explained by *Polyarthra* spp., *Filinia* spp., and *Brachionus angularis* densities.

The qualitative sample collected in the riverine section of the reservoir in October 1997 contained 7 species (6 rotifers and one cladoceran, see species description) not recorded near the dam. These were heleoplanktonic and benthic organisms, found in a shallow environments (1 m) rich in macrophytae (mainly *Phragmites australis* (Cav.)). *Itura aurita aurita*, a very rare rotifer in the Iberian Peninsula, was recorded here. A more frequent sampling in this reservoir section would have probably found more taxa not recorded here.

The riverine section of new small reservoirs may act as new habitats for species' dispersion and refuge, especially for microcrustacea and Rotifera, which have a high dispersal ability (Shurin, 2000; Shurin *et al*., 2000). These movements could have been important south of the Pyrenees during the second half of the 20th century, when more than 600 small reservoirs

were built (MOPU, 1988) in a country where inland wetlands were scarce and isolated. Indeed, some planktonic rotifers first appeared in Spanish reservoirs during the 1980's, such as *Wolga spinifera* and *Filinia opoliensis*. Others expanded their distribution, i.e. *Keratella tropica* and *K. irregularis* (Guiset & de Manuel, 1993). Unfortunately, the riverine section of the reservoirs was not included in the sampling designs of surveys conducted in the 1970's and 1980's. These surveys also focused on large reservoirs. Thus, we cannot establish the impact of these relatively new small reservoirs on the distribution of benthic and heleoplanktonic microfauna.

Taxonomic studies in reservoirs should take into consideration spatial heterogeneity, if detailed taxa richness and time variability is required. Small Mediterranean reservoirs like Foix are strongly forced by climatic variability at short and medium time scales. Also, Spanish reservoirs are recent systems where colonization is still in progress (Guiset & de Manuel, 1993). This can introduce variability at larger time scales.

ACKNOWLEDGMENTS

This work has been possible through the financial support of Diputació de Barcelona. It has also been partially funded by the project REN2001-2185-CO2-O2 of the Science and Technology Ministery. The contribution 1999SRG 28 from the Generalitat de Catalunya is also greatly appreciated. We are thankful to the staff of 'Parc del Foix' for their help. We are also grateful to Maria Romero for her advice on zooplankton identification and counting. David Balayla also gave useful comments on early drafts and carefully revised the English manuscript.

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