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Seasonal succession of zooplankton populations in the hypertrophic lagoon Albufera of Valencia (Spain)

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With 6 figures and 2 tables in the text

Abstract

The seasonal distribution of zooplankton in a hypertrophic coastal lagoon is described. The dominant zooplankton species were the copepod *Acanthocyclops robustus* and the rotifer *Brachionus angularis*, which reached average densities, for the 3 m water column, up to 700 (12 May) and 7,000 (5 July) individuals l^{-1}, respectively, at the time of their maxima. The zooplankton biovolume varied between approximately 0.6 ml m^{-2} (November) and 7 ml m^{-2} (July). Copepods form the largest part of the biovolume (annual mean 60%). Species diversity shows an inverse fluctuation with respect to the biovolume with a spring-early-summer minimum (0.5 bits ind^{-1}), which increased progressively to an autumn maximum (2 bits ind^{-1}). *A. robustus* and *B. angularis* dominate in spring and early summer along with *Polyarthra* sp. pl., *Brachionus quadridentatus* and *Alona rectangula*. Characteristically summer species were *Asplanchna girodi*, *Anuraeopsis fissa*, *Brachionus bidentata* and *Moina macrocopa*. In autumn, *Brachionus urceolaris* had its maximum coinciding with declining perennial and summer species and some incipient winter populations. In winter, *Brachionus leydigi*, *Synchaeta oblonga*, *Notholca acuminata*, *Notholca salina* and *Daphnia magna* could be found together with the perennial species *A. robustus* and *Polyarthra* sp. pl. Compared to past studies, a reduction in the number of cladocera and rotifer species was very apparent, while the numerical presence of copepods has increased due to the developing of *A. robustus*.

Introduction

Recent studies on the Albufera of Valencia have shown the effects of the ever-increasing pollution (BLANCO 1974, DAFAUCE 1975, SERRA et al. 1984, MIRACLE et al. 1984). A reduction in the bird and fish species has been observed, as

1964–1974 (Dafauce 1975), and the increase in chlorophyll concentration, the annual average of which was ten times greater in 1980 than in 1972 (Serra et al. 1984).

Although the Albufera of Valencia is the largest oligohaline coastal lagoon in Spain, very few studies on its zooplankton have been published. The first studies (Arevalo 1916, 1918, Wiszniewski 1931, Pardo 1942) yielded basically brief descriptions of species found in samples taken sporadically. Later Blanco (1974, unpublished thesis) carried out a more systematic study of the zooplankton annual cycle during 1972–1973, but only quantifying some species and groups of organisms. The present study is a detailed description of the zooplankton of this lagoon during an annual cycle (1980–1981). Later, in 1982, we undertook a study on the horizontal heterogeneity of zooplankton of this lagoon comparing samples taken at different sampling stations (Oltra & Miracle 1984).

Material and Methods

Study area

The Albufera of Valencia (39° 20′ N, 0° 20′ W) is a shallow lagoon with a surface area of 22 km^2 and an average depth of 1 m, although in some dredged areas it can be up to 3 m deep. The sampling station was situated in one of these areas (2.7–3.2 m deep), at approximately 200 m from the east bank.

Originally, the lagoon was linked directly to the sea, but it now functions as a reservoir regulated by floodgates, due to the demands of local rice cultivation. The manipulation of the floodgates affects the limnological parameters of the lake, especially its salinity.

The studies by Serra et al. (1984) and Garcia et al. (1984) on the physico-chemical characteristics and phytoplankton of the Albufera, respectively, are based on measurements and samples taken simultaneously with the zooplankton samples studied in this paper. They revealed the oligohaline nature of the lake (salinity 1 to 2 $g\,l^{-1}$, $SO_4^{2-} > Cl^- > CO_3^{2-}$, $Na^+ \geqslant Ca^{2+} \geqslant Mg^{2+} > K^+$) and also its hypertrophic features: high annual mean concentrations of NH_4^+ (10.8 $\mu mol\,l^{-1}$), NO_3^- (20 $\mu mol\,l^{-1}$), orthophosphate (0.47 $\mu mol\,l^{-1}$), total phosphorus (15 $\mu mol\,l^{-1}$) and chlorophyll-a (400 $mg\,m^{-3}$), elevated pH value at midday (around 9–10), low alkalinity (1 to 2 $meq\,l^{-1}$) and phytoplankton dominated by cyanobacteria. The proportions of cyanobacteria (mainly *Pseudoanabaena, Lyngbya* and *Oscillatoria*) were around 90 % in summer, 75 % in January, 40 % in April and 80 % again in May. Chlorophyta (*Chlamydomonas, Scenedesmus, Monoraphidium*) was the second-most important group, always tivity measurements were made using a YSI mod 33 salinometer, and water samples were taken to determine pH, redox and limnological parameters, according to the methods described by Golterman et al. (1978) and Strickland & Parsons (1978).

The samples for counting zooplankton were taken with an 8 l Van Dorn plankton bottle or a 2.6 l Ruttner bottle. They were filtered through a nytal gauze of 45 μm mesh size and fixed by a 4 % formaline solution. Sedimented zooplankton species were then counted using an inverted microscope at 100 and 200 × magnifications (Miracle 1976), and several individuals of each species (instars in crustacea) were randomly measured.

To calculate the zooplankton biovolume, the number of individuals in each species was multiplied by its average volume in each sample, which was calculated according to expressions of Edmondson & Winberg (1971) for copepods and cladocerans and Ruttner-Kolisko (1977) for rotifers.

The relationships between the biotic and abiotic variables has been analysed by means of simple correlation and by multiple regression analysis.

Results

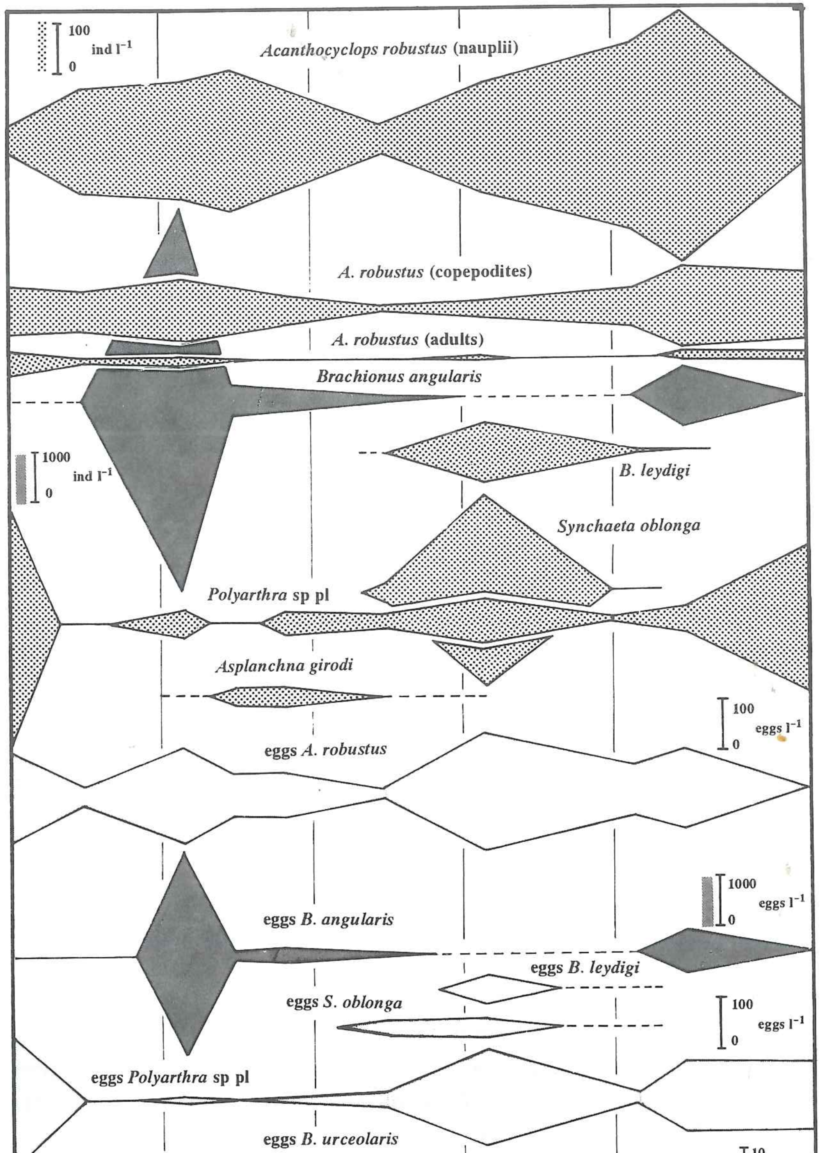
Zooplankton species composition

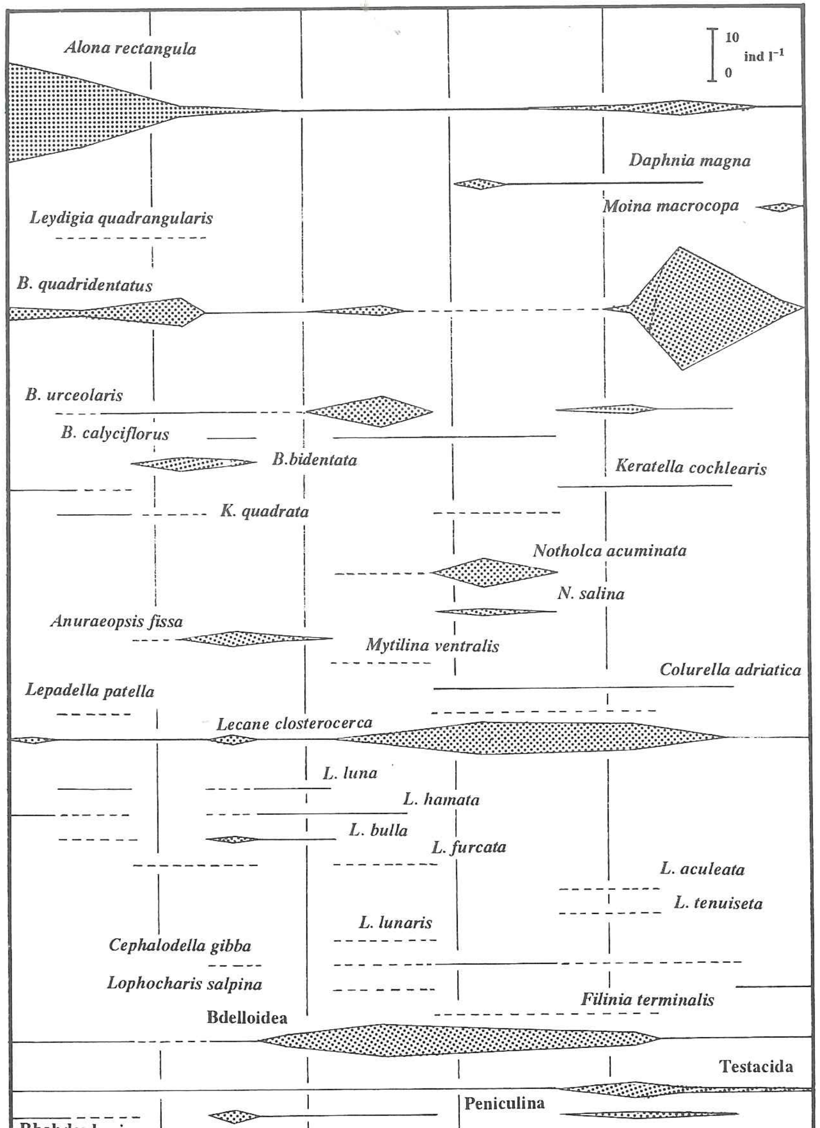
The zooplankton community is very simple; it is mainly formed by the copepod *Acanthocyclops robustus,* accompanied by high densities of the rotifer *Brachionus angularis,* except in winter, when this species vanishes and is substituted by *Brachionus leydigi* and other rotifers. Mean densities per water column of the major and minor species and eggs studied during the annual cycle are represented in Fig. 1 (A, B).

Copepoda: *Acanthocyclops robustus*

1. Morphological and taxonomical aspects

This species was the predominant zooplankter of the lagoon. It constituted, on average, 60 % of the total amount of zooplankton biovolume (75 % during mid-spring and mid-autumn, but 35 – 40 % at the end of summer and winter). The presence of *A. robustus* had not been previously recorded in the Albufera. Pardo (1942) and Blanco (1974) recorded *Macrocyclops albidus, Paracyclops fimbriatus* and *Halycyclops* sp. as the only cyclopod species. Although we first considered it to be *Acanthocyclops vernalis* (Oltra & Miracle 1984), because in the specimens observed the bristle of endopodite 3 of leg 4 had not been converted into spine, a more detailed review revealed that the form of genital segment is typical of *A. robustus* (Fig. 2).


100
ind l-1
0
Acanthocyclops robustus (nauplii)
A. robustus (copepodites)
A. robustus (adults)
Brachionus angularis
1000
ind l-1
0
B. leydigi
Synchaeta oblonga
Polyarthra sp pl
Asplanchna girodi
100
eggs l-1
0
eggs A. robustus
1000
eggs l-1
0
eggs B. angularis
eggs B. leydigi
eggs S. oblonga
100
eggs l-1
0
eggs Polyarthra sp pl
eggs B. urceolaris


10
ind l⁻¹
0
Alona rectangula
Daphnia magna
Moina macrocopa
Leydigia quadrangularis
B. quadridentatus
B. urceolaris
B. calyciflorus
B.bidentata
Keratella cochlearis
K. quadrata
Notholca acuminata
N. salina
Anuraeopsis fissa
Mytilina ventralis
Colurella adriatica
Lepadella patella
Lecane closterocerca
L. luna
L. hamata
L. bulla
L. furcata
L. aculeata
L. tenuiseta
L. lunaris
Cephalodella gibba
Lophocharis salpina
Filinia terminalis
Bdelloidea
Testacida
Peniculina

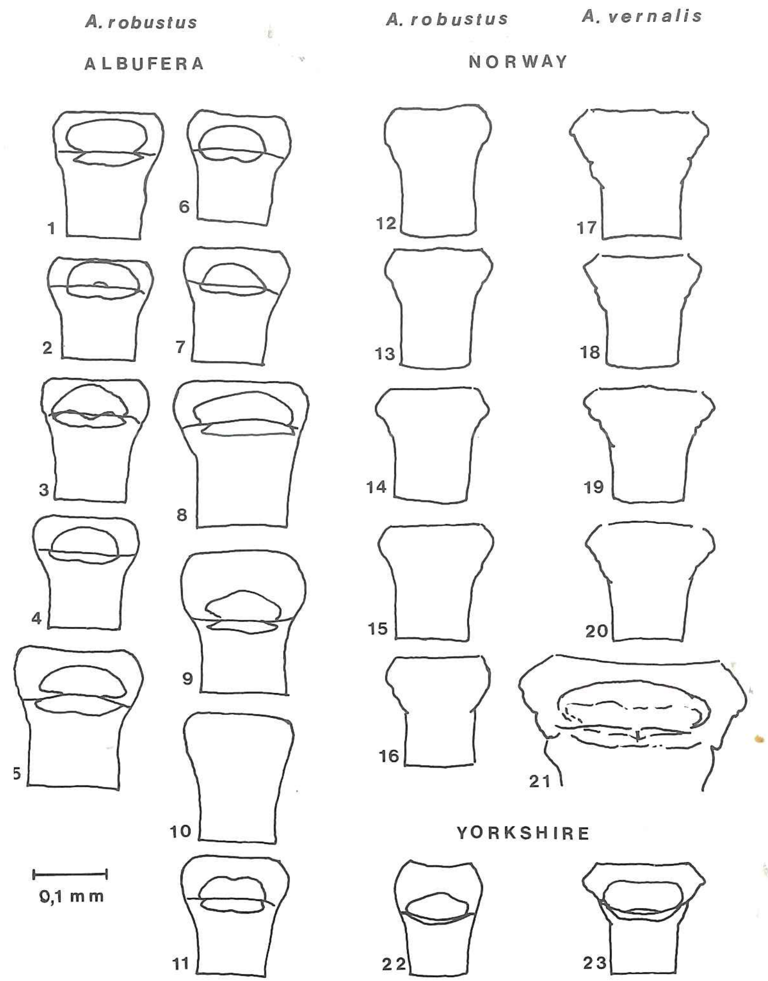


Fig. 2. Genital female segment of several populations of *A. robustus* and *A. vernalis.* The scale is only for drawings corresponding to specimens from Albufera of Valencia, 1 to 11 (12 to 21 from KIEFER 1976 and 22 to 23 from FRYER 1985).

resources are scarce. The same tendencies have been observed in other cope-

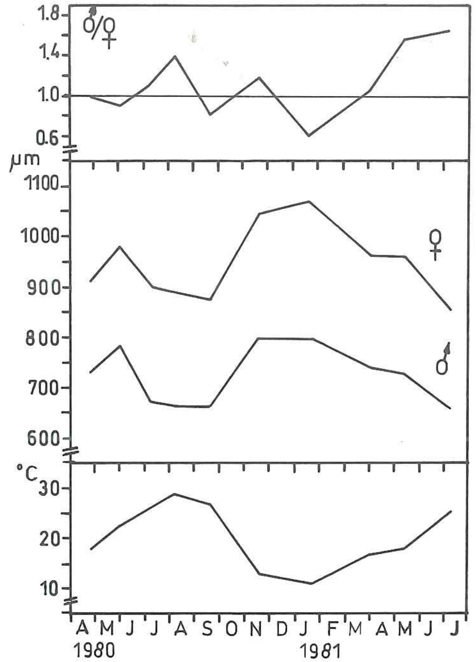


Fig. 3. Seasonal variation of *Acanthocyclops robustus* male/female relationship, in numbers of individuals, in relation to their size variation and to temperature annual change.

Table 1. Percentage of *Acanthocyclops robustus* ovigerous females, number of eggs per egg sac, egg diameter (μm), egg biovolume per egg sac ($mm^3 \times 10^{-3}$) and percentage of total adults with epibionts of *Epistylis* sp. pl. with the percentage of females with respect to that total, for each sampling date.

				Fertility			Epibionts	
	% Females with eggs	Eggs/sac mean	sd	E. diameter mean	sd	E. biov. per sac	% Infected adults	% Infected females
1980								
25 Apr.	11.7	31.0	1.4	74.3	3.1	6.7	7.4	100
30 May	8.9	30.0	–	70.0	–	5.4	3.0	100

has been recorded for other copepods (Margalef 1983, Miracle 1976). Egg production is affected by various factors, the amount of available food being the most important. Thus, the numbers of adults and eggs (Fig. 1) are more or less coincident with the maxima of *B. angularis*, the most probable *A. robustus* prey except for winter. The peak of eggs and the high proportion of ovigerous females observed in January is due to the longer egg development time in the colder periods. Egg size has also its maximum in this month.

In the Albufera, *A. robustus* is more abundant in spring and summer. The population consists mainly of nauplii and copepodites. The population of nauplii increases immediately after periods of maximum reproductive effort and then diminishes rapidly as individuals become copepodites and also through mortality (Fig. 1 A). The most important reproductive period is in spring when the larger females, having grown slowly during winter, produce a high number of eggs which give rise to a peak of nauplii; the whole population increases with smaller, fast-developing individuals, which reach maturity in summer. Two generations coexist at this time, confirmed by the observation of two size classes of adults. A secondary peak of nauplii can be produced in summer; but by the end of summer, food resources may have decreased and the population decreases. The population reaches a minimum in later summer-autumn, coinciding with minimum chlorophyll-a concentration. This is not due only to the decrease of the population after its main growth period but is also caused in part by the dramatic increase of the water renewal rate derived from the hydrological manipulation of the lagoon. In autumn, following the closing of the floodgates, the reproductive activity is again favoured, and another peak of nauplii occurs in winter.

3. Epibionts

In all sampling months, adults were found with the epibionts *Epistylis anastatica* and *Epistylis ovum* (Table 1). In July 1980 and November 1980 the percentage of adults with epibionts rose to 25.4 and 21.8 % respectively, though at other times oscillated between 2.4 and 8.0 %. The greater part of copepods affected were females. Males with epibionts were found only on four sampling dates in proportions which represented between 9 and 25 % of the affected

D. magna was most abundant in winter and spring when the percentage of cyanobacteria diminished. *Moina* was found in July, a mixed population of *Moina micrura* and *Moina macrocopa,* the latter being very rare. It has been found in the Iberian peninsula only in Gandia, by AREVALO (1920), who identified it as *M. rectrirostris* var. *casañi.* Another cladoceran of limited distribution found in this study is *Leydigia quadrangula.*

Rotifers

Densities of rotifers rarely exceeded 1,000 ind l^{-1} in 1980 – 1981, and nearly all the species found could be grouped into three families: Brachionidae, Lecanidae and Synchaetidae.

B. angularis was clearly dominant, reaching densities of over 10,000 ind l^{-1} at its peak, which doubles the figure of 5,000 ind l^{-1} quoted by RUTTNER-KOLISKO (1974) as being the maximum concentration found in eutrophic ecosystems. This species was cited by AREVALO (1918) as being infrequent, whereas, at present, it is the most abundant rotifer by far, being present all year round. The maxima of *B. angularis* population density were in spring and early summer. The highest percentage of ovigerous females was also at this time. The population decreased at the end of summer and then fell in autumn and nearly disappeared in winter when it was substituted by *B. leydigi.* In November, as the population fell, the production of resting eggs reached its maximum. Through the year, *B. angularis* showed a certain cyclomorphosis, indicated by a greater size and more spherical form in autumn, whereas in summer and spring it was more lentiform.

B. leydigi is the second-most abundant species of the genus and makes its characteristic appearance in winter. *Brachionus urceolaris* has its occurrence in November, between these two species' maxima. PARDO (1942) considered it to be a perennial species widely found in the wetlands of Valencia, and yet at the time of the study it was hardly represented in the Albufera.

Brachionus quadridentatus is a highly polymorphic species. The *brevispinus* form and the *cluniorbicularis* and *ancylognatus* varieties have been identified. The *cluniorbicularis* var. is the most abundant. BLANCO (1974) recorded the tive development of *P. dolichoptera* and *P. longiremis* populations. Given the difficulty of precisely identifying each one when counting, the *Polyarthra* species have been counted together.

Asplanchna girodi reaches its maximum in August with densities of up to 30 ind l^{-1}.

Synchaeta oblonga appeared in winter reaching a maximum of 250 ind l^{-1} in January.

Other species found at low densities were: *Notholca acuminata, Notholca salina* and *Filinia terminalis* in winter, *Keratella cochlearis, Keratella quadrata* in spring and *Anuraeopsis fissa* in summer. It is also worth mentioning the relative abundance of tetoplanktonic species. Their distribution over the annual cycle can be observed in Fig. 1.

Protozoa

Several protozoa have been identified in the samples, which are represented in Fig. 1 placed together under the name of the group to which they belong, i.e.: Testacida (*Arcella discoides, Difflugia arcula*), Rhabdophorina (*Cyclotrichium* sp.), Peniculina (*Paramecium* sp.) and Sessilina (*Vorticella* sp., *Epistylis anastatica* and *Epistylis ovum*).

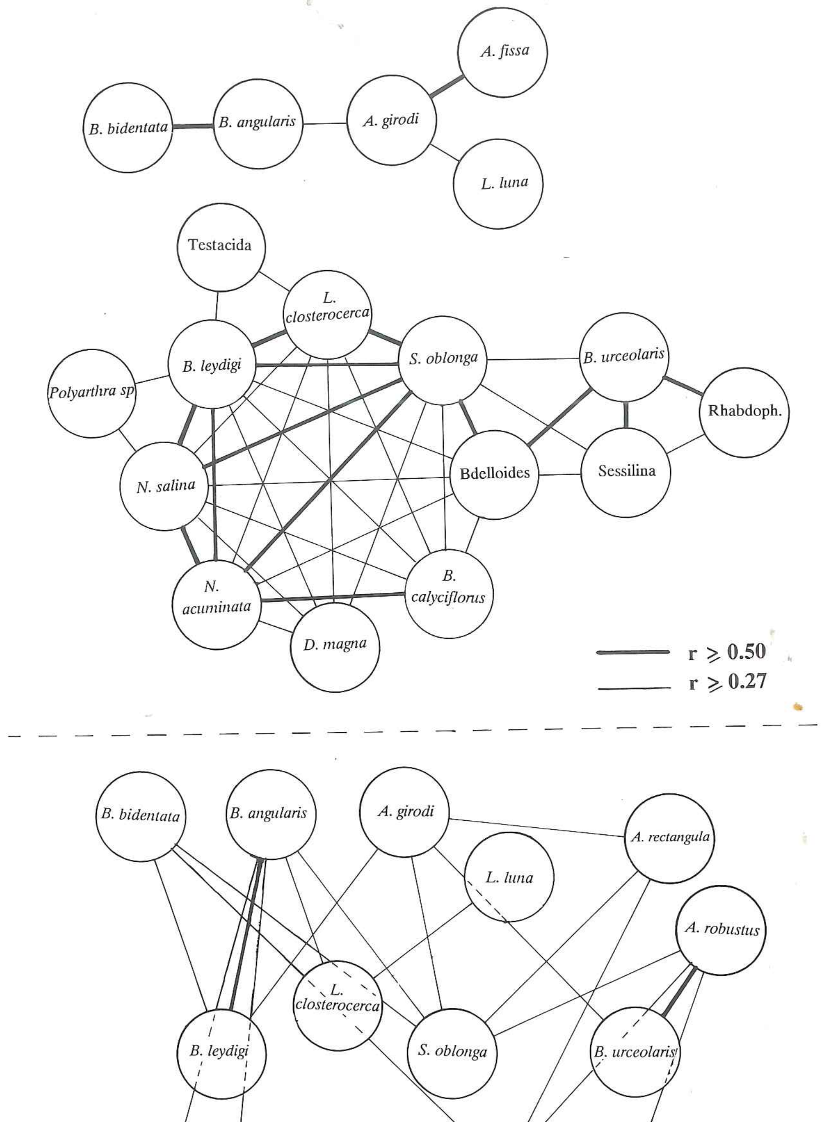
Seasonal succession

Basically two different periods in the annual cycle of the Albufera could be distinguished: late spring-summer, characterized by cyanobacteria blooms, and autumn-winter-early spring with a reduced phytoplankton production and higher diversity due to the increased proportion of other algal groups (chlorophytes and diatoms). From May to September the dams are mostly closed, to have a slow flow during rice cultivation in flooded ricefields. Temperature ranges between 20 and 30 °C, nutrients virtually disappear and fall to minimum concentrations (0.1 to 1 μg N-NO_3^- l^{-1}), and chlorophyll-a reaches its maximum annual concentration. In mid-September, the dams are opened to empty the ricefields to harvest, and the water renewal rate of the lagoon is high, producing a diminution of chlorophyll-a. Then in November, dams are summer species *A. girodi, A. fissa, B. bidentata,* several species of *Lecane* and *M. macrocopa* were present. In November the declining populations of some of these species coexisted with several other winter species which were at the beginning of their development, giving rise to the greatest diversity of the annual cycle. The typical winter species of the lake were found in January: *Polyarthra* sp. pl., *B. leydigi, S. oblonga, N. acuminata, N. salina* and *D. magna,* together with the perennial *A. robustus.*

Correlation analysis (Fig. 4) clusters the species mainly according to seasonal co-occurrence. The correlations are stronger in species whose presence is restricted to a single season. They show the existence of a first group of winter species the nucleus of which is formed by *N. acuminata, N. salina, S. oblonga, B. leydigi, B. calyciflorus, D. magna, Lecane closterocerca* and Bdelloidea and a second less numerous group of summer species formed by *A. girodi, B. angularis, B. bidentata, A. fissa, Lecane luna.* The highest negative correlations are centred in the main species: *A. robustus* shows its maximum exclusion with *B. urceolaris,* ciliates and bdelloids and *B. angularis* with *B. leydigi* and other species of the winter group.

Congeneric species are interesting because, given their morphological similarity, greater temporal separations between them could be expected, a situation described in most lakes (Miracle 1976). The most commonly found genera in the Albufera are *Brachionus* and *Lecane* with six and eight species respectively. A tendency of seasonal separation among these has been also observed. For example, *B. angularis* and *B. leydigi* occurred in very different periods, and *B. urceolaris* had its maximum density between the maxima of the other two. However *B. quadridentatus, B. bidentata* coincided in part with *B. angularis* and *B. calyciflorus* with *B. leydigi* but their densities are an order of magnitude lower. Among the species of *Lecane, L. closterocerca,* which is the most abundant, had a displaced maximum in relation to the occurrence of *L. bulla, L. hamata* and *L. luna.*

Fig. 5 shows the relative position of the most abundant species in the space defined by temperature, chlorophyll-a and alkalinity, according to their respective multiple regression coefficients with the mentioned parameters. How clearly the congeneric *Brachionus* species separate in that ecological space can also be observed.


A. fissa
B. bidentata
B. angularis
A. girodi
L. luna
Testacida
L. closterocerca
B. leydigi
S. oblonga
B. urceolaris
Polyarthra sp
Rhabdoph.
N. salina
Bdelloides
Sessilina
N. acuminata
B. calyciflorus
D. magna
r ≥ 0.50
r ≥ 0.27
B. bidentata
B. angularis
A. girodi
A. rectangula
L. luna
A. robustus
L. closterocerca
B. leydigi
S. oblonga
B. urceolaris

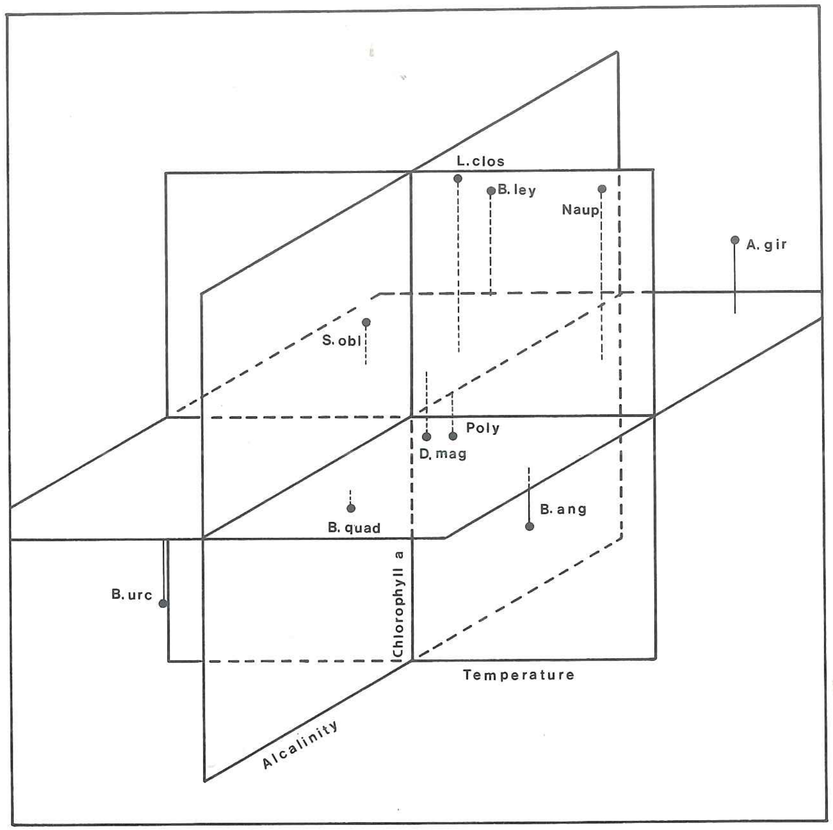


Fig. 5. Relative position of the main zooplankton species in the space defined by temperature, chlorophyll-a and alkalinity. The coordinates are the respective regression coefficients.

Zooplankton biovolume values varied between 0.6 and 2.3 $mm^3 l^{-1}$, average values of November and July 1980 respectively. These results can be considered typical for eutrophic lakes (Bosselman & Riemann 1986).

Diversity (Shannon-Weaver index) increases from spring to autumn, generally tracing an inverse relationship to chlorophyll-a concentration and to zoo-

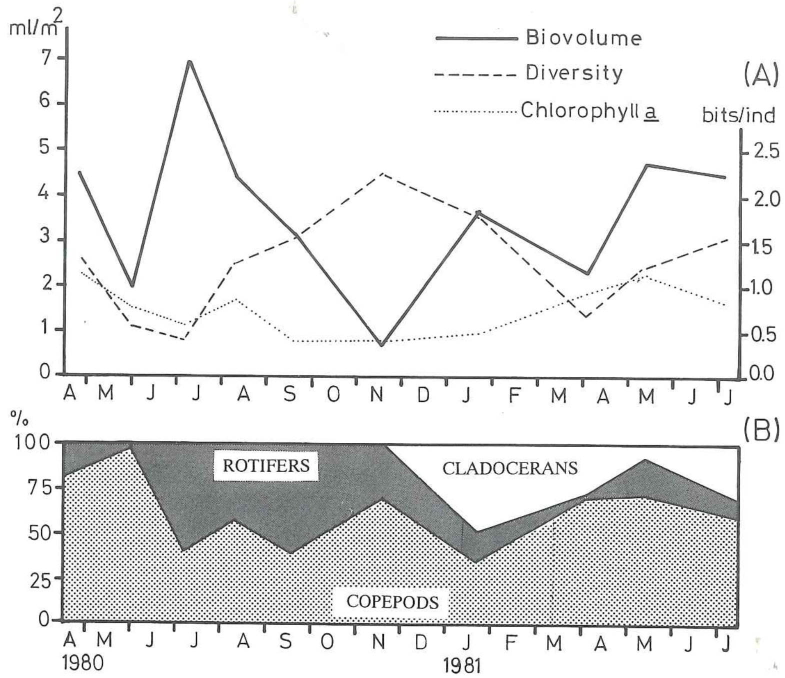


Fig. 6. A: Seasonal variation of zooplankton biovolume, chlorophyll-a and diversity. B: relative contribution of the different zooplanktonic groups to biovolume. (All values are means per water column for different times of the day).

Discussion

Zooplankton seasonal variations are affected by the manipulation of the floodgates and other activities related to rice farming but follow the general trends of succession from winter-spring to summer. Species with greater motility and higher consumption rates succeed smaller, slower and less powerful species; *S. oblonga* is succeeded by *A. girodi*, *P. dolichoptera* by *P. longiremis*. However, among filter feeders and detritivores the changes from winter to summer species are more in accordance with the direct relationship between

A comparison between the zooplankton in 1980–81 and that of previous years shows remarkable differences, both quantitatively and qualitatively (Table 2), which could be associated with the recent human impact on the lagoon. The change from nursery-gardening to direct sowing in rice farming in 1970's, which involves the use of higher amounts of pesticides and the drastic

Table 2. Cladocerans, copepods and rotifers found in the Albufera of Valencia by Arevalo (1916, 1918), Wiszniewski (1931), Blanco (1974) and in present study.

Copepoda			1973	1981		1918	1929	1973	1981
Paracyclops fimbriatus			○	–	*Colurella uncinata*	○	○	–	–
Macrocyclops albidus			○	–	*Colurella adriatica*	–	○	○	○
Halycyclops sp.			○	–	*Lecane luna*	●	○	○	○
Acanthocyclops robustus			–	●	*Lecane lunaris*	○	○	○	○
Cladocera	1916		1973	1981	*Lecane bulla*	○	○	○	○
Ceriodaphnia laticaudata	○		–	–	*Lecane quadridentata*	●	○	○	–
Iliocryptus sordidus	○		–	–	*Lecane signifera*	○	–	–	–
Macrothrix hirsuticomis	○		–	–	*Lecane ohionenesis*	●	○	–	–
Alona guttata	○		–	–	*Lecane papuana*	–	○	○	–
Alonella exigua	○		–	–	*Lecane ungulata*	–	○	–	–
Pleuroxus aduncus	○		–	–	*Lecane crepida*	–	○	–	–
Chydorus sphaericus	○		–	–	*Lecane hornemanii*	–	○	–	–
Simocephalus vetulus	○		○	–	*L. inopinata* f. *sympoda*	–	○	–	–
Alona rectangula	○		–	●	*Lecane stichaea*	–	○	–	–
Bosmina longirostris	–		○	–	*Lecane lamellata thalera*	–	○	–	–
Daphnia pulex	–		●	–	*Lecane stenroosi*	–	○	–	–
Daphnia magna	–		●	○	*Lecane obtusa*	–	○	–	–
Leydigia quadrangularis	–		○	○	*Lecane punctata*	–	○	–	–
Moina micrura	–		○	○	*Lecane arcuata*	–	○	–	–
Moina macrocopa	–		–	○	*Lecane closterocerca*	–	○	–	●
Rotifera	1918	1929	1973	1981	*Lecane hamata*	–	○	–	○
Brachionus urceolaris	●	○	○	○	*Lecane aculeata*	–	○	–	○
Brachionus quadridentatus	●	○	○	●	*Lecane furcata*	–	○	–	○
Brachionus calyciflorus	●	–	●	○	*Lecane tenuiseta*	–	–	–	○
Brachionus angularis	○	–	●	●	*Monommata grandis*	–	○	–	–
Brachionus polyacanthus	○	○	○	–	*Cephalodella gibba*	–	–	○	○
Brachionus leydigi	○	–	–	●	*Trichocerca pusilla*	○	–	–	–
Brachionus bidentata	–	–	–	○	*Trichocerca cylindrica*	○	–	–	–
Keratella quadrata	●	○	●	○	*Trichocerca longiseta*	●	–	–	–
Keratella cochlearis	–	○	●	○	*Trichocerca rattus*	–	○	○	–
Keratella valga	–	–	●	–	*Trichocerca tenuior*	–	○	–	–
Keratella tropica	–	–	○	○	*Synchaeta pectinata*	○	–	●	–
Notholca acuminata	●	–	○	○	*Synchaeta oblonga*	–	–	–	●
Notholca salina	–	–	–	○	*Polyarthra platyptera*	○	○	●	●
Anuraepsis fissa	●	○	●	○	*Asplanchna brightwelli*	–	–	●	–

increase of sewage from growing populations and industries in recent years, and which is discharged without purification to the Albufera of Valencia tributary waters, are assumed to have led to drastic changes in this ecosystem. The first noticeable change was the disappearance of the subaquatic macrophytes that covered the bottom and were perfectly visible from the water surface until the 1960's. The second change was the shift of phytoplankton to nearly permanent blooms of cyanobacteria. In 1974, Blanco reported that cyanobacteria were only abundant in autumn-winter and that the maximum values of chlorophyll-a detected during the years 1972 and 1974 were respectively 20 and 88 mg m^{-3} and the water was transparent to the bottom. While, at the time of the present study, densities of one million cyanobacteria filaments per ml were observed, the chlorophyll maximum rose to 700 mg m^{-3} (Fig. 6 A) and Secchi disk values varied from 0.15 to 0.38 m.

Cladocerans have been drastically reduced in number of species and abundance. Arevalo (1916, 1918) identified 9 species of cladocerans, among which *Simocephalus vetulus* and a species of *Ceriodaphnia* were found in abundance in the plankton. The rest were littoral-benthic species of chydorids and macrothricids which, except *A. rectangula*, have not been found in later works. Blanco (1974) describes a totally different cladoceran community, a succession starting with the growth of *D. magna* in winter-spring, followed by a brief and sporadic occurrence of *Daphnia pulex*, then by a brief peak of *Bosmina longirostris*, and finally ending with the growth of *M. micrura* (named *Moina rectrirostris*) during summer and early autumn.

In our study we have found *D. magna*, *M. micrura* and *M. macrocopa* still to be present but in extremely low numbers and relegated to restricted periods (Fig. 1 B). The disappearance of macrophytes, phytoplankton shift to the dominance of cyanobacterial filaments, and use of pesticides in rice farming, could be the causes of this reduction. Planktonic cladocerans can not survive well when cyanobacteria predominate in the plankton (Porter & Orcutt 1980, Infante & Abella 1985) and are very sensitive to pesticides (Lim et al. 1984, Forés & Comin 1987).

Copepoda were not studied at the beginning of the century. Blanco (1974) quantified the total number of copepod individuals without specifying species, tury. AREVALO (1918) records a few specimens in only one sample of May; WISZNIEWSKI (1931) did not find any, but his work was based only on samples taken in autumn. At that time, the most abundant planktonic species mentioned by AREVALO (1918) and WISZNIEWSKI (1931) were: (1, in summer) *A. fissa* and *Hexarthra mira;* (2, in winter-spring) *K. quadrata, F. terminalis, Trichocerca longiseta, N. acuminata, B. urceolaris* and a species of *Synchaeta* (some of these species were also abundant in autumn, namely *F. terminalis, B. urceolaris* and *K. quadrata*); (3, species with two annual peaks in spring and autumn) *B. calyciflorus, Polyarthra* spp. and *Testudinella patina;* (4, species found only in autumn) *Trichocerca cristata, K. cochlearis, B. quadridentatus* and *Hexarthra fennica* and *Hexarthra oxyuris.* BLANCO (1974) found all these species except *T. longiseta* and the *Hexarthra* species. However, diversity was probably reduced because only a few species had significant relative proportions. These species were: *Keratella* spp., *B. calyciflorus* and *Polyarthra* spp., which were more or less permanent. *Keratella* had a very high maximum in early autumn (over 1.000 ind l^{-1}) and the others had their maxima in spring and autumn. Other species which were rather abundant but with occurrence restricted to a limited period were *A. fissa,* with high summer densities, *F. terminalis,* developing in winter-spring and *B. angularis,* which in 1972–73 had already acquired some importance, showing a small development in July and a higher abundance in October and January. These observations confirm the large changes in the rotifer fauna; before 1980–81 *B. angularis* had drastically increased to become almost the only dominant species and all the other previously predominant species had been dramatically reduced. Furthermore, with regard to the 64 different rotifer species recorded in previous works (AREVALO recorded 27, WISZNIEWSKI 46 and BLANCO 30) we have only found 30. However, we have recorded 5 for the first time.

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