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Research Article

Zooplankton diversity and its relationship with environmental changes after the filling of a temporary saline lake in the semi-arid region of La Pampa, Argentina

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ABSTRACT. Temporary water bodies can remain active as such for varying periods. However, they are reservoirs (as "egg banks") of species adapted to these special conditions. In central Argentina, there are numerous temporary lakes, which have only recently begun to be studied. The aim of this work was to describe the succession of changes in diversity, abundance and biomass of zooplankton as well as in the environment, over a period of eleven months, as from the filling of a temporary saline lake, and test the hypothesis that i) salinity affects negatively the richness and abundance but positively the biomass, and ii) due to changes in environmental conditions produced by advancing the hydroperiod, different species emerge from the egg bank at different times. At the beginning, when salinity was reduced and the concentration of chlorophyll-*a* was higher, we recorded the highest diversity, due mainly by less tolerance species. Later, as salinity increased, the macrophyta *Ruppia cirrhosa* developed and covered 90% of the surface of the lake, the concentration of chlorophyll-*a* decreased and the water transparency increased. The zooplankton richness decreased and the community was integrated only by halotolerant species. In the first two months, there was an increased replacement of species, indicated by the high value of Whittaker's beta diversity index (0.63), the density was high, with a predominance of microzooplankton, so the registered biomass was relatively reduced. Then, abundance decreased markedly, and was mostly dominated by macrozooplankton, so the biomass increased. When salinity exceeded 11 g L^{-1}, there was a predominance of the halophilic cladoceran *Daphnia menucoensis*, a species of ecological importance because it's high grazing pressure on phytoplankton. In this study, in addition to the modulating effect of salinity on the richness, abundance and zooplankton biomass, it was verified that the diversity present in the egg bank of temporary saline lakes is higher than that recorded in the water column at any time during hydrophases.

Keywords: temporary lakes, saline lakes, *Daphnia menucoensis*, egg bank, central Argentina.

Diversidad zooplanctónica y su relación con cambios ambientales luego del llenado de una laguna salina temporaria de la región semiárida de La Pampa, Argentina

RESUMEN. Los cuerpos de agua temporarios pueden permanecer activos durante períodos variables, pero son reservorios ("bancos de huevos") de especies adaptadas a estas especiales condiciones. En el centro de Argentina existen numerosos lagos temporarios, que sólo recientemente han comenzado a ser estudiados. El objetivo de este trabajo fue describir la sucesión de cambios en la diversidad, abundancia y biomasa de zooplancton y en los parámetros ambientales, durante once meses, a partir del llenado de un lago salino temporario y probar las hipótesis de que i) la salinidad afecta negativamente la riqueza y abundancia pero positivamente a la biomasa y ii) debido a los cambios ambientales producidos al avanzar el hidroperíodo, diferentes especies emergen del banco de huevos en momentos diferentes. Al principio, cuando la salinidad fue reducida y la concentración de clorofila-*a* elevada, se registró la mayor diversidad, con especies menos tolerantes. Más tarde, la salinidad aumentó, la macrófita *Ruppia cirrhosa* cubrió el 90% de la superficie del lago, la concentración de clorofila-*a* disminuyó y la transparencia aumentó. La riqueza disminuyó y la comunidad pasó a estar integrada por especies halotolerantes. Durante los primeros dos meses se verificó alto reemplazo de especies, indicado por elevados valores del índice de diversidad beta de Whittaker (0,63), la densidad fue más elevada, y predominó el microzooplancton, lo que produjo que la biomasa fuese relativamente reducida. Luego, la abundancia decreció marcadamente y dominó el macrozooplancton, aumentando la biomasa. Cuando la salinidad superó 11 g L^{-1}, se registró el predominio del cladócero halófilo *Daphnia menucoensis*, una especie de importancia ecológica debido a su elevada presión de pastoreo sobre el fitoplancton. En este estudio, además del efecto modulador de la salinidad sobre la riqueza, abundancia y biomasa zooplanctónica, se verificó que la diversidad presente en el banco de huevos de los lagos temporarios salinos es mayor que la registrada en la columna de agua en cualquier momento de las hidrofases.

Palabras clave: lagos temporarios, lagos salinos, *Daphnia menucoensis*, banco de huevos, Argentina central.

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INTRODUCTION

Much of the Earth's surface is arid or semi-arid, with levels of evapotranspiration higher than those of rainfall. The water bodies in these regions, which constitute more than half of the total extension of epicontinental waters, are temporary and usually located in arheic or endorheic basins, and often have high content of salts (Margalef, 1983).

Temporary wetlands are ecosystems that contain water during periods that can vary from a few months to several years (Schwartz & Jenkins, 2000), thus constituting reservoirs of species adapted to these harsh environmental conditions. They usually develop in shallow depressions, and their size can vary from a few square meters to hundreds of hectares (Williams, 1987; Schwartz & Jenkins, 2000).

Several authors have studied some aspects of the alternation of wet and dry phases and their influence on the biota of temporary or episodic environments in Australia (Williams *et al*., 1998; Bayly, 2001; Roshier *et al*., 2001), North America (Smith *et al*., 2003; Wallace *et al*., 2005) and Europe (Mura & Brecciaroli, 2003; Frisch *et al*., 2006). However, in Argentina, although these kinds of environments are very common, especially in the semi-arid central west region of the country, their ecology has received little attention.

On the other hand, it is well known that there is an inverse relationship between zooplankton richness and abundance and the concentration of total dissolved solids (Hammer, 1986; Green, 1993; Williams *et al*., 1998; Hall & Burns, 2003; Ivanova & Kazantseva, 2006), due to the increasing environmental stress produced by the increase in salinity (Herbst, 2001), but in saline lakes, biomass tends to be higher due to the occurrence of large-sized zooplankton species that can thrive since the environmental stress causes lack of fishes (Evans *et al*., 1996).

Although many of the conclusions on the functioning of temporary saline ecosystems in other parts of the world are applicable to those of Argentina, the composition of species assemblages differs from those of other continents, particularly among crustaceans, which show endemic elements to the neotropical region (Paggi, 1998; Menu-Marque *et al*., 2000; Adamowicz *et al*., 2004; Echaniz *et al*., 2006; Vignatti *et al*., 2007; Boxshall & Defaye, 2008; Forró *et al*., 2008), of which ecological knowledge is scarce.

Despite the abundance of these ecosystems in the province of La Pampa, in the central region of Argentina, there is only one study on zooplankton diversity and changes in some of the physical and chemical parameters that occurred from the filling until the drying of wetlands (Echaniz & Vignatti, 2010), although this was a subsaline environment (Hammer, 1986).

Thus, the purpose of this work was to describe the changes in the main environmental parameters and diversity, abundance and biomass of zooplankton, along eleven months after the filling of a temporary saline lake in the central region of the province of La Pampa, and verify the hypotheses that i) the higher concentrations of dissolved solids have a direct negative influence on the richness and density of zooplankton, promoting the presence of species that are adapted to withstand the increase in salinity but positive influence on the biomass, and ii) changes in the environmental conditions produced by an earlier hydroperiod, in particular the concentration of dissolved solids, leading to the emergence of different species from the egg bank at different times, depending on their tolerance to environmental stress generated by salinity.

MATERIALS AND METHODS

Study area

El Carancho is a temporary lake located in a depression of the dune system of the Argentine Valley, in the central region of the province of La Pampa (65°03’W, 37º27’S) (Fig. 1). It is mainly fed

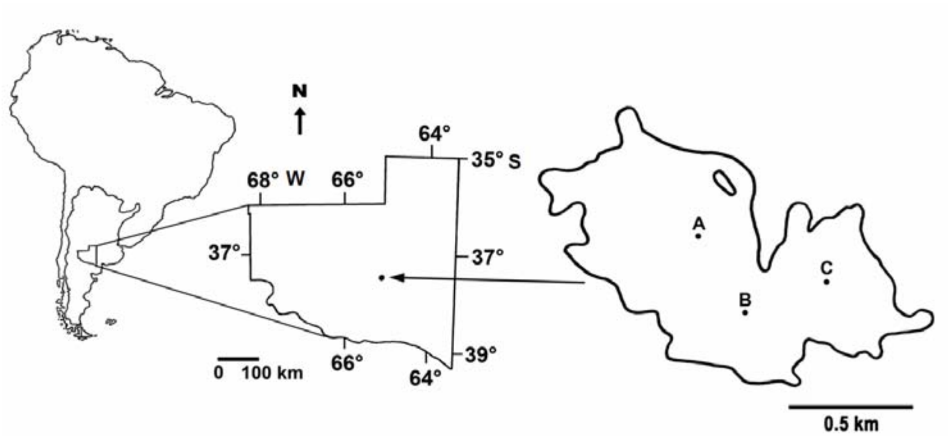

Figure 1. Geographical ubication of El Carancho shallow saline lake. A, B y C: Sampling sites.
Figura 1. Ubicación geográfica de la laguna salina El Carancho. A, B y C: Sitios de muestreo.

by rainfall and, to a lesser extent, by phreatic contributions and intermittent streams formed in the chain of sand dunes in the north. The mean annual rainfall of the region is around 550 mm (Casagrande *et al*., 2006), with maxima in summer (Cano, 1980), but the annual potential evapotranspiration is 800 mm (Ponce de León, 1998). It is an arheic water body, whose losses are caused by evaporation or infiltration, with large fluctuations in its level. It is found in the ecotone between the Espinal and Monte regions (Cabrera, 1976), which is why native forests with predominance of relatively low caldenes (*Prosopis caldenia* Burkart) and jarillas (*Larrea* sp.) are recorded throughout its perimeter. The land use carried out in its basin is limited to extensive cattle rearing.

The lake has been dry for more than two years, until the torrential rainfall in early February 2007 (more than 160 mm), which produced its filling in approximately two days. During the study, carried out between February and December 2007, the lake had a maximum length and maximum width of 1670 and 842 m respectively, an area of 85.1 ha, and a maximum depth of 1.6 m.

Throughout the study, the lake was covered with *Ruppia cirrhosa* (Petagna Grande), a rooted-submerged macrophyte which began to develop in June and reached the water surface in December covering approximately 90% of the total surface. It lacked ichthyological fauna, but presented a very rich avifauna constituted mainly by flamingos (*Phoenicopterus chilensis* Molina, 1782), black-necked swans (*Cygnus melancoryphus* Molina, 1782), white-necked swans (*Coscoroba coscoroba* Molina, 1782) and small gallaretas (*Fulica leucoptera* Vieillot, 1817) (*pers. obs*).

Field and laboratory work

Monthly samples of water and zooplankton were collected between February and December 2007, at three stations (Fig. 1). The water temperature, the concentration of dissolved oxygen (measured with a Lutron® OD5510 oxymeter), the water transparency (Secchi disk), and the pH (Cornning® PS15 pH meter) were recorded at each station, and water samples, which were kept refrigerated until analysis, were collected for physical and chemical determinations. In addition, a qualitative sample of zooplankton was taken by vertical and horizontal dragging, with a net of 22 cm of mouth diameter and 0.04 mm mesh opening; quantitative samples were taken with a Schindler-Patalas-like trap of 10 L with a net of 0.04 mm mesh opening, by means of two vertically aligned extractions, so as to integrate the water column. Samples were anesthetized with CO_2 and kept refrigerated until their analysis. The maximal depth of the lake was measured by probing and the length and width with a GPS Garmin® E-Trex Legend.

Salinity was determined by the gravimetric method, with drying at 104°C of 50 mL of previously filtered water. The concentration of chlorophyll-*a* was determined by extraction with aqueous acetone to 90% and subsequent reading in a spectrophotometer (APHA, 1999; Arar, 1997), total nitrogen by the Kjeldahl method and total phosphorus using the ascorbic acid method, previously digested with potassium persulfate. The content of suspended solids was determined with Microclar FFG047WPH fiberglass filters, dried at 103-105°C until constant weight and later calcined at 550ºC (EPA, 1993).

Counts of macro- and microzooplankton (Kalff, 2002) of each sample were carried out under stereoscopic and conventional optical microscopes in

Bogorov and Sedgewick-Rafter cameras respectively. Once analyzed, the samples were fixed with 5% formalin and then deposited at the plankton collection of the Facultad de Ciencias Exactas y Naturales de la Universidad Nacional de La Pampa. To determine the biomass of zooplankton, a minimum of 30 specimens of all species were measured with a Carl Zeiss ocular micrometer and formulas that relate the total length with the dry weight of the specimens were used (Dumont *et al*., 1975; Ruttner-Kolisko, 1977; Rosen, 1981; McCauley, 1984; Culver *et al*., 1985).

We used the classification of epicontinental waters based on salinity proposed by Hammer (1986). Non-parametric Spearman correlation coefficients (r_s) (Zar, 1996) and Whittaker's index of beta diversity in temporal sense (Magurran, 2004) were calculated. In order to characterize the lake as a function of its transparency, we calculated the relationship between the mean depth and the depth of the photic zone (Quirós *et al*., 2002). For the calculation of the depth of the photic zone, we multiplied the reading of the Secchi disk by a factor of 3 (Cole, 1988; Kalff, 2002). We used the programs Past (Hammer *et al*., 2001) and Infostat (Di Rienzo *et al*., 2010).

RESULTS

Environmental parameters

The maximum depth of the lake (1.6 m) was recorded in February, immediately after the filling. Then, it gradually decreased more than 0.35 m, until its minimum (1.24 m) in December (Fig. 2).

The annual average concentration of dissolved solids was 13.38 g L^{-1} (± 4.02). With the exception of September, when there was a decrease by action of local rainfall, this parameter showed a steady increase during the study, which led the lake to change from hyposaline at the time of the filling (5.7 g L^{-1}) to mesosaline in December (20.7 g L^{-1}) (Fig. 2).

The water temperature followed a seasonal pattern, with a maximum close to 25°C in March and a minimum below 5°C in June (Fig. 3). The concentration of dissolved oxygen presented an annual mean of 10.12 mg L^{-1} (±1.3). Although this was a variable parameter, which fluctuated between 8.5 mg L^{-1} in March and 12.9 mg L^{-1} in November, no seasonal pattern was detected (Fig. 3).

Mean pH was 9.47 (±0.21), a relatively stable parameter, given that it increased throughout the annual cycle, but within a very narrow margin.

Mean water transparency was relatively high (1.28 m ± 0.36). Although it was higher than 1.2 m for eight months, in the first two samples we recorded lower values (Fig. 4). The value of the relationship between the depth of the photic zone and the mean depth was 0.52.

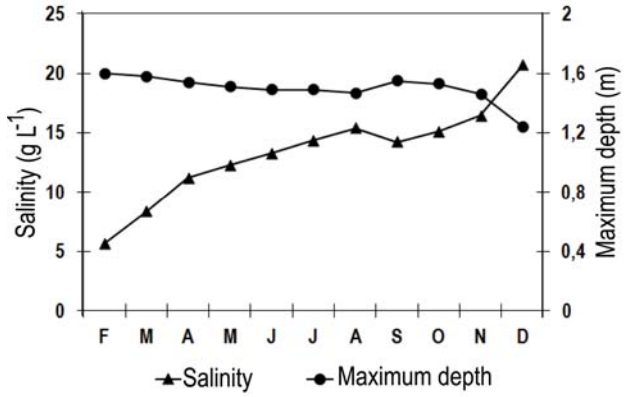

Figure 2. Monthly variation of the maximum depth and salinity in El Carancho shallow saline lake during 2007.

Figura 2. Variación mensual de la profundidad máxima y salinidad en la laguna salina El Carancho durante 2007.

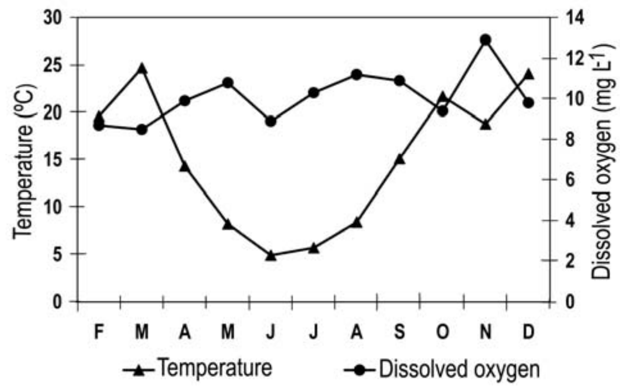

Figure 3. Monthly variation of the water temperature and dissolved oxygen concentration in El Carancho shallow saline lake during 2007.

Figura 3. Variación mensual de la temperatura del agua y la concentración de oxígeno disuelto en la laguna salina El Carancho durante 2007.

The mean concentration of chlorophyll-*a* throughout the study was low (1.89 mg m^{-3} ± 3.7). It was higher than 3.5 mg m^{-3} during the first sampling, a few days after the filling, and then reached a peak higher than 12 mg m^{-3} at the end of the summer. It then decreased to remain below 1 mg m^{-3} during the rest of the study (Fig. 4).

The nutrient concentrations determined throughout the study were high. Total phosphorus reached an average of 4.6 mg L^{-1} (±1.9) whereas mean total nitrogen was 7.79 mg L^{-1} (±2.46). Both showed a different pattern of variation, as during the colder

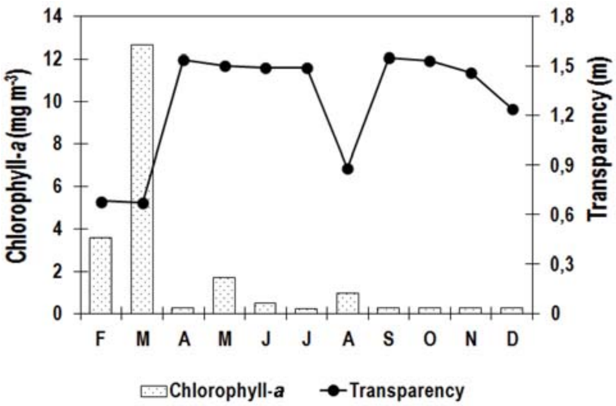

Figure 4. Monthly variation of the chlorophyll-*a* concentration and water transparency in El Carancho shallow saline lake during 2007.

Figura 4. Variación mensual de la concentración de clorofila-*a* y la transparencia del agua en la laguna salina El Carancho durante 2007.

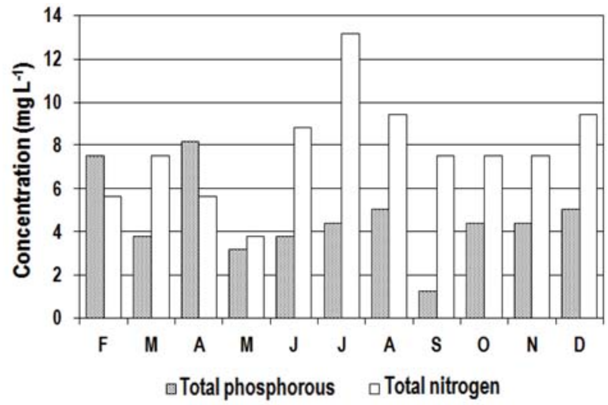

Figure 5. Monthly variation of the nutrients concentration in El Carancho shallow saline lake during 2007.

Figura 5. Variación mensual de la concentración de nutrientes en la laguna salina El Carancho durante 2007.

months recorded the lowest phosphorus concentrations but the highest nitrogen ones (Fig. 5).

The annual mean concentration of total suspended solids was 7.12 mg L^{-1} (±5.1), with a predominance of the organic fraction, which represented 61% of the total. The highest concentrations were recorded in March (19.5 mg L^{-1}), provided mostly by the organic suspended solids (70%), and August (11.1 mg L^{-1}), provided mostly by the inorganic fraction (58%) (Fig. 6).

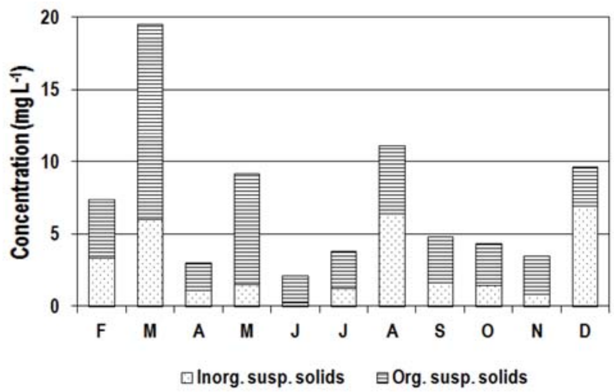

Figure 6. Monthly variation of the suspended solids concentration in El Carancho shallow saline lake during 2007.

Figura 6. Variación mensual de la concentración de sólidos suspendidos en la laguna salina El Carancho en el ciclo anual de 2007.

Zooplankton

A total of 18 zooplankton taxa were recorded (Table 1). Richness was maximum in February (10 species) and then decreased to be minimal in November and December (4 species) (Fig. 7). A positive correlation between zooplankton richness and chlorophyll-*a* concentration (r_s = 0.76; P = 0.0067) was found. Four cladoceran and two rotifer species were registered only during the February but other species appeared the second month (Fig. 7). This was the case of *Daphnia menucoensis* and, later, of *Boeckella poopoensis*, both recorded until the end of the study (Fig. 7). The replacement of species was reflected by the high value of the beta diversity index calculated between February and March (0.63), a period in which the salinity of the water increased by more than 30% (Fig. 2). Later, after May-June, the values of this index ranged from 0 to 0.45, which indicated a smaller replacement.

The total density of zooplankton presented maximum in February (4852.2 ind L^{-1}), with predominance of nauplii (69%), and March (3953.3 ind L^{-1}), with predominance of *Brachionus angularis* (67%) (Fig. 8). This parameter decreased to 291 ind L^{-1} in April, after which macrozooplankton predominated. The total density showed no correlation with the environmental parameters. The mean biomass was 2078.09 µg L^{-1} (±892.8) and showed fluctuations throughout the study (Fig. 8). Although for nine months 75-99% of the total was contributed by cladocerans, in February and March the contribution of copepods (adults, copepodites and nauplii) exceeded 46% of the total. No correlations were found between biomass and environmental parameters.

Macrozooplankton was dominated by cladocerans (Fig. 9, Table 1). The highest mean annual density was provided by *D. menucoensis* (68% of the total), reaching its highest abundance in May (over than 90

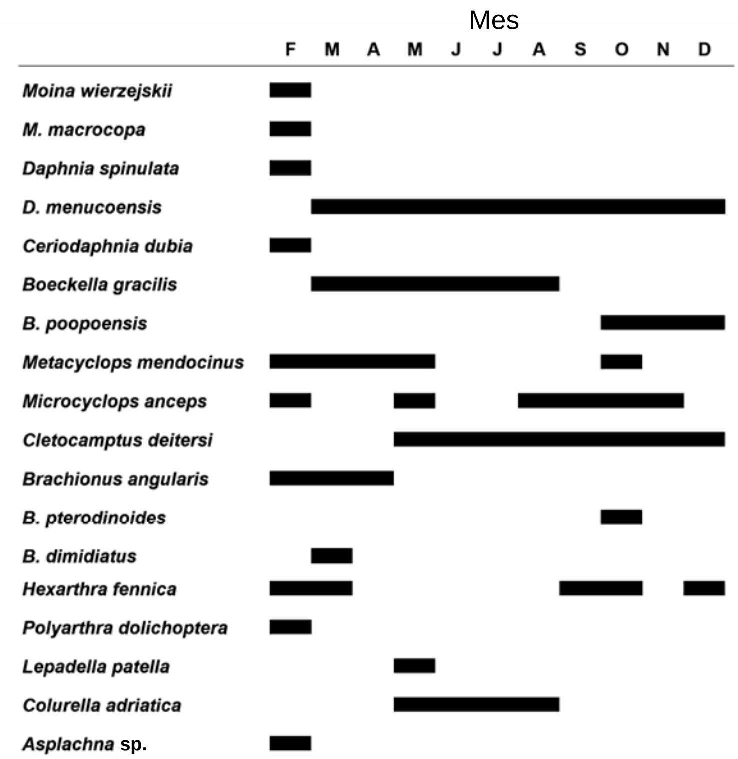

Figure 7. Zooplanktonic taxa registered in El Carancho shallow saline lake between February and December 2007.

Figura 7. Taxones zooplanctónicos registrados en la laguna salina El Carancho entre febrero y diciembre 2007.

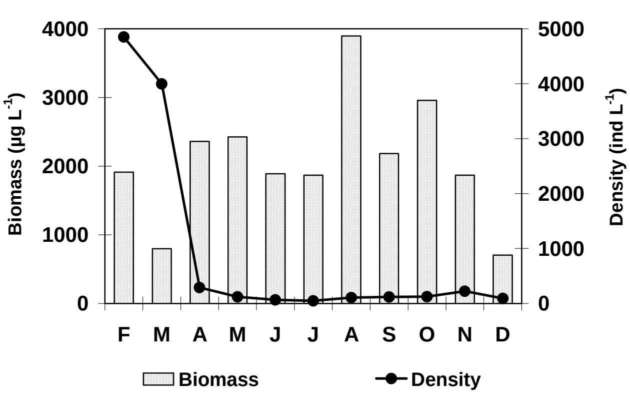

Figure 8. Monthly variation of the total density and biomass in El Carancho shallow saline lake during 2007.

Figura 8. Variación mensual de la densidad total y biomasa en la laguna salina El Carancho durante 2007.

ind L^{-1}), and was the species that higher biomass provided along the study, exceeding 76% of the total (Table 1). During the first month of sampling, in which this species was absent, the highest density was that of *Metacyclops mendocinus* (117.3 ind L^{-1}), followed by *Moina macrocopa* (67 ind L^{-1}).

In microzooplankton, nauplii accounted for 76% of annual total density and, as mentioned above, reached their peak in February. *Hexarthra fennica*, with 863.3 ind L^{-1} in February, and *Brachiounus angularis*, which reached 2621.7 ind L^{-1} in March, were the most abundant rotifers (Fig. 10). The rest of the species showed very low densities (Table 1).

DISCUSSION

Most of the aquatic ecosystems of La Pampa are temporary, a feature which differentiates them from typical *pampean* or *pampasic* lakes located in the province of Buenos Aires (Ringuelet, 1972; Torremorell *et al*., 2007), which are characterized by being permanent.

The type of water input and high evapotranspiration of the region lead the shallow lakes of La Pampa suffer large variations in their level and extension, sometimes abrupt, a feature also verified in El Guanaco lake, which, after being dry for several years, reached a depth of near 0.5 m during a single rain occurred in December 2003 (Echaniz & Vignatti, 2010).

Temporality affects especially the concentration of total dissolved solids, as previously verified in different lakes of the province (Echaniz *et al*., 2006) and in El Carancho (this study), where salinity increased four-fold. This occurred probably as a result

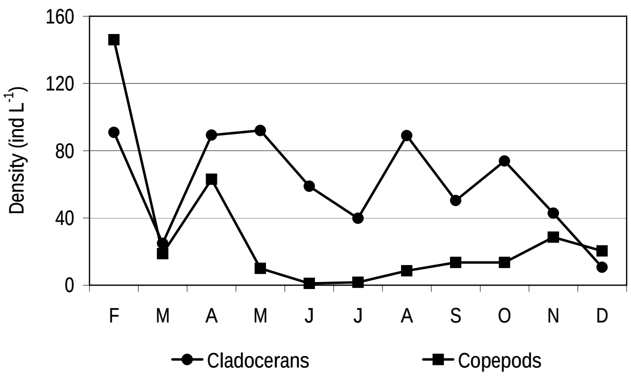

Figure 9. Monthly variation of the density of macrozooplankton in El Carancho shallow saline lake during 2007.

Figura 9. Variación mensual de la densidad de macrozooplancton en la laguna salina El Carancho durante 2007.

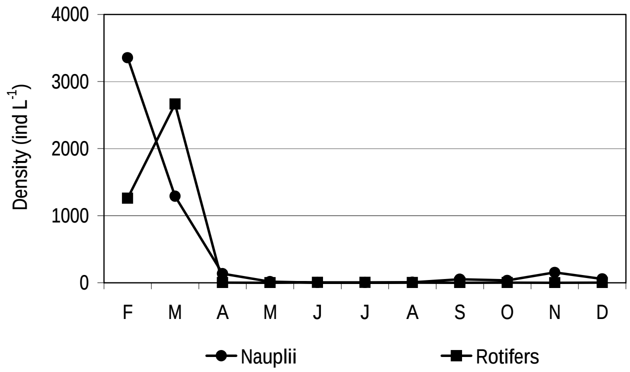

Figure 10. Monthly variation of the density of microzooplankton in El Carancho shallow saline lake during 2007.

Figura 10. Variación mensual de la densidad de microzooplancton en la laguna salina El Carancho durante 2007.

of the resolubilization of the salts of the basin during the first months and by the evaporation of the water in the last months, when the temperatures were higher.

Mean water transparency was relatively high and the relationship between the depth of the photic zone and mean depth as indicated by Quirós *et al*. (2002), was lower than one, which is why El Carancho can be categorized as a clear lake. The lower values recorded during the first two months coincided with greater concentrations of chlorophyll-*a* and organic suspended solids. The decrease in transparency during August coincided with a high concentration of suspended solids in the water, probably due to the resuspension of bottom sediments, since this is one of the months during which winds of great intensity are normally recorded (Cano, 1980).

The high concentrations of nutrients in the water allowed categorizing it as hypertrophic and were similar to those recorded in shallow lakes in the province of Buenos Aires (Quirós *et al*., 2002), but lower than those found in other shallow lakes of La Pampa (Echaniz *et al.*, 2010a).

The high concentration of nutrients from El Carancho could be due to inputs, especially during rainfall, from the feces of animals that graze in the surrounding area, which have proven to be a strongly eutrophication factor (Carpenter *et al*., 1998; Bennett *et al*., 1999; Bremigan *et al*., 2008). In addition, as it is an arheic environment, the outputs of water by evaporation lead to processes of accumulation and concentration of both phosphorus and nitrogen (Echaniz, 2010; Echaniz *et al*., 2010a; Vignatti, 2011).

In this study, we verified the high diversity present in the egg bank in a temporary saline lake, which has been shown to be greater than that recorded in the water column at any time of the hydrophases (Moscatello & Belmonte, 2004, 2009), and the efficiency of the adaptations of the different forms of resistance deposited in the bottom sediments, which allowed a rapid colonization of the environment after its filling.

The negative influence of the concentration of dissolved solids on plankton richness was also evident, since, at the beginning, when the salinity was reduced, the emergence of a large number of species from the resistance forms led us to record a high diversity. This was given by species which have been recorded only in other lakes of low salinity (Echaniz & Vignatti, 1996, 2010; Vignatti *et al.*, 2007). The high replacement occurred later could be due to the fact that most of the species that appeared at the beginning did not tolerate the environmental stress caused by the increase in salinity (Herbst, 2001). Thus, when this parameter increased three-fold with respect to the initial value, it favored the emergence of adapted species and the charac-teristic association between hypo- and mesosaline environments of La Pampa Province, characterized by halophilic crustaceans such as *D. menucoensis*, *B. poopoensis* and *Cletocamptus deitersi* (Echaniz *et al.*, 2006; Vignatti *et al.*, 2007; Echaniz, 2010; Vignatti, 2011). The interannual variation in the taxonomic composition and relative abundance of this lake was reflected in the absence during all the study of *Moina eugeniae*, the dominant cladoceran in this lake in previous years (Echaniz *et al.*, 2006, 2010; Vignatti *et al.*, 2007, 2011). Instead, *D. menucoensis*, also found previously, although at much lower densities (Echaniz & Vignatti, 1996; Echaniz *et al.*, 2006), predominated

Table 1. Mean density (ind L^{-1}), biomass (µg L^{-1}) and standard deviation (SD) of the taxa recorded between February and December 2007 in the zooplankton of El Carancho shallow saline lake.

Tabla 1. Densidad media (ind L^{-1}), biomasa media (µg L^{-1}) y desviación estándar (SD) de los taxa registrados entre febrero y diciembre de 2007 en el zooplancton de la laguna salina El Carancho.

	Density		Biomass	
	Mean	SD	Mean	SD
Moina wierzejskii Richard, 1895	1.02	3.41	7.26	24.09
M. macrocopa (Straus, 1820)	6.10	20.20	63.35	210.09
Daphnia spinulata Birabén, 1917	1.01	3.30	15.04	49.88
D. menucoensis Paggi, 1996	52.0	32.02	1741.92	1168.16
Ceriodaphnia dubia Richard, 1895	0.13	0.51	0.18	0.61
Boeckella gracilis (Daday, 1902)	6.42	17.20	29.76	60.34
B. poopoensis Marsh, 1906	4.21	9.30	64.22	142.00
Metacyclops mendocinus (Wierzejski, 1892)	12.80	35.01	26.62	60.43
Microcyclops anceps (Richard, 1897)	3.60	8.51	7.14	14.43
Cletocamptus deitersi (Richard, 1897)	2.60	3.50	7.98	10.09
Brachionus angularis Gosse, 1851	257.80	786.52	3.83	11.80
B. pterodinoides Rousselet, 1913	0.001	0.12	0.01	0.02
B. dimidiatus Bryce, 1931	3.30	11.1	0.05	0.17
Hexarthra fennica (Levander, 1892)	79.20	260.10	6.58	21.58
Polyarthra dolichoptera Idelson, 1925	16.50	0.00	0.83	0.00
Lepadella patella (Müller, 1773)	0.001	0.00	0.001	0.00
Colurella adriatica (Ehrenberg, 1831)	0.90	1.51	0.002	0.003
Asplachna sp.	0.30	0.00	0.001	0.00

during this study and contributing with the higher biomass.

This could be due to the fact that, like other species of *Daphnia*, whose dominance at the beginning of succession has been verified (Louette & De Meester, 2004), *D. menucoensis* seems to be more efficient to colonize environments which have been recently filled or which have suffered sudden changes of salinity (within hours), as it has been demonstrated in other ecosystems of La Pampa (Echaniz *et al*., 2006).

The fact that we recorded *B. gracilis* and *B. poopoensis*, two species of the genus widely distributed in South America (De los Ríos, 2005; De los Ríos *et al*., 2010a) and halophilic (Bayly, 1993; De los Ríos & Contreras, 2005; Echaniz *et al*., 2006), although not coexisting, may be due to the greater tolerance of *B. poopoensis* to salinity (De los Ríos, 2005; De los Ríos *et al*., 2010b; Echaniz, 2010), since the presence of *B. gracilis* coincided with the lower concentrations; instead, *B. poopoensis* was found during the last months of the study.

The modulating effect of salinity (Herbst, 2001) was also evidenced in the decrease in the total density of the zooplankton community along the year, a situation due to the high abundance of nauplii and rotifers recorded during the first two months. The decrease in the density of microzooplankton until almost 5% of that recorded in the first two months could have also been due to their lower ability to take advantage of the resources, since, in the framework of the size-efficiency hypothesis, it has been verified that copepods and cladocerans have competitive superiority over rotifers (Brooks & Dodson, 1965; Dodson, 1974; MacIsaac & Gilbert, 1989, 1991).

It has been observed that the populations of rotifers can be affected by cladocerans through the direct competition for shared resources (Conde-Porcuna *et al*., 2004) and experimental studies have demonstrated the competitive exclusion of rotifers by cladocerans of the genus *Daphnia* (Gilbert, 1985), similar in size to *D. menucoensis*. It has also been found that the intensity of competition increases with the increase in density (Gilbert, 1985; Burns & Gilbert, 1986; Gilbert & MacIsaac, 1989), such as that observed in El Carancho, together with the fact that rotifers can be damaged and even die by action of the filtering appendages of large cladocerans during feeding (MacIsaac & Gilbert, 1991). On the other hand, although *B. poopoensis* feeds mainly on small algae, as most of the Argentine species of the genus, it has also been reported that it can feed of ciliates, small nauplii and rotifers (Modenutti *et al*., 1998; Balseiro *et al*., 2001; Izaguirre *et al*., 2003; Vignatti, 2011).

In this study, we also verified the ecological importance of *D. menucoensis* on the most common type of ecosystem in the region, in which its temporary nature prevents the development of important ichthyological fauna and therefore of predation on zooplankton by vertebrates. This was reflected by the fact that during the first two months, when *D. menucoensis* was absent, the turbidity of the water was very high, due to the high concentration of chlorophyll-*a*, similarly to that observed in other saline lakes of La Pampa, where the presence of a zooplanktivorous fish prevents the development of this cladoceran (Echaniz *et al*., 2010b). Later, after the hatching of individuals of this species from the eggs present in the sediments and despite the high amount of nutrients, the concentration of chlorophyll-*a* fell virtually to levels that characterize oligotrophic environments, resulting in a high transparency of the water. This could be because *D. menucoensis* belongs to a genus characterized by being the main grazer in aquatic ecosystems and given its filtration efficiency, prevents the development of high phytoplankton biomass, favors the growth of rooted vegetation, and leads to the establishment of a clear state, with high water transparency (Jeppesen *et al*., 1994, 2007; Scheffer, 1998).

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