Zooplankton richness, abundance and biomass of two hypertrophic shallow lakes with different salinity in central Argentina

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Abstract: The zooplankton of lakes is controlled by biological and physico-chemical parameters. Among the former, predation by fish can determine the replacement of large-sized species by small-sized ones and among the latter, salinity exerts negative effects on richness and abundance. Since it has been suggested that saline lakes without fishes have higher zooplankton biomass than low salinity ones, the aim of this study was to determine the richness, abundance and biomass of zooplankton in two lakes with different salinity and test the hypothesis that in the presence of zooplanktivorous fishes and at equal concentrations of nutrients and chlorophyll-*a,* saline lakes have higher biomass than those with low salinity. The study was conducted in two shallow lakes of the Province of La Pampa (central Argentina): a subsaline lake and a hyposaline lake, which shared high concentrations of chlorophyll-*a* and total phosphorus, reduced transparency and presence of planktivorous fish. Zooplankton richness was different and higher in the subsaline lake, whereas abundance and total biomass were similar, even when the taxonomic groups were considered separately. It is suggested that the presence of a halotolerant planktivorous fish controlled the size of zooplankton due to the predation on larger species and prevented the development of higher biomass in the saline lake, which is an important difference from previously recorded situations. This study shows that, regardless of the differences in salinity, the top-down effect in the food chain may have been a factor that equalized the zooplankton biomass by allowing only the development of small species and highlights the possible importance of fish predation in determining chlorophyll-*a* concentrations and water transparency.
Keywords: *shallow saline lakes, zooplankton biomass, fish predation, top down.*

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Resumen: El zooplancton lacustre es controlado por parámetros biológicos y fisicoquímicos. Entre los primeros, la depredación por peces puede determinar el reemplazo de especies de talla grande por pequeñas y entre los segundos la salinidad ejerce efectos negativos sobre la riqueza y abundancia. Dado que se ha indicado que los lagos salinos sin peces tienen mayores biomasas zooplanctónicas que los de baja salinidad, el objetivo de este trabajo es conocer la riqueza, abundancia y biomasa del zooplancton de dos lagos de diferente salinidad y probar la hipótesis de que a iguales concentraciones de nutrientes y clorofila "a" los lagos salinos tienen mayor biomasa que los de baja salinidad. El estudio se desarrolló en dos lagos de la provincia de La Pampa, en el centro de Argentina, uno subsalino y otro hiposalino, que compartieron elevadas concentraciones de clorofila *a* y fósforo total, reducida transparencia y presencia de un pez planctófago. Aunque la riqueza resultó diferente y más elevada en el lago subsalino, no ocurrió lo mismo con la abundancia y biomasa totales, ni al considerar los grupos taxonómicos por separado. La presencia de un pez planctívoro halotolerante controló la talla del zooplancton debido a la depredación sobre las especies de mayor tamaño e impidió el desarrollo de mayor biomasa en el lago salino, lo que constituye una importante diferencia con situaciones registradas anteriormente. Este estudio mostró que a pesar de la diferencia en la salinidad, el efecto en cascada en la cadena trófica (top down) es un factor que iguala la biomasa zooplanctónica al permitir sólo el desarrollo de especies pequeñas y pone en evidencia la importancia de la depredación por peces en la determinación de las concentraciones de clorofila y transparencia del agua.
Palabras clave*: lagos someros salinos, biomasa zooplanctónica, depredación, cascada trófica.*

Introduction

The zooplankton of lakes is a key component of the ecology of water bodies because these organisms feed on phytoplankton, recycle the nutrients through excretion, and represent an important prey to many predators. Their composition, abundance and biomass are controlled by biotic and abiotic parameters. The former include the availability and quality of food resources, interspecific competition and predation by vertebrates and invertebrates (Lampert & Sommer 1997, Khan et al. 2003, Chang et al. 2004, Boveri & Quirós 2007, Manca et al. 2008). The negative effects of poor quality food supply are known (DeMott et al. 2001, Wilson & Hay 2007) as is the fact that the predation by zooplanktivorous fish produces the replacement of larger species by smaller ones is also known (Brooks & Dodson 1965). This, in turn, leads to changes in grazing pressure and phytoplankton biomass (top-down effect) (Bertolo et al. 2000, Kalff 2002, Boveri & Quirós 2007, Manca et al. 2008).

Among the abiotic parameters, the structure of zooplankton is affected by the concentration of dissolved solids, the temperature, the size and land use of the basins, and environmental heterogeneity, because the higher number of habitats offered by larger lake environments exerting positive effects on the richness and abundance of zooplankton (Kobayashi 1997, Hobæk et al. 2002, Kalff 2002, Hall & Burns 2003, Dodson et al. 2007). In addition, it is known that an increase in salinity may exert negative effects on the richness and abundance of zooplankton (Herbst 2001, Ivanova & Kazantseva 2006). It has also been reported that salinity favors indirectly the secondary production of zooplankton, because saline lakes tend to lack fish fauna, which allows the development of larger zooplankton species and therefore to have higher biomass of zooplankton than low salinity lakes, although they have lower phytoplankton biomass and chlorophyll-*a* concentrations (Campbell & Prepas 1986, Evans et al. 1996).

Shallow lakes, in general, do not exceed three meters in depth, and are not stratified because of the mixing effect of the wind. Such water-bodies usually have a high trophic state (Scheffer 1998, Quirós et al. 2002, Scheffer & Jeppesen 2007, Grosman 2008) and those with total dissolved solids concentrations greater than 3 $g.L^{-1}$ are classified as saline (Hammer 1986).

In the central semiarid region of Argentina (Province of La Pampa), there are many shallow lakes with a wide range of concentrations of dissolved solids, ranging from subsaline to hypersaline (Echaniz et al. 2006, Vignatti et al. 2007). Many of these lakes have suffered marked deterioration due to the human activities carried out in their basins, such as livestock breeding, growing of cereal and oilseed crops and development of urbanized areas of increasing size. Although most are temporary and clear, anthropogenic influence has led many lakes become permanent, or to become turbid due to the introduction of fish, particularly the zooplanktivorous *Odontesthes bonariensis* (Cuvier and Valenciennes 1835) (Echaniz et al. 2008, 2009, 2010a,b).

We have previously carried out several studies on the composition and density of zooplankton in several shallow lakes of La Pampa (Echaniz et al. 2006, 2008, 2009, 2010b, Vignatti et al. 2007), but not compared the zooplankton biomass in the studied environments. Therefore, the aim of this study was to determine the taxonomic composition, abundance and biomass of zooplankton in two shallow lakes of La Pampa with different salinity and test the hypothesis that in presence of zooplanktivorous fishes and at equal concentrations of nutrients and chlorophyll-*a*, saline lakes have higher biomass of zooplankton than lakes of low salinity.

Material and Methods

1. *Study area*

The study was conducted in two permanent shallow lakes located in the vicinity of the city of Santa Rosa, La Pampa Province, Argentina: the Bajo de Giuliani and Don Tomás (Figure 1).

The Bajo de Giuliani lake (64° 15' W and 36° 41' S) is hyposaline (Hammer 1986) and has a surface of 1171.3 ha and a maximum depth of 2.8 m. It is located 10 km south of the city of Santa Rosa, in a deep arheic depression. Most of its perimeter is surrounded by fields

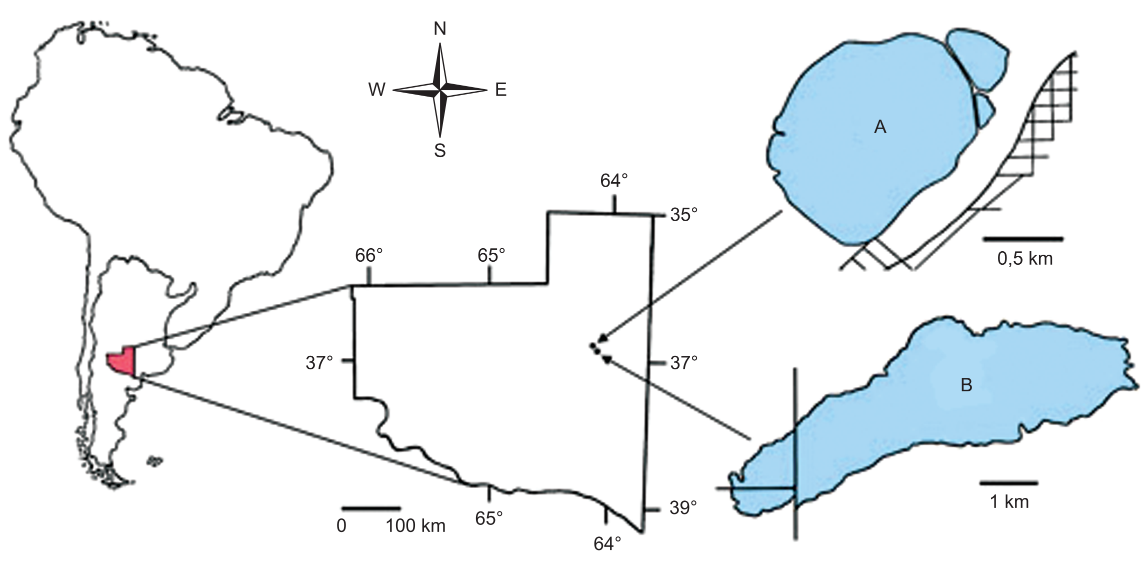

Figure 1. Geographical location and sketch of studied lakes. A: Don Tomás. B: Bajo de Giuliani.

Figura 1. Ubicación geográfica de los lagos estudiados. A: Don Tomás. B: Bajo de Giuliani.

used for farming, especially cattle breeding. In addition, it is the final recipient of the sewage treatment plant of the city.

Don Tomás Lake (64° 19' W and 36° 37' S) is subsaline (Hammer 1986) and has a surface of 148.3 ha and a maximum depth of 2.3 m. It is near the city of Santa Rosa and receives the input from storm drains. Under normal conditions, it does not receive sewage, although this may occur when heavy rains fill and overflow pipes. Since its perimeter has been rectified and dredged, it is very regular, almost circular.

Both environments have high organic turbidity, absence of aquatic vegetation, and presence of the planktivorous species *Odontesthes bonariensis* (Rosso 2006, Boveri & Quirós 2007).

2. *Field work*

Samplings were carried out at three sites in the limnetic region in each lake during each season of 2006 and 2007 (January, April, July and October). Water temperature, dissolved oxygen (oximeter Lutron OD 5510), and water transparency (Secchi disk) were determined in situ. Water samples were collected and refrigerated for physical and chemical analysis and determination of chlorophyll-*a* concentrations. Since no significant differences were found between the values of the environmental variables measured at each site of the two lakes, the mean values were used for the analysis.

Quantitative zooplankton samples were collected at each site, with a 10 L capacity Schindler-Patalas trap equipped with a 0.04 mm mesh size, at three depths that were integrated into a single sample which represented a total filtrate volume of 30 L. Qualitative samples also were taken by vertical and horizontal drags with a net of 22 cm mouth diameter and 0.04 mm mesh size. All the samples were anesthetized with CO_2 and kept refrigerated until measurements, with the aim of avoiding contractions that may deform the individuals collected. The samples were fixed with formalin 5-8% and deposited in the plankton collection of the Facultad de Ciencias Exactas y Naturales de la Universidad Nacional de La Pampa, La Pampa Province, Argentina.

3. *Laboratory Work and Data Analysis*

The pH was determined by means of a Cornning PS 15 pH meter, the conductivity with an Oakton TDSTestr 20 conductivity meter, and the concentration of dissolved solids by the method of solid residue. Chlorophyll-*a* concentration was estimated by extraction with aqueous acetone with Microclar FFG047WPH filters and spectrophotometry (Metrolab 1700 spectrophotometer) (APHA 1992, Arar 1997), total nitrogen by the Kjeldahl method and total phosphorus by digestion of the sample with potassium persulfate in acidic medium and spectrophotometry (APHA 1992).

The content of organic and inorganic suspended solids was determined by filtering a known volume of water through Microclar FFG047WPH filters, dried at 103 to 105 °C to constant weight and then calcined at 550 °C (EPA 1993).

The density of macro and microzooplankton (Kalff 2002) was estimated with a stereomicroscope and conventional optical microscope in Bogorov and Sedgwick-Rafter chambers respectively. 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 (Ruttner-Kolisko 1977, Dumont et al. 1975, Rosen 1981, McCauley 1984, Culver et al. 1985).

The physical, chemical and biological differences were tested by nonparametric Kruskal-Wallis analysis of variance and the relationships between the environmental factors and the zooplankton features were assessed by Spearman correlation (r_s) (Sokal & Rohlf 1995, Zar 1996) and Principal Components Analysis (PCA) (Pérez 2004, Mangeaud 2004), using Past (Hammer et al. 2001) and Infostat (Di Rienzo et al. 2010) softwares.

Results

1. *Abiotic parameters*

Water temperature followed a similar seasonal pattern in both lakes, and although the mean was slightly lower in Don Tomás, the differences were not significant (Table 1).

The concentration of dissolved solids ranged between 0.64 and 1.16 $g.L^{-1}$ in Don Tomás, and between 9.64 and 11.2 $g.L^{-1}$ in Bajo de Giuliani (Figure 2), being this a significant difference (Table 1).

Water transparency in both lakes was low and ranged between 0.11 and 0.22 m, but there were no significant differences between the values (Table 1). No significant correlations were found between transparency and chlorophyll-*a* or suspended solids concentrations.

The average concentration of nutrients was very high in both water bodies and there were significant differences only in total nitrogen (Table 1). No significant correlation was found between the concentrations of both nutrients. The pH and dissolved oxygen concentration were different and higher in Bajo de Giuliani (Table 1).

The concentrations of inorganic and organic suspended solids in both lakes were different (Table 1) and correlation was found only between the latter parameter and dissolved solids (r_s = 0.69, p = 0.0033).

2. *Chlorophyll-a concentrations and zooplankton*

The phytoplanktonic chlorophyll-*a* concentration was high in both lakes, and fluctuated between 88.8 $mg.m^{-3}$ (Don Tomás) and 352.4 $mg.m^{-3}$ (Bajo de Giuliani), although the differences were not significant (Table 1, Figure 3). A significant correlation was found only between chlorophyll-*a* and TN concentrations (r_s = 0.65, p = 0.0063).

A total of 33 taxa were recorded: 7 cladocerans, 6 copepods and 20 rotifers. The number of species was significantly different (H = 8.91, p = 0.0028) between the lakes: 26 were found in Don Tomás and 17 in Bajo de Giuliani (Table 2). While seven taxa were recorded only in Bajo de Giuliani and 16 only in Don Tomás, two cladocerans, one copepod and seven rotifers were recorded in both water bodies (Table 2).

The (PCA), whose first two components explained almost 50% of the total variance, showed the negative influences of the concentration of total dissolved solids and suspended solids on the cladocerans

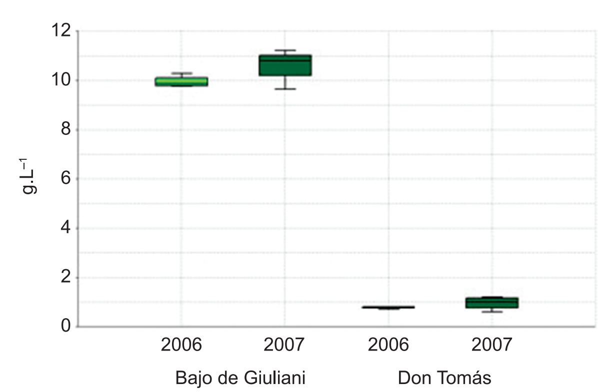

Figure 2. Dissolved solids concentrations in the water of both studied lakes.

Figura 2. Concentración de sólidos disueltos en el agua de las dos lagunas estudiadas.

Table 1. Main limnological parameters of the studied lakes (means and standard deviations) and results of Kruskal Wallis test (K.W.) (*indicates significative differences).

Tabla 1. Principales parámetros limnológicos medidos en los lagos someros estudiados (promedios y desviaciones estándar) y resultados del test de Kruskal Wallis (K.W.) (*indica diferencias significativas).

	Bajo de Giuliani	Don Tomás	K.W.
Water temperature	**17.6** ± 8.1	**16.7** ± 7.3	H = 0.01 p = 0.9164
Transparency (m)	**0.17** ± 0.04	**0.16** ± 0.04	H = 0.34 p = 0.5603
Total dissolv. solids (g.L^{-1})*	**10.27** ± 0.58	**0.87** ± 0.18	H = 11.29 p = 0.0008
Conductivity (mS.cm^{-1})*	**16.9** ± 1.04	**1.48** ± 0.23	H =11.31 p = 0.0008
pH*	**9.1** ± 0.15	**8.4** ± 0.50	H = 9.83 p = 0.0201
Total phosphorus (mg.L^{-1})	**8.91** ± 2.81	**6.57** ± 4.50	H =7.12 p = 0.0682
Total nitrogen (mg.L^{-1})*	**18.77** ± 4.91	**10.16** ± 2.13	H =8.46 p = 0.0375
Dissolved oxigen (mg.L^{-1})*	**12.41** ± 3.10	**8.79** ± 1.35	H = 9.71 p = 0.0212
Inorg. susp. solids (mg.L^{-1})*	**38.05** ± 27.3	**4.03** ± 4.6	H = 6.35 p = 0.0117
Org. susp. solids (mg.L^{-1})*	**89.33** ± 14.83	**52.05** ± 13.15	H = 9.94 p = 0.0016
Chl *a* (mg.m^{-3})	**201.16** ± 69.74	**143.5** ± 45.02	H = 5.28 p = 0.1524

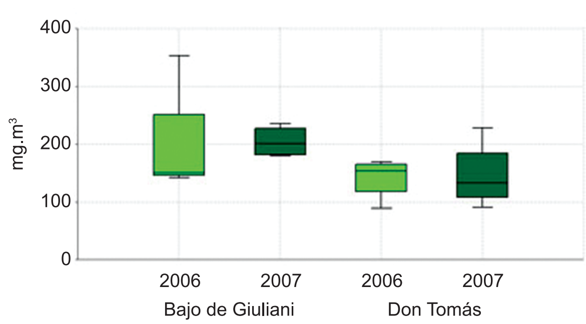

Figure 3. Phytoplanktonic chlorophyll-*a* concentration in both studied lakes.

Figura 3. Concentración de clorofila-*a* fitoplanctónica de las dos lagunas estudiadas.

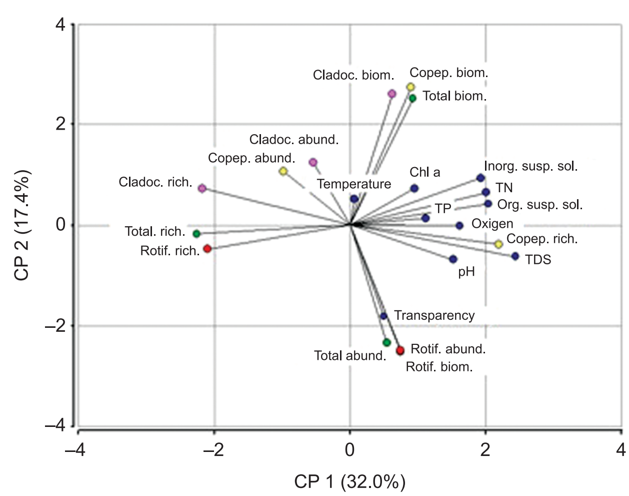

Figure 4. Biplot of the Principal Component Analysis (PCA).

Figura 4. Resultados del análisis de componentes principales (ACP).

and rotifers richness. In contrast, both parameters showed a positive influence on the number of copepod species (Figure 4).

The most common crustaceans in Don Tomás were *Eubosmina huaronensis* (Delachaux, 1918), *Acanthocyclops robustus* (G.O. Sars, 1863) and *Microcyclops anceps* (Richard, 1897), the latter was the most abundant species (mean = 707.5 ± 1051.1 ind.L^{-1}). The crustaceans most frequently recorded in Bajo de Giuliani were *Cletocamptus deitersi* (Richard, 1897), *Boeckella poopoensis* Marsh, 1906 and *Metacyclops mendocinus* (Wierzejski, 1892); the latter reached the highest density (mean = 159.9 ± 300.5 ind.L^{-1}).

The rotifers that predominated in both lakes belonged to the genus *Brachionus*. *B. angularis* Gosse, 1851 and *B. dimidiatus* Bryce, 1931 were the most frequent species in Don Tomás, although the most abundant species was *B. plicatilis* Müller, 1786 (mean = 208.7 ± 586.4 ind.L^{-1}). In Bajo de Giuliani, the most frequent were *B. ibericus* Ciros-Pérez, Gómez & Serra, 2001 and *B. dimidiatus* (Table 2), the latter being the one which reached the highest density (mean = 2114.4 ± 4934.7 ind.L^{-1}).

No significant differences were found in zooplankton total abundance in both lakes, even when the taxonomic groups were considered separately (Table 3, Figure 5). The PCA showed that the total density was determined especially by the high abundances

Table 2. Taxa registered in the studied shallow lakes and frequency in samples.

Tabla 2. Taxones registrados en los lagos someros estudiados y frecuencia de aparición en las muestras.

Taxa	Bajo de Giuliani	Don Tomás
Cladocera		
Diaphanosoma birgei Korinek, 1981		37.5
Moina micrura Kurz, 1874	12.5	50
Moina eugeniae Olivier, 1954	12.5	
Eubosmina huaronensis (Delachaux, 1918)		100
Daphnia menucoensis Paggi, 1996	25	
Daphnia spinulata Birabén, 1917	12.5	12.5
Alona sp.		37.5
Copepoda		
Boeckella gracilis (Daday, 1902)		12.5
Boeckella poopoensis Marsh, 1906	87.5	
Microcyclops anceps (Richard, 1897)		100
Acanthocyclops robustus (G.O. Sars, 1863)		100
Metacyclops mendocinus (Wierzejski,1892)	87.5	
Cletocamptus deitersi (Richard, 1897)	100	12.5
Rotifera		
Brachionus plicatilis Müller, 1786		50
Brachionus ibericus Ciros-Pérez, Gómez & Serra, 2001	62.5	
Brachionus havanaensis Rousselet, 1913	12.5	25
Brachionus angularis Gosse, 1851	37.5	62.5
Brachionus dimidiatus Bryce, 1931	62.5	50
Brachionus calyciflorus (Pallas, 1766)		12.5
Brachionus pterodinoides Rousselet, 1913	50	25
Brachionus caudatus Barrois & Daday, 1894		25
Brachionus quadridentatus Hermann, 1783		25
Keratella tropica (Apstein, 1907)	12.5	75
Keratella cochlearis (Gosse, 1851)	12.5	37.5
Hexarthra intermedia (Wiszniewski, 1929)		25
Hexarthra fennica (Levander, 1892)	12.5	
Polyarthra dolichoptera Idelson, 1925		50
Lepadella acuminata (Ehrenberg, 1834)		12.5
Lecane sp.		25
Lecane lunaris (Ehrenberg, 1832)	12.5	12.5
Lecane bulla (Gosse, 1851)		25
Anuraeopsis fissa (Gosse, 1851)	12.5	
Pompholyx complanata Gosse, 1851		25
Richness	**17**	**26**

of rotifers and that it was positively affected by water transparency (Figure 4).

When analyzing the abundance of the taxonomic groups separately, the PCA showed a positive relationship between the abundance of cladocerans and copepods and water temperature, but a negative relationship with the concentration of dissolved solids (Figure 4).

The average size of zooplankton in Bajo de Giuliani was 413.5 µm ± 286.3, whereas in Don Tomás this value was slightly lower (295.74 µm ± 109.4), but the difference was not significant.

The biomass of zooplankton in both lakes was similar (Figure 6), since no significant differences were found in total biomass or when considering the taxonomic groups separately (Table 3).

Zooplankton biomass was not influenced by the concentration of dissolved solids, but was positively influenced by the concentrations of chlorophyll-*a* and inorganic suspended solids (Figure 4). Copepods and cladocerans were the ones that contributed most to the total biomass in both lakes.

Among the crustaceans of Bajo de Giuliani, the greatest mean biomass was provided by *B. poopoensis* (1510.6 ± 2234.5 $\mu g.L^{-1}$) followed by *M. mendocinus* (511.4 ± 1034.2 $\mu g.L^{-1}$), and, among the rotifers, by *B. ibericus* (258.8 ± 435.8 $\mu g.\ L^{-1}$). In Don Tomás, *M. anceps* contributed with the highest mean crustacean biomass (1505.7 ± 1212.9 $\mu g.\ L^{-1}$) and *B. plicatilis* with the highest mean rotifer biomass (49.9 ± 125.7 $\mu g.L^{-1}$).

In Bajo de Giuliani, the zooplankton biomass presented its peaks in spring (3375.6 and 8375.6 in 2006 and 2007 respectively),

Table 3. Mean abundance and biomass (in bold), minimum and maximum (in italics) by taxonomic group and total zooplankton in both lakes and results of Kruskal Wallis test. (BG: Bajo de Giuliani, DT: Don Tomás).

Tabla 3. Abundancia y biomasa medias (en negritas), mínimas y máximas (en cursivas) por grupo taxonómico y del total del zooplancton de ambas lagunas y resultados del test de Kruskal Wallis. (BG: Bajo de Giuliani, DT: Don Tomás).

	Abundance (ind.L^{-1})			Biomass (µg.L^{-1})		
	BG	DT	K.W.	BG	DT	K.W.
Cladocera	**11**	**130.6**	H = 2.84	**298**	**257**	H = 0.89
	0 – 70.5	*1.4 – 771.6*	p = 0.0919	*0 – 2246*	*1.4 – 1071.7*	p = 0.3431
Copepoda	**295.4**	**758.6**	H = 0.54	**2030.6**	**1547.7**	H = 0.11
	23 - 892	*15.2 – 3813*	p = 0.4623	*180.7 – 6119*	*38.9 - 3834*	p = 0.7527
Rotifera	**7060.3**	**510.6**	H = 0.89	**390.2**	**87.9**	H = 0.39
	47 – 3399	*10 - 1840*	p = 0.3446	*5.9 – 1549*	*1.2 – 388.4*	p = 0.5286
Total	**7768.4**	**2174.3**	H = 0.54	**2850.2**	**2120.9**	H = 0.18
	261.1 – 34495	*87 - 8291*	p = 0.4623	*341.3 – 8376*	*48.6 – 4612.4*	p = 0.6744

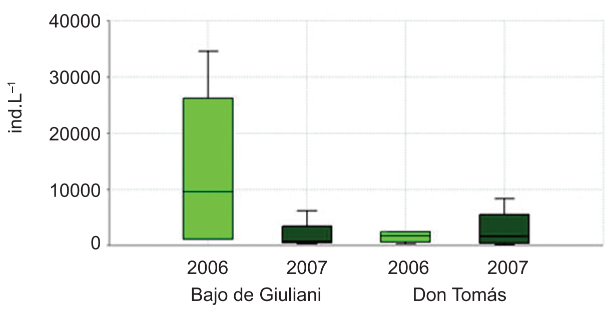

Figure 5. Annual zooplanktonic abundance in both studied lakes.

Figura 5. Densidad zooplanctónica anual de las dos lagunas estudiadas.

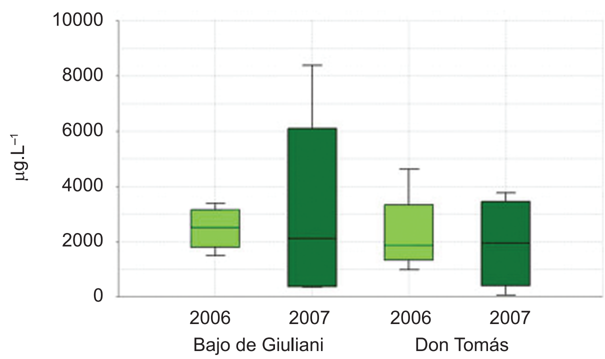

Figure 6. Zooplanktonic biomass in both studied lakes.

Figura 6. Biomasa zooplanctónica de los dos lagos someros estudiados.

whereas, in Don Tomás, peaks were in spring 2006 (4612.4 µg. L^{-1}) and in summer 2007 (3753.7 µg.L^{-1}). No correlation was found between the zooplankton biomass and the abiotic variables, and when considering the groups separately. The relationship was significant only between the biomass of cladocerans and water temperature ($r_s = 0.54$, $p = 0.0309$).

Discussion

Although the two lakes differed in their salinity, they shared features such as high concentrations of phosphorus and reduced transparency (caused by high concentrations of chlorophyll-*a* and organic and inorganic suspended solids), which allowed their categorization as hypertrophic environments (OECD 1982). According to the model of alternative states of shallow lakes, they are organic turbid environments (Torremorell et al. 2007, Allende et al. 2009) and their primary production is dominated by phytoplankton due to the absence of macrophytes.

The number of zooplankton taxa in both lakes differed because it was negatively influenced by the concentration of dissolved salts in the water. The higher zooplankton richness of Don Tomás, typical of subsaline environments, had been previously reported (Echaniz et al. 2008). In contrast, the lower number of taxa recorded in Bajo de Giuliani showed the modulating effect of the higher salt concentration, which means it can be inhabited by a smaller number of halotolerant species (Herbst 2001, Ivanova & Kazantseva 2006).

Although some species were present in both lakes, the crustaceans *E. huaronensis*, *A. robustus* and *M. anceps* predominated in Don Tomás. These species are more commonly found in other environments of low salinity of La Pampa (Vignatti et al. 2007, Echaniz et al. 2008). The species that prevailed in Bajo de Giuliani were the halotolerants *Cletocamptus deitersi*, *M. mendocinus* and *B. poopoensis* (Menu-Marque & Locascio de Mitrovich 1998, Echaniz et al. 2006, Vignatti et al. 2007). The highest number of shared species was recorded among rotifers and most of the taxa recorded were of cosmopolitan distribution (Segers & De Smet 2008) and euryhaline (Fontaneto et al. 2006). The presence of large-sized cladocerans, especially that of the genus *Daphnia*, was sporadic and never reached high densities, possibly due to the predation exerted by fish (Grosman & Sanzano 2003, Boveri & Quirós 2007, Manca et al. 2008) present in both lakes. The high standard deviation values found in the abundance and biomass of both lakes were due to the pronounced seasonality of the pampean environments, that have produced marked differences in both parameters (Echaniz et al. 2006, 2009).

In Redberry Lake, Evans et al. (1996) found that, due to its high salinity, the lake lacked fish fauna, which constitutes an important difference with the lakes included in this study, which are characterized by fish fauna dominated by *Odontesthes bonariensis*, a very tolerant species that can inhabit water bodies with salinities of up to 35.8 g.L^{-1} (Rosso 2006, Mancini & Grosman 2008). The lack of fish in Redberry Lake allowed the increased abundance of the large herbivorous zooplankton species, including *Daphnia pulicaria*

Forbes, 1893, and the diaptomid copepods *Diaptomus sicilis* (Forbes, 1882) and *Diaptomus nevadensis* (Light, 1938). This, in turn, allowed the development of a high zooplankton biomass (Evans et al. 1996). In contrast, the presence of a visual planktivorous fish such as *Odontesthes bonariensis* (Rosso 2006, Boveri & Quirós 2007) in the lakes of La Pampa prevents the development of large-sized zooplankton species (Quirós et al. 2002, Grosman & Sanzano 2003, Rosso 2006, Boveri & Quirós 2007). So, the composition of the zooplankton is dominated by rotifers and small crustaceans producing zooplanktonic communities of similar size, and resulted in no differences in biomass. The lower efficiency of the smaller zooplankton to filter the algae would have allowed the development of high phytoplankton biomass, with the consequent reduced transparency in the studied lakes.

Although it has been reported that lakes that exceed 1 $g.L^{-1}$ of salt tend to have lower phytoplanktonic biomass (expressed by the concentrations of chlorophyll-*a* and higher zooplanktonic biomass than subsaline lakes with similar nutrient concentrations (Evans et al. 1996), the present study not found higher zooplanktonic or lower phytoplanktonic biomasses in Bajo de Giuliani lake. The study showed that the taxonomic composition and biomass of zooplankton seemed to depend largely on the effect of predation, evidencing the importance of the top-down effect exerted by planktivorous fish. Despite the wide difference in the concentration of dissolved solids recorded between the two lakes, it is suggested that the trophic cascade caused both chlorophyll-*a* concentration and zooplankton abundance and biomass to show no significant differences between the two lakes.

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