Diversity and changes in the horizontal distribution of crustaceans and rotifers in an episodic wetland of the central region of Argentina

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Abstract: Although episodic wetlands are very frequent environments in Argentina, the knowledge about their ecology is scarce. Thus, the aim of this study was to describe the diversity and changes in the horizontal distribution of crustaceans and rotifers in the episodic wetland El Guanaco, Province of La Pampa, Argentina, during the hydroperiod that took place between December 2003 and March 2004. After three years during which it was dry, torrential rains made it reach a depth of 0.42 m. After 48 hours, ovigerous females and males of *Metacyclops mendocinus* (Wierzejeski 1892), juveniles of *Moina wierzejskii* (Richard 1895), and larvae of *Triops longicaudatus* (LeConte 1846) were recorded. The conductivity was reduced, the ionic content was dominated by bicarbonates and sodium and the concentrations of nutrients were high. The samplings were carried out in three stations, which at first were in open waters. The stations presented a homogeneous horizontal distribution of microcrustaceans and rotifers, with a predominance of limnetic species. Later, two of the stations were surrounded by *Eleocharis macrostachya* Britton plants, which allowed us to determine changes in the taxonomic composition and the appearance of species associated with the presence of vegetation. We recorded 35 taxa, being *Moina micrura* Kurz 1874 constantly present and highest in numbers. Among rotifers, the genus *Brachionus* was the predominant one. The species richness was higher in the station which was covered by *E. macrostachya* plants. After a period of high temperatures, we observed that the richness and abundance of microcrustaceans decreased, whereas those of rotifers increased.
Keywords: *episodic wetland, rotifer and crustacean diversity, Triops, horizontal distribution, Argentine.*

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Resumen: El conocimiento sobre la ecología de los humedales episódicos de Argentina es escaso, a pesar de que son ambientes muy frecuentes. El objetivo de este estudio es describir la diversidad y los cambios en la distribución horizontal de los crustáceos y rotíferos que ocurrieron durante el hidroperíodo que tuvo lugar entre diciembre de 2003 y marzo de 2004 en El Guanaco, un humedal episódico, alimentado por precipitaciones, de la provincia de La Pampa. Luego de tres años en los que permaneció seco, lluvias torrenciales hicieron que alcanzara una profundidad de 0,42 m. A las 48 horas del llenado se registraron hembras ovígeras y machos de *Metacyclops mendocinus* (Wierzejeski 1892), juveniles de *Moina wierzejskii* Richard 1895 y larvas de *Triops longicaudatus* (LeConte 1846). La conductividad fue reducida, el contenido iónico estuvo dominado por bicarbonatos y sodio y las concentraciones de nutrientes fueron elevadas. Los muestreos se hicieron en tres estaciones, que al inicio estaban en agua abierta, y presentaron una distribución horizontal de microcrustáceos y rotíferos homogénea, con predominio de especies limnéticas. Posteriormente, dos estaciones quedaron ubicadas en un juncal de *Eleocharis macrostachya* Britton, a partir de lo cual se verificaron cambios en la composición taxonómica, con la aparición de especies asociadas a la vegetación. Se registraron 35 taxa, siendo *Moina micrura* Kurz 1874 de presencia constante y la más numerosa. Entre los rotíferos predominó el género *Brachionus*. La riqueza específica fue mayor en la estación que quedó cubierta por las plantas. Luego de un período de altas temperaturas se verificó que la riqueza y abundancia de microcrustáceos disminuyeron mientras que las de los rotíferos aumentaron.
Palabras-clave: *humedales episódicos, diversidad, Triops, distribución horizontal, Argentina.*

Introduction

Temporary wetlands are ecosystems that can remain dry for either a few months or many years (Schwartz & Jenkins 2000). According to the topography, the soil and the climate of the area where they are located, temporary wetlands can be either seasonal, which alternate dry and wet phases in the same year, or episodic, which can persist without water for years until precipitations fill them again in a short time, and in which the duration of the hydroperiod is variable (Williams 1987, Boulton & Brock 1999, Schwartz & Jenkins 2000). The size of these environments, which are widely distributed, can be of either a few square meters or hundreds of hectares (Williams 1987, Schwartz & Jenkins 2000). The organisms that inhabit them during the wet phases have adaptations that allow them to go through the dry phases. These adaptations include diapause or dormant stages (Schwartz & Jenkins 2000, Bruno et al. 2001), deposition of resting eggs, such as that observed in anostracans, notostracans, cladocerans and rotifers (Fryer 1996, Su & Mulla 2002, Alekseev & Ravera 2004, Mura 2004, Schröder 2005), and the burial of individuals in the sediments, sometimes in larval stage, such as that observed in cyclopoid copepods (Hairston & Bohonak 1998, Santer & Hansen 2006).

Several authors have studied diverse aspects of the cycles that alternate the wet and dry phases, as well as their influence on the biota, in both temporary and episodic wetlands of 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 episodic wetlands are very frequent, especially in the central-west semiarid region of the country, their ecology has not yet received much attention. At the present, the few studies about these ecosystems have been carried out in relation with the conservation of wetlands of importance for certain bird species (Canevari et al. 1998), but there is little information about the ecology of the invertebrates that inhabit them during the wet phases.

The rate at which these environments are disappearing due to human action, usually to transform them in agricultural lands, with the consequent loss of some species (Simovich 1998, Boix et al. 2002), emphasize the importance of acquiring knowledge about their ecology (Belk 1998, Williams 2002, Jenkins et al. 2003, Eitam et al. 2004) because of the significant contribution of these wetlands to regional biodiversity (Waterkeyn et al. 2008).

On the other hand, since temporary water bodies are developed in a great diversity of landscapes, very few generalizations can be made on their ecology (Fahd et al. 2000). In addition, the biodiversity of South American aquatic environments is not completely known (Lévêque et al. 2005) and the neotropical region possesses numerous local elements, different from those recorded in other latitudes (Paggi 1998, Echaniz et al. 2005, 2006, Vignatti et al. 2007).

The aim of this work was to gain insights into the diversity of crustaceans and rotifers, as well as into the changes in the horizontal distribution of some physico-chemical parameters and the taxonomic composition, richness and abundance of such organisms, during the period from the filling until the drying of a shallow subsaline episodic wetland of La Pampa province, in the central semiarid region of Argentina.

Material and Methods

1. Study site

El Guanaco (36° 19' S and 64° 16' W) is an episodic wetland located in a slight depression with NE-SW orientation, 25 km to the North of Santa Rosa, capital of the Province of La Pampa (Figure 1). It has a maximum length of 1700 m, a maximum width of 630 m and a surface of 82.5 ha. It is fed by precipitation and is frequently dry for periods that can last several years. It is situated in a rural establishment where extensive cattle breeding is carried out, is surrounded by very open native forest, and its bed is not ploughed or sowed, although the cattle generally feeds on the natural vegetation that grows in it during the dry phases.

The mean annual precipitations in the area are about 700 mm, with a maximum at the end of spring and summer (Casagrande et al. 2006), but the potential evapotranspiration is over 800 mm, indicating the semiarid conditions of the region (Ponce de León 1998).

After a period of three years during which it remained dry, torrential rains of more than 120 mm in 24 hours, between 26th and 27th December 2003, made it reach a depth of 0.42 m. Other not so intense precipitations allowed it to remain with water for 66 days, after which it dried again.

2. Field and laboratory work

Samplings were carried out from 28th December 2003, every 48 or 72 hours, until the end of January 2004, and then with every week until complete drying, which took place at the beginning of March (Table 1). The samplings were carried out in three stations (North, Center and South). At the beginning of the study the three stations were in open waters, but, later, the Center and South stations were surrounded by plants of *Eleocharis macrostachya* Britton (Poales, Cyperaceae), which developed during mid-January. The Center station remained in an opening among the plants, whereas the South station was completely covered by them (Figure 1).

Data of depth, transparency (measured with a Secchi disc), temperature and pH (measured with a digital thermo-pH-meter Lutron PH-206), and conductivity (with a digital conductivity meter Oakton TDSTestr-20) were obtained in the field.

The amount of rain fell was determined by means of a pluviometer located in the administration of Luan Lauquen establishment, 500 m from the wetland. In three occasions (28th December 2003, 5th January 2004 and 20th January 2004), water samples were taken to determine the ionic concentration according to stipulated routines in Standard Methods (APHA 1992). Nitrates were measured by means of cadmium-sulphanilamide reduction, total phosphorus by digestion of the sample with potassium persulfate in acid medium, and orthophosphate by means of a UV-visible spectrophotometer.

Quantitative samples were taken for the determination of abundance of cladocerans, copepods and rotifers, which, due to the scarce depth of the lagoon, had to be taken in 10 L tared containers and filtered with 40 μm mesh plankton nets. Qualitative samples were also collected for taxonomic determinations by means of drag nets of the same mesh size. Notostracans were captured qualitatively by means of hand nets of 1 mm mesh size.

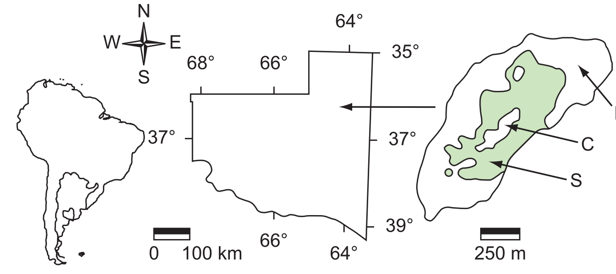

Figure 1. Map and sketch of El Guanaco wetland, showing their geographical ubication in La Pampa province, central Argentina and the sampling sites. N: North, C: Center and S: South. The colored area indicates the *Eleocharis macrostachya* plants coberture.

Table 1. Sampling dates and values of the ambiental parameters registered in El Guanaco wetland during the period December 2003 to March 2004. Water temperature, pH and conductivity: values of means and standard deviations.

Sample date	Max. depth (m)	Transparency (m)	Water temp. (°C)	pH	Conductivity (µS.cm^{-1})
28 Dec.	0.42	0.15	25.2 ± 0.09	6.78 ± 0.04	310 ± 3.61
30 Dec.	0.42	0.19	20.5 ±.17	7.66 ± 0.03	630 ± 2.65
1 Jan.	0.39	0.22	21.0 ± 0.17	8.15 ± 0.05	690 ± 2.68
3 Jan.	0.37	0.37	25.0 ± 0.17	8.94 ± 0.02	930 ± 1.73
5 Jan.	0.33	0.33	30.0 ± 0.26	8.46 ± 0.03	1060 ± 2.52
7 Jan.	0.38	0.38	27.2 ± 0.17	7.82 ± 0.03	1060 ± 3.51
10 Jan.	0.36	0.36	23.1 ± 0.10	7.61 ± 0.03	1250 ± 2.00
13 Jan.	0.34	0.34	28.0 ± 0.10	8.23 ± 0.04	1390 ± 1.53
17 Jan.	0.29	0.29	25.5 ± 0.17	8.78 ± 0.01	1570 ± 3.06
20 Jan.	0.27	0.27	26.5 ± 0.17	8.69 ± 0.04	2430 ± 3.72
23 Jan.	0.31	0.31	24.5 ± 0.17	8.80 ± 0.03	2250 ± 1.37
29 Jan.	0.29	0.29	34.5 ± 0.17	9.12 ± 0.03	2600 ± 2.64
7 Feb.	0.17	0.17	26.0 ± 0.55	8.90 ± 0.49	2880 ± 2.75
14 Feb.	0.19	0.19	25.7 ± 1.17	8.91 ± 0.30	2670 ± 3.70
22 Feb.	0.10	0.10	25.4 ± 1.50	9.15 ± 0.56	3460 ± 5.03
1 Mar.	0.05	0.05	21.2 ± 0.00	8.92 ± 0.46	3730 ± 4.20

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.

Counts to determine the abundance of microzooplankton (rotifers and *nauplii*) (Kalff 2002) were carried out in 1-mL Sedgwick-Rafter chambers under an optical microscope with 40-100 X magnification. Macrozooplankton (cladocerans and copepods) (Kalff 2002) were counted in Bogorov chambers under a stereomicroscope with 20× magnification, taking aliquots with a Russell subsampler of 5 mL. The number of aliquots was determined with Cassie's equation (Downing & Rigler 1984).

Levene's test was carried out to verify the homocedasticity of the variances, and the Shapiro Wilkins normality test was applied. To determine the differences in environmental and biological parameters between the stations we used ANOVA, and when there were differences, we used Tukey's test a posteriori (Sokal & Rohlf 1980, Zar 1996). To determine species clustering, Morisita's cluster analysis of paired groups was carried out.

Results

1. Environmental parameters

El Guanaco is a shallow wetland; during the study period it reached a maximum depth of 0.42 m (Figure 2). Water transparency was not total in the first three samplings (0.22 m ± 0.03), whereas it was total during the rest of the study period.

Although the depth recorded in the first two samplings was similar, the conductivity measured on the first day (310 µS.cm^{-1}) doubled after 48 hours (630 µS.cm^{-1}). This later evidenced a concentration process by evaporation, which coincided with the drying, before which it reached 3730 µS.cm^{-1} on 1st March.

Water ionic content was dominated by sodium (among cations), which increased from 1.8 mg.L^{-1} on 28th December to 171 mg.L^{-1} on 20th January, and by bicarbonate (among anions), which increased from 98 mg.L^{-1}on 28th December to 484 mg.L^{-1} on 20th January (Figure 3).

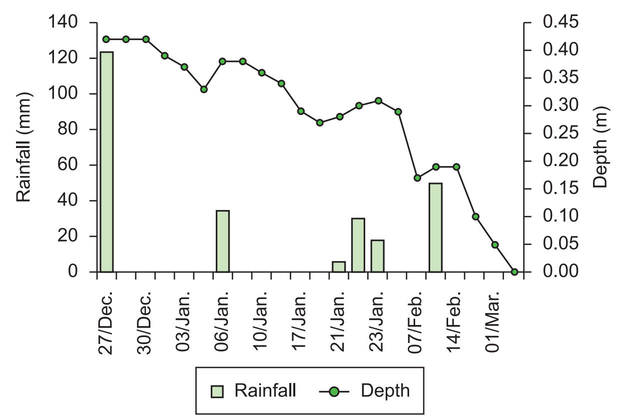

Figure 2. Rainfall and maximal depth in El Guanaco during the period 27 December 2003 and 1st March 2004.

The pH (Figure 4) also increased from 6.78 to 9.48. The analysis of variance showed that during the first month of the hydroperiod this variable was similar in the three stations ($F = 0.003$; $p = 0.9966$), but that during the second month, as plants of *Eleocharis macrostachya* Britton developed, it behaved differently in the three stations ($F = 26.74$; $p = 0.0002$). Tukey's post hoc test indicated that the South station was the different one ($p < 0.0005$).

Water temperature was also similar in the three stations during the first month ($F = 0.002$; $p = 0.9981$), and although during the second month it differed, the ANOVA did not show significant differences ($F = 2.919$; $p = 0.1054$). This parameter showed marked oscillations related to the mean daily temperature of the air ($r = 0.55$; $p < 0.05$) and reached a maximum of 34.5 °C on 29th January.

The concentration of nutrients in the water was high. The concentration of nitrate was higher during the first days, reaching 18.5 mg.L^{-1}, and then decreased during the drying period up to 9.8 mg.L^{-1}; instead, the concentration of total phosphorus showed an increase from 1.1 to 14.5 mg.L^{-1} (Figure 5).

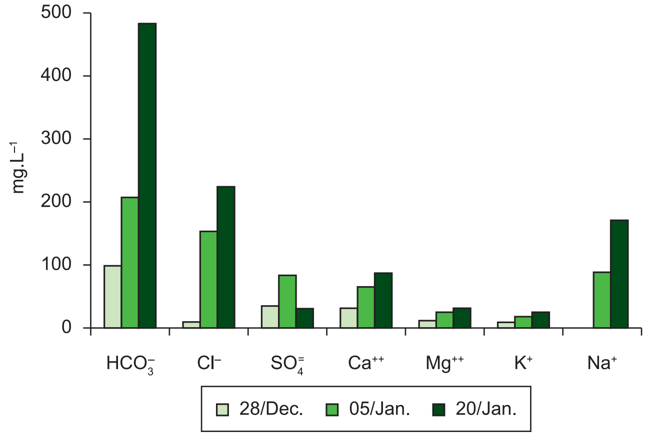

Figure 3. Variation in the major ions concentration in the three sampling dates in El Guanaco.

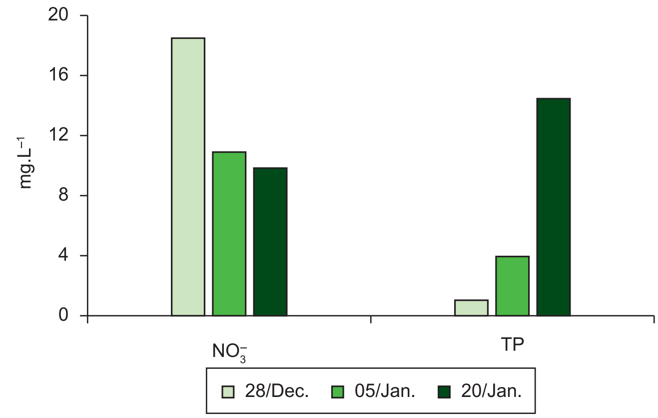

Figure 5. Variation in the nitrates and total phosphorus concentration in El Guanaco, in the three sampling occasions.

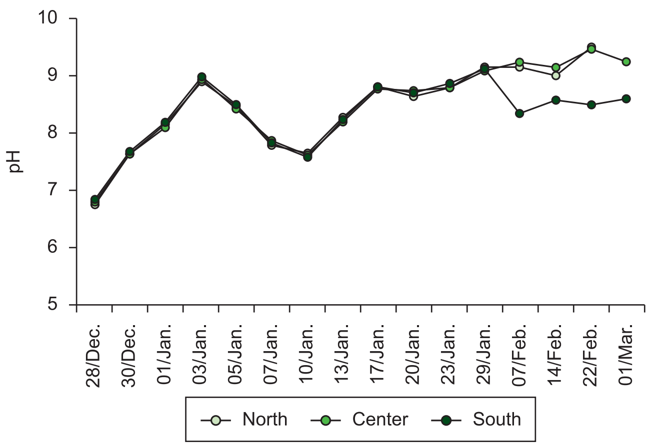

Figure 4. Variation in pH in the sampling sites in El Guanaco, during the period December 2003 to March 2004.

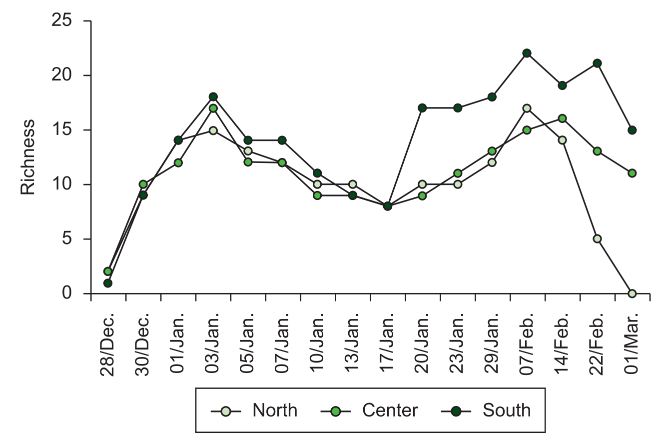

Figure 6. Changes in richness and comparation between sampling sites in El Guanaco, during the period December 2003 to March 2004.

2. Biological parameters

A total of 35 taxa were recorded: 11 crustaceans and 24 rotifers (Table 2). At 48 hours of filling, ovigerous females and males of *Metacyclops mendocinus* (Wierzejski, 1892) (Cyclopoida, Cyclopidae), juveniles of *Moina wierzejskii* Richard, 1895 (Diplostraca, Moinidae), larvae of *Triops longicaudatus* LeConte, 1846 (Notostraca, Triopsidae), and a high number of ephippia of cladocerans, especially of *Daphnia* O. F. Müller, 1785 and *Moina* Baird, 1850. *Nauplii* of copepods were observed as from the second sampling.

Although total species richness (S) (Figure 6) was similar in the three stations until 18th January, this parameter was different along the complete hydroperiod ($F = 3.355$; $p = 0.0438$). The different station was South ($p < 0.05$), where a maximum of 22 species were recorded, whereas 17 species were found in the north and center stations.

The maximum number of taxa of microcrustaceans (cladocerans and copepods) was observed before the peak of temperature at the end of January, with eight species in the south station. Although the maximum number of taxa of rotifers (16) was also observed in the south station, this was found after an increase in temperature.

Although the analysis of variance did not reveal differences in the total zooplankton abundance of the three stations ($F = 0.9739$; $p = 0.3854$), when separately analyzing the fractions integrating the community, the abundance of macrozooplankton showed significant differences between stations ($F = 6.07$; $p = 0.0046$). The greatest abundance was recorded in the South station ($p < 0.05$).

In contrast, the density of microzooplankton did not show significant differences between the stations ($F = 1.015$; $p = 0.3707$).

The Shannon indices calculated considering the complete hydroperiod (North: 1.721; Center: 1.615 and South: 1.904) were significantly different ($F = 3.626$; $p = 0.0355$), being the south station the one that differed ($p < 0.05$).

The abundance of cladocerans and copepods reached its maximum on 10th January (1524 ind.L^{-1}) and then decreased towards the end of the month (Figure 7). *Moina micrura* Kurz, 1874 (Diplostraca, Moinidae) and *M. mendocinus* were predominant among them, and their presence was almost constant and of higher abundance. The two recorded species of *Moina* behaved oppositely. *M. wierzejskii* was more abundant in the North station reaching a maximum of 778 ind.L^{-1} on 13th January, where plants did not develop, and its density decreased markedly and it was not registered after 23rd January. In contrast, *M. micrura,* as well as *M. mendocinus,* showed maximum densities (1305 and 344 ind.L^{-1}, respectively, on 10th January) in the South station, where plants grew, although their densities then decreased markedly. *M. micrura* was not found in the station after the peak of temperature at the end of January, when the plants reached their maximum height.

Daphnia spinulata Birabén, 1917 (Diplostraca, Daphniidae) showed a similar pattern to that of *M. wierzejskii*, because although its

Table 2. Taxa registered in the three sampling sites of El Guanaco wetland during the period December 2003 to March 2004, with indication of their relative frecuency (%) and density (ind.L^{-1}).

Taxa	North		Centre		South	
	Frec. (%)	Density (ind.L^{-1})	Frec. (%)	Density (ind.L^{-1})	Frec. (%)	Density (ind.L^{-1})
Notostraca						
Triops longicaudatus (LeConte, 1846)	-	-	-	-	-	-
Cladocera						
Moina micrura Kurz, 1874	81.3	107	87.5	61.9	75	490.5
Moina wierzejskii Richard, 1895	68.8	167	68.8	115.5	56.3	145.8
Daphnia spinulata Birabén, 1917	75	62.4	68.8	114.4	62.5	81.1
Simocephalus serrulatus (Koch, 1841)	-	-	-	-	43.8	8.5
Leydigia leydigi (Schoedler, 1863)	-	-	-	-	6.3	2
Alona sp.	12.5	2	43.8	1.7	56.3	203
Pleuroxus sp.	-	-	-	-	25	7.5
Macrothrix sp.	50	10.5	43.8	5.3	62.5	363
Copepoda						
Metacyclops mendocinus (Wierzejeski, 1892)	93.8	61	100	35	93.8	90.6
Microcyclops anceps (Richard, 1897)	62.5	40.7	56.3	58.6	81.3	62.3
Rotifera						
Brachionus plicatilis Müller, 1786	25	22.5	43.8	776.2	31.3	168.5
B. urceolaris (O. F.Muller, 1773),	68.8	621.8	43.8	440.7	56.3	419.8
B. budapestinensis Daday, 1885	25	285	25	2171.8	25	378.8
B. quadridentatus Hermann, 1783	37.5	25.2	37.5	46.7	68.8	28.6
B. angularis Gosse, 1851	50	904.5	56.3	3832.9	56.3	805.1
B. dimidiatus Bryce, 1931	50	73.8	62.5	191.4	43.8	91.8
B. calyciflorus Pallas, 1766	31.3	189	50	54.9	31.3	239.6
B. pterodinoides (Rousselet, 1913)	12.5	7.5	12.5	5	6.3	30
B. caudatus Barrois y Daday, 1894	6.3	5	-	-	6.3	5
Platyias quadricornis (Ehrenberg, 1832)	6.3	30	6.3	4	12.5	16
Keratella sp.	12.5	17.5	6.3	5	6.3	40
Polyarthra sp.	68.8	226	87.5	435	68.8	648
Trichocerca sp.	25	25	50	117.8	37.5	119.2
Lecane lunaris (Ehremberg, 1832)	12.5	45	25	189.4	31.3	228
L. bulla (Gosse, 1851)	-	-	-	-	18.8	18.3
L. quadridentata (Ehremberg, 1832)	6.3	20	6.3	5	43.8	98.6
Lecane sp.	-	-	-	-	18.8	123.3
Lepadella sp.	-	-	12.5	3.8	43.8	330
Colurella sp.	25	42.2	18.8	17.5	31.3	69.6
Euchlanis sp.	-	-	6.3	4	37.5	93.3
Hexarthra sp.	6.3	20	18.8	24.2	6.3	100
Filinia longiseta (Ehremberg, 1834)	56.3	517.6	62.5	468.7	62.5	552
Testudinella patina (Hermann, 1783)	12.5	90	6.3	17.5	37.5	199.2
Asplachna sp.	31.3	192	50	89.5	56.3	74

maximum densities were recorded in the Center station (652 ind.L^{-1} on 5th January), its abundance decreased and was no longer found in the South station as from 23rd January, when macrophytes reached a relatively large size.

Cladocerans of the genera *Macrothrix* Baird, 1843 and *Alona* Baird, 1850 were found only as from mid-January and reached their maximum abundances in the South station. Their densities were high: 1224 and 358 ind.L^{-1} respectively.

Unlike microcrustaceans, rotifers showed their maximum abundance during the second month (Figure 8), reaching 26325 ind.L^{-1} on 14th February. Among them, the genus *Brachionus* Pallas, 1766 was the predominant one, with nine species. Some of them, such as *B. angularis* Gosse, 1851 (Ploima, Brachionidae) and *B. budapestinensis* Daday, 1885 (Ploima, Brachionidae), reached high densities (18255 and 8280 ind.L^{-1} respectively) in the Center station, but at different moments.

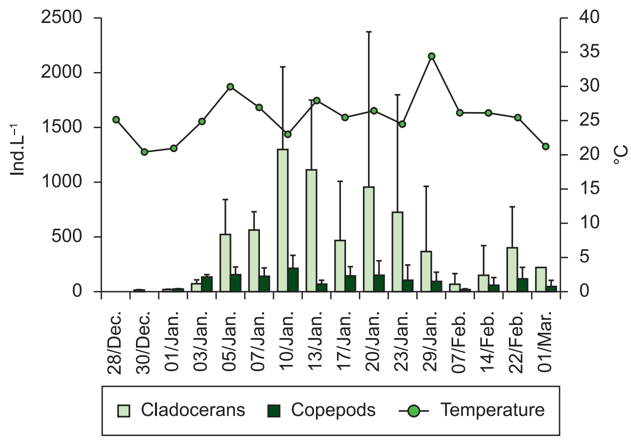

Figure 7. Variations in crustacean (cladocerans and copepods) density and water mean temperature in El Guanaco, during the period December 2003 to March 2004.

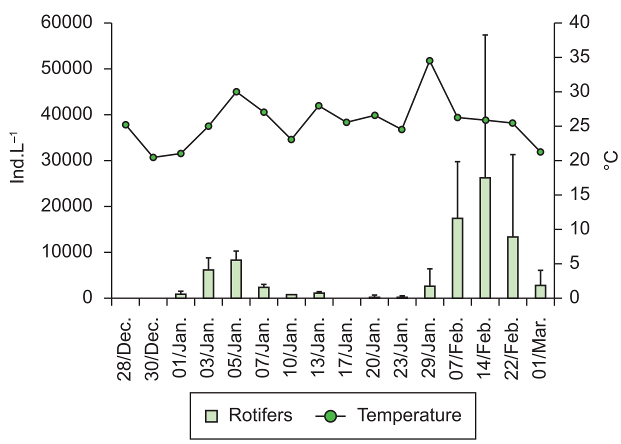

Figure 8. Variations in rotifer density and water mean temperature in El Guanaco, during the period December 2003 to March 2004.

Although some species, such as *B. plicatilis* O. F. Muller, 1786 (Ploima, Brachionidae), *B. urceolaris* (O. F.Muller, 1773) (Ploima, Brachionidae), *B. quadridentatus* Hermann, 1783 (Ploima, Brachionidae) and *B. calyciflorus* Pallas, 1766 (Ploima, Brachionidae), were more abundant when there was no development of macrophytes and were then absent, others, such as *Lecane quadridentata* (Ehremberg, 1832) (Ploima, Lecanidae). Species of the genera *Testudinella* Bory de St. Vincent, 1826 and *Lepadella* Bory de St. Vincent, 1826, were recorded only in the South station as from mid-January, when the height of plants reached the surface of the water.

The cluster analysis (Figure 9) showed two groups: one group with the taxa which presented their highest abundances in the stations influenced by the plants of *E. macrostachya*, and another with those that preferred open waters.

Discussion

Although subsaline shallow lakes are not frequent in the central semiarid region of Argentina, the water conductivity measured in El Guanaco wetland was lower than that in other natural lakes of the region (Echaniz et al. 2006, Vignatti et al. 2007). The values recorded are more similar to those of some permanent shallow lakes that receive pluvial contributions from cities or to those of water springs in dunal landscapes (Vignatti et al. 2007, Echaniz et al. 2008).

In El Guanaco, although the development of *Eleocharis macrostachya* plants produced differences in the pH and habitat type between the stations, the conductivity showed similar values, even during the drying period, evidencing the mix of water.

The mean concentration of nutrients recorded was high. The concentration of nitrates was higher during the fist days and then decreased during the drying period, probably due to the requirements caused by the growth of plants.

In contrast, the increase in the concentration of total phosphorus could be due to the cattle feces dragged into the water during rainfall, as well as by the decomposition of the accumulated feces, and the plant cover developed during the dry periods.

The presence of *Triops longicaudatus* only in the samples of the first 12 days indicates its association with environments of the wet phase of short duration (Fahd 2000, Bayly 2001). This situation differed from that found by Boix et al. (2002), who recorded *T. cancriformis* (Bosc, 1801) (Notostraca, Triopsidae) along complete hydroperiods of 46 and 100 days.

The short presence of *T. longicaudatus* in El Guanaco could be due to the fact that the pH of the water during those days was close to neutral; it has been demonstrated that neutral pH favors the hatching of resistant eggs of *T. cancriformis*, which stop hatching at pH 9 (Schönbrunner & Eder 2006). Taking into consideration that other species of the genus have shown a wide feeding range, including detritus, plants, cladocerans and copepods (Boix et al. 2006), or mosquito larvae (Su & Mulla 2002), we can hypothesize that the short presence of *T. longicaudatus* is due to other environmental factors rather than to a lack of food resources.

The diversity, especially of cladocerans, recorded in El Guanaco was high. Simovich (1998) reported the presence of 18 species of cladocerans in 14 ephemeral wetlands of California, in contrast to the 8 species recorded by us in El Guanaco. This high diversity could be due to the fact that El Guanaco is a considerably large lagoon, and it has been verified that there is a positive correlation between the number of species and the surface of water bodies (Simovich 1998, Mura & Brecciaroli 2003). In addition, its high diversity is probably due to its reduced salinity, because of the inverse relationship between these two parameters (Derry et al. 2003, Ivanova & Kazantseva 2006). Besides, in temporary wetlands, the diversity is directly related to the length of the hydroperiod (Eitam et al. 2004, Waterkeyn et al. 2008). Frisch et al. (2006) found that in 25 temporary environments of the Southwest of Spain, the diversity was higher than when the hydroperiod ranged between three and five months. In El Guanaco, the duration of the hydroperiod, which was over two months, may have allowed the development of high species richness.

The zooplanktonic association recorded in El Guanaco was similar to that in other permanent environments of low salinity of the region (Echaniz & Vignatti 2001, Vignatti et al. 2007, Echaniz et al. 2008), because of the presence of the cladocerans *Daphnia spinulata*, *Moina micrura* and *M. wierzejskii,* the cyclopoid *Metacyclops mendocinus* and *Microcyclops anceps* (Richard, 1897) (Cyclopoida, Cycloipidae), and the rotifers *Brachionus angularis, B. pterodinoides* (Rousselet, 1913) (Ploima, Brachionidae) and *B. caudatus* Barrois & Daday, 1894 (Ploima, Brachionidae). However, the diversity found in El Guanaco was higher probably due to the environmental heterogeneity caused by the development of *E. macrostachya* plants, which generated a larger diversity of habitats (Kalff 2002).

The presence of cladocerans of the genera *Moina* and *Daphnia*, among which *M. micrura* and *M. wierzejskii* were the most constant and the ones with highest abundances, showed a situation similar to that confirmed in temporary environments of Israel (Eitam et al. 2004), but different from that reported by Mura & Brecciaroli (2003) and Schell et al. (2001), who did not record this genus in their studies on nine water bodies of the center of Italy and 54 water bodies of Wisconsin, USA, respectively.

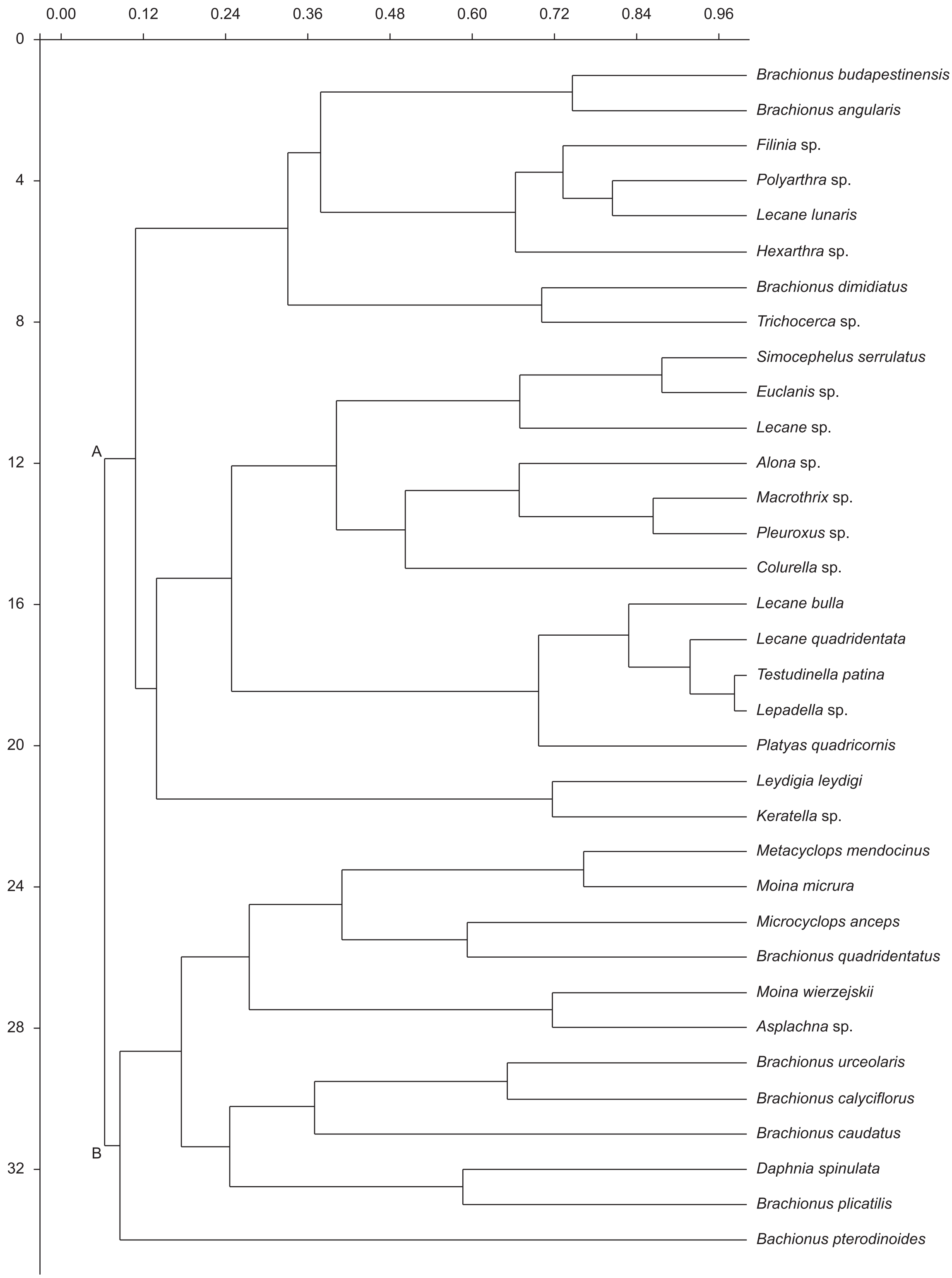

Figure 9. Cluster analysis of Morisita (paired groups; cophenetic correlation = 0,802) of the species association registered in El Guanaco during the period December 2003 to March 2004. A - species associated to vegetation; B - species of open waters.

The fact that species of the genus *Moina*, such as *M. micrura* and *M. wierzejskii*, lives together, has been reported by other authors (Simovich 1998) and in shallow lakes of similar salinity of La Pampa (Vignatti et al. 2007). In El Guanaco, these two species shared the water body most of the time and their abundances in each station were relatively similar along the time during which *E. macrostachya* plants did not develop. We later confirmed the preference of *M. wierzejskii* for the station of open waters and the preference of *M. micrura* for the station with relatively developed plants.

A similar situation was found in the case of rotifers, although with different abundances and moments of appearance, nine species of the genus *Brachionus* were found living together. The dominance of this genus, sometimes with high abundances, is another important difference between El Guanaco and the wetlands in Spain, because the presence of only one species of the genus, *B. quadridentatus,* was recorded in three out of the 32 ephemeral environments of Doñana National Park, Spain, studied by Mazuelos et al. (1993).

In contrast, *Platyias quadricornis* (Ehrenberg, 1832) (Ploima, Brachionidae), one of the dominant species in Doñana (Mazuelos et al. 1993) and present in the water ponds of the Chihuahuan desert (Wallace et al. 2005), in El Guanaco it was recorded only in one occasion, with very low abundances.

At the beginning of the hydroperiod, the open waters of the three stations presented a homogeneous horizontal distribution of species, with a predominance of limnetic organisms. Later, at the beginning of February, since two of the stations remained surrounded by *E. macrostachya* plants, the environmental heterogeneity increased considerably because the structure and surface of the plants create conditions of differential habitats for different animals, evidencing an important role in the structuring of the aquatic communities (Kuczyńska-Kippen & Nagengast 2003).

Differences in the taxonomic composition were thus confirmed, with an increase in the diversity in the South station, as indicated by the Shannon diversity and the appearance of species associated with vegetation, such as *Alona* sp. and *Macrothrix* sp. cladocerans.

After the heat wave that increased the temperature of the water to 34.5 ºC after seven days, we confirmed a decrease in the abundance of microcrustaceans, which would have allowed a decrease of the pressure of the competition and predation, which would have promoted an increase in the diversity and abundance of rotifers, since from that moment and towards the end of the study, they reached their maximum abundances, especially in the opening among the *E. macrostachya* plants (Center station).

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