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Mollusk communities differ between microenvironments within a shallow lake in the Pampean Region, Argentina

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Abstract. The aim of this study is to compare the faunistic mollusk composition at a local scale, in different sites within a shallow lake, and to evaluate the relation between abundance and richness of mollusks and the environmental variables. The distribution of the mollusks within the water body was patchy but not random. Three of the sites were deeper, mainly dominated by emergent macrophytes and were characterized by the dominance of the gastropods *Heleobia parchappii*, *Physa acuta* and *Uncancylus concentricus*. In contrast, the other two sites were dominated by *Biomphalaria peregrina* and the bivalve *Musculium argentinum*, and were characterized by lower depth and pH, and higher vegetation diversity and water temperature. This study evidences the patchiness of freshwater mollusk species in a Pampean shallow lake, where environmental factors partially explain the local distribution within the lake.

[Keywords: freshwater mollusks]

Resumen. Comunidades de moluscos difieren entre microambientes en un lago somero de la región pampeana, Argentina. El objetivo de este trabajo es comparar la distribución de los ensambles de moluscos en diferentes sitios dentro de un lago somero pampeano y evaluar la relación que existe entre la abundancia y la riqueza de moluscos y las variables ambientales. Los moluscos mostraron una distribución en parches, pero no azarosa. Tres de los sitios que eran más profundos y que estaban dominados por macrófitas emergentes estuvieron caracterizados por mayores abundancias de los gasterópodos *Heleobia parchappii*, *Physa acuta* y *Uncancylus concentricus*. En contraste, los otros dos sitios que estuvieron caracterizados por menores profundidades, menores pH, mayor diversidad de vegetación y temperaturas del agua más altas estuvieron dominados por *Biomphalaria peregrina* y por el bivalvo *Musculium argentinum*. Este estudio evidencia la distribución en parches de moluscos dulceacuícolas en lagos someros de la ecorregión pampeana donde las variables ambientales explican de forma parcial la distribución local dentro del lago.

[Palabras clave: moluscos dulceacuícolas]

Introduction

One of the main objectives of community ecology is to explain patterns of species composition and distributions. Several variables are responsible for the observed patterns, and the requirements of the species are especially important at smaller scales (Horsak et al. 2007). Freshwater mollusks play an important role in aquatic ecosystems, providing food for many fish species (McMahon and Bogan 2001; García et al. 2006; Fagundes et al. 2008) and vertebrates (Cummins and Bogan 2006; Maltchik et al. 2010). When environmental factors, which determine the mollusk richness and distribution in continental waters, were investigated, water hardness, conductivity, pH, substrates, vegetation and biotic interactions were reported as the most important environmental factors affecting mollusk distribution (Dillon 2000; Horsák et al. 2007).

The Pampean plain represents one of the largest wetland areas of South America (Diovisalvi et al. 2015; Viglizzo et al. 2011). The low morphogenetic energy of the flat landscape combined with their occurrence in humid to sub-humid climates results in a variety of freshwater bodies (e.g., ponds, shallow lakes and marshes) (Geraldi et al. 2011). Freshwater mollusks of this region are an important component of macroinvertebrate assemblages and present a small number of species (1-5; mostly snails) and low regional variability (low beta-diversity) (Tietze and De Francesco 2010, 2012; De Francesco et al. 2013). Therefore, mollusks species are widely distributed due to the similar environmental characteristics exhibited by the habitats as consequence of the environmental homogeneity of the area. However, some differences between sites related to the microhabitat availability were found in a previous study (Tietze and De Francesco 2010).

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In the present study we hypothesized that environmental variables influence the composition of mollusk assemblages at site scale. Thus, the aim of the present contribution was to compare the faunistic mollusk composition at a local scale in different sites within a shallow lake, and to evaluate the relation between abundance and richness of mollusks and the environmental variables. The study was performed during a year to capture a high variability in the environmental variables, mollusk presence and species abundance.

Materials and Methods

Study area and sites

The study was carried out in the shallow lake Nahuel Rucá, a Pampean water body located near Mar del Plata city (NR; 37°37'21'' S - 57°25'42'' W) (Figure 1). Pampean lakes are very shallow (about 2 m of mean depth), permanent or temporary, and lack thermal stratification except for short periods of time (Quirós and Drago 1999). Owing to their shallowness, the dynamics of Pampean lakes are tightly tied in with climate conditions, and the annual precipitation and evaporation volumes are within the same order of magnitude as their hydric volumes (Fernández Cirelli and Miretzky 2004; Diovisalvi et al. 2015). Their low depths favor water-sediment interaction by wind action, especially during periods with lower precipitation.

The climate in the region is temperate humid or subhumid with a mean annual temperature of 15 °C, with warm summers and mild winters and a mean annual precipitation of 1100 mm (Feijoó and Lombardo 2007). The water residence time is highly variable due to the periodic alternation between flood and drought periods.

Data collecting

We sampled five sites within NR for eleven months between August 2014 and September 2015. The sites were chosen in order to represent different microenvironments within the same water body. Sites 1 and 2 were behind the macrophyte ring of bulrush *Schoenoplectus californicus*, which characterize Pampean lakes. Site 3 was an open site on the shore with the same emergent macrophyte, but distributed in patches and with submerged macrophytes also present in the site. Sites 4 and 5 were also sites on the shore of the lake but with lower depths. Both sites presented *S. californicus* as rooted emergent macrophyte, free-floating macrophytes (*Azolla* sp., Lemnaceae) and also vegetation that characterize the transitional zone between aquatic and terrestrial habitats. During December the water level of the lake decreased, disabling the possibility of sampling S4 and S5 because they got dry. Since January the water level increased slowly. Usually, Pampean shallow lakes decrease its size naturally during summer due to evaporation, but during the sampling year a floodgate that controls water level of the

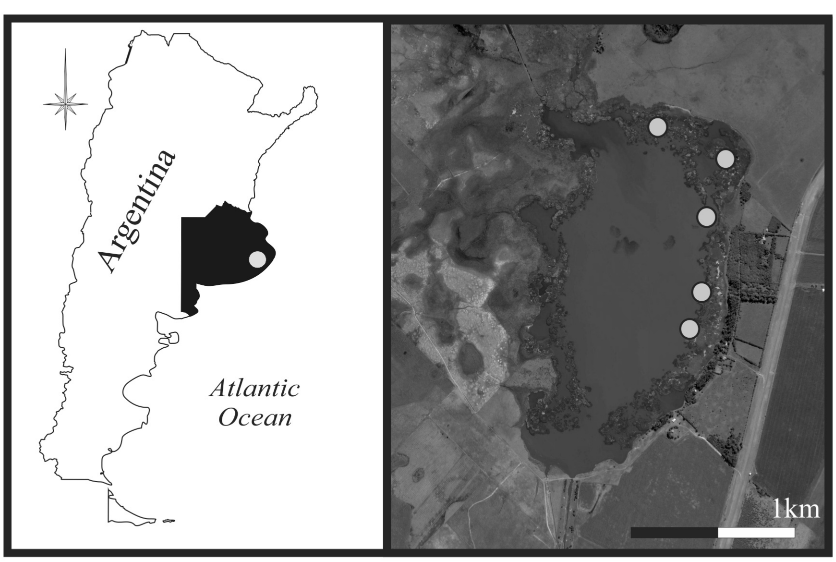

Figure 1. Location of the study area: Nahuel Rucá shallow lake.

Figura 1. Mapa del área de estudio: laguna Nahuel Rucá.

lake NR was lost and the decrease was higher than most of the years.

Living mollusks were searched among the emergent, free-floating and submerged vegetation, under stones, and on the substratum. Sites were delimited using a quadrant with a sampling area of 5 m^2 and a penetration depth of few centimeters (~5 cm). According to Cummins (1994) and Martello et al. (2006), this sampling area is adequate to the low abundance of mollusks in freshwater habitats. Mollusks were collected both manually (picking up by hand) and with the aid of sieves (0.5 mm). Sampling was carried out for time of effort (number of snails caught per hour) following Martín et al. (2001), and conducted by the same person to avoid sampling bias. The time between the different substrata or methods is not standardized, depends on each site and the type of substrata present. Mollusk species were identified using external (shell) and internal (soft parts) morphology, and counted. Mollusk identification was based on Castellanos and Fernández (1976), Gaillard and Castellanos (1976), Fernández (1981a b), Castellanos and Gaillard (1981), Rumi (1991), and Castellanos and Landoni (1995).

Water temperature was measured on the field at each sampling site. To assess chemical parameters one subsurface water sample (1 L) was taken at each site. Water samples were collected in polyethylene bottles and stored in ice until they were transported to the laboratory. Water samples were analyzed within 15 days of collection for concentrations of sodium (Na^+), phosphorous (P^{-5}), chloride (Cl^-), phosphate (PO_4^{3-}), carbonate (CO_3^{-2}), bicarbonate (HCO_3^-), magnesium (Mg^{2+}), calcium (Ca^{2+}), silica (SiO_2) and hardness (mg/L $CaCO_3$). Chemical analyses were performed applying standard methods (APHA 1992).

Statistical analyses

Species richness and dominance patterns of malacocoenoses were described in individual sites per month. Species diversity in individual sites per month was estimated with Shannon-Wiener index (H′) (Magurran 1988) and the dominance with Simpson index (1-D) (Simpson 1949).

Differences in species composition between sites were tested using the PERMANOVA procedure to a Bray-Curtis dissimilarity matrix based on squared rooted mollusk abundances. The design was a one-way PERMANOVA with Site as a factor with five levels (S1, S2, S3, S4, S5). The PERMANOVA is a non-parametric procedure that incorporates permutations to test for significance, thereby not relying on normality assumptions (Anderson 2001). The design was run using a permutation of residuals under a full model (9999 permutations) with Type III (partial) sums of squares. Terms found to be significant in the full model were examined individually using pair-wise tests of the PERMANOVA test statistic with 9999 random permutations. Multivariate patterns were shown by non-metric multidimensional scaling (nMDS) plot (Clarke and Warwick 2001). Although the PERMANOVA allows making a posteriori comparisons among levels of factors or groups, it does not identify which variables are responsible for the differences found. Thus, a Similarity Percentages Analysis (SIMPER) (Clarke 1993) was performed in order to identify which species contributed to the differences found with the PERMANOVA analysis.

The relationship between environmental variables and mollusk abundances was investigated using distance-based multivariate analysis for a linear model (DISTLM) (Anderson 2005). For this analysis a draftsman plot was used to identify possibly strong correlated variables and the variables were log-transformed. Multivariate analyses were performed using the software PERMANOVA + for PRIMER (Plymouth Routines in Marine Ecological Research) (v. 5.2) (Anderson et al. 2008).

RESULTS

Water temperature varied between 14° and 25 °C, approximately. The temperature was higher than 20 °C from August to March and then decreased to approximately 16 °C between April and September 2015. Sites were characterized by alkaline pH, which varied between 8.20 (October 2014) and 9.57 (May 2015). The percentage of organic matter varied between 8.20% in December and 16.74% in August 2014 (Table 1), and was similar between sites, with the exception of S3 where was lower than at the other sites (Figure 2).

A total of 10 mollusk species (9 gastropods and 1 bivalve) and a total of 3012 individuals were recorded (Table 2, Figure 3). In terms of abundance (overall abundance during the year) the species recorded were: *Heleobia*

Table 1. Environmental variables measured at the different sites (mean, min=minimum and max=maximum) during the study. Concentrations of ions are expressed in mg/L, humidity (%), organic content (%, estimated using the loss-on-ignition method), water temperature (°C) and hardness (mg/L of $CaCO_3$).

Tabla 1. Variables ambientales medidas en los distintos sitios (medias, min=mínimas y máx=máximas) durante el período de estudio. Concentraciones de iones expresadas en mg/L, humedad (%), contenido de materia orgánica (%, estimado por medio del método de pérdida por ignición), temperatura del agua (°C) y dureza (mg/L de $CaCO_3$).

Variable	S1			S2			S3			S4			S5		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Carbonates	20.6	0.0	81.5	30.9	0.0	114.0	28.3	0.0	81.5	20.4	0.0	81.5	18.4	0.0	102.0
Bicarbonates	668.1	278.0	1083.0	622.3	313.0	895.0	677.7	313.0	865.0	633.7	265.0	995.0	704.7	200.0	974.0
Chloride	282.0	102.3	402.0	305.0	95.0	424.0	285.5	102.3	388.0	321.0	137.0	570.0	317.0	161.0	461.0
Hardness	293.0	152.0	434.0	293.1	152.0	352.0	304.9	162.0	444.0	301.3	147.0	458.0	285.3	134.0	367.0
Calcium	56.6	12.0	102.0	57.7	13.0	110.0	66.7	10.0	132.0	72.5	8.0	172.0	61.0	10.0	112.0
Magnesium	35.0	5.8	64.0	33.3	12.4	59.0	29.8	7.4	50.1	25.5	6.7	58.5	28.5	4.6	66.0
Phosphates	9.0	3.4	19.5	9.8	4.3	19.8	8.8	4.4	15.6	11.4	3.9	20.1	14.6	5.9	31.2
Phosphorous	2.7	1.1	6.0	2.8	1.4	6.5	2.6	1.4	5.0	3.5	1.3	6.5	4.6	1.6	10.3
Sodium	253.5	25.0	450.0	229.6	46.0	360.0	268.2	35.0	450.0	242.5	25.0	420.0	219.0	20.0	380.0
Potassium	19.1	1.0	40.0	17.1	3.5	36.0	16.6	3.0	28.0	18.8	2.0	31.0	20.6	2.0	38.0
Silicium dioxide	31.3	2.2	88.0	36.2	1.0	108.7	29.8	0.9	81.4	28.3	2.3	55.3	35.6	8.7	90.5
Water temperature	18.7	12.6	23.0	19.7	13.4	24.3	19.8	13.1	24.0	23.2	15.3	32.0	23.0	14.8	32.0
pH	9.0	7.4	10.0	9.1	7.3	9.9	9.0	7.3	9.8	8.8	7.6	9.7	8.7	7.3	10.0
Humidity	69.9	42.1	78.0	70.1	54.1	77.8	49.6	28.8	76.2	58.5	50.9	81.4	61.0	46.7	79.4
Organic matter	11.9	8.5	15.5	13.3	7.6	25.9	7.4	2.7	18.5	15.4	9.7	25.3	12.6	10.0	17.9

Table 2. Table of mollusk abundances at the different sites. Absolute abundance and relative abundance in relation to total mollusk abundance at each site in brackets. Absolute abundance is expressed in number of mollusks caught per hour in a 5 m^2 sampling area.

Tabla 2. Tabla de abundancias de moluscos en los sitios. Entre paréntesis figura la abundancia absoluta y la abundancia relativa en relación a las abundancias de moluscos totales en el sitio. La abundancia absoluta está expresada como el número de moluscos capturados por hora en un área de muestreo de 5 m^2.

Species	S1	S2	S3	S4	S5
Heleobia parchappii	170 (55.9)	292 (60.2)	531 (71)	12 (2.9)	9 (0.8)
Biomphalaria peregrina	3 (1)	3 (0.6)	7 (0.9)	152 (37.7)	360 (33.6)
Uncancylus concentricus	59 (19.4)	73 (15.1)	37 (4.9)	65 (16.1)	220 (20.5)
Physa acuta	69 (22.7)	105 (21.6)	158 (21.1)	37 (9.2)	48 (4.5)
Musculium argentinum	0 (0)	0 (0)	0 (0)	61 (15.1)	263 (24.5)
Drepanotrema heloicum	1 (0.3)	1 (0.2)	0 (0)	44 (10.9)	62 (5.8)
Antillorbis nordestensis	0 (0)	0 (0)	0 (0)	7 (1.7)	92 (8.6)
Pomacea canaliculata	2 (0.7)	5 (1)	14 (1.9)	18 (4.5)	5 (0.5)
Omalonyx sp.	0 (0)	5 (1)	1 (0.1)	7 (1.7)	13 (1.2)
Stenophysa marmorata	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)

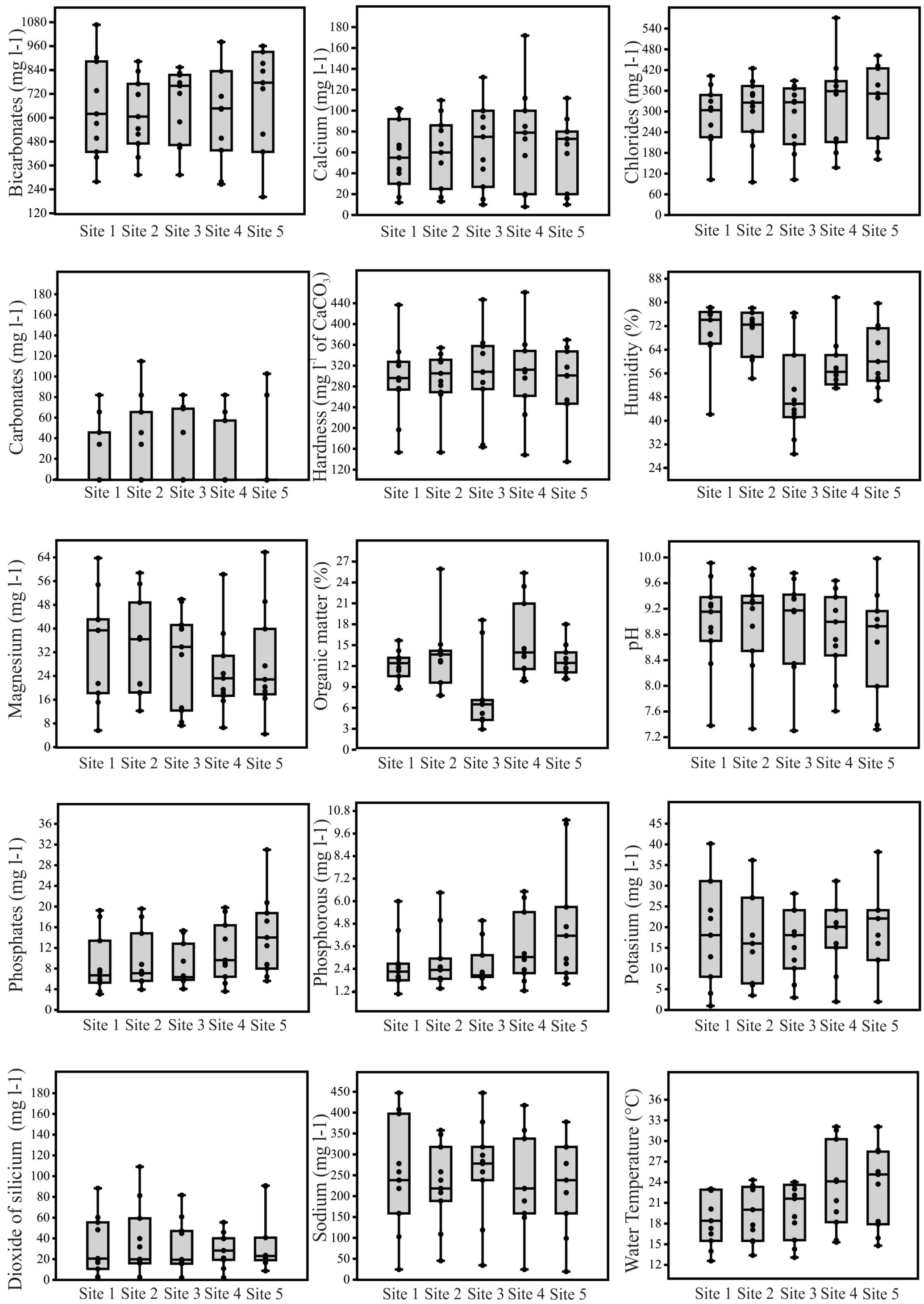

Figure 2. Box-plot of environmental variables at the sampled sites. Concentrations of ions are expressed in mg/L, humidity (%), organic content (%, estimated using the loss-on-ignition method), water temperature (°C) and hardness (mg/L of CaCO3).

Figura 2. Box-plot de las variables ambientales en los sitios muestreados. Las concentraciones de iones están expresadas en mg/L, humedad (%), contenido orgánico (%), temperatura del agua (°C) y dureza (mg/L de CaCO3).

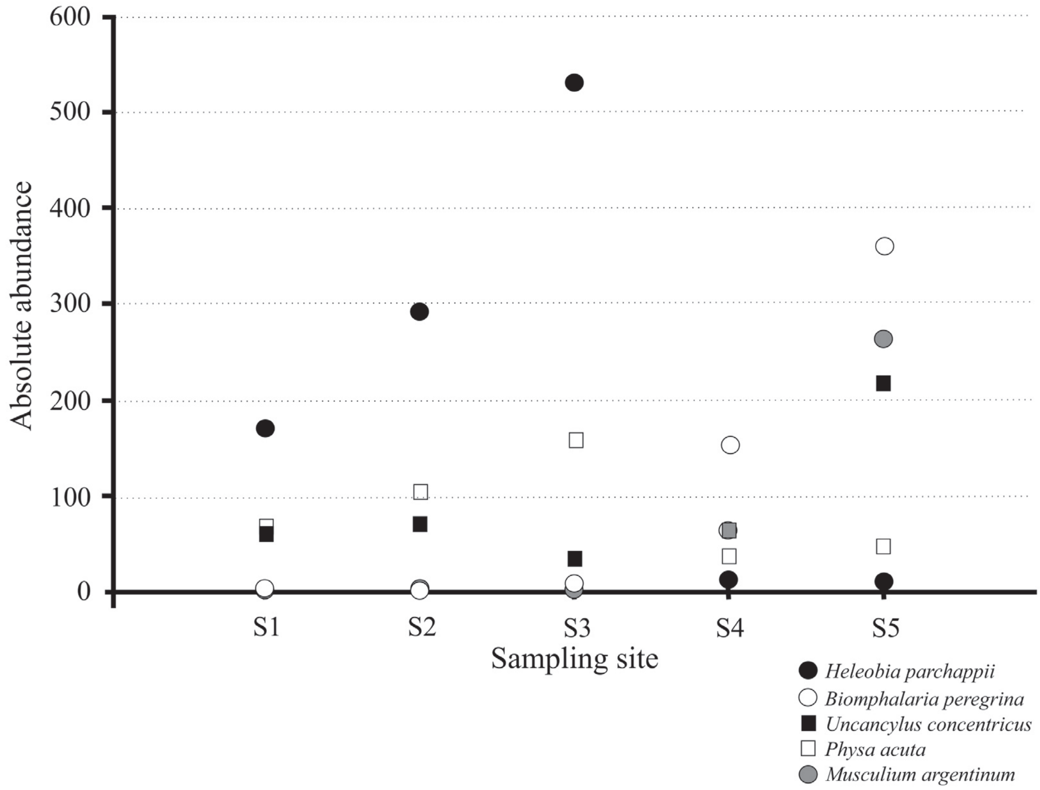

Figure 3. Number of individuals (caught per hour in a 5 m^2 sampling area) of the most abundant species at the sites. Mollusk species: dark circle: *Heleobia parchappii*; white circle; *Biomphalaria peregrina*; dark square: *Uncancylus concentricus*; white square: *Physa acuta*; gray circle: *Musculium argentinum*.

Figura 3. Número de individuos (capturados por hora en un área de muestreo de 5 m^2) de las especies más abundantes por sitio. Especies de moluscos: círculo oscuro: *Heleobia parchappii*; círculo blanco; *Biomphalaria peregrina*; cuadrado oscuro: *Uncancylus concentricus*; cuadrado blanco: *Physa acuta*; círculo gris: *Musculium argentinum*.

parchappii, *Biomphalaria peregrina*, *Uncancylus concentricus*, *Physa acuta*, the bivalve *Musculium argentinum*, *Drepanotrema heloicum*, *Antillorbis nordestensis*, *Pomacea canaliculata*, *Omalonyx* sp., and *Stenophysa marmorata*. *Heleobia parchappii* was more abundant in S1, S2 and S3 and its abundance increased since February 2015. *Biomphalaria peregrina* was very abundant in S4 and S5, and nearly absent in S1, S2 and S3. In November and December its abundance decreased and then it achieved three peaks during January and February, May 2015 and September 2015. *Uncancylus concentricus* was very abundant in all sites between August and December 2014, and during April and May 2015 in S4 and S5. *Physa acuta* had a peak of abundance in all sites during November 2014 and in S2 and S3 in February 2015. The bivalve *M. argentinum* had a high abundance in S4 and S5 between October and November 2014. *Drepanotrema heloicum* was very abundant in S4 during August 2014 and since May 2015 in S5. *Antillorbis nordestensis* had a high abundance since May 2015 in S5. *Pomacea canaliculata* had a peak of abundance during summer months in S2, S3, S4 and S5. Only two or three individuals of *Omalonyx* sp. were recorded in S2 during summer, while in March and April were more abundant in S4 and S5. Just one individual of *S. marmorata* was found in S2 in October 2014.

Richness varied between 1 and 7, Shannon-Wiener diversity index between 0 and 1.54, and dominance index between 0 and 0.84 (Table 3). Mean values of the community indices such as S, H , and 1-D were not significantly different between sites, with the exception of richness between S1-S5 and S3-S5 and diversity between S3-S5 (Table 4).

Multivariate analysis performed on mollusk abundances showed significant differences between sites (PERMANOVA, $P<0.01$) (Table 5). Pair-wise results for sites showed p values lower than 0.01 between S4 and S5 with S1, S2 and S3 respectively. Plots evidence these differences (Figure 4).

SIMPER results showed that the average similarity within each sampling site calculated by species was lower in S5 and higher in S1

Table 3. Species richness (S), absolute abundance (n), Shannon-Wiener diversity index (H) and dominance Simpson index (1-D) for the different sites and months analyzed.

Tabla 3. Riqueza de especies (S), abundancia absoluta (n), índice de diversidad de Shannon-Wiener (H) e índice de dominancia de Simpson (1-D) para los diferentes sitios y meses analizados.

	Site 1				Site 2				Site 3				Site 4				Site 5			
	S	n	H	1-D	S	n	H	1-D	S	n	H	1-D	S	n	H	1-D	S	n	H	1-D
Aug.	3	10	1.05	0.71	3	30	0.94	0.60	3	21	0.93	0.60	7	91	1.42	0.71	3	44	0.84	0.51
Oct.	3	12	0.57	0.32	6	44	1.19	0.62	3	22	0.89	0.57	5	92	1.07	0.60	5	318	1.03	0.61
Nov.	3	60	0.95	0.58	3	103	1.07	0.65	4	119	0.51	0.27	3	26	1.04	0.65	7	163	1.26	0.65
Dec.	4	30	1.16	0.66	3	37	1.09	0.68	3	40	0.72	0.43	-	-	-	-	-	-	-	-
Jan.	3	7	1.00	0.71	5	10	1.50	0.84	4	21	1.14	0.67	2	30	0.15	0.07	2	46	0.10	0.04
Feb.	2	20	0.61	0.44	5	25	1.47	0.77	5	70	1.23	0.66	1	9	0.00	0.00	2	50	0.10	0.04
Mar.	3	29	0.64	0.36	1	57	0.00	0.00	2	123	0.05	0.02	7	37	1.54	0.74	5	33	1.37	0.72
Apr.	2	53	0.16	0.07	5	19	1.04	0.53	3	84	0.13	0.05	4	44	0.87	0.45	4	58	1.01	0.55
May	4	45	0.39	0.17	2	13	0.62	0.46	3	115	0.10	0.03	5	18	1.49	0.80	5	118	1.30	0.69
Jun.	3	23	0.83	0.55	2	52	0.10	0.04	3	84	0.13	0.05	2	9	0.69	0.56	5	62	1.24	0.64
Sep.	2	15	0.39	0.25	2	95	0.10	0.04	1	49	0.00	0.00	6	47	1.40	0.72	6	180	1.55	0.77

Table 4. Mean differences of diversity indexes between sites. Significant differences at α=0.05 are indicated with a *.

Tabla 4. Diferencia de medias en los índices de diversidad entre sitios. Las diferencias significativas a un α=0.05 se indican con un *.

Comparison	Richness (S)	Diversity (H′)	Dominance (1-D)
S1-S2	0.50	0.52	0.73
S1-S3	0.81	0.32	0.23
S1-S4	0.08	0.19	0.41
S1-S5	0.01*	0.14	0.43
S2-S3	0.75	0.18	0.18
S2-S4	0.36	0.55	0.67
S2-S5	0.19	0.51	0.84
S3-S4	0.16	0.06	0.08
S3-S5	0.05*	0.04*	0.08
S4-S5	0.91	0.95	0.93

Table 5. PERMANOVA and pair-wise PERMANOVA results for mollusk abundances among sites. Significant differences at α=0.05 are indicated with a *.

Tabla 5. Resultados del PERMANOVA y de los PERMANOVA parciales para las abundancias de moluscos entre sitios. Las diferencias significativas a un α=0.05 se indican con un *.

Source	df	SS	MS	Pseudo F	*P* (perm)
Site	4	45097	11274	7.5242	0.001*
Residuals	48	71923	1498.4		
Total	52	1.1702E5			

Groups	t	*P* (perm)
S1, S2	0.73	0.688
S1, S3	1.43	0.117
S1, S4	3.12	0.001*
S1, S5	3.28	0.001*
S2, S3	0.90	0.454
S2, S4	3.39	0.001*
S2, S5	3.48	0.001*
S3, S4	3.44	0.001*
S3, S5	3.50	0.001*
S4, S5	1.12	0.248

with respect to the rest of the sites, and the highest dissimilarity values were found when compared S4 and S5 with S1, S2 and S3 (Table 6). The species which mostly contributed to the similarity within each sampling site, and thus typify their mollusk assemblages were *H. parchappii*, *U. concentricus* and *P. acuta* in S1, S2 and S3, constituting about 98.58, 97.23, and 97.71 cumulative % of the total

Table 6. SIMPER average similarity (greyed) and average dissimilarity calculated on the base of mollusk composition among sites.

Tabla 6. Resultados del análisis de SIMPER. Similitud (sombreada) y disimilitud calculadas en base a la composición de moluscos entre sitios.

	S1	S2	S3	S4	S5
S1	53.92				
S2	44.36	54.27			
S3	49.87	46.15	52.21		
S4	73.60	75.82	79.07	40.90	
S5	76.10	77.39	80.49	59.81	40.47

Table 7. DISTLM results of the relationship between environmental variables and mollusk abundances. Significant differences at α=0.05 are indicated with a *.

Tabla 7. Resultados de DISTLM de la relación entre las variables ambientales y las abundancias de moluscos. Las diferencias significativas a un α=0.05 se indican con un *.

Variable	SS	Pseudo-F	*P*
Carbonates	3341.2	1.499	0.171
Bicarbonate	6951.2	3.221	0.022
Chlorides	7465.4	3.475	0.013
Hardness	3830.8	1.726	0.129
Calcium	2794.8	1.248	0.289
Magnesium	4351.3	1.969	0.098
Phosphates	7932.6	3.708	0.011*
Phosphorous	14350.0	7.128	0.001*
Sodium	6340.1	2.921	0.034
Potassium	4451.4	2.016	0.070
Silicium dioxide	7001.1	3.245	0.015
Temperature	16324.0	8.267	0.001*
pH	13883.0	6.865	0.001*
Humidity	4369.2	1.978	0.092
Organic matter	2985.0	1.335	0.255

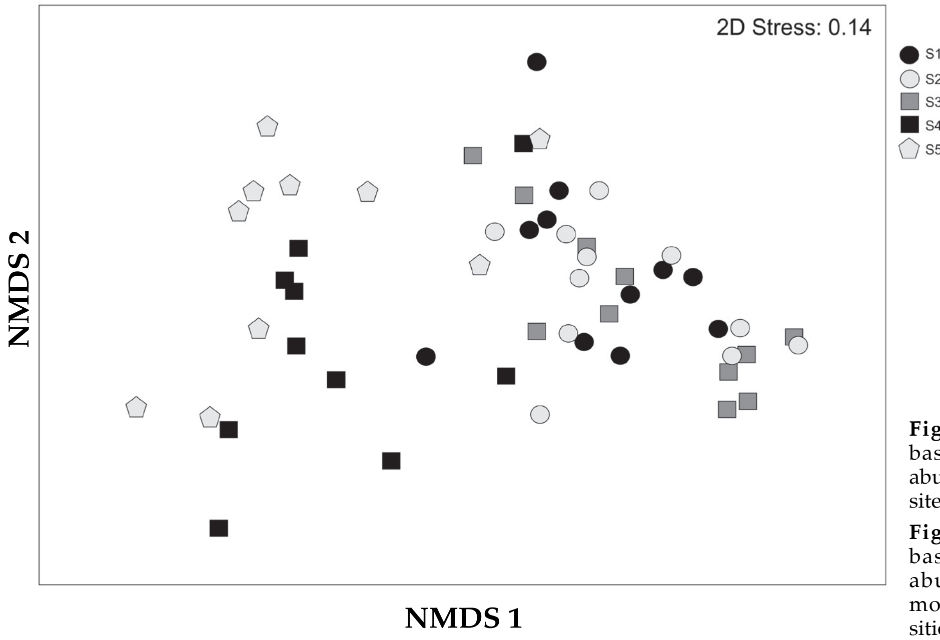

Figure 4. NMDS based on mollusk abundances at each site among site.

Figura 4. NMDS basado en las abundancias de moluscos en cada sitio.

similarity respectively; *Heleobia parchappii* was the dominant species. In S4 and S5 *B. peregrina*, *U. concentricus*, *P. acuta*, and *M. argentinum* represented 96.1 and 89.63%, respectively, being *B. peregrina* the dominant species. Besides, *D. heloicum* contributed with 4.91% to the total similarity of S5. The different composition in these two groups reflects the difference between sites found in PERMANOVA analysis. The marginal test of the DISTLM procedure highlighted that mollusk abundances were significantly related to four environmental variables: phosphorous, temperature, pH and phosphates (Table 7).

DISCUSSION

All mollusk species found in this study were previously recorded in other studies conducted in the southeastern pampas. The two dominant species, *H. parchappii* and *B. peregrina*, were also commonly found as dominant species in Pampean freshwater systems (Tietze et al. 2010). The number of mollusk species found was higher than in previous studies performed in the same lake (two and eight in Tietze and De Francesco 2010 and 2012, respectively). The differences between the three studies can be consequence of the sampling frequency, which was just one sample in the first case, seasonal sampling in the second case and monthly samples in the present contribution. For diverse taxa, as more individuals are sampled, more species will be recorded (Bunge and Fitzpatrick 1993; Gotelli and Colwell 2001).

As it was explained above, mollusk species that dominate the lake were species commonly found in Pampean freshwater systems (Tietze and De Francesco 2010, 2012). Yet, the structure of mollusk communities between microenvironments showed some significant differences. Despite richness, diversity and dominance was similar between sites, the faunistic composition was different depending on the microhabitats sampled. While colonization and water chemistry can be important to determine snail distribution across a large biogeographic scale, available evidence suggests that disturbance and biotic factors are more important to determine the distribution and abundance of snails among and within water bodies (Lodge et al. 1987).

The different mollusk composition found between groups of sites S1, S2, S3 and S4, S5, is probably related to the characteristics at microhabitat scale. Sites 1 to 3 were deeper sites, dominated mainly by emergent macrophytes. In fact, S3 showed lower values of organic matter probably due to the lower macrophyte cover in the site. In contrast, S4 and S5 exhibited higher temperature, phosphorous and phosphates, and lower pH, conditions that may be related to the lower depth and higher diversity of macrophytes in the sites. These two sites were dominated by free floating plants, submerged macrophytes, and transitional vegetation, however, emergent rooted macrophytes were also present. Phosphorus concentration may be explained by the decaying of macrophytes that act as an internal phosphorus source for the lake and add considerable quantities of phosphorus to the water (Granéli and Solander 1988). The decaying organic matter also produces a decrease in pH values, acidifying the medium. The discussed differences between microenvironments are influencing the composition of mollusk assemblages. However, other biological factors (as predation), may also be important to determine the composition of mollusk assemblages, which were not considered in this study and deserve further investigation.

Mollusk species composition varied between sites, probably related to their ecological requirements. Sites 1, 2 and 3 were dominated by *H. parchappii*, *P. acuta* and *U. concentricus*. *Heleobia parchappii* is a plastic species with a wide range of distribution in Argentina and very abundant in the Pampean Ecoregion (Gaillard and de Castellanos 1976; Castellanos and Landoni 1995). Indeed, it has been found living in freshwater environments of the region varying from oligohaline sites (Tietze and De Francesco 2010, 2012, 2017) to hipersaline sites (De Francesco and Isla 2003). Despite being very widespread in freshwater environments, its distribution within the same freshwater body has not been focus of researches yet. *Uncancylus concentricus* is a pulmonate species that lives attached to a firm substrate (macrophytes, rocks, artificial substrates, among others), and its abundance is probably related to the dominance of emergent macrophytes in these sites. *Physa acuta* is an invader species also very common in the Pampean ecoregion. This snail has a life-cycle that is characterized by high proliferation rates, high passive dispersal capacities and high tolerance to polluted water (Bernot et al. 2005). The presence and high abundance of *H. parchappii* and *P. acuta*, both plastic species that are very tolerant to different environmental conditions in the area, in sites 1 to 3, and almost absence in site 4 and 5 is striking. Studies considering biological variables as predation, competition, parasitism and other environmental factors would be necessary to depict the situation.

Sites 4 and 5 were dominated by *B. peregrina* and the bivalve *M. argentinum*, and were common two planorbid species (*D. heloicum* and *A. nordestensis*), which were nearly absent in sites 1 to 3. These two sites were characterized by lower depth and higher vegetation cover; the low depth favor higher water temperatures and lower pH values at this site. Depth and vegetation are variables that have been previously mentioned as important in explaining mollusk distribution. Macrophytes serve as sources of food, substrate, and buffers of current velocity (Dillon 2000). In fact, *B. peregrina* develops abundant populations preferably in calm waters with submerged macrophytes (Rumi 1986, 1991). *Musculium argentinum* is an infaunal bivalve that lives buried within the first few centimeters below the sediment-water interface with density population positively influenced by eutrophic waters and water flow (Peredo et al. 2009). In conclusion, the presence and abundance of the planorbids and the bivalve species is in accordance with the previous results found in other studies with respect to their ecology preferences.

As a summary, despite the enormous amount of research regarding the factors that determine diversity of freshwater mollusk species worldwide, little is actually known from South American habitats. At the same time, there are no studies regarding the mechanisms that determine species coexistence, share of resources, predator effects and inter- and intraspecific competition (Chase et al. 2001). This study contributes to the knowledge of the freshwater mollusk assemblages in Pampean shallow lakes, reflecting their patchiness in these systems, where environmental factors partially explain part of the local distribution within the lake, but where some other biological variables would be also needed for depict the distribution of these species at a microhabitat scale. Our results are in accordance with a hierarchical model presented by Lodge et al. (1987), which proposed that physicochemical factors explain freshwater snail distribution within a region, but disturbance and food selection seems to be determining variables within a waterbodies scale.

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