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Malacofauna of the littoral benthos of a saline lake in southern Mendoza, Argentina

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With 4 figures and 4 tables

Abstract: The Bañado Carilauquen (BC) is part of the "Laguna Llancanelo" Watershed, an area of international relevance for biodiversity conservation that holds interest for oil production. Records on the biological attributes of the system's waters are scarce, particularly regarding benthic macroinvertebrate assemblages. The goal was to study the diversity of malacofauna in the BC and the relationship between its distribution patterns and water physicochemical parameters. Biological samplings and records of environmental parameters were carried out between summer of 2000 and spring of 2001 for five reaches of the BC. Complete individuals and empty shells of each species were recorded for every sample, and height and width were measured for all shells. Conchological relationships were estimated and sizes compared. The relationship between presence and abundance of molluscs and environmental parameters was explored using CCA. Five gastropod species were identified: *Heleobia parchappii*, *H.hatcheri*, *Chilina mendozana, Lymnaea viator* and *Biomphalaria peregrina.* A growing gradient of conductivity and hardness was detected between the headwaters (relatively soft waters) and the outlet-lake (very hard and saline waters). The distribution of molluscs is related to this gradient. Our results suggest that, except for the headwaters, the BC is hardly favourable for the development of gastropod populations. This was expressed in low species diversity, low densities, reduced sizes, fluctuating populations and high proportion of empty shells (> 80 %).

Key words: Freshwater molluscs, hard waters, distribution patterns, arid regions, Laguna Llancanelo, Mendoza, Argentina.

Introduction

The Bañado Carilauquen is one of the major constituents of the endorheic hydrological system locally known as "Laguna Llancanelo" (Department of Malargüe, Mendoza Province, Argentina). The word "Bañado" is a geographic term and means a wetland under arid conditions. The area has particular importance because it is of interest for both the conservationist agenda and the development of valuable oil reserves. The Llancanelo Lake, including the Bañado Carilauquen, supports several tens of thousands of individuals of over 70 avian species, some of which are migrant birds that use the area as a resting and feeding stop during their migration (Blendinguer & Alvarez 2002, Coconier 2005). The Llancanelo Lake was declared to be a Provincial Fauna Reserve in 1980, and was included as a RAMSAR site in the List of Wetlands of International Importance in 1995. At the same time, its subsoil comprises the Cuyo Basin, an oil reservoir that began to be exploited in the 1930s and never ceased to draw the interest of governments and oil companies.

The importance mentioned above is in clear contrast with the very few available records on the biological attributes of the Llancanelo system. Peralta & Fuentes (2005) studied the plankton and phytobenthos communities, and analyzed water quality at the Bañado Carilauquen. These authors reported hard waters distributed in accordance with a salinity gradient that increases from the headwaters towards the

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outlet, and defined the wetland, from the requirements of the species found (dominance of pennate diatoms in plankton communities, and of thecate amoebas, rotifers, ostracods and ciliates in benthic communities), as a eutrophic and saprobiotic system, with records of hydrocarbon presence.

Except for one unpublished technical report prepared for the Repsol YPF Oil Company (which does not include mollusc species), there is no information on the macroinvertebrates inhabiting this wetland, despite their importance as biological indicators of water quality (Hellawell 1986, Johnson et al. 1993, Rosenberg & Resh 1993, Figueroa et al. 2003). Molluscs, along with aquatic insects, generally represent one of the most abundant groups of macroinvertebrates, and are frequently used as environmental sentinels (Moore et al. 1987, Foeckler et al. 1991, Camargo 1993, 1994, Salanki et al. 2003). In fact, several mollusc families with representatives in Mendoza Province (Lymnaeidae, Planorbidae, Physidae, Sphaeriidae, among others) are frequent constituents of the lists of biological pollution indicators in North American and European freshwater environments (Hellawell 1986, Phillips & Rainbow 1993, García-Criado et al. 1999, Dahl et al. 2004, Alonso & Camargo 2004). Nonetheless, there is no information on mollusc species inhabiting key sites as the Llancanelo Lake system, or on how the physical features of water in this region would model the distribution patterns of macroinvertebrates in general and of the malacofauna in particular. Among others, water hardness has been pointed out as one of the major factors influencing mollusc distribution in regions with high levels of salt, such as the area studied in the present work (Nazneen & Begum 1994, Costil et al. 2001).

In addition to the above cited environmental importance, the study of the molluscs of the Llancanelo Watershed has epidemiological relevance because there are gastropods (Lymnaeidae) in the area acting as vectors of fasciolasis, which is an endemic parasitosis of veterinary and medical interest (Mera et al. 2006). Furthermore, the study of environmental parameters constraining the distribution of current mollusc species living in the Bañado Carilauquen will contribute to the reconstruction of the region's Quaternary palaeoenvironments where fossil molluscs, particularly indicator groups such as the Cochliopidae, are abundant.

The goal of the present study is to examine the diversity of the benthic malacofauna occurring in the Bañado Carilauquen, as well as the relationship between its distribution patterns and water physicochemical parameters.

Study site

The Bañado Carilauquen (BC) is located west of the Llancanelo Lake (LL), a saline water body situated at a mean altitude of 1300 m a.s.l. in the Centre-West of Argentina (Fig. 1). The LL has an area of about 65,000 ha and occupies the depression of the same name generated by compensating sinking during the rise of the Andes in the Tertiary period (Sosa et al. 1989, Ostera & Dapeña 2003). This lowland, in turn, is part of the Llancanelo Basin, an extensive area comprising around 10,600 km^2, between 35º 00 – 36º 30 S and 68º 30 – 70º 00 W, approximately.

The mean depth of the LL is 30 cm, reaching 2 m on some sites. The Malargüe river is the major tributary. The system is also fed by small streams (e.g. Arroyo Malo and Arroyo Mocho) and by several semi-permanent watercourses, among which the Arroyo Carilauquen stands out. This stream runs for about 10 km from the West (headwaters originating from outcropping of the water table) to the East (outlet into the lake), draining the BC that covers some 70 km^2, with a maximum depth of approximately 2 m (headwaters and isolated pools) and a depth of about 20 cm over most of its extent. There are salt flats between the lake and the system marshes. Flooded grounds consist of clay/silt-type soils, and the dominant vegetation is composed of hygrophytic macrophytes such as *Scirpus californicus, Cortadeira selloana* and *Chara vulgaris* (Peralta & Fuentes 2005).

The climate in the region is extremely dry. Mean annual precipitation (rain and snow) is approximately 241 mm, and mean annual temperature 12.5 °C (January: 21.3 °C, July: 3.6 °C). The hydrological balance of the system is very fragile. Evaporation prevails over precipitation, stream flow contributions, infiltration and surface runoff, and therefore, except for sporadic hydrologically exceptional years when a recovery is recorded, the water level shows a tendency to slowly drop (Ostera & Dapeña 2003).

Methods

Sampling

Five areas were defined along a spatial gradient that extends from the headwaters of the Carilauquen "stream" to its outlet into the Llancanelo Lake with the following designations: i) headwaters (HD), ii) higher middle reach (HMR), iii) central middle reach (CMR), iv) lower middle reach (LMR), v) outlet-lake (OL, Fig. 1). Seasonal samplings were carried out over a complete annual cycle, between the summer of 2000 and the spring of 2001. Two replicates were taken at each sampling site. A modified Petersen dredge (352 cm^2 sampling area) was used for sampling.

The following physicochemical variables were measured for each site: pH (Hanna peachimeter, HI 9025), conductivity (μS cm^{-1}, Hanna conductimeter HI 9033), transparency (m, Secchi disk), water and air temperature (°C, mercury thermometer) and depth (m, calibrated stick).

At the extremes of the spatial gradient (HD and OL) and at one of the middle reaches (LMR) complementary seasonal records of SO_4^{2-}, Cl^-, Na^+, K^+, Ca^+, Mg^+, HCO_3^- and dissolved oxygen (Winkler method) were used for increasing the number of variables to be considered in the multivariate analyses performed to correlate environmental parameters with species den-

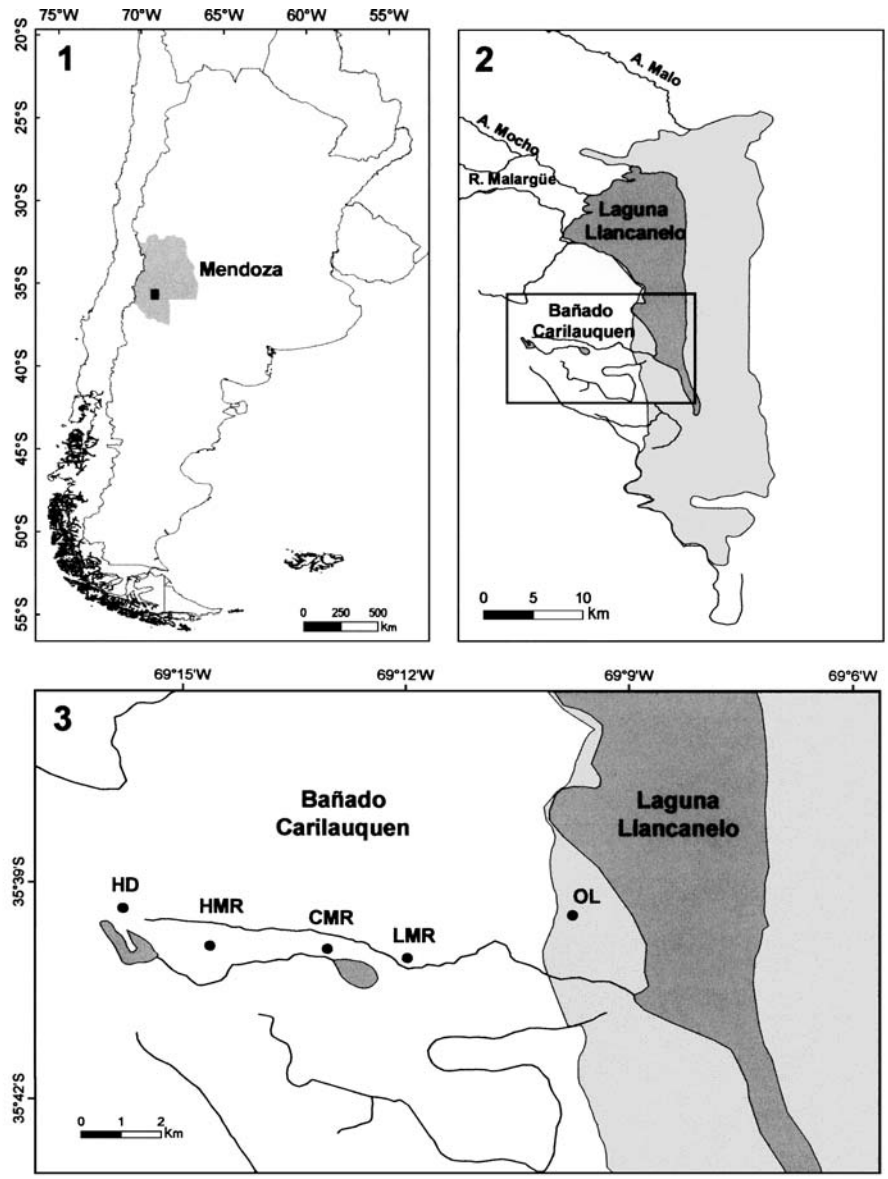

Fig. 1. Study area maps. 1: Location of Mendoza Province, 2: Location of Bañado Carilauquen, 3: Sampling sites (HD: headwaters, HMR: higher middle reach, CMR: central middle reach, LMR: lower middle reach, OL: outlet-lake).

sity. HCO_3^-, Ca^+ and Mg^+ were measured through volumetric methods, K^+ and Ca^+ by photometry and SO_4^{2-} and Cl^- by Benzidine and Mohr methods, respectively. CO_3^{-2} was not considered because historical records for the region's surface waters reveal lack or traces of this ion.

Collected specimens were preserved in 5 % formol for later taxonomic identification (keys by Castellanos & Landoni 1995) and processed in the laboratory. Shell length and width were recorded for each individual (maximum diameter in planorbids) using vernier callipers or stereoscopic microscope equipped with scaled eyepiece (0.01 mm accuracy). The proportion of complete individuals and empty shells was also recorded for each sample.

Data analysis

Linear equations synthesizing the relationships between conchological dimensions were estimated, and sizes were compared (only in abundant species) between sampling sites and seasons of the year using one-way ANOVA and subsequent comparisons (Tukey test, $p < 0.05$).

For exploratory reasons, a Non-parametric Correlation Analysis (Spearman) was conducted among the physicochemical variables to check whether there was a high level of correlation between them. Only those correlations with $R_s \geq 0.60$ ($p < 0.05$) were considered to be significant. A Canonical Correspondence Analysis (CCA) was used to explore the relationship between species and environmental variables at the sampling sites and the different seasons of the year. The data on species density and environmental variables (except pH) were transformed using Log (x+1) to normalize and stabilize variances. The data matrix corresponding to annual data on the environmental variables for the HD, LMR and OL sites was used for performing CCA (software MVSP, version 3.1, Multi-Variate Statistical Package 2000) and Non-parametric analyses.

Results

Species found, density and proportion of empty shells/complete individuals

In total, 749 individuals belonging to only five gastropod species: *Heleobia parchappii* (d'Orbigny, 1835) (Cochliopidae: 493 specimens), *Heleobia hatcheri* (Pilsbry, 1911) (Cochliopidae: 9 specimens), *Chilina mendozana* Strobel, 1874, (Chilinidae: 135 specimens), *Lymnaea viator* (d'Orbygni, 1835) (Lymnaeidae: 82 specimens), and *Biomphalaria peregrina* (d'Orbigny, 1835) (Planorbidae: 30 specimens) were identified and measured.

Throughout the year, *H. parchappii* was the most frequent and abundant species, with practically constant records from the headwaters to the outlet into the lake, and a mean annual density of 484.66 individuals m^{-2} (range: 0–2188) (Table 1). The second species in terms of mean annual density was *Ch. mendozana* with 106.53 individuals m^{-2} (range: 0–2528), which was restricted to samples from the headwaters, where it was abundant. Except for one individual found in samples from the CMR, also *H. hatcheri* was confined to the headwaters, though with a very low mean annual density: 7.10 individuals m^{-2}. *L. viator* and *B. peregrina*, with mean annual densities of 64.77 and 6.53 individuals m^{-2}, respectively, were species with mid to low relative frequency, found exclusively in samples from the middle reaches of the BC.

Considering all species together, we collected most individuals in spring (relative annual abundance: 34.3 %) and summer (26.2 %). Density peaks for the most abundant species were recorded in spring (*Ch. mendozana*: 89 specimens/sample, HD2) and summer (*H. parchappii*: 77 specimens/sample, HMR2).

We found that 81.5 % of the individuals sampled during the study were empty shells (Table 1). All individuals of species found at the lower middle reach and at the outlet into the lake were empty shells, as were also most individuals from samples from the central middle reach (98.3 %) and higher middle reach (87.5 %). The highest proportion of complete individuals was recorded for samples from the head-

Table 1. Total density/m^2 (only empty shells/m^2) per mollusc species, sampling site (replicates) and season of the year in Bañado Carilauquen. Ref.: *H.parch. = Heleobia parchappii, H.hatch. = Heleobia hatcheri, Ch.mend. = Chilina mendozana, L.viator = Lymnaea viator, B.pereg. = Biomphalaria peregrina*, nd = no data available, HD: headwaters, HMR: higher middle reach, CMR: central middle reach, LMR: lower middle reach, OL: outlet-lake

	Summer					Autumn				
Site/Species	*H.parch.*	*H.hatch.*	*Ch.men.*	*L.viator*	*B.pereg.*	*H.parch.*	*H.hatch.*	*Ch.men.*	*L.viator*	*B.pereg.*
HD1	313 (256)	57 (0)	256 (0)	0	0	1335 (0)	28 (0)	653 (0)	0	0
HD2	nd	nd	nd	nd	nd	85 (0)	28 (0)	256 (57)	0	0
HMR1	0	0	0	0	0	0	0	0	0	0
HMR2	2188 (2188)	0	0	85 (28)	0	0	0	0	280 (280)	28 (28)
CMR1	227 (170)	0	0	28 (28)	0	28 (28)	28 (28)	0	57 (57)	28 (28)
CMR2	256 (199)	0	0	57 (28)	142 (142)	57 (57)	0	0	57 (57)	28 (28)
LMR1	57 (57)	0	0	0	0	0	0	0	0	227 (227)
LMR2	256 (256)	0	0	142 (142)	114 (114)	280 (280)	0	0	227 (227)	28 (28)
OL1	142 (142)	0	0	0	0	280 (280)	0	0	28 (28)	0
OL2	1165 (1165)	0	0	0	0	170 (170)	0	0	0	0

	Winter					Spring				
Site/Species	*H.parch.*	*H. hatch.*	*Ch.men.*	*L.viator*	*B.pereg.*	*H.parch.*	*H.hatch.*	*Ch.mend.*	*L.viator*	*B.pereg.*
HD1	170 (0)	0	0	0	0	227 (227)	0	28 (28)	0	0
HD2	256 (0)	114 (0)	114 (85)	57 (0)	0	142 (142)	0	2528 (2415)	0	0
HMR1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
HMR2	85 (85)	0	0	57 (57)	0	511 (511)	0	0	142 (142)	28 (28)
CMR1	0	0	0	57 (57)	0	682 (682)	0	0	739 (739)	170 (170)
CMR2	540 (256)	0	0	28 (28)	0	170 (170)	0	0	28 (28)	0
LMR1	nd	nd	nd	nd	nd	0	0	0	0	0
LMR2	994 (994)	0	0	57 (57)	0	1165 (1165)	0	0	142 (142)	28 (28)
OL1	625 (625)	0	0	0	0	341 (341)	0	0	0	0
OL2	1023 (1023)	0	0	0	0	227 (227)	0	0	0	0

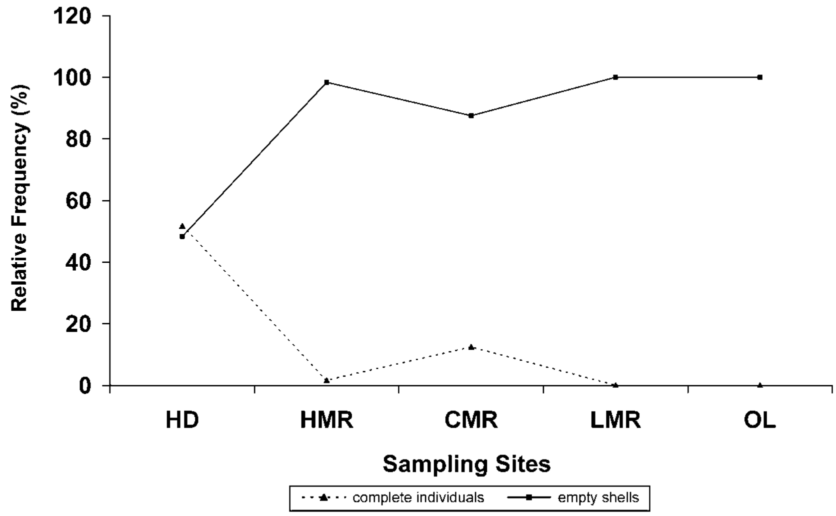

Fig. 2. Relative frequency of Complete individuals/Empty shells by sampling sites in Bañado Carilauquen (all species and seasons together).

Table 2. Conchological morphometry of the five mollusc species found in Bañado Carilauquen. Mean sizes for each species and parameters of Width/Length linear equations estimated from annual values. References: ML: mean length, MW: mean width, *: maximum diameter, (..): standard deviation, b: slope, a: ordinate at origin, R: correlation coefficient, n: number of individuals.

Species	ML (mm)	MW (mm)	b	a	R	n
H. parchappii	4.42 (1.27)	2.13 (0.49)	0.348	5.862	0.909	423
H. hatcheri	3.36 (0.89)	2.37 (0.37)	–	–	–	9
Ch. mendozana	9.24 (2.81)	4.85 (1.49)	0.510	1.312	0.960	108
L.viator	5.20 (1.27)	3.06 (0.69)	0.511	4.060	0.936	69
B. peregrina	*4.80 (1.67)	–	–	–	–	28

waters (51.7 %, all species and all seasons together), and declined abruptly from the higher middle reach to the outlet into the lake (Fig. 2). The species showing the highest mean proportion of complete individuals per sample was *Ch. mendozana* (51.2 %), exclusive to the headwaters. The mean proportion of complete individuals of *H.parchappii* per sample from the headwaters was 59.7 %, and then dropped to under 10 % at the higher and central middle reaches and to 0 % at the lower middle reach and at the outlet into the lake. All individuals of *H. hatcheri* from the headwaters were complete, whereas all individuals of *B. peregrina* were empty shells, independently of the reach from which the samples were taken. The only complete individuals of *L. viator* were recorded for samples from the headwaters and the higher and central middle reaches, representing overall less than 7 % of the total specimens found for this species (Table 1).

Conchological morphometry

Mean sizes per species (only unbroken shells, complete individuals and empty shells together) and the linear relationships between estimated length and width considering all four seasons of the year are indicated in Table 2 (parameters of *H. hatcheri* were not calculated).

Because of the low abundance of individuals found in this study, the only species that allowed comparison of sizes between sampling sites and seasons of the year was *H. parchappii*. The length of individuals of this species collected at the headwaters (mean: 5.88 mm, SD: 1.22) was significantly higher ($p < 0.0001$) than that of specimens of the same species found in the other reaches (HMR: 3.92 mm, SD: 0.93, CMR: 4.99 mm, SD: 0.96, LMR: 4.30 mm, SD: 0.99, OL: 3.6 mm, SD: 0.87). The length of *H. parchappii* individuals collected in autumn was significantly higher ($p < 0.0001$) than that of individuals from the other seasons of the year.

Environment parameters

Sampled waters can be classified as hard to very hard according to the scale used by the US Department of Interior and the US Water Quality Association, with records of conductivity ranging between 914 µS cm^{-1} (HD2, winter) and 19520 µS cm^{-1} (OL1, autumn) (Table 3). There is a conductivity gradient that starts in the low saline waters of the headwaters (mean for all four seasons together: 966.63 µS cm^{-1}, SD: 59.44) and ends in the extremely saline and very hard waters of the outlet into the lake (mean for the four seasons: 11220 µS cm^{-1}, SD: 3834).

Overall, the pH was neutral, with the mean annual average for the five sampled reaches oscillating between 7.24 and 7.65, with a maximum record of 8.9 (HMR1 summer) and a minimum one of 6.6 (OL2 spring). Mean annual temperature of the water at the five sampling sites varied between 12.7 and 14.6 °C, with a temperature peak of 25.6 °C recorded in summer at the central middle reach, and a minimum value of 5.3 °C corresponding to one of the winter records taken for the higher middle reach. Mean annual depth in the different reaches varied between 1.6 m (HD) and 0.19 m (CMR), transparency records corresponded to clear waters (Table 3).

The conductivity gradient described above is consistent with an increase, from the headwaters (minimum values) to the outlet into the lake (maximal values), in the concentration of ions recorded at HD, LMR and OL sampling sites according to the following ranges (all seasons of the year together, in mg l^{-1}): sulphates, 278.4–2747, chlorides, 10–6933.2, sodium, 13.8–9913, potassium, 2.34–159.9, calcium, 152–1290, magnesium, 6.3–226.8, bicarbonates, 122–170. In the same three reaches, mean values of dissolved oxygen fluctuated between 7 mg l^{-1} (HD) and 6.50 mg l^{-1} (OL).

Relationship between environmental variables and species

Ion concentrations Ca^+, Mg^+, K^+, Na^+, Cl^- and SO_4^{2-} were the environmental variables showing significant correlations to conductivity values ($p < 0.0001$). Transparency, on the other hand, was highly correlated with depth ($p < 0.0001$). Therefore, for the Canonical Cor-

Table 3. Environment parameters per sampling site (replicates) and season of the year in Bañado Carilauquen. References: Cd: conductivity (µS cm^{-1}), WT: water temperature (°C), AT: air temperature (°C), pH: potential of hydrogen, Tr.: transparency (m), Dp.: Depth (m), HD: headwaters, HMR: higher middle reach, CMR: central middle reach, LMR: lower middle reach, OL: outlet-lake, nd: no data available.

	Summer						Autumn						Winter						Spring					
Site/Param.	Cd.	WT	AT	pH	Tr.	Dp.	Cd.	WT	AT	pH	Tr.	Dp.	Cd.	WT	AT	pH	Tr.	Dp.	Cd.	WT	AT	pH	Tr.	Dp.
HD1	952	13.4	15.7	7.2	2	2	948	13.3	8.2	6.8	2	2	930	10.3	8.5	7.1	2	2	1000	14.9	7.5	7.8	2	2
HD2	954	13.7	18.7	7.6	1.2	1.2	935	14.3	6.1	7.1	1.2	1.2	914	11.7	10	7.59	1.2	1.2	1100	15.3	8	7.7	1.2	1.2
HMR1	1385	24.2	19.8	8.9	0.3	0.3	1521	9.3	9	7.01	0.3	0.3	1400	7.1	10	7.19	0.3	0.3	1600	16.3	8	7.6	0.2	0.2
HMR2	954	25.5	23.5	8.1	0.25	0.25	932	11.4	9	7.05	0.25	0.25	1500	5.3	9	7.7	0.2	0.2	nd	nd	nd	nd	nd	nd
CMR1	1054	25.6	30.8	8.1	0.2	0.2	1448	10.6	10	7.27	0.2	0.2	1200	7.4	9	7.11	0.15	0.15	1400	9.2	8.8	7.11	0.1	0.1
CMR2	1056	18.8	30	7.1	0.2	0.2	1034	6.5	4	7.9	0.2	0.2	1100	6.3	9	7.4	0.3	0.3	1200	12.9	9.3	7.6	0.2	0.2
LMR1	1249	24.5	27.4	7.6	0.3	0.3	1307	7.7	7.9	6.48	0.3	0.3	1200	8	10	7.35	0.3	0.3	1300	15.3	10.3	7.6	0.3	0.3
LMR2	1217	23.9	21	8.7	0.6	0.6	1472	10.9	10	7.59	0.6	0.6	1200	5.8	8.2	7.33	0.6	0.6	1300	12.4	9.9	7.14	0.4	0.4
OL1	8000	25.3	22.3	8.2	0.4	0.4	19520	9.4	5.9	6.5	0.4	0.4	9800	5.8	8	6.7	0.4	0.4	9200	13.1	11.2	7.6	0.6	0.6
OL2	8830	22.8	19.1	8.2	0.6	0.6	14070	7.5	5.8	6.97	0.6	0.6	11040	5.5	9	6.6	0.6	1.10	9300	11.1	11	7.17	0.5	1

Table 4. Results of the Canonical Correspondence Analysis applied to seven environmental variables (water and air temperature, conductivity, transparency, bicarbonate, potential of hydrogen and dissolved oxygen) and all five mollusc species (*H. parchappii, H. hatcheri, Ch. mendozana, L. viator and B. peregrina)* from three sampling sites (headwaters, lower middle reach and outlet-lake) and the four seasons in Bañado Carilauquen. Weighted intraset correlation of environmental variables.

Variable	Axis 1	Axis 2	Axis 3
Eigenvalues	0.384	0.186	0.038
Percentage variance of species-environmental data	32.911	15.953	3.390
Cumulative percentage variance of species-environmental data	32.911	48.864	52.154
Species-environment correlation	0.851	0.721	0.600
Water temperature	0.243	–0.156	0.071
Air temperature	–0.075	–0.011	0.445
Conductivity	–0.405	0.781	0.077
Transparency	0.954	–0.016	–0.036
HCO_3^-	0.622	–0.541	–0.069
pH	–0.119	–0.116	–0.296
O_2	0.114	–0.184	0.563

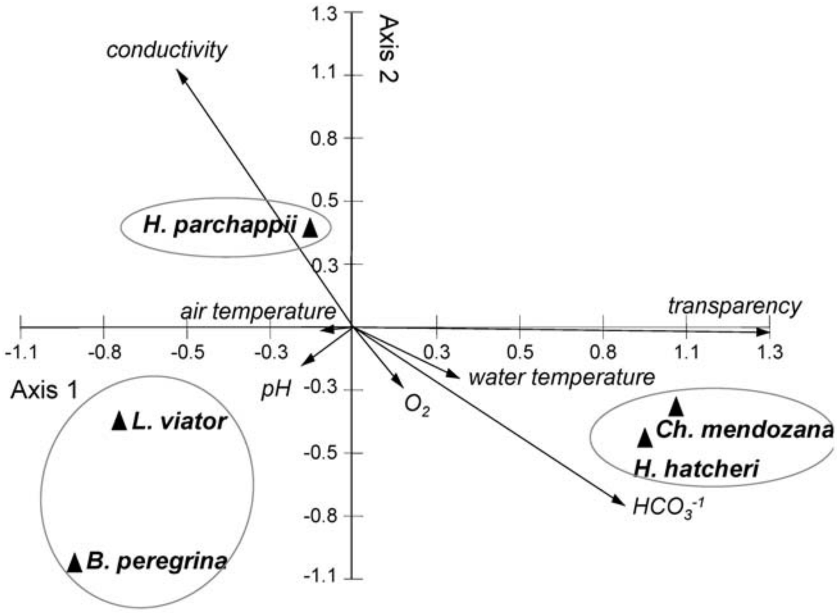

Fig. 3. Canonical correspondence analysis ordination plot for sampling sites by season and environmental variable.

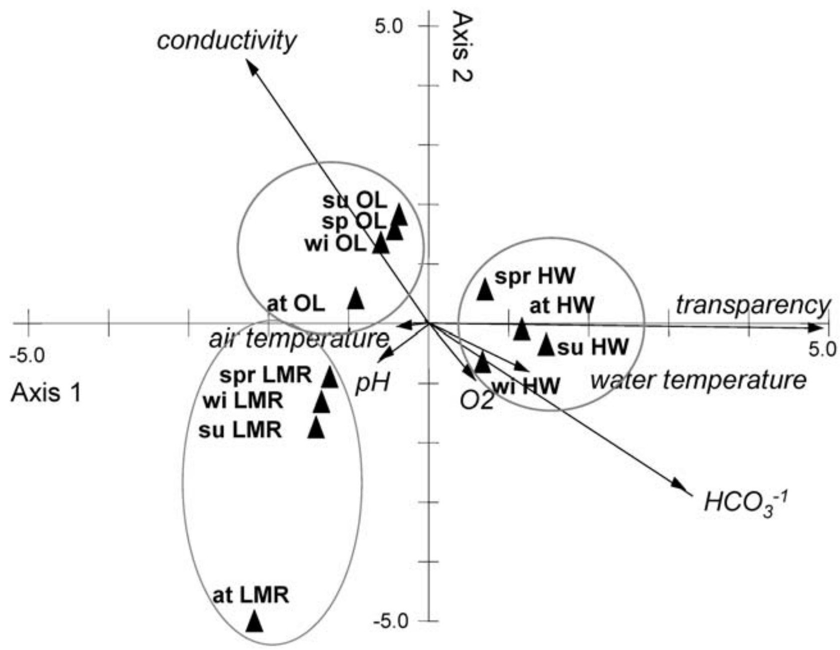

Fig. 4. Canonical correspondence analysis ordination diagram showing the relationship between species and environmental variables. Ref: **su**: summer, **at**: autumn, **wi**: winter, **spr**: spring, HD: headwaters, LMR: lower middle reach, OL: outlet-lake

respondence Analysis (CCA) the following variables were excluded: Ca^+, Mg^+, K^+, Na^+, Cl^- and SO_4^{2-} and depth. The CCA analysis revealed that the three first ordination axes explained 52 % of the total variance. Eigenvalues found were CCA1: 0.384, CCA2: 0.186, CCA3: 0.038. Values for the species-environment correlation varied between 0.851 and 0.6 (Table 4), exhibiting a significant correlation between mollusc species distribution and measured environmental variables.

Environmental variables displaying a higher correlation with the two first axes were water temperature, conductivity, transparency and bicarbonates (Fig. 3). The biplot of sampled sites and environmental variables shows that headwater sites located in the right-bottom quadrant were characterized by more transparent, more oxygenated, bicarbonate waters, with higher temperature and low conductivity values. Higher conductivity values were observed towards the outlet (left-top quadrant), as well as an environmental gradient inverse to that found for the headwaters.

Ch. mendozana and *H. hatcheri* were found at the system headwaters, and they showed preference for bicarbonate waters, with higher temperature, higher transparency and lower conductivity (Fig. 4). *H. parchappii* was associated with sites at the outlet of the lake, where conductivity values were very high. *L. viator* and *B. peregrina* had a closer association with the middle reach of the wetland (left-bottom quadrant, Fig. 4).

Discussion

The low malacofauna diversity found at the Bañado Carilauquen (5 gastropod species) is similar to the low diversity found for the Centre-West of Argentina. Species richness of freshwater gastropods in Argentina (in total 101 species) behaves in accordance with a decreasing North-South gradient and a less marked East-West gradient (Rumi et al. 2006). Based on a comprehensive revision of data, the cited authors found a few more than 30 gastropod records for the Province of Mendoza (a record = a species collected at one place at each time), and reported a species richness of mostly between 1 and 5 (range: 0–10 depending on the area considered).

Morales et al. (2006) reported a total of 6 genera for the Llancanelo Watershed, of which neither "*Physa*" (Physidae) nor *Succinea* (Succinidae) were found during our study. Prior to this study, *Heleobia parchappii* (as *Littoridina parchappii*, Hydrobiidae) had been cited as a species of wide distribution in Argentina, abundant in the Pampean Region, and present in the north of Patagonia (Gaillard & Castellanos 1976, Castellanos & Landoni 1995). Gaillard & Castellanos (1976) pointed out the presence of *Heleobia occidentalis* (Doering, 1884) across the Centre-West of Argentina including the Mendoza Province. These authors indicated that, because of its conchological similarity with *H. parchappii* and its affinity with saline waters, *H. occidentalis* could be a geographical variety of *H. parchappii*. De Francesco (2007) also pointed out the possibility of a synonymy of *H. occidentalis* with *H. parchappii*, which will continue to be unresolved until micro-anatomical descriptions of the reproductive system of *H. occidentalis* are available, possibly in addition to genetic studies. The conchological affinity between the individuals found during our study and the diagnosis of *H. parchappii* suggests the presence of this species in the south of Mendoza Province, an intermediate area between northern Patagonia and the Andean sector of the Centre-West of Argentina.

The distribution patterns of the Cochliopidae species are constrained by salinity, in fact, the range of tolerance to salinity for several current species is used to reconstruct palaeoenvironments (Hylleberg 1986, De Francesco & Zárate 1999, De Francesco 2007). *Heleobia australis*, for example, inhabits sea water and tolerates salinities of up to 40 ‰ and *Heleobia conexa* occurs in mixohaline waters (up to 34 ‰, optimal: 4-7 ‰, De Francesco & Isla 2003). It is known that *H. parchappii*, initially described as a freshwater species (salinity < 1 ‰), with no permanent populations in mesohaline waters (Cazzaniga 1982), is able to develop in estuaries of the Argentinian Atlantic littoral (mean salinity between 17 ‰ and 23 ‰; De Francesco & Isla 2004). Our results suggest that *H. parchappii* would also tolerate relatively saline continental waters. Notwithstanding, the overly high proportion of empty shells found at the Bañado Carilauquen, with salinity between 0.8 and 7.2 ‰ (conductivity to salinity conversion factor = 0.64; McNeil & Cox 2000), suggests high fluctuations and high mortality rates for populations of *H. parchappii* on sites with salinity > 0.8 ‰.

The presence of *H. hatcheri* in our study area is consistent with its reported distribution, including Patagonia and reaching, in the northern extreme, the Centre-West of Argentina (Gaillard 1973, and Castellanos & Landoni 1995, as *Littoridina hatcheri*; Cazzaniga 1981, as *Strobeliella hatcheri*). The physicochemical parameters limiting the distribution range of this species are not yet known. The absence of individuals downstream of the headwaters of the Bañado Carilauquen suggests that *H. hatcheri* does not tolerate mean conductivity levels > 1000 $\mu S\ cm^{-1}$.

Lymnaea viator is widespread over several countries in South America, among others Perú, Bolivia, Chile and Uruguay (Hubendick 1951, Paraense 1982). In Argentina it ranges from the Northeast-East to the Centre-West of the country, and from its northern extreme to 41° S (Castellanos & Landoni 1995, Kleiman et al. 2004). Recently, Paraense (2005) has reported it even at latitudes of 50° S. *L. viator* is an amphibian species highly resistant to harsh environmental conditions, including extreme cold, high altitude (e.g. Puna de Atacama, Bolivia; Cusco, Perú; Florez Bustamante 1967) and water stress. In various watersheds from Mendoza (Tunuyán, Mendoza, Diamante and Llancanelo) "Lymnaeidae" species have been found in water bodies with pH and conductivity ranges of 6.26–8.22 and 96–721 $\mu S\ cm^{-1}$ respectively, occurring between 1526 and 2638 m a.s.l. (Mera y Sierra et al. 2005a,b). Our results indicate that *L. viator* can tolerate waters with slightly higher conductivities: maximum recorded for complete individuals: 1056 µS cm^{-1} (pH: 7.1–8.1, 1300 m a.s.l.). From the epidemiological perspective, hard brackish waters have been pointed out as a natural barrier for the genus *Lymnaea* and consequently for fasciolasis (Olaechea 1994). Our results agree with this prediction because, along the spatial gradient studied in Carilauquen, we found complete individuals of *L. viator* in waters with conductivity of 954–1056 µS cm^{-1}, and empty shells in a range of mean conductivities between 967 and 1281 µS cm^{-1}, and, except for one empty shell, no individuals were recorded at the outlet-lake where mean conductivity was 11220 µS cm^{-1}. Sequencing studies of ribosomal DNA applied to the "Lymnaeidae" of Mendoza Province indicated the presence of the European species *Lymnaea* (*Galba) truncatula* in Argentina (Bargues et al. 2006). This vector species of *Fasciola hepatica* tolerates mean salinities in Europe (4 ‰; Costil et al. 2001), higher than the ones reported here for complete individuals of *L. viator* (0.6–0.7 ‰; conductivity to salinity conversion factor = 0.64; McNeil & Cox 2000).

The different species of the genus *Chilina* (only genus of the family Chilinidae endemic to South America) are found in transparent waters of temperate and temperate-cold areas (Castellanos & Gaillard 1981). *Ch. mendozana* has been described as a species from Mendoza Province (watersheds of the Mendoza, Atuel and Tunuyán rivers), up to 800 m a.s.l., and is likely present in the watershed of the Desaguadero River and Laguna El Bebedero, San Luis Province (Castellanos & Gaillard 1981). Morales et al. (2006) reported the presence of *Chilina* sp. in the Llancanelo watershed. This is the first reference to the species *Ch. mendozana* for this watershed, its documented occurrence at 1300 m a.s.l. enhances its range of altitudinal distribution. The high proportions of complete individuals detected at the headwaters of the Bañado Carilauquen and the absence of complete individuals and of empty shells in the other sampled reaches suggest that *Ch. mendozana* does not tolerate waters with conductivity levels > 1000 µS cm^{-1}. This species was detected also in Potrerillos dam, Mendoza River watershed (Darrigran 2004), where water conductivity does not exceed 1000 µS cm^{-1}.

Biomphalaria peregrina is widely distributed over South America and is particularly frequent across a wide latitudinal range in Argentina (22–40º S), including Mendoza (Rumi 1991, Castellanos & Landoni 1995, Paraense 2005). *B. peregrina* develops abundant populations, preferably in lentic waters with submerged vegetation occurring in the pampas of Buenos Aires Province and the NE of Argentina, where floodable lands and permanent water bodies abound (Rumi 1986). The lagoons of the region are characterized by waters with low levels of electrolytes and neutral to slightly acid pH. Nothing is known about the ecology of *B. peregrina* in the Centre-West of Argentina. The absence of individuals of this species at the outlet-lake of the Bañado Carilauquen would indicate either that *B. peregrina* does not tolerate saline water or that hard water constrains both vegetation development and the creation of microhabitats suitable for settlement of this planorbid. A marked spatial distribution has been reported for the littoral vegetation of the Bañado Carilauquen, with a conspicuous decline in cover and species diversity towards the outlet, where vegetation consists only of the submerged macrophyte species *Salicornia ambigua* and associated filamentous chlorophytes (Peralta & Fuentes 2001). However, the fact that the few individuals found in the middle reaches (mean conductivity values between 1186.5 and 1327.4 µS cm^{-1}) turned out always to be empty shells suggests that *B. peregrina* has a low tolerance for waters with mean conductivities > 1000 µS cm^{-1}.

As has been observed for *H. parchappii* in this study, quite frequently a species of the Cochliopidae family is found to be the most abundant in a community of molluscs, in either present or fossil and subfossil assemblages (Gaillard & Castellanos 1976). Along a spatial gradient extending from the mouth of the Quequén Grande River into the Atlantic Ocean to approximately 25 km upstream, De Francesco & Isla (2003) reported a mean density of 19.5 individuals/100 cm^{-2} of *H. parchappii* for the sampling site farthest from the influence of tides (salinity < 1 ‰), and mean densities < 0.05 individuals 100 cm^{-2} for sites within the estuary (mean salinities estimated between 4 and 12 ‰). The cited authors suggested that the few individuals found near the outlet would have been carried there by the river. In the spatial gradient studied at the Bañado Carilauquen, the density of *H. parchappii* (mostly empty shells, mean: 4.83 individuals 100 cm^{-2}, range: 0–21.9) did not show a defined pattern despite the conductivity gradient detected. The lentic and shallow waters of the Bañado Carilauquen suggest low probability of massive and regular transport of individuals from the headwaters towards the outlet. Nonetheless, exceptional climate and hydrological conditions might trigger abrupt increases in water volume and changes in demographic structure due to selective transport of smaller sizes towards the outlet into the lake. Despite the stable lentic conditions of the headwaters, the water volume of the Bañado Carilauquen shows significant seasonal variations from the middle reaches to the outlet due to high evaporation rates (Peralta & Fuentes 2001). Anyway, our results allow the assumption that *H. parchappii* develops populations with highly fluctuating densities and high mortality along the entire spatial gradient studied.

In favourable subtropical environments *Lymnaea viator* and other lymnaeids can be extremely abundant; for the NE of Argentina there are estimates exceeding 20 million individuals ha^{-1} (Lombardero et al. 1979). Although *L. viator* has a high capacity of adaptation to diverse climates, including harsh environmental conditions, the situation in semi-desert environments such as the one studied here is not comparable to a subtropical situation, especially in semi-permanent water bodies. There are no population-ecological studies of *L. viator* for environments comparable to that of Carilauquen. Our data suggest that *L. viator* would develop populations of low density (< 0.65 snails 100 cm^{-2}) in waters having conductivity conditions near the species' limit of tolerance. The same would be the case for *B. peregrina*. In waters suitable for its development, such as the headwaters of the Bañado Carilauquen, *Ch. mendozana* can develop abundant populations, with density peaks of up to 25 individuals 100 cm^{-2}. In contrast, in the same environment but in the northern extreme of its geographical distribution, there occur only isolated individuals of *H. hatcheri*, a typically Patagonian species.

The mean size of *H. parchappii* (length: 4.42 mm) was smaller than that of individuals from freshwater bodies at the south of the Pampean region (average length of the dominant size in oligohaline waters: 5.36 mm, Cazzaniga 1982) and relatively similar to the mean sizes reported for adult populations in brackish estuary waters (3.98–4.02 mm for the most abundant cohort, De Francesco & Isla 2004). In freshwaters, pre-reproductive subadults of *H. parchappii* have a shell length of 2.5–4.1 mm and present 4 whorls, whereas adults have 4.1–5.5 mm and 5–6 whorls (Cazzaniga 1982). In brackish estuary waters they reach maturity at a smaller size; in this environment one cohort attained an average length of 4.02 mm in approximately 8 months (De Francesco & Isla 2004), a similar size to that of the specimens from the Bañado Carilauquen (4.42 mm). The individuals found at Carilauquen would consequently be adults showing a lower growth rate than those inhabiting more favourable environments. The non-detection of a pattern of seasonal size in our results suggests that populations of *H. parchappii* at Carilauquen do not consist of a dominant, stable-in-time cohort, but of diverse age classes with fluctuating density.

Individuals of *H. hatcheri* from Carilauquen were slightly wider (mean width: 70.5 % of length) in relation to the description by Cazzaniga (1981, width: 50–65 % of length, as *Strobeliella hatcheri*). Mean sizes of *L. viator* from Carilauquen were smaller than those of the type and other specimens not from the province, but similar to those reported for shells from Mendoza Province (e.g. Uspallata, 1891 m a.s.l., Mera y Sierra et al. 2005a), suggesting that individual growth rate could be constrained by altitudinal environmental conditions. Also the individuals of *Ch. mendozana* showed smaller mean sizes (length: 9.24, SD: 2.81) than those from the drinking water treatment plant of the Potrerillos dam, Mendoza river watershed: mean length: 12.2, SD:1.74, mean width: 7.8, SD: 0.98, n = 25 (Darrigran 2004). It has been pointed out that the genus *Chilina* preferably inhabits transparent waters of lakes and creeks with rocky substrates and that its individuals reach a small size in silt substrates (Castellanos & Gaillard 1981), such as the one at Carilauquen. Similarly, while individuals of *B. peregrina* developing in more favourable environments, like the pampas in Buenos Aires Province and the NE of Argentina, reach diameters over 7.1–12.3 mm, and in Brazil up to 16.5 mm (Rumi 1991), shells from Carilauquen showed a maximum diameter lower than 5 mm.

With the exception of the headwaters, the study area was scarcely favourable for the development of abundant and stable aquatic mollusc populations. This was expressed by the low species diversity, low densities, low individual growth, highly fluctuating low-density populations and, above all, the high proportion of empty shells detected. Our results confirm an increasing conductivity gradient towards the outlet into the lake, with high concentrations of sulphates and bicarbonates. Adding to this is a high load of organic matter (eutrophic waters) and the presence of contaminants at certain sites (hydrocarbons, Peralta & Fuentes 2005). The conductivity gradient determined by increased concentration of sulphates and bicarbonates from the headwaters towards the outlet into the lake is consistent, overall, with the progressive decrease in diversity and abundance of complete individuals from the upper reaches toward the lake. We did not observe any drastic seasonal changes. The distribution patterns of the malacofauna in the Bañado are defined by environment parameters, particularly the salt concentration gradient. Hard, eutrophic, polysaprobic and contaminated waters such as those of the Bañado Carilauquen represent critical conditions for the development of populations of the gastropod species found. The variation in malacofauna along the Bañado can be explained by the environmental gradient, which confirms the usefulness of molluscs as indicators of water conditions.

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References

Alonso, A. & Camargo, J. A., 2004: Sub-Lethal responses of the aquatic snail *Potamopyrgus antipodarum* (Hydrobiidae, Mollusca) to unionized ammonia: a tolerant invading species. – Fresen. Environ. Bull. **13:** 607–615.

Bargues, M. D., Mera y Sierra, R., Gómez, H., Artigas, P. & Mas-Coma, S., 2006: Ribosomal DNA ITS-1 sequencing of *Galba truncatula* (Gastropoda, Lymnaeidae) and its potential impact on fasciolasis transmission in Mendoza. – Anim. Biodivers. Conserv. **29:** 191–194.

Blendinguer, P. G. & Alvarez, M. E., 2002: Ensambles de aves de los bañados de Carilauquen (Laguna Llancanelo, Mendoza, Argentina): consideraciones para su conservación. – Hornero **17:** 71–83.

Camargo, J. A., 1993: Macrobenthic surveys as a valuable tool for assessing freshwater quality in the Iberian Peninsula. – Environ. Monit. Assess. **24:** 71–90.

– 1994: The importance of biological monitoring for the ecological risk assessment of freshwater pollution: a case study. – Environ. Int. **20:** 229–238.

Castellanos, Z. J. A. de & Gaillard, M. C., 1981: Chilinidae. – In: Ringuelet, R. A. (eds): Fauna Dulce de la República Argentina. – FECIC, Buenos Aires, Argentina, **15** (4): 23–51.

Castellanos, Z. J. A. de & Landoni, N., 1995: Moluscos Pelecypoda y Gastropoda. – In: Lopretto, E. & Tell, G. (eds): Ecosistemas de Aguas Continentales. Metodología para su estudio. – Ediciones Sur, La Plata, Argentina, Tome II, pp. 759–801.

Cazzaniga, N. J., 1981: Notas sobre hidróbidos argentinos III (Gastropoda Rissoidea). *Strobeliella*, un nuevo género para la Patagonia. – Neotrópica **27** (77): 3–10.

– 1982: Notas sobre hidróbidos argentinos II. Una *Littoridina* del 'grupo *parchappii*' en Península Valdés (Chubut). – Revista del Museo de La Plata (Argentina), Sección Zoología **129:** 11–16.

Coconier, E., 2005: Aves acuáticas de la Argentina. Reporte Final. – Aves Argentinas & Wetlands Internacional, 137 pp.

Costil, K., Dussart, G. B. J. & Daguzan, J., 2001: Biodiversity of aquatic gastropods in the Mont St-Michel basin (France) in relation to salinity and drying of habitats. – Biodivers. Conserv. **10:** 1–18.

Dahl, J., Johnson, R. & Sandin, L., 2004: Detection of organic pollution of streams in southern Sweden using benthic macroinvertebrates. – Hydrobiologia **516:** 161–172.

Darrigran, G., 2004: Determinación de Moluscos Gasterópodos de agua dulce. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina. – Unpubl. Technical Report prepared for Ente Provincial del Agua y Saneamiento, EPAS, Gobierno de Mendoza, Argentina. 12 pp.

De Francesco, C. G., 2007: Las limitaciones a la identificación de especies de *Heleobia* Stimpson, 1865 (Gastropoda: Rissooidea) en el registro fósil del Cuaternario tardío y sus implicancias paleoambientales. – Ameghiniana (Rev. Soc. Paleontol. Argentina) **44:** 631–635.

De Francesco, C. G. & Isla, F. I., 2003: Distribution and abundance of hydrobiid snails in a mixed estuary and a coastal lagoon, Argentina. – Estuaries **26:** 790–797.

– – 2004: Reproductive period and growth rate of the freshwater snail Heleobia parchappii (d´Orbigny, 1835) (Gastropoda, Rissooidea) in shallow brackish habitat (Buenos Aires Province, Argentina). – Malacologia **45:** 443–450.

De Francesco, C. G. & Zárate, M. A., 1999: Análisis tafonómico de Littoridina Souleyet 1852 (Gastropoda: Hydrobiidae) en perfiles holocenos del río Quequén Grande (provincia de Buenos Aires): significado paleobiológico y paleoambiental. – Ameghiniana (Rev. Soc. Paleontol. Argent.) **36:** 297–310.

Figueroa, R., Valdovinos, C., Araya, E. & Parra, O., 2003: Macroinvertebrados bentónicos como indicadores de calidad de agua de ríos del sur de Chile. – Rev. Chil. Hist. Nat. **76:** 275–285.

Florez Bustamante, A. E., 1967: Contribución al conocimiento de los gasterópodos de la Región de Cusco. – Doctoral Thesis. Facultad de Ciencias, Universidad Nacional de San Antonio Abad del Cusco. Perú. 75 pp.

Foeckler, F., Diepolder, U. & Deichner, O., 1991: Water Mollusc Communities And Bioindication Of Lower Salzach Floodplain Waters. – Regul. Riv.: Res. Manage. **6:** 301–312.

Gaillard, M. C., 1973: Contribución al conocimiento del género *Littoridina* Souyelet, 1852 en la República Argentina. – Doctoral Thesis. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina. 120 pp.

Gaillard, M. C. & Castellanos, Z. J. A. de, 1976: Hydrobiidae. – In: Ringuelet, R. A. (ed.): Fauna de Agua Dulce de la República Argentina. – FECIC. Buenos Aires, Argentina, **15** (2):7–40.

García-Criado, F., Tomé, A., Vega, F. J. & Antolín, C., 1999: Performance of some diversity and biotic indices in rivers affected by coal mining in northwestern Spain. – Hydrobiologia **394:** 209–217.

Hellawell, J. M., 1986: Biological indicators of freshwater pollution and environmental management. – Elsevier, London, New York, 546 pp.

Hubendick, B., 1951: Recent Lymnaeidae. Their variation, morphology, taxonomy, nomenclature and distribution. – Kungl. Svenska. Vetens. Handl. (Stockholm) **3:** 1–223.

Hylleberg, J., 1986: Distribution of hydrobiid snails in relation to salinity, with emphasis on shell size and co-existence of the species. – Ophelia **4:** 85–100.

Johnson, R. K., Wiederholm, T. & Rosenberg, D. M., 1993: Freshwater biomonitoring using individual organism, population and species assemblages of benthic macroinvertebrates. – In: Rosenberg, D. M. & Resh, V. H. (eds): Freshwater Biomonitoring and Benthic Macroinvertebrates. – Chapman & Hall, New York, pp. 40–157.

Kleiman, F., Pietrokovsky, S., Paraense, W. L. & Wisnivesky-Colli, C., 2004: Southernmost finding of *Lymnaea viatrix* d´Orbigny, 1835 (Pulmonata, Lymnaeidae), intermediate host of *Fasciola hepatica* (Linnaeus, 1758) (Trematode, Digenea), in urban and rural areas of Argentina. – Mem. Inst. Oswaldo Cruz (Río de Janeiro) **99:** 11–27.

Lombardero, O., Moriena, R., Racioppi, O. & Quiroz, L., 1979: Bionomía de *Lymnaea* sp. en la provincia de Corrientes. – Veterinaria (Corrientes, Argentina) **2:** 5–19.

McNeil, V. H. & Cox, M. E., 2000: Relationship between conductivity and analysed composition in a large set of natural surface-water samples, Queensland, Australia. – Environ. Geol. **39:** 1325–1333.

Mera, R., Artigas, P. & Mas-Coma, S., 2006: Lymnaeid Vectors of Fasciolasis in Endemic Areas of Mendoza, Argentina. – ICOPA XI, 11th International Congress of Parasitology, Glasgow, Scotland, 6th-11th August, 2006. Abstracts CD.

Mera y Sierra, R., Morales, J., Cuervo, P., Catroppa, V., Laforet, L. & Artigas, P., 2005a: Water Conductivity, pH, Hardness and total ions in natural biotopes of lymnaeid molluscs in Mendoza, Argentina. – XXIII Reunión Científica Anual, Sociedad Biológica de Cuyo, Uspallata, Mendoza, Argentina. Biocell, Abstracts **29:** 371.

Mera y Sierra, R., Morales, J., Guiñazú, M., Sidoti, M. & Artigas, L., 2005b: Altitudinal distribution of Lymnaeid molluscs in Mendoza Province, Argentina. – XXIII Reunión Científica Anual, Sociedad Biológica de Cuyo, Uspallata, Mendoza, Argentina. Biocell, Abstracts **29:** 371.

Moore, M. N., Livingstone, D. R., Widdows, J., Lowe, D. M., Pipe, R. K. & Jones, R. E., 1987: Molecular, Cellular and Physiological Effects of Oil-Derived Hydrocarbons on Molluscs and Their Use in Impact Assessment [and Discussion]. – Phil. Transact. R. Soc. Lond., Ser. B: Biol. Sci. **316:** 603–623.

Morales, J. R., Guiñazú, M. E., Catroppa, V., Sidoti, L., & Mera y Sierra, R., 2006: Lymnaeidos y otros moluscos de agua dulce en la provincia de Mendoza. – XX Jornadas de Investigación de la Universidad Nacional de Cuyo. Mendoza, Argentina. Septiembre de 2006. Abstracts Book, Tome I: 245.

Nazneen, S. & Begum, F., 1994: Distribution of molluscs in Layari River (Sindh), Pakistan.– Hydrobiologia **273:** 95–100.

Olaechea, F. V., 1994: Epidemiología y control de *Fasciola hepatica* en la Argentina. – In: Nari, A. & Fiel, C. (eds.): Enfermedades Parasitarias de Importancia Económica en Bovinos. – Editorial Hemisferio Sur, Argentina. pp. 213–233.

Ostera, H. A. & Dapeña, C., 2003: Environmental Isotopes And Geochemistry Of Bañado Carilauquen. Mendoza, Argentina . – IV South American Symposium On Isotope Geology Short Papers: 461–464.

Paraense, W. L., 1982: *Lymnaea viatrix* and *Lymnaea columella* in the Neotropical Region: a distributional outline. – Mem. Inst. Oswaldo Cruz (Río de Janeiro) **77:** 181–188.

– 2005: Planorbidae, Lymnaeidae and Physidae of Argentina (Mollusca: Basommatophora). – Mem. Inst. Oswaldo Cruz (Río de Janeiro) **100:** 491–493.

Peralta, P. & Fuentes, V., 2001: Vegetación Litoral. Estudio Base Cero Bañado Carilauquen. – Fundación Cricyt, Mendoza, Argentina. Technical Report. 22 pp.

– – 2005: Fitobentos, fitoplancton y zooplancton litoral del bañado de Carilauquen, Cuenca de Llancanelo, Mendoza, Argentina. – Limnética **24:** 183–198.

Phillips, D. J. H. & Rainbow, P. S., 1993: Biomonitoring of Trace Aquatic Contaminants. – Elsevier, New York, 388 pp.

Rosenberg, D. M. & Resh, V. H., 1993: Freshwater biomonitoring and benthic macroinvertebrates. – Chapman & Hall, London, 488 pp.

Rumi, A., 1986: Estudio morfológico, taxonómico y bioecológico de los Planórbidos argentinos. – Doctoral Thesis. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina. 208 pp.

– 1991: La familia Planorbidae Rafinisque, 1815, en la República Argentina. – In: Castellanos, Z. A. de (ed.): Fauna de Agua Dulce de la República Argentina. – PROFADU (CONICET), La Plata, Argentina, **15** (8): 1–51.

Rumi, A., Gutiérrez Gregoric, D.E., Núñez, V., César, I.I., Roche, M.A., Tassara, M.P., Martín, S.M. & López Armengol, F. 2006: Freshwater Gastropoda from Argentina: species richness, distribution patterns and evaluation of endangered species. – Malacología **49:** 189–208.

Salanki J., Farkas, A., Kamardina, T. & Rozsa, K.S., 2003: Molluscs in biological monitoring of water quality. – Toxicol. Lett. **11:** 403–410.

Sosa, H., Videla, F. & Puig, S., 1989: Marcación de límites biológicos del Sector NO de la Reserva Provincial Laguna de Llancanelo. – Dirección de Recursos Renovables, Gobierno de la Provincia de Mendoza, Argentina. Technical Report. 20 pp.

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