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FRESHWATER GASTROPODA FROM ARGENTINA: SPECIES RICHNESS, DISTRIBUTION PATTERNS, AND AN EVALUATION OF ENDANGERED SPECIES

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ABSTRACT

Few studies have dealt with the geographic distribution of freshwater snails in Argentina. The objectives of this study were to: (1) determine species and family richness and diversity patterns; (2) verify if species richness behaves according to Rapoport's rule; (3) identify and classify species according to their distributions; and (4) identify endangered species. A grid was applied to a map of Argentina, with each of 340 squares (SUs) representing 10,000 km^2. A database of 3,376 records was analyzed. Of the 101 species belonging to ten families recorded in Argentina, four are introduced and 40 are endemic to Argentina. The Lithoglyphidae have the highest number of species (22). The highest species richness/SU was recorded in the Brazilic subregion at Salto Grande (32 species) on Uruguay River, and parts of the Río de la Plata (31). In this subregion the species richness values increase from west to east. The highest richness in the Chilean-Patagonian subregion was detected at San Carlos de Bariloche, Río Negro province (9), and the Chilinidae contained the largest number of species. In Argentina, the north-south decline species pattern could be explained through Rapoport's rule. In Patagonia, the species richness gradients do not show significant west-east trends. Most of the native species of freshwater molluscs of restricted distribution can be considered endangered (about 45 species) but need further study.

Key words: freshwater Gastropoda, native species, richness, distribution, Del Plata basin, Patagonia, Argentina.

INTRODUCTION

Natural ecosystems are progressively being destroyed, leading to a loss of biodiversity. A total of 1.4 million living species have been recorded (Wilson, 1988), of which, about 135,000 are molluscs, and of these more than 2,000 are known to be at risk of extinction (Seddon, 1998). The Molluscs Specialists Group (MSG) of the World Conservation Union (International Union for Conservation of Nature - IUCN) provides advice and data to the Species Survival Commission (SSC) of the IUCN, and through it, to the IUCN "Conservation Program for Sustainable Development". The aim of this program is to ensure the conservation of natural resources within the concept of sustainable development (Kay, 1995).

Argentina occupies most of the southern portion of South America, with an area of 2,780,403 km^2 and a population of 36 million people (National Census, 2001). The climate varies from sub-tropical in the north to cold-temperate in the south. Three of the ecoregions (biomes) with the greatest biodiversity in South America have their southern distributional limit in Argentina: the Paranaense and Yungas rainforests and the wetlands of Chaco (Brown & Grau, 1993; Bucher & Chain, 1998; Bertonatti & Corcuera, 2000). Molluscs were not included among the taxa considered by these authors in making these biodiversity assessments. These three ecoregions include the main rivers of the Del Plata basin. The distribution and quality of the different types of continental waters reflect the

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major hydrographic subregions to which they belong and are important in determining the distribution and composition of the freshwater mollusc faunas.

While the overall taxonomic composition of the freshwater gastropod fauna of Argentina is fairly well known, little information is available on their geographic distributions of the species (Bonetto et al., 1990; Castellanos & Miquel, 1991; Rumi et al., 1997) and patterns of diversity. According to “Rapoport’s rule” (Rapoport, 1982), species richness peaks near the Equator and declines toward the poles, suggesting that species richness should be greater in northern than in southern Argentina.

This paper is part of a series of studies with the objective of identifying for Argentina the native species of freshwater gastropods that are endangered or at risk of extinction and to define the areas or ecosystems that should be protected in order to preserve them. The purpose of this paper is to identify the major groups of native species on the basis of their richness and distribution. With a macroecological focus, four objectives were defined in order to: (1) determine patterns of species and family richness and diversity; (2) verify if species richness behaves according to “Rapoport’s rule”; (3) identify and classify groups of species according to their distributions; and (4) identify endangered species.

METHODS

Rivers in South America are distributed in two subregions: Brazilic in the north and Chilean-Patagonian in the south (Bonetto, 1994). There is a Transitional Zone between them, which has no characteristics of its own and includes primarily the Salí-Dulce, Primero and Segundo rivers of Córdoba Province, Argentina, which flow into the Mar Chiquita pond and form the greatest endorheic basin in South America. In Argentina (Fig. 1), the Brazilic subregion includes the Del Plata basin, and the Chilean-Patagonian subregion includes various lakes and rivers that mainly flow into the Atlantic Ocean.

A Gauss-Krüger map projection that divides the world into bands was used. A grid was applied to the map, with each square a sampling unit (SU) representing 10,000 km^2 (100 x 100 km) (Rabinovich & Rapoport, 1975; Heller & Kadmon, 2004). Argentina has 340 SUs, of which 19 (5.6% of the total area of the country) fall in dry zones without any riverbeds or permanent freshwater habitats and which were therefore excluded from the analysis.

Molluscan records were taken from several sources, including: (1) collections in the Museo de La Plata, Buenos Aires Province, Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”, Buenos Aires city, and “Miguel Lillo” Foundation, Tucumán Province; (2) information obtained from sampling field trips; and (3) data reported in the literature, including large expedition reports and revisionary works. A “record” is a species collected at one place each time. Appendix 1 shows the collection material revised and the taxonomic criteria employed. Diversity of species of freshwater Gastropoda, ignoring subspecific distinctions, was expressed as the number of species per family per SU.

The number of species and families per SU were considered as units for richness (*S*) analysis. To show richness grid-maps, data were gathered at intervals of five species. Both north-south and west-east gradient analyses were performed, excluding SUs without any records. The average and range of species richness was estimated for each row and column of the grid, thereby removing the effect of differing area in each row/column. For both trend lines obtained the coefficient of determination was calculated (R^2 is a proportion of the total variation in Y that is explained or accounted for by the fitted regression). The distribution of species among families in each SU, is a measure of taxonomic diversity, which we estimated by means of the Shannon diversity index ($H = -\Sigma\, p_i \ln p_i$). Thus, for each SU, we did not evaluate specific diversity in the usual manner, in which each species is weighed by the number of individuals, but rather, we considered the distribution of species in families (Rabinovich & Rapoport, 1975), so that p_i = (number of species of family *i*) / (total number of species of SU). Thus, a zero value of *H* represents occurrence of only one family in the SU.

The following terms were used to characterize each species’ distribution: endemic – species reported only from Argentina; restricted - species only present in 1 to 3 SUs; continuous – species that occur in adjacent SUs or in SUs that belong to the same river basin; discontinuous – species that occupy isolated SUs or in different river basin; exotic – species that are not native to Argentina.

Following UICN (1994), the list of endangered native species was developed as those species with a limited distribution in particular areas and those that had not been recorded since 1975.

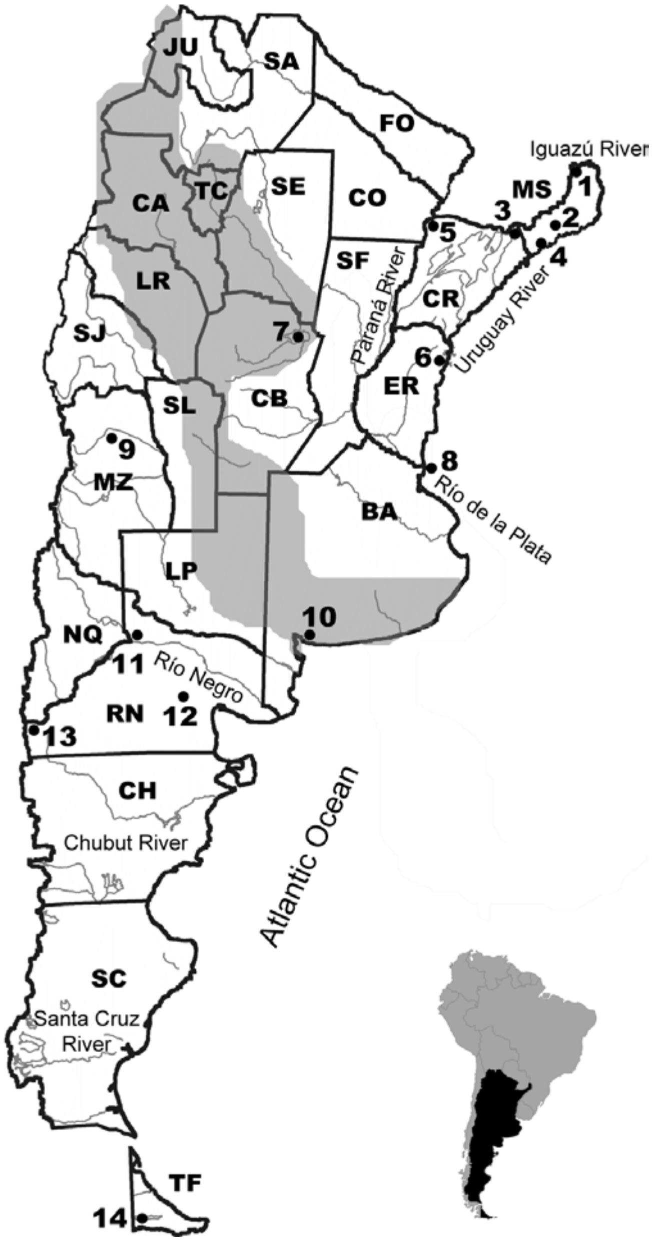

FIG. 1. Distribution of the rivers of Argentina. In grey, the Transitional Zone; to the north and east of it, the Brazilic subregion with the Del Plata basin; to the south and west of it, the Chilean – Patagonian subregion (adapted from Bonetto, 1994). Localities indicated as follows: 1 – Parque Nacional Iguazú; 2 – Salto Encantado; 3 – Yacyretá – Posadas; 4 – San Javier; 5 – Resistencia; 6 – Salto Grande; 7 – Mar Chiquita pond; 8 – Martín García Island; 9 – Mendoza city; 10 – Bahía Blanca; 11 – Neuquén-Cipolletti; 12 – Valcheta; 13 – San Carlos de Bariloche and Gutiérrez Lake; 14 – Yehuín Lake. BA: Buenos Aires; CA: Catamarca; CB: Córdoba; CH: Chubut; CO: Chaco; CR: Corrientes; ER: Entre Ríos; FO: Formosa; JU: Jujuy; LP: La Pampa; LR: La Rioja; MS: Misiones; MZ: Mendoza; NQ: Neuquén; RN: Río Negro; SA: Salta; SC: Santa Cruz; SE: Santiago del Estero; SF: Santa Fe; SJ: San Juan; SL: San Luis; TC: Tucumán; and TF: Tierra del Fuego.

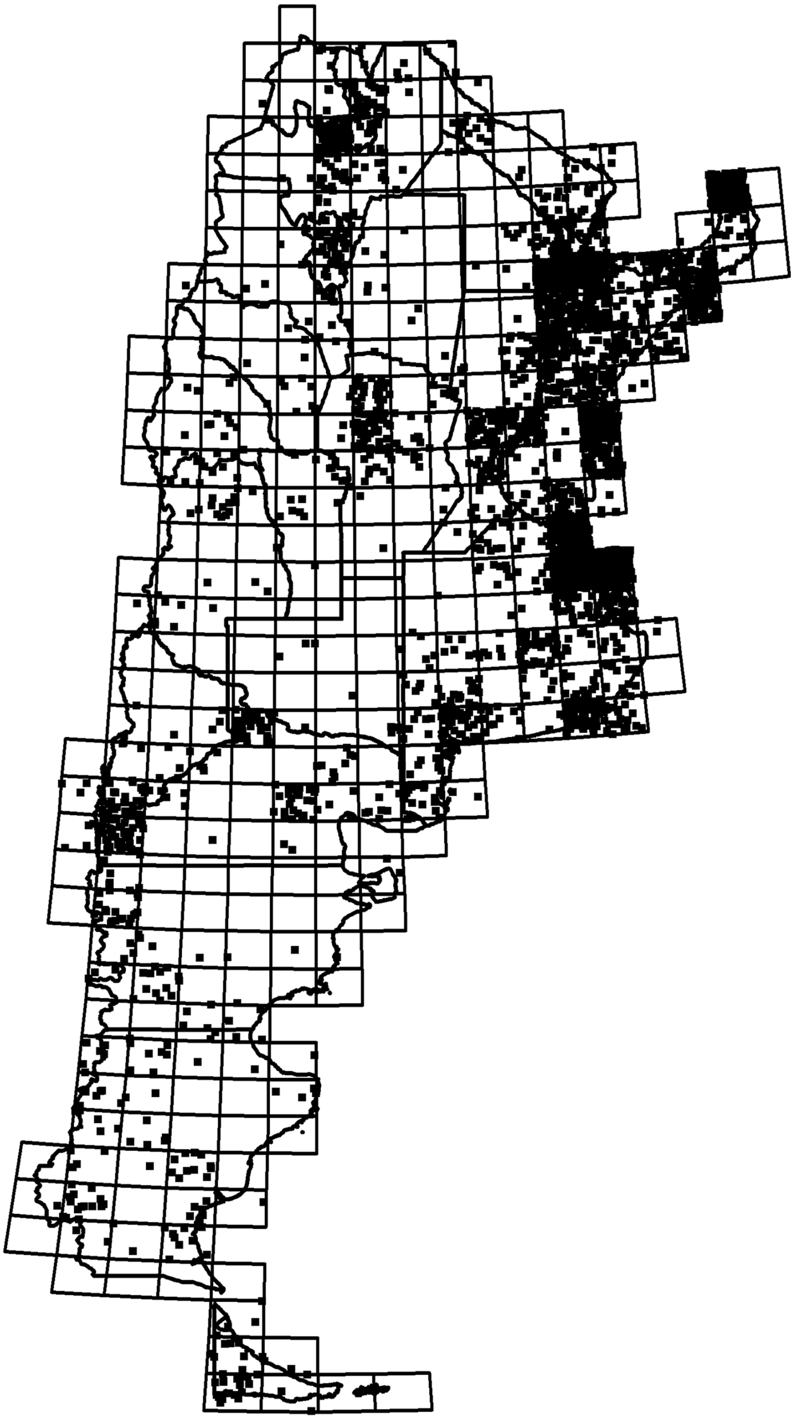

FIG. 2. Record density in each SU.

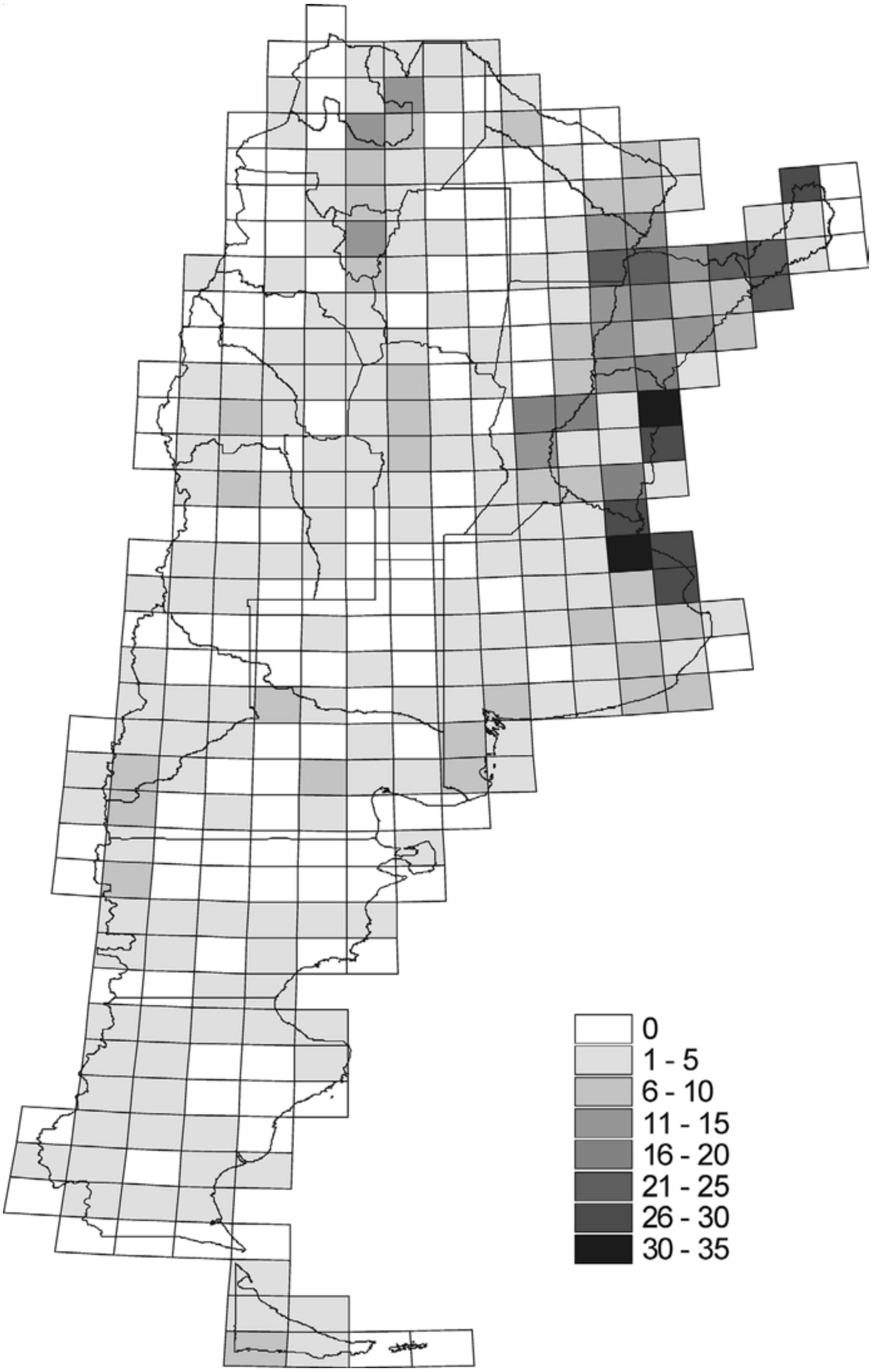

FIG. 3. Species richness in each SU.

RESULTS

The database includes a total of 3,376 records. Fig. 2 shows the number of records per SU, with randomly distributed spots within each SU. The largest number of records is from the Río de la Plata (219) and Parque Nacional Iguazú (216). Of the total of 340 SUs, 102 have no records (either because no freshwater species were found, or because the SU was not sampled); 26 are from the Brazilic subregion, 23 are from the Transitional Zone, and 53 are from the Chilean-Patagonian subregion.

A total of 101 nominal species belonging to ten freshwater gastropod families have been reported from Argentina: Ampullariidae (12 species), Cochliopidae (16), Lithoglyphidae (22), and Thiaridae (4) (Caenogastropoda); Ancylidae (5), Chilinidae (16), Glacidorbidae (1), Lymnaeidae (5), Physidae (5), and Planorbidae (15) (Heterobranchia). The Brazilic subregion has 75 species, the Chilean-Patagonian subregion 36, and the Transitional Zone 26. Of these species, 13 are found in all three regions. An additional 11 are found in two regions, three of them in the Transitional Zone and the Chilean-Patagonian subregion, seven in the Transitional Zone and the Brazilic subregion, and one in the Chilean-Patagonian and Brazilic subregions. Some species were found only in the Brazilic subregion (54), the Chilean Patagonian subregion (16), or the Transitional Zone (3).

The highest species richness per SU was found at Salto Grande (32 species), parts of the Río de la Plata (31), Parque Nacional Iguazú (26), Yacyretá-Posadas (25), San Javier, and at the confluence of the Paraná and Paraguay rivers (22), all of them belonging to the Brazilic subregion (Fig. 3). The Lithoglyphidae had the highest number of species in this subregion (21). In the Chilean-Patagonian subregion, the highest species richness was at San Carlos de Bariloche, Río Negro Province (9), and the Chilinidae had the highest number of species (10). In the Transitional Zone, the highest richness was in the centre of Tucumán Province (11) and the Cochliopidae had the highest number of species (9).

The correlation between record densities and species richness per SU (r = 0.87; N = 218) as seen in Figure 4. The highest richness value (32) corresponds to 122 records (3.8 times the richness value).

Family richness reached a maximum in the Yacyretá-Posadas area (9 families), Río de la Plata (8), Salto Grande (8), and Parque Nacional Iguazú (8), all in the Brazilic subregion. In the Chilean-Patagonian subregion the greatest family richness (6) was found at San Carlos de Bariloche, Mendoza city, and at the confluence of the Neuquén, Limay and Negro rivers at the cities of Neuquén and Cipolletti. In the Transitional Zone, the highest richness (7) was recorded from Bahía Blanca (Fig. 5).

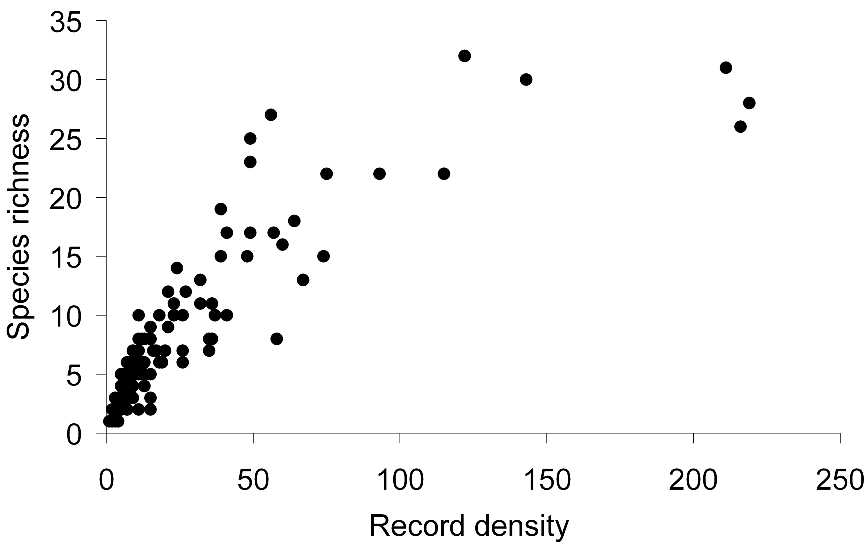

FIG. 4. Correlation between record densities and species richness.

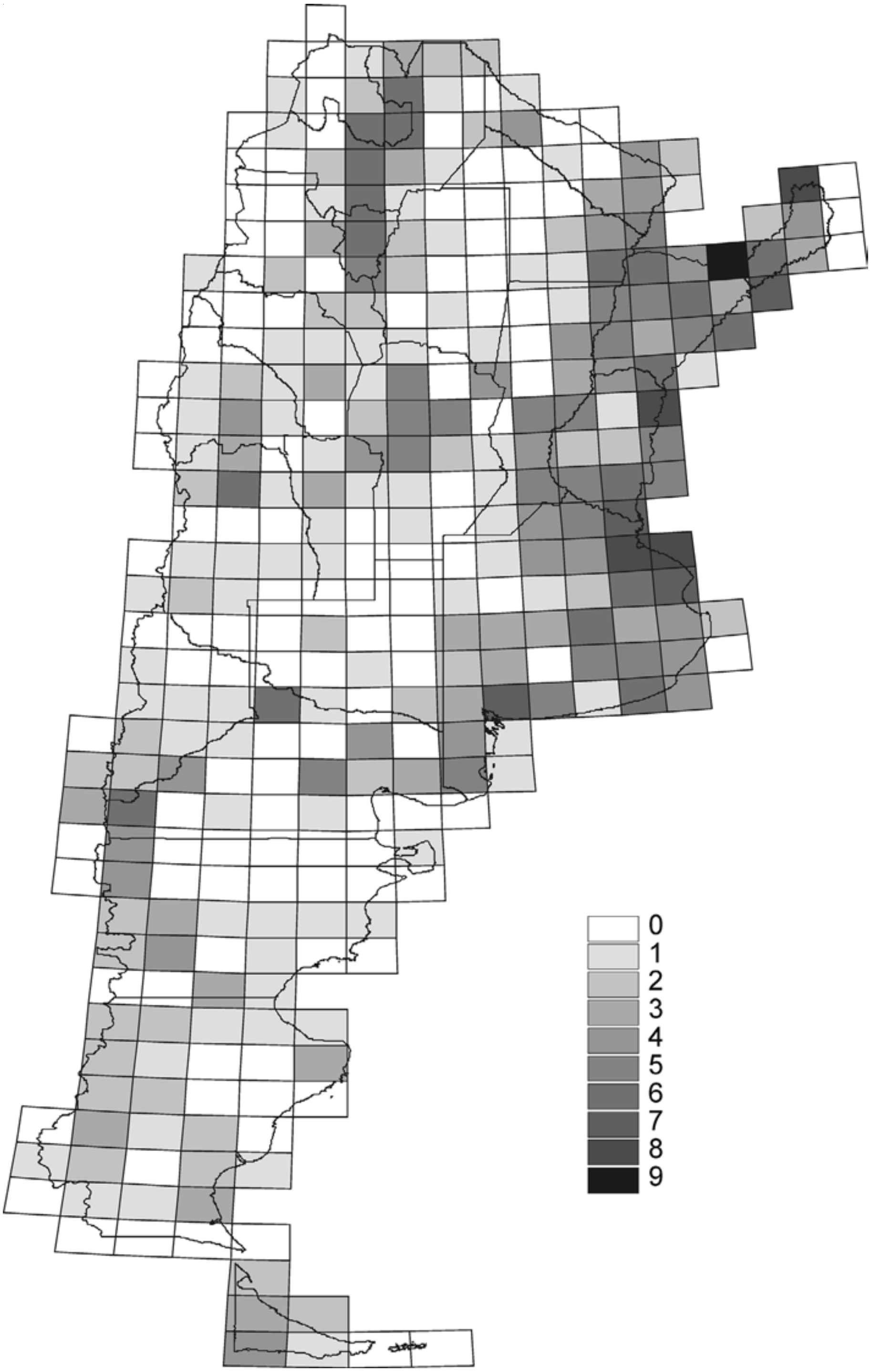

FIG. 5. Family richness in each SU.

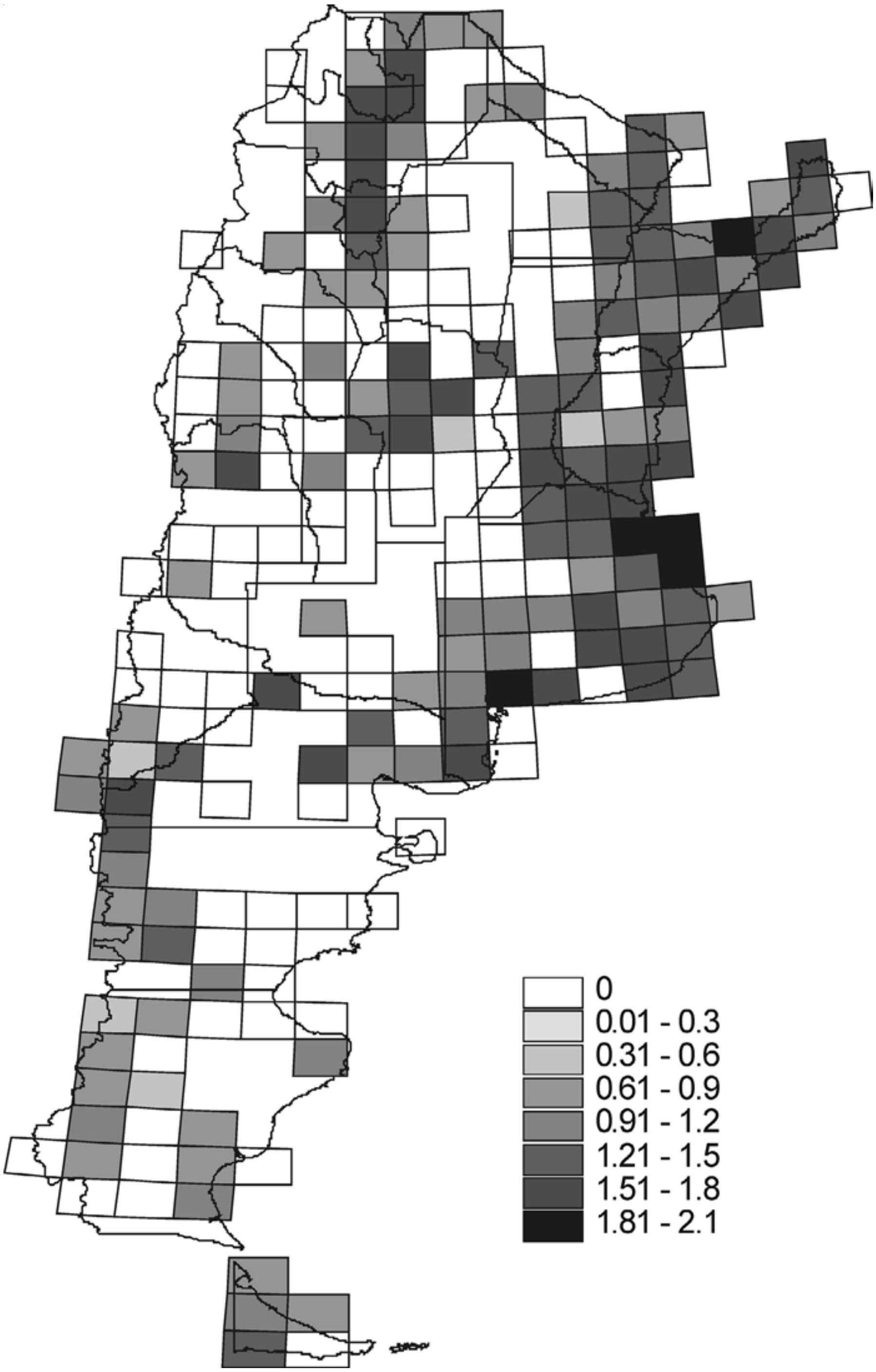

FIG. 6. Shannon diversity index value for each SU. Any SU own values of diversity in the interval 0.01–0.3.

The highest Shannon diversity indices were found in Yacyretá-Posadas (H = 2.05) and Río de la Plata (H = 1.91) (both in the Brazilic subregion) (Fig. 6). In the Chilean Patagonian subregion, the highest diversity indices were found at Mendoza city (H = 1.79) and Neuquén and Cipolletti cities (H = 1.67). In the Transitional Zone, the highest diversity index was in Bahía Blanca (H = 1.83), with a relatively low species richness (10 species). Seventy-five SUs had a diversity index of zero.

The north-south gradient of maximum and means of species richness is shown in Fig. 7A. Both regression of species richness per grid row on latitude exhibited a negative slope (b), with a low coefficient of determination (R^2 = 0.37; $P << 0.005$). The b absolute value for maximum richness (b = -0.53) is higher than b obtained for means (b = -0.13). In the north, the low values of richness correspond to a desert area (rows = 1–4), while the highest mean values per row occur in areas of the Yungas rainforests in the north-west and Paraná river in the north-east between Resistencia and Posadas (mean S = 10.17; range = 1–25; row = 7). The ranges of species richness rise towards the south of Del Plata basin (rows = 11–15), from the centre, the mean per row of SUs diminishes (row = 16). The decline in mean and range of species richness becomes more evident towards Patagonia. The highest value of richness by row (S = 7; row = 24) in Patagonia is from a row with data in only one SU. The north-south distribution of family richness (Fig. 7B) exhibits a similar pattern to that of species richness (maximum: R^2 = 0.51, b = -0.13; mean: R^2 = 0.32, b = -0.04; $P << 0.005$).

The west-east gradient of species richness is shown in Fig. 8A: it increases from west to east (maximum and mean: R^2 = 0.64; $P <<$ 0.005; maximum: b = 1.36; mean: b = 0.74),

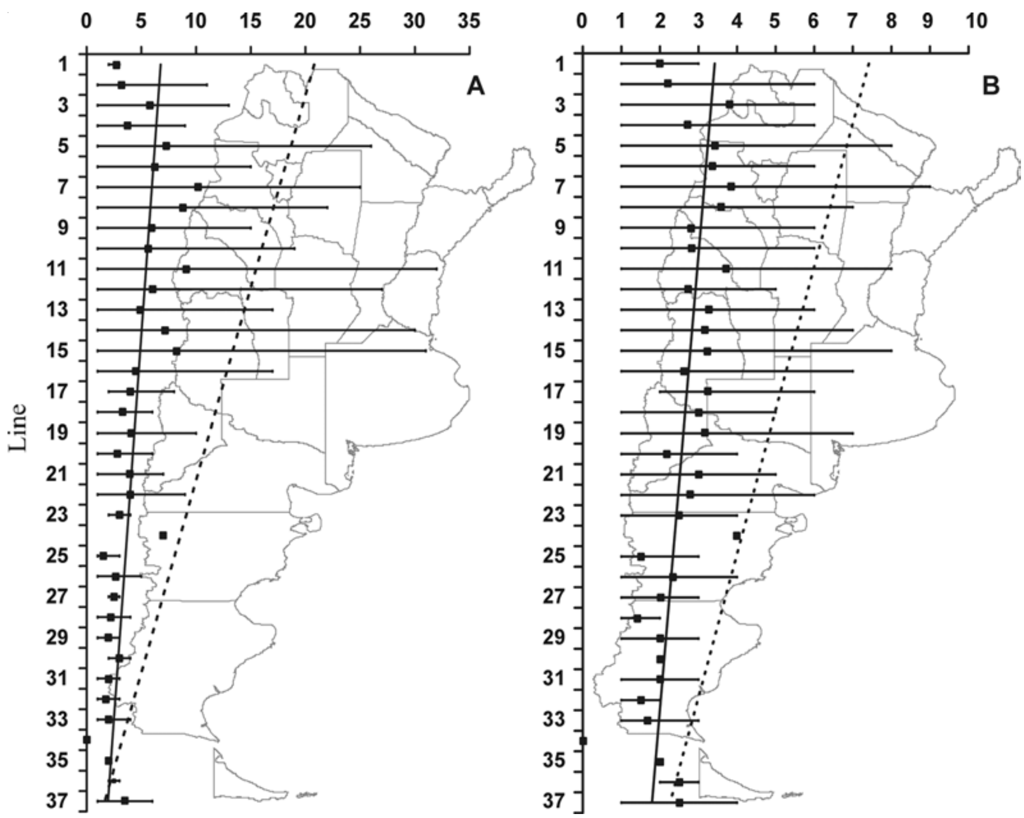

FIG. 7. North-south richness gradients expressed as mean (black dots and continued line), maximum (dashed), and range of values for SUs in each row of SUs. A: Species; B: Families.

with a greater overall range than in the north-south gradient. If only the northern region is considered (Fig. 8B), comprising mainly the big rivers of the Del Plata basin (Paraná, Uruguay and Río de la Plata), there is a strong increase in species richness from west to east (maximum: $R^2 = 0.73$; $b = 1.68$; mean: $R^2 = 0.72$; $b = 0.84$; $P << 0.005$). However, when only the southern area is considered (Fig. 8C) no trend was found (maximum: $R^2 = 0.28$; $b = -0.4$; $P = 0.12$; mean: $R^2 = 0.0007$; $b = 0.01$; $P = 0.95$). The ranges of richness are higher in the west, along column two where are located the majority of the great lakes, and along column five around the cities of Neuquén and Cipolletti and at some areas of Tierra del Fuego Province.

There are forty (40) endemic species in Argentina: Thiaridae (3), Ampullariidae (1), Cochliopidae (10), Lithoglyphidae (11), Chilinidae (11), Lymnaeidae (2), and Physidae (2). Notably, of the species of Lithoglyphidae, Cochliopidae, and Chilinidae, 50%, 62.5%, and 68.7%, respectively, are endemic. Among the 45 species evaluated as endangered on the basis of the criteria given in the Methods (Table 1), 32 are endemic, ten have only been reported from their type localities, 19 have no recent records, 25 have a continuous restricted distribution and six a discontinuous one. Fifteen of these endangered species occur in protected areas.

Only four exotic freshwater gastropod species are reported in Argentina: *Physella*

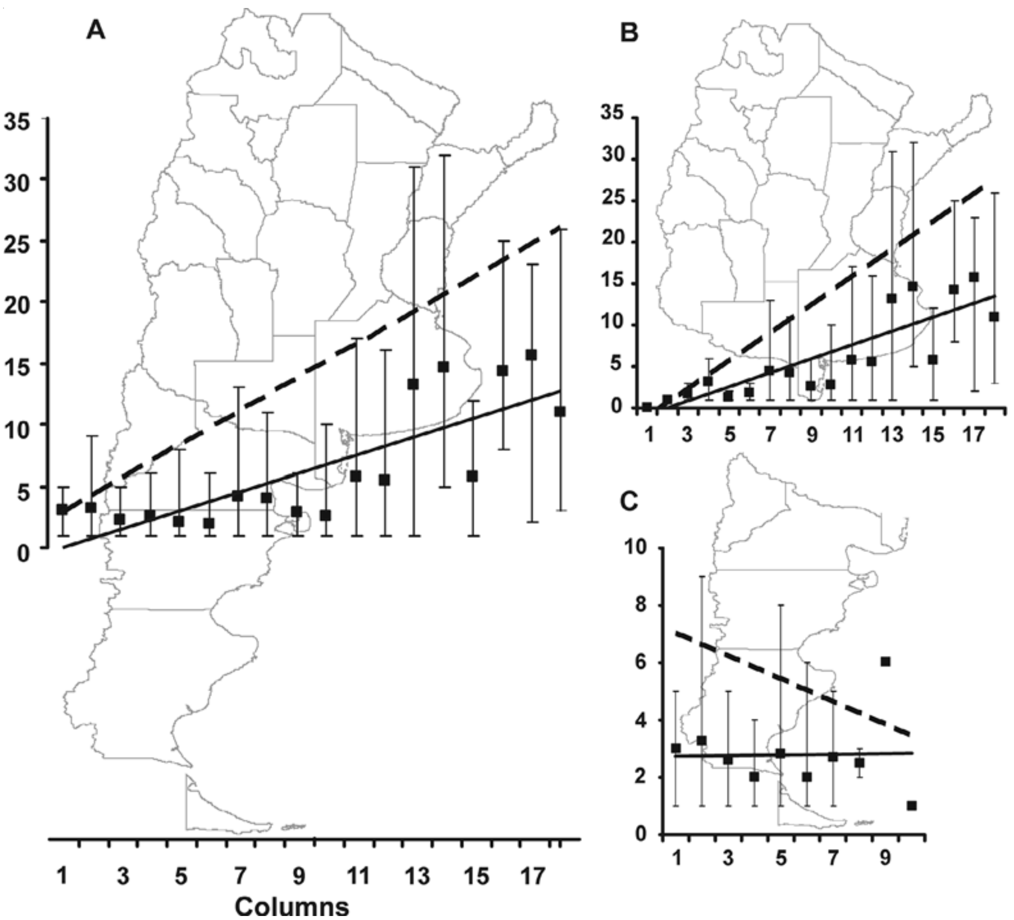

FIG. 8. West-east species richness gradient expressed as mean (black dots and continued line), maximum (dashed), and range of values for SUs in each row of SUs. A: All of Argentina; B: northern Argentina; C: southern Argentina.

cubensis (Pfeiffer, 1839), *P. venustula* (Gould, 1848) (Miquel & Zelaya, 1999) (Physidae); *Lymnaea columella* (Say, 1817) (Lymnaeidae); and *Melanoides tuberculata* Müller, 1758 (Thiaridae) (Castellanos & Miquel, 1991; Quintana et al., 2001–2002).

TABLE 1. Endangered native species: CRD: continuous restricted distribution; DRD: discontinuous restricted distribution; E: endemic; PA: species occurring in protected areas; TL: only known from the type locality; WRR: without recent records. Species authors and dates are included in Appendix 1.

Family	Species	E	TL	WRR	CRD	DRD	PA
Thiaridae	*Aylacostoma chloroticum*	X	X				
	A. guaraniticum	X	X				
	A. stigmaticum	X	X				
Ampullariidae	*Asolene platae*	X			X		
	Felipponea elongata				X		
	F. iheringi				X		
Cochliopidae	*Heleobia castellanosae*	X		X	X		
	H. conexa	X				X	
	H. isabelleana			X	X		
	H. kuesteri	X			X		
	H. montana	X		X	X		
	H. occidentalis	X		X		X	
	H. peiranoi	X	X	X			
	H. rionegrina	X	X	X			X
	H. tucumana	X		X			
	H. sublineata	X	X	X			
	H. vianai	X		X			
Lithoglyphidae	*Potamolithus concordianus*	X	X	X			
	P. valchetensis	X	X				X
	P. quadratus			X	X		
	P. tricostatus	X		X	X		X
	P. agapetus	X			X		
	P. dinochilus	X			X		
	P. catherinae				X		
	P. conicus	X			X		X
	P. doeringy				X		
	P. hidalgoi	X			X		
	P. microtauma				X		
	P. orbignyi				X		X
	P. bushii	X			X		X
	P. simplex	X			X		X
Glacidorbidae	*Gondwanorbis magallanicus*					X	X
Chilinidae	*Chilina aurantia*			X	X		X
	C. guaraniana	X	X	X			
	C. megastoma	X				X	X
	C. neuquenensis	X			X		X
	C. perrieri	X		X	X		
	C. portillensis	X		X	X		
	C. strebeli	X				X	X
Lymnaeidae	*Lymnaea plicata*	X	X	X			
Planorbidae	*Acrorbis petricola*					X	X
Ancylidae	*Gundlachia ticaga*				X		X
	Laevapex sp.				X		X
Physidae	*Physa aspii*	X		X			
	P. loosi	X		X			

DISCUSSION

The areas of greatest diversity of freshwater gastropods do not correspond exactly with the three ecoregions cited as having the greatest diversity in Argentina (Paranaense and Yungas rainforest and Chaco wetlands) (Brown & Grau, 1993; Bucher & Chain, 1998; Bertonatti & Corcuera, 2000). For gastropods, the SUs with the greatest diversity are found in the ecoregion of Delta and Paraná islands (Yacyretá - Posadas and Río de La Plata SUs) (Brazilic subregion) and in La Pampa ecoregion (Bahía Blanca) (Transitional Zone). Paranaense and Yungas rainforest follow in importance in diversity values. With respect to the Paranaense rainforest, Bonetto & Hurtado (1999) reported two species of *Aylacostoma* (Thiaridae) and many species of Chilinidae and *Heleobia* from the Iguazú River and its falls. However, the present work does not confirm the presence of *Aylacostoma* species in the Iguazú River. Also, in this study only one species of Chilinidae (*Chilina megastoma* Hylton Scott, 1958) and one undetermined species of *Heleobia* were recorded from the Iguazú River.

The Del Plata basin has the highest richness and diversity in Argentina, because three groups of gastropods with clearly different distribution patterns co-occur in this region. The first group includes species of Planorbidae, Ampullariidae, Thiaridae, Physidae, and Ancylidae, families with wide distribution that reach their southern limit in this area. Among the Planorbidae, *Drepanotrema* spp. is an endemic group from southern Texas to South America (Baker, 1945), and *Biomphalaria* spp. are also found in Africa and North America. The Ampullariidae are found in Africa, Asia, and Central and South America. The Thiariidae occur in South America, Africa, and Asia. The Physidae and Ancylidae are the most cosmopolitan groups. The second group comprises the Chilinidae, which has a southern distribution, with its greatest richness in the Chilean-Patagonian subregion, but which reaches its northern limit in northeast Argentina around the Tropic of Capricorn. The Lithoglyphidae constitute the third group and are almost entirely endemic to this basin, being most prevalent in the Uruguay River.

The absence of species of the second and third group beyond the Tropic of Capricorn, and the presence in the south of species of the first group, several coming from Holartic region, support the suggestions of Parodiz (1977) that at the beginning of the Tertiary, a very rich fauna of freshwater molluscs and mammals were involved in a unique migratory in a north-south orientation.

According to Bonetto (1994), the Transitional Zone, which has no characteristics of its own, only includes the Central Endorheic basins. Its fauna is more similar to the Brazilic one, as has been observed for fishes (A. Scione, pers. comm.). This zone marks the western distributional limit of the Paranoplatensean (the Del Plata basin) ichthyofauna, with species of Characidae and Loricariidae (López et al., 2002). The Ampullariidae have a similar distributional limit. The Transitional Zone shares seven species of freshwater gastropods with the Brazilic subregion but only three with the Chilean-Patagonian subregion.

In the Chilean-Patagonian subregion, besides the Chilinidae, there is one species of Glacidorbidae, *Gondwanorbis magallanicus* (Meier-Brook & Smith, 1976). This family, with about 20 species in Oceania (Ponder & Avern, 2000), constitutes a disjunctive element of distribution, that is, South America-Oceania.

In southern South America a north-south latitudinal gradient in species richness is a widely recognised pattern for many taxa and habitats (Taylor & Gaines, 1999). Brazil extends from 5°N to 34°S and harbours about 181 native species and subspecies and six exotic species of freshwater snails (M.C. Mansur, per. comm.). To the south, Argentina, extending from 22°S to 55°S, has 97 native species and four exotic taxa. This decrease between Brazil and Argentina and within Argentina could be explained through Rapoport's rule. The increase of species richness from west to east is evident only in the northern part of Argentina, where the eastern area includes the big rivers of the Del Plata basin. When analysing the southern part of Patagonia, the highest richness values are found in the west, where the great lakes of the Andes act as reservoirs of this mollusc fauna, in contrast to the northern area, which lacks great lakes, but the south of Argentina is the shape of an inverted cone, wherein the Andean region and its lakes move to the southeast on the grid, thereby reducing the west-east richness gradient.

Regarding endemism in the freshwater gastropods of Argentina, Castellanos & Miquel (1991) considered there to be few endemic Basommatophora. Given that in Perú only nine species of freshwater Basommatophora are endemic (28.1%) (Ramirez et al., 2003), we consider that 15 species of Basommatophora endemic to Argentina (32.6%) is a significant number. Overall, 39.6% of the freshwater gastropod species of Argentina are endemic, with

9.9% belonging to the Cochliopidae, 10.9% to the Lithoglyphidae, and 10.9% to the Chilinidae.

Among the endangered species known only from their type localities, only the species of *Aylacostoma* (Thiaridae) have multiple records, all of them prior to the completion of the Yacyretá hydroelectric dam in 1990. This dam has greatly modified their natural habitat, turning a river with rapids and numerous falls into a lake. According to Quintana & Mercado Laczkó (1997), these species can be considered extinct in their natural habitat. The same could have happened with *Chilina guaraniana* Castellanos & Miquel, 1980, and *Acrorbis sp*., also collected before the filling of the reservoir (Rumi, 1986).

Other species collected only from their type localities are *Heleobia rionegrina* (Gaillard, 1974) and *Potamolithus valchetensis* Miquel, 1998, from Valcheta stream of Somuncurá system (Chilean-Patagonian subregion). The latter species was found in the stomach of *Gymmocharacinus bergi* Steindachner, 1903, a fish endemic to the Somuncurá system. This snail is probably the only living species of *Potamolithus* that lives outside of the Del Plata basin. *Potamolithus australis* Biese, 1944 (type locality Llanquihue lake, Chile; Holotype: Museo Historia Natural de Chile 200,619), which according to López Armengol (1985), is a doubtful species as only one specimen without soft part (Holotype). However, within a historical context, *P. windhauseni* (Parodiz, 1961) was described for the Paleocene in Nahuel Niyeu, a locality that belongs to the Somuncurá system (Parodiz, 1969). The genus *Potamolithus* also includes fossil species from the Patagonia's early Tertiary, occurring at both sides of the Andes (Parodiz, 1965).

Most of the species lacking recent records occur in areas rarely sampled, with the exception of *H. castellanosae* (Gaillard, 1974), *H. isabelleana* (d'Orbigny, 1835), and three species of *Potamolithus* (*P. concordianus* Parodiz, 1966; *P. quadratus* Pilsbry & Ihering, 1911; *P. tricostatus* (Brot, 1967)). These have been recorded in areas where sampling was frequent, such as the Río de la Plata and Uruguay rivers. *Physa loosi* Holmberg, 1909, and *P. aspii* Holmberg, 1909, are represented each by only two records with incomplete geographic information.

In general, the endangered species discussed here need further morphological, systematic, biological, and ecological study in order to categorize them more adequately.

Two species with restricted distribution in Argentina but not considered as endangered as they are more widely distributed in South America are *Biomphalaria intermedia* (Paraense & Deslandes, 1962) and *B. oligoza* Paraense, 1974.

Among the exotic species, *Physella cubensis* (= *Physa acuta* Draparnaud, 1805) is a species introduced with the import and transportation of aquatic plants (Miquel & Zelaya, 1999). The rare findings of *P. venustula* in Argentina do not allow us to make a conclusion about its exotic or native character. *Melanoides tuberculata* is considered an invasive species in other neotropical areas (Fernández et al., 2003). This species was introduced to Texas, United States, in the 1960s (Murray, 1964), Brazil in the 1970s, and Argentina by the end of the 1990s, when it was found in the reservoir of the Yacyretá hydroelectric dam. Finally, we should mention the risk of introduction of *Helisoma duryi* (Wetherby, 1879) (Rumi et al., 2002) in Buenos Aires Province, because of the introduction and commercialization of aquatic plants with this snail species.

The relationship between record density and richness has an asymptotic tendency because the SUs with the highest numbers of records also had the highest richness, that is, the Rio de la Plata and Parque Nacional Iguazú SUs. These results can be interpreted that there is a low probability that more species in those areas could be found**.** The sparse records (SUs with no data) from southern Argentina may be due to few roads in the Southern-Patagonian and Desaguadero and Colorado rivers areas, making large areas inaccessible. At least for molluscs, as shown in Fig. 2, greater sampling effort (and biological studies) has been undertaken in the Río de la Plata than elsewhere in Argentina. Most of the records derive from exploratory expeditions at the beginning of the twentieth century. Further focused sampling programs are necessary. In spite of these problems, our results show general trends in freshwater gastropod richness and diversity that will help guide future actions related to their conservation.

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APPENDIX 1

Species list with taxonomic remarks. Material examined (record numbers) by collection: MLP (Museo de La Plata); MACN (Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”); FML (Fundación Miguel Lillo). *: Material from private collections; TM: Type Material; RM: Reference Material.

CAENOGASTROPODA Cox, 1960

Ampullariidae Gray, 1824	MLP	MACN	FML	Reference Lot
Gen. *Asolene* d’Orbigny, 1875				
A. (A.) platae (Maton, 1809)	15			MLP: 361 (RM)
A. (A.) pulchella (Anton, 1839)	19	34	1	MLP: 360 (RM)
A. (A.) spixii (d’Orbigny, 1835)	20		1	MLP: 10932 (RM)
Gen. *Felipponea* Dall, 1919				
F. elongata (Dall, 1921)	2			MLP: 6678 (RM)
F. iheringi (Pilsbry, 1933)	2	9		MLP: 8820 (RM)
F. neritiniformis (Dall, 1919)	8	3		MLP: 5338 (RM)
Gen. *Marisa* Gray, 1824				
M. planogyra Pilsbry, 1933	11	12		MLP: 359 (RM)
Gen. *Pomacea* Perry, 1810				
P. canaliculata (Lamark, 1822)	191	60	29	MLP: 281 (RM)
P. insularum (d’Orbigny, 1835)	2	7	1	MLP: 341 (RM)
P. scalaris (d’Orbigny, 1835)	31	23	4	MLP: 358 (RM)
Gen. *Pomella* Gray, 1847				
P. (P.) americanista (Ihering, 1919)	15	5	3	MACN: 8776 (TM)
P. (P.) megastoma (G. B. Sowerby I, 1825)	34	5	1	MLP: 1187 (RM)

Remarks: For the nomenclature of these species, the revision of Cowie & Thiengo (2003) was followed. *Pomacea insularum*: possible synonym of *Pomacea gigas* (Spix, 1827) (Castellanos & Fernández, 1976; Cowie & Thiengo, 2003). Lot MLP 11359 corresponds to the syntype of *P. canaliculata chaquensis*.

Thiaridae Troschell, 1857	MLP	MACN	FML	Reference Lot
Gen. *Aylacostoma* Spix, 1827				
A. chloroticum Hylton Scott, 1954	2			MLP: 10958 (TM)
A. guaraniticum (Hylton Scott, 1951)	3			MLP: 11213 (TM)
A. stigmaticum Hylton Scott, 1954	3			MLP: 10963 (TM)
Gen. *Melanoides* Oliver, 1804				
M. tuberculatus (Müller, 1774)	*			

Remarks: Castellanos (1981), with a synonymy of each species, and Quintana & Mercado Lackzó (1997) were followed. *Aylacostoma cingulatum* Hylton Scott (in schedule) was not taken into account as well as a new morphotype (Quintana & Mercado Lackzó, 1997), because there is as yet no proper description.

Cochliopidae Tryon, 1866	MLP	MACN	FML	Reference Lot
Gen. *Heleobia* Stimpson, 1865				
H. australis (d'Orbigny, 1835)	9	11		MLP: 4049 (TM)
H. castellanosae (Gaillard, 1974)	3			MLP: 4052 (TM)
H. conexa (Gaillard, 1974)	6			MLP: 4053 (TM)
H. guaranitica (Doering, 1884)	3			MLP: 4441 (RM)
H. hatcheri (Pilsbry, 1911)	18	3		MLP: 373 (RM)
H. isabelleana (d'Orbigny, 1835)		1		MACN: 28791 (RM)
H. kuesteri (Strobel, 1874)		4	2	FML: 5813 (RM)
H. montana (Doering, 1884)	1	1		MLP: 9153 (RM)
H. occidentalis (Doering, 1884)	1			MLP: 9097 (RM)
H. parchappii (d'Orbigny, 1835)	16	16		MLP: 11746 (RM)
H. peiranoi (Weyrauch, 1963)			1	FML: 41 (TM)
H. piscium (d'Orbigny, 1835)	9	14	1	MLP: 6760 (RM)
H. rionegrina (Gaillard, 1974)	1	1		MLP: 4050 (TM)
H. sublineata (Pilsbry, 1911)	*			
H. tucumana (Gaillard, 1974)	3		1	MLP: 4051 (TM)
H. vianai (Parodiz, 1960)	4	2		MLP: 387 (RM)

Remarks: According to Davis et al. (1982), *Littoridina australis* and the related species of Brazil, Uruguay and Argentina are included in the genus *Heleobia*. According to Kabat & Hershler (1993), *Strobeliella* Cazzaniga, 1981, is a synonym of *Heleobia*. The synonymic list of this family was published by Gaillard & Castellanos (1976) based on studies of the shell and penis morphology. Cazzaniga (1981) mentions *H. vianai* as a possible synonym of *H. occidentalis*. *Heleobia scotti* (Pilsbry, 1911) was not considered due to incomplete geographic information. *Helobia isabelleana* (type locality: Montevideo, Uruguay) was not included in the list of species of the Uruguay by Scarabino (2004).

Lithoglyphidae Troschel, 1857	MLP	MACN	FML	Reference Lot
Gen. *Potamolithus* Pilsbry, 1896				
P. agapetus Pilsbry, 1911	21	5		MLP: 4650 (RM)
P. buschii (Frauenfeld, 1865)	24	13		MLP: 4621 (RM)
P. callosus Pilsbry, 1925	3	1		MLP: 4615 (RM)
P. catharinae Pilsbry, 1911	*			
P. concordianus Parodiz, 1966		1		MACN: 17334 (RM)
P. conicus (Brot, 1867)	2	13		MLP: 4623 (RM)
P. dinochilus Pilsbry, 1896	1			MLP: 4615 (RM)
P. doeringi Pilsbry, 1911	6	2		MLP: 4617 (RM)
P. hidalgoi Pilsbry, 1896	2			MLP: 371 (RM)
P. iheringi Pilsbry, 1896	4	3		MLP: 4615 (RM)
P. lapidum (d'Orbigny, 1835)	19	26		MLP: 371 (RM)
P. microthauma Pilsbry, 1896	2	1		MLP: 9948 (RM)
P. orbignyi Pilsbry, 1896	1	4		MLP: 4623 (RM)
P. paranensis Pilsbry, 1911	6	3		MLP: 4614 (RM)
P. peristomatus (d'Orbigny, 1835)	7	1		MLP: 4618 (RM)
P. petitianus d'Orbigny, 1840	3	17		MLP: 4623 (RM)
P. philipianus Pilsbry, 1911	8	4		MLP: 4616 (RM)
P. quadratus Pilsbry & Ihering, 1911		1		MACN: 17338 (RM)
P. rushii Pilsbry, 1896	2	1		MLP: 4615 (RM)
P. simplex Pilsbry, 1911	2	1		MLP: 4623 (RM)
P. tricostatus (Brot, 1867)	2	1		MLP: 4615 (RM)
P. valchetensis Miquel, 1998		3		MACN: 3411 (TM)

Remarks: *Potamolithus jacuhyensis* Pilsbry, 1899, was mentioned by Parodiz (1965), but in later revisions it is considered present only in Brazil (López Armengol, 1985). Likewise, no lot was found in the collections consulted. López Armengol (1985) published the synonymy list of this family, which was then completed by López Armengol & Darrigran (1998).

HETEROBRANCHIA Burmeister, 1837

Glacidorbidae Ponder, 1986	MLP	MACN	FML	Reference Lot
Gen. *Gondwanorbis* Ponder, 1986				
G. magallanicus (Meier-Brook & Smith, 1976)	2			MLP: 5503 (RM)

Remarks: Only one species belongs to the Glacidorbidae in South America. According the revision of *Glacidorbis* by Ponder & Avern (2000), the genus is restricted to Australian species and the South American taxon is assigned to *Gondwanorbis*.

Chilinidae Gray, 1828	MLP	MACN	FML	Reference Lot
Gen. *Chilina* Gray, 1828				
C. aurantia Marshall, 1924		1		MACN: 23298 (RM)
C. dombeiana (Bruguière, 1789)	8	3		MLP: 769 (RM)
C. fluminea (Maton, 1809)	15	30		MLP: 386 (RM)
C. fulgurata Pilsbry, 1911	5	7		MLP: 2262 (RM)
C. gallardoi Castellanos & Gaillard, 1981	5	7		MLP: 4096 (TM)
C. gibbosa G. B. Sowerby I, 1839	16	25		MLP: 698 (RM)
C. guaraniana Castellanos & Miquel, 1980		1		MACN: 568 (TM)
C. megastoma Hylton Scott, 1958	9			MLP: 11068 (TM)
C. mendozana Strobel, 1874	3			MLP: 7391 (RM)
C. neuquenensis Marshall, 1933	1	1		MLP: 8262 (RM)
C. parchappii (d'Orbigny, 1835)	28	37		MLP: 764 (RM)
C. patagonica Sowerby II, 1874	4	2		MLP: 2903 (RM)
C. perrieri Mabille, 1833	2			MLP: 4102 (RM)
C. portillensis Hidalgo, 1880	2			MLP: 2967 (RM)
C. rushii Pilsbry, 1911	4	3		MLP: 8276 (RM)
C. strebeli Pilsbry, 1911	1	2		MLP: 6725 (RM)

Remarks: Castellanos & Gaillard (1981) prepared a synonymic list of this family. The material of *C. guaraniana* cited as deposited in the MLP collection by Castellanos & Miquel (1980) was not found in that collection. Lots 9927 (Paratype, Río Cochuna) (TC) and 9954 from MACN correspond to *C. fluminea tucumanensis.* At present, the species of this family are under revision.

Lymnaeidae Rafinesque, 1815	MLP	MACN	FML	Reference Lot
Gen. *Lymnaea* Lamarck, 1799				
"L." columella Say, 1817	8	2		MLP: 9234 (RM)
L. diaphana King, 1830	8	5	4	MLP: 9245 (RM)
L. pictonica Rochebrune & Mabille, 1885	1	3		MLP: 9253 (RM)
L. plicata Hylton Scott, 1953	3			MLP: 11264 (TM)
L. viatrix (d'Orbigny, 1835)	19	30	11	MLP: 11266 (TM)

Remarks: Castellanos & Landoni (1981) published a synonymic list of this family. There is no agreement among specialists with respect to the generic location of "*L.*" *columella*: Paraense (1983) places it in that genus whereas Hylton Scott (1953), Walter (1968), Castellanos & Landoni (1981), and Rudolph (1983) have it as *Pseudosuccinea columella*.

Planorbidae Rafinesque, 1815	MLP	MACN	FML	Reference Lot
Gen. *Antillorbis* Harry & Hubendick, 1963				
A. nordestensis (Lucena, 1954)	8			MLP: 7015 (RM)
Gen. *Acrorbis* Odhner, 1937				
A. petricola Odhner, 1937	8			MLP: 5089 (RM)
Gen. *Biomphalaria* Preston, 1910				
B. intermedia (Paraense & Deslandes, 1962)	*			
B. occidentalis Paraense, 1981	1			MLP: 7162 (RM)
B. oligoza Paraense, 1974	1			MLP: 11956 (RM)
B. orbignyi Paraense, 1975	5			MLP: 2261 (RM)
B. peregrina (d'Orbigny, 1835)	55	94	12	MLP: 780 (RM)
B. straminea (Dunker, 1848)	17	9		MLP: 7850 (RM)
B. tenagophila (d'Orbigny, 1835)	66	21	8	MLP: 350 (RM)
Gen. *Drepanotrema* Fischer & Crosse, 1880				
D. anatinum (d'Orbigny, 1835)	13	1		MLP: 4441 (RM)
D. cimex (Moricand, 1839)	13			MLP: 6757 (RM)
D. depressissimun (Moricand, 1839)	4	2		MLP: 5324 (RM)
D. heloicum (d'Orbigny, 1835)	3	1		MLP: 8534 (RM)
D. kermatoides (d'Orbigny, 1835)	21	18		MLP: 2136 (RM)
D. lucidum (Pfeiffer, 1839)	20	1		MLP: 7004 (RM)

Remarks: Rumi (1991) prepared a synonymic list of this family. For Apipé Falls in Corrientes Province, the presence of *Acrorbis sp.* (Rumi, 1986) was recorded. Lot MLP 5089 corresponds to the syntype of *Acrorbis odhneri*, a species is now synonymized with *A. petricola*.

Ancylidae Rafinesque, 1815	MLP	MACN	FML	Reference Lot
Gen. *Anisancylus* Pilsbry, 1924				
A. obliquus (Broderip & G. B. Sowerby I, 1832)	5			MLP: 2154 (RM)
Gen. *Gundlachia* Pfeiffer, 1849				
G. ticaga (Marcus & Marcus, 1962)	*			
Gen. *Hebetancylus* Pilsbry, 1913				
H. moricandi (d'Orbigny, 1837)	15			MLP: 3610 (RM)
Gen. *Laevapex* Walker, 1903				
Laevapex sp.	*			
Gen. *Uncancylus* Pilsbry, 1913				
U. concentricus (d'Orbigny, 1835)	26			MLP: 2153 (RM)

Remarks: Barbosa dos Santos (2003) was followed. Fernández (1981) published the synonymic list of this family. We considered Ancylidae as a family, although Bouchet & Rocroi (2005) include the tribu Ancylini into Planorbidae.

Physidae Fitzinger, 1833	MLP	MACN	FML	Reference Lot
Gen. *Physa* Draparnaud, 1801				
P. aspii Holmerg, 1909		1		MACN: 1407 (RM)
P. loosi Holmerg, 1909		1		MACN: 1404 (RM)
Gen. *Physella* Haldeman, 1843				
"P. cubensis"	12	2		MACN: 32605 (RM)
"P." venustula (Gould, 1848)	*			
Gen. *Stenophysa* Martens, 1898				
"S." marmorata (Guilding, 1828)	19	65	7	MLP: 7193 (RM)

Remarks: This family is still the object of important systematic revisions. According to the revision of Taylor (2003), *P. loosi* and *P. aspii* would be categorized as *incertae sedis*. Taylor (2003) placed *Physa acuta* Draparnaud, 1805, *P. cubensis* (Pfeiffer, 1839), and *P. venustula* in the genus *Haitia* Clench & Aguayo, 1932, on the basis of the absence of gland tissue in the sheath of the penis and considered that the species present in Argentina is *Haitia acuta* or *Haitia mexicana* (Philippi, 1841). However, Paraense & Pointier (2003) considered *P. cubensis* to be a synonym of *P. acuta.* Taylor (2003, 2004) pointed out in addition that the distribution of "*S. marmorata*" would not reach the Argentine territory and the specimens from Argentina could belong to other entities not assigned to any generic or specific category. Thus, it was decided not to innovate in the denomination of the referred or type material until the question is solved, which does not imply an agreement with such denomination.