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Biodiversity of Terrestrial Gastropods in Two Urban Ecological Reserves in Argentina

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Urban ecological reserves in Buenos Aires city (Argentina) were intended as spaces for outdoor recreation, preservation of natural environments and protection of native species. Reserva Ecológica Costanera Sur (RECS) and Reserva Ecológica Ciudad Universitaria Costanera Norte (RECUCN) are located on the right bank of the Río de la Plata estuary. In view of the repeated appearance of non-native land snails and slugs in Argentina during the last four decades, we wanted to know to what extent the terrestrial gastropod faunas of these two reserves were composed of native or non-native species. As RECS is larger than RECUCN, we also tested the hypothesis that abundance, species richness and diversity would be higher in the former than in the latter. Fifty-two and 25 sites were sampled for terrestrial snails and slugs in RECS and RECUCN, respectively. Land gastropod species richness was similar in RECS (14 species) and RECUCN (12 species). Non-native gastropods were much more diverse and overwhelmingly more abundant than native ones. The terrestrial gastropod fauna is dominated by non-native snails and slugs (98.4% non-native individuals vs. 1.6% native in RECS, 97.5% vs. 2.5% in RECUCN), most of them never previously reported from these reserves. More than 78% of the individuals found in RECUCN belonged to the non-native snail *Vallonia pulchella*, which was the species that most contributed to the dissimilarity between reserves. This study shows that so far, urban ecological reserves in Buenos Aires city are sites where mainly exotic rather than native terrestrial molluscs are being preserved. The dominance of non-native species in these urban ecological reserves endorses the pervasive advance of synanthropic species in urban land snail assemblages already documented for other biogeographic regions.

Keywords: Land snails, Slugs, Introduced species, Buenos Aires city, Argentina

BACKGROUND

South American non-marine molluscs exhibit high species diversity (Miyahira et al. 2022), although their conservation status is often unknown because of significant gaps in knowledge (Lydeard et al. 2004; Miyahira et al. 2022). This is mainly because it is undergoing constant taxonomic, systematic and biogeographic revisions (Darrigran et al. 2020). The risk of introduction of non-native terrestrial gastropods has increased because of enhanced trade volume and commodity movements worldwide (Robinson 1999; Cowie and Robinson 2003). With the help of a citizen science database, Gladstone et al. (2020) showed that the prevalence of non-native terrestrial gastropods in the United States increased through time and is largely associated with urbanized areas with high human population density. Studies on the biodiversity of terrestrial gastropods in Brazil and California also found that urban areas were mainly populated by non-

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native or synanthropic species (Vendetti et al. 2018; Rangel et al. 2021). Fernandes et al. (2025) found 35.5% synanthropic species of land snails within a conservation unit in Rio de Janeiro, and that anthropic sites were clearly not favourable for the native species. On the contrary, reserves in more natural areas show greater biodiversity of native terrestrial gastropods, with few or no non-native species (Salas Oroño et al. 2007; Salvador et al. 2018).

Among the major zoological groups, non-marine molluscs have the largest number of documented extinctions and threatened species worldwide (IUCN 2026), but a great number of species being introduced globally are molluscs (*e.g.*, Darrigran et al. 2025). Non-native gastropods are being introduced to most parts of the world for intentional (*e.g.*, biological control, medicinal purposes and aesthetics) or unintentional (*e.g.*, horticultural products, shipment of commodities, soil transportation) reasons (Robinson 1999; Cowie and Robinson 2003). The horticultural industry is regarded as an important vector for the inadvertent introduction of non-native slugs and snails (Cowie and Robinson 2003; Bergey et al. 2014; Yeung et al. 2019; Darrigran et al. 2020; Gutiérrez Gregoric et al. 2020). Quarantine measures have only limited efficacy in preventing the spread of gastropods, particularly for small species that are often transported inadvertently (Cowie et al. 2008). Argentina is no exception to the appearance and spread of non-native land snails and slugs, a process that increased in the last four decades (Miquel et al. 1995; Parent and Miquel 1999; Rumi et al. 2010; Gutiérrez Gregoric et al. 2011 2013; Virgillito and Miquel 2013; Díaz et al. 2017; Beltramino et al. 2018; Serniotti et al. 2019; Daglio et al. 2020; Darrigran et al. 2020 2023; Gutiérrez Gregoric and Beltramino 2021; Miquel and Santin 2021; Pizá et al. 2022; Rau et al. 2022; Cuezzo and Dellagnola 2024). For instance, the introduction in Misiones province (Argentina) of the non-native snail *Ovachlamys fulgens* (Gude), which may have been facilitated by the orchid trade (Beltramino et al. 2018).

Urban habitats can harbour self-sustaining populations of rare and endangered native species. For instance, *Adelopoma paulistanum* Martins and Simone was described from an urban park from Sao Paulo, Brazil (Martins and Simone 2014). Non-native species, however, can lead to homogenization among urban regions (Kowarik 2011). Biodiversity conservation is one of the main objectives for the establishment of protected areas in human dominated landscapes (Borgström et al. 2013). Preserving the local diversity and protecting populations of rare species are some of the main goals for urban biodiversity conservation (Dearborn and Kark 2010). Nevertheless, the diversity of land snails in urban areas of Argentina has been rarely studied (Miquel and Santin 2021). In Buenos Aires city, the capital of Argentina, land gastropods have been only sporadically reported as part of more comprehensive works (*e.g.*, Virgillito and Miquel 2013; Santin and Miquel 2015; Sirolli et al. 2018; Agnolin et al. 2019). Buenos Aires City has two urban ecological reserves, Reserva Ecológica Costanera Sur (RECS) and Reserva Ecológica Ciudad Universitaria Costanera Norte (RECUCN). The terrestrial gastropod faunas of these reserves are almost totally unknown, except for isolated records (Santin and Miquel 2015; Sirolli et al. 2018), as so far no specific surveys of terrestrial gastropod diversity have been performed in these areas.

Therefore, based on this background, the main aim of this study was to compare the abundance, species richness, diversity, and composition of the terrestrial gastropod assemblages, and the proportion of non-native species in both reserves. As RECS is larger than RECUCN, we also tested the hypothesis that abundance, species richness and diversity would be higher in the former than in the latter.

MATERIALS AND METHODS

Study area

RECS and RECUCN are located on the right bank of the Río de la Plata estuary. They are separated by ca. 9.7 km (Fig. 1), but both were the result of constant anthropogenic alteration and filling of coastal areas (Marcomini and López 2004). RECS has an area of 350 ha; it was officially established in 1986, but its surface has been exposed to colonization by both native and non-native species since the 1980s (Sirolli et al. 2024). RECUCN has an area of 23 ha; land filling began gradually during the 1960s and 1970s, but only in 2018 was an agreement between the city government and Buenos Aires University signed to co-manage the area (Melzi Fiorenza et al. 2020).

Natural plant associations in RECS consist mainly of *Salix humboldtiana* Willd. (“sauce criollo”) and *Tessaria integrifolia* Ruiz and Pav. (“aliso de río”) forests, shrubs, grasslands and wetlands (Faggi and Cagnoni 1987). Frequent fires occur within the reserve, in the forest-grassland gradient (Sirolli and Kalesnik 2011). Plant assemblages in RECUCN are dominated by the invasive *Ligustrum sinense* Lour. (“ligustrina”), *L. lucidum* W.T. Aiton (“ligustro”) and *Melia azedarach* L. (“paraíso”), together with grasslands composed mainly of Poaceae and Asteraceae (Melzi Fiorenza et al. 2020).

Sampling

Sampling sites were georeferenced with a GPS. The locations and dates of all the sampling sites (52 in RECS, 25 in RECUCN, Fig. 1) are listed in table S1. Sampling sites were arranged so that all habitat types in the two reserves were represented. A soil sample with a depth of 5 cm and an area of 25 × 12.5 cm was taken from a random location within the site. In addition, the undersides of stones, bark, and fallen stems and branches were visually examined for gastropods within a radius of 2 m from the soil sample for half an hour. Soil and leaf litter from the surface of the soil sample, together with all the associated fauna of each site, were transported to the laboratory in labelled zip-lock plastic bags and sieved under water using two sieves with mesh sizes of 4 and 0.5 mm. Live specimens (land snails and slugs) and/or shells were separated from the sediment under a stereoscopic microscope and euthanized. Voucher material (live specimens and empty shells) were stored either in 70% ethanol or dry (respectively) and deposited in the National Collection of Invertebrates at the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN-In; see Table 1). All the specimens were identified to species level, except for an unknown non-native species of the family Achatinidae. Identifications took into account the original descriptions and subsequent redescriptions of the species and were performed considering both shell morphology and internal anatomical features as available.

A previous collection, gathered between 2018

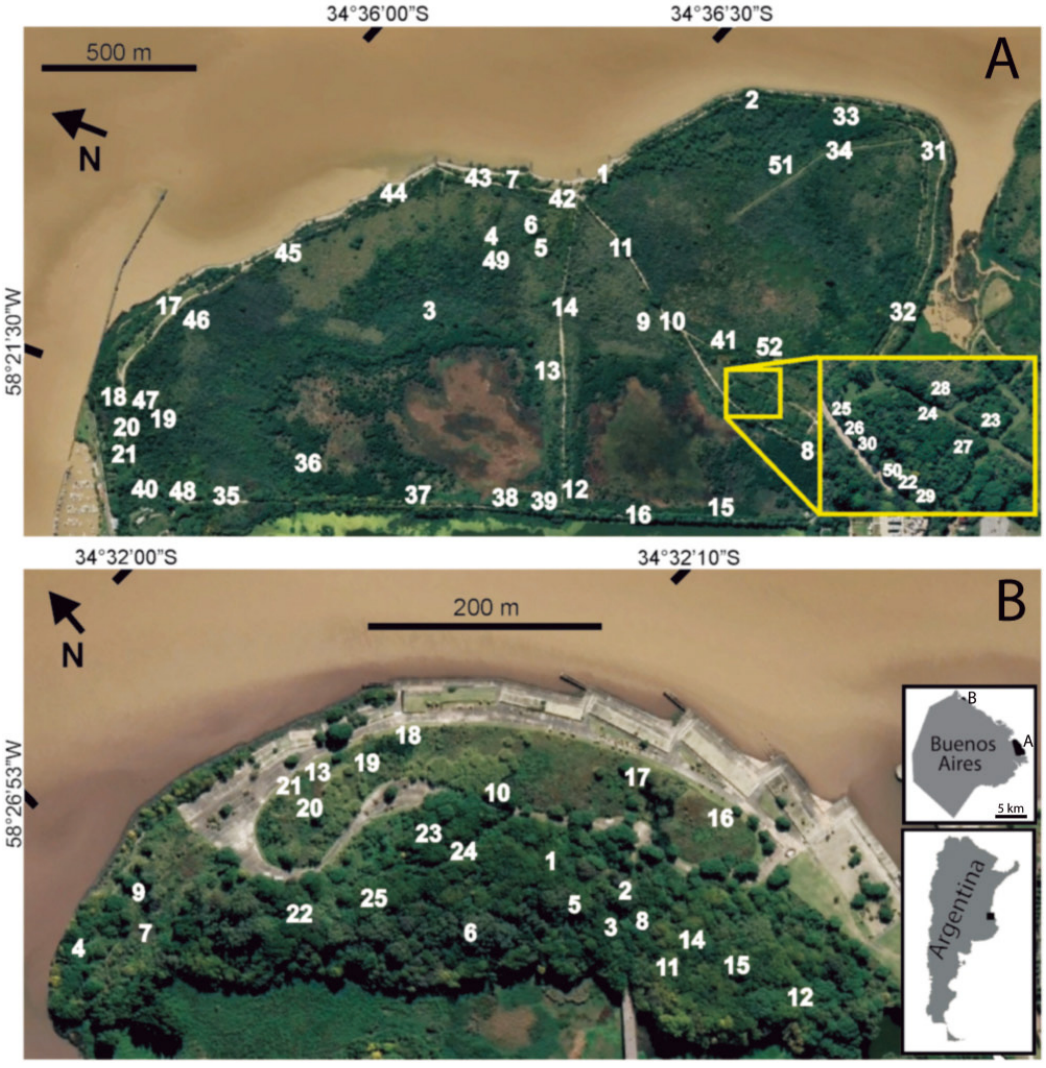

Fig. 1. Study areas, showing the location of collection sites in (A) Reserva Ecológica Costanera Sur (RECS) and (B) Reserva Ecológica Ciudad Universitaria Costanera Norte (RECUCN). These two images are a magnified version of the area in Buenos Aires map. Coordinates and dates of samples are listed in table S1. Modified from Google Earth.

Table 1. List of terrestrial gastropods found in Reserva Ecológica Costanera Sur (RECS) and Reserva Ecológica Ciudad Universitaria Costanera Norte (RECUCN)

Species	Family	Ab RECS	% RECS	Ab RECUCN	% RECUCN	Status	Area of origin	Distribution in Argentina (Provinces)	Repository information
Angustipes difficilis (Colosi)	Veronicellidae	2	3.8	×	-	N	Argentina (Santin and Miquel 2015)	Buenos Aires, Buenos Aires city, Chaco, Corrientes, Entre Ríos, Misiones, Salta, Santa Fe, Tucumán (Santin and Miquel 2015; Daglio et al. 2020)	RECS: 44117 (1 ex., e.); 44119 (1 ex., e.)
Phyllocaulis soleiformis (d'Orbigny)	Veronicellidae	-	-	×	-	N	South America (Santin and Miquel 2015)	Buenos Aires, Buenos Aires city, Catamarca, Chaco, Córdoba, Corrientes, Entre Ríos, Jujuy, La Rioja, Mendoza, Misiones, Salta, Santa Fe, Santiago del Estero, Tucumán (Santin and Miquel 2015)	RECUCN: 44457 (1 ex., e.); 44458 (1 ex., e.); 44470 (1 ex., e.)
Scolodonta enigmatica Miquel and Santin	Scolodontidae	2	3.8	-	-	NN?	Probably introduced (Miquel and Santin 2021)	Buenos Aires (Miquel and Santin 2021), Buenos Aires city (this study)	RECS: 44116 (1 ex., d.)
Allopeas gracile (Hutton)	Achatinidae	19	5.8	15	32.0	NN	East Africa, South Asia (Christensen and Weisler 2013)	Buenos Aires, Buenos Aires city, Catamarca, Corrientes, Entre Ríos, La Pampa, Misiones, Tucumán, (Miquel et al. 2015)	RECUCN: 44098 (2 exs, d.). RECS: 44109 (2 exs, d.); 44127 (2 exs, e.)
Achatinidae indet.	Achatinidae	37	3.8	1	4.0	?			RECS: 44114 (2 exs, e.)
Rumina decollata (Linnaeus)	Achatinidae	6	1.9	4	8.0	NN	Mediterranean region (Rau et al. 2022)	Buenos Aires, Buenos Aires city, Chubut, Córdoba, Entre Ríos, Jujuy, La Pampa, La Rioja, Mendoza, Misiones, Neuquen, Río Negro, San Juan, San Luis, Santa Fe, Santiago del Estero (Pizá et al. 2022)	RECUCN: 44101 (3 exs, d.). RECS: 44112 (3 exs, d.)
Cecilioides acicula (Müller)	Ferrusaciidae	5	7.7	24	24.0	NN	Palaearctic region (Díaz et al. 2017)	Buenos Aires, Santa Fe, Buenos Aires city (Miquel et al. 1995; Díaz et al. 2017)	RECUCN: 44096 (3 exs, d.). RECS: 44107 (2 exs, d.)
Vallonia pulchella (Müller)	Valloniidae	355	23.1	1,350	84.0	NN	Europe and eastern and central North America (Hayes et al. 2012)	Buenos Aires, Jujuy, La Rioja, Salta (Rumi et al. 2010; Virgillito and Miquel 2013), Buenos Aires city (this study)	RECUCN: 44094 (3 exs, e.); RECUCN: 44103 (3 exs, e.); 44104 (4 exs, d.)

Species	Family	Ab RECS	% RECS	Ab RECUCN	% RECUCN	Status	Area of origin	Distribution in Argentina (Provinces)	Repository information
Bulimulus bonariensis (Rafinesque)	Bulimulidae	13	19.2	42	40.0	N	Pampean region, Argentina (Darrigran et al. 2023)	Buenos Aires, Buenos Aires city, Córdoba, Corrientes, Chaco, Entre Ríos, Formosa, Jujuy, Misiones, Santa Fe, Tucuman (Miquel 1991; Cuezzo et al. 2013)	RECUCN: 44097 (2 exs, d.). RECS: 44108 (4 exs, d.); 44129 (1 ex., e.); 44130 (1 ex., e.); 44131 (1 ex., e.); 44132 (1 ex., e.); 44133 (1 ex., e.)
Paralaoma servilis (Shuttleworth)	Punctidae	312	38.5	230	68.0	NN	Australia (Nekola et al. 2025)	Buenos Aires, Chubut, Entre Ríos, Formosa, Jujuy, Misiones, Salta, Santa Fe, Tierra del Fuego, Tucumán (Rumi et al. 2010; Virgillito and Miquel 2013); Buenos Aires city (this study)	RECUCN: 44095 (4 exs, e.). RECS: 44105 (3 exs, d.); 44106 (3 exs, d.)
Zonitoides arboreus (Say)	Gastrodontidae	14	7.7	-	-	NN	Nearctic region and Central America (Barker 1999)	Buenos Aires, Buenos Aires city, Catamarca, Córdoba, Corrientes, Entre Ríos, Jujuy, Misiones, Salta, Santiago del Estero, Tucumán (Virgillito and Miquel 2013; Miquel et al. 2015)	RECS: 44115 (3 exs, d.); 44126 (1 ex., e.); 44136 (1 ex., e.)
Oxychilus draparnaudi (Beck)	Oxychilidae	101	21.6	25	20.0	NN	Widespread in Europe (Welter-Schultes 2012)	Buenos Aires (Virgillito and Miquel 2013), Buenos Aires city (this study)	RECUCN: 44102 (1 ex., e.). RECS: 44113 (4 exs, d.)
Hawaiia minuscula (Binney)	Pristilomatidae	121	19.6	23	12.0	NN	Apparently Nearctic (Baker 1941; Virgillito and Miquel 2013)	Buenos Aires, Buenos Aires city, Catamarca, Córdoba, Jujuy, Salta, Tucumán (Rumi et al. 2010; Virgillito and Miquel 2013)	RECUCN: 44100 (3 exs, d.). RECS: 44111 (4 exs, d.). RECS: 44135 (2 exs, e.)
Deroceras laeve (Müller)	Agriolimacidae	11	15.7	-	-	NN	Palaearctic region (Barker 1999; Araya 2015)	Buenos Aires, Chubut, Córdoba, Jujuy, Mendoza, Misiones, Neuquen, Río Negro, Salta (Fernández 1973), Tucumán (Miranda et al. 2022), Buenos Aires city (this study)	RECS: 44120 (1 ex., e.); 44121 (1 ex., e.); 44122 (1 ex. e.); 44123 (1 ex. e.); 44124 (1 ex. e.); 44125 (1 ex. e.); 44128 (1 ex. e.); 44134 (1 ex. e.); 44137 (1 ex. e.)
Cornu aspersum (Müller)	Helicidae	1	2.0	8	28.0	NN	Mediterranean region (Guiller and Madec 2010)	Widely distributed throughout Argentina (Reyna et al. 2018)	RECUCN: 44099 (1 ex., d.). RECS: 44110 (1 ex., d.)
Number of species		14		12					
Abundance		999		1722					

Ab: abundance (number of individuals). %: percentage of sites where the species was present in each reserve. N: native. NN: non-native. ×: only collected by undergraduate students of Buenos Aires University, not present during our surveys. Area of origin: original distribution of each species. Repository information: MACN-In repository number, number of specimens (ex./exs) and preservation state (d: dry; e: ethanol). Classification at the family level follows MolluscaBase (MolluscaBase eds, 2023).

and 2022 by undergraduate biology students of Buenos Aires University, added two more species [*Phyllocaulis soleiformis* (d'Orbigny), *Angustipes difficilis* (Colosi)] to the RECUCN inventory. These additional specimens, however, were neither included in the quantitative analyses nor in the accumulation curves.

According to iNaturalist records, *Bulimulus bonariensis*, *Oxychilus draparnaudi* and an undetermined subulinid species were observed in RECUCN. *Milax gagates*, *Phyllocaulis* spp. and Euconulidae spp. are also recorded in RECS by iNaturalist, but we could not confirm these records.

Data analysis

The expected number of species of the study areas was estimated statistically with the Diversity menu of EstimateS 9.1. This software was used to calculate the ICE (incidence-based coverage), Chao 2, and the first- and second-order Jackknife estimators (Colwell 2013). One hundred randomizations and a curve-fitting method were used to estimate these parameters in a species accumulation graph (Chao et al. 2009). Richness values were obtained after stabilization, *i.e.*, in the asymptotic part of the curve.

The Sørensen (or Dice) index, which is based on presence/absence data (Clarke and Warwick 2001), was used to analyse beta diversity (Whittaker 1960; Tuomisto 2010), *i.e.*, the ratio between regional (gamma, the entire reserve) and local (alpha, each individual sample) diversities. The values of this index were calculated using EstimateS for all pairwise combinations of samples within each reserve. Then, the null hypothesis of no difference between reserves in the median value of the Sørensen index was tested in *R* with the Mann-Whitney U test (Zar 2010).

A quantitative matrix of abundances was assembled with the number of specimens of each species per sample. Shannon's H ($\log_e$) diversity index and Pielou's evenness index (Pielou 1966) of each sample were calculated with the PRIMER statistical package (Clarke and Warwick 2001). The null hypotheses of no differences in species richness, evenness or in Shannon's diversity index between RECS and RECUCN were tested with the Mann-Whitney *U* test using *R* (R Core Team 2021).

Species composition was compared between reserves using *R*, by following these steps: (1) samples without terrestrial gastropods (11 in RECS, 3 in RECUCN, see table S1) were excluded from the analysis, (2) in order to obtain a balanced design and compare the two reserves based on the same number of samples, 22 samples out of 41 were randomly selected once in RECS using the function *sample* in *R*, (3) data were transformed with the *sqrt* (square root) function to decrease the excessive influence of the most abundant species, (4) a distance matrix was assembled using the function *vegdist* with the Bray-Curtis index using the package vegan (Oksanen et al. 2022), (5) a permutational multivariate analysis of variance using the distance matrix was performed using *adonis2* in *vegan*, to check whether the differences in species composition between reserves were significant, (6) a Non-metric Multidimensional Scaling analysis was performed with PRIMER, to view the ordination of samples in a bidimensional space, and (7) a SIMPER analysis was performed with PRIMER, to find which species were most responsible for the difference between reserves.

RESULTS

In total, 2,721 specimens belonging to 15 species and 12 families were collected, 999 in RECS and 1,722 in RECUCN (Table 1). Fourteen species of terrestrial snails and slugs were found in RECS and 12 in RECUCN, with 11 species in common between the two areas (Figs. 2, 3). There were more species of non-native than of native gastropods, both in RECS (11 non-native vs. 2 native species) and RECUCN (8 vs. 3) (Table 1). Non-native species were also much more abundant than native ones, both in RECS [984 (98.5%) vs. 15 (1.5%) non-native and native individuals, respectively] and RECUCN [1,680 (97.6%) vs. 42 (2.4%)] (Table 1).

Three species [*Zonitoides arboreus* (Say) (Figs. 2K, 3D), *Deroceras laeve* (Müller) (Fig. 2F) and *Scolodonta enigmatica* Miquel and Santin (Figs. 2I, 3A)] were present in RECS but absent in RECUCN. The slug *Phyllocaulis soleiformis* (Fig. 2L) was only found in RECUCN (Table 1). More than 78% of the gastropod specimens found in RECUCN belonged to only one species, the non-native snail *Vallonia pulchella* (Müller) (Figs. 2D, 3B; Table 1).

Randomized species richness curves of RECS stabilized around 13 and 14 species in three of the four applied estimators (Fig. 4A), showing that terrestrial gastropods were comprehensively sampled in this reserve, in which 14 species were found (Table 1). Accumulation curves in RECUCN, in which 10 species were found during the sampling period, stabilized between 9 and 10 species (Fig. 4B).

Alpha species richness per sample was significantly higher in RECUCN than in RECS (median RECUCN: 3 species, median RECS: 2, Mann-Whitney $U = 353$, $p = 0.0010$; Fig. 5A). Shannon's H diversity index was also significantly higher in RECUCN than in RECS ($U = 470.5$, $p = 0.045$; Fig. 5B). Evenness was significantly lower (Mann-Whitney $U = 406$, $p = 0.003$;

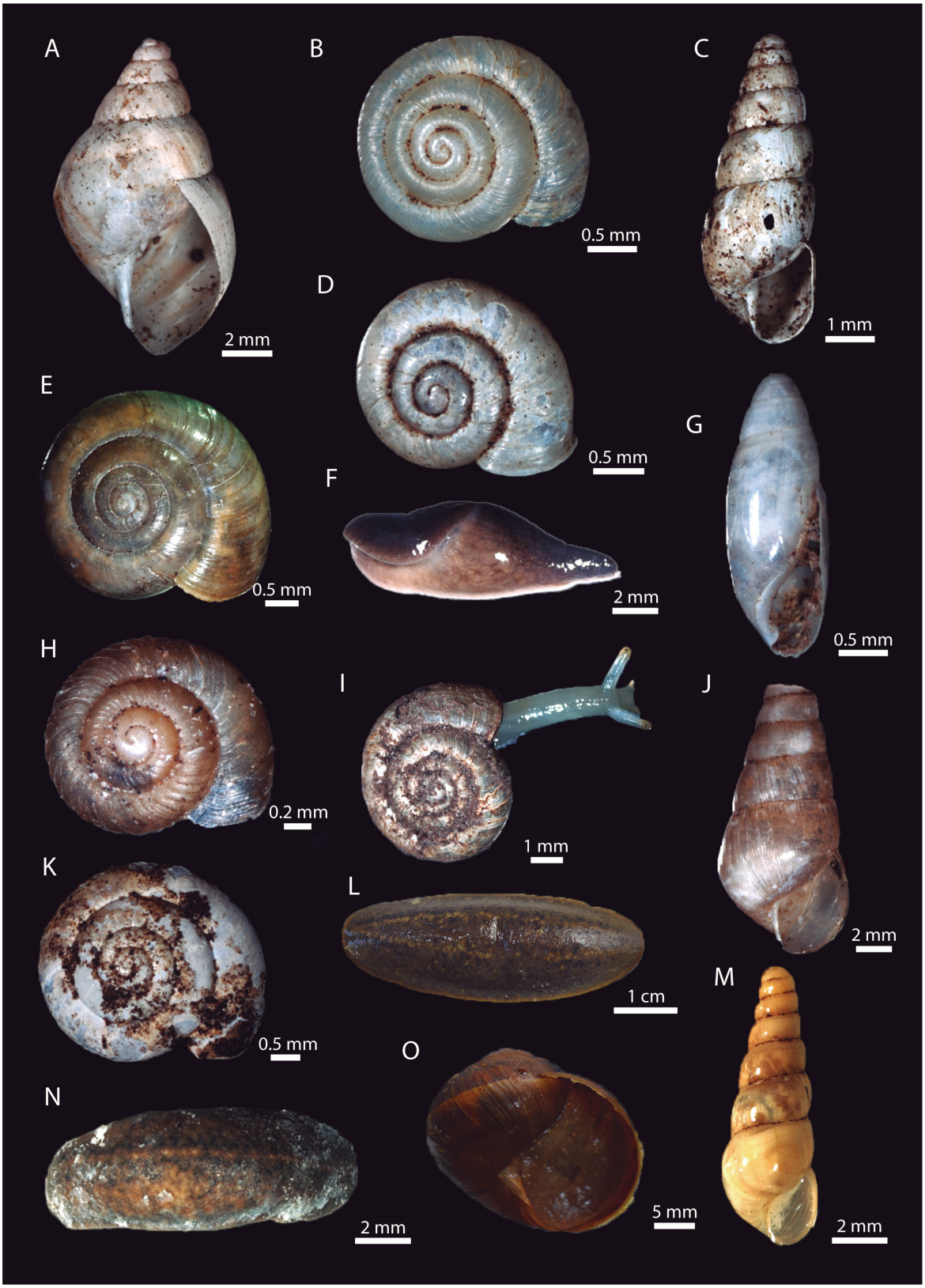

Fig. 2. Biodiversity of terrestrial molluscs found in RECS and RECUCN. A, *Bulimulus bonariensis*. B, *Hawaiia minuscula*. C, *Allopeas gracile*. D, *Vallonia pulchella*. E, *Oxychilus draparnaudi*. F, *Deroceras laeve*. G, *Cecilioides acicula*. H, *Paralaoma servilis*. I, *Scolodonta enigmatica*. J, *Rumina decollata*. K, *Zonitoides arboreus*. L, *Phyllocaulis soleiformis*. M, Achatinidae undet. N, *Angustipes difficilis*. O, *Cornu aspersum*.

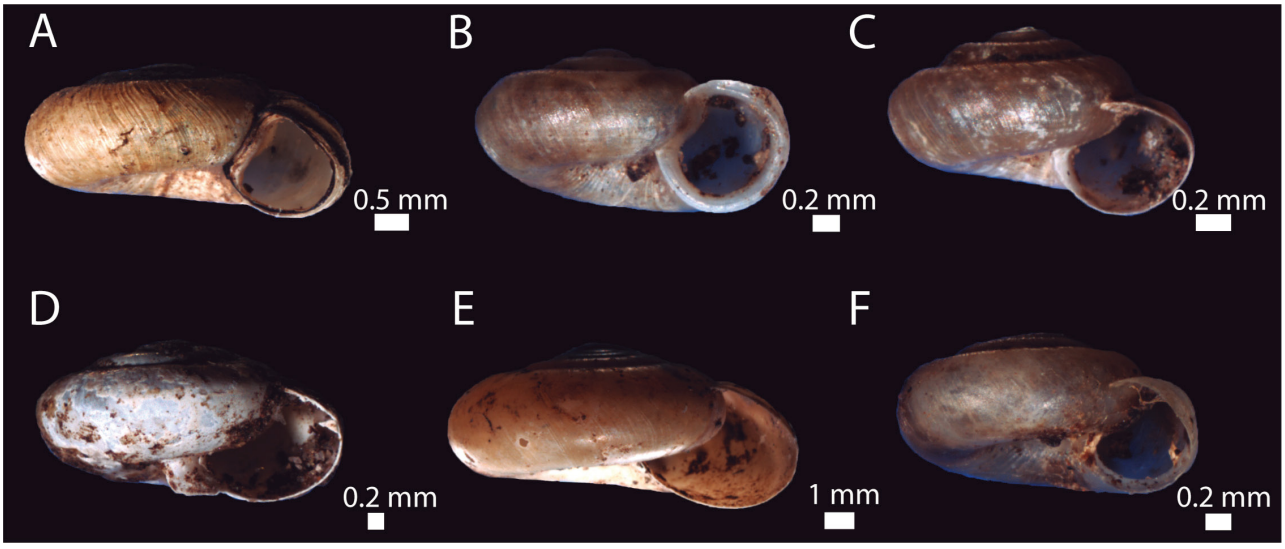

Fig. 3. Apertural view of A, *Scolodonta enigmatica*; B, *Vallonia pulchella*; C, *Paralaoma servilis*; D, *Zonitoides arboreus*; E, *Oxychilus draparnaudi* and F, *Hawaiia minuscula*.

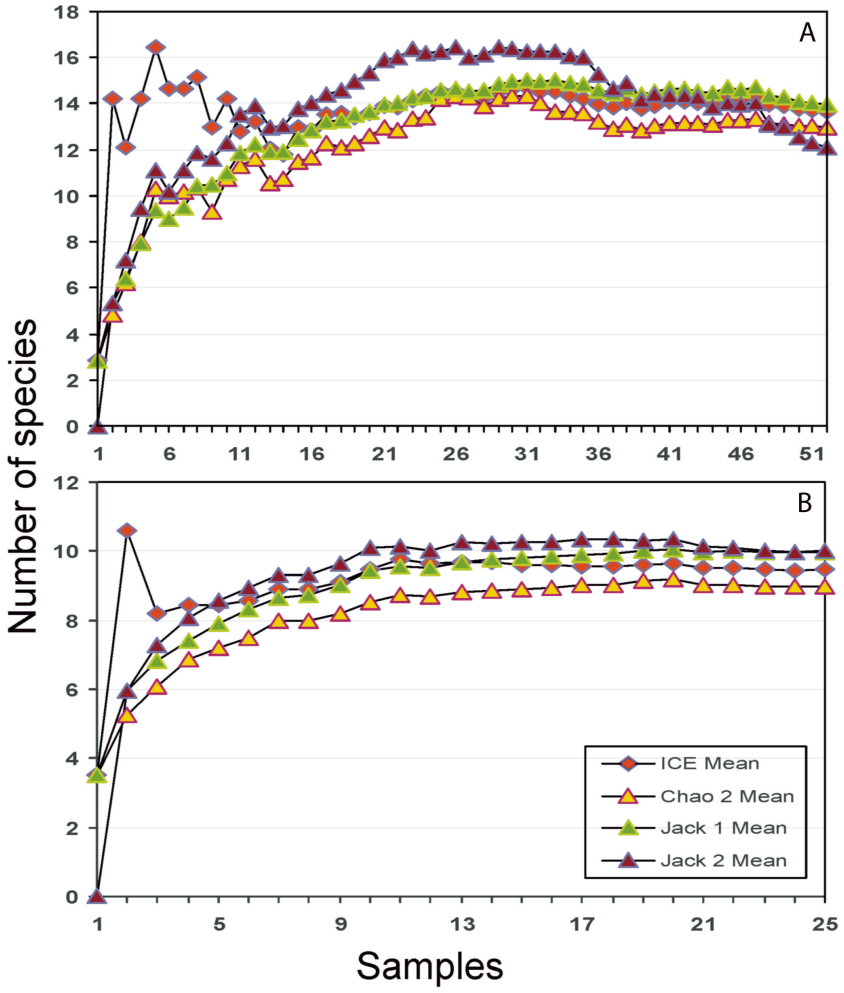

Fig. 4. Species accumulation curves comparing the values of ICE, Chao 2, first and second Jackknife estimators computed using the EstimateS 9.1 software. (A) RECS. (B) RECUCN.

Fig. 5C) in RECUCN than in RECS because of high abundance of the non-native snail *Vallonia pulchella*. The values of the Sørensen index were significantly higher in RECUCN than in RECS (median RECUCN: 0.67, median RECS: 0.5, Mann-Whitney $U = 138{,}690$, $p < 0.001$), meaning that species turnover between samples was significantly higher in RECS than in RECUCN (Fig. 5D).

There were no clear patterns as to the area of origin of the non-native species: introduced snails and slugs were originally native to Nearctic, Palaearctic and Mediterranean regions, Central and South America, Africa, South Asia and Australia (Table 1). Some of these species, however, are widely invasive globally and the immediate origins of their populations in Argentina are largely unknown. Most species are widely distributed in Argentina, none of them being only present in Buenos Aires city (Table 1).

Differences in species composition between the two reserves were highly significant ($p < 1 \times 10^{-4}$, Table S2, Fig. 6). The species that most contributed to the dissimilarity between reserves was *Vallonia pulchella*,

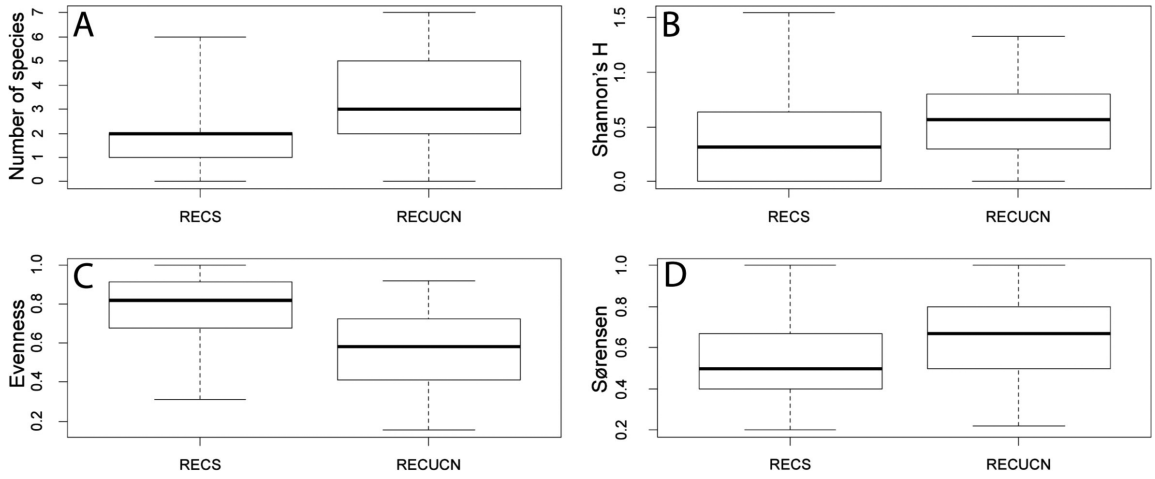

Fig. 5. (A) Species richness, (B) Shannon's H diversity index, and (C) Pielou's evenness of each sample in RECS and RECUCN; (D) Sørensen coefficient between all pairs of samples in RECS and RECUCN. All the differences between reserves were statistically significant. Solid line: median, box: upper and lower quartiles, whiskers: range.

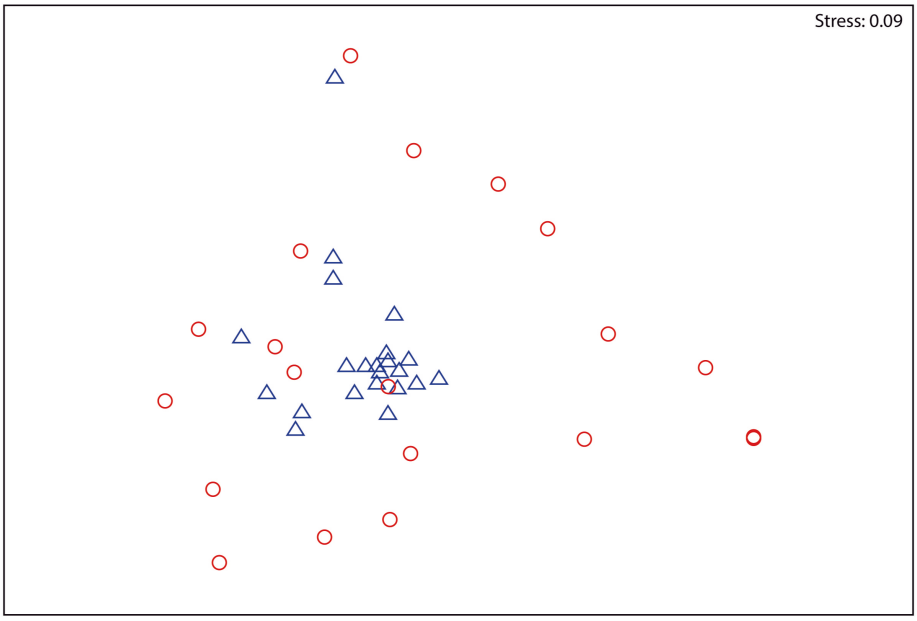

Fig. 6. Ordination of samples from RECS (circles) and RECUCN (triangles) by Non-metric Multidimensional Scaling. The low stress value shows that the bidimensional representation corresponds to a good ordination with no real prospect of a misleading interpretation (Clarke and Warwick 2001).

which was much more abundant in RECUCN than in RECS (Tables 1, S3).

DISCUSSION

The present study is the first intensive sampling of terrestrial gastropods in the two urban protected areas of Buenos Aires City, RECS and RECUCN. Records for 14 species are provided for these areas (Table 1).

Information on the occurrence of terrestrial gastropods in the study area is scarce. Only three other species have been mentioned in the literature from Buenos Aires city, but were not found by us in RECS and RECUCN: the non-native slugs *Deroceras reticulatum* (Müller) and *Ambigolimax valentianus* (A. Férussac), and the native slug *Phyllocaulis variegatus* (Semper) (Virgillito and Miquel 2013; Santin and Miquel 2015; Agnolin et al. 2019). However, *Ambigolimax valentianus* occurs within the campus of Buenos Aires University, less than 500 m away from RECUCN.

Richness was higher for non-native gastropods than for native ones both in RECS and RECUCN. The non-native snails and slugs not only exhibited greater species richness, but their populations were overwhelmingly more abundant than those of native species. A similar conclusion was obtained by Moss and Hermanutz (2010), who found that 90% of the slugs of a national park in Newfoundland (Canada) were non-native.

The comparison with other Argentine reserves more distant from urbanized areas suggests that the proportion of non-native gastropod species is correlated with their proximity to urban areas and with time since the reserve was established. For instance, in the Reserva Natural Municipal de Vicente López (Miquel and Santin 2021), which is also located on the right bank of the Río de la Plata estuary but north of Buenos Aires city (ca. 5.7 km NW of RECUCN), more than half of the land gastropods recorded were non-native. By contrast, in an environment relatively more isolated from urban areas such as the Reserva Natural de Punta Lara, ca. 37 km SE of RECS, De Lucía et al. (2023) found 9 species of terrestrial gastropods, of which only 3 were non-native. Salas Oroño et al. (2007) found 21 species of micro-molluscs, including only 3 non-native, in a natural rainforest area of northern Argentina.

The diversity and abundance of non-native gastropods found in this study in RECS and RECUCN contrasts with information gathered for other invertebrate groups. For example, from a total of 191 species of spiders recorded by Zapata and Grismado (2015) in RECS, only 2 were non-native, and another 3 can be regarded as probably introduced, *i.e.*, only 2.6% of the species may be non-indigenous. Carpintero et al. (2014) found 156 species of Heteroptera in RECS, all native. Rhopalocera (Núñez Bustos 2008) and diurnal Lepidoptera (Núñez Bustos 2015) were speciose in RECS, with 75 and 96 taxa, respectively. Of these, only one non-native species, the common Palaearctic butterfly *Aglais io* (Linnaeus), was found in RECS (Núñez Bustos 2012).

The sharp contrast between the proportion of non-native to native species found in terrestrial gastropods and arthropods could be related to the close relationship between snails and slugs with their plant substrates and to the origin of the floral assemblages present in both reserves. Ecological surveys of vascular plants in RECS and RECUCN showed also that the percentage of non-native species is high in these two reserves. Systematic sampling of RECS found 43 plant species (23.3% herbaceous), of which 48.8% were non-native (Sirolli and Kalesnik 2011). Similar sampling in RECUCN recorded 144 plant species (58.8% herbaceous), of which 37.9% were non-native (Melzi Fiorenza et al. 2020).

Two abundant non-native gastropods, *Vallonia pulchella* and *Paralaoma servilis* (Shuttleworth), were the species that contributed most to the dissimilarity between reserves. The expansion of synanthropic and introduced species in urban areas was also documented in the United States (Dinkins and Dinkins 2018; Vendetti et al. 2018; Gladstone et al. 2020) and Europe (Capinha et al. 2014). According to Cowie and Robinson (2003) and Capinha et al. (2015), the dominance of non-native gastropods is part of a global trend towards a breakdown of biogeographic barriers and the homogenization of the world's terrestrial gastropod biota.

Contrary to our expectation, the number of species of terrestrial gastropods per sample (alpha diversity) was significantly higher in the smaller (RECUCN) than in the larger reserve (RECS). This was largely due to the same assemblage of species being regularly present in many samples of RECUCN. By contrast, the turnover and the heterogeneity of species composition were significantly higher in RECS than in RECUCN. Future studies could analyse whether this high species turnover is related to a greater heterogeneity of the plant assemblages in RECS relative to RECUCN.

Although invertebrates represent a large proportion of terrestrial biodiversity, priority areas for conservation are not usually chosen based on invertebrate biodiversity (Ovando et al. 2019). Apart from their value for outdoor recreation and preservation of environments (Borgström et al. 2013), urban ecological reserves of Buenos Aires city were intended as natural spaces for the protection of representatives of the native biota. This study shows

that, so far, RECS and RECUCN are sites where mainly exotic rather than native terrestrial molluscs are being preserved. The dominance of non-native species in these urban ecological reserves reflects the pervasive advance of synanthropic species in urban land snail assemblages already documented for other biogeographic regions (Bergey et al. 2024).

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Supplementary materials

Table S1. Dates of collection, locations of sites and species collected at each site in *Reserva Ecológica Costanera Sur* (RECS) and *Reserva Ecológica Ciudad Universitaria Costanera Norte* (RECUCN). See also figure 1. (download)

Table S2. Result of a Permutational Multivariate Analysis of Variance applying the function *adonis2* in *vegan*. (download)

Table S3. Result of the SIMPER analysis showing which species contributed most to the dissimilarity between reserves. Average dissimilarity: 81.34. Data were square root transformed. The species list was truncated when the cumulative percent exceeded 50%. (download)