



# Species composition, abundance and diet of a squamate assemblage from the Carnaval stream headwaters (Buenos Aires, Argentina)

Leandro Alcalde<sup>1</sup> · María Julia Cassano<sup>1</sup> · Rocío María Sánchez<sup>1</sup> · Ana Belén Tenorio<sup>2</sup>

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## Abstract

The present work summarizes 10 years of field observations of an exurban squamate assemblage occupying a 1200 ha patch in the suburbs of La Plata City (Los Porteños, Buenos Aires, Argentina). Crossed by two streams (Martin and Carnaval), the area is characterized by intensive horticulture and floriculture, poultry and pig farming, exhibits a low housing density (1 house/ha), and the roads are largely unpaved. This area is under stress due to continuous expansion of the neighboring city in detriment of rural areas, determining a stressing environmental scenario. Field data were complemented and contextualized with museum records of the squamates present in the area and in neighboring departments of La Plata. The field-based species list of squamates from Los Porteños comprises one amphisbaenian (*Amphisbaena darwini* = 26 specimens), five snakes (*Paraphimophis rustica* = 24, *Xenodon dorbignyi* = 6, *Erythrolamprus poecilogyrus* = 3, *Erythrolamprus semiaureus* = 2, *Lygophis anomalus* = 1), and one lizard (*Salvator merianae* = 11). The number of species of squamates in Los Porteños was higher than the expected compared with the species from surrounding areas. Fossorial, nocturnal and generalist species were the most abundant in Los Porteños. These urban adapter species lack dietary constraints and their living habits minimize the encounters with humans, who commonly kill them.

**Keywords** Squamate assemblage · Urban herpetology · La Plata City · Argentina

## Introduction

As a whole, the native squamate fauna from Buenos Aires Province comprises 49 species: 30 snakes, 16 lizards, and three amphisbaenians (Abdala et al. 2012; Giraud et al. 2012). Six of them occur at the coastal dunes on the Atlantic Ocean shoreline and in the hill systems of central Buenos Aires (Koslowsky 1895; Gallardo 1968; Cei 1986; Avila et al. 2012). The remaining 43 species may be classified into two groups: a less diverse group formed by 11 species that are restricted to the arid environments in the Plains and Plateaus Monte Eco-region (Burkart et al. 1999), which occupies the southwest of the province. Excluding the lizard *Anisolepis*

*undulatus* (known from a single locality for which vouchers have been lost, see Saibene et al. 2012), the other group contains 32 species, 22 of which are snakes. These species inhabit the Pampa and Espinal Eco-regions (Burkart et al. 1999) that occupy the north part of the province. These northern environments constantly receive fauna supplied by the Paraná and Uruguay Rivers, from the richest hot spots in the northeast of the country (Ringuelet and Aramburu 1955; Arzamendia et al. 2015). Classic examples of such river-carried squamates are the snakes *Erythrolamprus jaegeri*, *Helicops leopardinus*, and *Hydrodynastes gigas* (Williams and Scrocchi 1994; Saibene et al. 2012).

The greatest squamate diversity within the Pampa and Espinal Eco-regions occurs in the Delta del Paraná Islands (considered an Eco-region in themselves, see Burkart et al. 1999) and in coastal environments of the Rio de La Plata River and its tributaries (Williams and Kacoliris 2009; Saibene et al. 2012). The area is threatened by habitat destruction, ecosystem fragmentation, and pollution associated to the second-largest South American urban settlement, with about 10 million people (INDEC 2016).

The interaction between certain species and human-modified environments has recently become of interest for

✉ Leandro Alcalde  
alcalde@ilpla.edu.ar

<sup>1</sup> Instituto de Limnología Dr. R.A. Ringuelet, Consejo Nacional de Investigaciones Científicas y Técnicas - Universidad Nacional de La Plata, Boulevard 120 y 62, CP 1900 La Plata, Buenos Aires, Argentina

<sup>2</sup> Museo de La Plata, Anexo Laboratorios, Sección Herpetología, Boulevard 120 y 62, CP 1900 La Plata, Buenos Aires, Argentina

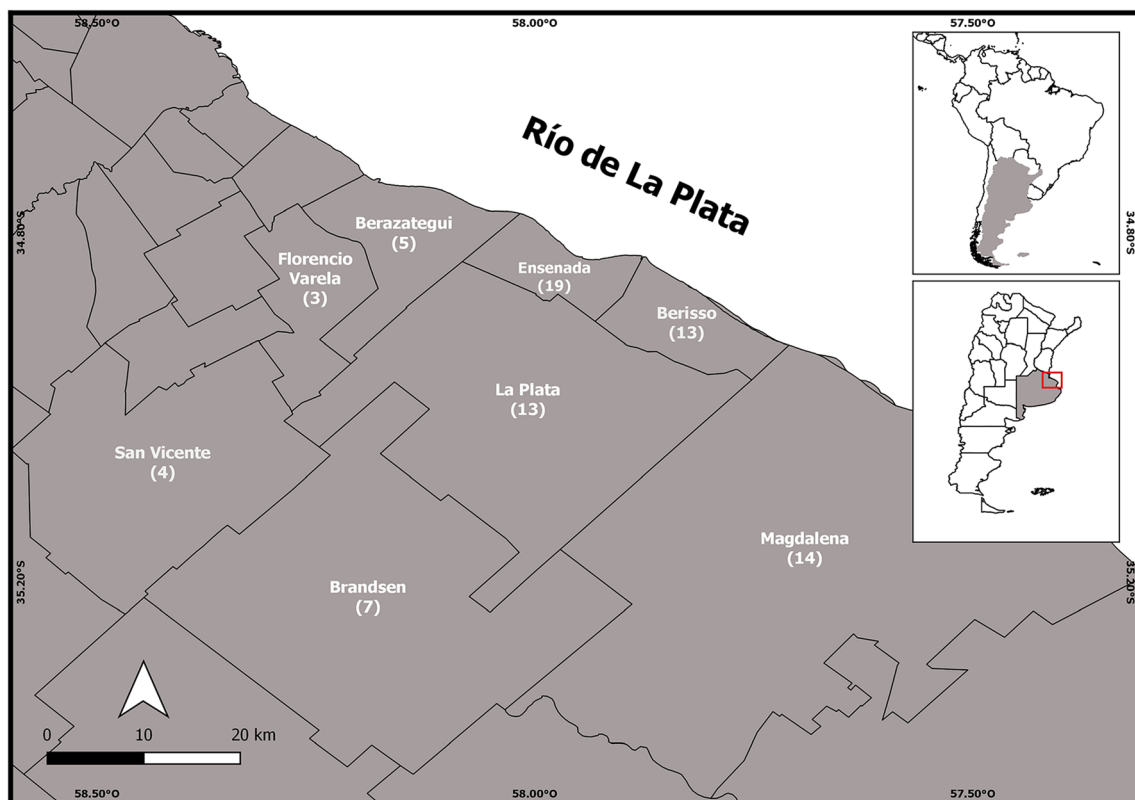
the discipline termed urban herpetology (Mitchell and Jung Brown 2008). The present work fits the spirit of this discipline because it (1) provides a long term study on the species composition, abundance and diet of an exurban squamate assemblage (*sensu* Theobald 2005), (2) contextualizes this exurban assemblage by comparing it with rural and urban squamate assemblages from neighbouring departments of La Plata City, (3) identifies urbanophile and urbanophobe species (*sensu* Grant et al. 2011), and (4) discriminates which key factors better explain presence/ absence of some species in urban and exurban environments.

## Methods

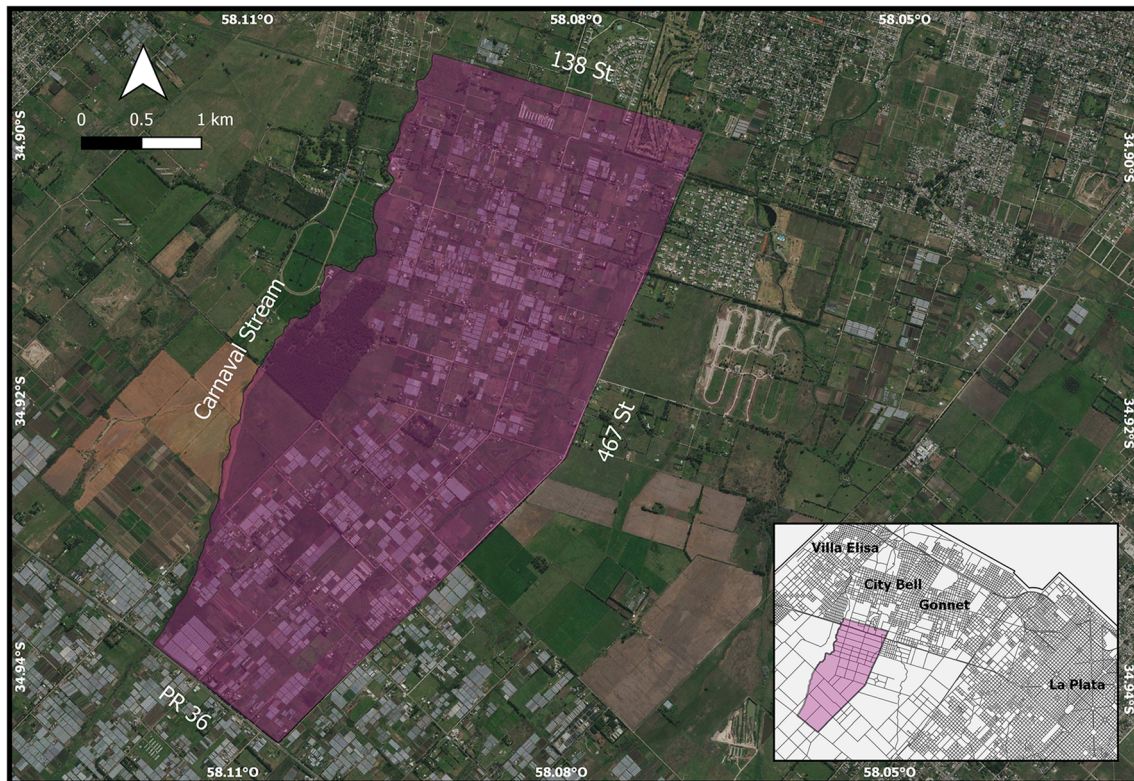
The exurban area under study comprises 1200 ha of highly modified Pampa environments. This patch is part of the north-western suburbs of La Plata City (Buenos Aires province, Argentina) and includes three diffuse population nodes: “Los Porteños”, “Las Banderitas” and “Colonia Urquiza” (Fig. 1 and 2). The area is delimited by the Carnaval stream on the NE, Martín stream and 467th Street on the SW, 138th Street on the E, and Route 36 on the W. Land use is predominantly intensive (horticulture, greenhouse floriculture, beekeeping, poultry farming, small cow and sheep farms and pig

breeding), urbanization is low (1 house/ha), and most pathways are unpaved. The area is a modified environment where the expansion of the city in detriment of rural areas configures a stressing social and ecological scenario (Frediani 2013).

Data were collected daily between July 2008 and April 2018 by one of the authors (LA) who resides in the area. Records come from two sources: (1) dead specimens, mainly roadkill, and also intentionally killed by humans, and (2) live specimens found under rocks, trunks, and garbage, or while crossing paths. At least one specimen of each species was collected and deposited at the herpetological collection of Museo de La Plata (MLP). Additional records of specimens deposited in the major herpetological collections of the province (MLP and Museo Argentino de Ciencias Naturales Bernardino Rivadavia, MACN) were also analyzed. The distributional data from our field records and from museum specimens are shown in Tables 1 and 2. They were grouped according to the following categories: (1) records from the exurban area under study (Los Porteños, City Bell, La Plata) and from nearest neighborhoods (Gonnet and Villa Elisa, La Plata), (2) records from La Plata department but excluding City Bell, Gonnet and Villa Elisa neighborhoods, (3) records from fully urban areas of La Plata, (4) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (5) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (6) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (7) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (8) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (9) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (10) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (11) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (12) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (13) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (14) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (15) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (16) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (17) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (18) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (19) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen), (20) records from all of the La Plata department and from adjacent departments (San Vicente, Berazategui, Florencio Varela, Ensenada, Berisso, Magdalena, Brandsen).



**Fig. 1** Map of the northeast of Buenos Aires province with a detail of La Plata and adjacent departments. Numbers in brackets indicate the squamate species recorded for each department



**Fig. 2** Detail of Los Porteños (City Bell, La Plata), the exurban area studied in this work. Note the large number of greenhouses used for horticulture and floriculture

Magdalena, and Brandsen), and (5) records of species that entered the region during exceptional floods of the Rio de la Plata River. Massive museum collects made before 1960 lacking reliable provenance and isolated records made before 1957 (the year in which Berisso and Ensenada became departments separated from La Plata) were not considered for the squamate species composition of La Plata department. This was the case for some snakes such as *Tomodon ocellatus* and *Thamnodynastes hypoconia* (Table 1 and 2).

Well preserved roadkill specimens were measured (total length, 1 mm accuracy) and sexed. Live specimens were identified but rarely measured and never sexed. Dietary items were obtained from dissections of the entire digestive system of roadkill specimens. Prey items were determined to the highest taxonomic level that could be reached depending on their degree of degradation. Each species was classified as specialist, tending to specialization or generalist, following Giraud et al. (2012).

## Results

### Squamate species composition in Los Porteños (City bell)

Our primary records between July 2008 and April 2018 identify seven species for the exurban area under study.

Three are most abundant: (1) the fossorial, small-sized amphisbaenian *Amphisbaena darwini* (26 specimens), (2) the nocturnal, medium to large-sized snake *Paraphimophis rustica* (24), and the diurnal, large lizard *Salvator merianae* (11). The remaining species are diurnal, medium-sized snakes: *Xenodon dorbignyi* (6 specimens), *Erythrolamprus poecilogyrus* (3), *E. semiaureus* (2), and *Lygophis anomalus* (1). Most records correspond to the warmer months, from late August to late May (spring, summer and autumn). Only a few amphisbaenids were detected in winter, during tillage activities. Specimen aggregation was detected only for *Amphisbaena darwini* in two occasions, with two specimens each. Juveniles and adults were observed for *A. darwini* (range 40–150 mm), *P. rustica* (170–1200 mm), *X. dorbignyi* (100–900 mm), and *S. merianae* (160–975 mm). Juveniles of the other species were not found in the area. The alive / dead on road / killed-by-humans number of records for each species are: *L. anomalus* (1/0/0); *E. semiaureus* (1/0/1), *E. poecilogyrus* (2/1/0), *X. dorbignyi* (4/2/0), *S. merianae* (7/1/3), *P. rustica* (14/9/1), and *A. darwini* (21/1/4). Three *Salvator merianae* were killed by humans when they were surprised stealing and eating poultry eggs. All cases of human-killed *Amphisbaena darwini* occurred accidentally during tillage activities; the circumstances of human-killed *E. semiaureus* and *P. rustica* are unknown.



### Comparison of species composition between the study area and surrounding exurban neighborhoods

The north of La Plata City comprises several neighborhoods with diverse degree of urbanization (which has been increasing for the last two decades). These are Ringuelet, Hernandez, Gonnet, Gorina, City Bell, Villa Elisa and Arturo Segui. We focused on historical museum records of squamates from three of these localities: City Bell (which includes the study area), and its nearest neighborhoods (Gonnet and Villa Elisa) (Table 1). The main differences between the historical records and the primary data we obtained were: (1) the lizard *Salvator merianae*, which was absent in herpetological collections before the present study; (2) the small lizard *Cercosaura schreibersii* (two museum specimens from Villa Elisa and Gonnet); and (3) the semi-fossorial snake *Phalotris bilineatus* (two museum specimens from Villa Elisa): The last two species were not recorded in the area during the course of the present study.

### Urban, exurban and rural assemblages. Comparison of historical records

Tables 1 and 2 summarize the squamate species composition of La Plata and surrounding departments. Most of these departments have one or more important urban nuclei (cities and towns) and diverse degrees of exurban areas. Two departments (Brandsen and Magdalena) are typically rural. The species composition of squamates from La Plata City (excluding, as previously stated, the “Occasional” and “Old records” in Table 1) was compared to the species composition of the exurban areas of La Plata City and to those corresponding to the abovementioned rural departments. The species composition of squamates from La Plata City (one amphisbaenian, one lizard, one snake) is clearly impoverished when compared with the assemblages from rural departments which totalize one species of amphisbaenian, three lizards and 11 snakes. The exurban areas of La Plata City appear as intermediate between the rural and urban zones, with one amphisbaenian, three lizard and six snake species.

**Table 1** Number of specimens of amphisbaenians, lizards and snakes housed in the herpetological collections of MLP and MACN. Records were counted as number of individuals/species for each of the following categories: (1) **Other records** (from departments that border La Plata); (2) **City Bell and surroundings** (including the area under study plus two

adjacent localities: Gonnet and Villa Elisa); (3) **La Plata City** (from fully urban areas of the city); (4) **Occasional** (collected during years of extraordinary river floods, mainly from Ensenada and Berisso departments); (5) **Old records** (correspond to massive collections made for La Plata department before 1960); and (6) **Total** (sum of records for each category)

Species	Other registers	City Bell and surroundings	La Plata City	Occasional	Old registers	Total
<i>Amphisbaena darwini</i>	45	11	4	–	1	61
<i>Cercosaura schreibersii</i>	13	2	2	–	–	17
<i>Ophiodes vertebralis</i>	9	–	–	–	8	17
<i>Salvator merianae</i>	11	–	–	–	–	11
<i>Teius oculatus</i>	1	–	–	–	–	1
<i>Bothrops alternates</i>	1	–	–	1	–	2
<i>Epicitia munoai</i>	11	–	3	–	–	14
<i>Erythrolamprus jaegeri</i>	–	–	–	5	–	5
<i>Erythrolamprus poecilogyrus</i>	32	1	–	–	37	70
<i>Erythrolamprus semiaureus</i>	40	4	–	9	40	93
<i>Helicops infrataeniatus</i>	4	–	–	37	–	41
<i>Helicops leopardinus</i>	4	–	–	11	–	15
<i>Lygophis anomalus</i>	20	1	–	–	78	99
<i>Paraphimophis rustica</i>	20	3	–	1	–	24
<i>Phalotris bilineatus</i>	6	2	–	–	–	8
<i>Philodryas aestivus</i>	1	–	–	1	–	2
<i>Philodryas patagoniensis</i>	35	–	–	–	–	35
<i>Thaeniophallus poecilopogon</i>	2	–	–	–	–	2
<i>Thamnodynastes hypoconia</i>	4	–	–	29	40	73
<i>Thamnodynastes strigatus</i>	3	–	–	–	–	3
<i>Tomodon ocellatus</i>	13	–	–	3	6	22
<i>Xenodon dorbignyi</i>	40	7	–	–	–	47

**Table 2** Museum records of squamate species from La Plata and boundary departments. Certain species (*Bothrops ammodytoides*, *Erythrolamprus jaegeri*, *Notomabuya* spp., and *Xenodon semicinctus*) were excluded from the table because they are considered occasional

visitors for Buenos Aires province, occurring either during extraordinary river floods or brought by wood-shiptments from northern and western areas of the country

Species/Department	Berazategui	Florencio Varela	San Vicente	Ensenada	Berisso	La Plata	Magdalena	Brandsen
<i>Amphisbaena darwini</i>		X		X	X	X	X	
<i>Cercosaura schreibersii</i>	X		X	X		X	X	
<i>Mabuya dorsivittata</i>				**				
<i>Ophiodes vertebralis</i>			X	X	X	X		*
<i>Salvator merianae</i>				X	X	X	X	X
<i>Teius oculatus</i>				X	X			
<i>Bothrops alternatus</i>				X	X			
<i>Epictia munoai</i>				X		X		
<i>Erythrolamprus poecilogyrus</i>				X	X	X	X	
<i>Erythrolamprus semiaureus</i>	X			X	X	X	X	X
<i>Helicops infrataeniatus</i>				X	X			
<i>Helicops leopardinus</i>				X				
<i>Lygophis anomalus</i>			X	X	X	X	X	
<i>Paraphimophis rustica</i>	X			X	X	X	X	X
<i>Phalotris bilineatus</i>						X	X	
<i>Philodryas aestivus</i>				X			X	
<i>Philodryas patagoniensis</i>	X			X	X	X	X	X
<i>Thaeniophallus poecilopogon</i>							X	
<i>Thamnodynastes hypoconia</i>				X			X	
<i>Thamnodynastes strigatus</i>				X	X			
<i>Tomodon ocellatus</i>		X	X	X		X	X	X
<i>Xenodon dorbignyi</i>	X	X		X	X	X	X	X
TOTAL	5	3	4	19	13	13	14	7

\*Authors' field observation

\*\*Record taken from Saibene et al. (2012)

## Diet

Table 3 summarizes primary diet data obtained from dissections of road-killed specimens and from published diet information for the seven species we found in the study area. These species may be grouped into four trophic groups: broad generalists (*Salvator merianae*), mice eaters (*Paraphimophis rustica*), anuran eaters (*Xenodon dorbignyi*, *Lygophis anomalus*, *Erythrolamprus poecilogyrus*, *E. semiaureus*), and invertebrate eaters (*Amphisbaena darwini*).

## Discussion

The squamate assemblage of the study area (Los Porteños) is impoverished when compared with surrounding rural squamate assemblages. This impoverishment is different for each squamate group. We recorded one of the three lizards (33%) and five of the 11 snakes (41%) reported for surrounding rural areas (excluding those species clearly associated to the Rio de La Plata coastal

areas. The only amphisbaenian found in Los Porteños represents 100% of the species reported for the area, since the other *Amphisbaena* from Buenos Aires *Amphisbaena kingii* is restricted to more southern localities. Regarding snakes, one of the species (*Paraphimophis rustica*) was clearly prevalent, and in turn, it represents 70% of the 36 snake specimens we found at Los Porteños. Other snake species were represented by no more than six specimens each. Species impoverishment and prevalence of certain species are characteristics of exurban and urban assemblages of many animal groups (Rugiero 2004; Bateman and Fleming 2012). Species that take advantage of exurban and disturbed landscapes may be classified as urban adapters and urban exploiters (Blair 2001; McKinney 2006), whereas species that are not capable of adapting or those that become expelled from modified urban environments may be classified as human avoiders. The specific responses of each species explain both the impoverishment of exurban assemblages and the dominance of certain species over others in assemblage composition. There are many factors that account for the presence/absence and abundance of species in altered landscapes (Zappalorti and Mitchell

**Table 3** Primary data and literature reports of the diet of the squamate species present in Los Porteños. Our primary feeding data was obtained from stomach and upper intestine dissections. Frequency, Frequency of occurrence and Total volume of each primary food item was quantified (F - FO - TV)

Species	Primary feeding data (*)	Literature feeding data
<i>A. darwini</i>	Larval coleopterans (1-1 -1,2 ml)	Isopterans Coleopterans
	Adult coleopterans (1-1 - >0.1 ml)	Formicids, Orthopterans
	Formicids (2-1 - >0.1 ml)	Larval lepidopterans (Gallardo 1967, 1977; Cabrera and Merlini 1990)
	Annelids (1-1 - 0.3 ml)	
<i>S. merianae</i>	Fruits (17-1 - 13.6 ml)	Fruits, seeds and flowers
	Adult coleopterans (1-1 - 0.4 ml)	Small to medium size fish, anurans, birds, and mammals (alive or dead, as carrion) Amphisbaenians, lizards and snakes
	Larval coleopterans (5-1 - >0.1 ml)	Bird and turtle eggs
	Gastropods (2-1 - 1 ml)	Annelids; crustaceans; gastropods; arthropods (Kiefer and Sazima 2002; Sazima and D'Angelo 2013; Kasperoviczus et al. 2015)
<i>E. poecilogyrus</i>	Adult anurans (1-1 - 50 ml)	Anurans (adults), fish and lizards (Pinto and Fernandes 2004; Palmuti et al. 2009; Cacciali and Motte 2010; Prieto et al. 2012; Alencar and Nascimento 2014)
<i>E. semiaureus</i>	Fish (1-1 -?)	Fish, Anurans (tadpoles and eggs) (Marques and Castro Souza 1993; Palmuti et al. 2009; Figueiredo de Andrade and Kindlovits 2012)
<i>L. anomalus</i>	No data	Mostly anurans, occasionally lizards (Panzeria and Maneyro 2014)
<i>P. rustica</i>	Rodents (fetuses and adults) (1-1 - 11.5 ml)	Mammals, lizards, snakes (Alencar et al. 2013)
<i>X. dorbignyi</i>	Adult anurans (1-1 - 15 ml)	Adult anurans and lizard eggs (Oliveira et al. 2001)

2008; Perry et al. 2008). For instance, the presence and survival of certain snake species in a North American urban-rural edge habitat were explained by (1) high density of prey at these locations, (2) presence of riparian corridors connecting suitable areas, and (3) habitats that are only moderately human-modified provide basking, shelter and shedding sites (Zappalorti and Mitchell 2008). Other authors have also listed benefits for urban snake populations but noted that automobile traffic is the main cause of death of snakes in urban habitats (Gaul Jr 2008). Direct and indirect road impacts on reptile assemblages were summarized by Andrews et al. (2008). The authors note that roads are basking site attractors for certain species that choose to bask there, thereby increasing their probability of being hit by vehicles.

Barbo and Sawaya (2008) studied the species composition of an amphisbaenian assemblage in a remnant forest within one of the most densely urbanized South American cities, São Paulo. They found that two genera and seven species of amphisbaenians inhabited the urban forest patches, but also detected the loss of two species that had been historically

recorded within the area. These facts reveal that an underground mode of life and an arthropod-based diet are key factors to survive under urban pressures. The next most abundant species after *Amphisbaena darwini* in Los Porteños were the snake *Paraphimophis rustica* and the tegu lizard *Salvator merianae*, which behave as urban adapters. Almost all people in the area kill snakes because they have negative notions about them. With respect to tegu lizards, they are sometimes killed when they enter chicken coops to steal and eat eggs, but other people like them and favor their presence in the vicinity of houses. Thus, the broad trophic niche of *Salvator merianae* (Table 3), the large amount of artificial shelters (e.g., domestic garbage) and the positive response this species elicits from many people seem to be compensating factors that explain its moderate to high abundance in the area. The high abundance of *P. rustica* detected in Los Porteños contrasts with the low abundance reported for other areas (e.g., from Brazil, see Pizzato 2005). This is the largest snake species in the area (adults reach 1200 mm or more). The use of artificial shelters

present in the vicinity of houses, their rodent-based diet and nocturnal activity pattern that contribute to prevent human encounters are key factors that explain the abundance of *P. rustica* in the area. Diurnal snakes (*E. semiaureus*, *L. anomalus*, *X. dorbignyi*; Tozzeti et al. 2009; Panzera and Maneyro 2014; pers. obs.) are low abundant but prevalent in Los Porteños, while one species, the most abundant, is nocturnal (*P. rustica*; pers. obs.), and another is both diurnal and nocturnal (*E. poecylogirus*; Alencar and Nascimento 2014). Diurnal activity patterns make most snakes more susceptible to be killed in the course of human encounters. In addition, the diet of diurnal snakes is based largely on anurans (Table 3). Although abundance of the nine anuran species (four leptodactylids, three hylids and two bufonids) recorded in Los Porteños was not assessed, we think that some of them are decreasing due to soil modifications that tend to maximize water runoff and drainage.

In conclusion, the most abundant squamate species in the area are those that lack food constraints and avoid contact with humans. We think that decreasing roadkills by means of awareness campaigns would have a positive impact on the conservation of squamates in peripheral city areas.

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