

RESEARCH ARTICLE

Living on the edge: Herpetofauna of the buffer zone of the Parque Estadual da Serra da Tiririca, Rio de Janeiro State, Brazil

Miguel R. Ugalde^{1,2} , Thaylan P. Alves Salles¹ , Amanda F. Marinho¹  and Mara C. Kiefer¹ 

¹*Departamento de Biologia Geral, Instituto de Biologia, Universidade Federal Fluminense. Rua Professor Marcos Waldemar de Freitas, 24210-201 Niterói, RJ, Brazil.*

²*Laboratório de Coleções Biológicas e Biodiversidade, Instituto Vital Brazil. 24230-410 Niterói, RJ, Brazil.*

Corresponding author: Miguel Relvas Ugalde (miguelrugalde.ivb@gmail.com)

<https://zoobank.org/33A29438-F334-401F-88E8-785E9D04FCAA>

ABSTRACT. Habitat loss and fragmentation is the greatest threat to global biodiversity and is especially acute in biodiversity hotspots such as the Atlantic Forest of Brazil. Because the Brazilian fauna suffers from ongoing human impacts both inside and outside protected areas and their buffer zones, inventories of the faunal assemblages in these areas remain vital. Based on field surveys and the examination of museum specimens, we report on the herpetofauna of the buffer zone of Parque Estadual da Serra da Tiririca, located in the Brazilian state of Rio de Janeiro. Across nine sampling areas during 2017 and 2018, we documented 30 species of anurans, one caecilian, 18 snakes, eight lizards, and one crocodilian. This assemblage includes the first record for five species from the protected area. Our inventory offers fundamental information that can promote actions to maintain populations of these taxonomic groups and their habitats within and outside of this protected area.

KEYWORDS. Amphibia, Atlantic Forest, conservation, diversity, protected areas, Squamata, urban forest.

INTRODUCTION

Land/sea use change is the primary direct driver of the global biodiversity crisis, although it interacts synergistically with other threats (Jareguiberry et al. 2022). The Atlantic Forest is a biodiversity hotspot with high rates of endemism and species richness in addition to being severely threatened by forest loss (Myers 1988, 2003). The creation of protected areas became a major conservation strategy on a national level in Brazil, following the emergence of the hotspot concept (Milano 2001, Fonseca and Venticinque 2018). Although the Atlantic Forest increased in forest area in recent years due to reforestation of agricultural land (Rezende et al. 2018, Hu et al. 2021), urban and peri-urban growth in direct conflict with endangered species and protected areas is alarming (Weller et al. 2019). Therefore, to minimize impacts to core area, many of these established protected areas in the country include buffer zones that are under more lax land use restrictions—following the Sistema Nacional de Unidades de Conservação da Natureza (SNUC), Brazilian Federal Law

9985/2000. In the Rio de Janeiro state, considerable remnants of Atlantic Forest and associated ecosystems still exist (SOS Mata Atlântica and INPE 2021), but many of them are not legally protected and much of the forest lies inside buffer zones. Despite the great conservation potential of buffer zones, they are often neglected in faunal inventories.

Amphibians are among the most threatened vertebrate groups globally (Rhodin et al. 2018). In comparison, despite evidence indicating an ongoing global decline of reptiles (Huey et al. 2010, Tingley et al. 2016), conservation of the group is comparatively neglected (Geyle et al. 2020). Data on amphibians and reptiles (hereafter herpetofauna) that persist in peri-urban, urban and agricultural environments is mostly restricted to basic studies of species richness and composition (French et al. 2018). Moreno-Rueda and Pizarro (2007, 2009) demonstrate that reptile populations can thrive in urban and agricultural areas, but the species assemblage in such human-modified environments is often dominated by opportunists or generalists, as well as non-natives species (Guerra and Araoz 2015). The quality of habitat patches can

be an important predictor of the composition and evenness of herpetofaunal assemblages because loss of pristine habitat and increased landscape fragmentation often have severe negative consequences for specialist taxa (Sullivan et al. 2014, Guerra and Araoz 2015).

Herpetofauna generally has specific temperature and moisture requirements for metabolism and reproduction, on top of having generally narrow habitat tolerances and low dispersal abilities (Houlahan and Findlay 2003, Bowne and Bowers 2004, Tuberville et al. 2015). These traits may lead to population declines of these taxonomic groups, even within protected areas and buffer zones. As these buffer zones usually represent different land uses and landscapes, studies assessing them have the potential to shed light on how species assemblages change in response to human disturbance. They can also inform efforts to enhance connectivity of habitat (Zhang et al. 2021), in addition to directing improved protection of peripheral populations in these oft-neglected areas (Sayer 1991, Gonz  les-Catellano et al. 2023).

The Parque Estadual da Serra da Tiririca (PESET) in state of Rio de Janeiro, Brazil, encompasses a great variety of ecosystems and lies within a fast-changing anthropic area (Pontes 1987). The PESET has many biodiversity knowledge gaps that remain unfilled (Barros 2008), and is ripe for more detailed study of its herpetofauna. Some studies targeting core conserved areas and specific taxa have detected declines or disappearance of once-abundant species in the PESET (Rocha et al. 2009, Pontes and Pontes 2016, Citeli et al. 2016), although the herpetofaunal assemblage in the protected area remains remarkably diverse (Pontes et al. 2013, Pontes and Pontes 2016, Citeli et al. 2016). Nonetheless, to date, no study has specifically examined the herpetofauna of the buffer zone. To fill this knowledge gap, the current study presents a preliminary inventory of the buffer zone herpetofauna of the PESET and contextualizes the results in a conservation framework. Because our study sites were composed mostly of disturbed areas, we were expecting to find more generalist species and a lower species richness in comparison with the core protected area.

MATERIAL AND METHODS

Study area

The Parque Estadual da Serra da Tiririca is located in coastal Rio de Janeiro state, southeastern Brazil. The local climate is characterized by rainy summers and dry winters, and it is listed as Aw Tropical by K  ppen (1936). The buffer zone study sites in the PESET lie within the Niter  i, Maric  

and S  o Gon  alo municipalities (Fig. 1). These areas encompass fragments of different Atlantic Forest ecosystems, from secondary forests to rocky shores, sandy coastal plains with restinga vegetation, mangroves and marshes, in varying degrees of preservation. The buffer zone of PESET has 7,601.29 ha of which 3,657.95 ha is terrestrial environment and 3,943.28 ha is marine, overlapping the Reserva Extrativista Marinha de Itaipu area.

We selected the survey areas to cover all ecosystems present in the buffer zone and the majority of surroundings harboring the buffer zone except for marine ecosystem. Hence, the sampling transects represented the best available access points to forests, wetlands and sandbanks of the buffer zone, considering the time available to carry out the sampling and the safety of the team.

We divided our survey area into four sectors: Darcy Ribeiro (forest; 96–155 m above sea level [a.s.l.]; areas 1–3), Serra da Tiririca (forest; 92–200 m a.s.l.; areas 4–5), Itaipua   (marsh, restingas and forest; 5–76 m a.s.l.; areas 6–8) and Itacoatiara (restingas; 1–8 m a.s.l.; area 9). Sampled areas comprised remnant natural vegetation intermixed with roads, gardens, crops and pastures.

Data collection and analyses

We completed nighttime surveys from January to June 2017, involving 51 person-hours of sampling effort, and both daytime/nighttime surveys from January to May 2018, involving 70.5 hours of sampling, for a total of 121.5 person-hours of sampling. During this sampling, our efforts were limited to 30-minute visual encounter surveys (VES; Crump and Scott 1994) in defined transects, conducted by four researchers per sampling period. Incidental observation of certain species outside of these defined transects, when accompanied by high-quality photographs that enabled precise identification, were also considered. From July to October 2016, the team also sampled areas 1–8 during the daytime and collected a subset of the specimens found. Likewise, from June 2018 to March 2019, the team made sporadic visits to area 1 and species collected or photographed for the first time in the buffer zone were included in the species list, even though no standardized methods were used. We also included photographs of specimens taken by residents at the sampling sites from 2015 to 2021. Although we recognize the replicability issues that emerge from our inclusion of species detected using non-standardized methods, this choice allowed us to build a more complete species list for the buffer zone of PESET. Our sampling was authorized under permit issued by SISBIO (#22527-1). Voucher specimens collected during

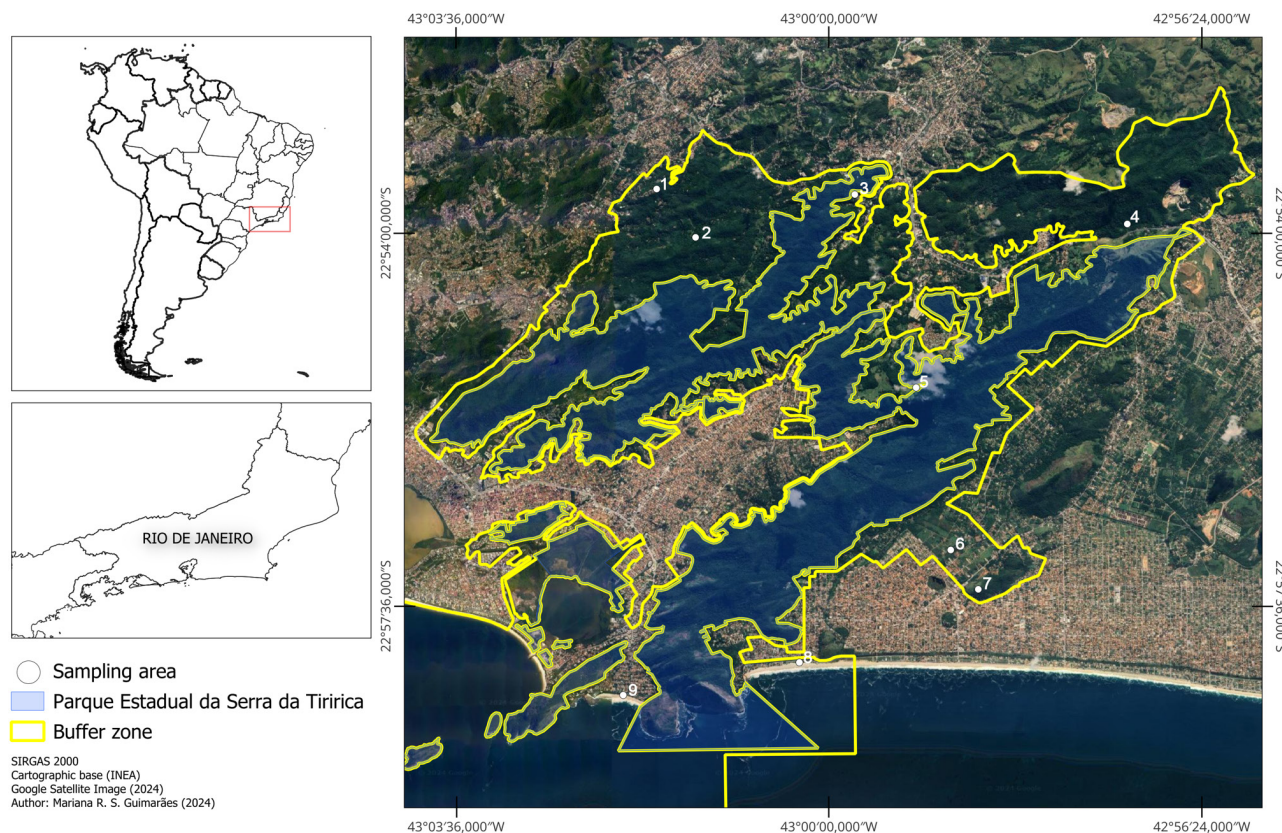


Figure 1. Location of sampling areas in the buffer zone of Serra da Tiririca State Park (PESET) in the municipalities of Niterói (S1: Matapaca, S2: Muriqui, S3: Rio do Ouro, S5: Várzea das Moças, S9: Itacoatiara), Maricá (S6: Brejo Costa Verde, S7: Morro do Céu, S8: Restinga de Itaipuaçu) and São Gonçalo (S4: Serra do Calaboca).

the present study were deposited at Coleção de Répteis do Museu Nacional (MNRJ), Coleção de Anfíbios do Museu Nacional (MNRJ), Universidade Federal do Rio de Janeiro, Brazil and Coleção de Lagartos Instituto Vital Brazil (IVBL) (Appendix 1).

Due to the difficulty of sampling snakes in the field (Reinert 1984), we consulted the herpetological collection of the Instituto Vital Brazil (IVB) to obtain additional data on snake species from the region. We only considered snake specimens with accurate identifications and with detailed location data for inclusion within the PESET buffer zone species list. We also only considered IVB specimens of species that were unrecorded during our field sampling efforts.

We evaluated sampling efficiency by applying sample-based rarefaction curves with 1.000 randomizations using the software EstimateS 9.1.0 (Colwell 2013). We applied this method only to VES data and ran separate analyses for all anurans combined, and for all reptiles combined.

RESULTS

We documented 31 species of amphibians in six families from the buffer zone of the PESET. The family with the highest richness was Hylidae with 20 species followed by Leptodactylidae with seven species. Other families were represented by only one species (Bufonidae, Craugastoridae, Cycloramphidae and Siphonopidae; Table 1; Fig. 2). Some species were only detected outside of our standardized survey transects, including *Phyllomedusa burmeisteri* Boulenger, 1882 (2018) and *Luetkenotyphlus* sp. (2020) at Sector Darcy Ribeiro (area 1) (Fig. 3). The sector with the highest richness of amphibian species were Darcy Ribeiro and Itaipuaçu with 14 species, followed by Serra da Tiririca with 11 and Itacoatiara with no species recorded. Nine species are endemic to the Atlantic Forest and none is considered threatened internationally although some show trends of population decline according to the IUCN (Table 1). The rarefaction curves of reptiles and amphibians did not stabilize (Fig. 4).



Figure 2. Amphibians species recorded during surveys in the buffer zone of Parque Estadual da Serra da Tiririca, southeastern Brazil: (A) *Rhinella ornata*; (B) *Haddadus binotatus*; (C) *Thoropa miliaris*; (D) *Nyctimantis brunoi*; (E) *Dendropsophus elegans*; (F) *Dendropsophus meridianus*; (G) *Dendropsophus decipiens*; (H) *Dendropsophus bipunctatus*; (I) *Scinax cuspidatus*; (J) *Scinax* aff. *x-signatus*; (K) *Boana albomarginata*; (L) *Trachycephalus nigromaculatus*; (M) *Phyllodytes luteolus*; (N) *Leptodactylus latrans*; (O) *Physalaemus signifer*; (P) *Leptodactylus mystacinus*; (Q) *Leptodactylus fuscus*; (R) *Adenomera marmorata*. Photos by M.R. Ugalde.

Table 1. Amphibians' species recorded in the buffer zone of Parque Estadual da Serra da Tiririca in the municipalities of Niterói, Maricá and São Gonçalo, Rio de Janeiro state, southeastern Brazil. Other information include: Population trend (IUCN 2023), whether they are endemic or exotic to the Atlantic Forest and to Rio de Janeiro state; and Sectors of the buffer zone where each species was recorded based on primary data: Darcy Ribeiro, Serra da Tiririca, Itaipuaçu, Itacoatiara sector.

Taxa	Number of collected specimens	Atlantic Forest	Population trend (IUCN 2023)	Records		
				Darcy Ribeiro	Serra da Tiririca	Itaipuaçu
Anura						
Bufonidae						
<i>Rhinella ornata</i> (Spix, 1824)	11	Endemic	Stable	X	X	
Craugastoridae						
<i>Haddadus binotatus</i> (Spix, 1824)	6	Endemic	Stable		X	
Cycloramphidae						
<i>Thoropa miliaris</i> (Spix, 1824)	2	Endemic	Stable	X	X	
Hylidae						
<i>Boana faber</i> (Wied-Neuwied, 1821)	4		Stable		X	
<i>Boana albomarginata</i> (Spix, 1824)	2	Endemic	Stable			X
<i>Dendropsophus minutus</i> (Peters, 1872)	29		Stable	X	X	
<i>Dendropsophus meridianus</i> (Lutz, 1954)	2	Endemic	Stable			
<i>Dendropsophus microps</i> (Peters, 1872)	7		Stable	X		
<i>Dendropsophus seniculus</i> (Cope, 1868)	3	Endemic	Stable	X		
<i>Dendropsophus elegans</i> (Wied-Neuwied, 1824)	4		Stable		X	
<i>Dendropsophus anceps</i> (Lutz, 1929)	1		Stable			X
<i>Dendropsophus bipunctatus</i> (Spix, 1824)	4	Endemic	Stable	X		X
<i>Dendropsophus decipiens</i> (A.Lutz, 1925)	19		Stable			X
<i>Nyctimantis bruno</i> i (Miranda-Ribeiro, 1920)	4	Endemic	Decreasing			X
<i>Oligogon argyreornata</i> (Miranda-Ribeiro, 1926)	1	Endemic	Stable			X
<i>Scinax</i> aff. <i>x-signatus</i> (Spix, 1824)	6		Stable	X		X
<i>Scinax cuspidatus</i> (Lutz, 1925)	3	Endemic	Stable	X		X
<i>Scinax alter</i> (B. Lutz, 1973)	1		Stable		X	
<i>Scinax</i> sp.	4			X		
<i>Scinax perpusillus</i> (Lutz & Lutz, 1939)**		Endemic	Stable	X		
<i>Trachycephalus nigromaculatus</i> (Tschudi, 1838)	4		Stable			X
<i>Phyllodytes luteolus</i> (Wied-Neuwied, 1824)	1	Endemic	Stable	X		
<i>Phyllomedusa burmeisteri</i> Boulenger, 1882*			Stable	X		
Leptodactylidae						
<i>Physalaemus signifer</i> (Girard, 1853)	3	Endemic	Decreasing		X	
<i>Leptodactylus latrans</i> (Steffen, 1815)	8	Endemic	Stable	X	X	X
<i>Leptodactylus fuscus</i> (Schneider, 1799)	1		Stable			X
<i>Leptodactylus mystacinus</i> (Burmeister, 1861)	1		Stable			X
<i>Leptodactylus spixi</i> (Heyer, 1983)	2		Stable			X
<i>Adenomera marmorata</i> (Steindachner, 1867)	2		Stable		X	
<i>Adenomera thomei</i> (Almeida & Angulo, 2006)	1	Endemic	Stable		X	
Gymnophiona						
Siphonopidae						
<i>Luetkenotyphlus</i> sp.*	1			X		

* Species recorded in non-standardized encounters. **Visual record only (no specimens collected).

For reptiles, we documented 27 species across thirteen families, comprising eight lizards (six families), 18 snakes (five families) and a single crocodilian (Table 2; Fig. 5). The reptile family with the highest richness was Dipsadidae with nine species, followed by Colubridae with four, Teiidae, Vipe-

ridae and Boidae with two each, and Anguidae, Gekkonidae, Phyllodactylidae, Polychrotidae Tropiduridae, Scincidae, Elapidae and Alligatoridae with only one species each. The sector with the highest richness of reptile species were Darcy Ribeiro with 15 species, followed by Itaipuaçu with nine,



Figure 3. Species recorded only by photographs in the buffer zone of Parque Estadual da Serra da Tiririca, southeastern Brazil: (A) *Caiman latirostris*; (B) *Salvator merianae*; (C) *Boa constrictor*; (D) *Chironius bicarinatus*; (E) *Pseudablabes olfersii*; (F) *Bothrops jararacussu*; (G) *Polychrus marmoratus*; (H) *Phyllomedusa burmeisteri*; (I) *Luetkenotyphlus* sp. Photos by: (B) T.P.A. Salles, (D) Sylvio Relvas, (E) by Jean-Marc Costa, (all others) M.R. Ugalde.

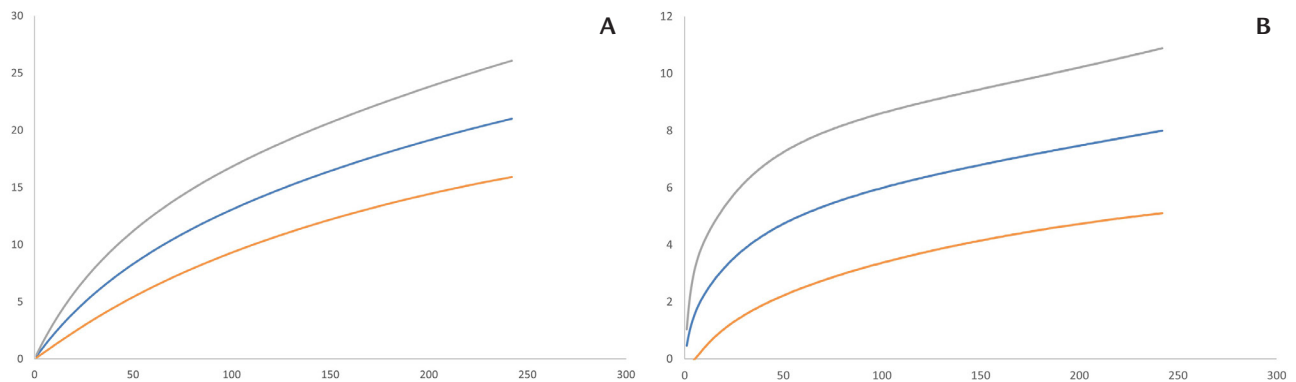


Figure 4. Rarefaction curve of anuran amphibian species (A) and reptile species (B) for the buffer zone of the Parque Estadual da Serra da Tiririca, RJ, generated from 1,000 randomizations in the order of entry. Blue: mean. Gray and Orange: standard deviation.

Serra da Tiririca with six and Itacoatiara with four species. We recorded eight species of snakes only from pre-existing specimens in the IVB collection: *Chironius laevis*, *Corallus*

hortulana, *Elapomorphus quinquelineatus*, *Erythrolamprus poecilogyrus*, *Micrurus corallinus*, *Oxybelis aeneus*, *Palusophis bifossatus* and *Pseudablabes patagoniensis*. The two additional



Figure 5. Reptiles species recorded during surveys in the buffer zone of the Parque Estadual da Serra da Tiririca, southeastern Brazil: (A) *Ameiva ameiva*; (B) *Ophiodes cf. fragilis*; (C) *Brasiliscincus agilis*; (D) *Gymnodactylus darwini*; (E) *Tropidurus torquatus*; (F) *Erythrolamprus miliaris*; (G) *Oxyrhopus petolarius*; (H) *Bothrops jararaca*; (I) *Dryophylax nattereri*. Photos by: (A, B) T.P.A. Salles, (C–I) M.R. Ugalde.

species that we detected only outside of our standardized survey transects were *Chironius cf. bicarinatus* (2015) and *Polychrus marmoratus* (2021) at Sector Darcy Ribeiro (area 1). Eight species are endemic to the Atlantic Forest and none is considered threatened internationally although some show trends of population decline according to the IUCN (Table 2).

DISCUSSION

As expected, the buffer zone of PESET has lower richness compared to the core zone, but yet harbouring an important portion of the total diversity. Comparing our results with data presented for PESET by its current management plan and Pontes and Pontes (2016), 59% of amphibian and 35% of reptile species recorded in the core area of PESET can be found in the buffer zone. Although the buffer zone harbors approximately half of the total diversity of the reserve, this richness might be considered unusually high for a disturbed area when compared to other protected

remnants of similar size, ecosystem type, sampling method and effort in Rio de Janeiro state, such as Estação Ecológica Estadual do Paraíso with 30 amphibian species and 29 reptile species (Vrcibradic et al. 2011), and Ilha da Marambaia with 24 amphibian species (Silva et al. 2008) and 12 lizard species (Carvalho et al. 2007). In addition, five species are new records for PESET: the snake *Dibbernardia affinis*; the anurans *Adenomera thomei*, not commonly sampled in the region (see Ferrante et al. 2014), *Dendropsophus microps*, and *Phyllodytes luteolus*—the latter is a species that seems to be expanding distribution through human activities (Melo-Dias et al. 2023); and the caecilian *Luetkenotyphlus* sp., a genus with southeastern distribution and rarely sampled (Mott et al. 2011). These new observations demonstrate how buffer zones inventories can provide novel information about taxa present in protected areas. The fact that the curves did not stabilize suggests that additional surveys are welcome for the groups in the buffer zone. Despite this, the number of reptiles species could be closer to its total diversity in the

Table 2. Reptile species recorded in the buffer zone of Parque Estadual da Serra da Tiririca in the municipalities of Niterói, Maricá and São Gonçalo, Rio de Janeiro state, southeastern Brazil. Other information include: Population trend (IUCN 2023), whether they are endemic or exotic to the Atlantic Forest and to Rio de Janeiro state; and Sectors of the buffer zone where each species was recorded based on primary data: Darcy Ribeiro, Serra da Tiririca, Itaipuaçu, Itacoatiara sector; or secondary data on Instituto Vital Brazil scientific collection (IVB – pre-existing specimens).

Taxa	Number of collected specimens	Atlantic Forest	Population trend (IUCN 2023)	Records				
				Darcy Ribeiro	Serra da Tiririca	Itaipuaçu	Itacoatiara	IVB
Crocodylia								
Alligatoridae								
<i>Caiman latirostris</i> (Daudin, 1801)**			Stable			X		
Squamata								
Lacertilia								
Anguidae								
<i>Ophiodes fragilis</i> (Raddi, 1820)*	1		Unknown	X				
Gekkonidae								
<i>Hemidactylus mabouia</i> (Moreau de Jonnés, 1818)	260	Non-native	Stable	X	X	X	X	
Scincidae								
<i>Brasiliscincus agilis</i> (Raddi, 1823)	13	Endemic	Unknown	X	X	X	X	
Phyllodactylidae								
<i>Gymnodactylus darwinii</i> (Gray, 1845)	3	Endemic	Unknown	X				
Polychrotidae								
<i>Polychrus marmoratus</i> (Linnaeus, 1758)*			Stable	X				
Teiidae								
<i>Ameiva ameiva</i> (Linnaeus, 1758)	2		Stable		X	X	X	
<i>Salvator merianae</i> (Duméril & Bibron, 1839)**			Stable	X		X		
Tropiduridae								
<i>Tropidurus torquatus</i> (Wied, 1820)	6		Unstable	X	X	X	X	
Serpentes								
Boidae								
<i>Boa constrictor</i> (Linnaeus, 1758)**				X				
<i>Corallus hortulana</i> (Linnaeus, 1758)			Stable					X
Colubridae								
<i>Chironius cf. bicarinatus</i> (Wied, 1820)*			Decreasing	X				
<i>Chironius laevis</i> (Wied, 1824)		Endemic	Unknown					X
<i>Palusophis bifossatus</i> (Raddi, 1820)			Unknown					X
<i>Oxybelis aeneus</i> (Wagler in Spix, 1824)			Stable					X
Dipsadidae								
<i>Elapomorphus quinquelineatus</i> (Raddi, 1820)			Unknown					X
<i>Erythrolamprus miliaris</i> (Linnaeus, 1758)	2		Stable	X	X			
<i>Erythrolamprus poecilogyrus</i> (Wied, 1824)			Increasing					X
<i>Helicops carinicaudus</i> (Wied, 1824)	1	Endemic	Unknown			X		
<i>Oxyrhopus petolarius</i> (Reuss, 1834)			Unknown	X				
<i>Pseudablabes olfersii</i> (Liechtenstein, 1823)**			Stable	X				
<i>Pseudablabes patagoniensis</i> (Girard, 1858)			Stable					X
<i>Dryophylax nattereri</i> (Mikan, 1828)	1					X		
<i>Dibbernardia affinis</i> (Günther, 1858)	1	Endemic	Unknown	X				
Elapidae								
<i>Micrurus corallinus</i> (Merrem, 1820)		Endemic	Unknown					X
Viperidae								
<i>Bothrops jararaca</i> (Wied, 1824)	2	Endemic	Unknown	X	X			
<i>Bothrops jararacussu</i> (Lacerda, 1884)**		Endemic	Unknown	X		X		

*Species recorded in non-standardized encounters. **Visual record only (no specimens collected).

buffer zone compared to amphibians due to the richness attained through secondary data and a better tendency of the group curve to stabilize (Fig. 4).

Also as expected, most species recorded are species commonly found in disturbed areas and some of them have generalist habits (see Dixo and Metzger 2009, Mageski et al. 2018) such as the anurans *Boana faber*, *Dendropsophus minutus*, *Leptodactylus latrans*, *Rhinella ornata* and *Scinax aff. x-signatus*, and the reptiles *Boa constrictor*, *Bothrops jararaca*, *Brasiliscincus agilis*, *Erythrolamprus miliaris*, *Salvator merianae* and *Tropidurus torquatus*. Factors such as intolerance to environmental changes and the unavailability of specific microhabitats may explain the absence of some specialist taxa in the buffer zone. As an example, amphibian families such as Aromobatidae, Hemiphractidae, Hylodidae, Odontophrynidae and Microhylidae have not been documented in the buffer zone, only inside the core of PESET. We also have not documented amphibian species in restinga areas. The proximity to the sea and the small, disturbed patches surveyed seems to harbour little or no available habitat to the group due to anthropical influence and high salinity. Roadkill, intentional killing of snakes by humans, pollution and the presence of feral cats and dogs were major problems detected in most areas during our surveys, which are factors that may have further reduced the buffer zone species richness.

The anurans *Dendropsophus minutus*, *Dendropsophus de-cipiens* and *Leptodactylus latrans* were frequent species in our samples. We recorded *D. minutus* at ponds and artificial water bodies in great numbers and *L. latrans* mostly in channels and marshes with high anthropic influence. The lizards *Tropidurus torquatus*, *Brasiliscincus agilis* and *Hemidactylus mabouia* were the most frequently found in the buffer zone in our samples. In general, they are open area species (Rodrigues 1987, Rocha 2000, Solé et al. 2009) and more generalist in terms of their diet composition and microhabitat use (Rodrigues 1987, Solé et al. 2009, Leivas et al. 2018, Siqueira et al. 2013). The species *T. torquatus* and *B. agilis* are typical restinga and rocky shore species (Rodrigues 1987, Rocha 2000) but we also found them in open disturbed areas. The exotic lizard *Hemidactylus mabouia* was the most frequent herpetofauna species in the buffer zone. It was present in high numbers at most habitats surveyed, except for marshes. Even though non-native species can represent a threat to local biodiversity (Rodríguez 2001), knowledge on the potential impacts of this species is still largely unknown (Downey and Richardson 2016, Essl et al. 2020). Despite the high number of *H. mabouia* specimens, it might be having no negative impacts to sympatric native lizards (Winck et al. 2016) but further investigations are

needed. On the other hand, we found only one specimen of the anuran *Phyllodytes luteolus*, a bromeliad-inhabiting frog distributed at coastal region from Paraíba to northern Rio de Janeiro state (Frost 2021). Records from neighborhoods in the nearby metropolitan region of Rio de Janeiro suggest that the species is spreading in Rio de Janeiro territory probably through ornamental bromeliads trade (Izecksohn and Carvalho-e-Silva 2001, Salles and Silva-Soares 2010). The specimen was recorded in an ornamental bromeliad in a private garden in sampling area 1. Long-term monitoring of the species might help to understand if it represents a threat to the core zone of PESET.

Our results have the potential to inform conservation actions directed at maintaining reptile and amphibian diversity within the buffer zone of the PESET. We observed that many specimens of different species were using artificial water reservoir in degraded areas. Thus, we suggest the use of artificial water systems to offer valuable amphibian microhabitats that can be adequate substitutes when natural water systems are rare or heavily altered. Promoting the establishment of artificial water bodies as reproductive sites for amphibians, could help to ensure the persistence of many species in urban areas as proposed by other authors (Hamer and McDonnell 2008, Caballero-Díaz et al. 2022, Romano et al. 2023). In addition, enhancing environmental awareness through education and sensibilization programs could help reduce conflicts between the population and amphibians and reptiles of the buffer zone (Zamani et al. 2020). Buffer zones and core areas of PESET have been subjects of legal disputes with eventual habitat loss. Thus, characterization of buffer zones can contribute to a better management and conservation of biodiversity in these areas, where the conflicts between socioeconomical interests and conservation objectives are intensified.

ACKNOWLEDGMENTS

We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico for the scholarship (117850/2016-0) received by Miguel R. Ugalde during this study. Our thanks to those who allowed us to work on private lands and facilitated the sampling logistics. Finally, we also thank the anonymous reviewers for suggestions that improved the content of this manuscript.

LITERATURE CITED

Barros AAM (2008) Análise florística e estrutural do Parque Estadual da Serra da Tiririca, Niterói E Maricá, RJ, Brasil.

- PhD Thesis, Escola Nacional de Botânica Tropical, Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, 237 pp.
- Bowne DR, Bowers MA (2004) Interpatch movements in spatially structured populations: a literature review. *Landscape Ecology* 19: 1–20. <https://doi.org/10.1023/B:LAND.0000018357.45262.b9>
- Caballero-Díaz C, Sánchez-Montes G, Gómez I, Díaz-Zúñiga A, Martínez-Solano Í (2022) Artificial water bodies as amphibian breeding sites: the case of the common midwife toad (*Alytes obstetricans*) in central Spain. *Amphibia-Reptilia* 43(4): 395–406. <https://doi.org/10.1163/15685381-bja10115>
- Carvalho ALGD, Araújo AFBD, Silva HRD (2007) Lagartos da Marambaia, um remanescente insular de Restinga e Floresta Atlântica no Estado do Rio de Janeiro, Brasil. *Biota Neotropica* 7: 221–226. <https://doi.org/10.1590/S1676-06032007000200025>
- Citeli N, Hamdan B, Guedes T (2016) Snake richness in urban forest fragments from Niterói and surroundings, state of Rio de Janeiro, southeastern Brazil. *Biodiversity Data Journal* 4: e7145. <https://doi.org/10.3897/BDJ.4.e7145>
- Colwell RK (2013) EstimateS: Statistical estimation of species richness and shared species from samples. Version 9.1.0, <http://purl.oclc.org/estimates>
- Crump ML, Scott Jr NJ (1994) Visual encounter surveys. In: Heyer WR, Donnelly MA, McDiarmid RW, Hayek LC, Foster MS (Eds) *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians*. Smithsonian Institution, Washington, DC, 84–92.
- Dixo M, Metzger JP (2009) Are corridors, fragment size and forest structure important for the conservation of leaf-litter lizards in a fragmented landscape? *Oryx* 43: 435–442. <https://doi.org/10.1017/S0030605309431508>
- Downey PO, Richardson DM (2016) Alien plant invasions and native plant extinctions: a six-threshold framework. *Aob Plants* 8: plw047. <https://doi.org/10.1093/aobpla/plw047>
- Essl F, Lenzner B, Bacher S, Bailey S, Capinha C, Daehler C, et al. (2020) Drivers of future alien species impacts: An expert-based assessment. *Global Change Biology* 26: 4880–4893. <https://doi.org/10.1111/gcb.15199>
- Ferrante L, Angulo A, Sacramento M (2014) Notes on range extension and geographic variation of calls in *Adenomera thomei* (Anura: Leptodactylidae). *Check List* 10(6): 1560–1562. <https://doi.org/10.15560/10.6.1560>
- Fonseca CR, Venticinque EM (2018) Biodiversity conservation gaps in Brazil: A role for systematic conservation planning. *Perspectives in Ecology and Conservation* 16: 61–67. <https://doi.org/10.1016/j.pecon.2018.03.001>
- French SS, Webb AC, Hudson SB, Virgin EE (2018) Town and country reptiles: A review of reptilian responses to urbanization. *Integrative and Comparative Biology* 58: 948–966. <https://doi.org/10.1093/icb/icy052>
- Frost DR (2021) Amphibian species of the world: an online reference. Version 6.0, <http://research.amnh.org/herpetology/amphibia/> [Accessed: 10/09/2021]
- Geyle HM, Tingley R, Amey AP, Cogger H, Couper PJ, Cowan M, et al. (2020) Reptiles on the brink: identifying the Australian terrestrial snake and lizard species most at risk of extinction. *Pacific Conservation Biology* 27(1): 3–12. <https://doi.org/10.1071/PC20033>
- González-Castellano I, Marí-Mena N, Segelbacher G, Lopez-Vaamonde C, González-López J, Fagúndez J, Vila M (2023) Landscape genetics of the protected Spanish Moon Moth in core, buffer, and peripheral areas of the Ordesa y Monte Perdido National Park (Central Pyrenees, Spain). *Conservation Genetics* 24: 1–16. <https://doi.org/10.1007/s10592-023-01536-z>
- Guerra C, Aráoz E (2015) Amphibian diversity increases in a heterogeneous agricultural landscape. *Acta Oecologica* 69: 78–86. <https://doi.org/10.1016/j.actao.2015.09.003>
- Hamer AJ, McDonnell MJ (2008) Amphibian ecology and conservation in the urbanizing world: a review. *Biological Conservation* 141: 2432–2449. <https://doi.org/10.1016/j.biocon.2008.07.020>
- Houlahan JE, Findlay CS (2003) The effects of adjacent land use on wetland amphibian species richness and community composition. *Canadian Journal of Fisheries and Aquatic Sciences* 60: 1078–1094. <https://doi.org/10.1139/f03-095>
- Hu X, Huang B, Verones F, Cavalett O, Cherubini F (2021) Overview of recent landcover changes in biodiversity hotspots. *Frontiers in Ecology and the Environment* 19(2): 91–97. <https://doi.org/10.1002/fee.2276>
- Huey RB, Losos JB, Moritz C (2010) Are lizards toast? *Science* 328(5980): 832–833. <https://doi.org/10.1126/science.1190374>
- IUCN (2023) The IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources, v. 2023-1. <https://www.iucnredlist.org>
- Izecksohn E, Carvalho-e-Silva SP (2001) Anfíbios do município do Rio de Janeiro. Editora UFRJ, Rio de Janeiro, 158 pp.
- Jareguiberry P, Titeux N, Wiemers M, Bowler DE, Coscieme L, Golden AS, et al. (2022) The direct drivers of recent global anthropogenic biodiversity loss. *Science Ad-*

- vances 8(45): eabm9982 <https://doi.org/10.1126/sciadv.abm9982>
- Köppen W (1936) Das geographische System der Klimate. In: Köppen W, Geiger R (Eds) *Handbuch der Klimatologie*. Gebrüder Bornträger, Berlin, 1–44.
- Leivas PT, Mayer TB, Leivas FW, Fávaro LF (2018) Trophic niche of *Dendropsophus minutus* (Anura: Hylidae) in southern Brazil. *Phyllomedusa: Journal of Herpetology* 17: 267–272. <https://doi.org/10.11606/issn.2316-9079.v17i2p267-272>
- Mageski MM, Silva-Soares T, Duca C, Santos DCBMO, Jesus Filho PR, Costa LC, Clemente-Carvalho RBG (2018) Anuran species in a remnant of the Atlantic rainforest in an urban area. *Papéis Avulsos de Zoologia* 58: 1–4. <https://doi.org/10.11606/1807-0205/2018.58.16>
- Melo-Dias M, de Souza-Cruz PG, Moreira IG, de Almeida Curi NH, de Carvalho NS, de Freitas MA, Rosa C (2023) Invasive amphibians and reptiles living in Brazil. *South American Journal of Herpetology* 29(1): 38–65. <https://doi.org/10.2994/SAJH-D-20-00036.1>
- Milano MS (2001) Unidades de conservação-técnica, lei e ética para a conservação da biodiversidade. In: Benjamin AH (Ed.) *Direito ambiental das áreas protegidas: o regime jurídico das unidades de conservação*. Forense Universitária, Rio de Janeiro, 3–41.
- Moreno-Rueda G, Pizarro M (2007) The relative influence of climate, environmental heterogeneity, and human population on the distribution of vertebrate species richness in south-eastern Spain. *Acta Oecologica* 32: 50–58. <https://doi.org/10.1016/j.actao.2007.03.006>
- Moreno-Rueda G, Pizarro M (2009) Relative influence of habitat heterogeneity, climate, human disturbance, and spatial structure on vertebrate species richness in Spain. *Ecological Research* 24: 335–344. <https://doi.org/10.1007/s11284-008-0509-x>
- Mott T, de Moura MR, Maciel AO, Feio RN (2011) Morphological variation and geographical distribution of *Luetkenotyphlus brasiliensis* (Gymnophiona: Siphonopidae). *Phyllomedusa: Journal of Herpetology* 10(2): 153–163. <https://doi.org/10.11606/issn.2316-9079.v10i2p153-163>
- Myers N (1988) Threatened biotas: “hot spots” in tropical forests. *Environmentalist* 8:187–208. <https://doi.org/10.1007/BF02240252>
- Myers N (2003) Biodiversity hotspots revisited. *BioScience* 53(10): 916–917. [https://doi.org/10.1641/0006-3568\(2003\)053\[0916:BHR\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2003)053[0916:BHR]2.0.CO;2)
- Pontes JAL (1987) Serra da Tiririca, RJ. Necessidade de conservação (1ª Contribuição). *Boletim da Fundação Brasileira para Conservação da Natureza* 22: 89–94.
- Pontes RC, Pontes JAL (2016) Anfíbios da Serra da Tiririca: diversidade e conservação. In: Santos MG (Ed) *Biodiversidade e Sociedade no Leste Metropolitano do RJ*. EdUERJ, Rio de Janeiro, 19–68.
- Pontes RC, Santori RT, Cunha FC, Pontes JAL (2013) Habitat selection by anurofauna community at rocky seashore in coastal Atlantic Forest, Southeastern Brazil. *Brazilian Journal of Biology* 73: 533–542. <https://doi.org/10.1590/S1519-69842013000300011>
- Reinert HK (1984) Habitat separation between sympatric snake populations. *Ecology* 65: 478–486. <https://doi.org/10.2307/1941410>
- Rezende CL, Scarano FR, Assad ED, Joly CA, Metzger JP, Strassburg BBN, Tabarelli M, Fonseca GA, Mittermeier RA (2018) From hotspot to hopespot: an opportunity for the Brazilian Atlantic Forest. *Perspectives in Ecology and Conservation* 16: 208–214. <https://doi.org/10.1016/j.pecon.2018.10.002>
- Rhodin AGJ, Stanford CB, Dijk PP, Eisemberg C, Luiselli L, Mittermeier RA, et al. (2018) Global Conservation Status of Turtles and Tortoises (Order Testudines). *Chelonian Conservation and Biology* 17: 135–161. <https://doi.org/10.2744/CCB-1348.1>
- Rocha CFD (2000) Biogeografia de répteis de restinga. In: Lacerda LD, Esteves FA (Eds) *Ecologia de Restingas e Lagoas Costeiras*. NUPEM, UFRJ, Macaé, 99–116.
- Rocha CFD, Siqueira CC, Ariani CV (2009) The endemic and threatened lizard *Liolaemus lutzae* (Squamata: Liolaemidae): current geographic distribution and areas of occurrence with estimated population densities. *Zoologia* 26: 454–460. <https://doi.org/10.1590/S1984-46702009000300009>
- Rodrigues MT (1987) Sistemática, ecologia e zoogeografia dos *Tropidurus* do grupo *torquatus* ao sul do Rio Amazonas (Sauria, Iguanidae). *Arquivos de Zoologia* 31: 105–230. <https://doi.org/10.11606/issn.2176-7793.v31i3p105-230>
- Rodríguez JP (2001) Exotic species introductions into South America: an underestimated threat? *Biodiversity & Conservation* 10: 1983–1996. <https://doi.org/10.1023/A:1013151722557>
- Romano A, Bernabò I, Rosa G, Salvidio S, Costa A (2023) Artificial paradises: Man-made sites for the conservation of amphibians in a changing climate. *Biological Conservation* 286: 110309. <https://doi.org/10.1016/j.biocon.2023.110309>
- Salles ROL, Silva-Soares T (2010) *Phyllodytes luteolus* (Anura, Hylidae) as an alien species in the Rio de Janeiro municipality, state of Rio de Janeiro, southeastern Brazil. *Herpetology Notes* 3: 257–258.

- Sayer J (1991) Buffer zones in rainforests: fact or fantasy? *Parks* 2: 20–24.
- Silva HR, Carvalho ALG, Bittencourt-Silva GB (2008) Frogs of Marambaia: a naturally isolated Restinga and Atlantic Forest remnant of southeastern Brazil. *Biota Neotropica* 8: 166–174. <https://doi.org/10.1590/S1676-06032008000400017>
- Siqueira CC, Kiefer MC, Van Sluys M, Rocha CFD (2013) Variation in the diet of the lizard *Tropidurus torquatus* along its coastal range in Brazil. *Biota Neotropica* 13: 93–101. <https://doi.org/10.1590/S1676-06032013000300012>
- Solé M, Dias IR, Rodrigues EA, Marciano Jr E, Branco SM, Cavalcante KP, Rödder D (2009) Diet of *Leptodactylus ocellatus* (Anura: Leptodactylidae) from a cacao plantation in southern Bahia, Brazil. *Herpetology Notes* 2: 9–15.
- SOS Mata Atlântica, INPE (2021) Atlas dos remanescentes florestais da Mata Atlântica, Período 2019-2020. Fundação SOS Mata Atlântica, Instituto Nacional de Pesquisas Espaciais, São Paulo, 78 pp.
- Sullivan BK, Vardukyan D, Sullivan KO (2014) Historic and Current Composition of Lizard Communities in Urban Preserves of Central Arizona, USA. *Urban Naturalist* 2: 1–18.
- Tingley R, Meiri S, Chapple DG (2016) Addressing knowledge gaps in reptile conservation. *Biological Conservation* 204: 1–5. <https://doi.org/10.1016/j.biocon.2016.07.021>
- Tuberville TD, Andrews KM, Sperry JH, Grosse AM (2015) Use of the NatureServe climate change vulnerability index as an assessment tool for reptiles and amphibians: lessons learned. *Environment Management* 56: 822–834. <https://doi.org/10.1007/s00267-015-0537-6>
- Vrcibradic D, Rocha CFD, Kiefer MC, Hatano FH, Fontes AF, Almeida-Gomes M, et al. (2011) Herpetofauna, Estação Ecológica Estadual do Paraíso, state of Rio de Janeiro, southeastern Brazil. *Check List* 7: 745–749. <https://doi.org/10.15560/11013>
- Weller R, Drozd Z, Kjaersgaard SP (2019) Hotspot cities: Identifying peri-urban conflict zones. *Journal of Landscape Architecture* 14(1): 8–19. <https://doi.org/10.1080/18626033.2019.1623542>
- Winck GR, Hatano F, Vrcibradic D, Van Sluys M, Rocha CFD (2016) Lizard assemblage from a sand dune habitat from southeastern Brazil: a niche overlap analysis. *Anais da Academia Brasileira de Ciências* 88: 677–687. <https://doi.org/10.1590/0001-3765201620150335>
- Zamani N, Hatami J, Shobeir SM, Kaboodvandpour S (2020) The impacts of environmental education on reducing human-wildlife conflict. *Journal of Animal Environment* 12(1): 31–40.
- Zhang J, Wang X, Xie Y (2021) Implication of buffer zones delineation considering the landscape connectivity and influencing patch structural factors in nature reserves. *Sustainability* 13: 10833. <https://doi.org/10.3390/su131910833>

Submitted: July 6, 2023

Accepted: November 21, 2024

Editorial responsibility: Fabricius M.C.B. Domingos

Author Contributions

MRU: Conceptualization, Data Curation, Investigation, Methodology, Writing–Original draft, Writing–review & editing. TPAS, AFM: Data curation, Investigation, Methodology. MCK: Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing–Original draft, Writing–review & editing.

Competing Interests

The authors have declared that no competing interests exist.

How to cite this article

Ugalde MR, Salles TPA, Marinho AF, Kiefer MC (2025) Living on the edge: Herpetofauna of the buffer zone of the Parque Estadual da Serra da Tiririca, Rio de Janeiro State, Brazil. *Zoologia* 42: e23037. <https://doi.org/10.1590/S1984-4689.v42.e23037>

Published by

Sociedade Brasileira de Zoologia at Scientific Electronic Library Online – <https://www.scielo.br/zool>

Copyright

© 2025 The Authors.

Appendix 1. Reptile and amphibian species and associated voucher numbers deposited in the herpetological collection of Museu Nacional da Universidade Federal do Rio de Janeiro (MNRJ) and Instituto Vital Brazil (IVBL).

Amphibians:

Bufonidae: *Rhinella ornata* (MNRJ 93220–93226, 94218–94221)

Craugastoridae: *Haddadus binotatus* (MNRJ 93261–93266)

Cycloramphidae: *Thoropa miliaris* (MNRJ 93240, 93241)

Hylidae: *Nyctimantis bruno*i (MNRJ 93272–93275); *Boana faber* (MNRJ 93234, 94225–94227); *Boana albomarginata* (MNRJ 92352, 93253); *Dendropsophus minutus* (MNRJ 93314, 93315, 93317–93330, 93332–93339, 93341–93343, 93346, 93347); *Dendropsophus meridianus* (MNRJ 93258,

- 93259); *Dendropsophus microps* (MNRJ 93286–93292); *Dendropsophus seniculus* (MNRJ 93269–93271); *Dendropsophus elegans* (MNRJ 93248–93250, 94222); *Dendropsophus anceps* (MNRJ 93267); *Dendropsophus bipunctatus* (MNRJ 93276–93279); *Dendropsophus decipiens* (MNRJ 93294–93312); *Ollolygon argyreornata* (MNRJ 93251); *Scinax alter* (MNRJ 93268); *Scinax* aff. *x-signatus* (MNRJ 93280–93285); *Scinax* sp. (MNRJ 93242–93245); *Trachycephalus nigromaculatus* (MNRJ 93227 - 93230); *Phyllodytes luteolus* (MNRJ 93260)
- Leptodactylidae:** *Adenomera marmorata* (MNRJ 93256, 93257); *Adenomera thomei* (MNRJ 93293); *Leptodactylus latrans* (MNRJ 93254, 92355, 94234–94236); *Leptodactylus fuscus* (MNRJ 93235); *Leptodactylus mystacinus* (MNRJ 93236); *Leptodactylus spixi* (MNRJ 93246, 93247); *Physalaemus signifer* (MNRJ 93231–93233)
- Siphonopidae:** *Luetkenotyphlus* sp. (MNRJ 94267)
- Reptiles:**
- Colubridae:** *Corallus hortulana* (IVB 1417); *Chironius laevis collis* (IVB 1521); *Oxybelis aeneus* (IVB 1591); *Palusophis bifossatus* (IVB 573)
- Diploglossidae:** *Ophiodes fragilis* (MNRJ 26545)
- Dipsadidae:** *Helicops carinicaudus* (MNRJ 27181); *Erythrolamprus miliaris* (MNRJ 27156, 27157); *Dryophylax nattereri* (MNRJ 26580); *Dibernardia affinis* (MNRJ 26579); *Elapomorphus quinquilineatus* (IVB 1490); *Erythrolamprus poecilogyrus* (IVB 86); *Pseudablabes patagoniensis* (IVB 839)
- Gekkonidae:** *Hemidactylus mabouia* (IVBL 175–241, 243, 244, 246–251, 253–262, 264, 266–370, 372, 387–427, 430–448, 450, 451, 453–457, 459, 467, 472, 474, 475, 478)
- Phyllodactylidae:** *Gymnodactylus darwinii* (MNRJ 27159–27161)
- Scincidae:** *Brasiliscincus agilis* (MNRJ 27162–27173, 2861)
- Teiidae:** *Ameiva ameiva* (MNRJ 27158)
- Tropiduridae:** *Tropidurus torquatus* (MNRJ 27176–27180, 27863)
- Viperidae:** *Bothrops jararaca* (MNRJ 26581, 26582)