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Inventory

Parque Nacional da Serra dos Órgãos: the highest Amphibian diversity within an Atlantic Forest protected area

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***In memoriam*

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Abstract: We studied the amphibian community of the Parque Nacional da Serra dos Órgãos (PARNASO) for over thirty years. The area of 20,024 hectares has a steep altitudinal gradient (200–2,263 m a.s.l.), and it is located in the municipalities of Guapimirim, Magé, Petrópolis and Teresópolis, middle of the state of Rio de Janeiro, Brazil. Most data were obtained from sampling sites in the municipality of Teresópolis, with additional data from zoological collections and bibliography. We recorded 83 amphibian species distributed in two orders, Anura, 13 families: Aromobatidae (1), Brachycephalidae (11), Bufonidae (5), Centrolenidae (2), Craugastoridae (2), Cycloramphidae (8), Hemiphractidae (7), Hylidae (28), Hylodidae (6), Leptodactylidae (5), Microhylidae (1), Odontophrynidae (3), Phyllomedusidae (3) and Gymnophiona, one family: Siphonopidae (1). In addition, we present six species that occurs in the buffer zone. Ten of these species are endemic of the park, 18 have PARNASO as its type locality, and five the type locality is at the buffer zone.
Keywords: *Anura, biodiversity, conservation, disappeared species, endemic species, species richness.*

Parque Nacional da Serra dos Órgãos: a maior diversidade de anfíbios em uma área de proteção da Mata Atlântica

Resumo: Estudamos a comunidade de anfíbios do Parque Nacional da Serra dos Órgãos (PARNASO) por mais de 30 anos. A área de 20.024 hectares possui um gradiente altitudinal de 200 a 2.263m acima do nível do mar, e está localizada nos municípios de Guapimirim, Magé, Petrópolis e Teresópolis, que ficam no meio do estado do Rio de Janeiro, Brasil. A maioria das coletas foram feitas no município de Teresópolis, com dados adicionais de outras coleções zoológicas e de bibliografia. Foram registradas ao todo 83 espécies de anfíbios distribuídos em duas ordens, Anura, 13 famílias: Aromobatidae (1), Brachycephalidae (11), Bufonidae (5), Centrolenidae (2), Craugastoridae (2), Cycloramphidae (8), Hemiphractidae (7), Hylidae (28), Hylodidae (6), Leptodactylidae (5), Microhylidae (1), Odontophrynidae (3), Phyllomedusidae (3) e Gymnophiona, uma família: Siphonopidae (1). Foram registradas, também, seis espécies que ocorrem na zona de amortecimento. Destas espécies 10 são endêmicas, 18 têm o PARNASO como localidade tipo e cinco têm a localidade tipo na zona de amortecimento.
Palavras-chave: *Anura, área montanhosa, biodiversidade, conservação, espécies desaparecidas, espécies endêmicas, inventário, Mata Atlântica, riqueza de espécies.*

Introduction

The Atlantic Rain Forest is a hotspot of biodiversity that harbors a large number of endemic species of vertebrates (Myers et al. 2000). More than 500 species of amphibians inhabit this biome, of which around 90% are endemic (Morellato & Haddad 2000, Haddad et al. 2013). The Atlantic Forest is one of the ecosystems mostly threatened by human activities around the world (Myers et al. 2000), and now it is reduced to a few fragments with only 12% of its original area (Ribeiro et al. 2009).

Located in the Atlantic Forest, the most devastated of Brazilian ecosystems, the Serra dos Órgãos National Park (Parque Nacional da Serra dos Órgãos - PARNASO) was created on November 30, 1939, being the third national park in the country. Initially covered an area of 10,653 hectares in the municipalities of Petrópolis, Guapimirim, Magé and Teresópolis, state of Rio de Janeiro (Cronemberger & Castro 2007). In 2008, its area was expanded, and now comprises 20,024 hectares (ICMBIO 2008). Nowadays, the Serra dos Órgãos National Park represents one of the few remaining spots of biodiversity in the state of Rio de Janeiro and stands out by protecting important water sources that feed two main watersheds, the Paraíba do Sul and Baía de Guanabara (Cronemberger & Castro 2007).

PARNASO has altitudes ranging from 200 m to 2263 m above sea level (a.s.l.). The park climate is tropical super humid (80% to 90% relative humidity), with an annual average temperature ranging from 13° C to 23° C, except for the elevation areas higher than 800 m a.s.l., which reaches the maximum average annual temperature of 19º C and the minimum of -5° C during the winter. The average annual rainfall ranges from 1,500 mm to 3,000 mm, with higher concentrations of rain during the summer (December to March), and dry season in the winter (June to August; Cronemberger & Castro 2007).

Amphibians are considered good indicators of environmental conditions due to its vulnerability to environmental changes (Wells 2007). This characteristic associated with other factors such as amphibian's habitats occupied by human activities, increased ultraviolet light, infectious diseases and climate changes have led amphibians' populations to decline in the last decades (Stebbins & Cohen 1995, Gardner 2001). In this scenario, PARNASO is highlighted for being the type locality of several species, including some species endemic to the park (ICMBIO 2008).

The main goal of this study is to present an updated checklist of the species occurring in the PARNASO area, encouraging researches on the species that lives there, as their taxonomy, behavior and natural history; and to help drive the management of the amphibian biodiversity in this conservation area.

Material and Methods

Our fieldwork at PARNASO began in 1962 by late Professor Eugenio Izecksohn, and we carried it until 2019, totaling 230 surveys during the rainy and dry seasons. During data collection, around three collectors worked at least three days. We performed two complementary methods for sampling the adults: active and auditory search (see Calleffo 2002). For the capture of tadpoles, we used sieves (see Heyer et al. 1994). Adults and tadpoles were collected, photographed, and then anesthetized and fixed according to the Brazilian law (CONCEA 2016). Specimens were deposited at the amphibian collection of the Universidade Federal do Rio de Janeiro (ZUFRJ) and at the amphibian collection of Universidade Federal do Estado do Rio de Janeiro (UNIRIO). During this period, we obtained information on the natural history and distribution of the species from the park.

Additional data were obtained from the amphibian's collections of the Eugênio Izecksohn (EI, Universidade Federal Rural do Rio de Janeiro), of Museu Nacional do Rio de Janeiro (MNRJ), of Kansas University (KU) and from bibliography (see Table 1). We also include a list of species that can be found in the buffer zone, including Represa dos Guinle and Granja Comary, in Teresópolis municipality.

These sources encompass more than 50 years of fieldwork in the area. Examined specimens are found in Appendix 3. Species richness estimates and Jackknife index (JK) were calculated using the software EstimateS 9.1.0 (Colwel 2013) with 1,000 randomizations. First order JK was chosen because it is indicated for possibly biased samples and performed best on both simulated and real datasets (Walther & Morand 1998, Chao & Chiu, 2016). The results were plotted in a graph, together with the species accumulation curve, on Microsoft Excel v. 1912. For these calculations, we excluded records that did not involve our team. Taxonomic nomenclature follows Frost (2020).

The sampling was more intense in places frequently visited by tourists, such as the swimming pool and dam, the trails Cartão Postal, Mozart Catão, Pedra do Sino, Primavera and Suspensa, all at the headquarters of Teresópolis; and the banks of Soberbo River, also in Teresópolis. We also sampled restricted places, just allowed to researchers, as the Rancho Frio trail, and more remote areas, such as the regions of Pedra do Sino at Teresópolis, Garrafão in Guapimirim, and Pico do Açu at Petrópolis (Figures 1 and 2).

Results

We recorded 83 species (Table 1) within the park belonging to two orders and 14 families (Figure 3): **order Anura**, Arobomatidae (1 sp.); Brachycephalidae (11 spp.); Bufonidae (5 spp.); Centrolenidae (2 spp.); Craugastoridae (2 spp.); Cycloramphidae (8 spp.); Hemiphractidae (7 spp.); Hylidae (28 spp.); Hylodidae (6 spp.); Leptodactylidae (5 spp.); Microhylidae (1 sp.); Odontrophinidae (3 spp.); Phyllomedusidae (3 spp.); **order Gymnophiona**, Siphonopidae (1 spp.). Ten of these species are considered endemic of the park, 18 have PARNASO as its type locality, and five the type locality is at the buffer zone (Table 1). The species accumulation, species richness estimates and Jackknife index curves are presented in the Figure 4. The species accumulation curve shows a fast increase followed by a decreasing in the number of new species found, with a tendency of stabilization in its end, reaching 69 species. The superior limit of the confidence interval of the richness curve estimates 78 species within the park, while the Jackknife frequency estimates the presence of 88 species. Figures 5–7 illustrates some of the recorded species.

Other six species were recorded at the buffer zone (Table 2), belonging to two orders and four families: **order Anura,** Ceratophryidae (1 sp.); Hylidae (1 sp.); Leptodactylidae (2 spp.); and **order Gymnophiona,** Siphonopidae (2 sp.).

Examined material is listed on Appendix 1.

Discussion

Considering the more than 1,000 described species of Brazilian amphibians, the amphibian fauna of PARNASO together with its buffer

Table 1. Amphibians found in Parque Nacional da Serra dos Órgãos (PARNASO), state of Rio de Janeiro, Brazil.

Taxa	IUCN status	Habitat	Breeding/Period of Activity	Type of Register	Endemic	Type locality
AMPHIBIA (CLASS)						
ANURA (ORDER)						
AROMOBATIDAE (FAMILY)						
Allobates olfersioides (Lutz, 1925)	VU/Dc	LL, S	TN, PC/D	AD	-	-
BRACHYCEPHALIDAE (FAMILY)						
Brachycephalus didactylus (Izecksohn, 1971)	LC/Dc	LL	TE, DDi/D, N	AD	-	-
Brachycephalus ephippium (Spix, 1824)	LC/St	LL	TN, DDi/D, N	AD	-	-
Ischnocnema erythromera (Heyer, 1984)	DD/Dc	LL	DDi/D, N	AD	X	X
Ischnocnema gualteri (Lutz, 1974)	LC/Dc	LL	TE, DDi/N	AD	-	-
Ischnocnema aff. *guentheri*	Un	LL	TN, DDi/D, N	AD	-	-
Ischnocnema holti (Cochran, 1948)	DD/Un	LL	TE, DDi/N	AD	-	-
Ischnocnema nasuta (Lutz, 1925)	LC/Dc	B, LL	DDi/D	AC	-	-
Ischnocnema octavioi (Bokermann, 1965)	LC/Dc	LL	DDi/ D, N	AD	-	-
Ischnocnema parnaso Taucce, Canedo, Parreiras, Drummond, Nogueira-Costa and Haddad, 2018	Un	LL	-	AD	X	X
Ischnocnema parva (Girard, 1853)	LC/Dc	LL	TE, DDi/ N	AD	-	-
Ischnocnema venancioi (Lutz, 1958)	LC/Dc	LL	PhE, DDi/ N	AD	-	X
BUFONIDAE (FAMILY)						
Dendrophryniscus brevipollicatus Jiménez de la Espada, 1870	LC/Dc	B, LL	PhE/ D, N	AD	-	-
Dendrophryniscus organensis Carvalho-e-Silva, Mongin, Izecksohn and Carvalho-e-Silva, 2010	Un	B, LL	PhE/N	AD	X	X
Rhinella crucifer (Wied-Neuwied, 1821)	LC/Dc	LL, P, S	AE/N	AD	-	-
Rhinella icterica (Spix, 1824)	LC/St	LL, P, S	AE/N	AD	-	-
Rhinella ornata (Spix, 1824)	LC/St	LL, P, S	AE/N	AD	-	-
CENTROLENIDAE (FAMILY)						
Vitreorana eurygnatha (Lutz, 1925)	LC/Dc	S, T	LF/N	AD	-	-
Vitreorana uranoscopa (Müller, 1924)	LC/Dc	S, T	LF/N	AD	-	-
CRAUGASTORIDAE (FAMILY)						
Euparkerella cochranae Izecksohn, 1988	LC/Dc	HG, LL	TE, DDi/N	AD	-	X
Haddadus binotatus (Spix, 1824)	LC/St	HG, LL	TE, DDi/D, N	AD	-	-
CYCLORAMPHIDAE (FAMILY)						
Cycloramphus brasiliensis (Steindachner, 1864)	NT/Dc	HR, S	RE, PC/D, N	AD	-	-
Cycloramphus eleutherodactylus (Miranda-Ribeiro, 1920)	DD/Un	HG, LL	TN/N	AD	-	-
Cycloramphus ohausi (Wandolleck, 1907)	DD/Dc	S	Un/N	AD	-	-
Cycloramphus organensis Weber, Verdade, Salles, Fouquet, and Carvalho-e-Silva, 2011	DD/Un	HL, Ms	Un/D	AD	X	X
Cycloramphus stejnegeri (Noble, 1924)	DD/Dc	LL	TN, PC/N	AD	X	X
Thoropa miliaris (Spix, 1824)	LC/St	HR, LL	RE, PC/N	AD	-	-
Thoropa petropolitana (Wandolleck, 1907)	VU/Dc	HR	RE, PC/D	AD	-	-
Zachaenus parvulus (Girard, 1853)	LC/Dc	HG, LL	NT, PC/D, N	AD	-	-
HEMIPHRACTIDAE (FAMILY)						
Fritziana cf. *fissilis* (Miranda-Ribeiro, 1920)	LC/St	B	BP/N	AD	-	-

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Fritziana goeldii (Boulenger 1895)	LC/St	B, T	BP/D, N	AD	-	*
Fritziana izecksohni Folly, Hepp and Carvalho-e-Silva, 2018	Un	B	BP/N	AD	X	X
Fritziana ohausi (Wandolleck, 1907)	LC/St	B, Bb, T	BP/N	AD	-	-
Gastrotheca albolineata (Lutz and Lutz, 1939)	LC/Dc	T	BP, DDi/D, N	AD	-	*
Gastrotheca ernestoi Miranda-Ribeiro, 1920	DD/Un	T	BP, DDi/N	AD	-	-
Gastrotheca fulvorufa (Andersson, 1911)	DD/Un	T	BP, DDi/N	AD	-	-
HYLIDAE (FAMILY)						
Aplastodiscus arildae (Cruz and Peixoto, 1987)	LC/St	B, S, T	AN/N	AD	-	*
Aplastodiscus eugenioi (Carvalho-e-Silva and Carvalho-e-Silva, 2005)	NT/Un	B, S, T	AN/N	TD	-	-
Aplastodiscus flumineus (Cruz and Peixoto, 1985)	DD/Dc	S, T	AE/N	AD	X	X
Aplastodiscus leucopygius (Cruz and Peixoto, 1985)	LC/St	S, T	AN/N	AD	-	*
Aplastodiscus musicus (Lutz, 1949)	DD/Dc	S, T	AE/N	AD	X	X
Boana albomarginata (Spix, 1824)	LC/St	P	AE/N	AD	-	-
Boana faber (Wied-Neuwied, 1821)	LC/St	P	AN/N	AD	-	-
Boana pardalis (Spix, 1824)	LC/St	P	AN/N	AD	-	-
Boana polytaenia (Cope, 1870)	LC/St	P	AE/D, N	AD	-	-
Bokermannohyla carvalhoi (Peixoto, 1981)	LC/Dc	S, T	AE/N	AD	-	X
Bokermannohyla circumdata (Cope, 1871)	LC/Dc	B, S, T	AN/N	AD	-	-
Bokermannohyla claresignata (Lutz and Lutz, 1939)	DD/Dc	B	AE/N	Lutz and Lutz, 1939	-	*
Dendropsophus bipunctatus (Spix, 1824)	LC/St	P, T	AE/N	TD	-	-
Dendropsophus elegans (Wied-Neuwied, 1824)	LC/St	P, T	LF/N	AD	-	-
Dendropsophus giesleri (Mertens, 1950)	LC/Dc	P, T	AE/N	Campos and Lourenço-de-Moraes (2017)	-	-
Dendropsophus minutus (Peters, 1872)	LC/St	P	AE/D, N	AD	-	-
Dendropsophus seniculus (Cope, 1868)	LC/St	P, T	AE/N	AC	-	-
Ololygon albicans (Bokermann, 1967)	LC/Dc	P, S	AE/N	AD	-	X
Ololygon argyreornata (Miranda-Ribeiro, 1926)	LC/St	P, S	AE/D, N	AD	-	-
Ololygon flavoguttata (Lutz and Lutz, 1939)	LC/Dc	S	AE/N	AD	-	-
Ololygon hiemalis (Haddad and Pombal, 1987)	LC/Dc	P	AE/N	AD	-	-
Ololygon melloi (Peixoto, 1989)	DD/Un	B	PhE/N	AD	X	X
Ololygon obtriangulata (Lutz, 1973)	LC/Dc	S	AE/N	AD	-	-
Ololygon v-signata (Lutz, 1968)	LC/Dc	B	PhE/N	AD	-	X
Scinax crospedospilus (Lutz, 1925)	LC/St	P	AE/N	AD	-	-
Scinax hayii (Barbour, 1909)	LC/St	P, S	AE/N	AD	-	-
Sphaenorhynchus platycephalus (Werner, 1894)	DD/Un	P, T	AE/N	Araújo-Vieira et al. 2018	-	-
Trachycephalus imitatrix (Miranda-Ribeiro, 1926)	LC/Dc	P	AE/D, N	AD	-	-
HYLODIDAE (FAMILY)						
Crossodactylus aeneus Müller, 1924	DD/Dc	S	AE/D	AD	-	X

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Hylodes asper (Müller, 1924)	LC/St	S	AE/D	AD	-	X
Hylodes charadranaetes Heyer & Cocroft, 1986	DD/Un	S	AE/D	AD	-	X
Hylodes lateristrigatus (Baumann, 1912)	LC/Dc	S	AE/D	AD	-	-
Hylodes pipilans Canedo and Pombal, 2007	DD/Un	S	AE/D	AD	X	X
Megaelosia goeldii (Baumann, 1912)	LC/Dc	S	AE/D	AD	-	-
LEPTODACTYLIDAE (FAMILY)						
Adenomera bokermanni (Heyer, 1973)	LC/St	HG, LL	FN, TN/N	AC	-	-
Adenomera marmorata Steindachner, 1867	LC/St	HG, LL	FN, TN/D, N	AC	-	-
Crossodactylodes pintoi Cochran, 1938	DD/Un	B	PhE/N	TD	-	-
Physalaemus cuvieri Fitzinger, 1826	LC/St	P, LL	FN/N	Campos and Lourenço-de-Moraes (2017)	-	-
Physalaemus signifer (Girard, 1853)	LC/St	P, LL	FN/N	AD	-	-
MICROHYLIDAE (FAMILY)						
Myersiella microps (Duméril and Bibron, 1841)	LC/St	HG, LL	TE, DiD/N	AD	-	-
ODONTOPHRYNIDAE (FAMILY)						
Proceratophrys appendiculata (Günther, 1873)	LC/Dc	HG, LL P, S,	AE/D, N	AD	-	-
Proceratophrys boiei (Wied-Neuwied, 1824)	LC/St	HG, LL, P, S,	AE/D, N	AD	-	-
Proceratophrys melanopogon (Miranda-Ribeiro, 1926)	LC/Dc	HG, LL, P, S	AE/N	Izecksohn et al. (1998)	-	-
PHYLLOMEDUSIDAE (FAMILY)						
Phasmahyla guttata (Lutz, 1924)	LC/Dc	S, T	LF/N	AD	-	-
Phyllomedusa burmeisteri Boulenger, 1882	LC/St	P	LF/N	AD	-	-
Phrynomedusa vanzolinii Cruz, 1991	DD/Un	S	RE/N	Baêta et al. (2016)	-	-
GYMNOPHIONA (ORDER) **SIPHONOPIDAE (FAMILY)**						
Siphonops annulatus (Mikan, 1820)	LC/Un	HG	DiD/Un	AD	-	-

Caption IUCN status (International Union for Conservation of Nature and Natural Resources): DD = Deficient Data; LC = Least Concern; VU = Vulnerable; NT = Near Threatened; Stable population (St); Decreasing population (Dc); Unknown status (Un). Habitat: B = bromeliads; Bb = bamboo; HG = Hidden in galleries or holes in the ground; HL = Highlands; HR = Humid rocks; LL = Leaf litter or understory; Ms= moss; P = ponds; S = Streams; T = Trees. Breeding activity: AE = Aquatic eggs; AN = Aquatic nest; BP = Brooding pouch; DiD = Direct development; FN = Foam Nest; LF = Leaf eggs; PC = parental care; PhE = Phytotelmata eggs; RE = Rock eggs; TE = Terrestrial eggs; TN = Terrestrial nest; Un = unknown. Period of activity: D = Diurnal; N = Nocturnal. Type of Register: AC = acoustic record only; AD = Adult record; TD = Tadpole record only. Species that are endemic and/or its type locality is at PARNASO are marked with "X" and the asterisk "*" represents species with type locality at the buffer zone.

zone, represent almost 10% of all country diversity, highlighting the importance of the park in the preservation of this group.

Previously, two other inventories were conducted in the area. Campos & Lourenço-de-Moraes (2017) reported 25 species, of which *Dendropsophus giesleri* (Mertens, 1950) and *Physalaemus cuvieri* Fitzinger, 1826 were not found in the present study. The authors did not mention the voucher specimens; thus, we could not verify the species identification. The second inventory was conducted by Folly et al. (2016) focusing on the anuran species restricted to the high elevation areas of PARNASO, recording 28 species, all included in the present study.

According to Dorigo et al. (2018), the state of Rio de Janeiro has 201 species distributed in 51 genera and 16 families of amphibians, of which 54 are considered endemic. After that, three more species were described, all endemic to the state: *Fritziana izecksohni* Folly, Hepp & Carvalho-e-Silva, 2018, *Ischnocnema parnaso* Taucce, Canedo, Parreiras, Drummond, Nogueira-Costa, & Haddad, 2018, and *Phasmahyla lisbella* Pereira, Rocha, Folly, Silva, & Santana, 2018 (Folly et al. 2018, Taucce et al. 2018b, Pereira et al. 2018, respectively). Whereas endemic species are more prone to extinction (Isik 2010), the park plays a major role protecting 10 species, around 3% of the Rio de Janeiro state biodiversity, that only occurs over there.

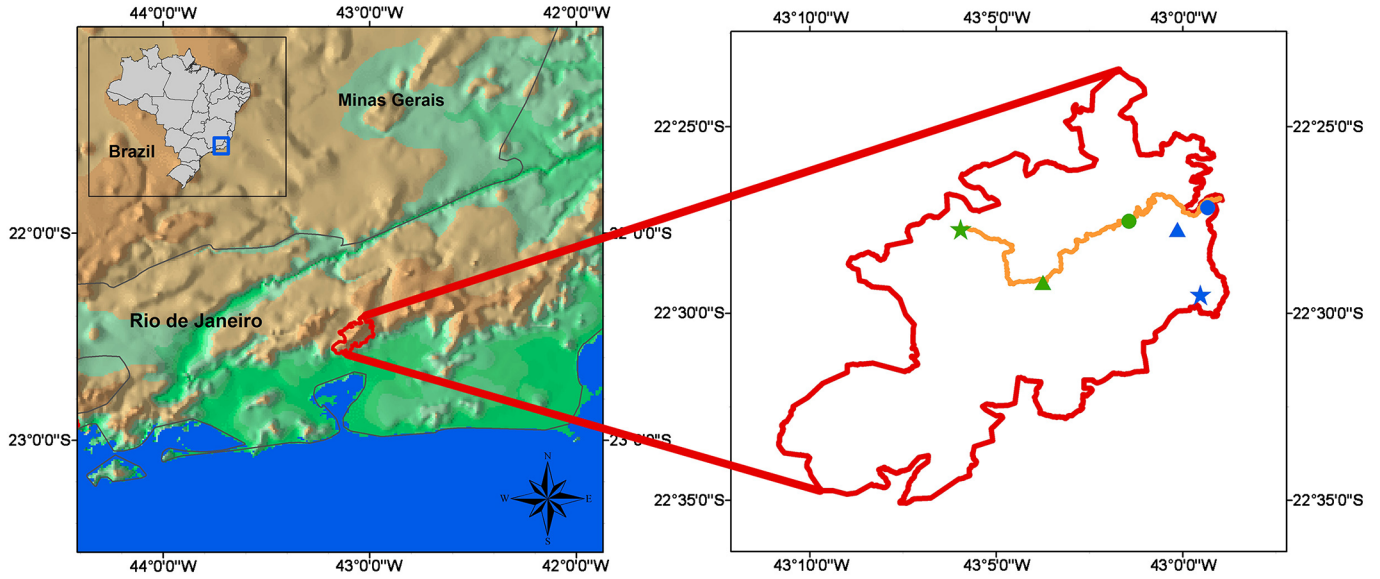

Figure 1. Map of PARNASO showing the main sampling sites. Red line: limits of PARNASO. Orange line: main trail from Petrópolis to Teresópolis. Green star: trails in the Petrópolis headquarters. Green triangle: Pico do Açu (Açu peak). Green circle: "Pedra do Sino". Blue triangle: trails in the Teresópolis headquarters. Blue circle: park administration and swimming pool. Blue star: trails in the Guapimirim headquarters.

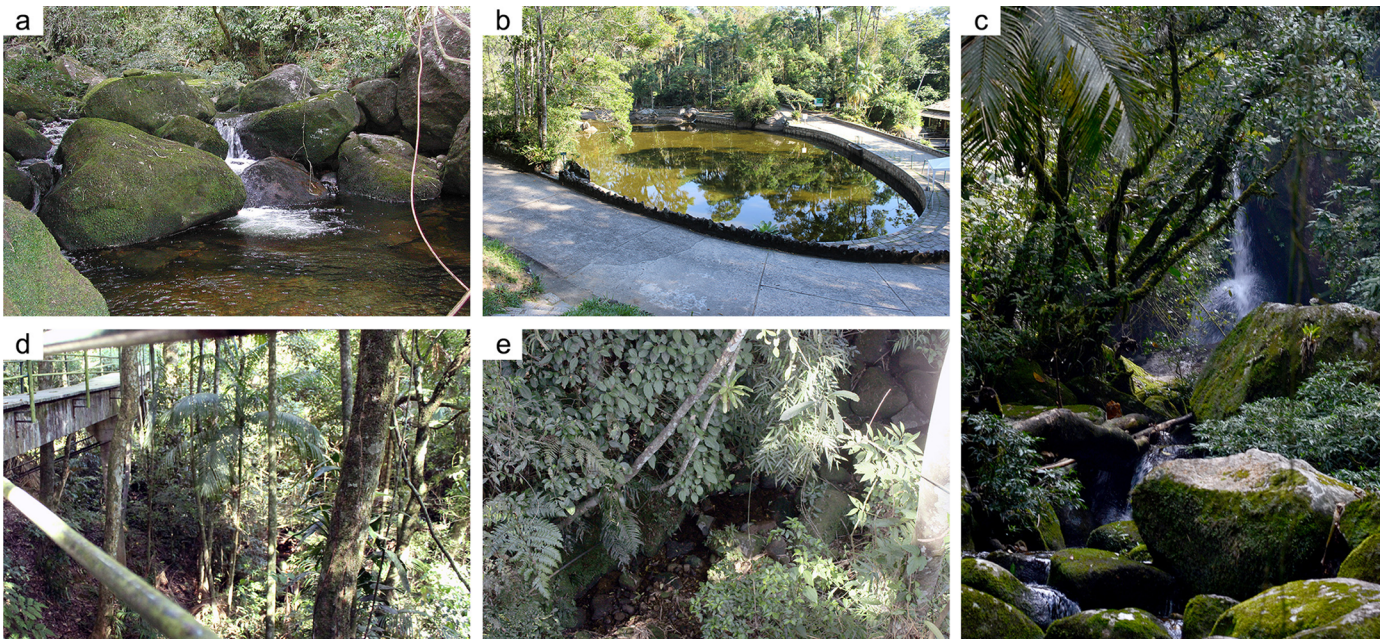

Figure 2. Examples of sampled environments. (A) and (C) streams in primary forest. (B) artificial lake known as "swimming pool". (D) secondary forest. (E) stream in secondary forest.

The amphibian diversity found in this study places the PARNASO as the natural reserve with highest species richness in the Atlantic Forest area, surpassing the Paranapiacaba Biological Reserve, in the state of São Paulo, considered as the greatest one by Verdade et al. (2009) with 69 species at that time, and Serra Bonita, in the state of Bahia, considered a new hotspot in Brazil, with 80 species (Dias et al. 2014). On a national scale, species inventories are not available for several natural reserves individually. As long as we could track, no individual strict protection reserve area in Brazil surpasses the PARNASO in number of amphibian species. Even the largest tropical forest reserves in the world located in Brazil (according to UNEP-WCMC and IUCN. 2018) that have amphibian's species inventories published have lower richness: Estação Ecológica Grão-Pará (42,000 km², 70 species; Avila-Pires et al. 2010) and Parque Nacional Montanhas do Tumucumaque (38,600 km², 70 species; Lima 2008), both in the state of Pará, Brazil, on Amazonia area.

The number of amphibian species of PARNASO has increased in the last years, either by new records (*e.g.*, *Ololygon hiemalis*, Caram et al. 2011, *Rhinella crucifer*, Marques et al. 2006) or by the discovery of new species (*e.g.*, *Ischnocnema parnaso,* Tauce et al. 2018b, *Fritziana izecksohni*, Folly et al. 2018, *Dendrophryniscus organensis* Carvalho-e-Silva et al., 2013, *Cycloramphus organensis* Weber et al., 2011,

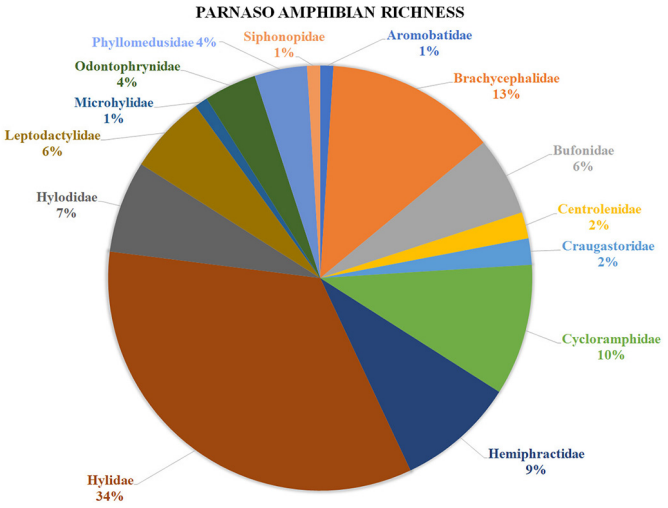

Figure 3. Species richness per family of the amphibians from PARNASO.

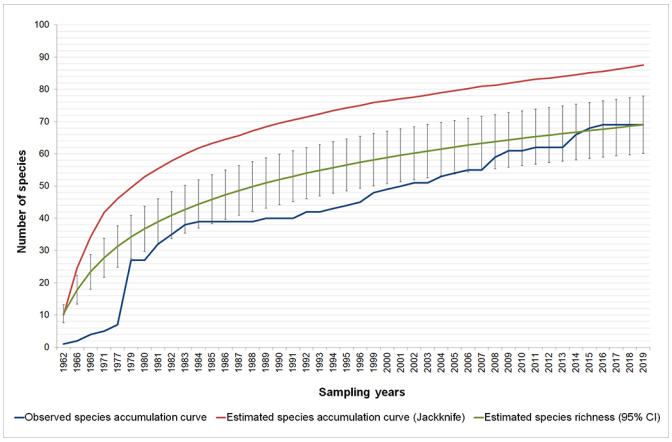

Figure 4. Sampling effort and species richness in PARNASO. Observed species accumulation curve, estimated species accumulation curve and estimated species richness. Estimated species accumulation curve calculated through Jackknife index using 1000 replications. Estimated species richness based in 1000 randomizations, including 95% confidence interval (CI). The years with no sampling were removed.

Hylodes pipilans Canedo & Pombal, 2007, *Aplastodiscus eugenioi* Carvalho-e-Silva & Carvalho-e-Silva, 2005, *Ololygon melloi* Peixoto, 1989, *Bokermannohyla carvalhoi* Peixoto, 1981). During the last few years, members of our team participated in the descriptions of five of these endemic species (Peixoto 1989, Weber et al. 2011, Carvalho-e-Silva et al. 2013, Folly et al. 2018) (Table 1).

According to the Red List of the International Union for Conservation of Nature and Natural Resources (IUCN 2019), 57 of the registered species are classified as Least Concern (LC), 20 have not enough information on its conservation (DD), two are classified as Near Threatened (NT), two are classified as Vulnerable (VU) and two have unknown data (see Table 1). Still, in the Brazilian list of endangered species (ICMBio 2016), three species are listed: one Vulnerable (*Allobates olfersioides*) and two Endangered (*Cycloramphus ohausi* and *Thoropa petropolitana*).

Despite our data do not allow abundance analysis, some of the species as *Aplastodiscus arildae*, *Brachycephalus ephippium*, *Ischnocnema parva*, *Ololygon albicans* and *Scinax hayii*, were found in most of our surveys, indicating that they are probably abundant inside the Park.

Some species have become rare or even disappeared from PARNASO without an apparent reason, such as *Aplastodiscus musicus,* disappeared for more than 20 years and reencountered in 2016 (Bezerra et al. 2020); *Allobates olfersioides*, which has not been found since 1969 in the park, and has been reported as declining or disappeared from other localities (Weygoldt 1989, Izecksohn & Carvalho-e-Silva 2001, Gasparini et al. 2007, Caram et al. 2016); and *Vitreorana uranoscopa*, which also disappeared for almost 20 years, and was reencountered by us in 2009. Similar disappearance was reported by Izecksohn & Carvalho-e-Silva (2001) for the Parque Nacional da Floresta da Tijuca, municipality of Rio de Janeiro, where the species was also found recently (AMPTCS and SPCS pers. obs.).

Only one individual of *Proceratophrys melanopogon* was recorded in PARNASO. As noted by Izecksohn et al. (1998), this individual was collected in 1952, together with five individuals of *P. appendiculata*, a common species within the park boundaries. Although common in the locality of Macaé de Cima (Izecksohn et al. 1998, Prado & Pombal Jr. 2008), approximately 50 km east from PARNASO, *P. melanopogon* remains with only one register in PARNASO and its vicinity.

Gehara et al. (2013) restricted the name *Ischnocnema guentheri* to just one population of the city of Rio de Janeiro, Brazil. Other populations formerly associated with this name from the states of Santa Catarina, Paraná, São Paulo, Minas Gerais, and other populations from the state of Rio de Janeiro, actually represent unnamed species. Due to that, we could not determine the specific status of *Ischnocnema* aff. *guentheri*. Despite recent taxonomic efforts (*e.g.*, Gehara et al. 2013, Taucce et al. 2018a, b), the *Ischnocnema guentheri* species series is still being taxonomically confusing, composed by several morphologically cryptic species (Taucce et al. 2018a). New efforts must be done to clarify this question, specially involving molecular and acoustic data, which have shown great relevance to the taxonomy of this species series (*e.g.*, Kwet & Solé 2005, Gehara et al. 2013, Hepp & Canedo 2013, Taucce et al. 2018a, b).

The species accumulation curve represents the rate at which new species were recorded considering our continued sampling effort (Figure 4). The stabilization found at the end suggests that our sampling effort possibly recorded a number of species close to the real species richness occurring in PARNASO. The fast increase in the species accumulation curve followed by a decreasing in the number of new species recorded along the years is expected since the common and abundant species are usually found more easily, i.e. in the first expeditions, and along the years rare species are slowly being added (Ugland et al. 2003). The superior limit of the confidence interval of the richness curve and the Jackknife frequency estimated a number of species close to the number that we recorded considering the additional data from literature and other collections.

Considering our effort time of more than 50 years, and more than 200 expeditions, it is expected the number of recorded species to be close to the real species richness occurring in PARNASO, as suggested by the stabilization at the final portion of the curve. Nevertheless, we would like to emphasize the importance of continue studying the PARNASO amphibian fauna, including taxonomic revisions, acoustic descriptions, population dynamics and every possible aspect of these taxa natural history. These studies are essential to aggregate knowledge about the

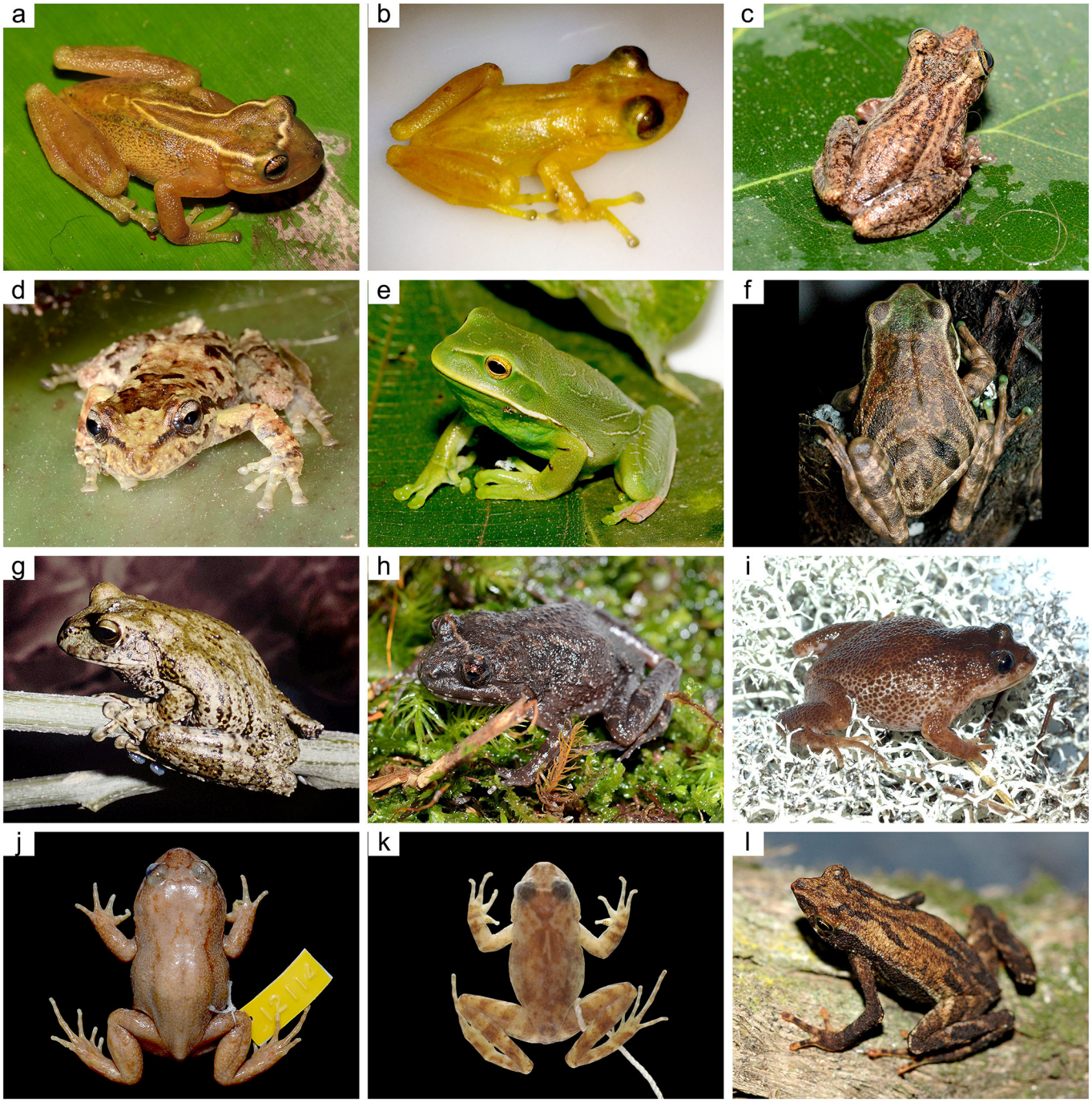

Figure 5. Species of anurans recorded on PARNASO. (A) *Fritziana Izecksohni*. (B) *Fritziana* cf. *fissilis*. (C) *Fritziana ohausi*. (D) *Fritziana goeldii*. (E) *Gastrotheca albolineata*. (F) *Gatrotheca ernestoi*. (G) *Gastrotheca fulvorufa*. (H) *Cycloramphus eleutherodactylus*. (I) *Cycloramphus organensis*. (J) *Cycloramphus stejnegeri*, fixed specimen. (K) *Thoropa petropolitana*, fixed specimen. (L) *Dendrophryniscus organensis*.

species, a very important aspect of our basic science, which is the basis of all applied knowledge. These studies are also indispensable for the elaboration of management plans of PARNASO, maintaining these species preserved and in balance with their habitat.

Since its foundation, PARNASO was the scene for several studies on different topics involving amphibians, such as tadpole morphology and development (*e.g.*, Carvalho-e-Silva & Carvalho-e-Silva 1994, Dias et al. 2013a, Mongin & Carvalho-e-Silva 2013, Silva et al. 2018), bioacoustics and breeding biology (*e.g.*, Orrico et al. 2006, Dias et al. 2013b), histology (*e.g.*, Felsemburgh & Gitirana 2008, Silva et al. 2017), osteology (*e.g.*, Izecksohn et al. 2005), diet (*e.g.*, Sabagh & Carvalho-e-Silva 2008), fungal infection or abnormalities (*e.g.*, Dias & Carvalho-e-Silva 2012, Ruggeri et al. 2017, Ruggeri et al. 2018), besides dozens of academic works of undergraduate and PhD students. This highlights the importance of nature reserves, and of the PARNASO itself, not only for biodiversity conservation, but also to facilitate advances on its understanding and execution of fieldworks, generating essential knowledge to conservation decisions, and for the formation of new scientists.

Figure 6. Species of anurans recorded on PARNASO. (A) *Brachycephalus ephippium*. (B) *Ischnocnema erythromera*. (C) *Haddadus binotatus*. (D) *Aplastodiscus arildae*. (E) *Aplastodiscus eugenioi*. (F) *Aplastodiscus flumineus*. (G) *Aplastodiscus leucopygius*. (H) *Aplastodiscus musicus*. (I) *Bokermannohyla carvalhoi*. (J) *Bokermannohyla circumdata*. (K) *Hylodes pipilans*. (L) *Megaelosia goeldii*.

Supplementary Material

The following online material is available for this article:
Appendix

Acknowledgments

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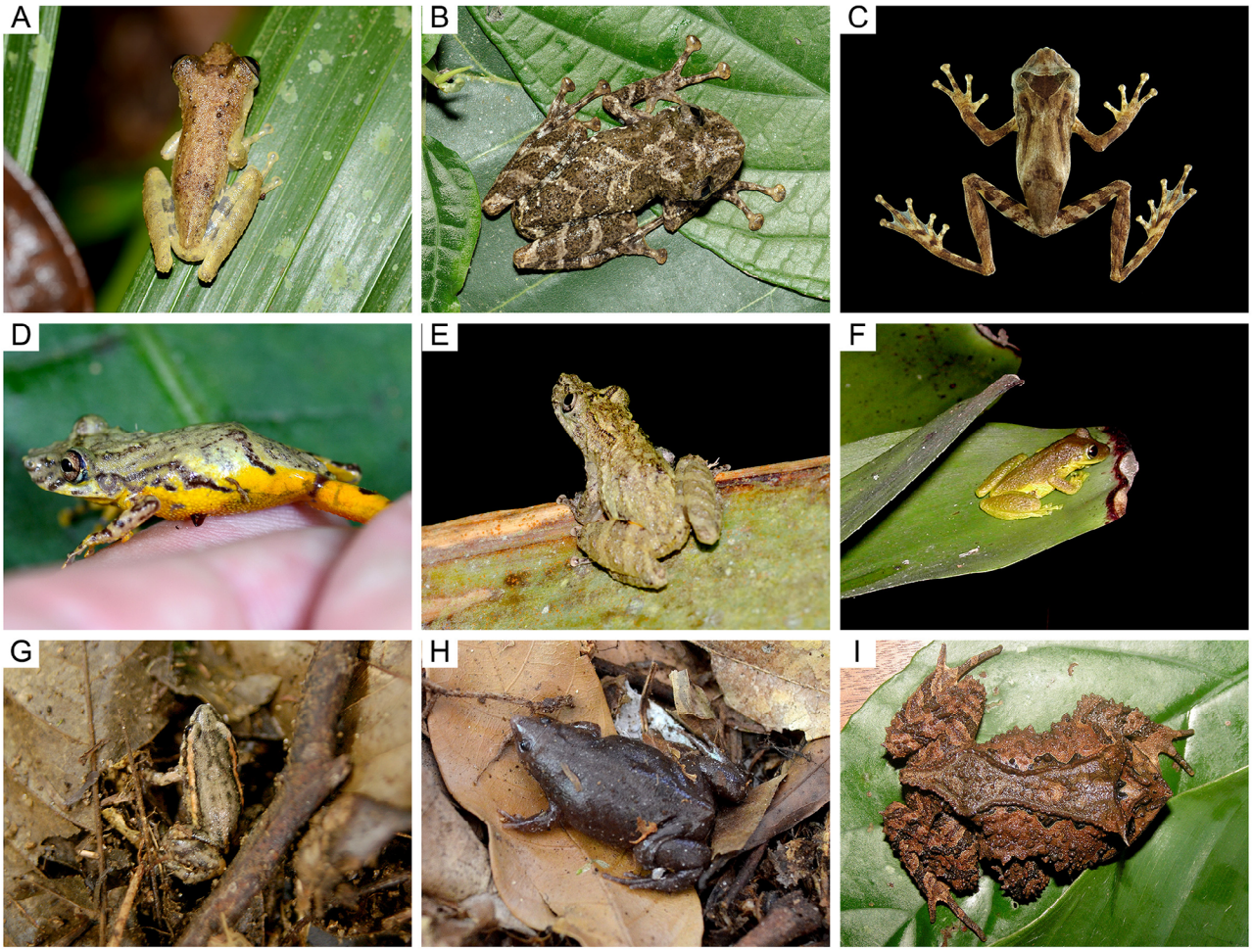

Figure 7. Species of anurans recorded on PARNASO. (A) *Ololygon albicans*. (B) *Ololygon flavoguttata*. (C) *Ololygon hiemalis*, fixed specimen. (D) *Ololygon melloi*. (E) *Ololygon v-signata*. (F) *Scinax hayii*. (G) *Adenomera marmorata*. (H) *Myersiella microps*. (I) *Proceratophrys appendiculata*.

Table 2. Amphibians found in buffer zone of Parque Nacional da Serra dos Órgãos, state of Rio de Janeiro, Brazil.

Taxa	Status in IUCN
AMPHIBIA (CLASS)	
ANURA (ORDER)	
CERATOPHRYIDAE (FAMILY)	
Ceratophrys aurita (Raddi, 1823)	LC/Dc
HYLIDAE (FAMILY)	
Boana albopunctata (Spix, 1824)*	LC/St
LEPTODACTYLIDAE (FAMILY)	
Physalaemus maculiventris (Lutz, 1925)	LC/Dc
Physalaemus olfersii (Lichtenstein and Martens, 1856)	LC/St
GYMNOPHIONA (ORDER)	
SIPHONOPIDAE (FAMILY)	
Mimosiphonops vermiculatus Taylor, 1968*	DD/Um
Siphonops hardyi Boulenger, 1988	LC/St

Caption IUCN (International Union for Conservation of Nature and Natural Resources): DD = Deficient Data; LC = Least Concern; Stable population (St); Decreasing population (Dc); Unknown status (Un). * Additional data from zoological collections.

Author Contributions

Sergio Potsch de Carvalho-e-Silva: Contribution in the concept of the study; data collection; manuscript preparation; contribution to critical revision, adding intellectual content.

Ana Maria Paulino Telles de Carvalho-e-Silva: Contribution to data collection; manuscript preparation; contribution to critical revision, adding intellectual content.

Manuella Folly: Contribution to data collection; manuscript preparation; contribution to critical revision, adding intellectual content.

Cyro de Luna-Dias: Contribution in the concept of the study; data collection; data analysis and interpretation; manuscript preparation; contribution to critical revision, adding intellectual content.

Andressa de Mello Bezerra: Contribution in the concept of the study; data analysis and interpretation; manuscript preparation; contribution to critical revision, adding intellectual content.

Marcia dos Reis Gomes: Contribution to data collection; manuscript preparation; contribution to critical revision, adding intellectual content.

Joana Caram: Contribution to data collection; manuscript preparation.

Oswaldo Luiz Peixoto: Contribution in the concept of the study; contribution to critical revision, adding intellectual content.

Eugenio Izecksohn: Substantial contribution in the concept and design of the study as well as data collection.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

Ethics

We declare that the procedures used in this study have no conflict with the Brazilian Laws regarding the use of vertebrates in scientific research.

Data availability

Our data was compiled from collection and is available along the manuscript.

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