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ANURAN FAUNA OF THE HIGH-ELEVATION AREAS OF THE PARQUE NACIONAL DA SERRA DOS ÓRGÃOS (PARNASO), SOUTHEASTERN BRAZIL

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ABSTRACT
There is a lack of knowledge regarding the diversity of anurans in high-elevation areas of the Brazilian Atlantic Forest. In order to improve the knowledge about the diversity of this group in this kind of environment, we present a list of anuran amphibians recorded in high-elevation areas (above 1,200 m) of the Parque Nacional da Serra dos Órgãos (PARNASO), in southeastern Brazil. The list was compiled based on primary data (from fieldwork) and on secondary data (from surveys of institutional collections). Twenty-eight species belonging to seven families were recorded: Brachycephalidae (6 species), Bufonidae (3 spp.), Cycloramphidae (4 spp.), Hemiphractidae (5 spp.), Hylidae (8 spp.), Hylodidae (1 sp.), and Odontophrynidae (1 sp.). According to the IUCN Red List, eight of those species are classified as "Data Deficient" and two species have not been assessed yet (*i.e.*, *Dendrophryniscus organensis* and *Fritziana* sp. nov.). Ten species are classified as "Least Concern" but with populations in decline, although six of them (*Bokermannohyla carvalhoi*, *B. circumdata*, *Ischnocnema parva*, *Proceratophrys appendiculata*, *Scinax albicans* and *Zachaenus parvulus*) were frequently found during fieldwork at PARNASO and seem to be locally abundant. The other eight species classified as "Least Concern" have stable populations. We add three species to the list of anurans endemic to the high-elevation areas of Serra dos *Órgãos* (*Cycloramphus organensis*, *D. organensis*, and *Fritziana* sp. nov.), raising to 14 the number of endemic taxa in the area.
Keywords: Anura; Atlantic Forest; altitude; survey.

INTRODUCTION

The Brazilian anuran fauna is currently represented by 1,026 species, corresponding to 16% of the global anuran diversity (Segalla *et al.* 2014, Frost 2016). The Brazilian Atlantic Forest (*sensu* Ab'Saber 1977) has been labeled as one of the 34 biodiversity hotspots in the world (Mittermeier *et al*. 2011), harboring about 430 species of anurans, of which 80% are endemic to that biome (Cruz & Feio 2007, Lemes *et al*. 2014). Nevertheless, due to anthropogenic action, the Atlantic Forest is nowadays composed by only 12% of its original area (Ribeiro *et al.* 2009, SOS Mata Atlântica 2014), and most of the remnant patches are found in the mountains of the Serra do Mar and Serra da Mantiqueira ranges in southeastern Brazil (Eterovick *et al.* 2005). Only a small portion of what currently remains of the Atlantic Forest is known to occur within legally protected areas (Laurance 2009, Lemes *et al* 2014).

The Atlantic Forest biome encompasses the vegetation that occurs along the Brazilian coast (extending some distance inland), from the state of Rio Grande do Norte to the state of Rio Grande do Sul (Delabie *et al.* 2000). The vegetation mainly consists of dense ombrophilous forest, mixed ombrophilous forest and seasonal forests, including associated ecosystems, such as mangroves and salt marshes (Veloso 1992, Joly *et al*. 1999). It also encompasses areas of high-elevation, including the montane grasslands called *campos de altitude* (Safford 1999). *Campos de altitude* are composed by open vegetation habitats present above 1,900

m of altitude in the Serra do Mar and Serra da Mantiqueira ranges that are relatively poorly studied (Safford 1999). There are few studies so far conducted in this ecosystem, focusing mainly on plants (Safford 1999), birds (Mallet-Rodrigues *et al*. 2010, Vasconcelos & Rodrigues 2010) and mammals (Geise *et al*. 2004).

Currently, there are a few studies comprising the amphibian composition in areas above 1200 m a.s.l. in the Atlantic Forest. Most studies about the anuran fauna from highlands consist of descriptions of new species (*e.g.*, Pombal *et al.* 1998, Alves *et al*. 2006, Weber *et al.* 2011). Nevertheless, Cruz & Feio (2007) reviewed the diversity and endemism of anuran species from "mountain areas" of Serra do Mar and Serra da Mantiqueira, and Siqueira *et al.* (2011) surveyed the anuran species present in two high-altitude sites in the Serra dos Órgãos region, inserted in the Serra do Mar of state of Rio de Janeiro.

The Parque Nacional da Serra dos Órgãos (PARNASO) is inserted in the Atlantic Forest biome and contains some of the highest peaks of the Serra dos Órgãos mountain range, such as Pedra do Açu (2,245 m a.s.l.) and Pedra do Sino (2,275 m a.s.l.; ICMBIO 2008). Relatively little is known about the ecology, biogeography, or developmental history of these "sky island" formations (Safford 1999). PARNASO has a high diversity of habitats, which in turn promotes a high diversity of animal species (ICMBIO 2008). It harbors a great part of the overall diversity and endemic species of the Atlantic Forest, including around 100 species of anuran amphibians (ICMBIO 2008). It also represents the type locality for at least 20 species of anurans, of which seven are endemic of this mountainous massif (Carvalho-e-Silva *et al.* in prep.). The Serra dos Órgãos was identified by the ministry of the environment as an area of extreme biological importance (Cronemberg & Viveiros de Castro 2007). The PARNASO thus protects an important part of the Atlantic Forest's biodiversity.

Worldwide amphibian declines have been reported and several factors are suggested to be responsible for it, such as habitat loss and fragmentation; contamination of water and soil by chemical pollutants; climate change; and introductions of exotic species (Blaustein *et al.* 1994, Alford & Richards 1999, Lips *et al.* 2005, Hamer & McDonnel 2008, Laurance 2008). In the Atlantic Forest, some amphibian populations that were once abundant have decreased dramatically, mainly in the regions of Serra do Mar and Serra da Mantiqueira (Heyer *et al.* 1988, Weygoldt 1989).

Experimental studies, monitoring and inventories are useful in reporting amphibian declines (Biek *et al.* 2002). It is also important to conduct studies that provide support for amphibian conservation, especially in areas without previous knowledge of the local anuran fauna (Rocha *et al.* 2003, Diniz-Filho *et al.* 2004). Therefore, here we present a list of anuran species recorded in high-elevation areas (above 1,200 m a.s.l.) within the PARNASO, in the Serra dos Órgãos mountain range.

MATERIAL AND METHODS

Study area

The Serra do Mar mountain range complex is located at the Atlantic Forests morphoclimatic domain (Ab'Saber 1977) of the coast of the states of Santa Catarina, Paraná, São Paulo and Rio de Janeiro (Cruz & Feio 2007). The Parque Nacional da Serra dos Órgãos (PARNASO) is a national park located in the mountains of the Serra dos Órgãos range in the central part of the Serra do Mar complex, in the state of Rio de Janeiro. This conservation area (The headquarter of Teresópolis is at 22°24' and 22°32' S; 42°69' and 43°06' W) encompasses part of the municipalities of Teresópolis, Petrópolis, Magé and Guapimirim, totaling an area of 20,024 ha of dense ombrophilous forest and highland forest. High-elevation areas (above 1,200 m a.s.l.) are present only in Teresópolis and Petrópolis (ICMBIO 2008; Figure 1), representing around 60% of the park's area (Cronemberg & Viveiros de Castro 2007). PARNASO has an average annual temperature of 19°C, and rainfall varies between 1,500 mm and 3,000 mm per year (ICMBIO 2008).

Fieldwork was conducted in high-elevation areas along the Pedra do Sino trail, municipality of Teresópolis. The altitudinal range chosen for sampling in the present work (1,200 – 2,250 m a.s.l.) was based on the altitudinal range of the Pedra do Sino trail, which starts at 1,200 m a.s.l.

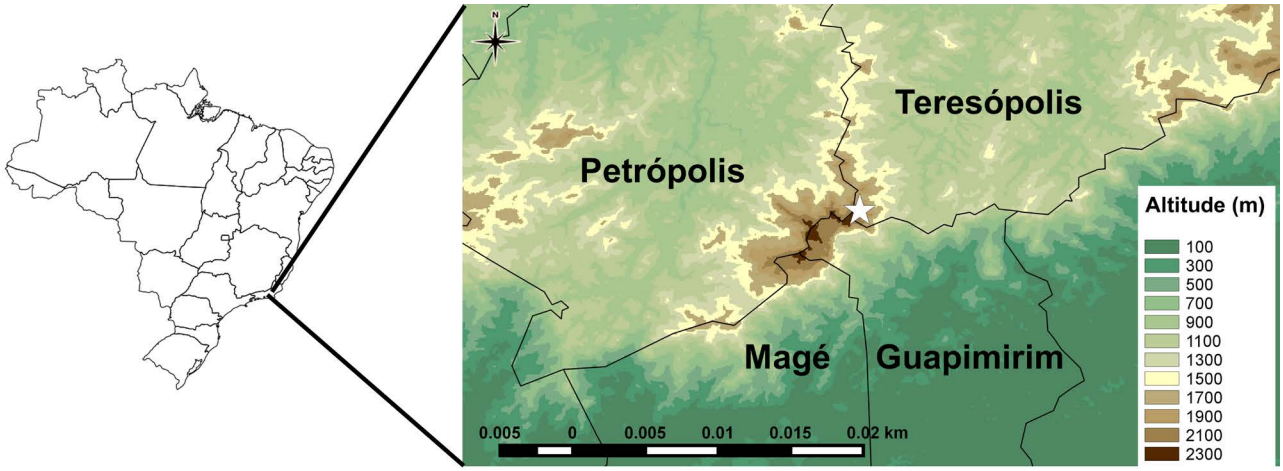

Figure 1. Locality where the majority of the fieldwork was conducted (white star; Pedra do Sino trail, Teresópolis, state of Rio de Janeiro, Brazil).

and ends near the mountain's peak at 2,250 m a.s.l. (Cronemberg & Viveiros de Castro 2007).

The area presents altitudinal variation of the vegetation and soil characteristics. Therefore, we used the altitudinal classification found in Mallet-Rodrigues *et al*. (2010), and present a quick description based on the management planning for PARNASO (ICMBIO 2008):

- Montane Forest ("Floresta Montana") – from 500 m to 1,500 m a.s.l.: formation with extensive vegetation stratification. Its structure varies according to the specific conditions of each area. Large trees reaching up to 40 m high dominate the tree layer and there are deep soils of composite crystalline rocks.
- High Montane Forest ("Floresta Pluvial Alto-Montana"; Figure 2A) – from 1,500 m to 1,900 m a.s.l.: it is a typical humid forest, often enveloped in mist. Shrubs and small trees between 5 m and 10 m in height dominate the vegetation. Trees typically have crooked trunks covered by moss and epiphytes.
- *Campos de altitude* (Figure 2B) – above 1,900 m a.s.l.: dominated by shrubby and herbaceous vegetation that grows among rocky outcrops. There is low input of organic matter and the vegetation is more xeric-adapted. The soil is shallow and solar radiation is intense. In areas with steep slopes and greater exposure to wind and rain, the rock is bare with almost no vegetation coverage.

Sampling

From 2009 to 2013, we conducted six surveys in the area (one or two per year) during both the rainy and dry seasons, totaling 15

Figure 2. Sampling sites: (A) High Montane Forest; (B) *Campos de altitude*; (C) *Pitfall* trap system set in *campos de altitude.*

sampling days. We used three complementary methods for sampling adult anurans: active search, acoustic search, and pitfall traps (see Calleffo 2002); and one method for sampling tadpoles: active search.

We performed the active and acoustic searches randomly along the Pedra do Sino trail. In addition, four Y and I-shaped pitfall traps (consisting of 60 L buckets five meters far apart, with drift fences) were set in *campos de altitude* at Pedra do Sino: the first three were located in different sites close to the "*Pedra da Baleia"* (22°27'37.0"S / 43°01'40.0"W; 2,131 m a.s.l) with five, seven, and eight buckets, respectively; the last one, with four buckets, was located in the "*Vale das Orquídeas*" (22°27'26.5"S / 43°01'10.4" W; 1,975 m a.s.l) (Figure 2C). The pitfall traps remained open during the survey period (between two and four days) and were checked daily. For the capture of tadpoles in the streams and in the bromeliads we used hand sieves and an entomological aspirator, respectively.

Adults and tadpoles were collected and photographed. Adults were anesthetized and killed with lidocaine injection (with insulin syringe needles) and tadpoles were immersed in a solution of lidocaine as specified in the Brazilian laws (Diretriz Brasileira para o Cuidado e a Utilização de Animais para Fins Científicos e Didáticos – Concea). Specimens were deposited at the Amphibian Collection of the Departamento de Zoologia, Universidade Federal do Rio de Janeiro (ZUFRJ) according to authorization (18155) provided by ICMBIO

We obtained additional data from the zoological collections of the Universidade Federal do Estado do Rio de Janeiro (Coleção de Anfíbios da Universidade Federal do Estado do Rio de Janeiro – UNIRIO), Universidade Federal Rural do Rio de Janeiro (Coleção Eugenio Izecksohn – EI), and Universidade Federal do Rio de Janeiro (ZUFRJ), which encompass more than 20 years of fieldwork in the area. We only included in our inventory specimens from PARNASO that have been sampled within the altitudinal range used in the present work (1,200 – 2,250 m a.s.l.). The list of examined specimens is given in Appendix 1. Taxonomic nomenclature used throughout the text follows Frost (2016).

RESULTS

We report twenty-eight anuran species from high-elevation areas of PARNASO, belonging to seven families (Table 1 and Figure 3): Brachycephalidae (6 species), Bufonidae (3 spp.), Cycloramphidae (4 spp.), Hemiphractidae (5 spp.), Hylidae (8 spp.), Hylodidae (1 sp.), and Odontophrynidae (1 sp.). Fourteen of these species were sampled during the field expeditions (2009-2013).

Dendrophryniscus cf. *brevipollicatus* (ZUFRJ: 11275 – 11276) and *Ischnocnema* cf. *nasuta* (ZUFRJ: 9661) could not be identified at the specific level due to the morphological differences observed in the recorded specimens compared to the known and described species of each genus, even though the former is very similar to *D. brevipollicatus* and the latter is very similar to *I. nasuta*.

Ischnocnema aff. *guentheri* is supposed to be a new species according to Gehara *et al.* (2013); these authors restrict the name *Ischnocnema guentheri* to only one population in the municipality of Rio de Janeiro, Brazil. Therefore, any other population previously associated with this species name, as the others populations in the state of Rio de Janeiro and the states of Santa Catarina, Paraná, São Paulo, Minas Gerais are actually four undescribed species.

DISCUSSION

The highest species richness was observed at 1,200–1,500 m with 26 species, of which 13 were exclusive to that altitudinal range (Table 1). Between 1,501–1,900 m we observed 14 species, of which none were exclusive to that range. Above 1,900 m we observed seven species of which only one was exclusive to that elevation (Figure 4). Species richness decreased with elevation above 1,500 m a.s.l. This pattern, known as a "diversity bulge" has been described by Grytnes & Vetaas (2002). The species richness found was inversely proportional to the altitudinal increase. This result may be due to the type of vegetation found at the lower altitudes (montane forest), as the taller and more closed tree canopy in those sites would not only provide shelter to different species of

Table 1. List of anurans from high-elevation areas of the Parque Nacional da Serra dos Órgãos (PARNASO), their status of conservation according to the International Union for Conservation of Nature and Natural Resources (IUCN), and altitudinal ranges (meters above sea level – m a.s.l.) within the study area. The altitudinal ranges of each species are categorized according to our records from fieldwork, zoological collections and literature data (Duellman & Gray 1983, Weber *et al*. 2011, Frost 2016). Vegetation was classified according to Mallet-Rodrigues *et al*. (2010) and (ICMBIO 2008): Montane Forest (MF), High Montane Forest (HMF) and *campos de altitude* (CA). IUCN status categories are: Least Concern (LC); Data Deficient (DD); Stable population (St); Declining population (Dc); Unknown status (Un); * Data collected in the fieldwork.

Taxa	Status in IUCN	Altitudinal range (m a.s.l.)			Preferred microhabitats	Sampling method	Vegetation
		1200–1500	1501–1900	>1,900			
Brachycephalidae							
Brachycephalus ephippium (Spix, 1824)	LC – St	X	X		Leaf-litter	Visual, Acoustic, Pitfall	MF, HMF
Ischnocnema aff. *guentheri* *		X	X		Leaf-litter		MF, HMF
Ischnocnema gualteri (Lutz, 1974)	LC – Dc	X	X		Leaf-litter		MF, HMF
Ischnocnema holti (Cochran, 1948)*	DD – Un	X	X	X	Shrubs	Visual, Acoustic, Pitfall	MF, HMF, CA
Ischnocnema cf. *nasuta*			X	X	Herbaceous vegetation		HMF, CA
Ischnocnema parva (Girard, 1853) *	LC – Dc	X	X	X	Leaf-litter	Visual, Acoustic	MF, HMF, CA
Bufonidae							
Dendrophryniscus cf. *brevipollicatus*		X	X		Bromeliads		MF, HMF
Dendrophryniscus organensis Carvalho-e-Silva, Mongin, Izecksohn & Carvalho-e-Silva, 2010		X			Bromeliads		M
Rhinella icterica (Spix, 1824)*	LC – St	X	X	X	Forest floor	Visual	MF, HMF, CA
Cycloramphidae							
Cycloramphus eleutherodactylus (Miranda-Ribeiro, 1920)	DD – Un	X			Forest floor		MF
Cycloramphus organensis Weber, Verdade, Salles, Fouquet, & Carvalho-e-Silva, 2011	DD – Un			X	*Campos de altitude* floor		CA
Cycloramphus stejnegeri (Noble, 1924)	DD – Dc	X			Leaf-litter		MF
Zachaenus parvulus (Girard, 1853)*	LC –Dc	X			Leaf-litter	Visual, Acoustic	MF

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Taxa	Status in IUCN	Altitudinal range (m a.s.l.)			Preferred microhabitats	Sampling method	Vegetation
		1200–1500	1501–1900	>1,900			
Hemiphractidae							
Fritziana fissilis (Miranda-Ribeiro, 1920)*	LC – St	X	X		Bromeliads	Visual, Acoustic	MF, HMF
Fritziana ohausi (Wandolleck, 1907)*	LC – St	X			Bamboo	Visual, Acoustic	MF
Fritziana sp. nov.*		X	X	X	Bromeliads	Visual	MF, HMF, CA
Gastrotheca ernestoi Miranda-Ribeiro, 1920*	DD – Un	X	X	X	Shrubs	Visual	MF, HMF, CA
Hylidae							
Aplastodiscus arildae (Cruz & Peixoto, 1987)*	LC – St	X			Vegetation near stream	Visual, Acoustic	MF
Aplastodiscus flumineus (Cruz & Peixoto, 1985)*	DD – Dc	X			Vegetation near stream	Visual, Acoustic	MF
Aplastodiscus musicus (Lutz, 1949)	DD – Dc	X			Vegetation near stream		MF
Bokermannohyla carvalhoi (Peixoto, 1981)*	LC – Dc	X			Rocks near streams	Visual, Acoustic	MF
Bokermannohyla circumdata (Cope, 1871)*	LC – Dc	X			Vegetation near stream	Visual, Acoustic	MF
Phasmahyla guttata (Lutz, 1924)	LC – Dc	X			Vegetation near stream		MF
Scinax albicans (Bokermann, 1967)	LC – Dc	X	X		Vegetation near stream		MF, HMF
Scinax obtriangulatus (Lutz, 1973)	LC – Dc	X	X		Vegetation near stream		MF, HMF
Hylodidae							
Hylodes charadranaetes Heyer & Cocroft, 1986	DD – Un	X			Streams		MF
Odontophrynidae							
Proceratophrys appendiculata (Günther, 1873)*	LC – Dc	X			Leaf-litter	Visual	MF

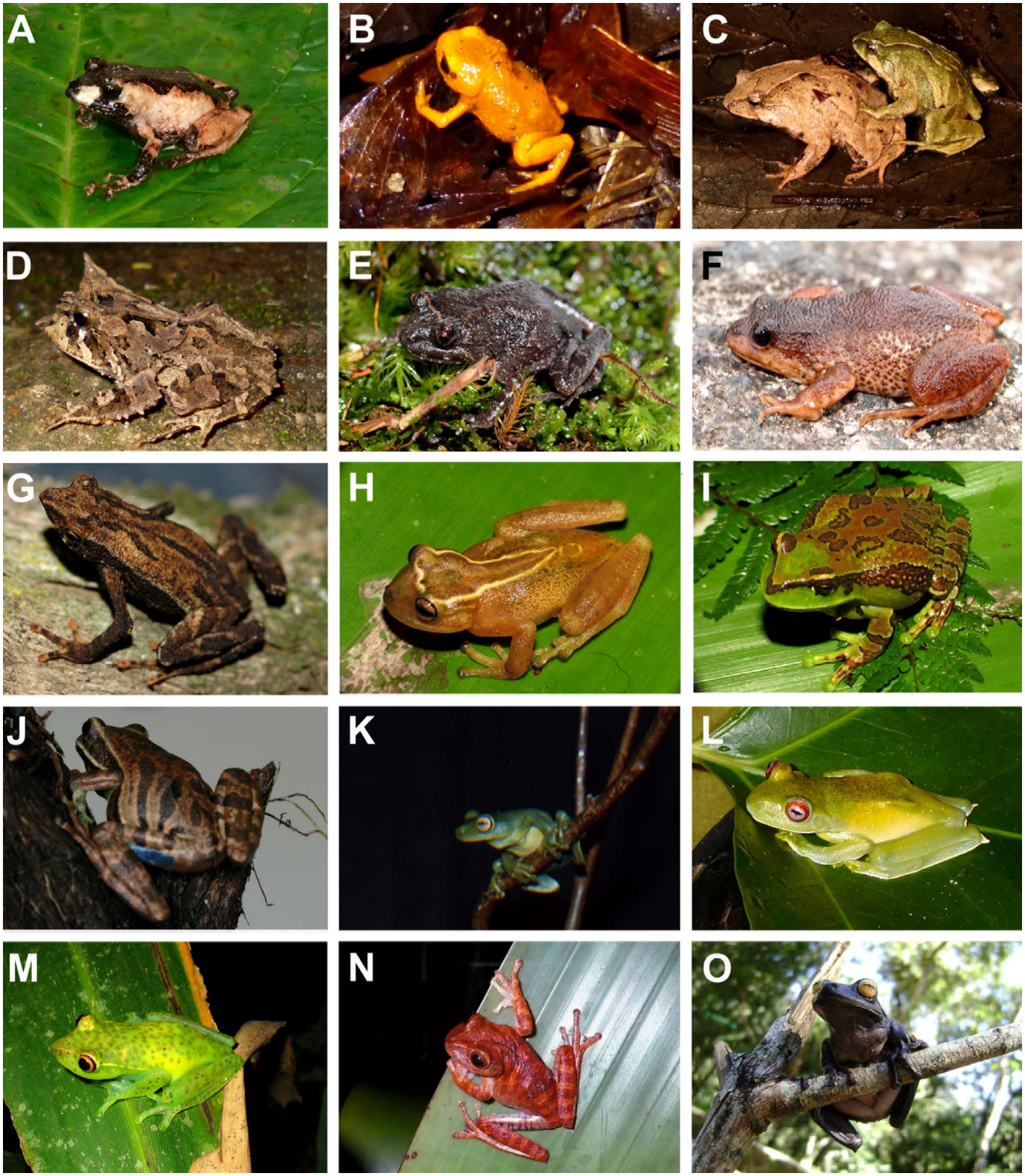

Figure 3. Anuran specimens from high-elevation areas of PARNASO, RJ, Brazil; A) *Ischnocnema holti*; B) *Brachycephalus ephippium*; C) *Zachaenus parvulus*; D) *Proceratophrys appendiculata*; E) *Cycloramphus eleutherodactylus*; F) *C. organensis*; G) *Dendrophryniscus organensis*; H) *Fritziana* sp. nov.; I-J) *Gastrotheca ernestoi*; K) *Aplastodiscus musicus*; L) *A. flumineus*; M) *A. arildae*; N) *Bokermannohyla circumdata*; O) *B. carvalhoi*. Photos A and H by Felipe Quintarelli Machado; Photo C by Daniel de Góes; Photo G by Cyro de Luna-Dias; All other photos by Sergio Potsch de Carvalho-e-Silva.

treefrogs but also keep the leaf-litter layer humid and deep along the forest floor, where the anuran fauna is abundant (Rocha *et al.* 2004). On the other hand, the difficulty in accessing higher elevation sites, such as *campos de altitude*, and the limited knowledge about the fauna found in this ecosystem may have influenced the sample size, showing the necessity of continuing to do fieldwork in these high-elevation areas.

Seven endemic species were previously reported for the altitudinal region in the Serra dos Órgãos Mountains (Cruz & Feio 2007, Weber *et al*. 2011) and were also recorded for the high-elevation areas at the present study: *Aplastodiscus flumineus*, *A. musicus*, *Bokermannohyla carvalhoi*, *Cycloramphus organensis, C. stejnegeri*, *Hylodes charadranaetes* and *Ischnocnema gualteri*. We also recorded 14 species that have been reported for high-elevation areas within the Parque Estadual dos Três Picos (PEPT) (Siqueira *et al.* 2011): *Aplastodiscus arildae*, *Bokermannohyla carvalhoi*, *B. circumdata*, *Dendrophryniscus* cf. *brevipollicatus*, *Fritziana fissilis*, *Gastrotheca ernestoi*, *Hylodes charadranaetes*, *Ischnocnema* aff. *guentheri*, *I. holti*, *I. parva*, *Rhinella icterica*, *Scinax albicans*, *S. obtriangulatus* and *Zachaenus parvulus*. The similarity of the anuran fauna assemblages in PARNASO and PETP may be due to them being located within the same mountain range and connected by a continuous habitat corridor and having similar environmental influences. Despite the similarities found in the high-elevation areas of both sites, several species are apparently exclusive to one of the two localities: PETP (21 species) and PARNASO (14 species).

Siqueira *et al.* (2011) removed two species [*Gastrotheca albolineata* (Lutz & Lutz 1939) and *Hylodes charadranaetes*] from the previous list of amphibians endemic to the high-elevation areas of the Serra dos Órgãos compiled by Cruz & Feio (2007), and added two species (*Holoaden pholeter* Pombal, Siqueira, Dorigo, Vrcibradic & Rocha, 2008 and *Brachycephalus garbeanus* Miranda-Ribeiro 1920), maintaining the list with currently 11 species. We add three more species to the list: *Cycloramphus organensis*, *Dendrophryniscus organensis*, and *Fritziana* sp. nov., raising to 14 the number of amphibian species considered endemic of high-elevation areas in the Serra dos Órgãos region.

Lemes *et al.* (2014) predict a decline of anuran species richness within protected areas in the Atlantic Forest under the change climate conditions by the year 2050. Additionally, the

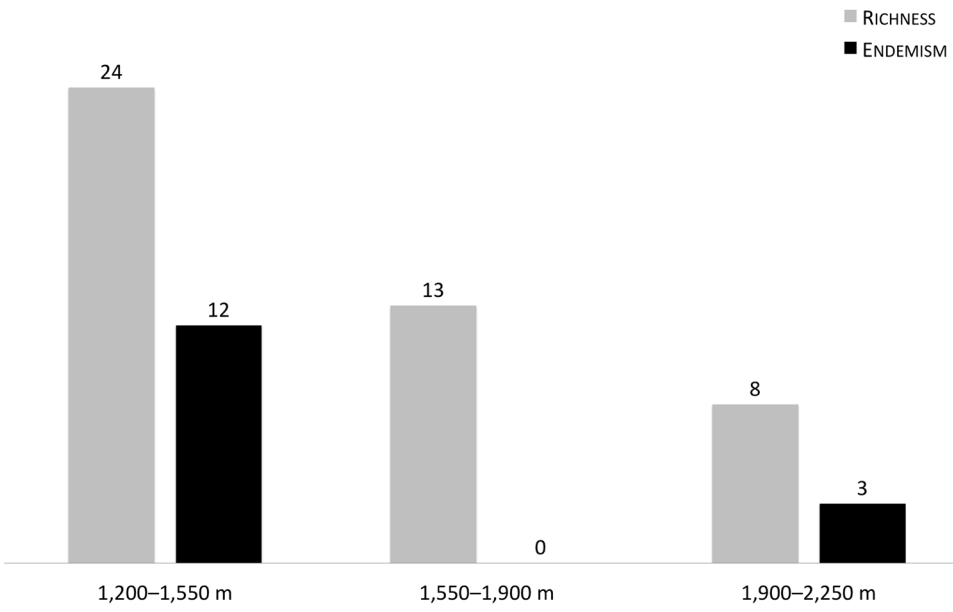

Figure 4. Species richness observed at three different ranges: 1,200–1,500 m; 1,501–1,900 m and above 1,500 m a.s.l. On left the number of species, on right the number of endemic species for each range. Note species richness decreasing proportionally to elevation.

ranges of some of these species are predicted to shift toward higher elevations, where a large number of endemic Atlantic Forest species already occur. Based on these predictions, Lemes *et al.* (2014) suggested that new protected areas in higher altitudes would be more effective in alleviating the effect of climate change on this endangered fauna. In this predicted scenario, mountainous regions would become a refuge for amphibians. The risk of the declining populations and the high levels of endemism observed at high-elevation areas highlight the importance of preserving these habitats.

Cycloramphus organensis is endemic to the high-elevation areas (Weber *et al.* 2011). In addition, a new species, *Fritziana* sp. nov., is being described from the high-elevation areas of the park (Folly *et al*. in prep.) and is so far also restricted to such habitats. *Gastrotheca ernestoi* and *Ischnocnema holti* are also probably restricted to high-elevation areas in PARNASO, despite not being endemic to the Serra dos Órgãos region (Costa *et al.* 2008, Izecksohn & Carvalho-e-Silva 2008, Siqueira *et al.* 2011).

The lack of research on the biology and demography of tropical anuran faunas complicates the design of appropriate strategies for the conservation of amphibians (Silvano & Segalla 2005). This deficiency is more evident regarding the fauna of high-elevation areas where, historically, the rugged and mountainous terrain has hampered access (Kattan & Franco 2004). In addition, the anurans of those regions tend to have their reproductive activity limited to a few short periods each year due to the severe cold weather, making it harder to find and record individuals during the cooler season. Moreover, some trapping methods such as pitfall traps, might be less efficient in the *campos de altitude* as a consequence of the rocky soil, which hampers their establishment on the ground. Only thirteen percent (13%) of the species were collected in the pitfall traps during field surveys; the other 87% of the species were collected during visual and acoustic searches. Thus, high sampling efforts and the usage of more than one method are necessary for adequate sampling the studied area, mainly because of the different microhabitats found at those sites. Yet, it is crucial to conduct more studies in high-elevation areas to improve the knowledge about this important ecosystem.

Among the ten species classified as "Least Concern", six (*Bokermanohyla carvalhoi*, *B. circumdata*, *I. parva*, *P. appendiculata*, *S. albicans* and *Z. parvulus*) are found in relatively high abundance at PARNASO, even though they are declining globally (IUCN 2015; Table 1). In addition, eight species are classified as "Data Deficient" (IUCN 2015). Despite the continuous fieldwork in the area, the species *Aplastodiscus flumineus* and *A. musicus*, both reported in this study, have not been recorded at PARNASO since 2003 and 1995, respectively. All these facts, in addition to the diversity and endemism found in the high-elevation areas of the park, highlight the importance of PARNASO for the conservation of the Atlantic Forest anuran fauna.

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REFERENCES

Ab'Saber, A. N. 1977. Os domínios morfoclimáticos na América do Sul. Primeira aproximação. Geomorfologia, 52, 1–22.

Alford, R. A., & Richards, S. J. 1999. Global amphibian declines: a problem in applied ecology. Annual Review of Ecology and Systematics, 30, 133–165. DOI: 10.1146/annurev.ecolsys.30.1.133

Alves, A. C. R, Ribeiro, L. F., Haddad, C. F. B., & Reis, S. F. 2006. Two new species of *Brachycephalus* (Anura: Brachycephalidae) from the Atlantic Forest in Paraná State, southern Brazil. Herpetologica, 62(2), 221–233. DOI: 10.1655/05-41.1

Biek, R., Funk, W. C., Maxell, B.A., & Mills, L.S. 2002. What is missing in amphibian decline research: insights from ecological sensitivity analysis. Conservation Biology, 16(3), 728–734. DOI: 10.1046/j.1523-1739.2002.00433.x

Blaustein, A. R., Wake, D. B., & Sousa, W. P. 1994. Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinctions. Conservation Biology, 8(1), 60–71. DOI: 10.1046/j.1523-1739.1994.08010060.x

Calleffo, M. E. V. 2002. Anfíbios. In: Auricchio, P. & Salomão, M. G. (Eds), Técnicas de coleta e preparação de vertebrados para fins científicos e didáticos. pp. 43–74. São Paulo: Instituto Pau Brasil de História Natural.

Costa, P. N. C., Carvalho-e-Silva, S. P., Carvalho-e-Silva, A. M. P. T., & Weber, L. N. 2008. Amphibia, Anura, Brachycephalidae, *Ischnocnema holti*: Distribution extension. Check List, 4(3), 232–233. DOI: 10.15560/4.3.232

Cronemberger, C., & Viveiros De Castro, E. B. 2007. Ciência e conservação na Serra dos Órgãos. Ibama. 298 p.

Cruz, C. A. G. & Feio, R. N. 2007. Endemismos em anfíbios em áreas de altitude na Mata Atlântica no sudeste do Brasil. pp. 117–126. In: L. B. Nascimento & M. E. Oliveira (Eds.), Herpetologia no Brasil II. Belo Horizonte: Sociedade Brasileira de Herpetologia.

Delabie, J. H. C., Agostini, D., & Nascimento, I. C. 2000. Litter ant communities of the Brazilian Atlantic rainforest region. pp.1–17. In: D. Agosti, J. D. Majer, L. Alonso & T. Schultz (Eds.), Sampling Ground-dwelling Ants: Case Studies from the World's Rain Forests. Australia: Curtin University School of Environmental Biology Bulletin N° 18, Perth.

Diniz-Filho, J. A. F., Bini, L. M., Vieira, C. M., Souza, M. C., Bastos, R. P., Brandão, D. & Oliveira, L. G. 2004. Spatial patterns in species richness and priority areas for conservation of anurans in the Cerrado region, Central Brazil. Amphibia-Reptilia, 25(1), 63–75. DOI: 10.1163/156853804322992841

Duellman, W. E., & Gray, P. 1983. Developmental Biology and Systematics of the Egg-Brooding Hylid Frogs, Genera *Flectonotus* and *Fritziana*. Herpetologica, 39(4), 333–359.

Eterovick, P. C., Carnaval, A. C. O. Q., Borges-Nojosa, D. M., Silvano, D. L., Segalla, M. V., Sazima I. 2005. Amphibian Declines in Brazil: An Overview. Biotropica, 27(2), 166–179. DOI: 10.1111/j.1744-7429.2005.00024.x

Frost, D. R. 2016. Amphibian Species of the World: an Online Reference. Version 6.0 (04.09.2016). Electronic Database accessible at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York, USA.

Gehara, M., Canedo, C., Haddad, C. F. B., & Vences M. 2013. From widespread to microendemic: molecular and acoustic analyses show that *Ischnocnema guentheri* (Amphibia: Brachycephalidae) is endemic to Rio de Janeiro, Brazil. Conservation Genetics, 14, 973–982. DOI: 10.1007/s10592-013-0488-5

Geise, L., Pereira, L. G., Bossi, D. E. P., & Bergallo, H. G. 2004. Pattern of elevational distribution and richness of non-volant mammals in Itatiaia National Park and its surroundings, in southeastern brazil. Brazilian Journal of Biology, 64(3), 599–612. DOI: 10.1590/S1519-69842004000400007

Grytnes, J.A., & Vetaas, O.R. 2002. Species richness and altitude: a comparison between null models and interpolated plant species richness along the Himalayan altitudinal gradient, Nepal. The American Naturalist, 159(3), 294–304. DOI: 10.1111/j.1365-2699.2007.01745.x

Hamer, A. J., & Mcdonnel, M. J. 2008. Amphibian ecology and conservation in the urbanizing world: A review. Biological Conservation, 141(10), 2432–2449. DOI: 10.1016/j.biocon.2008.07.020.

Heyer, W. R., Rand, A. S., Cruz, C. A. G., & Peixoto, O. L. 1988. Decimations, extinctions, and colonizations of frog populations in southeast Brazil and their evolutionary implications. Biotropica, 20(3), 230–235. DOI: 10.2307/2388238

ICMBIO (Instituto Chico Mendes de Conservação da Biodiversidade). 2008. Plano de manejo do Parque Nacional da Serra dos Órgãos. 665 pp.

Iucn (International Union for Conservation of Nature). 2015. IUCN Red List of Threatened Species. Version 2015.1. <www.iucnredlist.org>. (Accessed in 08/26/2015).

Izecksohn, E., & Carvalho-e-Silva, S. P. 2008. As espécies de *Gastrotheca* Fitzinger na Serra dos Órgãos, Estado do Rio de Janeiro, Brasil (Amphibia: Anura: Amphignathodontidae). Revista Brasileira de Zoologia, 25(1), 100–110. DOI: 10.1590/S0101-81752008000100014.

Joly, C. A., Aidar, M. P. M., Klink, C. A., Mcgrath, D. G., Moreira, A. G., Moutinho, P., Nepstad, D. C., Oliveira, A. A., Pott, A., Rodal, M. J. N., & Sampaio, E. V. S. B. 1999. Evolution of the Brazilian phytogeography classification systems: implications for biodiversity conservation. Ciência e Cultura, 51(5/6), 331–348. DOI:10.1016/j.biocon.2009.02.021

Kattan, G. H., & Franco, P. 2004. Bird diversity along elevational gradients in the Andes of Colombia: Area and mass effects. Global Ecology and Biogeography 13, 451–458. DOI: 10.1111/j.1466-822X.2004.00117.x

Laurance, W. F. 2008. Global warming and amphibian extinctions in eastern Australia. Austral Ecology, 33(1), 1–9. DOI: 10.1111/j.1442-9993.2007.01812.x

Laurance, W. F. 2009. Conserving the hottest of the hotspots. Biological Conservation, 142, 1137. DOI:10.1016/j.biocon.2008.10.011

Lemes, P., Melo, A. S., & Loyola, R. D. 2014 Climate change threatens protected areas of the Atlantic Forest. Biodiversity and Conservation, 23(2), 357–368. DOI: 10.1007/s10531-013-0605-2.

Lips, K. R., Burrowes, P. A., Mendelson III, Jr., & Parra-Olea, G. 2005. Amphibian declines in Latin America: widespread population declines, extinctions, and impacts. Biotropica, 37(2), 163–165. DOI: 10.1111/j.1744-7429.2005.00023.x

Mallet-Rodrigues, F., Parrini, R., Pimentel, L. M. S., & Bessa, R. 2010. Altitudinal distribution of birds in a mountainous region in southeastern Brazil. Zoologia, 27(4), 503–522. DOI: 10.1590/S1984-46702010000400003

Mittermeier, R. A., Turner, W. R., Larsen, F. W., Brooks, T. M., & Gascon, C. 2011. Global biodiversity conservation: the critical role of hotspots. pp. 3–22. In: Zachos, F.E., Habel, J.C. (Eds.), Biodiversity Hotspots. London: Springer Publishers.

Pombal, J. P., Wistuba, E. M., & Bornschein, M. R. 1998. A New Species of Brachycephalid (Anura) from the Atlantic Rain Forest of Brazil. Journal of Herpetology, 32(1), 70–74. DOI: 10.2307/1565481

Ribeiro, M. C., Metzger, J. P., Martensen, A. C., Ponzoni, F. J., & Hirota, M. M. 2009. The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation, 142, 1141–1153. DOI:10.1016/j.biocon.2009.02.021

Rocha, C. F. D., Bergallo, H. G., Van Sluys, M., & Alves, M. A. S. 2003. A biodiversidade nos grandes remanescentes florestais do Estado do Rio de Janeiro e nas restingas da Mata Atlântica. São Paulo: Rima. 160 p.

Rocha, C. F. D., Van Sluys, M., Hatano, F. H., Boquimpani-Freitas, L., Marra, R. V., & Marques, R. V. 2004. Relative efficiency of anuran methods in a (Jurubatiba, Rio de Janeiro, Brazil). Brazilian Journal of Biology, 64(4), 879–884. DOI: 10.1590/S1519-69842004000500018

Safford, H. D. 1999. Brazilian páramos I. An introduction to the physical environment and vegetation of the campos de altitude. Journal of Biogeography, 26, 693–712. DOI: 10.1046/j.1365-2699.1999.00313.x

Segalla, M. V., Caramaschi, U.; Cruz, C.A.G.; Grant, T.; Haddad, C.F.B.; Langone, J.A.; Garcia, P.C.A. 2014. Brazilian amphibians: list of species. Herpetologia Brasileira, 3(2), 37-48.

Silvano, D. L., & Segalla, M. V. 2005. Conservation of Brazilian amphibians. Conservation Biology, 19, 653–658. DOI: 10.1111/j.1523-1739.2005.00681.x

Siqueira C. C., Vrcibradic D., Dorigo, T. A., & Rocha, C. F. D. 2011. Anurans from two high-elevation areas of Atlantic Forest in the state of Rio de Janeiro, Brazil. Zoologia, 28 (4), 457–464. DOI: 10.1590/S1984-46702011000400007

SOS Mata Atlântica. 2014. Atlas dos remanescentes florestais da Mata Atlântica, período 2012-2013. São Paulo, 2014, 61p. Disponível em: www.sosma.org.br/ (Accessed in 12/04/2016).

Vasconcelos, M. F., & Rodrigues, M. 2010. Avifauna of southeastern Brazilian mountain tops. Papéis Avulsos de Zoologia, 50(1), 1–29.

Veloso, H. P. 1992. Sistema fitogeográfico. *Relatório Técnico.* Manual técnico da vegetação brasileira. Instituto Brasileiro de Geografia e Estatística (IBGE). 38 p.

Weber, L. N., Verdade, V. K., Lula-Salles, R. O., Fouquet, A., & Carvalho-e-Silva, S. P. 2011. A new species of *Cycloramphus* Tschudi (Anura: Cycloramphidae) from the Parque Nacional da Serra dos Órgãos, Southeastern Brazil. Zootaxa, 2737, 19–33. DOI:10.15468/j0rhjd

Weygoldt, P. 1989. Changes in the composition of mountain stream frog communities in the Atlantic mountains of Brazil: frogs as indicators of environmental deterioration? Studies on Neotropical Fauna and Environment, 243, 249-255.

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APPENDIX 1

Material examined. **Brachycephalidae**: *Brachycephalus ephippium* (ZUFRJ: 11270 –11274, 11482-11484; UNIRIO: 2537, 3750), *Ischnocnema parva* (ZUFRJ: 11097, 11098, 11281 –11283, 11720, 11721; UNIRIO: 10108, 3346), *Ischnocnema* aff. *guentheri* (ZUFRJ: 11279, 11280, 13977), *Ischnocnema gualteri* (ZUFRJ: 12402), *Ischnocnema holti* (ZUFRJ9664 – 9675, 11722-11725, 13975, 13976, 13979, 13992; UNIRIO: 4875), *Ischnocnema* cf. *nasuta* (ZUFRJ: 9661); **Bufonidae**: *Dendrophryniscus* cf. *brevipollicatus* (ZUFRJ: 11275 – 11276), *Dendrophryniscus organensis* (ZUFRJ: 9794; UNIRIO: 4946, 2406, 2183) *Rhinella icterica* (ZUFRJ: 11805), **Cycloramphidae**: *Cycloramphus stejnegeri* (ZUFRJ: 12113 – 12114), *Cycloramphus eleutherodactylus* (ZUFRJ: 12403), *Cycloramphus organensis* (ZUFRJ: 10348 – 10354, 10471 – 10474); *Zachaenus parvulus* (ZUFRJ: 14487-14488; UNIRIO: 4925, 4931 – 4933); **Hemiphractidae**: *Fritziana fissilis* (ZUFRJ: 9662-9663, 11717 – 11718), *Fritziana goeldii* (ZUFRJ: 8916), *Fritziana ohausi* (ZUFRJ: 12154 – 12155), *Fritziana* sp. nov. (ZUFRJ: 11680 – 11681, 11726, 13978), *Gastrotheca ernestoi* (ZUFRJ: 13974; UNIRIO: 2534); **Hylidae**: *Aplastodiscus arildae* (ZUFRJ: 11515; UNIRIO: 4944, 1581, 1590, 1630, 1755), *Aplastodiscus flumineus* (ZUFRJ: 6984 (tadpole); UNIRIO: 1589; EI: 7328), *Aplastodiscus musicus* (ZUFRJ: 6213, 6345, EI: 7532, 7533; MNRJ: 3213 lectotype, 3214 – 3219 paralectotypes), *Bokermannohyla carvalhoi* (ZUFRJ: 10232, 11806, 11809 (tadpole), 11810; UNIRIO: 1105, 1106, 1136, 1503, 3363), *Bokermannohyla circumdata* (ZUFRJ: 11265, 11811), *Phasmahyla guttata* (ZUFRJ: 6340, 12425; UNIRIO: 2347), *Scinax albicans* (ZUFRJ: 11099 – 11102, 12175), *Scinax obtriangulatus* (ZUFRJ: 2033), **Hylodidae**: *Hylodes charadranaetes* (ZUFRJ: 12408 – 12409); **Odontophrynidae:** *Proceratophrys appendiculata* (ZUFRJ: 11719, 12727 11807; UNIRIO: 4471, 4472, 4922).