Inventory

Anuran species composition and density estimates from an Atlantic Forest area within the APA Serra da Mantiqueira, Rio de Janeiro state, Brazil

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Abstract: Among amphibian species from high elevation areas in the Brazilian Atlantic Forest there is a high percentage of threatened and endemic species, but there is still a relative scarcity of local inventories for these organisms. Here, we present data on anuran composition, relative abundance and estimated densities for leaf-litter frogs from an Atlantic Forest area within the APA Serra da Mantiqueira, in Rio de Janeiro state, Brazil, based on results of a short-term survey carried out at altitudes of 1,350-1,750 m, in November 2005 (with additional records from surveys made in 2010 and 2011). Three sampling methods were used during the 2005 survey: plot sampling, visual encounter surveys (VES; performed during the day, at the dusk, and at night), and pitfall traps with drift fences; only non-standardized visual searches were employed during the 2010 and 2011 surveys. We recorded 24 species, with the direct-developer *Ischnocnema* sp. (gr. *lactea*) being the most abundant. Most anurans (90% of all individuals) sampled by VES were captured during the crepuscular and nocturnal periods. The estimated density of the local leaf-litter frog assemblage based on plot sampling was 18.4 ind/100 m², which is one of the highest values currently reported for Atlantic Rainforest areas. This is the first study analyzing the anuran fauna composition of an Atlantic Forest area within the APA Serra da Mantiqueira and adds to the body of knowledge on the fauna of the southern region of Rio de Janeiro state.
Keywords: amphibians, endemism, inventories, montane forest, southeastern Brazil.

Composição de espécies de anuros e estimativa de densidade em uma área de Floresta Atlântica dentro da APA Serra da Mantiqueira, estado do Rio de Janeiro, Brasil

Resumo: Entre as espécies de anfíbios de áreas de altas altitudes da Mata Atlântica brasileira há uma elevada porcentagem de espécies ameaçadas e endêmicas, mas ainda há relativa escassez de inventários locais desses organismos. Aqui, apresentamos dados sobre a composição de espécies, abundância relativa e densidade estimada para anfíbios anuros de serapilheira de área de Mata Atlântica na APA Serra da Mantiqueira, estado do Rio de Janeiro, Brasil, com base em resultados de estudo de curto prazo realizado a altitudes de 1.350-1.750 m, em novembro de 2005 (incluindo registros adicionais de coletas feitas em 2010 e 2011). Três métodos de amostragem foram utilizados na campanha de 2005: amostragem em parcelas, encontros visuais (realizados durante o dia, no crepúsculo e à noite) e armadilhas de queda; apenas procuras visuais não padronizadas foram usadas nas coletas de 2010 e 2011. Foram registradas 24 espécies, sendo a mais abundante *Ischnocnema* sp. (gr. *lactea*), uma forma com desenvolvimento direto. A maioria dos anuros (90% de todos os indivíduos) amostrados pelo método de encontros visuais foi capturada durante os períodos crepuscular e noturno. A densidade estimada para anuros de serapilheira com base nas amostragens em parcelas foi de 18,4 ind/100 m2, um dos valores mais altos registrados até o momento para áreas de Mata Atlântica. Este é o primeiro estudo que analisa a composição da fauna de anuros de área de Mata Atlântica da APA Serra da Mantiqueira e contribui para o conhecimento da fauna da região sul do estado do Rio de Janeiro.
Palavras-chave: anfíbios, endemismo, floresta serrana, inventários, sudeste do Brasil.

Introduction

Like many other animals (e.g., Kattan & Franco 2001, McCain 2004, Liew et al. 2010), anuran amphibians typically present comparatively lower species richness at higher altitudes (Duellman 1988; Zancolli et al. 2014, Siqueira et al. 2021). On the other hand, highland habitats are often important centers of endemism for these organisms, especially in the tropics, with many species being restricted to these areas (e.g., Fu et al. 2006, Cruz & Feio 2007, Bernal & Lynch 2008).

Recent surveys have provided lists of amphibian species, mostly preliminary, for some high montane Atlantic Forest areas (i.e., above 1,000 m) in southeast Brazil (Cruz et al. 2009, Siqueira et al. 2011a,b, Garey et al. 2014, 2016, Folly et al. 2016, Lima et al. 2021). These habitats are known for their high rates of endemism of anurans, particularly in portions of the Serra do Mar (Siqueira et al. 2011b, Carvalho-e-Silva et al. 2020) and Serra da Mantiqueira regions (Neves et al. 2018, Silva et al. 2018).

The mountain complex of Serra da Mantiqueira contains the highest areas of the Atlantic Forest domain (reaching nearly 2,900 m of altitude), harboring at least 234 amphibian species, 88 of them endemic to the region (Silva et al. 2018). In the Serra da Mantiqueira complex, the Serra do Itatiaia region is reported as the area with the highest amphibian richness, with 61 species (nine endemic), many of them originally described from the Parque Nacional de Itatiaia (Neves et al. 2018). However, there is still no published list of amphibian species for the region of Itatiaia since Neves et al. (2018) presented the species richness value but listed only the endemic species. Adjacent to the Parque Nacional de Itatiaia, there is another Conservation Unit, the Área de Proteção Ambiental Serra da Mantiqueira (APA Serra da Mantiqueira). In spite of covering more than 400,000 ha and encompassing portions of three Brazilian states (MMA 2018), published data on the amphibian fauna from this Conservation Unit is, to our knowledge, available for only one locality in the state of Rio de Janeiro. Information on the anuran species occurring in that locality is presently restricted to studies reporting an extension of the geographical distribution of *Paratelmatobius mantiqueira* (Vrcibradic et al. 2010), some ecological aspects of *Proceratophrys mantiqueira* (Almeida-Gomes et al. 2007, Almeida-Santos et al. 2017), and a record of snake predation on *Scinax cardosoi* (Dorigo et al. 2014). Another study presented data on sampling efficiency during different periods of the day and the number of species sampled at the area but did not provide information on the local species composition (Rocha et al. 2015).

The state of Rio de Janeiro, whose territory is entirely included within the Atlantic Forest domain, was recently reported to harbor 201 amphibian species (Dorigo et al. 2018), and new species with occurrence in the state are still being steadily described (e.g., Folly et al. 2018, Pereira Silva et al. 2018, Taucce et al. 2018, Cruz et al. 2019, Silva et al. 2020, Nunes et al. 2021). In recent years, lists of species of amphibians have been compiled or updated for several forested areas in the state of Rio de Janeiro (e.g., Almeida-Gomes et al. 2014, Martins et al. 2014, Caram et al. 2016, Rocha et al. 2018, Carvalho-e-Silva et al. 2020, Dorigo et al. 2021), contributing considerably to the knowledge of its amphibian fauna. However, gaps of knowledge for areas at high altitudes still remain, not only for the state of Rio de Janeiro, but for the Atlantic Forest biome as a whole (Lima et al. 2021).

In this study, we address some parameters of the amphibian assemblage from a locality within the APA Serra da Mantiqueira for which preliminary data on the anuran fauna has been previously published, as mentioned above (Almeida-Gomes et al. 2007, Vrcibradic et al. 2010, Dorigo et al. 2014, Rocha et al. 2015, Almeida-Santos et al. 2017).

We present data on species composition, richness and relative abundances of anuran amphibians in that locality, as well as density estimates (individuals per 100 m²) for frogs inhabiting the forest floor leaf litter.

Material and Methods

1. Study area

The study was carried out in a locality within the APA Serra da Mantiqueira, a Conservation Unit encompassing parts of the states of Minas Gerais, Rio de Janeiro and São Paulo, southeastern Brazil. Created in 1985, the APA Serra da Mantiqueira (437,525 ha) comprises an area varying from 458 m up to 2,798 m of elevation, and covers, totally or partially, approximately 50 Conservation Units (MMA 2018). This study's surveys were carried out within a private property, the Marimbondo Farm (22°21'50" S, 44°35'25" W; 34,475 ha), whose area is contained within both Resende and Itatiaia municipalities, state of Rio de Janeiro (Figure 1). Vegetation in the study area is characterized by Upper Montane Rain Forest (*sensu* Oliveira-Filho & Fontes 2000; Figure 2). Mean annual temperature in the region is 14.9°C, and mean annual precipitation is 1,813 mm (Attias et al. 2009).
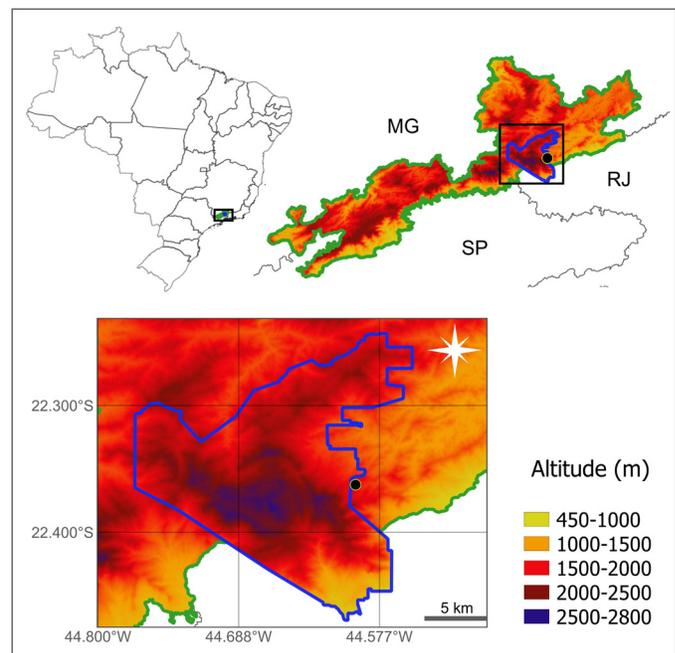

Figure 1. Map of Brazil (upper left) showing the region of the APA Serra da Mantiqueira and the Parque Nacional de Itatiaia (rectangle). The other maps (upper right and bottom) show the location of the study site (black dot), with the limits of the APA Serra da Mantiqueira outlined in green and those of the Parque Nacional de Itatiaia outlined in blue. State codes: MG - Minas Gerais; RJ - Rio de Janeiro; SP - São Paulo.

2. Research design, field methods and data analysis

Fieldwork was conducted at sites between 1,350 m and 1,750 m of elevation, in three different years: 2005, 2010, and 2011. In November 2005, to obtain a representative dataset of the anuran fauna for the study area (including both qualitative and quantitative data) we used three sampling methods. Two of them, visual encounter surveys (Crump & Scott 1994) and plot sampling (Jaeger & Inger 1994),

were performed from 14-18 November 2005. The third method, pitfall traps with drift fences (Corn 1994), was employed from 05-11 and from 14-19 November 2005. Additional sampling was carried out from 18-20 December 2010 and from 13-15 November 2011 using non-standardized methodology.

Figure 2. View of the montane Atlantic Forest (A) and large rocky stream within the forest (B) in the Marimbondo Farm, within the APA Serra da Mantiqueira, state of Rio de Janeiro, Brazil. Photos by D. Vrcibradic (A) and C.V. Ariani (B).

For visual encounter surveys (VES), 150 time-constrained searching bouts of 30 minutes each were carried out daily by ten people wearing headlamps, totaling 75 hours of sampling effort. Equal numbers of transects (50) were surveyed during the diurnal (11:00-16:30h), crepuscular (17:30-18:30h) and nocturnal (19:30-22:00h) periods. During transect sampling, each observer moved at a slow walking pace, carefully searching all types of potential microhabitats for anurans (e.g., leaf litter, water bodies, bromeliads, fallen logs, tree trunks, shrubs, rocks).

For the plot method, 30 quadrats of 5 x 5 m were established on the forest floor during the afternoon, totaling 750 m² of area sampled. The corners of each plot were marked with wooden stakes and the area inside was enclosed with a 50 cm high soft plastic fence, whose base was buried or attached to the ground. Soon after sunset, each plot was carefully searched for about half an hour by a crew of five persons using headlamps, moving on hands and knees, side-by-side.

During the searches the leaf-litter was stirred with hand rakes, and leaves, stones and fallen branches were overturned; rock crevices and fissures among tree roots were also checked for anurans. Plot sampling was performed during five consecutive days, with six quadrats surveyed per night.

Three pitfall trap systems were established within the forest and remained open for a total of 11 days. Each system consisted of ten 30-liter buckets buried on the ground up to their rims, each bucket set *ca.* 5 m apart from the nearest one, with soft plastic drift fences about 50 cm high extended between them. Six buckets were set in line and the other four were placed at opposite ends of the fence, perpendicular to the main axis. Pitfalls were checked once per day for captured animals, always in the morning.

All anurans found by the three sampling methods were collected and identified (whenever possible). Estimates of leaf litter frog density (ind/100 m²) were produced based on the data obtained through plot method. An evaluation of sampling effectiveness was undertaken by cumulative and individual-based rarefaction curves performing 1,000 randomizations without replacement, using the program EstimateS 9.1.0 (Colwell 2013). We carried out this procedure for VES and plot methods separately, using abundance data.

Further excursions for sampling the same area occurred in December 2010 and in November 2011 for collection of additional specimens. In these excursions, a three-person team performed haphazard visual searches (not standardized by time, unlike those of 2005) between 17:00 and 22:00h, at altitudes of 1,450-1,550 m, during two consecutive nights. Additionally, in 2011, funnel traps (made with five-liter plastic bottles) baited with ham were set at the bottom of a stream to capture tadpoles. Records obtained by these collections were incorporated into the local species list but were not used in quantitative analyses.

3. Taxonomic issues

Voucher specimens of anuran species collected during the study were deposited at the amphibian collection of the Museu Nacional, Universidade Federal do Rio de Janeiro (MNRJ), in the municipality of Rio de Janeiro (see Appendix).

Bokermannohyla circumdata can be potentially confused with *B. luctuosa* (Pombal & Haddad, 1993) (which also occurs in the region of Itatiaia; see Silva et al. 2018) since the taxonomic limits between these two species may be considered problematic (M. F. Napoli, pers. comm.). The larger *Bokermannohyla* individuals from the Marimbondo Farm were assigned to *B. circumdata* due to the presence (albeit not in all specimens) of bifid distal subarticular tubercles on fingers III and IV (see Napoli 2000). Also, Silva et al. (2018) cited our specimens as *B. circumdata* in their list of material examined, which indicates that those authors have seen that material and confirmed its identification. A second, smaller form of *Bokermannohyla* recorded during our surveys could not be positively identified to any currently described species in the genus and is treated herein as *Bokermannohyla* sp.

Phantasmarana (formerly *Megaelosia*) *lutzae* remained unrecorded for decades since the types and other associated specimens were collected in the Parque Nacional de Itatiaia (Izecksohn & Gouvêa 1987). Even though only tadpoles were recorded in our surveys, we felt confident in assigning them to *P. lutzae* as this is the only species of large-bodied hylodid currently known from the region of Itatiaia and its surroundings (Vittorazzi et al. 2021). Moreover, some traits of the tadpoles, such as the presence of distinct dark blotches on the tail and the small marginal papillae (compared to those of *Megaelosia goeldii* tadpoles) match the brief description given by Izecksohn & Gouvêa (1987).

Results

A total of 24 anuran species belonging to eight families were recorded, of which six were registered only during samplings carried out in 2010 and 2011 (Table 1, Figures 3 and 4). For two species, *Phantasmarana lutzae* and *Phasmahyla cochranae*, only tadpoles were recorded. The anuran assemblage was dominated by species of the family Hylidae (ten species).

The VES method yielded records of 132 individuals from 17 anuran species, with *Proceratophrys mantiqueira* (N = 28, or 21.1% of all individuals found), *Ischnocnema* sp. (gr. *lactea*) (N = 21, or 15.9%), and *Bokermannohyla circumdata* (N = 18, or 13.6%) being the ones most frequently sampled (Table 1). Most anuran species recorded during transects were found during the nocturnal (N = 14 species) and crepuscular periods (N = 9), with eight species being recorded only at night and three species found only during crepuscular samplings (Table 1). Four species were recorded both during crepuscular and nocturnal periods, and only the two most abundant species, *P. mantiqueira* and *Ischnocnema* sp. (gr. *lactea*), were recorded on all three sampling periods (Table 1). Moreover, most individuals (regardless of the species) were found during the nocturnal (N = 78, or 59.1%) and crepuscular (N = 41, or 31.1%) transect searches.

Table 1. Anuran species recorded at the Atlantic Rainforest of the Marimbondo Farm, APA Serra da Mantiqueira, state of Rio de Janeiro, Brazil. Number of individuals is presented for each species recorded by visual encounter surveys (VES) during diurnal (D), crepuscular (C) and nocturnal (N) periods, plot and pitfall trap sampling. Species added to the list in 2010 (*) and 2011 (**) were not quantified. T = species recorded only as tadpoles.

| Species	VES			Plot	Pitfall	Total
	D	C	N			
Brachycephalidae						
Brachycephalus rotenbergae Nunes, Guimarães, Moura, Pedrozo, Moroti, Castro, Stuginski & Muscat, 2021						*
Ischnocnema aff. *guentheri*		2	8	1	1	12
Ischnocnema juipoca (Sazima & Cardoso, 1978)			1			1
Ischnocnema sp. (gr. *lactea*)	3	15	3	121	1	143
Bufonidae						
Rhinella icterica (Spix, 1824)		3	5	1		9
Centrolenidae						
Vitreorana uranoscopa (Müller, 1924)		3				3
Hylidae						
Aplastodiscus arildae (Cruz & Peixoto, 1987)		2				2
Aplastodiscus leucopygius (Cruz & Peixoto, 1985)			4			4
Boana pardalis (Spix, 1824)						*
Boana polytaenia (Cope, 1870)			8			8
Bokermannohyla circumdata (Cope, 1871)		1	17			18
Bokermannohyla sp. (gr. *circumdata*)		1	5			6
Dendropsophus minutus (Peters, 1872)						*
Scinax cardosoi (Carvalho-e-Silva & Peixoto, 1991)			13			13
Scinax dolloi (Werner, 1903)			5			5
Scinax flavoguttatus (Lutz & Lutz, 1939)		1				1
Hylodidae						
Phantasmarana lutzae (Izecksohn & Gouvêa, 1987) (T)						**
Leptodactylidae						
Leptodactylus latrans (Steffen, 1815)						**
Paratelmatobius mantiqueira Pombal & Haddad, 1999			1			1
Physalaemus cuvieri Fitzinger, 1826						*
Odontophrynidae						
Odontophrynus americanus (Duméril & Bibron, 1841)			1			1
Proceratophrys boiei (Wied-Neuwied, 1824)			2			2
Proceratophrys mantiqueira Mângia, Santana, Cruz & Feio, 2014	10	13	5	15	7	50
Phyllomedusidae						
Phasmahyla cochranae (Bokermann, 1966) (T)						*
Total	13	41	78	138	9	279
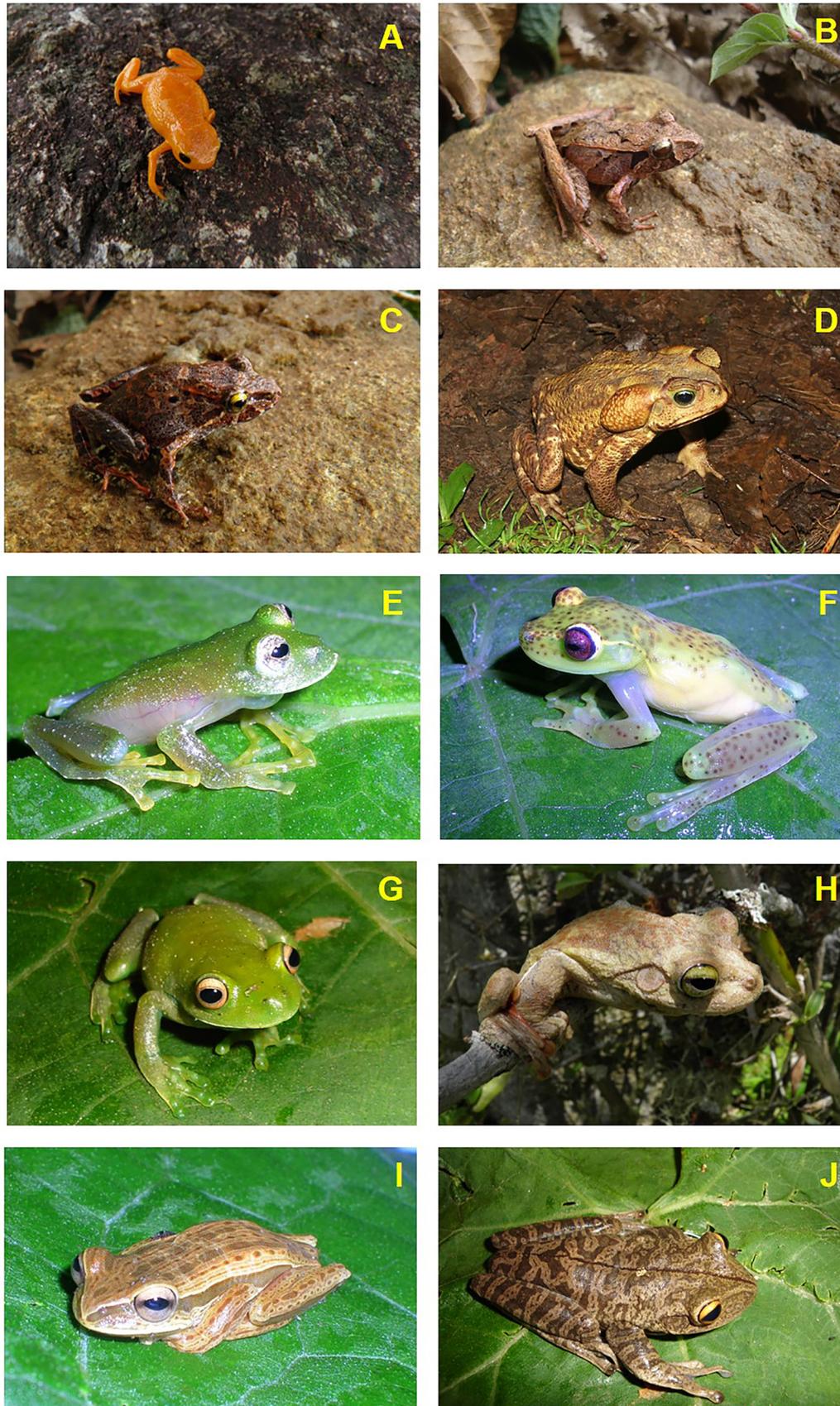
Figure 3. Some anurans recorded in an Atlantic Rainforest area within the APA Serra da Mantiqueira, state of Rio de Janeiro, Brazil: (A) *Brachycephalus rotenbergae*; (B) *Ischnocnema* aff. *guentheri*; (C) *Ischnocnema* sp. (gr. *lactea*); (D) *Rhinella icterica*; (E) *Vitreorana uranoscopa*; (F) *Aplastodiscus arildae*; (G) *Aplastodiscus leucopygius*; (H) *Boana pardalis*; (I) *Boana polytaenia*; (J) *Bokermannohyla circumdata*. Photos by D. Vrcibradic (A, C, D, H), M. Targino (B), T. Klaion (E, F, I) and V.N.T. Borges-Júnior (G, J).

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Figure 4. Some anurans recorded in an Atlantic Rainforest area within the APA Serra da Mantiqueira, state of Rio de Janeiro, Brazil: (A) *Bokermannohyla* sp. (gr. *circumdata*); (B) *Dendropsophus minutus*; (C) *Scinax cardosoi*; (D) *Scinax dolloi*; (E) *Scinax flavoguttatus*; (F) *Paratelmatobius mantiqueira*; (G) *Physalaemus cuvieri*; (H) *Odontophrynus americanus*; (I) *Proceratophrys boiei*; (J) *Proceratophrys mantiqueira*. Photos by C.V. Ariani (A, D, F, J), M. Targino (B), V.N.T. Borges-Júnior (C, E) and D. Vrcibradic (G, H, I).

A total of 138 individuals belonging to four anuran species were found during plot sampling (Table 1). The number of anurans per plot ranged from zero (7/30 or 23.3% of all plots) to 25 (1/30 or 3.3% of all plots). The estimated overall density of the local leaf litter frog assemblage was 18.4 ind/100 m^2. The highest density was that of *Ischnocnema* sp. (gr. *lactea*) (16.1 ind/100 m^2), followed by *Proceratophrys mantiqueira* (2.0 ind/100 m^2), and those two species together comprised about 98.5% of individuals found in plots. Both *Ischnocnema* aff. *guentheri* and *Rhinella icterica* had an estimated density of 0.1 ind/100 m^2.

Nine individuals of three species were captured in pitfall traps, with *Proceratophrys mantiqueira* (N = 7) being the most frequent (Table 1). Overall (i.e., including all methodologies pooled) the most abundant species recorded during the study were *Ischnocnema* sp. (gr. *lactea*) and *P. mantiqueira* (comprising 51.3% and 17.9% of all individuals collected, respectively).

Cumulative and individual-based species-rarefaction curves showed an asymptotic shape for VES, but it was non-asymptotic for plot-sampling data (Figure 5).
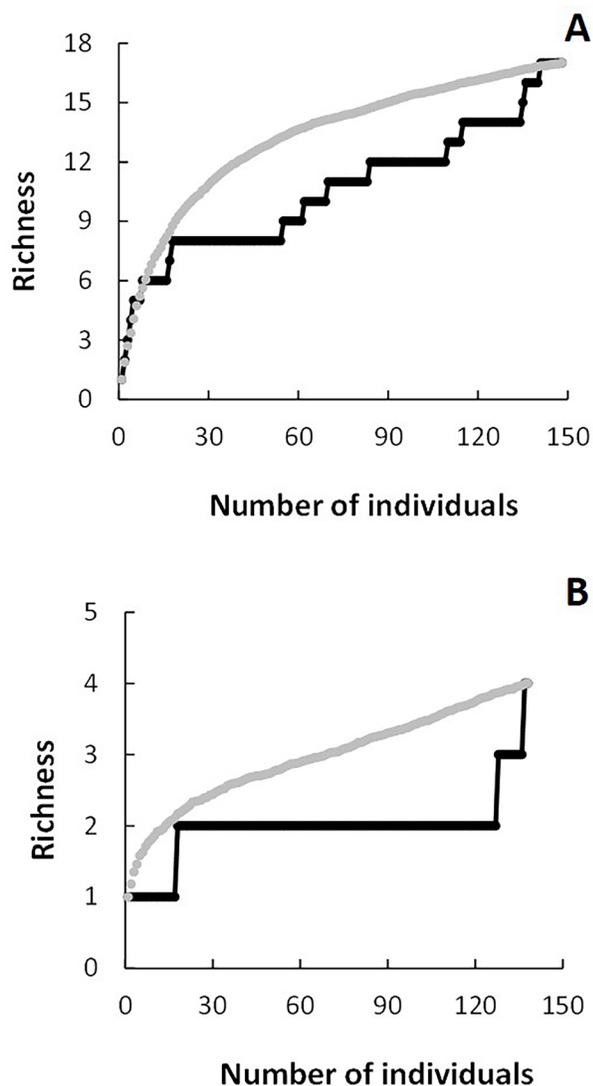

Figure 5. Cumulative (black) and rarefaction (gray) curves of species sampled of anurans recorded using VES (A) and plot (B) methods, in an Atlantic Rainforest area within the APA da Mantiqueira, in Rio de Janeiro state, Brazil.

Discussion

This is the first study to provide an approach of species composition, richness and estimated density (on the forest floor) of amphibians for any area within the APA Serra da Mantiqueira, reporting a total of 24 anuran species for the local assemblage. The anuran assemblage in the study area was dominated by species of the family Hylidae, which is the richest anuran family in the Atlantic Forest domain (Rossa-Feres et al. 2017). Most of the hylids here recorded were found in disturbed areas, and many individuals in five species (*Boana polytaenia*, *Bokermannohyla circumdata*, *Bokermannohyla* sp., *Scinax cardosoi*, and *S. dolloi*) were collected in a single marsh. The higher species richness of hylids found in tropical regions of the Americas, compared to that of temperate regions, may reflect the fact that these anurans originated in tropical South America and there has been a long time for species to accumulate through in-situ speciation (Wiens et al. 2006).

Some of the anurans recorded in this study represent new or undetermined species. The anuran most frequently found during our fieldwork was an undetermined species of *Ischnocnema* of the *lactea* group (currently in the process of being formally described) that superficially resembles other members of that group such as *I. melanopygia* Targino, Costa & Carvalho-e-Silva, 2009 and *I. concolor* Targino, Costa & Carvalho-e-Silva, 2009 (which also occur in the Itatiaia region, but at higher altitudes; Targino et al. 2009). We also recorded members of the *Ischnocnema guentheri* species complex (see Gehara et al. 2013), which also likely represents an undescribed taxonomic entity. Gehara et al. (2013) restricted *I. guentheri sensu stricto* to the Parque Nacional da Tijuca, municipality of Rio de Janeiro, based on molecular and bioacoustic data. The specimens reported herein may belong to the *Ischnocnema* aff. *guentheri* lineage CS3 of Gehara et al. (2013), since the samples from Itatiaia used in their study fell within that lineage in their phylogenetic tree. *Bokermannohyla* sp. (gr. *circumdata*) may also represent an undescribed taxon (A.C.C. Lourenço, *pers. comm.*).

Two other species recorded during our surveys have only been described within the last ten years, being previously confused with other taxa: *Proceratophrys mantiqueira* (split off from *P. melanopogon* by Mângia et al. 2014) and *Brachycephalus rotenbergae* (split off from *B. ephippium* by Nunes et al. 2021). *Paratelmatobius mantiqueira* was also described relatively recently, based on specimens collected in 1953 (Pombal & Haddad 1999), and remained unrecorded in the wild for more than 50 years until one specimen was collected during our 2005 surveys at the studied site in the APA Serra da Mantiqueira (Vrcibradic et al. 2010). Finally, *Scinax dolloi* is a taxon that remained in obscurity for more than a century, with no natural populations being associated with this name since its description by Werner (1903), until its "rediscovery" in 2016 (Santos et al. 2021). The latter authors reported a population of the species from its type locality in Vila de Maringá, municipality of Itatiaia (see Caramaschi et al. 2013), some 2.6 km in straight line from the locality where the present study was carried out. These cases, together with the aforementioned undescribed/undetermined taxa, highlight how incomplete the knowledge of the Atlantic Forest anuran fauna still is, particularly in the Serra da Mantiqueira region.

The genus *Megaelosia* has recently been rendered monotypic (for *M. goeldii*) due to non-monophyly, and a new genus (*Phantasmarana*) was erected to accommodate the other species, including *M. lutzae* (Vittorazzi et al. 2021).

Phantasmarana lutzae was described (as *Megaelosia lutzae*) by Izecksohn & Gouvêa (1987) based on a few adult and juvenile specimens collected between 1949 and 1964 and some tadpoles (not included in the type series) without collection date. This species remained unrecorded in the wild for more than five decades until Vittorazzi et al. (2021) reported five tadpoles collected at the type locality (Parque Nacional de Itatiaia), which they used in a molecular analysis. Rosa et al. (2003) referred some tadpoles from the municipality of Pindamonhangaba, São Paulo state (ca. 100 km westward from Parque Nacional de Itatiaia), to *Megaelosia lutzae*, but Vittorazzi et al. (2021) re-identified those specimens as *Phantasmarana jordanensis* (Heyer 1983) based on analyses of DNA samples. Thus, *P. lutzae* is currently known only from the type locality and its surroundings. Our record of *P. lutzae* tadpoles for the APA Serra da Mantiqueira represents the second confirmed report of the species since its description (but it does not constitute an actual range extension, as our study site is located adjacent to and just outside the limits of the Parque Nacional de Itatiaia). Although no adults were found, the fact that several tadpoles were collected in 2011 in spite of relatively little sampling effort suggests that *P. lutzae* may not be an uncommon species, at least in our study site. Further sampling is required to gather information on this poorly known species.

The treefrog *Scinax cardosoi* is another species that remains poorly known (Kirchmeyer et al. 2019), being currently reported from a few isolated localities in the states of Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo, in southeastern Brazil (Frost 2021). Studies updating the geographic distribution of this species (Pinto et al. 2009, Linares et al. 2011, Moroti et al. 2017) have omitted its presence in Visconde de Mauá, in the municipality of Resende, state of Rio de Janeiro, apparently overlooking the fact that one of its paratypes came from that locality (Carvalho-e-Silva & Peixoto 1991). The village of Visconde de Mauá is about 6 km distant from our study site. More recently, Kirchmeyer et al. (2019) reported five newly metamorphosed individuals from the Parque Nacional de Itatiaia. Those records, together with those of our study, confirm the presence of *S. cardosoi* in the region of Itatiaia and its occurrence in other areas within the state of Rio de Janeiro besides its type locality in Teresópolis municipality (Carvalho-e-Silva & Peixoto 1991).

The estimated overall density of the local leaf litter frog assemblage was high (18.1 ind/100 m²) when compared to those found for most other sites sampled (also with large quadrats) within the Atlantic Forest in southeastern and southern Brazil (1.4-13.2 ind/100 m²; Giaretta et al. 1997, 1999, Rocha et al. 2001, 2007, 2011, 2013, Almeida-Gomes et al. 2008, 2010, Santos-Pereira et al. 2011, Siqueira et al. 2011a, Oliveira et al. 2013). Exceptions are two localities in the municipality of Cachoeiras de Macacu, state of Rio de Janeiro, that yielded comparable (17.1 ind/100 m²; Siqueira et al. 2009) or higher estimates (24.6 ind/100 m²; Siqueira et al. 2014). However, the high frog density observed in this study reflects the high local abundance of *Ischnocnema* sp. (gr. *lactea*), since 88% of the frogs found in plots represented that species. Indeed, this small direct-developing anuran numerically dominated the anuran assemblage at the studied site in the APA Serra da Mantiqueira (as also evidenced by the VES methodology). Several other plot-sampling studies in Atlantic Forest areas have also evidenced a clear dominance of species with direct development of terrestrial eggs in the local leaf-litter frog assemblages (e.g., Giaretta et al. 1997, 1999, Rocha et al. 2001, 2007, 2013, Almeida-Gomes et al. 2008, 2010, Siqueira et al. 2009, 2011a, 2014), and this has also been observed in

Amazonian (e.g., Rodriguez 1992, Gascon 1996) and Central American forest areas (e.g., Scott 1976, Toft 1981, Liebermann 1986, Fauth et al. 1989, Hofer & Bersier 2001). Direct-developing anurans may be more widely distributed within the forest due to their independence of water bodies for reproduction (Haddad & Prado 2005), though other factors such as rates of dehydration/rehydration (Dabés et al. 2012) and a generalist diet (Alves-dos-Santos et al. 2021) may also play a role.

Cumulative and rarefaction curves using data from VES method indicated that sampling effort was almost enough to obtain a representative sample of the local anuran fauna, with a tendency toward stabilization, despite plot methodology falling short of reaching the asymptote. Plot sampling is useful for sampling anurans typical of forest floor leaf litter in Atlantic Forest areas (Giaretta et al. 1997, 1999, Rocha et al. 2001, 2007, 2013, Siqueira et al. 2009, 2011a) and, despite our effort being not enough using this method, members of that guild of anurans were also recorded by VES, adding four leaf litter species to our list that were not recorded in plots (e.g., *Ischnocnema juipoca*, *Paratelmatobius mantiqueira*, *Odontophrynus americanus* and *Proceratophrys boiei*). Moreover, our additional effort with non-standardized samplings in 2010 and 2011, added two additional species that live in the forest floor (*Brachycephalus rotenbergae* and *Physalaemus cuvieri*), besides five more anuran taxa with arboreal or semi-aquatic habits (*Boana pardalis*, *Dendropsophus minutus*, *Leptodactylus latrans*, *Phantasmarana lutzae* and *Phasmahyla cochranae*). The exception is *P. lutzae*, which was sampled only as tadpoles, through the use of funnel traps (the only other species recorded only in larval stage, *Phasmahyla cochranae*, was sampled as a tadpole found during haphazard visual searching). Thus, our data showed that visual searches were sufficient to produce a representative sample of the anuran fauna of our study site, with pitfall traps and plot sampling providing no additional species records. However, in some other short-term inventories employing multiple sampling methods in tropical areas, plot and/or pitfall trap sampling added anuran species that had not been recorded by standardized visual searches or occasional encounters (Almeida-Gomes et al. 2008, Ribeiro-Júnior et al. 2008, Siqueira et al. 2009, Rocha et al. 2011). Nevertheless, pitfall traps are generally considered to have low cost-benefit for simple short-term surveys of tropical amphibians (Cechin & Martins 2000, Rödel & Ernst 2004), which is supported by the results of our study.

Phantasmarana lutzae and *Scinax dolloi* are the only species recorded in our study that are currently known only from the state of Rio de Janeiro and are possibly endemic to the Itatiaia region (Frost 2021, Vittorazzi et al. 2021), though Santos et al. (2021) suggested that *S. dolloi* may occur more widely. Neves et al. (2018) considered the Serra do Itatiaia as the area of highest amphibian endemicity rate within the Mantiqueira/Espinhaço/Canastra mountain complex in southeastern Brazil, with nine endemic anuran species (*Scinax dolloi* was not mentioned, possibly because it was a species of problematic identity at the time). Among the undescribed species recorded in the APA Serra da Mantiqueira survey, at least one, *Ischnocnema* sp. (gr. *lactea*), may be endemic to the Itatiaia region, and it is possible that the degree of anuran endemicity in the area is still underestimated.

Regarding their conservation status, most species from the APA Serra da Mantiqueira are listed under "Least Concern" (LC) by the IUCN (2021), though the status of *Brachycephalus rotenbergae*, *Proceratophrys mantiqueira*, *Scinax dolloi*, and the undescribed species have not been assessed.

Phantasmarana lutzae (Carvalho-e-Silva & Carvalho-e-Silva 2004) and *Paratelmatobius mantiqueira* (Nascimento & Garcia 2004) are both classified as "Data Deficient" (DD) with population trends classified as "unknown" and "decreasing", respectively (IUCN 2021). None of the species found in the present survey is listed as threatened in the Red Book of Threatened Brazilian Fauna (ICMBio/MMA, 2018) either. Threatened species are usually the focus of conservation efforts and funding programs, but little attention is given to species considered "Data-Deficient", contradicting the IUCN's recommendation to give them the same degree of attention as threatened taxa (Pimenta et al. 2005, Siqueira et al. 2011b).

Lists of species present in a given area constitute a fundamental tool for the development and management of effective conservation interventions. Our inventory at an area within the APA Serra da Mantiqueira adds to the body of knowledge on the amphibian diversity of high-elevation forests in an Atlantic Forest area, which is still insufficiently known.

Supplementary Material

The following online material is available for this article:

Appendix I - Voucher specimens of species collected in the present study deposited at the Museu Nacional, Universidade Federal do Rio de Janeiro (MNRJ), Rio de Janeiro municipality, Rio de Janeiro state, Brazil.

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Carla Costa Siqueira: Substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation; contribution to critical revision, adding intelectual content.

Davor Vrcibradic: Substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation; contribution to critical revision, adding intelectual content.

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Carlos Frederico D. Rocha: Substantial contribution in the concept and design of the study; contribution to data analysis and interpretation; contribution to critical revision, adding intelectual content.

Conflicts of Interest

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

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