



DIVERSITY AND DISTRIBUTION OF ANURANS FROM MATA DAS FLORES STATE PARK, ESPÍRITO SANTO, SOUTHEASTERN BRAZIL

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Abstract: The scarcity of information on anurans to many areas makes it difficult to delimit new conservation areas with higher relevance to the taxa, and therefore, knowledge of community composition and the study of ecological specialties are of fundamental importance for the conservation of the biodiversity. We studied the anuran community of Mata das Flores State Park (MFSP), located in the municipality of Castelo, Espírito Santo state, Southeastern Brazil, evaluating the richness, composition, abundance, and distribution of anurans species. We sampled the MFSP from March/2017 to January/2018, with four occasions during this time period. We performed sampling at night in six plots of 250 meters distributed along the MFSP area, three plots in flooded environments and three plots in forest environments. We sampled the anurans using the active search method, with visual and auditory sampling. During each transect, the plot was surveyed by two observers. We recorded 226 individuals from 18 species of anurans, distributed in six families. The composition and abundance of the anuran species differed between the plots located near the flooded areas and those located in forest areas of the MFSP. Our study is the first to provide data from the MFSP anuran community and our results point to a worrying scenario for the biodiversity of the area, due to the diverse anthropic impacts and presence of the exotic species *Lithobates catesbeianus*. The Park is an important forest fragment, being continuous to the ecological corridor Pedra Azul - Forno Grande, but it is the conservation unit that suffers the most impacts due to its proximity to urban areas. Thus, long-term studies are necessary, mainly to quantify and evaluate the effects of these impacts on local fauna.

Keywords: amphibians; Atlantic Forest; ecology; frogs; richness.

INTRODUCTION

Anurans represent a broadly diverse group and perform a variety of functions in ecosystems, playing

an important role in energy flow and nutrient cycling in both terrestrial and aquatic environments, as well as assisting in pest control (Valencia-Aguilar *et al.* 2013), and are natural indicators of impacts on

the environment, mainly due to their physiological characteristics (such as permeable skin) which makes them sensitive to environmental changes (Zanella *et al.* 2013).

Across the world, amphibians have been experiencing sharp population declines due to various threats such as fragmentation, climatic changes and diseases as that caused by the pathogen *Batrachochytrium dendrobatidis* (Eterovick *et al.* 2005). Brazil is considered the country with the highest diversity of anurans in the world, with occurrence of 1,039 species (Segalla *et al.* 2016, IUCN 2017). The Atlantic Forest is the biome that has the largest number of anuran species in Brazil, with about 625 species of anurans, where most species are endemic to this formation (77.6%) (Rossa-Feres *et al.* 2017). However, it is also a biome that suffers various threats, especially continuous degradation and deforestation, remaining mainly small forest fragments surrounded by a less permeable matrix such as agriculture, pasture and urban environments (Ribeiro *et al.* 2009, Joly *et al.* 2014). Habitat loss due to continuous suppression of native Atlantic Forest vegetation is considered to be the main threat to amphibians in this biome, especially for those with specific habitat requirements such as exclusively forest species (Eterovick *et al.* 2005). Consequently, the Neotropical region was the one experiencing the highest rates of population decline in the world (63.1%) (Stuart *et al.* 2004).

Mata das Flores State Park (MFSP) is part of the Pedra Azul - Forno Grande Ecological Corridor together with three other protected areas, located in the state of Espírito Santo, southeastern Brazil, totaling approximately 4500 hectares (IEMA 2018). The MFSP presents diverse anthropogenic threats because it is surrounded by rural settlements with practices related to cattle raising and coffee plantations (Christ *et al.* 2016). In addition, the MFSP is located only about 1 km from the urban area of the municipality of Castelo and is intercepted by a state highway, where in addition to the high traffic of vehicles, it is common the practice of motocross (Christ *et al.* 2016, Luber *et al.* 2016).

Despite the importance of this protected area for the Pedra Azul - Forno Grande Corridor, there is no information available on the local anurans community. The scarcity of information on communities of anurans living in different areas makes it difficult to delimit additional conservation

areas with higher relevance to the taxa, and therefore, knowledge of community composition and the study of ecological specialties are of fundamental importance for the conservation of the area's biodiversity. In this study we evaluate the richness, composition, abundance and local distribution of anurans species of the anurans community of Mata das Flores State Park, an Atlantic forest remnant located in the municipality of Castelo, Espírito Santo, Southeastern Brazil.

MATERIAL AND METHODS

Study area

The study was carried out in the Mata das Flores State Park (MFSP; 20°35'54" S, 41°10'53" W), located in the municipality of Castelo, Espírito Santo state, southeastern Brazil (Figure 1), with a total area of 800 ha, being an important ecological corridor between the Forno Grande and Pedra Azul State Parks (IEMA 2018).

The park is completely at the Atlantic Rainforest biome, and there are two vegetation types (sensu IBGE 2012): (1) the main vegetation in the lowlands is composed of a dry forest classified as Semi-Deciduous Seasonal Forest from the Lowlands; and (2) the small highland area is a wet forest classified as Dense Ombrophilous Montane Forest, with some rocky outcrops (IBGE 2012, IEMA 2018). The MFSP presents an elevation ranging from 150 to 450 m a.s.l., but with a small area represented by mountains ranging from 500 to 750 m (IEMA 2018).

Data survey

We sampled the MFSP in four occasions from March/2017 to January/2018. We performed sampling at night (18:00 to 22:00 h) in six plots of 250 m distributed along the MFSP area (Figure 1), three plots in flooded environments and three plots in forest environments. The plots followed the contour line ground level curve and were distant from each other by at least 250 m. Each plot was sampled for about 40 to 60 min, depending on the number of individuals found. Each plot was sampled three times over the sampled period, totaling a sampling effort of 45,000 m².

We sampled the anurans through transection along the plots, using the active search method, with visual and auditory sampling (Crump & Scott 1994). During each transect, the plot was carefully

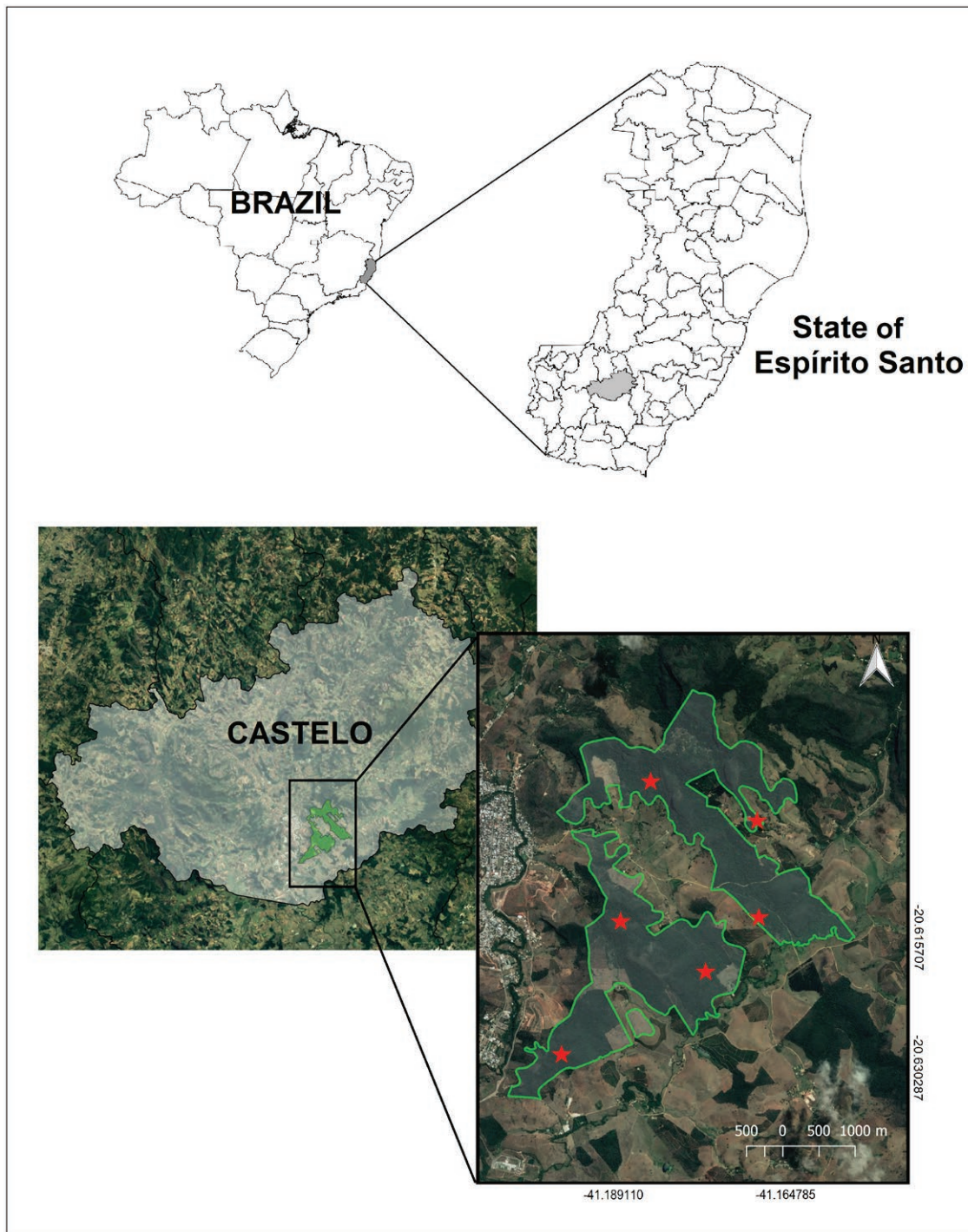


Figure 1. Location of the Mata das Flores State Park, municipality of Castelo, state of Espírito Santo, southeastern Brazil, showing the location of the sampled sites.

surveyed by two observers and all individuals located visually or by their calling activity at a distance of approximately five meters to each side from the plot-central-line (totaling a range of 10 m of search). Together, were recorded information on the specific plot, time that individual was found and the species was identified. We have identified the species of anurans in the field with the aid of specific guides

for the Atlantic Forest anurans (e.g., Haddad *et al.* 2013). Additionally, when possible, two individuals of each species of anuran were collected for later deposit in an institutional collection (National Museum of Rio de Janeiro - MNRJ), as specimen testimony of their occurrence in the area (license no. 76433846 - IEMA and 56580-1 - Sisbio). The collected anurans were euthanized with anesthetic Lidocaine

1.8 in ointment and fixed in 10% formaldehyde. After fixation, subjects were kept in 70% alcohol. We followed the taxonomic arrangement of Frost (2018).

Data analysis

To evaluate the similarity in the composition of frogs among the types of sampled vegetation (forest and flooded), we use the Multidimensional Scaling Non-Metric (NMDS), with the composition and presence / absence data of the species, calculating the dissimilarity between the composition of species with the Jaccard metric (McCune & Grace 2002). To test the difference between areas (i.e. forests and flooded), we performed a Student T-Test with the axes of the NMDS.

RESULTS

We recorded 226 individuals from 18 species of anurans, distributed in six families (Figure 2). Hylidae (nine species, 50%) was the richest family, followed by Leptodactylidae (four species, 22.2%), Bufonidae (two species, 11%), Cycloramphidae (one species, 5.6%), Craugastoridae (one species, 5.65%), and Ranidae (one species, 5.6%) (Table 1). In general, *Scinax alter* was the frog species with the highest number of records (48 individuals, 21.2%), followed by *Boana faber* (24 individuals, 10.6%), and *Dendropsophus* sp. (22 individuals, 9.7%).

The composition and abundance of the anuran species differed between the plots located near the



Figure 2. Some anurans registered in the Mata das Flores State Park, municipality of Castelo, state of Espírito Santo, southeastern Brazil: 1 – *Rhinella schneideri*, 2 - *Haddadus binotatus*, 3 - *Boana albomarginata*, 4 - *Boana faber*, 5 - *Boana semilineata*, 6 - *Dendropsophus anceps*, 7 - *Dendropsophus bipunctatus*, 8 - *Dendropsophus branneri*, 9 - *Dendropsophus decipiens*, 10 - *Leptodactylus fuscus*, 11 - *Leptodactylus spixi*, 12 - *Physalaemus crombiei*.

flooded areas and those located in forest areas of the MFSP (Figure 3). In the plots located in the flooded areas we obtained a higher richness and number of records (17 species, 218 individuals) in relation to forested areas (three species, eight individuals) (t-Test, $p = 0.04$; Figure 4).

DISCUSSION

The number of species found in this study (18 species) represents about 40% of the richness already known for the adjacent area Pedra Azul - Forno Grande corridor (PA-FG Corridor; Montesinos *et al.* 2012, Silva-Soares & Scherrer

2013). However, although the MFSP has a connection with the other protected areas that make up the ecological corridor, this area has not been previously sampled for compiling the ecological corridor list of anurans. In fact, we recorded five species which occurrence that were not previously recorded for the ecological corridor PA-FG: *Dendropsophus* sp., *D. anceps*, *Boana semilineata*, *Rhinella schneideri* and *Lithobates catesbeianus*. This is probably related to differences in altitude and vegetation among the areas sampled in the studies developed. The state parks of Pedra Azul and Forno Grande have altitudes between 960-1910m and 1200-2039m,

Table 1. Species of anurans recorded in Mata das Flores State Park, municipality of Castelo, state of Espírito Santo, southeastern Brazil, their respective abundances, the respective habitat types in which they were found (FA= Flood areas and F = Forest) and conservation status according to the IUCN Red List (LC = Least Concern).

Taxon	Abundance	Type of habitat	Status (IUCN)
Bufonidae			
<i>Rhinella crucifer</i> (Wied-Neuwied, 1821)	4	FA	LC
<i>Rhinella schneideri</i> (Werner, 1894)	5	FA	LC
Craugastoridae			
<i>Haddadus binotatus</i> (Spix, 1824)	1	FA	LC
Cycloramphidae			
<i>Thoropa miliaris</i> (Spix, 1824)	2	FA	LC
Hylidae			
<i>Boana albomarginata</i> (Spix, 1824)	8	FA	LC
<i>Boana faber</i> (Wied-Neuwied, 1821)	24	FA, F	LC
<i>Boana semilineata</i> (Spix, 1824)	14	FA	LC
<i>Dendropsophus anceps</i> (Lutz, 1929)	19	FA	LC
<i>Dendropsophus bipunctatus</i> (Spix, 1824)	12	FA	LC
<i>Dendropsophus branneri</i> (Cochran, 1948)	18	FA	LC
<i>Dendropsophus decipiens</i> (Lutz, 1925)	14	FA	LC
<i>Dendropsophus</i> sp.	22	FA, F	LC
<i>Scinax alter</i> (Lutz, 1973)	48	FA	LC
Leptodactylidae			
<i>Leptodactylus fuscus</i> (Schneider, 1799)	16	FA	LC
<i>Leptodactylus latrans</i> (Steffen, 1815)	10	FA	LC
<i>Leptodactylus spixi</i> (Heyer, 1983)	2	FA	LC
<i>Physalaemus crombiei</i> (Heyer & Wolf, 1989)	5	FA	LC
Ranidae			
<i>Lithobates catesbeianus</i> (Shaw, 1802)	2	FA	LC

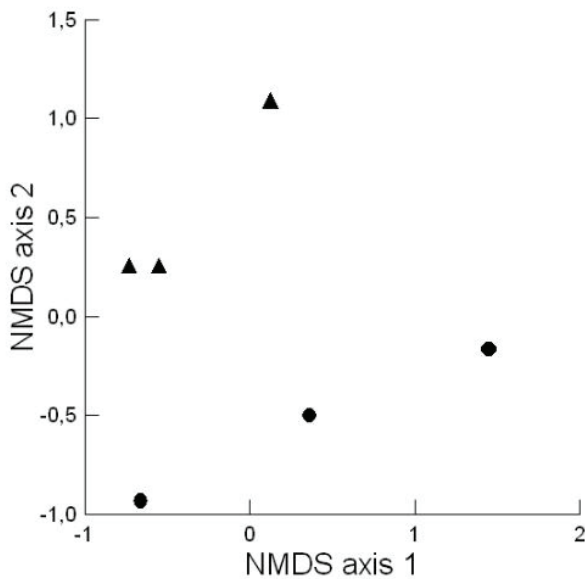


Figure 3. Results of Non-metric Multidimensional Scaling (NMDS) with the composition and presence/absence data of the species of anurans in the Mata das Flores State Park, municipality of Castelo, state of Espírito Santo, southeastern Brazil. Vegetation type: Forest (dots), flooded areas (triangles).

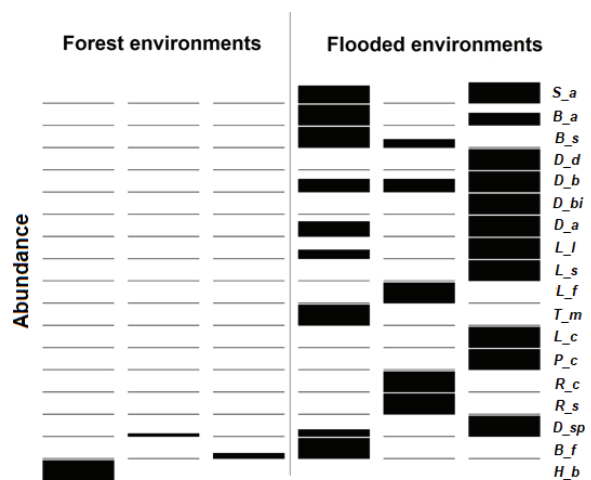


Figure 4. Relationship between habitat types and abundance (bars) and species composition of anurans for each plot located in Mata das Flores State Park, Castelo, Brazil. S_a = *Scinax alter*, B_a = *Boana albomarginata*, B_s = *Boana semilineata*, D_d = *Dendropsophus decipiens*, D_b = *Dendropsophus branneri*, D_bi = *Dendropsophus bipinctatus*, D_a = *Dendropsophus anceps*, L_l = *Leptodactylus latrans*, L_s = *Leptodactylus spixi*, L_f = *Leptodactylus fuscus*, T_m = *Thoropa miliaris*, L_c = *Lithobates castebianus*, P_c = *Physalaemus crombiei*, R_c = *Rhinella crucifer*, R_s = *Rhinella schneideri*, D_sp = *Dendropsophus sp.*, B_f = *Boana faber*, H_b = *Haddadus binotatus*.

respectively, while the MFSP has a maximum altitude of 740m. In general, it is well known that differences in altitude can result in significant changes in the composition and structure of frog communities, changing the diversity and density of organisms (Janzen 1967, Siqueira & Rocha 2013, Goyannes-Araújo 2015). In addition, the fragmentation and incidence of various impacts in the MFSP area, such as human settlements inside the park area, intense noise and dust (due to the road intersecting the Park) and the presence of exotic species may have influenced the absence of species more sensitive to environmental disturbances.

The presence of the exotic species *Lithobates castebianus* points to a need for studies that aim to characterize the population of this species in the MFSP, as well as its distribution. In this study, two individuals were found in a permanent wetland environment near degraded forest areas and with presence of agriculture. It was not possible to collect these individuals. In general, it is known that *L. castebianus* can interfere in the community mainly due to predation and competition with native anurans (Lowe *et al.* 2000) and has a high capacity to rapidly spread in natural areas (Santos-Pereira & Rocha 2015). Thus, it is essential to monitor this species so that actions can be planned for the conservation of native species (Lowe *et al.* 2000, Ficetola *et al.* 2007).

Species richness and abundance of frogs was higher in flooded environments, with about 83% of all species recorded were found in this type of habitat. In fact, most of the species recorded in this study are frogs' species with generalist habits and occurring in swampy environments. For example, *Scinax alter*, which was the most abundant species in this study, is a species commonly occurring in open areas and is often found in vegetation above ponds and other standing water areas (Carvalho-Silva & Kwet 2010). Another species was also recorded exclusively in flooded environments was *Boana semilineata*, which is usually associated with water bodies (Mendes *et al.* 2012) and is often found on herbaceous plants at the margins of swamps and creeks (Lisboa *et al.* 2011). In contrast, only *Haddadus binotatus* was recorded exclusively in the forest environment. In general, it is known that *H. binotatus* is an important component of the

communities of litter anurans, being abundant in some areas of the Atlantic Forest (e.g., Rocha *et al.* 2007, Almeida-Gomes *et al.* 2010, Oliveira *et al.* 2013).

We conclude that the richness and abundance of the anurans in the studied area differs among the types of habitat studied, being most exclusive of the flooded environments. Our study is the first to provide data from the MFSP anuran community and our results point out to a worrying scenario for the biodiversity of the area, due to the presence of the exotic species *L. catesbeianus*. The Mata das Flores State Park is an important remnant of forest, being continuous to the ecological corridor Pedra Azul - Forno Grande, but it is the conservation unit that suffers most of the anthropogenic impacts due to its proximity to urban areas. Thus, long-term studies are necessary, mainly to quantify and evaluate the effects of these impacts on local fauna.

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