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Medium-sized and large mammals of the Floresta da Cicuta Area of Relevant Ecological Interest, a protected area in southeastern Brazil

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Abstract

The Atlantic Forest is one of the most biodiverse biomes in the world and has been severely degraded and fragmented, with the extirpation of most medium-sized and large vertebrates from the forest remnants. Here we present the results of a survey of medium-sized and large mammals in an area of protected seasonal semideciduous forest, the Floresta da Cicuta Area of Relevant Ecological Interest (ARIE-FC), Rio de Janeiro, Brazil, part the Atlantic Forest biome. We used camera traps (2,257 camera days) and direct observations over a 23-month period. We recorded 19 species (including two domestic species), seven of which are classified as at-risk, such as *Leopardus guttulus* (Hensel, 1872), *Sylvilagus tapetillus* Thomas, 1913, *Alouatta clamitans* Cabrera, 1940, and *Chrysocyon brachyurus* (Illiger, 1815). A diverse terrestrial mammal assemblage in the ARIE-FC reinforces the importance of small forest fragments for the conservation of biodiversity in human-modified landscapes of the Brazilian Atlantic Forest.

Keywords

Atlantic Forest, camera traps, mammal survey, Rio de Janeiro, seasonal semideciduous forest, species inventory, threatened species

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Introduction

The Neotropical Atlantic Forest supports high environmental heterogeneity, including several soil and vegetation types and a wide variation of topography, temperature, and precipitation due to its extensive latitudinal and longitudinal range (Ribeiro et al. 2009, 2011; Marques et al. 2021). This environmental heterogeneity, along with a complex evolutionary history of its biota, has resulted in a unique biome with among the greatest biodiversity and endemism worldwide (Silva and Casteleti 2003; Marques et al. 2021).

Despite this high diversity, with threatened, endemic, and still-unknown species, extreme degradation and fragmentation, little protection, and insufficient conservation characterizes the current state of the Atlantic Forest (Ribeiro et al. 2009; Lira et al. 2021). The percentage of remaining forest in the Brazilian Atlantic Forest differs among authors due to different criteria and methods in its calculation, ranging from 11.4 to 26% (Ribeiro et al. 2009; Rezende et al 2018; SOS Mata Atlântica/INPE 2021). More than 97% of forest remnants are smaller than 250 ha (Ribeiro et al. 2009), and only a small amount (30%) of the total vegetation cover is located within protected areas (Rezende et al. 2018).

The seasonal forests of the Atlantic Forest biome, mainly the seasonal semideciduous forest, are the predominant vegetation covering the biogeographic subregion known as Interior Forest (Silva and Casteleti 2003; Carlucci et al. 2021). Currently, the Interior Forest is one of the most threatened biogeographic subregions of the Atlantic Forest biome, with only 7.1% of its original vegetation remaining, and only 6.8% of its forest remnants protected (Ribeiro et al. 2009; Carlucci et al. 2021). Despite large-scale destruction and the extensive fragmentation, Atlantic seasonal forests have a highly species-rich flora and a highly endemic and diversity fauna (Eisenlohr and Oliveira-Filho 2015). The mammalian fauna of the seasonal forests has been comparatively less studied than the assemblages from dense, humid forests of the biome.

The Neotropical region harbors the greatest number of extant mammalian species (Burgin et al. 2018). In Brazil, the latest compilation listed 762 species of native mammals (Abreu et al. 2021), which is considerably higher than in surrounding countries (Quintela et al. 2020). After the Amazon, the Atlantic Forest is the Brazilian biome with the greatest mammal species diversity, supporting more than 300 species, of which approximately 30% are endemic (Graipel et al. 2017; Souza et al. 2019). However, most of the Atlantic Forest remnants have high levels of anthropogenic defaunation, resulting in a loss of the majority of the medium-sized and large mammals, particularly in human-modified landscapes (Fernandez et al. 2017; Bogoni et al. 2018).

The increasing rate of habitat loss and fragmentation in the Atlantic Forest negatively affects mammals and their ecological functions (Magioli et al. 2021a); therefore, field efforts are essential to obtain data on species richness and composition, which are the bases of many conservation and management actions (Costa et al. 2005; Zipkin et al. 2009).

In this context, we investigated for the first time the assemblage of medium-sized and large terrestrial mammals in the Floresta da Cicuta Area of Relevant Ecological Interest, a fragment of the Atlantic seasonal semideciduous forest in southeastern Brazil, in order to provide data on species richness and composition, reinforcing the importance of this protected area for mammal conservation in the middle Paraíba do Sul river region.

Study Area

We conducted our study in the Floresta da Cicuta, which is a federally protected area, under the Brazilian category named "Area of Relevant Ecological Interest" (abbreviated ARIE in Portuguese; corresponding to IUCN Category IV). According to Brazilian Protected Area System (abbreviated SNUC in Portuguese; Federal Law no. 9985/2000), ARIEs are generally small areas (5,000 ha or less), either with extraordinary natural characteristics or harboring rare species of the regional biota. The Floresta da Cicuta Area of Relevant Ecological Interest (Área de Relevante Interesse Ecológico Floresta da Cicuta in Portuguese; hereinafter, ARIE-FC) was established in 1985 and comprises an area of approximately 125 ha. It is located between the municipalities of Barra Mansa and Volta Redonda, state of Rio de Janeiro, southeastern Brazil (center at 22°32.97′S, 044°05.49′W, WGS84 datum; Fig. 1), in the middle of the Paraíba do Sul river basin, which has been severely impacted by the economic natural resource exploitation cycles since the sixteenth century (Carlucci et al. 2021). The vegetation comprises secondary Atlantic Forest in the advanced successional stage of the submontane seasonal semideciduous forest type. Botanical studies in the ARIE-FC identified 184 woody species, distributed in 113 genera and 46 families, with a predominance of Euphorbiaceae, Fabaceae, Myrtaceae, and Lauraceae (Souza et al. 2007). Lianas (woody vines) are abundant and represent an essential food source for the local fauna, as they provide flowers and fruits when fruit supplies in trees are low (Alves and Zaú 2007; Yanoviak and Schnitzer 2013). The surroundings of the ARIE-FC are predominantly old pastures on private lands with cattle ranching and agriculture activities interspersed with fragments of the original forests of various sizes and successional stages (Alves and Zaú 2005). Together, the ARIE-FC and neighboring fragments with some degree of structural connectivity to this protected area form a larger forest tract of more than 500 ha.

The region has a mesothermal climate (Cwa in the Köppen classification), with two well-defined seasons: a dry season between May and September and a rainy season between October and April, with average annual temperatures between 17 and 24 °C and annual

precipitation of approximately 1000–1600 mm (Fonseca 2018). The seasonal climate reflects droughts during the winter and intense rains in the summer and is responsible for the semi-deciduous aspect of the forest cover, in which 20–50% of the trees lose their leaves during the dry season (IBGE 2012). The elevation in the ARIE-FC ranges between 390 m and 510 m a.s.l., and the hydrography consists of two main water bodies, the Brandão river and Água Fria stream, in addition to several small ephemeral streams (Alves 2004).

Methods

We conducted a survey of medium-sized and large mammals at ARIE-FC using camera traps from January 2017 to December 2018 (except July 2017), which included both dry and rainy seasons. We used six to nine analog camera traps (Tigrinus, model 6.0C, v. 1.0) fixed to trees at an average height of 40 cm from the ground and positioned to ensure the best likelihood of capturing records. The cameras took one photo when activated and had a 20-second delay prior to re-activation. Cameras were active for 23 months of sampling for 24 h per day, totaling a survey effort of 2,257 camera days (the number of survey days multiplied by the number of cameras used). We used no baits or lures in this study and did not systematically design the camera trap allocation. We selected 62 sampling points distributed throughout the ARIE-FC (Table 1; Fig. 1), including sites in the interior and at the edge of the forest where mammals were expected to pass. These included human-made old and freshly cut trails, along small streams and riverbanks, around fruiting trees, in natural shelters (including fallen trunks, tree roots, and small rocky caves), and at artificial shelters, such as old, abandoned constructions inside the forest.

We inspected the cameras at regular intervals of 7–15 days to check the condition, change batteries and

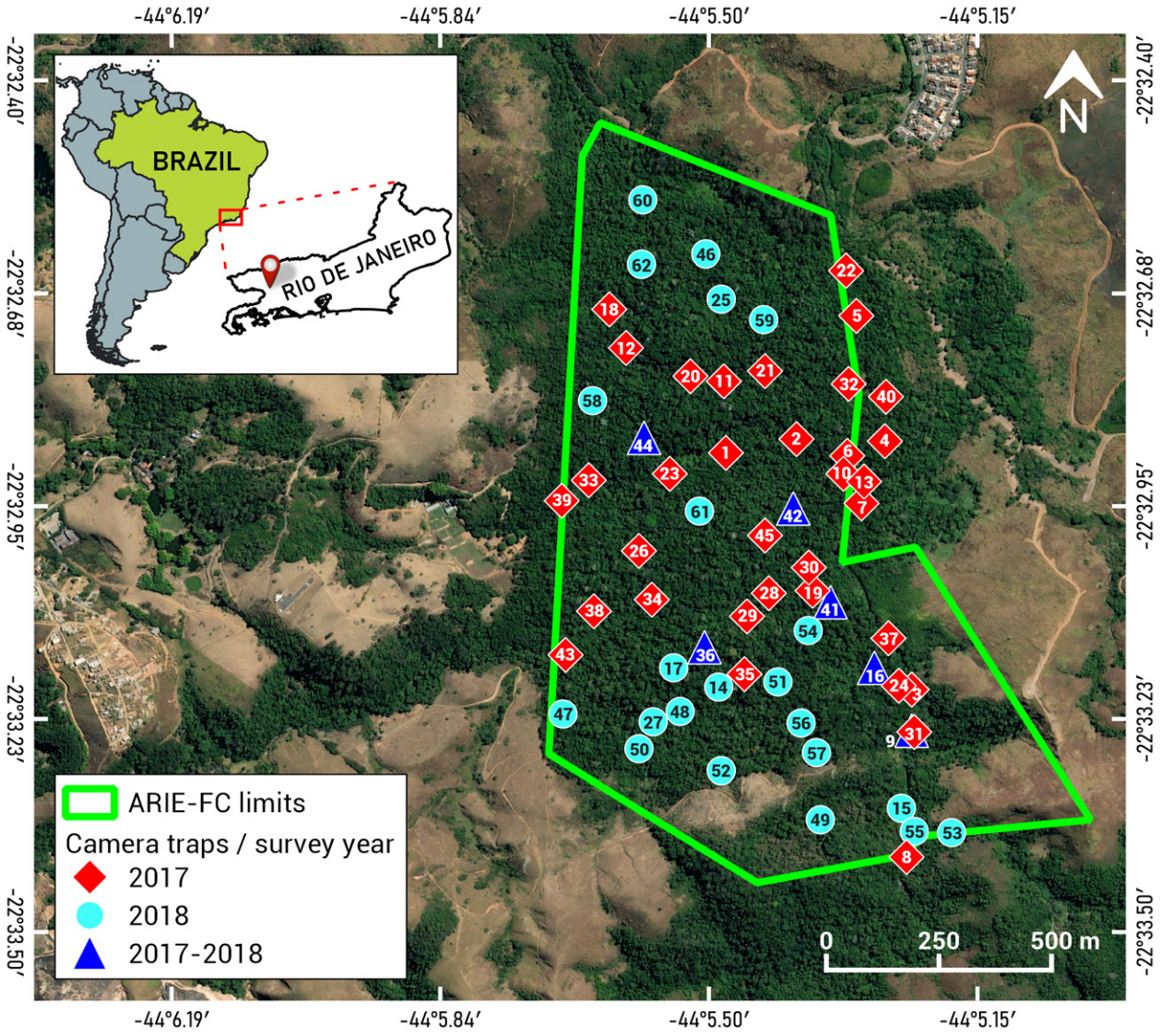

Figure 1. Map of the Floresta da Cicuta Area of Relevant Ecological Interest, state of Rio de Janeiro, Brazil, and locations of the 62 sampling points where camera traps were installed in 2017–2018. The geographic coordinates of the sampling points are shown in Table 1. Base map: Bing Satellite Imagery provided by QGIS v. 3.16.2.

film, and evaluate the efficiency of the sampling points. To evaluate species richness, moving cameras to new sites is more efficient than leaving cameras at fewer sites for a longer period (Tobler et al. 2008; Si et al. 2014). Thus, if the number of photographic records obtained at a sampling point was very small (less than one photograph every three days), we moved the camera to another sampling point in the study area to improve the spatial coverage of our survey. Final sampling effort among the 62 sampling points varied from 4 to 92 camera days (Table 1). To minimize detection of the same individual at distinct sampling points within a short temporal interval, we never left camera traps active simultaneously at sampling points less than 300 m apart. We considered records of each species by each camera made at an interval larger than 1 hour as an independent sample (Tobler et al. 2008; Srbek-Araujo and Chiarello 2013). Therefore, we excluded consecutive records of the same species obtained at intervals of less than one hour by the same camera trap.

We considered all the species larger than 1 kg as medium-sized and large, including native and domestic species, and adopted the body weight values presented by Paglia et al. (2012) as a reference for the native species. We also photographed all mammal species observed during the fieldwork and we used these opportunistic observations in the study area to augment the species list obtained by camera traps, especially for arboreal mammals.

To evaluate the effectiveness of our sampling, we generated a sample-based rarefaction (species accumulation) curve with 1000 randomizations and calculated Jackknife species richness estimators using the software EstimateS v. 9.1.0 (Colwell 2013). Here we considered only mammal species recorded by camera traps, excluding small mammals, domestic species, and species recorded opportunistically.

We followed Abreu et al. (2021) for species nomenclature, except for *Alouatta*, for which we follow Gregorin (2006) who recognized the southern populations of the Brazilian Atlantic Forest, from the state of Rio Grande do Sul to Rio de Janeiro and Minas Gerais, as a distinct species: *Alouatta clamitans* Cabrera, 1940. We recognized the species through the camera trap photographs and by direct observations in the field, with the help of specialized literature when necessary (e.g., Emmons and Feer 1997; Eisenberg and Redford 1999; Oliveira and Cassaro 2005; Reis et al. 2010, 2014). The species-level

Table 1. Geographic coordinates (WGS84 datum), elevations, sampling effort and number of species recorded in each of the 62 sampling points where camera traps were installed in the Floresta da Cicuta Area of Relevant Ecological Interest, state of Rio de Janeiro, Brazil.

Sampling point ID	Latitude	Longitude	Elevation (m)	Sampling effort (camera days)	Number of species
1	22°32.88′S	044°05.47′W	410	49	5
2	22°32.86′S	044°05.38′W	412	7	1
3	22°33.19′S	044°05.23′W	406	25	4
4	22°32.87′S	044°05.27′W	401	27	1
5	22°32.70′S	044°05.30′W	401	48	5
6	22°32.89′S	044°05.32′W	409	22	2
7	22°32.95′S	044°05.30′W	396	33	6
8	22°33.41′S	044°05.24′W	413	27	2
9	22°33.24′S	044°05.23′W	409	85	6
10	22°32.91′S	044°05.32′W	397	50	4
11	22°32.79′S	044°05.48′W	421	62	6
12	22°32.75′S	044°05.60′W	434	62	5
13	22°32.92′S	044°05.29′W	393	9	2
14	22°33.19′S	044°05.48′W	423	60	6
15	22°33.34′S	044°05.25′W	420	25	5
16	22°33.16′S	044°05.28′W	415	59	4
17	22°33.16′S	044°05.54′W	438	42	4
18	22°32.70′S	044°05.62′W	428	31	1
19	22°33.06′S	044°05.36′W	407	9	3
20	22°32.78′S	044°05.52′W	421	10	3
21	22°32.78′S	044°05.42′W	418	47	3
22	22°32.65′S	044°05.32′W	395	63	6
23	22°32.91′S	044°05.55′W	408	33	4
24	22°33.18′S	044°05.25′W	419	4	3
25	22°32.68′S	044°05.48′W	428	42	4
26	22°33.01′S	044°05.59′W	421	15	2
27	22°33.23′S	044°05.57′W	417	43	2
28	22°33.06′S	044°05.42′W	414	33	2
29	22°33.09′S	044°05.45′W	421	20	2
30	22°33.03′S	044°05.37′W	411	42	4
31	22°33.24′S	044°05.23′W	407	54	4
32	22°32.79′S	044°05.31′W	406	56	3
33	22°32.92′S	044°05.65′W	426	29	5
34	22°33.07′S	044°05.57′W	425	20	5
35	22°33.17′S	044°05.45′W	431	54	4
36	22°33.13′S	044°05.50′W	436	38	4
37	22°33.12′S	044°05.26′W	395	39	5
38	22°33.09′S	044°05.64′W	428	36	4
39	22°32.94′S	044°05.69′W	431	17	3
40	22°32.81′S	044°05.27′W	394	25	2
41	22°33.08′S	044°05.34′W	407	40	6
42	22°32.95′S	044°05.39′W	405	33	6
43	22°33.14′S	044°05.68′W	421	7	2
44	22°32.86′S	044°05.58′W	425	64	4
45	22°32.99′S	044°05.42′W	412	35	3
46	22°32.62′S	044°05.50′W	413	56	3
47	22°33.22′S	044°05.68′W	435	41	3
48	22°33.22′S	044°05.53′W	413	74	8
49	22°33.36′S	044°05.35′W	432	92	5
50	22°33.27′S	044°05.59′W	419	33	5
51	22°33.18′S	044°05.41′W	415	41	2
52	22°33.29′S	044°05.48′W	440	35	1
53	22°33.37′S	044°05.18′W	429	28	1
54	22°33.11′S	044°05.37′W	408	36	5
55	22°33.37′S	044°05.23′W	397	24	4
56	22°33.23′S	044°05.38′W	434	20	0
57	22°33.27′S	044°05.36′W	450	50	3
58	22°32.81′S	044°05.65′W	435	14	3
59	22°32.71′S	044°05.42′W	425	31	5
60	22°32.55′S	044°05.58′W	403	13	3
61	22°32.96′S	044°05.51′W	413	23	4
62	22°32.64′S	044°05.58′W	428	15	3

identification of felids and armadillos was confirmed, through photos, by specialists. We classified each species according to their conservation status, based on the extinction-risk categories in the official lists of threatened species at the global (IUCN 2021), national (Rodrigues et al. 2013; ICMBio 2018), and regional/state (SEMA 1998; Bergallo et al. 2000) levels.

We conducted our study under the legal authorization of the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), Ministry of the Environment (authorization SISBIO #55619).

Results

We recorded 17 native species (Figs. 2–4) and two domestic species (Fig. 5) of medium-sized and large terrestrial mammals in the ARIE-FC, distributed in 15 families and eight orders (Table 2). Carnivora was the richest order, with eight species from four families, followed by Rodentia with three species from three families. The orders Lagomorpha and Didelphimorphia were represented by only one species each, in addition to Cetartiodactyla with only one domestic species. The most

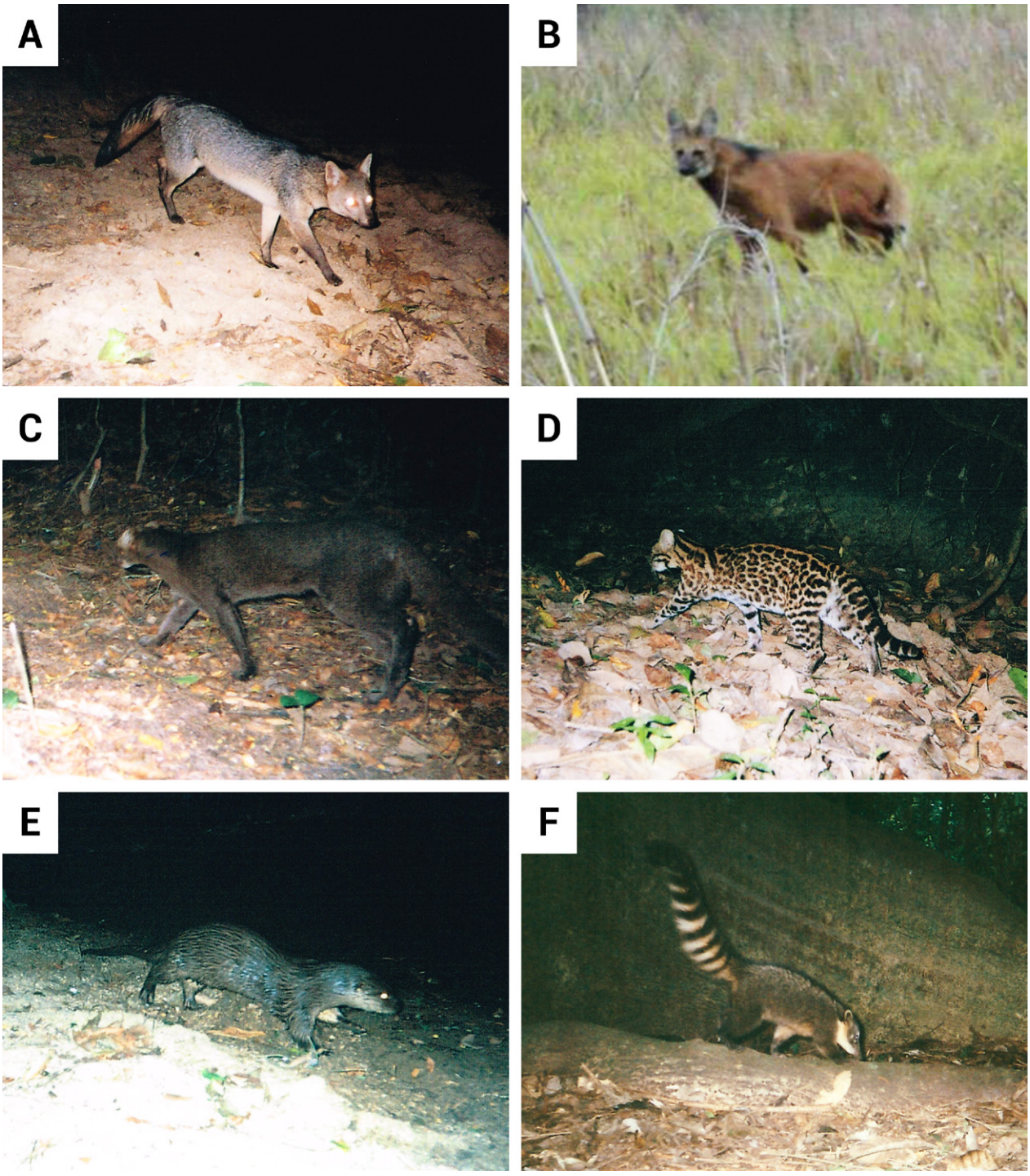

Figure 2. Native mammal species recorded in the Floresta da Cicuta Area of Relevant Ecological Interest, state of Rio de Janeiro, Brazil. **A.** *Cerdocyon thous*. **B.** *Chrysocyon brachyurus*. **C.** *Herpailurus yagouaroundi*. **D.** *Leopardus guttulus*. **E.** *Lontra longicaudis*. **F.** *Nasua nasua*.

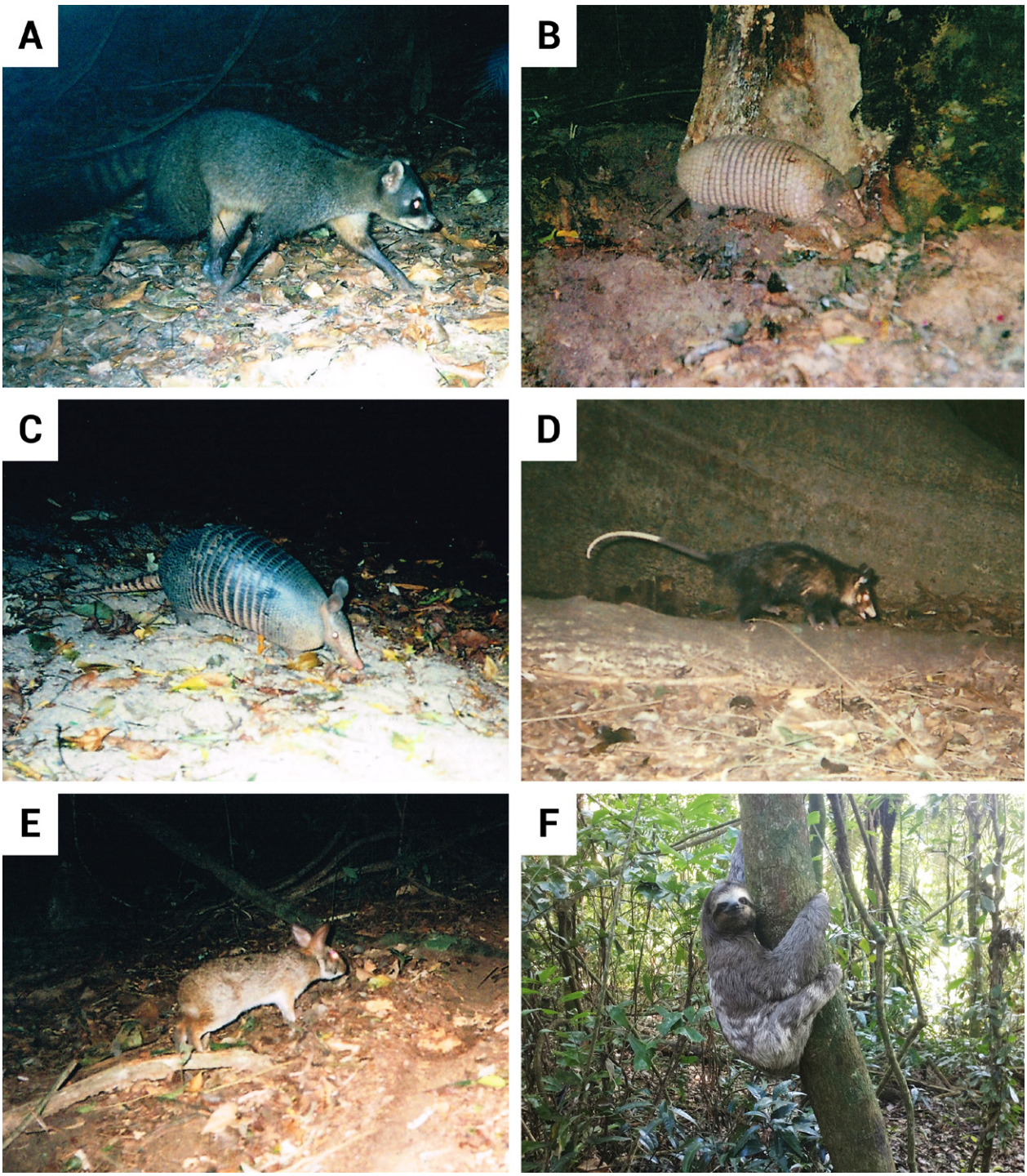

Figure 3. Native mammal species recorded in the Floresta da Cicuta Area of Relevant Ecological Interest, state of Rio de Janeiro, Brazil. **A.** *Procyon cancrivorus*. **B.** *Cabassous tatouay*. **C.** *Dasypus novemcinctus*. **D.** *Didelphis aurita*. **E.** *Sylvilagus tapetillus*. **F.** *Bradypus variegatus*.

representative families were Canidae (three species, including one domestic), followed by Felidae and Procyonidae (each with two species). We also recorded two species of small mammals, which are shown in Table 2 for information only, including possible hybrid individuals of non-native invasive marmosets, *Callithrix jacchus* (Linnaeus, 1758) and *Callithrix penicillata* (É. Geoffroy, 1812) (Fig. 4F)

Based on camera trap data alone, we obtained a total of 859 images corresponding to 660 independent records of 15 mammal species, with 11 species recorded exclusively using this method. Otherwise, we recorded four species, mainly arboreal, only in occasional sightings in the field. Some species were common at multiple sampling points, while we rarely recorded others and only at a few sites. *Herpailurus yagouaroundi* (É. Geoffroy, 1803) had only one record by camera trap in the southern part of the ARIE-FC.

The first- and second-order jackknife estimators (Jackknife 1 and 2) returned 14 species, similar to the 13 native species recorded by camera traps. The species accumulation curve for the camera trap recordings

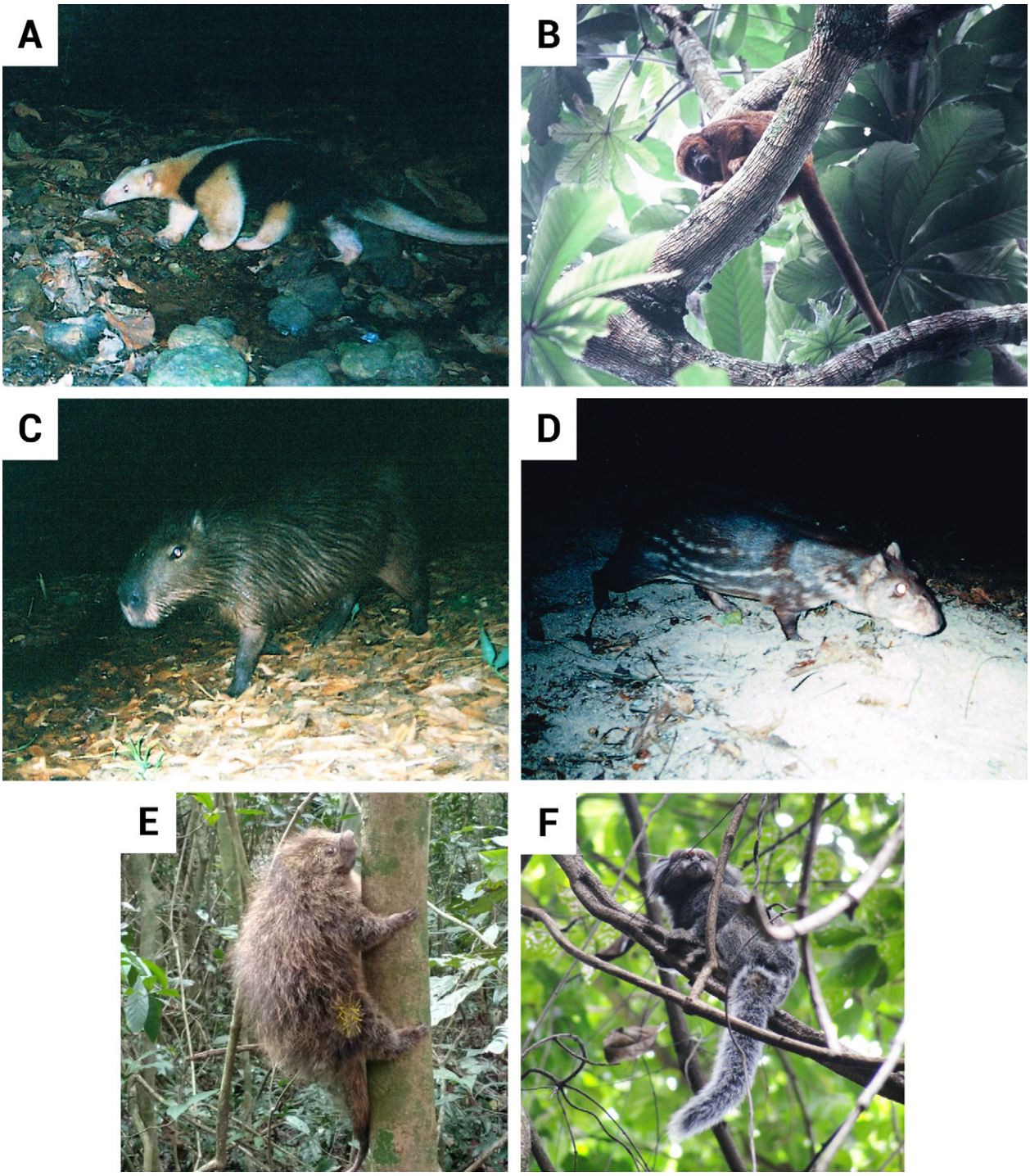

Figure 4. Native (A–E) and non-native invasive (F) mammal species recorded in the Floresta da Cicuta Area of Relevant Ecological Interest, Rio de Janeiro, Brazil. **A.** *Tamandua tetradactyla*. **B.** *Alouatta clamitans*. **C.** *Hydrochoerus hydrochaeris*. **D.** *Cuniculus paca*. **E.** *Coendou spinosus*. **F.** possible hybrid of *Callithrix jacchus* x *C. penicillata*.

reached the asymptote (Fig. 6), indicating sufficient sampling effort and that our sampling design was adequate for the survey of medium-sized and large mammal species in the ARIE-FC.

Of the 17 native species recorded, seven (41%) are classified under some extinction-risk category in at least one of the official lists of threatened species (Table 2), but only *Leopardus guttulus* (Hensel, 1872), *Sylvilagus tapetillus*, and *Alouatta clamitans* are globally threatened (IUCN 2021). At the national level, five species are categorized as Vulnerable: *Chrysocyon brachyurus* (Illiger, 1815), *Herpailurus yagouaroundi*, *Leopardus guttulus*, *Alouatta clamitans* (ICMBio 2018), and *Lontra longicaudis* (Olfers, 1818), which is categorized as Vulnerable only in the Atlantic Forest biome (Rodrigues et al. 2013). *Cuniculus paca* is the only species considered to be regionally threatened (in the state of Rio de Janeiro; SEMA 1998, Bergallo et al. 2000). Some species are in

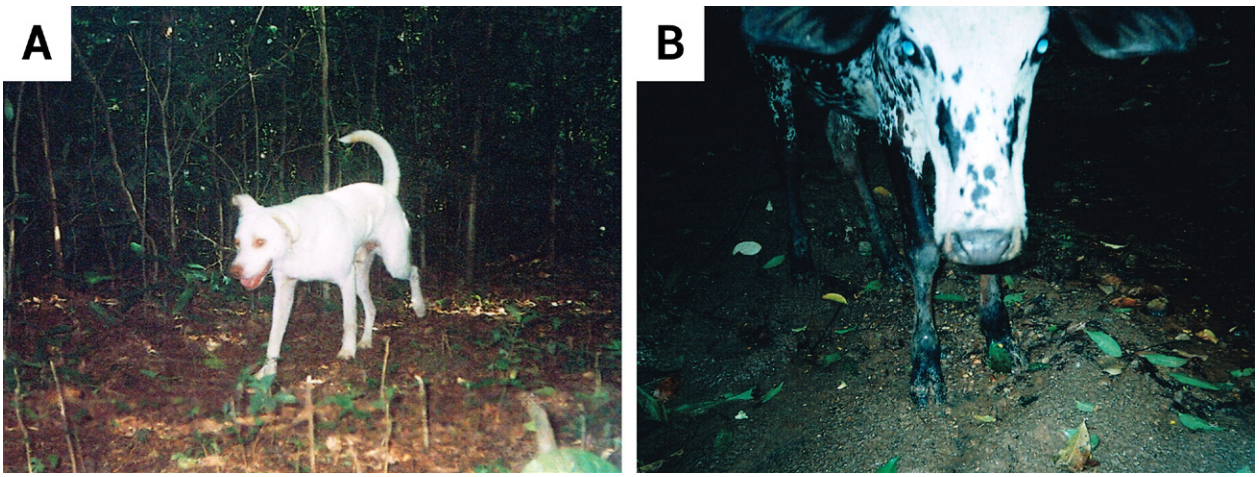

Figure 5. Domestic mammal species recorded in the Floresta da Cicuta Area of Relevant Ecological Interest, state of Rio de Janeiro, Brazil. **A.** *Canis lupus familiaris*. **B.** *Bos taurus*.

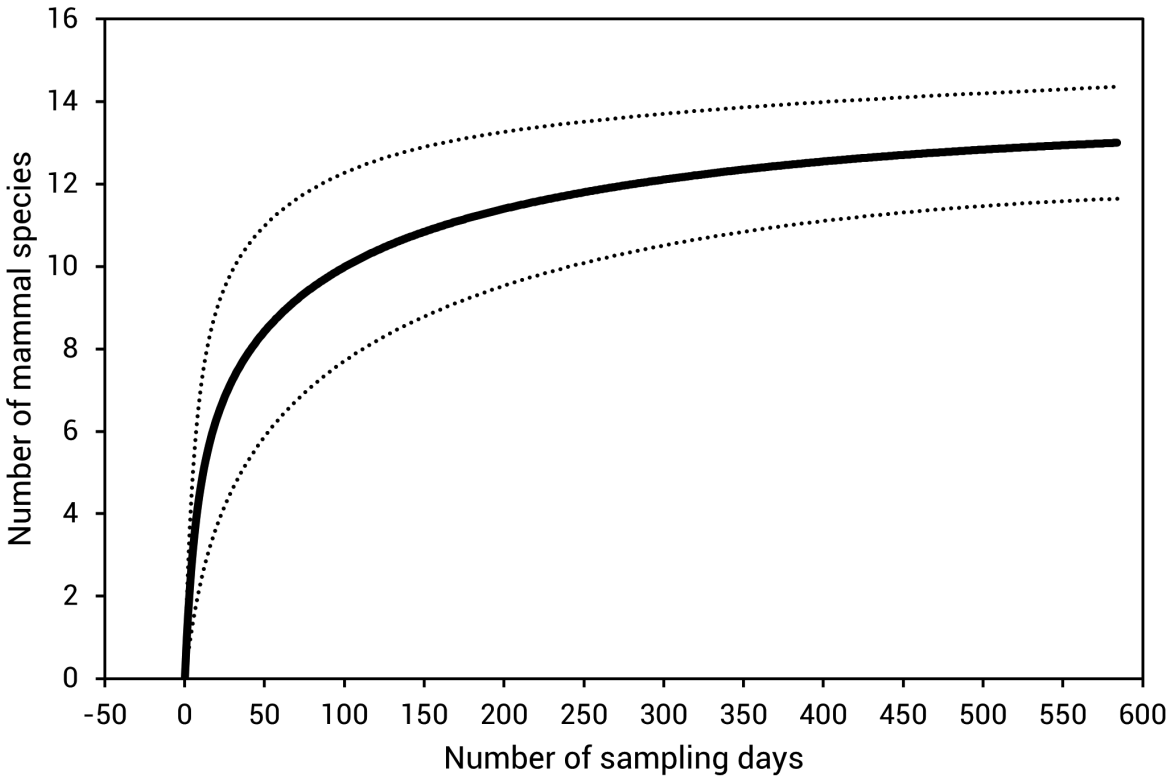

Figure 6. Species accumulation curve for medium-sized and large native mammals recorded by camera traps in the Floresta da Cicuta Area of Relevant Ecological Interest, state of Rio de Janeiro, Brazil, during 2017–2018.

the Near or Presumably Threatened categories in the global, national, or regional context (Table 2).

Order Carnivora
Family Canidae

***Cerdocyon thous* (Linnaeus, 1766)**, Crab-eating Fox
Figure 2A

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 1, 6–7, 9–13, 16, 23, 26, 33–34, 39, 42, 48–51 (Table 1); first record on 11.II.2017; camera trap photos.

Identification. Medium-sized canid with a large head and short, robust limbs that facilitate movement in forest environments (Berta 1982). The dorsal pelage is grizzled grayish brown, and the venter is grayish white. It has small, rounded ears, and a bushy long black tail. The hind legs, forearms, feet, and lips are all black (Eisenberg and Redford 1999).

***Chrysocyon brachyurus* (Illiger, 1815)**, Maned Wolf
Figure 2B

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; 22°33.09′S, 044°05.20′W; 409 m elev.; 07.XI.2017; S.L.

Table 2. Species list of terrestrial mammals recorded in the Floresta da Cicuta Area of Relevant Ecological Interest, state of Rio de Janeiro, Brazil. Record type: Ct = Camera trap; Os = Occasional sightings. Conservation status by IUCN = IUCN Red List of Threatened Species (global); BR = Brazilian List of Threatened Species (national); RJ = Rio de Janeiro State List of Threatened Species (regional). Conservation status categories: LC = Least Concern; NT = Near Threatened; PT = Presumably Threatened; VU = Vulnerable; DD = Data Deficient.

Taxon	Common name	Record	Conservation status		
			IUCN	BR	RJ
CARNIVORA					
Canidae					
Canis lupus familiaris (Linnaeus, 1758)*	Domestic Dog	Ct	—	—	—
Cerdocyon thous (Linnaeus, 1766)	Crab-eating Fox	Ct	LC	LC	—
Chrysocyon brachyurus (Illiger, 1815)	Maned Wolf	Os	NT	VU	PT
Felidae					
Herpailurus yagouaroundi (É. Geoffroy, 1803)	Jaguarundi	Ct	LC	VU	—
Leopardus guttulus (Hensel, 1872)	Southern Tiger Cat	Ct	VU	VU	PT
Mustelidae					
Lontra longicaudis (Olfers, 1818)	Neotropical Otter	Ct	NT	NT/VU†	—
Procyonidae					
Nasua nasua (Linnaeus, 1766)	South American Coati	Ct/Os	LC	LC	—
Procyon cancrivorus Cuvier, 1798	Crab-eating Raccoon	Ct	LC	LC	—
CETARTIODACTYLA					
Bovidae					
Bos taurus Linnaeus, 1758*	Domestic Cattle	Ct/Os	—	—	—
CINGULATA					
Chlamyphoridae					
Cabassous tatouay (Desmarest, 1804)	Greater Naked-tailed Armadillo	Ct	LC	DD	PT
Dasypodidae					
Dasypus novemcinctus Linnaeus, 1758	Nine-banded Armadillo	Ct	LC	LC	—
DIDELPHIMORPHIA					
Didelphidae					
Didelphis aurita (Wied-Neuwied, 1826)	Big-eared Opossum	Ct	LC	LC	—
LAGOMORPHA					
Leporidae					
Sylvilagus tapetillus Thomas, 1913‡	Rio de Janeiro Dwarf Cottontail	Ct	VU	—	—
PILOSA					
Bradypodidae					
Bradypus variegatus Schinz, 1825	Brown-throated Sloth	Os	LC	LC	—
Myrmecophagidae					
Tamandua tetradactyla (Linnaeus, 1758)	Southern Tamandua	Ct/Os	LC	LC	—
PRIMATES					
Atelidae					
Alouatta clamitans Cabrera, 1940‡	Southern Brown Howler Monkey	Os	VU	VU	PT
Cebidae					
Callithrix sp.§¶	Marmoset	Ct/Os	LC	LC	—
RODENTIA					
Caviidae					
Hydrochoerus hydrochaeris (Linnaeus, 1766)	Capybara	Ct/Os	LC	LC	—
Cuniculidae					
Cuniculus paca (Linnaeus, 1766)	Spotted Paca	Ct	LC	LC	VU
Erethizontidae					
Coendou spinosus (Cuvier, 1823)	Paraguayan Hairy Dwarf Porcupine	Os	LC	LC	—
Sciuridae					
Guerlinguetus brasiliensis (Gmelin, 1788)¶	Brazilian Squirrel	Ct/Os	—	LC	—

* Domestic species.
† NT at national level and VU in the Atlantic Forest biome according to Rodrigues et al. (2013).
‡ Endemic species of the Atlantic Forest biome.
§ Possible hybrids of non-native invasive species *Callithrix jacchus* × *C. penicillata*.
¶ Small species.

Alves obs.; 1 adult ♂ • Floresta da Cicuta Area of Relevant Ecological Interest; 22°33.34′S, 044°05.53′W; 430 m elev.; 15.VIII.2018; S.L. Alves obs.; 1 adult ♀.

Identification. The largest canid in South America, it is unmistakable because of its long, thick buff red pelage, long black limbs, and large ears (Eisenberg and Redford 1999). The posterior half of the tail is white, as are the insides of the ears and the underside of the chin (Dietz 1985).

Family Felidae

***Herpailurus yagouaroundi* (É. Geoffroy, 1803)**, Jaguarundi
Figure 2C

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling point ID 49 (Table 1); 11.VIII.2018; camera trap photo.

Identification. Pelage color is uniform, without spots or stripes. The body is slight, with a long back, long slender tail, long neck, and short limbs (Emmons and Feer 1997). The head is flat, elongated, and low, with small, rounded ears (Oliveira 1998). Its mustelid-shaped body resembles the Tayra (*Eira barbara*) but is distinguishable by its long and thin tail and lack of a pale spot on the throat. *H. yagouaroundi* is polymorphic with at least three common pelage colors, from reddish-yellow through gray to brownish-black (Kitchener et al. 2017). The only Jaguarundi record obtained in this study was a dark, brownish-black individual.

***Leopardus guttulus* (Hensel, 1872)**, Southern Tiger Cat
Figure 2D

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 9, 22, 24, 48–49, 55, 60 (Table 1); first record on 09.II.2017; camera trap photos.

Identification. Small size with an overall ground color of dark yellowish brown to ochraceous buff, lighter on the sides, and white or very light gray ventrum. Regarding the pattern of spots, small dark rosettes on the body sides are usually incomplete and rarely coalesce into small oblique bands (Oliveira and Cassaro 2005; Nascimento and Feijó 2017).

Family Mustelidae

***Lontra longicaudis* (Olfers, 1818)**, Neotropical Otter
Figure 2E

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 7, 37 (Table 1); first record on 19.IX.2017; camera trap photos.

Identification. Semiaquatic species presenting an elongated, fusiform body with a dense, short, glossy grayish-brown dorsal pelage, and slightly lighter ventrum (Eisenberg and Redford 1999). The head is small, flat, and rounded with a broad muzzle. The tail is long, thick at base, and thin at tip; the legs are short and robust with fully webbed feet (Emmons and Feer 1997).

Family Procyonidae

***Nasua nasua* (Linnaeus, 1766)**, South American Coati
Figure 2F

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 1, 5, 7, 9, 14–15, 17, 20, 24–25, 28–36, 38, 41, 43–52, 54–55, 57–59, 61–62 (Table 1); first record on 07.II.2017; camera trap photos; S.L. Alves, G.M. Tavares obs.

Identification. The pelage is usually brownish to orangish, but the species is widely variable throughout its geographic range. It is unmistakable with its distinctive elongated, mobile snout and black-ringed, thick tail (Eisenberg and Redford 1999). The ears are small and fringed white. The feet are dark brown to black.

***Procyon cancrivorus* Cuvier, 1798**, Crab-eating Raccoon
Figure 3A

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 1–3, 10–13, 15–16, 23, 31, 33–34, 37, 41, 48 (Table 1); first record on 28.I.2017; camera trap photos.

Identification. The dorsum is blackish grizzled gray or rusty brown with yellowing on the sides and ventrum. It is unmistakable by the prominent dark mask across the eyes and the furry tail striped with black and pale rings (Emmons and Feer 1997; Eisenberg and Redford 1999).

Order Cingulata
Family Chlamyphoridae

***Cabassous tatouay* (Desmarest, 1804)**, Greater Naked-tailed Armadillo
Figure 3B

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling point ID 59 (Table 1); first record on 25.X.2018; camera trap photos.

Identification. This is the largest species of the genus *Cabassous*. It has large funnel-shaped ears that extend well above the top of the head (Eisenberg and Redford 1999). The cephalic shield has regularly distributed dermal scutes, while the tail and cheek areas below the eye have only isolated scales (Hayssen 2014). The carapace has 10–13 movable bands. The forelimbs have five pale claws, with the centermost greatly elongated and sickle-shaped (Reis et al. 2010).

Family Dasypodidae

***Dasypus novemcinctus* Linnaeus, 1758**, Nine-banded Armadillo
Figure 3C

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 8–12, 14–17, 19–22, 25, 27–28, 32–33, 35–38, 40, 42, 44, 50, 54, 57–62 (Table 1); first record on 31.I.2017; camera trap photos.

Identification. This armadillo has an armored body with a carapace characterized by 8–11 transverse movable bands, usually nine. It has large ears, a long narrow

snout, and a long, tapered tail with distinct scale rings (Emmons and Feer 1997).

Order Didelphimorphia
Family Didelphidae

***Didelphis aurita* (Wied-Neuwied, 1826)**, Big-eared Opossum
Figure 3D

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 5–7, 11–12, 14–17, 19, 21–22, 24–27, 29–31, 33, 35–36, 38, 40–42, 44–50, 53–55, 57–62 (Table 1); first record on 01.II.2017; camera trap photos.

Identification. The pelage color is black or gray with a well-developed black centerline on the forehead. There are also dark spots over the eyes. It has black hairless ears, and a prehensile tail with a furred base, black in the basal part, followed by a yellowish-white part nearly of equal length (Emmons and Feer 1997).

Order Lagomorpha
Family Leporidae

***Sylvilagus tapetillus* Thomas, 1913**, Rio de Janeiro Dwarf Cottontail
Figure 3E

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 34, 41, 47 (Table 1); first record on 24.IX.2017; camera trap photos.

Identification. Similar to Tapeti (*Sylvilagus brasiliensis*) in general appearance, but smaller and with a pelage coloration generally not as dark brown/black; it has an orangish nuchal patch and the venter is primarily whitish (Ruedas and Smith 2018). The municipality of Porto Real, Rio de Janeiro state, Brazil (ca. 22°24.68′S, 044°19.25′W) is the type locality of *S. tapetillus*, which is considered an ecologically restricted species that occupies similar local habitats (Ruedas et al. 2017; Ruedas and Smith 2019). We recognized the species based on its general appearance and on the extent of occurrence assuming that the range of this species is restricted to the Paraíba do Sul river Valley (Ruedas and Smith 2018, 2019). The type locality of *S. tapetillus* is very close to the ARIE-FC, only 25 km northwest and without any geographical barriers (e.g., water barriers, mountain chains) and at the same altitude.

Taxonomic remarks. *Sylvilagus tapetillus* was originally described as a full species by Thomas in 1913. Hershkovitz (1950) subsequently classified *tapetillus* as a subspecies of *Sylvilagus brasiliensis* (*S. b. tapetillus*). Bonvicino et al. (2015) recently suggested a revision of the taxonomic status of the subspecies *S. b. tapetillus* based on chromosomal and molecular data, raising it to the species level. Ruedas et al. (2017) conducted morphological and molecular analyses and compared the neotype of *S. brasiliensis* to the holotype of *S. tapetillus*, finding sufficient distinction in characters and measurements between the two taxa to retain *S. tapetillus* as a valid species.

Order Pilosa
Family Bradypodidae

***Bradypus variegatus* Schinz, 1825**, Brown-throated Sloth
Figure 3F

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.70′S, 044°05.30′W; 401 m elev.; 12.VII.2017; S.L. Alves obs.; 1 adult sex indet. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.93′S, 044°05.37′W; 402 m elev.; 24.X.2018; S.L. Alves obs.; 1 subadult ♂.

Identification. The pelage consists of long, coarse, wavy hairs that are located ventrally and meet dorsally. The body varies from pale grayish brown to yellowish gray with patches of dirty white on the back and hindlegs. The head is small and rounded, and the face is whitish with a black stripe surrounding the eye that extends back toward the ear. The throat and chest are brown, and the limbs are long, each with three long, curved, hook-shaped claws (Emmons and Feer 1997; Eisenberg and Redford 1999).

Family Myrmecophagidae

***Tamandua tetradactyla* (Linnaeus, 1758)**, Southern Tamandua
Figure 4A

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 5, 14, 22, 35, 39, 42, 48, 50, 59 (Table 1); first record on camera 01.X.2017; camera trap photos; G.M. Tavares obs.

Identification. This species is easily recognizable due to its pale golden yellow coloration and black vest covering the dorsum and ventrum, crossing the shoulders in a black band. The snout is elongated, and the tail is long, prehensile, and sparsely haired (Eisenberg and Redford 1999).

Order Primates
Family Atelidae

***Alouatta clamitans* Cabrera, 1940**, Southern Brown Howler Monkey
Figure 4B

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.70′S, 044°05.30′W; 401 m elev.; 25.I.2017; S.L. Alves obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°33.14′S, 044°05.39′W; 412 m elev.; 31.I.2017; S.L. Alves, M.V.F. Porto obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.99′S, 044°05.56′W; 415 m elev.; 09.II.2017; S.L. Alves obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.90′S,

044°05.32′W; 405 m elev.; 22.II.2017; S.L. Alves obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.47′S, 044°05.62′W; 408 m elev.; 03.III.2017; S.L. Alves, G.M. Tavares obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°33.21′S, 044°05.41′W; 420 m elev.; 20.IV.2017; S.L. Alves obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.81′S, 044°05.34′W; 410 m elev.; 05.V.2017; S.L. Alves, M.V.F. Porto obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°33.22′S, 044°05.59′W; 432 m elev.; 23.V.2017; M.V.F. Porto obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.62′S, 044°05.48′W; 427 m elev.; 26.V.2017; S.L. Alves obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°33.11′S, 044°05.67′W; 423 m elev.; 07.VI.2017; S.L. Alves obs. • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.77′S, 044°05.58′W; 435 m elev.; 24.VIII.2017; S.L. Alves obs.

Identification. The primary characteristic of this medium-sized primate species is its sexual dichromatism, in which adult males have a dorsal pelage ranging from reddish-brown to yellowish red, with limbs and tail invariably darker than the back, while dark females have a dorsum and limbs ranging from blackish to reddish-brown (Gregorin 2006). Adult males have a thick, well-developed beard that is reddish-brown to dark red in color. The tail is relatively long, strong, and prehensile.

Order Rodentia
Family Caviidae

***Hydrochoerus hydrochaeris* (Linnaeus, 1766)**, Capybara
Figure 4C

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 3, 7, 22, 30, 41–42, 55 (Table 1); first record on 17.IX.2017; camera trap photos; S.L. Alves, G.M. Tavares obs.

Identification. The largest living rodent in the world, this unmistakable species has a large, stocky, pig-like body, covered with coarse uniform dark brown to reddish hair. The head is broad, ears are small and rounded, snout is large, and tail vestigial, not visible (Mones and Ojasti 1986; Emmons and Feer 1997).

Family Cuniculidae

***Cuniculus paca* (Linnaeus, 1766)**, Spotted Paca
Figure 4D

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; sampling points ID 1, 3, 5, 9–12, 14, 17, 20–23, 25, 30–31, 36–37, 41, 44–46, 54, 61 (Table 1); first record on 06.II.2017; camera trap photos.

Identification. Medium-sized rodent with a distinctive coloration: dorsum ranging from reddish-brown to dark chocolate, with irregular longitudinal lines of whitish spots along the flanks, from the neck to the rump, which can coalesce into stripes; the ventrum is creamy white (Eisenberg and Redford 1999). The body is heavy and robust, with short legs and ears; short, coarse, and flat pelage; large head and rump; large, widely spaced eyes; and tiny tail (Emmons and Feer 1997).

Family Erethizontidae

***Coendou spinosus* (Cuvier, 1823)**, Paraguayan Hairy Dwarf Porcupine
Figure 4E

Material examined. BRAZIL – **Rio de Janeiro** • Floresta da Cicuta Area of Relevant Ecological Interest; 22°32.80′S, 044°05.38′W; 410 m elev.; 28.XI.2017; S.L. Alves obs.; 1 sex indet.

Identification. The body is covered by a mix of soft, fine black fur with long, pale-yellow tips, and rigid, aculeiform, spiny hairs. The general color is grayish yellow with a thinly furred ventral surface with no spines. The tail is prehensile and relatively short, with rusty orange spines on the basal half, and naked on the distal half. The ears are short, and the eyes are large (Emmons and Feer 1997).

Discussion

This study provides the first published list of mammalian species from the ARIE-FC and represents an important contribution to the knowledge of the mammalian biodiversity in the seasonal forest remnants of the Atlantic Forest of the middle Paraíba do Sul river basin. This region has a centuries-old history of anthropic use and degradation of the quality of habitats, but it still supports significant biodiversity. However, it lacks biological studies and inventories, especially of its mammalian assemblages.

The mammal richness recorded in our study in the ARIE-FC, excluding domestic, invasive, and small species (n = 17), was similar to the mean richness of protected areas (n = 17) and greater than that of unprotected areas (n = 15), based on a compilation carried out by Souza et al. (2019) of 129 studies. Using only species recorded through camera traps, excluding small mammals, domestic species, and species observed only by opportunistic observations (n = 13), we obtained a similar species richness to that of medium-sized and large terrestrial mammals per site recorded by this method in the Atlantic Forest (n = 13 ± 6.07 SD; Lima et al. 2017). Regarding flying mammals (bats), a previous study identified 20 species occurring in the ARIE-FC (Costa et al. 2020), but the richness and diversity of mammalian species in the ARIE-FC will tend to increase by including the assemblage of small mammals that have not yet been studied in this protected area.

Our substantial sampling effort with camera trapping (2,257 camera days) was close to double the mean effort from studies that used camera traps to sample medium-sized and large terrestrial mammals in the Atlantic Forest

(1,185 camera days; Lima et al. 2017). Our results, based on the sampling effort employed, demonstrated the effectiveness of camera traps in detecting local species of terrestrial mammals at our study site.

Despite differences in the sample size and survey methods between distinct sites, the ARIE-FC harbors a richness of medium-sized and large mammals either greater than or similar to other studies in protected and unprotected fragments smaller than 500 ha of seasonal semideciduous forest in southeastern Brazil (e.g., Modesto et al. 2008; Prado et al. 2008; Pires and Cademartori 2012; Pereira et al. 2013; Magioli et al. 2014; Rosa and Souza 2017; Costa et al. 2019). Compared to larger remnants (>500 ha), the ARIE-FC had more species than some sites in the Atlantic Forest, including large protected areas (e.g., Pessôa et al. 2009; Albuquerque et al. 2013; Nunes et al. 2013; Aximoff et al. 2015). However, landscapes such as the highly fragmented lowlands and mid-elevation areas of the middle Paraíba do Sul river Valley, where the ARIE-FC is located, can no longer maintain viable populations of large mammals that are more sensitive to anthropic disturbances and dependent on larger areas, such as the major carnivores *Panthera onca* (Linnaeus, 1758) and *Puma concolor* (Linnaeus, 1771), and large herbivores like *Tapirus terrestris* (Linnaeus, 1758) and *Tayassu pecari* (Link, 1795) (Fahrig 2003; Bogoni et al. 2018).

The ARIE-FC is included in a priority area of extreme biological importance for the conservation of Brazilian biodiversity (SEA/INEA 2011; MMA 2018). In recent years, some biological inventories have demonstrated that the ARIE-FC retains some features of primary forests and acts as a refuge for plant and animal species (Souza et al. 2007; Tavares 2019; Costa et al. 2020; Alves et al. unpublished data). Therefore, it fulfills its role as a natural protected area by safeguarding a large proportion of the Atlantic Forest biodiversity, despite its small size, long isolation time, and the local extinction of some species of its vertebrate community.

The threatened Southern Brown Howler Monkey, *Alouatta clamitans*, one of the 25 most endangered primates in the world (Buss et al. 2019), is the flagship species of the ARIE-FC, and past studies have indicated that this protected area harbored a high population density of this primate (Alves 2004; Alves and Zaú 2007). However, an outbreak of yellow fever that spread through the southeastern and northeastern states of Brazil in 2017 and 2018 affected the populations of howler monkeys and other non-human primates (Mares-Guia et al. 2020), severely impacting the population of *A. clamitans* at ARIE-FC. Monitoring by researchers and by the local staff of the ARIE-FC/ICMBio since that time has found evidence that the population was reduced drastically to just a few surviving individuals or has become locally extinct (Alves et al. unpublished data). To reverse the effects of the probable local extinction of the *A. clamitans* population in the ARIE-FC, a possible conservation strategy is to translocate individuals to this protected area. Some recent studies have demonstrated how refaunation can effectively restore key ecological processes in the Atlantic Forest, despite the difficulties, uncertainties, and costs involved (Fernandez et al. 2017; Genes et al. 2019; Grelle et al. 2021). The re-establishment of *A. clamitans* in the ARIE-FC may provide a promising tool for the restoration of ecological interactions lost in the absence of this species, mainly those between plants and animals, such as seed dispersal (Genes et al. 2019).

The geographic range of the Vulnerable Rio de Janeiro Dwarf Cottontail, *Sylvilagus tapetillus*, is uncertain (Quintela et al. 2020), and data on its current distribution are scarce. Some authors have suggested the possible extinction of the species due to high human population density and the degradation of natural habitats in the state of Rio de Janeiro (Ruedas et al. 2017; Silva et al. 2019). Thus, new findings such as the records of *S. tapetillus* in the ARIE-FC presented here, just 25 km southeast of its type locality area, are a highly important contribution to the knowledge and conservation of this species and for the confirmation of its occurrence in the middle Paraíba do Sul river region.

The occurrence of exotic and invasive species in natural areas has increased disturbances on native fauna, such as predation and competition for resources (Gurevitch and Padilla 2004). The Common Marmoset, *Callithrix jacchus*, is native to the Caatinga (xeric shrublands) and Atlantic Forest of northeastern Brazil, and the Black-tufted-ear Marmoset, *C. penicillata*, occurs mainly in the Cerrado (savannas) of east-central Brazil (Rylands and Mittermeier 2013). Both species have been introduced in other parts of the Atlantic Forest in southern and southeastern Brazil, where well-established invasive populations have been reported (Quintela et al. 2020), including in urban and rural forest patches in the surroundings of the ARIE-FC (S.L. Alves pers. obs.). Although we did not observe pure groups of *C. jacchus* or *C. penicillata* in the ARIE-FC during this study, we recorded possible hybrid individuals with intermediate characteristics between these two non-native invasive marmoset species. There is no evidence available so far that can indicate whether the presence of these potential hybrids is harmful to other native species in the ARIE-FC, and genetic studies are necessary to elucidate if hybridization is occurring.

The data presented here regarding composition, richness, and conservation status of mammal species in the ARIE-FC highlight the high biological value of this protected area. They also reinforce the importance of the small native forest fragments, which contribute significantly to increasing the diversity at the landscape level providing valuable habitats for many forest species and playing an important role as stepping stones and, thus, preventing local extinctions (Turner and Corlett 1996; Ribeiro et al. 2009; Magioli et al. 2021a, 2021b). Approximately half of the mammal species recorded in the ARIE-FC are classified under some threat level or are near or presumably threatened, stressing the importance

of including the conservation value of the small fragments in specific management and conservation policies (Pellens et al. 2009; Ribeiro et al. 2009).

There is a strong correlation between the species richness of medium-sized and large mammals and the protection status of natural areas, with greater richness displayed in protected areas (Souza et al. 2019; Magioli et al. 2021b). However, several other factors influence the number of species capable of maintaining viable populations in a forest fragment, such as the size and degree of isolation of the fragment, the frequency and intensity of human disturbance, and the nature of the surrounding vegetation, irrespective of the protection status (Turner and Corlett 1996). Therefore, it is feasible and critical to convince private landowners to implement landscape management measures (e.g., Harvey et al. 2004; Tubenchlak et al. 2021) aimed at recovering degraded areas to enhance the habitat connectivity between small, isolated forest fragments surrounding the ARIE-FC to improve its conservation and to reduce edge effects. Furthermore, improving law enforcement and educational programs in the surrounding areas can help to reduce threats to native species and their habitats.

Regardless of its small area, the persistence of a diverse terrestrial mammal assemblage, including threatened species, allows the ARIE-FC to play an important role in the formulation of conservation priorities and strategies for mammalian biodiversity in the last remnants of the Atlantic seasonal forests in degraded landscapes marked by strong land cover changes in southeastern Brazil.

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