Oecologia Australis
28(4):297–310, 2024
http://doi.org/10.4257/oeco.2024.2804.06

SURVEY OF NON-FLYING MAMMALS IN A SEMI-DECIDUOUS SEASONAL FOREST FRAGMENT AT SÃO FRANCISCO FOREST STATE PARK

Tiago de Azevedo Pires[1], *Jader Almeida de Barros Silva*[1], *Marco Antonio Zanoni*[1], *Vlamir José Rocha*[2], *Matheus Pires Rincão*[3] & *Diego Resende Rodrigues*[1*]

[1] Universidade Estadual do Norte do Paraná, *campus* Luiz Meneghel, Laboratório de Zoologia, Centro de Ciências Biológicas, Rodovia BR-369 Km 54, Vila Maria, CP 261 - CEP 86360-000, Bandeirantes, PR, Brasil.

[2] Universidade Federal de São Carlos, Centro de Ciências Agrárias, Rodovia Anhanguera, km 174 - SP-330, CEP: 13600-970, Araras, SP, Brasil.

[3] Universidade Estadual de Londrina, Centro de Ciências Biológicas, Departamento de Biologia Geral, Centro de Ciências Biológicas, Rodovia Celso Garcia Cid, PR 445, Km 380, CP 10.011 - CEP 86.057-970, Londrina, PR, Brasil.

Emails: tiagodeazevedopires@hotmail.com; jader.barros321@gmail.com; zanoni@uenp.edu.br; vlamir@ufscar.br; matheus.rincao@uel.br; diegopardal@uenp.edu.br (*corresponding author)

Abstract: The Atlantic Forest is a highly diverse biome due to its significant geographical variation in latitude, longitude, and altitude. Mammals are particularly susceptible to habitat fragmentation. Surveys of these group in forest fragments essential for conservation efforts. Surveys of non-flying mamals provide critical data on biodiversity, aiding in the protection and management of species and their habitats. To assess the richness of non-flying mammals in the São Francisco Forest Conservation Unit, we used direct observation methods and camera traps. The study began in early 2022 and was concluded in September 2023. We recorded 24 native species and two exotic species. Four species found are vulnerable to extinction: *Herpailurus yagouaroundi*, *Leopardus guttulus*, *Leopardus wiedii*, and *Alouatta guariba clamitans*. Notably, the most frequently recorded species was the exotic *Sus scrofa* (37% of records), followed by native species *Dicotyles tajacu* (18%), *Didelphis albiventris*, and *Nasua nasua* (both around 7%). The low richness can be attributed to factors like habitat fragmentation, historical anthropogenic impacts and the size and degree of isolation of the Conservation Unit. These findings include significant new records for the region, such as *Dicotyles tajacu*, which had not been documented in this fragment previously. However, the high frequency of the invasive species *Sus scrofa* poses a concerning impact on local biodiversity. This study highlights the fragment's critical importance for maintaining the biodiversity of non-flying mammals in the Atlantic Forest biome.

Keywords: Atlantic Forest; camera trap; Conservation unit; inventory; mammalian.

INTRODUCTION

The Atlantic Forest is the oldest forest formation in Brazil, originally covering 150 million hectares. Its wide range of longitudinal, latitudinal, and altitudinal variations gives this biome diverse characteristics throughout its extent, resulting in high biodiversity and the presence of endemic species (Ribeiro *et al.* 2009, Pires & Galetti 2023, Oliveira *et al.* 2024). It accounts for about 1% to 8% of the world's total fauna and flora and is considered a conservation priority area (hotspot) due to its high biodiversity and significant levels of degradation and fragmentation (Myers *et al.* 2000, Marques & Grelle 2021, Rosa *et al.* 2021, Wilson *et al.* 2021).

Although deforestation levels remained stable between 1986 and 2020, even with an increase of 1 million hectares of forest, the biome has become even more fragmented, with 97% of the fragments being less than 50 hectares in size (Rosa *et al.* 2021, Vancine *et al.* 2024). Additionally, about 70% of the Brazilian population resides within the biome's area. Despite this, the Atlantic Forest provides 24 ecosystem services, including water supply, food, soil regulation, nutrient cycling, and drought and flood regulation (Coelho-Junior *et al.* 2021, Shennan-Farpón *et al.* 2024). Due to the conservation challenges facing the Atlantic Forest, it is the only Brazilian biome with specific legislation, the Atlantic Forest Law (Federal Law 11.428, 2006).

Up to 2009, estimates indicated that the current coverage of the Atlantic Forest biome ranged between 11% and 16% of its original extent (Ribeiro *et al.* 2009). More recent estimates suggest that only 12.4% of the native vegetation remains in areas larger than 3 hectares, with around 80% of the remaining fragments being less than 50 hectares in size (SOS Mata Atlântica & INPE 2024). The area of the Atlantic forest cover increases to 28% when considering any native vegetation area without size filtering (Rezende *et al.* 2018). Furthermore, only 9% of the fragments are located in fully protected conservation units, highlighting the need for a more effective approach to preserving this natural heritage (SOS Mata Atlântica & INPE 2024).

Habitat loss and fragmentation are major causes of global biodiversity loss, directly impacting animal populations and reducing the total biomass of ecosystems (Chiarello 1999, Lima *et al.* 2020, Faria *et al.* 2023, Yuan *et al.* 2024). Between 2001 and 2015, habitat loss was mainly driven by deforestation for agricultural expansion, urban development, and logging. These factors, fueled by increasing demand for food, housing, and forest products, led to significant degradation of natural areas (Curtis *et al.* 2018, Yuan *et al.* 2024).

Mammals are one of the vertebrate groups most susceptible to habitat fragmentation and loss (Kosydar *et al.* 2014, Scarano & Ceotto 2015, Lino *et al.* 2019, Villar *et al.* 2021, Oliveira *et al.* 2024). They form a highly diverse group of animals occupying a wide variety of niches and play a crucial role in tropical forest ecosystems as seed dispersers, pollinators, and population regulators. They also help control zoonoses and agricultural pests and influence soil composition and nutrient cycles, activities classified as ecosystem services (Jones & Safi 2011, Dirzo *et al.* 2014, Bogoni *et al.* 2020, Villar *et al.* 2021, Souza *et al.* 2022). These interactions have direct effects on the structure and dynamics of these ecosystems, promoting animal and plant species diversity, regulating populations, and contributing to soil formation and renewal (Jones & Safi 2011, Sandom *et al.* 2013, Rahman & Candolin 2022, Souza *et al.* 2022, Vale *et al.* 2023).

On the other hand, defaunation is a human-induced process that reduces the abundance and cause extinction of animal species. This threat is linked to hunting, natural resource exploitation, and climate change (Dirzo *et al.* 2014, Darimont *et al.* 2023, Pires & Galetti 2023). Mammals are among the most affected groups, with approximately 24% of global species facing some form of exploitation. This reduction in mammal abundance creates an imbalance, harming both ecosystems and humans (Ostfeld & Holt 2004, Bennie *et al.* 2014, Dirzo *et al.* 2014, Darimont *et al.* 2023).

Therefore, species surveys are essential for conservation, providing crucial data on the biological diversity of an ecosystem. By identifying and monitoring species in a region, it is possible to identify threatened species, analyze their distribution and abundance, and assess local diversity and population characteristics (Brocardo *et al.* 2019, Lindenmayer *et al.* 2020, Branco *et al.* 2022). These surveys help understand ecological interactions among species, identify potential human impacts, and aid in planning management and conservation strategies, contributing to biodiversity preservation (Galetti *et al.* 2017, Hübel *et al.* 2021, Oliveira *et al.* 2024).

Mammal inventories are crucial, providing essential data for the conservation of species and populations and to evaluate the effect of forest fragmentation on mammal diversity and the degree of disturbance of natural forest remnants. The aim of this study was to assess the richness of non-flying mammals in a Conservation Unit of Semideciduous Seasonal Forest following the arrival of the exotic species *Sus scrofa*. Although the most recent inventory was published in 2021 (Zequi *et al.* 2021), the data were collected between 2006 and 2010, highlighting the importance of a new survey in the Conservation Unit.

MATERIAL AND METHODS

Study Area

The São Francisco Forest State Park (SSFSP) (23°09'41.3"S 50°33'49.3"W, center of fragment), covers 832.58 hectares (Figure 1) and is the largest Conservation Unit in the northern part of Paraná State, located between the municipalities of Santa Marina and Cornélio Procópio. The SSFSP is part of the Atlantic Forest domain, predominantly characterized as a Seasonal Semideciduous Forest. The latest floristic survey reported the presence of 99 tree species, seven of which are under some degree of threat of extinction (Zama *et al.* 2012). According Köppen classification, the region's climate is characterized as Cfa—humid subtropical mesothermal (Alvares *et al.* 2013), with average rainfall between 1.200 and 1.400 mm. Rainfall is distributed unevenly throughout the year (Nitsche *et al.* 2019). The predominant soils are Eutroferric Red Latosols and Nitosols, with inclusions of Chernosols and Gleysols (Santos *et al.* 2013).

Data collection and analysis

We recorded non-flying mammals using eight Bushnell Prime Low-glow 24mp camera traps and through direct and occasional observations along the trails used for camera trap installation starting in January 2022 and ending in September 2023.

Within the Park, 96 points were established for camera trap installation using QGIS software, distributed randomly and equidistantly (200 meters apart), with a 200-meter distance from the edge of the park (Figure 1) to avoid theft by hunters frequently reported in the area. To set up the cameras at the 96 pre-determined points in the study area, 12 field campaigns were conducted. During each campaign, 8 cameras were installed, which remained in the field for 20 days before being retrieved to collect the recordings and then relocated to another 8 of the 96 points. The capture effort throughout the study was calculated using the formula (number of camera traps x number of sampling days), resulting in 160 camera days per campaign. The total sampling effort for the entire study amounted to 1920 camera/days.

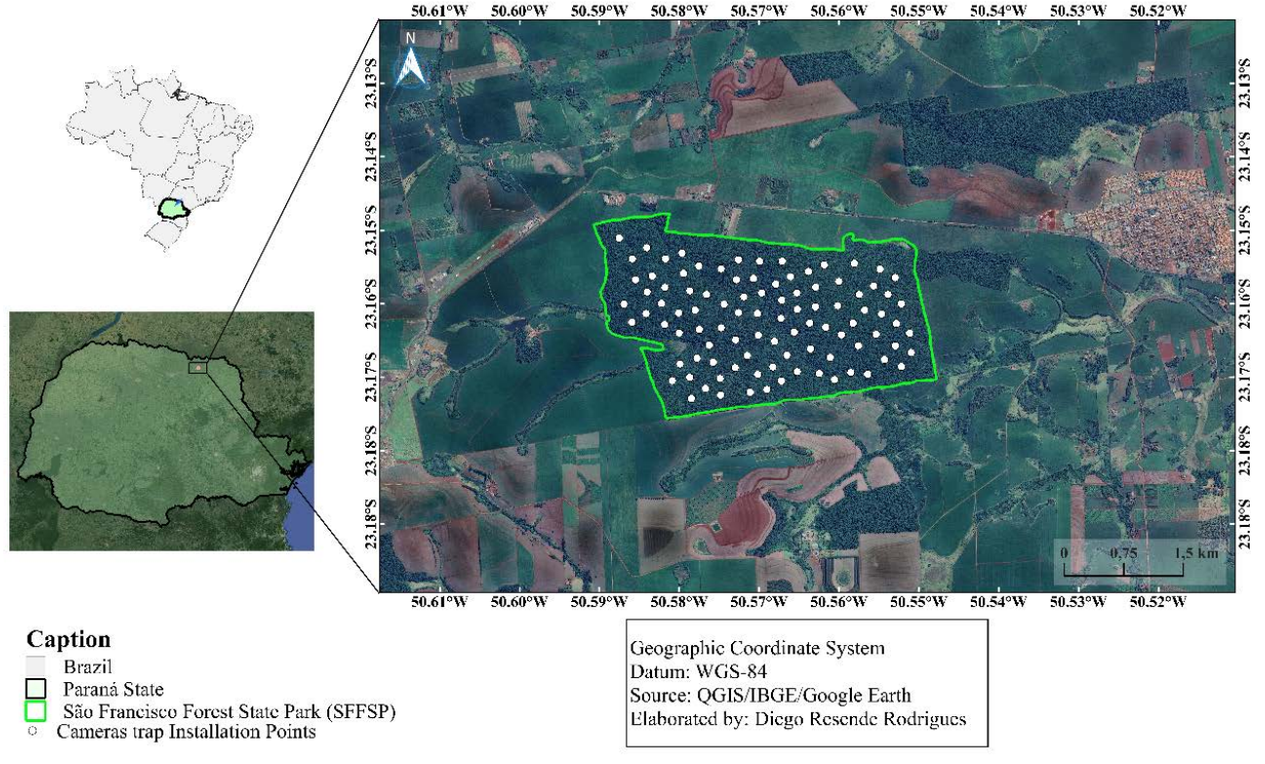

Figure 1. Location of the study area (green line) of São Francisco Forest State Park Conservation Unit, located in northern Paraná, highlighting the sites of the camera traps (white dots).

Upon reaching the sampling points (using a Garmin Oregon© – 700 GPS), we always trimmed the shrubs in front of the traps for better detection and visualization (to avoid recording shrub movements due to wind). The cameras were set to video mode, normal detection, 30 seconds per recording, 20-second intervals for the next motion detection, and 1080p resolution.

Occasional sightings of mammals were made during field activities on the days of camera trap installations, along the trails. Additionally, species with carcasses found on BR 369, km 79, directly in front of the Conservation Unit were considered potential occurrences.

We followed the nomenclature of Paglia *et al.* (2012), using the SALVE ICMBio platform (2024) and the Brazilian Society of Mastozoology (SBMz 2024). To evaluate the threat level of species internationally and nationally, we used Nature *et al.* (2021), IUCN (2024) and ICMBio (2024), respectively.

RESULTS

A total of 24 wild mammal species and two exotic species were recorded in the SSFSP, encompassing eight orders and 19 families. The order Carnivora had the highest species richness (N=9), followed by Rodentia (N=6) (Table 1). The species accumulation curve tended to stabilize close to the number of species found in the survey (Figure 2). Regarding conservation status, four of the recorded mammal species are under some degree of threat: *Herpailurus yagouaroundi* (Lacépède, 1809), *Leopardus guttulus* (Hensel, 1872), *Leopardus wiedii* (Schinz, 1821), and *Alouatta guariba clamitans* (Cabrera, 1940) are classified as vulnerable to extinction (Table 1). Two species accounted for more than half of the total records (N = 577, see Figure 3) by the camera traps: *Sus scrofa* (Linnaeus, 1758) (N = 216, 37.4%) and *Dicotyles tajacu* (Linnaeus, 1758) (N = 104, 18%).

The species *Sapajus nigritus* (Kerr, 1792), *A. guariba clamitans*, and *Lepus europaeus*, were recorded only through two occasional sightings, while *Coendou spinosus* (Cuvier, 1823), *Cerdocyon thous* (Linnaeus, 1766), and *Myocastor coypus* (Molina, 1782) were identified solely through carcasses. One domestic species was recorded, the domestic dog (*Canis lupus familiaris* (Linnaeus, 1758)), and two exotic mammal species, the wild boar (*S. scrofa*) and the European hare (*Lepus europaeus* (Pallas, 1778)). Among the native species, the most abundant order was Carnivora (N = 9), followed by Rodentia (N = 6), Primates, Cingulata, and Artiodactyla (N = 2) (Table 1).

DISCUSSION

The 24 non-flying mammal species recorded in São Francisco Forest State Park (Figures 4, 5 and 6) represent 11.94% of the total non-flying mammal species in the biome (N = 201; Graipel *et al.* 2017) (Brocardo *et al.* 2019). In contrast, larger conservation units, like Parque Nacional do Iguaçu, contain 31.34% (59 recorded species and 4 potential occurrences, N = 63) (Brocardo *et al.* 2019), while the Itatiaia National Park contains 34.82% (N = 70) of the biome's non-flying mammalian biodiversity (Graipel *et al.* 2017, Brocardo *et al.* 2019).

The low species richness observed in SSFSP is likely linked to some factors like: Conservation Unit size, the current degraded state due to anthropogenic impacts like selective logging, hunting, a fire that affected about 20% of the park area about 55 years ago (Tomé *et al.* 1999), the notable presence of opportunistic plant species such as *Merostachys paranaensis* (suggested species name according to Araújo, 2020), and the fragment's isolation within an agricultural landscape (Rodrigues *et al.* 2019, Araújo 2020, Bovolenta *et al.* 2022) (See Figure 1). Additionally, employing different methodologies for arboreal and flying mammals and including the fragment's edges could enhance mammal records (Cullen Jr. *et al.* 2006, Zequi *et al.* 2021). Despite this, the species accumulation curve showed that for the methodology used, a stabilizing trend was found for the richness found.

The presence of the puma (*Puma concolor*) suggests the use of forest fragments in the region as habitat since a puma's home range can vary between 33 to 775 km² (Gonzalez-Borrajo *et al.* 2017). Despite the low connectivity between fragments, this species manages to move among them (Azevedo *et al.* 2021). Large mammals like *Panthera onca*, *Tapirus terrestris*, *Tayassu pecari*, and *Mazama rufa* were not recorded in this or during the previous survey of the fragment (Zequi *et al.* 2021), suggesting possible local extinction, probably due to fragmentation and conversion of areas of the biome.

Table 1. List of mammal species recorded in São Francisco Forest State Park and surrounding areas. Conservation Status; NL: Not Listed; EN: Endangered; VU: Vulnerable; ID: Insufficient Data; BR: Brazil.

Order (Species Richness) **Family**	**Popular Name**	**Threat (2024)** **IUCN**	**BR**
DIDELPHIMORPHIA (N = 1)			
Didelphidae			
Didelphis albiventris (Lund, 1840)	Gambá-de-orelha-branca	LC	LC
ARTIODACTYLA (N = 3)			
Tayassuidae			
Dicotyles tajacu (Linnaeus, 1758)	Cateto	LC	LC
Suidae			
Sus scrofa (Linnaeus, 1758)	Javali	LC	
Cervidae			
Subulo gouazoubira (G. Fischer, 1814)	Veado	LC	LC
CINGULATA (N = 2)			
Dasypodidae			
Dasypus novemcinctus (Linnaeus, 1758)	Tatu-Galinha	LC	LC
Chlamyphoridae			
Cabassous tatouay (Desmarest, 1804)	Tatu-de-rabo-mole-grande	LC	LC
PILOSA (N = 1)			
Myrmecophagidae			
Tamandua tetradactyla (Linnaeus, 1758)	Tamanduá-mirim	LC	LC
LAGOMORPHA (N = 2)			
Leporidae			
Sylvilagus brasiliensis (Linnaeus, 1758)	Tapeti		LC
Lepus europaeus (Pallas, 1778)	Lebre-comum	LC	
PRIMATES (N = 2)			
Cebidae			
Sapajus nigritus (Kerr, 1792)	Macaco-prego	NT	NT
Atelidae			
Alouatta guariba clamitans (Cabrera, 1940)	Bugiu-ruivo	VU	VU
RODENTIA (N = 6)			
Caviidae			
Hydrocherus hydrochaeris (Linnaeus, 1766)	Capivara	LC	LC
Cuniculidae			
Cuniculus paca (Linnaeus, 1766)	Paca	LC	LC
Dasyproctidae			
Dasyprocta azarae (Lichtenstein, 1823)	Cutia	DD	LC
Echimyidae			
Myocastor coypus (Molina, 1782)	Ratão-do-banhado	LC	LC
Erethizontidae			
Coendou spinosus (Cuvier, 1823)	Ouriço-caixeiro	LC	LC
Sciuridae			
Guerlinguetus ingrami (Thomas, 1901)	Serelepe, Esquilo		LC

Table 1. Continues on the next page...

Table 1. continued...

Order (Species Richness) Family	Popular Name	Threat (2024) IUCN	BR
CARNIVORA (N = 9)			
Canidae			
Cerdocyon thous (Linnaeus, 1766)	Cachorro-do-mato	LC	LC
Felidae			
Herpailurus yagouaroundi (Lacépède, 1809)	Gato-mourisco	LC	VU
Leopardus pardalis (Linnaeus, 1758)	Jaguatirica	LC	LC
Leopardus guttulus (Hensel, 1872)	Gato-do-mato-pequeno-do-sul	VU	VU
Leopardus wiedii (Schinz, 1821)	Gato-maracajá	NT	VU
Puma concolor (Linnaeus, 1771)	Onça-parda	LC	NT
Mustelidae			
Eira barbara (Linnaeus, 1758)	Irara	LC	LC
Procyonidae			
Nasua nasua (Linnaeus, 1766)	Quati	LC	LC
Procyon cancrivorus (Cuvier, 1798)	Mão-pelada	LC	LC

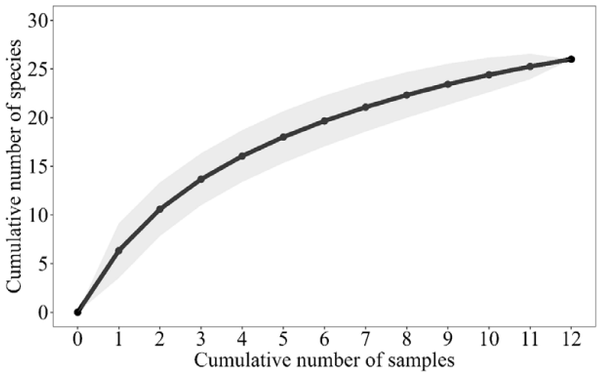

Figure 2. Cumulative species richness curve for all species found in the Mata São Francisco Forest State Park Conservation Unit (SSFSP), Paraná, Brazil. Each sample represents a field campaign, totaling 160 camera-trap days.

The wild boar (*Sus scrofa*) had the highest number of records in the UC, comprising 37.4% of the total. Since this is the first study surveying non-flying mammals in the Conservation Unit, it's still too early to estimate the population's abundance within the fragment. However, the data revealed that they were detected at nearly all 96 collection points. Its high frequency can cause a variety of ecosystem threats, such as competition for resources, which may reduce native species populations and alter their occupancy patterns (Batista 2019, Hegel *et al.* 2019, Garabedian & Kilgo 2024). In South America, *S. scrofa* is a public and animal health threat, because it is capable of transmitting 91 different pathogens, including rabies, cysticercosis, and brucellosis (Ruiz-Fons 2017, La Sala *et al.* 2021). Additionally, there has been parasite records in *S. scrofa* from the vampire bat *Desmodus rotundus* (E. Geoffroy, 1810), facilitating disease transmission since the bat acts as a vector and reservoir (Ruiz-Fons 2017, Hernández-Pérez *et al.* 2019, Grotta-Neto *et al.* 2021).

The European hare (*Lepus europaeus*) was only recorded around the UC, with studies indicating native forest as a barrier to this species, reducing its invasive potential (Pasqualotto *et al.* 2021). However, deforestation and the expanding of agricultural matrices may favor its population growth and dispersion. Like the wild boar, *L. europaeus* can serve as a disease reservoir, capable of transmitting 17 different pathogens to native fauna (La Sala *et al.* 2021).

Hunting activity is currently a significant threat to SSFSP and other Atlantic Forest fragments (Cullen Jr. *et al.* 2000, Benitez-Lopez *et al.* 2017). We found various signs of hunting within the conservation unit, such as snares, bait stations, and traps during field activities. Hunting is a major threat to biodiversity in the Neotropical region, potentially leading to declines in mammal populations (Benitez-Lopez *et al.* 2017, Gallego-Zamorano *et al.* 2020). In SSFSP, three records of domestic dogs showed them engaged in hunting activities. The presence of these animals in the natural environment can directly impact native species through predation

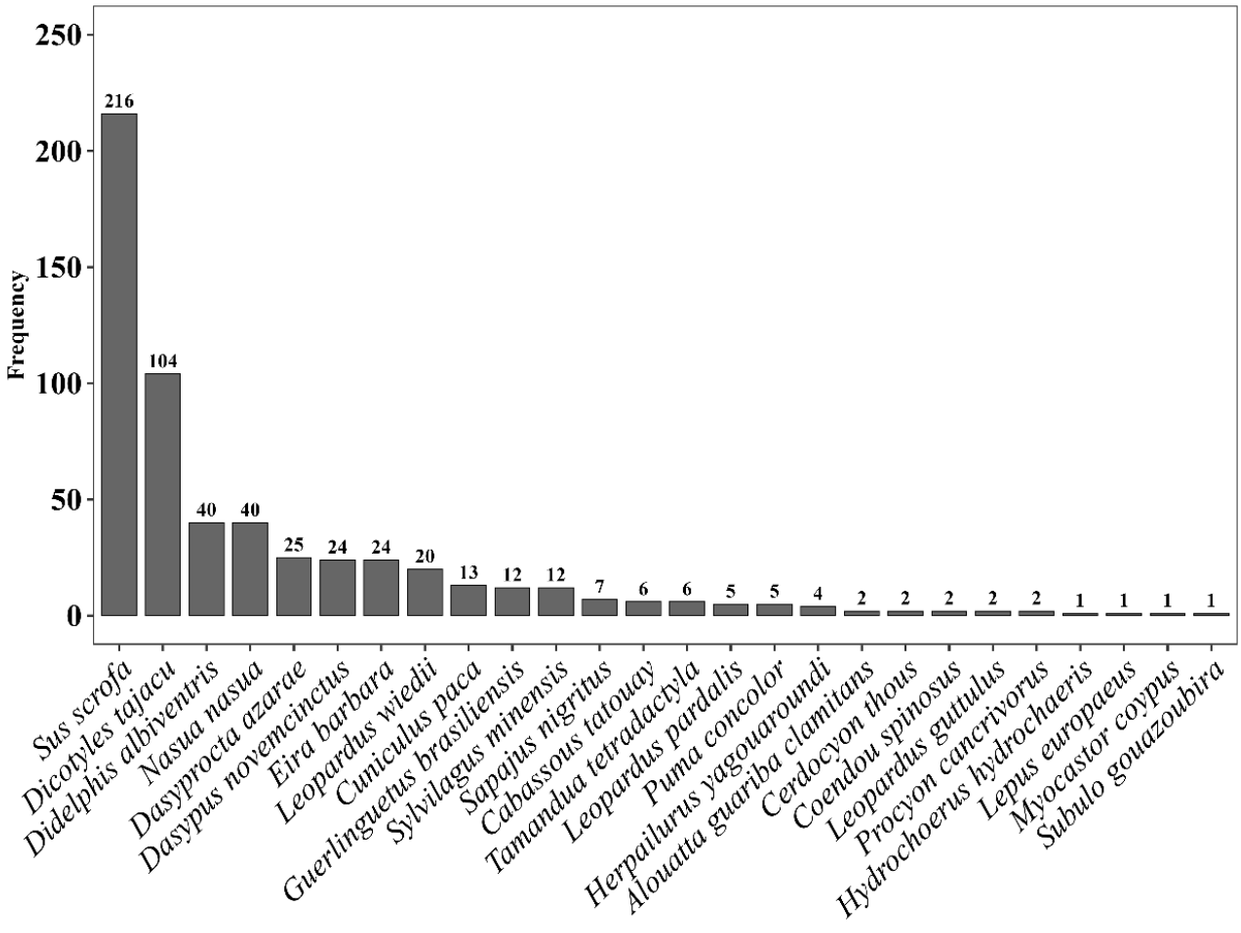

Figure 3. Frequency of records by camera trap and occasional sightings of non-flying mammals in São Francisco Forest State Park, between January 2022 and September 2023.

and competition, for instance. Additionally, the transmission of pathogens poses a risk to human health, and especially to other canids like *Cerdocyon thous* and *Lycalopex gymnocercus* (Almeida *et al.* 2010, Lessa *et al.* 2016, Guedes *et al.* 2021). The record of *Cabassous tatouay* (greater naked-tailed armadillo) in this fragment is new, likely due to the animal's elusive nature (burrowing habits).

The *Dicotyles tajacu* (collared peccary) was not recorded in the previous survey (Zequi *et al.* 2021), although it was present in surrounding fragments. The use of a larger number of cameras-trap, evenly distributed throughout the Conservation Unit, also seems to have contributed to this new record, together with the fact that hunting pressure decreased after the fragment became a Conservation Unit in 1994 (Tomé *et al.* 1999, Zequi *et al.* 2021). Its return is positive for the fragment, as herbivores play a crucial role in tropical ecosystems by cycling nutrients, disturbing the soil, and influencing the vegetation's biotic composition (Reider *et al.* 2013, Galetti *et al.* 2017, Villar *et al.* 2021, Souza *et al.* 2022).

The previous survey, conducted between 2006 and 2010, documented 30 non-flying mammal species, nine of which were not recorded in the current study (Caluromys philander (Linnaeus, 1758), *Didelphis aurita* (Wied-Neuwied, 1826), *Gracilinanus microtarsus* (Wagner, 1842), *Euphractus sexcinctus* (Linnaeus, 1758), *Mazama americana* (Erxleben, 1777), *Galictis sp.*, *Euryoryzomys russatus* (Wagner, 1848), *Oligoryzomys sp.*, *Oxymycterus sp.*). Various methodologies were developed to monitor non-flying mammals due to their diverse body sizes, habitat preferences, and life histories. Therefore, different techniques are necessary for different species groups (Carvalho *et al.* 2013). Although camera traps are recommended and useful for detecting nocturnal, elusive, or low-density species by allowing monitoring at multiple points over extended periods and reducing field time (Carvalho *et al.* 2013) there is a deficiency in capturing small mammals when using this method (Gompper *et*

Figure 4. Species recorded in São Francisco Forest State Park using camera traps. A: *Didelphis albiventris*; B: *Dicotyles tajacu*; C: *Sus scrofa*; D: *Dasypus novemcinctus*; E: *Cabassous tatouay*; F: *Tamandua tetradactyla*; G: *Sylvilagus brasiliensis*; H: *Sapajus nigritus*.

al. (2006), which probably explains the absence of some rodents (*E. russatus*, *Oligoryzomys sp.* e *Oxymycterus sp.*) in our survey. The lack of complementary methodologies (which could detect mammals in higher forest strata), combined with the absence of sampling at the fragment's edges, have contributed to the lower richness recovered in the present survey. The latest survey carried out in the SFFSP used more methods: linear census (transects), sand plots, camera traps (3 camera-traps), hair analysis (trichology) and occasional records, as well as considering areas on the edge of the fragment, which helps to explain the greater richness found in this latest survey of non-flying mammals (Zequi *et al.* 2021).

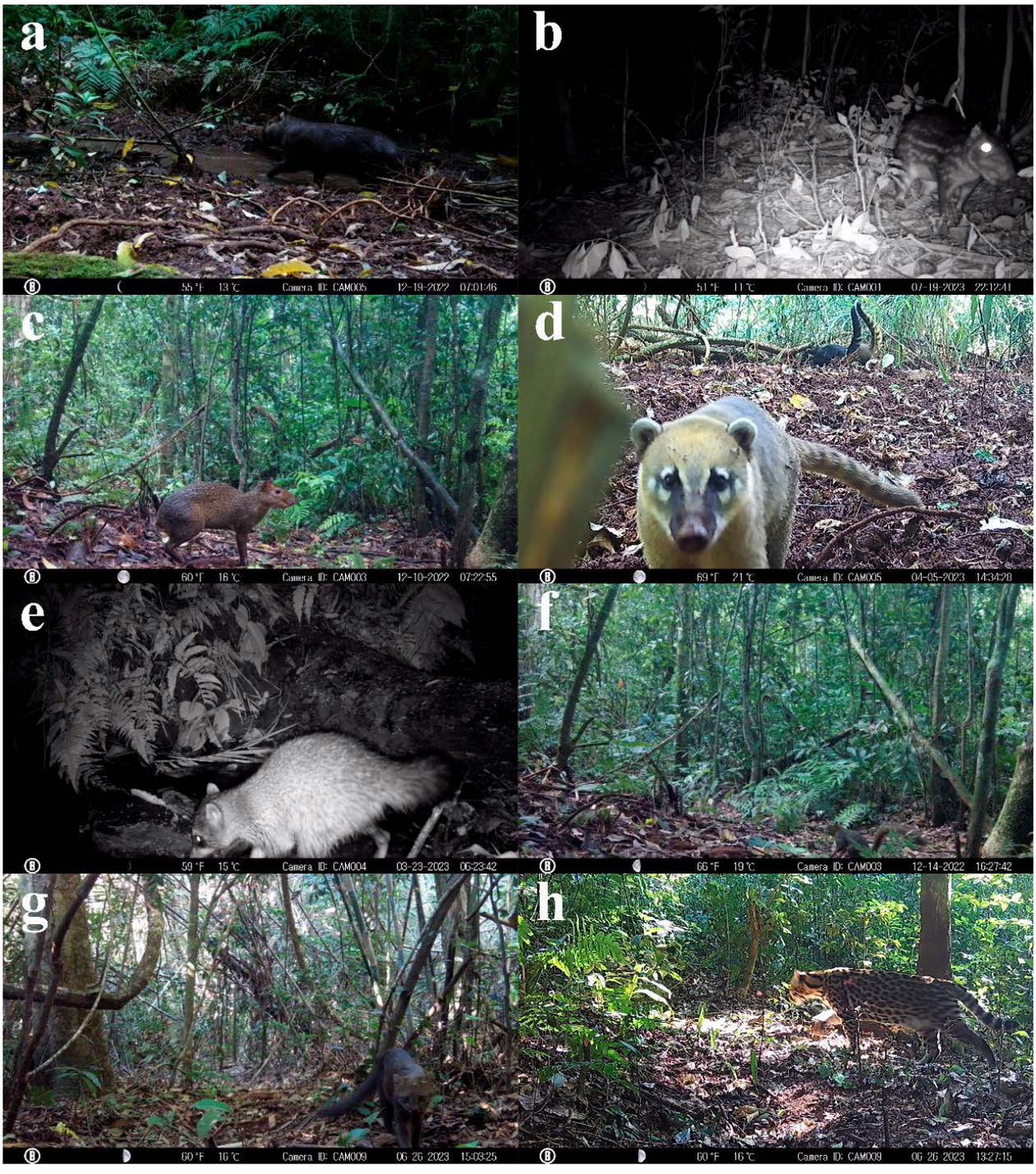

Figure 5. Species recorded in São Francisco Forest State Park using camera traps. A: *Hydrocherus hydrochaeris*; B: *Cuniculus paca*; C: *Dasyprocta azarae*; D: *Nasua nasua*; E: *Procyon cancrivorus*; F: *Guerlinguetus brasiliensis*; G: *Herpailurus yagouaroundi*; H: *Leopardus pardalis*.

Despite these limitations, the data collected help highlight the importance of this State Park as a wildlife refuge in the study area. The impacts of *S. scrofa* on the fragment are still unknown, but its invasive and detrimental nature poses a serious threat to native biodiversity (La Sala *et al.* 2023). The findings provide a foundation for future analyses and studies in the SSFSP demonstrated by the change in fauna from the last survey (Zequi *et al.* 2021) to the current one, especially about the arrival of an exotic and invasive species (*Sus scrofa*), as well as for developing management and control plans for hunting and invasive species.

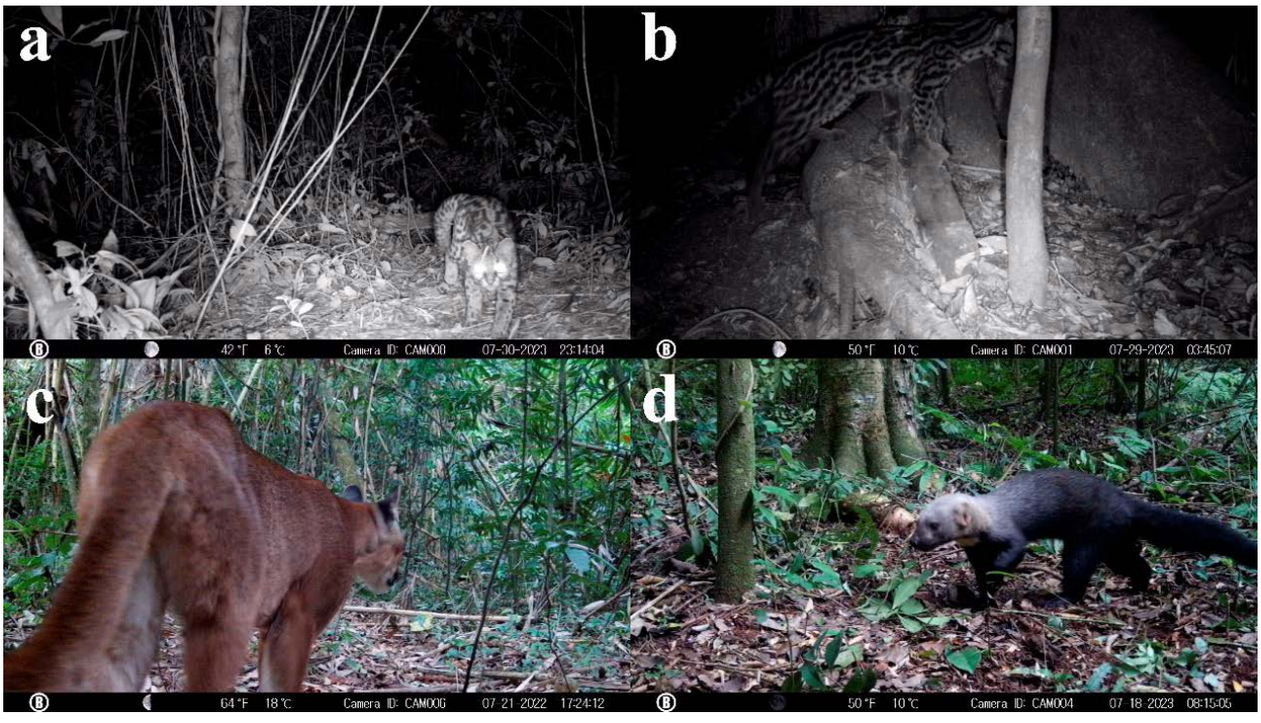

Figura 6. Species recorded in São Francisco Forest State Park using camera traps. A: *Leopardus guttulus*; B: *Leopardus wiedii*; C: *Puma concolor*; D: *Eira barbara*.

ACKNOWLEDGMENTS

Thanks to Secretaria do Estado do Desenvolvimento Sustentável e do Turismo (SEDEST) which offered the research funding (PUBLIC CALL 13/2019: Unique Applied Health Research Program) and Fundação Araucária (FA) and approved the Project: Assessment of the risk of emerging zoonoses from the biological invasion of *Sus scrofa* in the São Francisco Forest State Park (SUS2020111000001). Thanks as well to Universidade Estadual do Norte do Paraná who provided support for this study. Finally, we would like to thank the Instituto Água e Terra (IAT) for authorizing research in the Conservation Unit and Fernando Heberson Menezes who helped us identify the species Coendou spinosus.

REFERENCES

Almeida Curi, N. H., Araújo, A. S., Campos, F. S., Lobato, Z. I. P., Gennari, S. M., Marvulo, M. F. V., Silva, J. C. R., & Talamoni, S. A. 2010. Wild canids, domestic dogs and their pathogens in Southeast Brazil: disease threats for canid conservation. Biodiversity and Conservation, 19, 3513–3524. DOI: 10.1007/s10531-010-9911-0

Alvares, C. A., Stape, J. L., Sentelhas, P. C., Moraes, G., Gonçalves, J. L. M., & Sparovek, G. 2013. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, 22(6), 711–728. DOI: 10.1127/0941-2948/2013/0507

Araújo, C. G. de. 2020. A nova espécie *Merostachys paranaensis* Araujo & Bianchini e seus impactos sobre a vegetação lenhosa no Parque Estadual Mata São Francisco, sul do Brasil. Tese de Doutorado (Centro de Ciências Biológicas), Universidade Estadual de Londrina, Londrina, PR, Brasil. p. 80.

Azevedo, F. C., Lemos, F. G., Freitas-Junior, M. C., Arrais, R. C., Morato, R. G., & Azevedo, F. C. C. 2021. The importance of forests for an apex predator: spatial ecology and habitat selection by pumas in an agroecosystem. Animal Conservation, 24(3), 499–509. DOI: 10.1111/acv.12659

Batista, G. O. 2019. Relatório sobre áreas prioritárias para o manejo de javalis : aspectos ambientais , socioeconômicos e sanitários. IBAMA (Ed.), 1 ed. Brasília, DF: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis: p. 51.

Benitez-Lopez, A., Alkemade, R., Schipper, A. M., Ingram, D. J., Verweij, P. A., Eikelboom, J. A. J., & Huijbregts, M. A. J. 2017. The impact of hunting on

tropical mammal and bird populations. Science, 356(6334), 180–183. DOI: 10.1126/science.aaj1891

Bennie, J. J., Duffy, J. P., Inger, R., & Gaston, K. J. 2014. Biogeography of time partitioning in mammals. Proceedings of the National Academy of Sciences, 111(38), 13727–13732. DOI: 10.1073/pnas.1216063110

Bogoni, J. A., Peres, C. A., & Ferraz, K. M. 2020. Effects of mammal defaunation on natural ecosystem services and human well being throughout the entire Neotropical realm. Ecosystem Services, 45, 101173. DOI: 10.1016/j.ecoser.2020.101173

Bovolenta, Y. R., Rodrigues, D. R., Bianchini, E., & Pimenta, J. A. 2022. Allometric differentiation of tree species from different strata in a selectively logged Atlantic Forest remnant in southern Brazil. Tropical Ecology, 63(3), 365–374. DOI: 10.1007/s42965-021-00206-w

Branco, A. F. V. C., Lima, P. V. P. S., Medeiros Filho, E. S. de, Costa, B. M. G., & Pereira, T. P. 2022. Assessment of biodiversity loss in the Atlantic Forest. Ciência Florestal, 31, 1885–1909. DOI: 10.5902/1980509853310

Brocardo, C. R., Silva, M. X., Ferracioli, P., Cândido, J. F., Bianconi, G. V., Moraes, M. F. D., Galetti, M., Passamani, M., Policena, A., & Reis, N. R. 2019. Mamíferos do Parque Nacional do Iguaçu. *Oecologia Australis*, 23(2), 165–190. DOI: 10.4257/oeco.2019.2302.01

Carvalho, W. D., Adania, C. H., & Esbérard, Cel. 2013. Comparison of two mammalian surveys made with camera traps in southeastern Brazil, focusing the abundance of wild mammals and domestic dogs. Brazilian Journal of Biology, 73(1), 29–36. DOI: 10.1590/S1519-69842013000100005

Chiarello, A. G. 1999. Effects of fragmentation of the Atlantic forest on mammal communities in south-eastern Brazil. Biological Conservation, 89(1), 71–82. DOI: 10.1016/S0006-3207(98)00130-X

Coelho-Junior, M. G., de Oliveira, A. L., da Silva-Neto, E. C., Castor-Neto, T. C., de O. Tavares, A. A., Basso, V. M., Turetta, A. P. D., Perkins, P. E., & de Carvalho, A. G. 2021. Exploring plural values of ecosystem services: Local peoples' perceptions and implications for protected area management in the Atlantic forest of Brazil. Sustainability, 13(3), 1019. DOI: 10.3390/su13031019

Cullen Jr., L., Bodmer, R. E., & Pádua, C. V. 2000. Effects of hunting in habitat fragments of the Atlantic forests, Brazil. Biological Conservation, 95(1), 49–56.

Cullen Jr., L., Rudran, R., & Valladares-Padua, C. 2006. Métodos de estudos em biologia da conservação e manejo da vida silvestre. UFPR. Curitiba, PR. 2 ed. Curitiba/PR: Editora UFPR: p. 652.

Curtis, P. G., Slay, C. M., Harris, N. L., Tyukavina, A., & Hansen, M. C. 2018. Classifying drivers of global forest loss. Science, 361(6407), 1108–1111. DOI: 10.1126/science.aau3445

Darimont, C. T., Cooke, R., Bourbonnais, M. L., Bryan, H. M., Carlson, S. M., Estes, J. A., Galetti, M., Levi, T., & Maclean, J. L. 2023. Humanity's diverse predatory niche and its ecological consequences. Communications Biology, 6(609), 1–10. DOI: 10.1038/s42003-023-04940-w

Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J. B., & Collen, B. 2014. Defaunation in the Anthropocene. Science, 345(6195), 401–406. DOI: 10.1126/science.1251817

Faria, D., Morante-Filho, J. C., Baumgarten, J., Bovendorp, R. S., Cazetta, E., Gaiotto, F. A., Mariano-Neto, E., Mielke, M. S., Pessoa, M. S., & Rocha-Santos, L. 2023. The breakdown of ecosystem functionality driven by deforestation in a global biodiversity hotspot. Biological Conservation, 283(1), 110126. DOI: 10.1016/j.biocon.2023.110126

Galetti, M., Brocardo, C. R., Begotti, R. A., Hortenci, L., Rocha-Mendes, F., Bernardo, C. S. S., Bueno, R. S., Nobre, R., Bovendorp, R. S., & Marques, R. M. 2017. Defaunation and biomass collapse of mammals in the largest Atlantic forest remnant. Animal Conservation, 20(3), 270–281. DOI: 10.1111/acv.12311

Gallego-Zamorano, J., Benítez-López, A., Santini, L., Hilbers, J. P., Huijbregts, M. A. J., & Schipper, A. M. 2020. Combined effects of land use and hunting on distributions of tropical mammals. Conservation Biology, 34(5), 1271–1280. DOI: 10.1111/cobi.13459

Garabedian, J. E., & Kilgo, J. C. 2024. Rapid recovery of invasive wild pig (*Sus scrofa*) populations following density reduction. Biological Invasions, 26(4), 1075–1089. DOI: 10.1007/s10530-023-03230-0

Gompper, M. E., Kays, R. W., Ray, J. C., Lapoint, S. D., Bogan, D. A., & Cryan, J. R. 2006. A comparison of noninvasive techniques to survey carnivore communities in northeastern North America. Wildlife Society Bulletin, 34(4), 1142–1151. DOI:10.2193/0091-7648(2006)34[1142:ACONTT]2.0.CO;2

Gonzalez-Borrajo, N., López-Bao, J. V., & Palomares, F. 2017. Spatial ecology of jaguars, pumas, and ocelots: a review of the state of knowledge. Mammal Review, 47(1), 62–75. DOI: 10.1111/mam.12081

Graipel, M. E., Cherem, J. J., Monteiro-Filho, E. L. A., & Carmignotto, A. P. 2017. Mamíferos da Mata Atlântica. In: E. L. de A. Monteiro-Filho & C. E. Conte (Eds.), Revisões em Zoologia: Mata Atlântica. pp. 391–482. 1 ed. Curitiba: Editora UFPR Curitiba (PR).

Grotta-Neto, F., Peres, P. H. F., Piovezan, U., Passos, F. C., & Duarte, J. M. B. 2021. Hunting practices of feral pigs (*Sus scrofa*) and predation by vampire bats (*Desmodus rotundus*) as a potential route of rabies in the Brazilian Pantanal. Austral Ecology, 46(2), 324–328. DOI: 10.1111/aec.12971

Guedes, J. J. M., Assis, C. L., Feio, R. N., & Quintela, F. M. 2021. The impacts of domestic dogs (*Canis familiaris*) on wildlife in two Brazilian hotspots and implications for conservation. Animal Biodiversity and Conservation, 44(1), 45–58. DOI: 10.32800/abc.2021.44.0045

Hegel, C. G. Z., Santos, L. R. dos, Pichorim, M., & Marini, M. A. 2019. Wild pig (*Sus scrofa* L.) occupancy patterns in the Brazilian Atlantic forest. Biota Neotropica, 19(4), e20180719. DOI: 10.1590/1676-0611-BN-2018-0719

Hernández-Pérez, E. L., Castillo-Vela, G., García-Marmolejo, G., Sanvicente López, M., & Reyna-Hurtado, R. 2019. Wild pig (*Sus scrofa*) as prey of the common vampire bat (*Desmodus rotundus*). Therya, 10(2), 195–199. DOI: 10.12933/therya-19-685

Hübel, M., Aximoff, I. A., de Freitas, A. C., & Rosa, C. 2021. Mamíferos de médio e grande porte na Área de Proteção Ambiental Municipal do Rio Vermelho em Santa Catarina, sul do Brasil. *Oecologia Australis*, 25(3), 722–737. DOI: 10.4257/oeco.2021.2503.08

ICMBio. 2024. Instituto Chico Mendes de Conservação da Biodiversidade. Avalible in: https://www.gov.br/icmbio/pt-br. Acess data on: june 20th june 2024

IUCN. 2024. IUCN Red List of Threatened Species. Avalible in: https://www.iucnredlist.org/. Acess data on: 23th june 2024.

Jones, K. E., & Safi, K. 2011. Ecology and evolution of mammalian biodiversity. Philosophical Transactions of the Royal Society B: Biological Sciences, 366(1577), 2451–2461. DOI: 10.1098/rstb.2011.0090

Kosydar, A. J., Conquest, L. L., & Tewksbury, J. J. 2014. Can life histories predict the effects of habitat fragmentation? A meta-analysis with terrestrial mammals. Applied Ecology and Environmental Research, 12(2), 505–521. DOI: 10.15666/aeer/1202_505521

La Sala, L. F., Burgos, J. M., Caruso, N. C., Bagnato, C. E., Ballari, S. A., Guadagnin, D. L., Kindel, A., Etges, M., Merino, M. L., & Marcos, A. 2023. Wild pigs and their widespread threat to biodiversity conservation in South America. Journal for Nature Conservation, 73, 126393. DOI: 10.1016/j.jnc.2023.126393

La Sala, L. F., Burgos, J. M., Scorolli, A. L., VanderWaal, K., & Zalba, S. M. 2021. Trojan hosts: the menace of invasive vertebrates as vectors of pathogens in the Southern Cone of South America. Biological Invasions, 23, 2063–2076.

Lessa, I., Guimarães, T. C. S., de Godoy Bergallo, H., Cunha, A., & Vieira, E. M. 2016. Domestic dogs in protected areas: a threat to Brazilian mammals? Natureza & Conservação, 14(2), 46–56. DOI: 10.1016/j.ncon.2016.05.001

Lima, R. A. F., Oliveira, A. A., Pitta, G. R., de Gasper, A. L., Vibrans, A. C., Chave, J., Ter Steege, H., & Prado, P. I. 2020. The erosion of biodiversity and biomass in the Atlantic Forest biodiversity hotspot. Nature Communications, 11(1), 1–16. DOI: 10.1038/s41467-020-20217-w

Lindenmayer, D., Woinarski, J., Legge, S., Southwell, D., Lavery, T., Robinson, N., Scheele, B., & Wintle, B. 2020. A checklist of attributes for effective monitoring of threatened species and threatened ecosystems. Journal of Environmental Management, 262(1), 110312. DOI: 10.1016/j.jenvman.2020.110312

Lino, A., Fonseca, C., Rojas, D., Fischer, E., & Pereira, M. J. R. 2019. A meta-analysis of the effects of habitat loss and fragmentation on genetic diversity in mammals. Mammalian Biology, 94, 69–76. DOI: 10.1016/j.mambio.2018.09.006

Marques, M. C. M., & Grelle, C. E. V. 2021. The Atlantic Forest: An Introduction to the Megadiverse Forest of South America. In: E. Springer (Ed.), The Atlantic Forest: History, Biodiversity, Threats and Opportunities of the Mega-diverse Forest. Springer International Publishing. pp. 3–23. 1 ed. Cham/ Switzerland: Editora Springer.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Fonseca, G. A. B., & Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature, 403(6772), 853–858. DOI: 10.1038/35002501

Nature, I. U. for C. of, Nature, I. U. for C. of, Commission, N. R. S. S., & Commission, I. S. S. 2021. IUCN Red List categories and criteria. pp. 1–10. IUCN.

Nitsche, P. R., Caramori, P. H., Ricce, W. da S., & Pinto, L. F. D. 2019. Atlas Climático do Estado do Paraná. IAPAR, Londrina. http://www.iapar.br/.

Oliveira, M. E., Gonçalves, C. F., Machado, C. B., & Jr, P. M. G. 2024. Modeling responses of Brazilian Atlantic Forest mammals assemble to climate change. Biodiversity and Conservation, 33(2), 463–483. DOI: 10.1007/s10531-023-02749-x

Ostfeld, R. S., & Holt, R. D. 2004. Are predators good for your health? Evaluating evidence for top-down regulation of zoonotic disease reservoirs. Frontiers in Ecology and the Environment, 2(1), 13–20. DOI:10.1890/1540-9295(2004)002[0013:APGFYH]2.0.CO;2

Paglia, A. P., Da Fonseca, G. A., Rylands, A. B., Herrmann, G., Aguiar, L. M., Chiarello, A. G., Leite, Y. L. R., Costa, L. P., Siciliano, S., & Kierulff, M. C. M. 2012. Lista Anotada dos Mamíferos do Brasil 2a Edição/Annotated Checklist of Brazilian Mammals. Occasional Papers in Conservation Biology, 6, 1–82.

Pasqualotto, N., Boscolo, D., Versiani, N. F., Paolino, R. M., Rodrigues, T. F., Krepschi, V. G., & Chiarello, A. G. 2021. Niche opportunity created by land cover change is driving the European hare invasion in the Neotropics. Biological Invasions, 23(1), 7–24. DOI: 10.1007/s10530-020-02353-y

Pires, M. M., & Galetti, M. 2023. Beyond the "empty forest": The defaunation syndromes of Neotropical forests in the Anthropocene. Global Ecology and Conservation, 41, e02362. DOI: 10.1016/j.gecco.2022.e02362

Rahman, T., & Candolin, U. 2022. Linking animal behavior to ecosystem change in disturbed environments. Frontiers in Ecology and Evolution, 10(1), 893453. DOI: 10.3389/fevo.2022.893453

Reider, K. E., Carson, W. P., & Donnelly, M. A. 2013. Effects of collared peccary (*Pecari tajacu*) exclusion on leaf litter amphibians and reptiles in a Neotropical wet forest, Costa Rica. Biological Conservation, 163, 90–98. DOI: 10.1016/j.biocon.2012.12.015

Rezende, C. L., Scarano, F. R., Assad, E. D., Joly, C. A., Metzger, J. P., Strassburg, B. B. N., Tabarelli, M., Fonseca, G. A., & Mittermeier, R. A. 2018. From hotspot to hopespot: An opportunity for the Brazilian Atlantic Forest. Perspectives in Ecology and Conservation, 16(4), 208–214. DOI: 10.1016/j.pecon.2018.10.002

Ribeiro, M. C., Metzger, J. P., Martensen, A. C., Ponzoni, F. J., & Hirota, M. M. 2009. The Brazilian Atlantic Forest: how much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation, 142(6), 1141–1153. DOI: 10.1016/j.biocon.2009.02.021

Rodrigues, D. R., Bovolenta, Y. R., Pimenta, J. A., & Bianchini, E. 2019. Selective logging alters allometric relationships of five tropical tree species in seasonal semi-deciduous forests. Journal of Forestry Research, 30(5), 1633–1639. DOI: 10.1007/s11676-018-0705-7

Rosa, M. R., Brancalion, P. H. S., Crouzeilles, R., Tambosi, L. R., Piffer, P. R., Lenti, F. E. B., Hirota, M., Santiami, E., & Metzger, J. P. 2021. Hidden destruction of older forests threatens Brazil's Atlantic Forest and challenges restoration programs. Science Advances, 7(4), eabc4547. DOI: 10.1126/sciadv.abc4547

Ruiz-Fons, F. 2017. A Review of the Current Status of Relevant Zoonotic Pathogens in Wild Swine (*Sus scrofa*) Populations: Changes Modulating the Risk of Transmission to Humans. Transboundary and Emerging Diseases, 64(1), 68–88. DOI: 10.1111/tbed.12369

Sandom, C., Dalby, L., Fløjgaard, C., Kissling, W. D., Lenoir, J., Sandel, B., Trøjelsgaard, K., Ejrnæs, R., & Svenning, J.-C. 2013. Mammal predator and prey species richness are strongly linked at macroscales. Ecology, 94(5), 1112–1122. DOI: 10.1890/12-1342.1

Santos, H. G., Jacomine, P. K. T., Anjos, L. H. C., Oliveira, V. Á., Lumbreras, J. F., Coelho, M. R., Almeida, J. A., Cunha, T. J. F., & Oliveira, J. B. 2013. Sistema brasileiro de classificação de solos. 3rd ed. Rio de Janeiro, Embrapa Solos, p 304: p. 306. DOI: ISBN 978-85-7035-198-2

SBMz. 2024. Sociedade Brasileira de Mastozoologia. Avalible in: https://sbmz.org/brazilian-journal-of-mammalogy/. Acess data on: 25th june 2024.

Scarano, F. R., & Ceotto, P. 2015. Brazilian Atlantic forest: impact, vulnerability, and adaptation to climate change. Biodiversity and Conservation,

24(9), 2319–2331. DOI: 10.1007/s10531-015-0972-y

Shennan-Farpón, Y., Soterroni, A. C., Scarabello, M., & Visconti, P. 2024. Using policy scenarios to assess challenges and opportunities for reaching restoration targets in Brazil's Atlantic Forest. Environmental Research Letters, 1–24. DOI: 10.1088/1748-9326/ad5ab2

SOS Mata Atlântica, & INPE. 2024. Atlas dos Remanescentes Florestais da Mata Atlântica. (Retrieved on from http://mapas.sosma.org.br/).

Souza, Y., Villar, N., Zipparro, V., Nazareth, S., & Galetti, M. 2022. Large mammalian herbivores modulate plant growth form diversity in a tropical rainforest. Journal of Ecology, 110(4), 845–859. DOI: 10.1111/1365-2745.13846

Tomé, M., Miglioranza, E., Vilhena, A. H. T., & Fonseca, E. P. 1999. Composição florística e fitossociológica do Parque Estadual Mata São Francisco. Revista Do Instituto Florestal, 11(1), 13–23.

Vale, M. M., Vieira, M. V., Grelle, C. E. V, Manes, S., Pires, A. P. F., Tardin, R. H., Weber, M. M., de Menezes, M. A., O'Connor, L., & Thuiller, W. 2023. Ecosystem services delivered by Brazilian mammals: spatial and taxonomic patterns and comprehensive list of species. Perspectives in Ecology and Conservation, 21(4), 302–310. DOI: 10.1016/j.pecon.2023.10.003

Vancine, M. H., Muylaert, R. L., Niebuhr, B. B., de Faria Oshima, J. E., Tonetti, V., Bernardo, R., De Angelo, C., Rosa, M. R., Grohmann, C. H., & Ribeiro, M. C. 2024. The Atlantic Forest of South America: Spatiotemporal dynamics of the vegetation and implications for conservation. Biological Conservation, 291, 110499.

Villar, N., Paz, C., Zipparro, V., Nazareth, S., Bulascoschi, L., Bakker, E. S., & Galetti, M. 2021. Frugivory underpins the nitrogen cycle. Functional Ecology, 35(2), 357–368. DOI: 10.1111/1365-2435.13707

Wilson, O. J., Mayle, F. E., Walters, R. J., Lingner, D. V, & Vibrans, A. C. 2021. Floristic change in Brazil's Southern Atlantic forest biodiversity hotspot: From the last glacial maximum to the late 21st century. Quaternary Science Reviews, 264(1), 107005. DOI: 10.1016/j.quascirev.2021.107005

Yuan, R., Zhang, N., & Zhang, Q. 2024. The impact of habitat loss and fragmentation on biodiversity in global protected areas. Science of The Total Environment, 931, 173004. DOI: 10.1016/j.scitotenv.2024.173004

Zama, M. Y., Bovolenta, Y. R., Carvalho, E. S., Rodrigues, D. R., Araujo, C. G., Sorace, M. A. F., & Luz, D. G. 2012. Florística e síndromes de dispersão de espécies arbustivo-arbóreas no Parque Estadual Mata São Francisco, PR, Brasil. Hoehnea, 39, 369–378. DOI: 10.1590/S2236-89062012000300002

Zequi, J. A. C., Orsi, M. L., & Shibatta, L. S. 2021. Fauna e Flora do Parque Estadual Mata São Francisco: norte do Paraná. 1 ed. Londrina: Editora EDUEL: Londrina/PR: p. 369.

Submitted: 26 July 2024
Accepted: 30 September 2024
Published online: 7 October 2024
Associate Editor: Andre Andrian Padial, Rosana M Rocha