

MEDIUM AND LARGE-BODIED MAMMALS OF THE PRIVATE RESERVE OF NATURAL HERITAGE RECANTO DAS ANTAS, IN ESPÍRITO SANTO, BRAZIL

Andressa Gatti^{1,2*}, Paula Modenesi Ferreira^{1,2}, Cristina Jaques da Cunha^{2,3},
Jardel Brandão Seibert^{2,4} & Danielle de Oliveira Moreira^{2,4}

¹Universidade Federal do Espírito Santo (UFES), Centro de Ciências Humanas e Naturais, Departamento de Ciências Biológicas. Avenida Fernando Ferrari, 514, Goiabeiras, Vitória, Espírito Santo, Brasil. CEP: 29.075-910

²Instituto de Ensino, Pesquisa e Preservação Ambiental Marcos Daniel (IMD). Rua Fortunato Ramos, 123, Santa Lúcia, Vitória, Espírito Santo, Brasil. CEP: 29055-290

³Universidade de Vila Velha (UVV), Programa de Pós-Graduação em Ecologia de Ecossistemas. Avenida Comissário José Dantas de Melo, 21, Boa Vista, Vila Velha, Espírito Santo, Brasil. CEP: 29102-920

⁴Universidade Federal do Espírito Santo (UFES), Centro de Ciências Humanas e Naturais, Programa de Pós-Graduação em Ciências Biológicas (PPGBAN). Avenida Fernando Ferrari, 514, Goiabeiras, Vitória, Espírito Santo, Brasil. CEP: 29.075-910

E-mails: gatti.andressa@gmail.com, paulamodenesif@gmail.com, cristinajaques.bio@gmail.com, jardelseibert@gmail.com, daniomoreira@gmail.com

ABSTRACT

In Brazil, Private Reserves of Natural Heritage (RPPN) support protection of important forest patches that are essential habitats for endemic and endangered species. We present the first list of the medium and large-bodied mammals of RPPN Recanto das Antas from a heterogeneous landscape of Atlantic Forest in Espírito Santo, Brazil. We conducted camera-trapping surveys in 2015 in RPPN Recanto das Antas and adjacent areas in different habitats. We also made opportunistic records from direct observations during fieldwork. We recorded at least 21 wild mammals and two domestic species, comprising nine orders. In total, eight of these species are threatened with extinction according to State, National or Global (IUCN) red lists. RPPN Recanto das Antas is an important area for threatened large-bodied mammals and, along with the protected areas, it can help maintaining the biodiversity of the region, connecting the native forested areas of the landscape.

Keywords: Atlantic forest; camera trap; mammalia; protected areas; survey.

INTRODUCTION

Preserving significant tracts of forest is an important strategy for biodiversity conservation (Bruner *et al.* 2001, Geldmann *et al.* 2013, Gray *et al.* 2016), especially when natural areas occur in an anthropogenic landscape (Koh & Gardner 2010, Martin *et al.* 2014). A key tool that can contribute to the effectiveness of species protection is the establishment of protected areas (Rodrigues *et al.* 2004, Coad *et al.* 2008, Butchart *et al.* 2010). In this context, the Private Reserve of Natural Heritage (*Reserva Particular do Patrimônio Natural*, hereafter “RPPN”) is a private protected area, similar to the “International Union for Conservation of Nature” (IUCN) category IV. The goal of this type of protected area is to preserve biological diversity in perpetuity (Brazilian Law 9985/2000 and Decree 5746/2006; Rylands & Brandon 2005). The RPPNs promote the protection of important forest patches, which are essential habitats for endemic and endangered species (Rylands

& Brandon 2005), especially in areas under significant threat, such as the Brazilian Atlantic Forest, a global biodiversity hotspot (Myers *et al.* 2000).

In the north of Espírito Santo, Brazil, a large block of forest represents the last remaining “*Tabuleiro Forest*” (Rizzini 1997) of the Atlantic Forest, forming part of the Linhares-Sooretama protected area complex. This block of forest is part of the Atlantic Forest Central Corridor and is considered a center of high biological diversity and endemism (Kinzey 1982, Peixoto & Silva 1997). The region is extremely important for the conservation of several taxa (Conservation International do Brasil *et al.* 2000), including large mammals (Galetti *et al.* 2009). Four natural protected areas are present in the region Sooretama Biological Reserve, Vale Natural Reserve, RPPN Mutum-Preto and RPPN Recanto das Antas. This latter was established in 2007, connecting the three other aforementioned protected areas, and thereby protect several charismatic and threatened species in the area, such as the lowland tapir (*Tapirus terrestris*).

The region is considered of high importance for mammal conservation (Galetti *et al.* 2009), and published inventories about the medium and large-bodied mammals are only available for Vale Natural Reserve (*e.g.*, Srbek-Araujo *et al.* 2014, Srbek-Araujo & Kierulff 2016) and Sooretama Biological Reserve (Chiarello 1999). A complete list of mammal species for the RPPN Recanto das Antas has not been published. Therefore, it is important to gather information on the fauna in this protected area that is part of the Sooretama-Linhares complex, especially for RPPN Recanto das Antas which connects them. Hence, here, we present the first list of medium and large-bodied mammals occurring in RPPN Recanto das Antas and its surroundings.

MATERIAL AND METHODS

Study site

We conducted our study in RPPN Recanto das Antas (19°50'S, 39°58'W; 2,212 ha), which is owned by FIBRIA Celulose S.A., and in its direct surroundings (an estimated area of 5,618 ha), in the municipality of Linhares, Espírito Santo State, Brazil (Figure 1). The study area mostly consists of discontinuous primary vegetation, with a matrix interspersed with extensive eucalyptus and papaya plantations, cabruca (cacao trees planted in the shade of thinned native forest), seringal (rubber tree culture), and smaller amounts of coffee plantations and cattle pastures that are not part of the RPPN Recanto das Antas. Unpaved roads used for eucalyptus harvesting and transportation also traverse the area. RPPN Recanto das Antas is contiguous with the federally-owned Sooretama Biological Reserve (SBR - 27,858.68 ha), the private Vale Natural Reserve (VNR - 22,711.20 ha), and the RPPN Mutum-Preto (379 ha). Together, the four protected areas from the Linhares-Sooretama complex form a forest block of more than 500 km², the most important complex in the north of the State of Espírito Santo. The vegetation is classified as lowland Ombrophilous Dense Forest (IBGE 1987), also known as *Tabuleiro* Forest (Rizzini 1997), which dominates the northern coastal portion of the State of Espírito Santo (Peixoto *et al.* 2008).

Data collection and analysis

a) Camera-trapping

We conducted camera-trapping surveys from January to November 2015 in RPPN Recanto das Antas and its adjacent areas. We set camera traps at stations 0.5-2 km apart. To place the camera traps (camera stations) at regular intervals, we created grids of 500 x 500 m superimposed on a map of the study site using a GIS platform. To select the grids, we chose a stratified random sampling method, by which we divided our study area into five monitoring blocks. We placed the camera traps in one monitoring block at a time, and rotated the camera traps among blocks every two months, meaning each block was monitored just once. We started with eleven stations in the first block; eight stations in the second, third and fourth blocks; and then seven stations in the fifth block; a total of 42 camera trap stations during the camera-trapping surveys (Figure 1). Our sampling was not complete for all the stations because camera traps were stolen during our surveys.

Camera stations were placed in different habitats - within and along edges of forest fragments, eucalyptus plantations, marshes and floodplains - at a distance from roads between 1.36 and 689 m. We did not place cameras at potential feeding sites (*e.g.*, fruit trees) that would attract animals, nor did we use chemical attractants. Cameras were continuously active (24 hours a day, except for battery changes or malfunctions) and were set to shoot three pictures for each record, registering both the date and time of each photograph. We checked camera traps approximately every 20-30 days to replace batteries and to download the photos from memory cards.

To estimate the sampling effort, we multiplied the number of camera traps by the number of sampling days (not considering the inactive time, *e.g.*, when cameras stopped because of technical problems or when we changed batteries). Capture success was calculated by dividing the number of records by the sampling effort and multiplying the result by 100 (Srbek-Araujo & Chiarello 2007). We considered a temporally independent event when: (a) more than one photograph of the same species was obtained at the same station after a period of 1 hour; (b) consecutive photographs from the same station recorded different species or clearly



Figure 1. The Private Reserve of Natural Heritage Recanto das Antas (RPPN Recanto das Antas) in Linhares, State of Espírito Santo, Brazil, and locations of the camera trap stations distributed in five blocks (installed from January to November 2015): block one (black circles), block two (white circles), block three (black triangles), block four (black squares), block 5 (white squares). Datum: WGS 1984. Coordinate system/projection: UTM 24S. Cartographic base: Protected areas - (Cadastro Nacional de Unidades de Conservação 2015); Political boundaries - (IBGE 2001, 2005).

distinguishable individuals; (c) photographs from the same station were not consecutive; and (d) when a group of individuals of the same species was recorded, each individual was considered a single record (Wallace *et al.* 2012, Pérez-Irineo & Santos-Moreno 2016). We checked the camera trap sampling sufficiency using species accumulation curves, following Colwell *et al.* (2012).

Photos are provided for each species, including photos of species endemic from the Atlantic Forest and endangered species. Identification and taxonomic nomenclature followed recent mammal compilations (Paglia *et al.* 2012, Patton *et al.* 2015, Kitchener *et al.* 2017). Because of uncertainties in distinguishing two brocket deer species (*Mazama americana* and *M. gouazoubira*), two armadillo species (*Dasyopus novemcinctus* and *D. septemcinctus*), and the small cats

(*Leopardus guttulus* and *L. wiedii*) in some photographs, we pooled their respective records into three taxa, *i.e.*, *Mazama* spp., *Dasyopus* spp. and *Leopardus* spp. We followed Chiarello (2000a) in considering species with a body weight > 1 kg as a medium-bodied mammal, and Carbone *et al.* (1999) who defined large-bodied species as having body weights >20 kg. To assess risk/threatened status, we consulted the red list of the State of Espírito Santo (Passamani & Mendes 2007), the Brazilian red list (Ministério do Meio Ambiente 2014, ICMBio 2016) and the IUCN Red List (IUCN 2016).

b) Opportunistic records

We made opportunistic records from direct observations of medium and large-bodied mammals during camera-trapping fieldwork (average of five days for each month of monitoring) and two capture campaigns

aimed at the lowland tapir (in July and October 2015, each involving 15 days of fieldwork). For each event, we recorded the species, number of individuals, gender (when possible), time, locality and type of habitat where the species was observed. We received permits to conduct the study from SISBIO/Instituto Chico Mendes de Conservação da Biodiversidade (number 32565-5).

RESULTS

We recorded at least 21 mammal species, from nine orders and 17 families, in the RPPN Recanto das Antas and its surrounding areas, considering both camera trapping and opportunistic observations (Table 1 and Figures 2 and 3). In addition, two domestic (or invasive) species were also recorded during sampling: *Canis lupus familiaris* (Carnivora) and *Bos taurus*

(Cetartiodactyla) (Figure 4).

We captured at least 19 species using camera traps, seven of which were exclusively recorded by this method (Table 1): *Dasyurus novemcinctus*, *Euphractus sexcinctus*, *Herpailurus yagouaroundi*, *Leopardus* spp., *Procyon cancrivorus*, *Puma concolor*, and *Tamandua tetradactyla*. From a total of 2,149 trap days, we recorded 1,679 independent photographs, resulting in a total capture success of 78.1%. *Tapirus terrestris* was the species with the highest capture success (14.4%), followed by *Dasyprocta leporina* (11.4%) and *Mazama* spp. (9.4%). The species with the lowest capture success were the small wild cats of genus *Leopardus* (4.0%), *Euphractus sexcinctus* (3.0%), *Herpailurus yagouaroundi* (3.0%), *Puma concolor* (3.0%), and *Callicebus personatus* (1.0%). We recorded three independent photographs of domestic

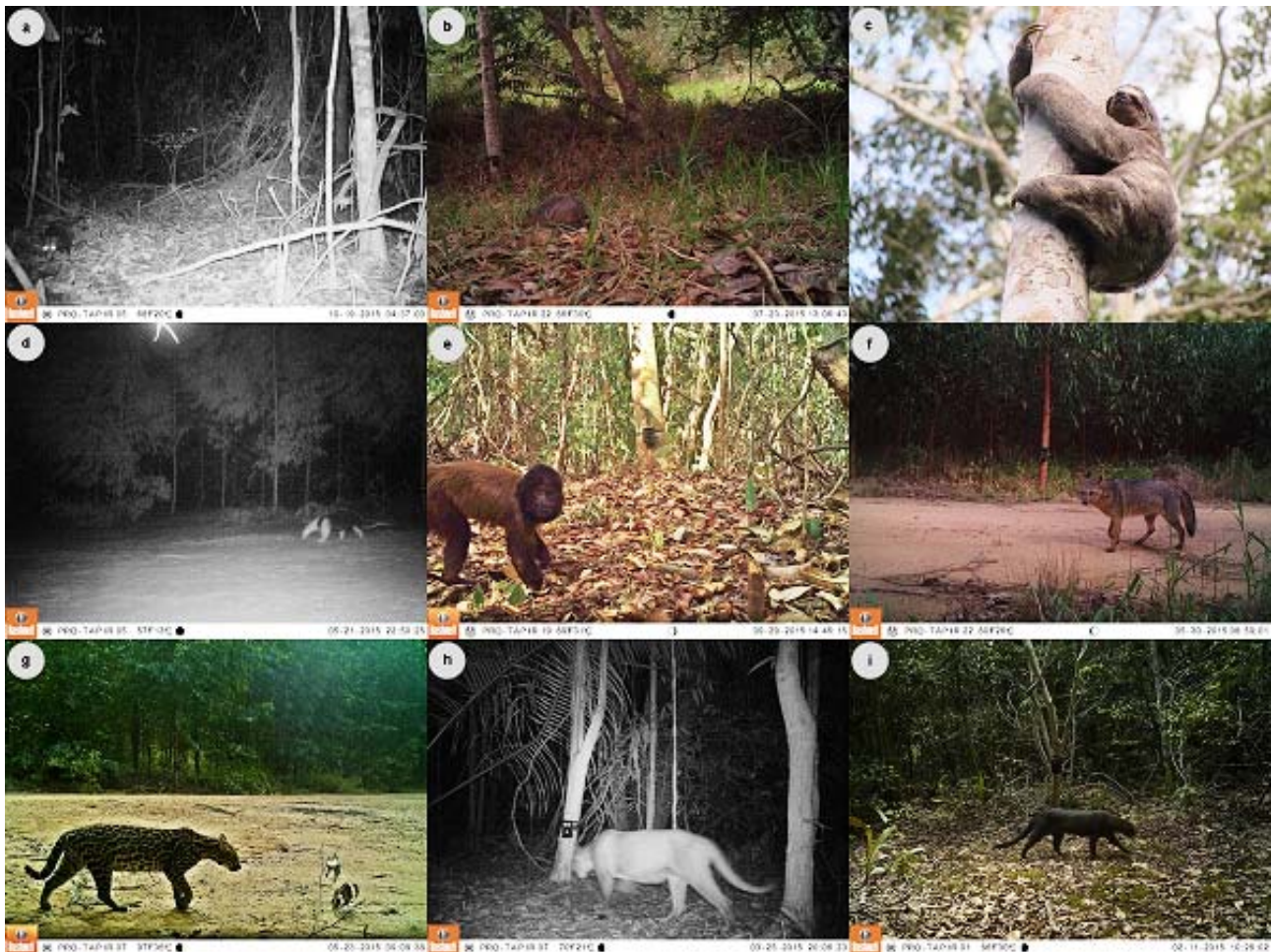


Figure 2. Mammal species recorded in the Private Reserve of Natural Heritage Recanto das Antas (RPPN Recanto das Antas) and its surroundings, municipality of Linhares, State of Espírito Santo, Brazil, from January to November 2015: *Didelphis aurita* (a); *Dasyurus novemcinctus* (b); *Bradypus variegatus* (c); *Tamandua tetradactyla* (d); *Sapajus robustus* (e); *Cercocyon thous* (f); *Leopardus pardalis* (g); *Puma concolor* (h); *Herpailurus yagouaroundi* (i).

dogs and five of cattle. The species accumulation curves showed sampling sufficiency after 33 sampling units (Figure 5). Our opportunistic observations yielded 16

species records, but only two species — *Bradypus variegatus* and *Sylvilagus brasiliensis* – were recorded exclusively by this method.



Figure 3. Mammal species recorded in the Private Reserve of Natural Heritage Recanto das Antas (RPPN Recanto das Antas) and its surroundings, municipality of Linhares, State of Espírito Santo, Brazil, from January to November 2015: *Eira barbara* (a); *Nasua nasua* (b); *Procyon cancrivorus* (c); *Pecari tajacu* (d); *Tapirus terrestris* (e); *Hydrochoerus hydrochaeris* (f); *Cuniculus paca* (g); *Dasyprocta leporina* (h).



Figure 4. Invasive species recorded in the Private Reserve of Natural Heritage Recanto das Antas (RPPN Recanto das Antas) and its surroundings, in Linhares, Espírito Santo, Brazil, from January to November 2015: *Canis lupus familiaris* (a); *Bos taurus* (b).

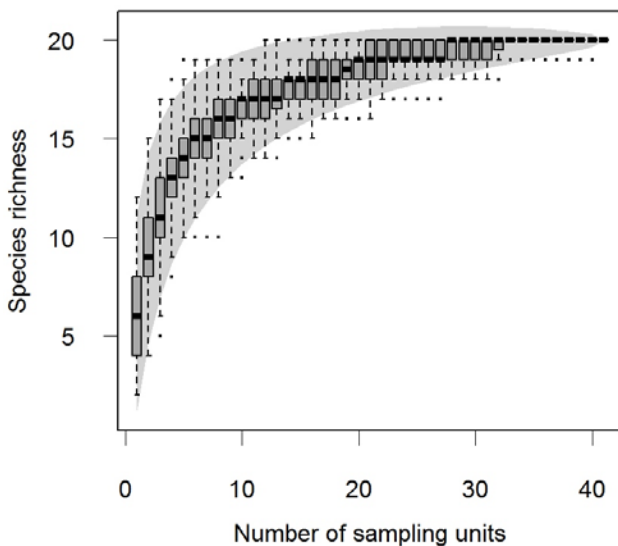


Figure 5. Species accumulation curves relating the number of species ($N = 21$) and the 42 sampled unities (*i.e.*, number of camera trap stations), showing the sampling sufficiency of the camera trap method, from January to November 2015, in the Private Reserve of Natural Heritage Recanto das Antas (RPPN Recanto das Antas) and its surroundings, municipality of Linhares, State of Espírito Santo, Brazil.

In total, eight of the recorded species are threatened with extinction based on state, national or international red lists. Seven of the species (Vulnerable = 5; Endangered = 2) are threatened with extinction in the State of Espírito Santo, five species (Vulnerable = 4; Endangered = 1) are at risk according to the Brazilian red list, and three are represented in the IUCN's threatened list (Vulnerable = 2; Endangered = 1) (Table 1). We recorded three endemic species of the Atlantic Forest—two primates, *Callicebus personatus* and *Sapajus robustus*, and a marsupial, *Didelphis aurita*.

DISCUSSION

The RPPN Recanto das Antas and its direct surrounding areas harbor about 32.0% of the medium and large-bodied terrestrial mammals of the Atlantic Forest (following Paglia *et al.* 2012) and 52.0% of that of the State of Espírito Santo (following Moreira *et al.* 2008). Previous fauna inventories carried out in different environments in Espírito Santo, including *restinga* (Venturini *et al.* 1996), lowland Ombrophilous Dense Forest (Chiarello 1999, Srбек-Araujo *et al.* 2014, Srбек-Araujo & Kierulff 2016), disturbed secondary forest (Passamani *et al.* 2005), and Montane and Sub-montane Atlantic Forest (Passamani *et al.* 2000, Srбек-Araujo & Chiarello 2005, 2007, Tonini *et al.* 2010, Gatti *et al.* 2014, Helder-José *et al.* 2016), recorded between 10 and 36 species of medium and large-bodied mammals. The region with the highest richness of medium and large-bodied wild mammals, recorded for the state, is the Linhares-Sooretama forest complex, which confirms the area as a priority for conservation of this group (see Galetti *et al.* 2009).

The number of mammal species we recorded for RPPN Recanto das Antas is a similar subset to that of VNR and SBR, in which 36 species of medium and large-bodied mammals have been reported, including species not recorded in the present study like *Alouatta guariba*, *Dasybus septemcinctus*, *Leopardus guttulus*, *Leopardus wiedii*, *Lontra longicaudis*, *Mazama americana*, *Mazama gouazoubira*, *Panthera onca*, *Potos flavus*, *Priodontes maximus*, and *Tayassu pecari* (Chiarello 1999, Srбек-Araujo *et*

al. 2014, Srbe-Araujo & Kierulff 2016). Therefore, we recorded at least 58.0% of the medium and large-bodied mammal species expected for the Linhares-Sooretama complex. Considering that our study area is located in the center of the Linhares-Sooretama complex, we expect that the number of mammals in RPPN Recanto das Antas is in fact higher than reported in this study, which reinforces the importance of RPPN Recanto das Antas in maintaining functional connectivity between the surrounding protected areas.

The presence of top predators within the study area, such as *Puma concolor*, indicates that RPPN Recanto das Antas still possesses a diversity of prey species and/or permits the movement of predators, such as large felids, that require large areas to survive (Carbone & Gittleman 2002, de la Torre *et al.* 2017). The growth and survivorship of individuals of many species, as well as their ability to move between forest fragments, can be influenced by the presence of other habitat patches and the type of landscape matrix (Saura *et al.* 2014).

We also recorded key seed-dispersing species in RPPN Recanto das Antas, such as *Callicebus personatus*, *Cerdocyon thous*, *Dasyprocta leporina*, *Pecari tajacu*, *Procyon cancrivorus*, *Sapajus robustus*, and *Tapirus terrestris*. Such species are important for plant recruitment and survival, and aid in forest regeneration (Gatti *et al.* 2006, Chapman & Russo 2007, Keuroghlian & Eaton 2008, Tobler *et al.* 2010, Pires & Galetti 2012, Bueno *et al.* 2013, Chalukian *et al.* 2013). Of particular importance is the lowland tapir, a megafrugivore that disperses the seeds of several plant species (Tobler *et al.* 2010, Bueno *et al.* 2013, Giombini *et al.* 2016).

The RPPN Recanto das Antas represents part of the last-remaining region of the State of Espírito Santo where iconic threatened mammalian species of the Atlantic Forest can still be found. For example, here, we report the occurrence of some threatened and endemic species of the Atlantic Forest in the complex, such as *Callicebus personatus*, *Puma concolor*, *Sapajus robustus*, and *Tapirus terrestris*. Chiarello (1999), Srbe-Araujo *et al.* (2014) and Srbe-Araujo & Kierulff (2016), also reported the presence of *Panthera onca*, *Priodontes maximus* and *Tayassu pecari*. Large herbivores and carnivores are generally the first mammal species to go locally extinct in Neotropical forests (Canale *et al.* 2012,

Dirzo *et al.* 2014, Ripple *et al.* 2015), because of their need for large home ranges and their intrinsic biological traits, such as naturally low densities and low reproductive rates (Cardillo *et al.* 2005).

For these reasons, RPPN Recanto das Antas is an important area for the medium and large threatened and endemic mammals in the Linhares-Sooretama complex. However, like other parts of the Atlantic Forest, RPPN Recanto das Antas is not free from threats. Several risks for the region have been reported, such as hunting, road-kill and conflict with farmers, all of which can increase the potential of regional extinctions (Chiarello 2000b, Flesher & Gatti 2010, Srbe-Araujo *et al.* 2014, Srbe-Araujo & Kierulff 2016, A. Gatti personal communication).

In addition, the presence of domestic species in the study area is an imminent threat. Domestic dogs and cattle can interact with the local fauna through competition, predation and pathogen transmission that can cause severe impacts on different species populations (Daszak *et al.* 2000, Delahay *et al.* 2001, Gortazar *et al.* 2007, Atickem *et al.* 2010, Hughes & Macdonald 2013, Kukielka *et al.* 2013). In some regions of Atlantic Forest, domestic/feral dogs are frequent visitors to natural forest fragments, including protected areas (Srbe-Araujo & Chiarello 2008, Lacerda *et al.* 2009, Paschoal *et al.* 2012, Gatti *et al.* 2014, Lessa *et al.* 2016). Given these several threats to the medium and large-bodied mammals of the Linhares-Sooretama complex, it is important not only to know the diversity of species in a given area, but also to monitor the threats to their populations.

The relevance of our results can be summarized as follows: (1) surveys of small or medium sized habitat patches that connect larger patches can provide important information on the presence of medium and large-bodied mammals in the overall landscape; (2) RPPN Recanto das Antas merits ecological studies to understand how its medium and large-bodied mammals use different habitats and move through its heterogeneous landscape, especially for species that typically have large home ranges; and (3) because several threats coincide in the study area, it is important to evaluate the adaptations of different species to the diverse anthropogenic pressures in the landscape, which could help to develop a sustainable wildlife management and conservation plan for RPPN Recanto das Antas and the surrounding protected areas.

Table 1. Medium and large-bodied mammals species recorded in the Private Reserve of Natural Heritage Recanto das Antas using the methods of sighting (SI) and camera trap (CT), including the number of independent records from camera traps (IR). Conservation status is provided at State (ES), national (BR) and global (IUCN) levels, considering the threat categories: LC = Least Concern; VU = Vulnerable; EN = Endangered. “Und.” = Undetermined. “-” = information not available.

Taxon	Method	IR	Conservation status		
			ES ¹	BR ²	IUCN ³
DIDELPHIMORPHIA					
Didelphidae					
<i>Didelphis aurita</i> *	CT, SI	25	-	-	LC
CINGULATA					
Dasypodidae					
<i>Dasypus novemcinctus</i>	CT	38	-	-	LC
<i>Dasypus</i> sp.	CT	68	-	-	-
<i>Euphractus sexcinctus</i>	CT	3	-	-	LC
Dasypodidae und.	CT, SI	16	-	-	-
PILOSA					
Bradyrodidae					
<i>Bradyrodus variegatus</i>	SI	-	-	-	LC
Myrmecophagidae					
<i>Tamandua tetradactyla</i>	CT	21	-	-	LC
PRIMATES					
Cebidae					
<i>Sapajus robustus</i> *	CT, SI	9	VU	EN	EN
Pitheciidae					
<i>Callicebus personatus</i> *	CT, SI	1	VU	VU	VU
CARNIVORA					
Canidae					
<i>Canis lupus familiaris</i>	CT, SI	3	-	-	-
<i>Cerdocyon thous</i>	CT, SI	108	-	-	LC
Felidae					
<i>Leopardus pardalis</i>	CT, SI	59	VU	-	LC
<i>Leopardus</i> spp.	CT	4	-	-	-
<i>Puma concolor</i>	CT	3	EN	VU	LC
<i>Herpailurus yagouaroundi</i>	CT	3	-	VU	LC
Mustelidae					
<i>Eira barbara</i>	CT, SI	9	-	-	LC
Procyonidae					
<i>Nasua nasua</i>	CT, SI	161	-	-	LC
<i>Procyon cancrivorus</i>	CT	34	-	-	LC
CETARTIODACTYLA					
Bovidae					
<i>Bos taurus</i>	CT, SI	5	-	-	-
Cervidae					
<i>Mazama</i> spp.	CT, SI	202	-	-	-
Tayassuidae					
<i>Pecari tajacu</i>	CT, SI	169	VU	-	LC
PERISSODACTYLA					
Tapiridae					
<i>Tapirus terrestris</i>	CT, SI	310	EN	VU	VU
RODENTIA					
Caviidae					
<i>Hydrochoerus hydrochaeris</i>	CT, SI	15	-	-	LC
Cuniculidae					
<i>Cuniculus paca</i>	CT, SI	177	-	-	LC
Dasyproctidae					
<i>Dasyprocta leporina</i>	CT, SI	244	VU	-	LC
LAGOMORPHA					
Leporidae					
<i>Sylvilagus brasiliensis</i>	SI	-	-	-	-

¹Threatened species at state level, following Chiarello *et al.* (2007); ²Threatened species at national level, following MMA (2014);

³Threatened species at global level, following IUCN (2016); *Endemic species.

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