

Medium and Large-sized Mammals in a Private Reserve of Natural Heritage in the Municipality of Jaú, São Paulo, Brazil

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ABSTRACT: Medium and large-sized mammals control invertebrate and vertebrate populations and are important seed dispersers. These animals are losing their territory and living range due to deforestation and the fragmentation of natural areas, particularly in the Atlantic Forest and Cerrado. The Private Reserve of Natural Heritage (PRNH) Amadeu Botelho is isolated from other forest fragments and is thus a wildlife refuge in the region of Jaú, central-western region of state of São Paulo, southeastern Brazil. Animals as such as the puma (*Puma concolor*), ocelot (*Leopardus pardalis*) and jaguarundi (*Puma yagouaroundi*) have been sighted in the reserve by wildlife guards and residents. This reserve, which belongs to "Santo Antônio dos Ipês" farm, is surrounded by several plantations, and is very close to the center of the city of Jaú. In addition to surveying the mammal species in the reserve, this study diagnosed the influence of the farm's activities and the proximity to the center of the municipality of Jaú on the fauna under study.

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INTRODUCTION

There are approximately 5,600 mammal species in the world, 701 of which are found in Brazil, *i.e.*, 12% of the all the world's mammal species. The species found in Brazil are divided into 12 orders (Paglia *et al.* 2012). The mammals found in the state of São Paulo comprise 231 species (32.9% of the Brazilian mammals), 206 except the cetaceans (de Vivo *et al.* 2011).

Medium and large-sized mammals play an important role in seed dispersal and population control of invertebrates and vertebrates. Mammalian predators such as the pumas (*Puma concolor* (Linnaeus, 1771)) and ocelots (*Leopardus pardalis* (Linnaeus, 1758)) are considered keystone species because they regulate prey populations and structure natural communities (Soulé 2000). Some are also considered umbrella species, because they require very large areas of land and are fundamental to the existence and survival of other species. These mammals can be used as indicator species in conservation planning and monitoring. Hence, maintaining viable populations of these species will also ensure the preservation of sufficient habitat for numerous other species that require smaller areas (Noss *et al.* 1997).

The Atlantic Forest biome, currently, only has 8.5% of forest remnants. Adding all the fragments of native forest above 3 ha, there are only 12.5% of the original area, which was 130 million ha. (Fundação SOS Mata Atlântica/ Instituto Nacional de Pesquisas Espaciais 2014).

Therefore, the few remaining forest fragments have great importance for conservation, and the fauna and

flora surveys are fundamental for the implementation of management plans and measures for the conservation of the biome.

The Amadeu Botelho Ecological Reserve (ERAB) is a Private Reserve of Natural Heritage (PRNH) that contains a preserved fragment of Atlantic Forest whose mammal fauna has yet to be thoroughly studied. Hence, the present study surveyed the mammalian fauna of the ERAB and evaluated the influence of the farm's plantations and its proximity to the urban center on these mammals.

MATERIALS AND METHODS

Study site

The study area is the Ecological Reserve Amadeu Botelho (ERAB), one Private Reserve of Natural Heritage (PRNH) created through the Ordinance No. 19 ICMBio (*Instituto Chico Mendes de Conservação da Biodiversidade*) in 2000. It is owned by the Santo Antonio Ipês farm located in the municipality of Jaú (22°18' S, 48°31' W), in the central-western region of the state of São Paulo, in southeastern Brazil. The farm was acquired by Arruda Botelho family in the late 19th century (Conselho Nacional da Reserva da Biosfera da Mata Atlântica 2008).

The farm grows various crops such as sugarcane, corn, sunflowers, oranges, as well as species of the genus *Cordia*, medicinal passion fruit, peaches and coffee. These plantations surround the entire forest fragment, giving it a clear cut and elongated appearance (Figure 1). Several dirt roads cut through these plantations, which are used to transport harvested crops. In addition, two roads cut



FIGURE 1. Aerial photo of Ecological Reserve Amadeu Botelho (ERAB), showing its elongated shape. Indicated in the figure are the Curumim, Cachoeira and João da Velha streams. Also shown is the Jaú river. Surrounding the ERAB are the different types of plantations.

through the forest fragment (Figure 2), serving only to link the plantations during harvest time, not being used during the rest of the year.

The reserve is a preserved remnant of Atlantic Forest containing approximately 190 ha of semi-deciduous forest, characterized by tall broad-leaved mesophilic trees, with a canopy varying in height from 15 to 20m, including the occurrence of emergent individuals (Adati 2001). More information about the flora of the region can be found in Souza and Veniziani-Jr (2012) and Kronka *et al.* (2005).

This is the most significant remnant of native forest existing in the municipality of Jaú, and one of the most important in the entire region (Conselho Nacional da Reserva da Biosfera da Mata Atlântica 2008). Albeit well preserved, the ERAB is located far away from other forest fragments and is virtually the only refuge for forest species within a radius of 30 kilometers. The forest fragment is a watershed, whose two extremes, (northwest-southeast direction), reach the Santo Antônio and João da Velha streams (Figure 1). These streams are tributaries of Jaú River (Figure 1), whose closest point to ERAB is 50 meters (Conselho Nacional da Reserva da Biosfera da Mata Atlântica 2008).

Data collection

Tracks, footprints and other signs are important indicators of the presence of a mammalian species in a given area (Borges and Tomás 2004). Thus, we used Borges and Tomás (2004) and Becker and Dalponte (1991) to identify the traces found in the work field. When the field guides were not enough to help in the recognition

of the most difficult tracks, these were measured, drawn, photographed and molded in plaster to make a more precise identification in the laboratory, compared to other materials (pictures database laboratory UNESP/FCA). The conservation status of the recorded species was based on the endangered species list of the state of São Paulo published by the Environment Secretariat of the State of São Paulo, Decree No. 60, 133, February 7, 2014.

Transects

An efficient method to search for animal tracks is the transect method (Pardini *et al.* 2003). Using this method, we walked along the roads that pass through the forest (Figure 2)



FIGURE 2. Roads that pass within the forest of ERAB (in red). Both are used exclusively in the transportation of production from the farm during harvest time, functioning as facilitators of the flow of harvests by connecting and bringing the plantations.



FIGURE 3. Stretch of road transect between cornfields of Santo Antonio dos Ipês Farm (Photo: Ricardo Reale).



FIGURE 4. Portion sand baited with banana (located in Group 2, Trail 1) (Photo: Ricardo Reale).

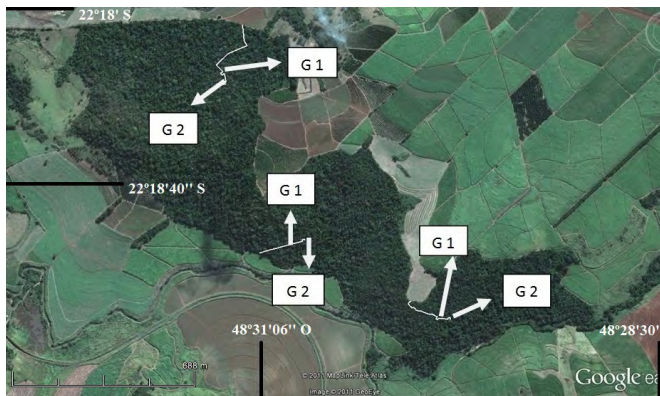


FIGURE 5. Map of trails and groups portions of sand. G1 = Group 1; G2 = Group 2.

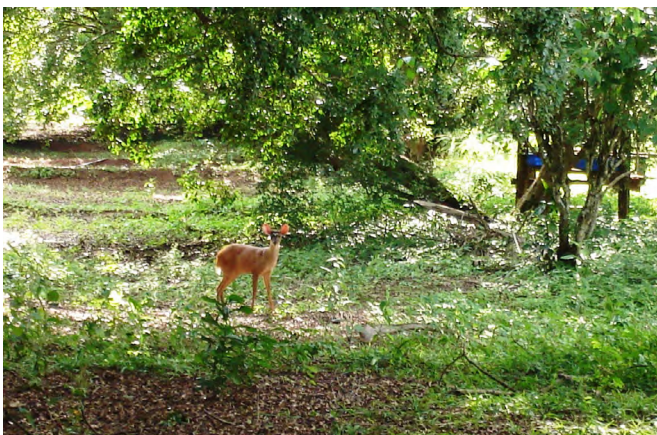


FIGURE 6. Brocket deer, *Mazama gouazoubira*, grazing along the orchard of Santo Antonio Ipês Farm (Photo: Ricardo Reale).

and through the plantations (Figure 3), which were traveled along on every day of fieldwork, covering a distance of 15 km per campaign day, and corresponding to 360 km of transect in four campaigns (28 days). We used this method to attempt to identify the animals that leave the forest and possibly use the plantations to feed on or shelter in.

Sand plots

To record the tracks of animals that rarely leave the forest, we used the sand plot technique. Each plot consists of a square of PVC pipe that delimits 0.80×0.80 m (that delimits an area of 0.64 m^2). This square is placed on the forest floor and about 3 to 4 cm of clear sand is placed inside it (Figure 4).

Three trails about 150 m long were made from the border of the forest into its interior. Two groups of sand plots were placed on each trail (Figure 5), each group comprising four plots spaced 10–15 m apart, forming a square on the forest floor, according to the unpublished method recommended by Nature Conservation Laboratory of UNESP's Department of Forest Sciences at Botucatu.

The border effect can cause changes in fauna, particularly in species with low tolerance for open areas (Laurance 1999). To minimize this problem, the first group of plots was placed at a distance of 100 meters from the border and the second group at 150 m from the border and 50 m from the first group. The trails were made as straight as possible.

Each day baits of bananas, mangos, papayas, avocados, bacon and pepperoni were placed on the sand plots. The plots of each group were baited with different types of food to prevent visits from the same animal on the same day. All plots were always baited with three equal pieces of baited. During the surveys 24 hours later, the baits were removed from the trail, so that only the new baits would attract animals. The baits were replaced every day.

On the first day of the campaign, the baits were placed on the plots and repairs made when necessary. On subsequent days, the baits were changed to attract a broader range of animals with different dietary preferences. In addition, the sand in the plots of each group had to be loosened, moistened and smoothed in order to create a suitable surface to record the tracks of animals visiting the plot. The tracks of the same species found on the same plots on different days of the campaign were considered as originating from different individuals. When footprints were found in the same group of plots on the same day, they were considered to belong to the same individual, and were therefore not counted again.

Camera traps

Five to eight camera traps (manufactured by Trapacamera, Brazil) were used at different sites: facing some of the sand plots inside the forest fragment; at forest borders; roadsides; at springs, water course and river banks; at transects between forest and plantations; and at transects within the plantations. The cameras, which were equipped with an infrared motion sensor, took pictures when the motion stopped. This method has been widely used in research of medium and large-sized mammals, as can be seen in the comparative study of photographic traps of Srbek-Araujo and Chiarello (2007).

Interviews

During the fieldwork, 10 of the farm's residents and employees were interviewed. A photo album of mammals was shown to the interviewees to help them correctly identify any species that had already been sighted by them within the boundaries of the farm. All interviewees had worked or lived in the farm for over 10 years. The interviews were conducted according to Alves (2009).

RESULTS

Twenty-six medium and large-sized species of mammals were recorded, distributed among 16 families and six orders. Table 1 lists the mammals recorded in the Amadeu Botelho Ecological Reserve, as well as their

regional conservation status.

The presence of *Chrysocyon brachyurus* (Illiger, 1815), a species typical of environments with open vegetation (Dietz 1985), is possibly a result of the recent expansion of the species in response to the transformation of Atlantic Forest areas into pastureland and agricultural areas. Further evidence is the fact that the reserve be located in an ecotone between Atlantic Forest and Cerrado, the latter area, typical of maned wolf.

The presence of five endangered species in the ERAB is an indicative of the importance of this area for conservation. The staff of the farm is always on the watch, to prevent hunters from entering the reserve, and always camouflaging the entrances to trails to conceal them and

TABLE 1. List of animals found in ERAB, English common name, type of record, and conservation status, based on the state of São Paulo red list. Forms of records: I = interviews, T = tracks on transects or plots, S = sighted. Level of threat: E = Endangered, NT = Near Threatened, DD = Data Deficient.

CLASSIFICATION	COMMON NAME	RECORD	CONSERVATION STATUS
ORDER ARTIODACTYLA			
FAMILY CERVIDAE			
<i>Mazama gouazoubira</i> (G. Fischer [von Waldheim], 1814)	brocket deer	I, T, S	
ORDER CARNIVORA			
FAMILY CANIDAE			
<i>Cerdocyon thous</i> (Linnaeus, 1766)	crab-eating fox	I, T	
<i>Chrysocyon brachyurus</i> (Illiger, 1815)	maned wolf	T	E
<i>Lycalopex vetulus</i> (Lund, 1842)	hoary fox	T	E
FAMILY FELIDAE			
<i>Leopardus pardalis</i> (Linnaeus, 1758)	ocelot	I, T	E
<i>Leopardus</i> sp. (Schinz, 1821)	Neotropical spotted cat	I, T	E
<i>Puma concolor</i> (Linnaeus, 1771)	puma, cougar	I, T	E
<i>Puma yagouaroundi</i> (É. Geoffroy Saint-Hilaire, 1803)	jaguarundi	I, T	
FAMILY MEPHITIDAE			
<i>Conepatus</i> sp. Gray, 1837	hog-nosed skunk	I, T	DD
FAMILY MUSTELIDAE			
<i>Eira barbara</i> (Linnaeus, 1758)	tayra	I, T	
<i>Galictis cuja</i> (Molina, 1782)	ferret	I, T	ND
<i>Lontra longicaudis</i> (Olfers, 1818)	otter	T	NT
FAMILY PROCYONIDAE			
<i>Nasua nasua</i> (Linnaeus, 1766)	coati	I, T, S	
<i>Procyon cancrivorus</i> (G. [Baron] Cuvier, 1798)	raccoon	I, T	
ORDER LAGOMORPHA			
FAMILY LEPORIDAE			
<i>Sylvilagus brasiliensis</i> (Linnaeus, 1758)	tapeti	I, T, S	DD
ORDER PRIMATES			
FAMILY CEBIDAE			
<i>Sapajus nigritus</i> (Goldfuss, 1809)	black capuchin monkey	I, T, S	
ORDER RODENTIA			
FAMILY CUNICULIDAE			
<i>Cuniculus paca</i> (Linnaeus, 1766)	paca	I, T	NT
FAMILY DASYPROCTIDAE			
<i>Dasyprocta azarae</i> Lichtenstein, 1823	agouti	T	
FAMILY ERETHIZONTIDAE			
<i>Sphiggurus villosus</i> (F. Cuvier, 1823)	orange-spined hairy dwarf porcupine	T	
FAMILY HYDROCAERIDAE			
<i>Hydrochoerus hydrochaeris</i> (Linnaeus, 1766)	capibara	I, T	
FAMILY MYOCASTORIDAE			
<i>Myocastor coypus</i> (Molina, 1782) *	nutria	T	DD
FAMILY SCIURIDAE			
<i>Guerlinguetus ingrami</i> (Thomas, 1901)	Brazilian squirrel	I, T, S	
ORDER XENATHRA			
FAMILY DASYPODIDAE			
<i>Cabassous</i> sp. McMurtrie, 1831	naked-tailed armadillo	T	
<i>Dasybus novemcinctus</i> Linnaeus, 1758	nine-banded armadillo	T	
<i>Euphractus sexcinctus</i> (Linnaeus, 1758)	six-banded armadillo	I, T	
FAMILY MYRMECOPHAGIDAE			
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)	collared anteater	I	
Total	26		E = 5; NE = 2; ND = 4

* Exotic species

hindering the access of unauthorized people to the forest.

Several animals were sighted during the field work, and whenever possible, photographs were taken. *Mazama gouazoubira* (G. Fischer [von Waldheim], 1814) (Figure 6), *Sapajus nigritus* (Goldfuss, 1809) (Figure 7), *Guerlinguetus ingrami* (Thomas, 1901) (Figure 8) and *Nasua nasua* (Linnaeus, 1766) were sighted (Figure 9).

Sand plots

Sixty-two footprints were recorded (considering each footprint to represent a single individual animal), and 11 tracks were from different mammal species, representing 42.30% of the total species found in ERAB. Three species were found solely by this method, representing 11.54% of the total species of ERAB, namely: *Dasyprocta azarae* Lichtenstein, 1823 (Although it is not possible to identify to species level only by trail, we reach this level by its geographic distribution, as Catzefflis *et al.* (2008)), *Myocastor coypus* (Molina, 1782) (exotic species in São Paulo) e *Sphiggurus villosus* (F. Cuvier, 1823). Although these species are small, they left tracks on the sand plots and were therefore easily recognized.

Table 2 lists the species recorded, the number of tracks of each species on each trail, and the frequency with which each species was recorded in ERAB, using the sand plot method.

The black-horned capuchin monkey was present on all the trails and in other areas of the farm. Three groups of these monkeys were recorded in the ERAB, each containing

an average of 14 individuals. This may explain the high frequency of records of black-horned capuchin on the plots. During the harvest season, the farm's workers and residents often see these monkeys feeding on sugarcane, corn and peaches.

It was found that the records of *S. nigritus* in sand plots decreased as the stages of the crops planted on the farm advanced. Its records were more frequent during harvest time in September/October, due to the easy access to food on the sand plots. In October groups of capuchin monkey were also sighted on the north side of the fragment, which faces the peach orchards.

The armadillos *Dasyus novemcinctus* Linnaeus, 1758 and *Euphractus sexcinctus* (Linnaeus, 1758) dens were found on trail 2, close to the sand plots, explaining the higher frequency of records of these animals on the trail. The differentiation of armadillo species was performed by comparing the entrances size of the burrows, according to Becker and Dalponte (1991) and Borges and Tomás (2004). Furthermore, the records of these armadillos occurred in sand plots near the burrows, and by comparing the size of the footprints and of the burrows, we were able to infer the species of armadillo.

Three species were identified exclusively on trail 1: *Procyon cancrivorus* (G. [Baron] Cuvier, 1798), *Myocastor coypus* and *Sphiggurus villosus*, with the last two identified exclusively by the sand plot technique. *Cuniculus paca* (Linnaeus, 1766) was identified exclusively on trail 3, but trail 2 did not present exclusive visitors. All the trails were



FIGURE 7. Black-horned capuchin, *Sapajus nigritus*, sighted near track 2, which lies between forests and plantations (Photo: Ricardo Reale).



FIGURE 9. Coati, *Nasua nasua*, sighted on the main road from the farm, located between forest and plantation. It was seen foraging along the border of the forest and plantation (Photo: Ricardo Reale).



FIGURE 8. Brazilian squirrel, *Guerlinguetus ingrami*, sighted in the Curumim environmental education school (Photo: Ricardo Reale).



Figure 10. Capybara, *Hydrochoerus hydrochaeris*, caught by camera trap installed nearby reforestation area of the Jaú river (Photo: Ricardo Reale).

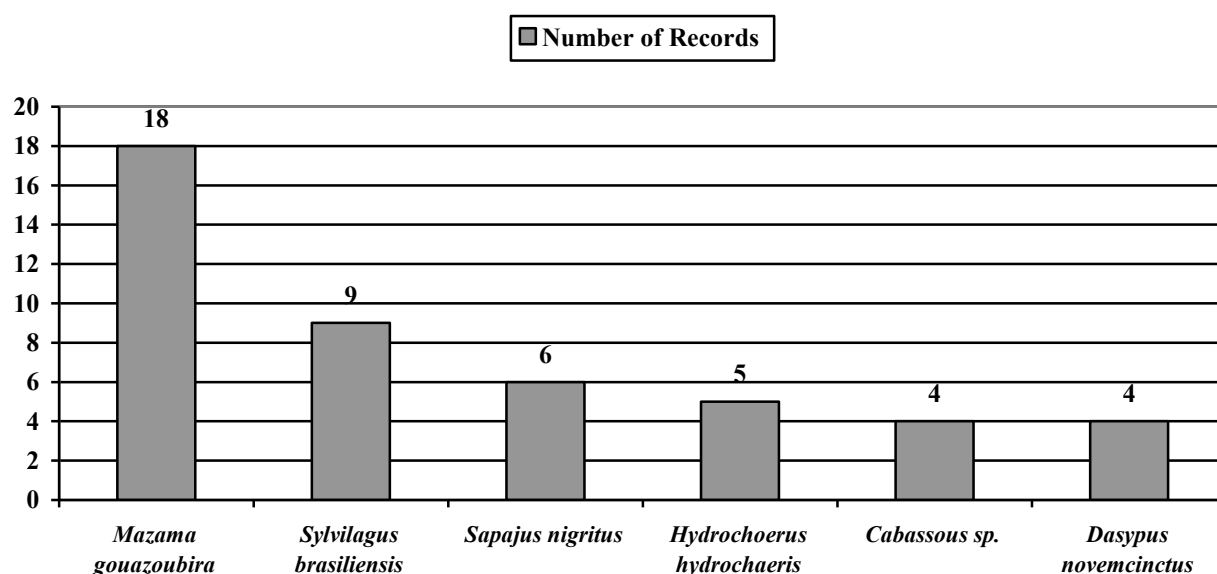
TABLE 2. Number of footprints and respective frequency of records (FR) of each species on trails 1, 2 and 3. Also shown is the total number of samples (number of sand plots visited by animals)

SPECIES	TRAIL 1	TRAIL 2	TRAIL 3 *	TOTAL	FR [†] (%)
<i>Sapajus nigritus</i>	10	12	3	25	40.32
<i>Dasybus novemcinctus</i>	1	7	1	9	14.52
<i>Dasyprocta azarae</i> [‡]	7	-	1	8	12.9
<i>Euphractus sexcinctus</i>	-	4	1	5	8.06
<i>Galictis cuja</i>	-	2	2	4	6.45
<i>Eira barbara</i>	-	1	2	3	4.84
<i>Procyon cancrivorus</i>	2	-	-	2	3.23
<i>Sylvilagus brasiliensis</i>	1	1	-	2	3.23
<i>Cuniculus paca</i>	-	-	2	2	3.23
<i>Myocastor coypus</i> [‡]	1	-	-	1	1.61
<i>Sphiggurus villosus</i> [‡]	1	-	-	1	1.61
Total records	23	27	12	62	100
Total sampled	192	192	48	432	14.35

* Due to heavy rains in May, trail 3 was damaged, leading to the loss of all the sand plots. Therefore, the results of trail 3 shown in this table correspond only to the February campaign.

[†] FR = frequency of records

[‡] Species recorded only on sand plots

**FIGURE 11.** Number (N) of footprints of the six mammals most commonly found in the transects of ERAB from Jaú.

equivalent in terms of the number of species, with trails 1 and 3 presenting seven species and trail 2 presenting six species.

There is a small water spring that passes by group two on Trail 3. The presence of this spring presumably influenced the occurrence of the lowland paca this trail, since this stream flows into Cachoeira Stream, a tributary of the Jaú River. Next to this tributary is an artificial lake that supplies the city of Jaú, accounting for 30% of the city's water supply (SAEMJA – Jaú Municipal Water and Sewer Service), where local residents claim to have sighted lowland pacas in previous years. However, according to the 10 interviewees, this species has not been sighted in the ERAB for several (~5) years.

TRANSECTS

The transect lines were chosen randomly along the roads on the farm (inside the forest and plantations) before and after examining the sand plots, and 92 animal tracks, over 21 different species of terrestrial mammals of medium and large-sized were recorded for this method. This record represents 80.77% of mammals of

medium and large sized found in ERAB.

The most frequent species recorded were *Mazama gouazoubira* (N=18), *Sylvilagus brasiliensis* (N=9), *Sapajus nigritus* (N=6), *Hydrochoerus hydrochaeris* (N=5), and *Cabassous sp.* and *Dasybus novemcinctus* (N=4 each).

The mammals most frequently recorded on the transect of ERAB, representing the species whose tracks were recorded at least four times (Figure 11).

Mammal richness was more concentrated between the forest and the Jaú River, in the region of the reserve is located farthest away from the city center. This part of the reserve is situated at about 20 meters from the river. On this side of the forest there are also two streams, Cachoeira and João da Velha, both of which are tributaries the Jaú River. Streams can act as ecological corridors between the forest and river, and the Jaú River may also work as an ecological corridor, connecting the ERAB with small fragments near it.

From the tracks found along the plantation roads, it was assumed that the species that make the most use of crops are *M. gouazoubira*, *S. nigritus*, *S. brasiliensis* and *Cabassous sp.* Along the transects between the planted

fields, this deer was also the most recurrent species, with eight records, i.e., almost half of this fauna found on the transects between plantations.

The species *D. novemcinctus*, *E. sexcinctus*, *Lycalopex vetulus* (Lund, 1842), *M. gouazoubira*, *C. paca* and *S. nigritus* were recorded along the forest transects (Figure 2). These species were found along the transect line of the Cachoeira's streams road. Only *S. nigritus* was recorded visually on the road close to trail 1.

Camera traps and interviews

The camera traps recorded only groups of *Sapajus nigritus* and an individual of *Hydrochoerus hydrochaeris* (Figure 10).

The interviews revealed that much of the fauna of the reserve lives in the forest of the ERAB, since felines such as *Puma yagouaroundi*, *Puma concolor* and *Leopardus pardalis* are commonly sighted. In addition to *H. hydrochaeris*, *D. novemcinctus*, *S. nigritus*, *M. gouazoubira*, *Procyon cancrivorus* and *Nasua nasua* are also frequently sighted.

Lontra longicaudis (Olfers, 1818) and *Galictis cuja* (Molina, 1782) were species less recognized by the interviewees, indicating that they are rarely sighted. *Chrysocyon brachyurus* and *Cabassous* sp. had never been sighted in the ERAB.

Long-time residents, who have lived there since the childhood, last sighted *Dasyprocta azarae* over 20 years ago. *Tamandua tetradactyla* (Linnaeus, 1758) was sighted a few times about a year ago (mid-2010) but has not been seen since then, not even its tracks (V.S. Uieda personal communication). This may indicate that this species no longer lives in the reserve, or that the sampling effort to find it was insufficient.

DISCUSSION

When comparing this study with others surveys of equal content, conducted in the Atlantic biome of São Paulo, as Dotta (2005), Carvalho (2011) and De-Vivo (2011), it is shown that the Amadeu Botelho Ecological Reserve has a rich fauna of medium and large-sized mammals, indicating that the forest fragment has a good state of preservation and conservation.

It therefore serves as a refuge for wildlife species at risk of extinction, which are classified as Vulnerable, such as *Chrysocyon brachyurus*, *Lycalopex vetulus*, *Leopardus pardalis*, and *Puma concolor*; as endangered: *Leopardus* sp. Other four species are classified of Near Threatened: *Lontra longicaudis*, *Sapajus nigritus*, *Cuniculus paca*, *Dasyprocta azarae*.

According to the interviews, *C. paca* has not been sighted for several years. However, three footprints were recorded in this study (one on a sand plot and two along the transects), indicating that this species still exists in the reserve, as do most of the mammals living in the ERAB, in low population densities.

The farm's activities also influence the dispersal of mammals on the farm and in the forest, and the fact that the southeast region of the reserve is less frequented at certain times of the year explains why they are in little evidence. This may be one of the reasons for the concentration of species richness in the southeastern of the reserve. Only the most generalist species were found in the region of the

reserve that faces only the plantations, such as *Mazama gouazoubira*, *Sylvilagus brasiliensis* and *Sapajus nigritus*, which are the ones that make the most use of the farm's crops, or that are most frequently found in the plantations.

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