



Mammals of the Saracá-Taquera National Forest, northwestern Pará, Brazil

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Abstract: The Amazonian rainforest harbors one of the most diverse mammal faunas found anywhere in the world, although this fauna is still poorly known. Inventories are essential for the understanding of the biology and ecology of species, and provide basic data for conservation. Over 15 years of sampling in the Saracá-Taquera National Forest, we recorded 72 species of small (nonvolant), medium, and large mammals belonging to 30 families in 10 orders. These taxa included 29 species endemic to the Amazon biome, and 14 classified as threatened with extinction. Overall, the mammalian species richness recorded in the present study was equal to or greater than that recorded in other Amazonian studies, reflecting high levels of diversity on a biogeographic scale. This reinforces the importance of this national forest for the maintenance of the region's mammalian fauna. Some of the species were recorded in the region for the first time, thus extending their known geographic distribution.

Keywords: *Trombetas, Oriximiná, Amazonia, species richness, environmental monitoring, species list.*

Mamíferos da Floresta Nacional de Saracá-Taquera, Pará, Brasil

Resumo: A floresta amazônica abriga uma das maiores riquezas de mamíferos do mundo. Entretanto, existe pouco conhecimento sobre a fauna local. Estudos de levantamentos podem contribuir para o incremento no conhecimento sobre a biologia e a ecologia das espécies e são a base para a conservação. Ao longo de 15 anos de amostragem, nós registramos 72 espécies de pequenos, médios e grandes mamíferos pertencentes a 10 ordens e 30 famílias, das quais 29 espécies são endêmicas da Amazônia e 14 são também consideradas ameaçadas de extinção. No geral, a riqueza de mamíferos foi igual ou superior ao de outros estudos conduzidos no bioma, indicando uma alta diversidade em escala biogeográfica. Os resultados mostram a importância desses ambientes para a manutenção das espécies. Algumas tiveram seu primeiro registro para a área e outras a ampliação da sua área de distribuição.

Palavras-chave: *Trombetas, Oriximiná, Amazônia, riqueza, monitoramento ambiental, lista de espécies.*

Introduction

Recent studies (Wilson and Reeder 2005; Paglia et al. 2012) have estimated that approximately 700 mammal species occur in Brazil, of which, at least 399 are present in the Amazon biome. This is the most diverse mammalian fauna of any equivalent region in South America. Even so, the number of species found in the Amazon continues to grow, as new species are described, including primarily primates, bats and small rodents (Gualda-Barros et al. 2012; Mittermeier et al. 2013; Dalponte et al. 2014; Oliveira et al. 2016; Pavan et al., 2017; Voss et al. 2018).

Mammals play a great variety of roles in the ecosystems in which they are present (Keuroghlian and Eaton 2009; Haugassen et al. 2010; Desbiez et al. 2013). Marsupials and rodents, in particular, influence

the ecological dynamics of Neotropical forests through seed predation and dispersal, as well as the dispersion of mycorrhizal fungi (Brewer and Rejmánek 1999, Mangan and Adler 1999, 2000). Larger-bodied mammals disperse over longer distances and are important in the acquisition and redistribution of nutrients and seeds within the landscape, as well as participating in the control of populations through predation (Asquith et al. 1999; Fragoso et al. 2006; Stoner et al. 2007). Given this, some mammals are considered to be bioindicator species, given their specific habitat and microhabitat preferences or requirements (Vieira and Monteiro-Filho 2003; Cullen-Jr. et al. 2005; Pardini and Umetsu 2006; Morrison et al. 2007).

Overall, 15.7% of Brazilian mammals are classified as threatened, and at least 10% of these species are found in the Amazon (Costa et al. 2005; Paglia et al. 2012; MMA 2014). The Amazon is the largest forest

formation in Brazil, and one of the most biodiverse ecosystems in the world (Mittermeier et al. 2003). However, its unique and complex environments and biota are being increasingly impacted by a range of anthropogenic disturbances, which affect the populations of large numbers of species (Peres and Lake 2003; Benchimol and Venticinque 2014; Antunes et al. 2016).

The mammalian fauna of the Amazon has only been well documented at a few localities, and most inventories are preliminary and incomplete (Voss and Emmons 1996; Peres 2005). This deficiency is related primarily to the vast size of the biome, and its many remote and inaccessible areas, which are hard to reach, and extremely difficult to survey, even in a minimally adequate fashion (Silveira et al. 2003; Peres and Lake 2013). Given this, many areas should be considered to be of high priority for surveys, especially given the importance of occurrence data for other types of ecological study, and in particular conservation planning (Margules and Pressey 2000; Peres 2005).

Saracá-Taquera National Forest (STNF), located in northwestern Pará, Brazil, was created by federal decree number 98,704 of December 27th, 1989, and has an area of 429,600 ha. Most studies of the mammalian populations of this protected areas have been conducted since early 2000, with the primary aim of monitoring and evaluating the response of local populations to environmental disturbance, in particular, the loss of habitat, and assessing species resilience (Calaça 2014). The management plan of STNF (STCP 2001) listed 58 species of terrestrial, aquatic, and semiaquatic mammals. In subsequent years, however, a number of additional species have been recorded, and the inventory was revised and the list of management plan updated (Gomes et al. 2014). Given their ecological and morphological differences, mammals can be allocated to three principal groups: “small flying mammals”, “small non-volant mammals” and “medium and large mammals”, with the latter two groups being the focus of the present study. The main objective of the present study was to update the list of mammalian species known to occur in the Saracá-Taquera National Forest, based on an ecological and conservationist approach, based on three long-term surveys conducted between 2009 and 2015.

Materials and Methods

1. Study area

The study area is located within the Saracá-Taquera National Forest (STNF), which is distributed among the neighboring municipalities of Oriximiná, Faro, and Terra Santa, in northwestern Pará (01°40' S, 56°00' W), a state in northern Brazil. STNF is formed predominantly by dense rainforest, interspersed with areas of alluvial forest, blackwater swamp (igapó), and, to a lesser extent, campinarana scrub (Gomes et al. 2014). The region's climate is of Köppen's *Am* type, with rainy summers and dry winters, mean annual precipitation of approximately 2200 mm, and temperatures of 20–35°C (Parrota et al. 1997). STNF area is rich in bauxite, which is being mined by a consortium of companies known as Mineração Rio do Norte (MRN), which operates on a small number of the plateaus found within the area of the national forest. In the present study, we sampled 12 plateaus, known locally as: Almeidas, Aviso, Aramã, Bacaba, Bela Cruz, Cipó, Greig, Monte Branco, Papagaio, Periquito, Saracá, and Teófilo (Figure 1).

2. Data collection and analysis

To compile the species list, we used primarily data from three surveys, conducted in 2009–2010, 2010–2012, and 2015. During these surveys, different approaches were used to sample small rodents and marsupials, and medium- and large-sized mammals (Silveira et al. 2003; Ribeiro and Melo 2013; Bovendorp et al. 2017) and, given this, the results are presented separately. The species richness is presented as the number of species recorded during any given period, independently of indices of biodiversity.

3. Small non-volant small mammals

During the three study periods, from from 2009 to 2015, we trapped small mammals in both rainy and dry seasons, focusing on the tropical rainforest in three topographies, plateau, slope, and valley bottom. Two types of trap were used, metal live traps (Tomahawk and Sherman) and pitfall traps. Captured specimens were identified using Patton et al. (2000, 2015), Bonvicino et al. (2008), and Rossi et al. (2010). Specimens were allocated to either the order Didelphimorphia (family Didelphidae) or the Rodentia (Cricetidae, Echimyidae and Scuridae). The sampling effort is presented in Table 1.

4. Medium and large mammals

Medium and large mammals, were surveyed by line transect, with individual transects varying in length from 500 m to 4000 m. In all three study periods, surveys were conducted during the day, in the morning (7:00–11:00 h) and afternoon (13:00–17:00 h), and at night, between 19:00 h and 22:00 h. Whenever an animal was visualized or some other evidence was detected, a standard set of data was compiled, including the identification of the species, the type of record, the number of individuals, the time and the location on the transect, and the geographic coordinates. Whenever possible, the animal or vestige were photographed.

To complement these data, we installed two to eight camera traps on each transect, which remained active for six to 20 days, depending on the duration of the fieldwork. During the first period, a trap was installed at each end of the trail on the 500-m transects. During the second period, four traps were installed at 50 m, 100 m, 250 m, and 500 m along the transect, to evaluate the influence of edge effects, while in the third period, the traps were installed at 1000-m intervals along the 4000 m transect. The camera traps were installed on tree trunks, 30 cm above the ground, and were baited with fruit, bacon and/or sardines, to maximize the chances of animals visiting the sites. The sampling effort for each period is shown in Table 1. Species were identified based on Paglia et al. (2012), with the nomenclature updated to include *Cingulata* and *Cetardiodactyla* (Montgelard et al. 1997; Delsuc et al. 2016).

To guarantee as complete an inventory as possible, in addition to the field surveys, records of mammals were gleaned from published studies and other records obtained during fieldwork at STNF, including interviews, although the interview data should obviously be treated with caution. These data were not included in the analyses. The trapping and transect data were grouped for the plotting of species accumulation curves using the first-order Jackknife method, run in EstimateS 8.20 (Heltshel and Forrester 1983; Colwell 2009).

Mammals of Saracá-Taquera, Brazil

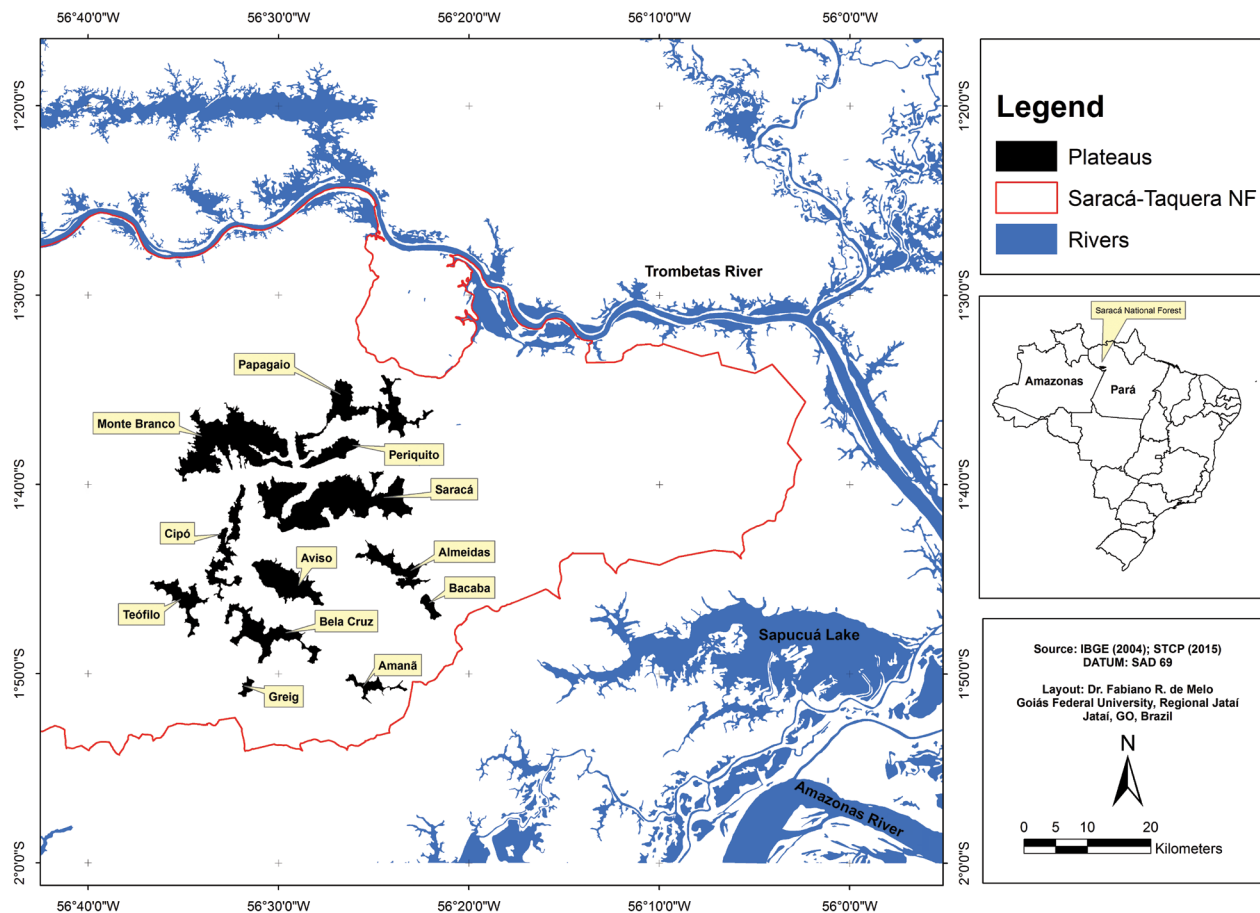


Figure 1. Location of the Saracá-Taquera National Forest and the sample sites, in the state of Pará, Brazil.

Table 1. Sampling effort employed in the three periods of studies to search for small, medium and large mammals at Saracá-Taquera National Forest, Pará.

	Sampling		
	2009-2010	2010-2012	2015
Effort (trap/night)	24.960	63.168	20.160
Census (km)	642	1.176	384
Cameras/day	4.388	5.232	2.304

Results

Over the 15 years of the study period, we recorded 72 species of small, medium and large mammals in the Saracá-Taquera National Forest (Table 2, Figures 2, 3), of which, five were recorded during interviews with local residents. The composition of the mammalian community was extremely diverse, and included representatives of 30 families and 10 orders. The most diverse orders were the rodents, with 16 species, followed by the carnivores, with 14 species, and the primates and marsupials, with 10 species each (Table 2).

Species accumulation curves for the trapping data, i.e., small non-volant mammals (Figure 4A), and the line transect data, i.e., medium-large mammals (Figure 4B) both reached the asymptote, indicating that the sampling effort employed was sufficient for the

registration of the majority of the species that occur in the study area. The accumulation curve for the cameras trap data (Figura 4C) was still following an upward trend, however, indicating that additional species would likely be added, with increased sample effort.

Discussion

Five of the 72 species recorded in the present study were confirmed only by interviews with local residents. While the data are important as complementary records, they must be treated with extreme caution, especially as some of the species cited may not actually occur in the region. In a review of the records of the Pilosa and Cingulata from the Saracá-Taquera National Forest, for example, Oliveira et al. (2006) found that some of the species cited, such as the Brazilian three-banded armadillo (*Tolypeutes tricinctus* (Linnaeus, 1758)) are typical of other biomes, such as the semi-arid Caatinga, and are unlikely to be found in the northern Amazon basin. Similarly, while the six-banded armadillo (*Euphractus sexcinctus* (Linnaeus, 1758)) has been recorded in interviews, and listed in technical reports, it has never been recorded during fieldwork (Oliveira et al. 2006). Also, the occurrence of two primates, *Cebus olivaceus* (Schomburgk, 1848) and *Aotus trivirgatus* (Humboldt, 1812), in the STNF has been confirmed

Table 2. List of mammal species recorded in Saracá-Taquera National Forest, northwest of State Pará, Brazil. Type of record: VO = visual observation, V = vocalization, T = track, F = feces, B = burrow, C = carcass, CT = camera trap, LT = live trap, PT = pitfall trap, I = interview. Global (IUCN 2016), National (MMA 2014) and Regional (Pará 2006) threat category. EN = Endangered, VU = Vulnerable; NT = Near Threatened and DD = Data Deficient.

TAXON	COMMON NAME	TYPE OF RECORD	CONSERVATION STATUS		
			Global	National	Regional
Order Didelphimorphia					
Family Didelphidae					
<i>Caluromys philander</i> (Linnaeus, 1758)	Bare-tailed Woolly Opossum	LT			
<i>Didelphis imperfecta</i> (Mondoli & Pérez-Hernández, 1984)	Guianan White-eared Opossum	LT			
<i>Didelphis marsupialis</i> (Linnaeus, 1758)	Common Opossum	LT, PT			
<i>Gracilinanus emiliae</i> (Thomas, 1909)	Emilia's Gracile Opossum	PT	DD		
<i>Marmosa murina</i> (Linnaeus, 1758)	Linnaeus's Mouse Opossum	LT, PT			
<i>Marmosops parvidens</i> (Tate, 1931)	Delicate Slender Mouse Opossum	LT, PT			
<i>Metachirus nudicaudatus</i> (E. Geoffroy, 1803)	Brown Four-eyed Opossum	LT, PT			
<i>Marmosa demerarae</i> (Thomas, 1905)	Woolly Mouse Opossum	LT, PT			
<i>Monodelphis arlindoi</i> (Pavan, Rossi & Schneider, 2012 Erxleben, 1777)	Short-tailed opossums	LT, PT			
Philander opossum (Linnaeus, 1758)	Gray Four-eyed Opossum	LT			
Order Cingulata					
Family Chlamyphoridae					
<i>Cabassous unicinctus</i> (Linnaeus, 1758)	Southern Naked-tailed Armadillo	VO, CT, T, B, C, PT			
<i>Euphractus sexcinctus</i> (Linnaeus, 1758) ¹	Yellow Armadillo	I			
<i>Priodontes maximus</i> (Kerr, 1792)	Giant Armadillo	VO, CT, T, B	VU	VU	VU
Family Dasypodidae					
<i>Dasypus novemcinctus</i> Linnaeus, 1758	Nine-banded Armadillo	VO, CT, T, B, C			
<i>Dasypus kappleri</i> Kraus, 1862	Greater Long-nosed Armadillo	VO, CT, T, B			
<i>Dasypus septemcinctus</i> Linnaeus, 1758	Brazilian Lesser Long-nosed Armadillo	VO			
Order Pilosa					
Family Bradypodidae					
<i>Bradypus tridactylus</i> Linnaeus, 1758	Pale-throated Three-toed Sloth	VO, C			
Family Megalonychidae					
<i>Choloepus didactylus</i> (Linnaeus, 1758)	Two-toed Sloth	VO			
Family Cyclopedidae					
<i>Cyclopes didactylus</i> (Linnaeus, 1758)	Silky Anteater	VO, PT			
Family Myrmecophagidae					
<i>Myrmecophaga tridactyla</i> Linnaeus, 1758	Giant Anteater	VO, CT, T	VU	VU	VU
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)	Southern Tamandua	VO, CT, T			
Order Primates					
Family Aotidae					
<i>Aotus trivirgatus</i> (Humboldt, 1811) ²	Northern Night Monkey	I			
Family Atelidae					
<i>Allouatta macconnelli</i> Elliot, 1910	Guianan Red Howler Monkey	VO, V, F, C			
<i>Ateles paniscus</i> (Linnaeus, 1758)	Guiana Spider Monkey	VO, V, F, C	VU	EN	

Continuation Table 2.

TAXON	COMMON NAME	TYPE OF RECORD	CONSERVATION STATUS		
			Global	National	Regional
Family Callitrichidae					
<i>Saguinus martinsi</i> (Thomas, 1912)	Martin's Ochraceous Bare-face Tamarin	VO, V			
<i>Saguinus midas</i> (Linnaeus, 1758)	Golden-handed Tamarin	VO			
Family Cebidae					
<i>Cebus olivaceus</i> Schomburgk, 1848 ²	Weeper Capuchin	I			
<i>Saimiri sciureus</i> (Linnaeus, 1758)	Common Squirrel Monkey	VO, CT, V			
<i>Sapajus apella</i> (Linnaeus, 1758)	Bearded Capuchin	VO, CT, V			
Family Pitheciidae					
<i>Chiropotes sagulatus</i> (Traill, 1821)	Bearded Saki	VO, V			
<i>Pithecia pithecia</i> (Linnaeus, 1766)	White-faced Saki	VO			
Order Carnivora					
Family Canidae					
<i>Speothos venaticus</i> (Lund, 1842)*	Bush Dog	VO	NT	VU	
Family Felidae					
<i>Leopardus pardalis</i> (Linnaeus, 1758)	Ocelot	VO, CT, T			
<i>Leopardus wiedii</i> (Schinz, 1821)	Margay	VO, CT	NT	VU	
<i>Leopardus tigrinus</i> (Schreber, 1775) ³	Northern Tiger Cat	I	VU	EN	
<i>Panthera onca</i> (Linnaeus, 1758)	Jaguar	VO, CT, T, F, C	NT	VU	VU
<i>Puma concolor</i> (Linnaeus, 1771)	Puma	VO, CT, T, F		VU	VU
<i>Puma yagouaroundi</i> (É. Geoffroy, 1803)	Jaguarundi	VO, CT		VU	
Family Mustelidae					
<i>Eira barbara</i> (Linnaeus, 1758)	Tayra	VO, CT			
<i>Galictis vittata</i> (Schreber, 1776)*	Greater Grison	VO, C			
<i>Lontra longicaudis</i> (Olfers, 1818)	Neotropical Otter	VO, F, T, B	NT		
<i>Pteronura brasiliensis</i> (Gmelin, 1788)	Giant Otter	VO, F, T, B	EN	VU	VU
Family Procyonidae					
<i>Nasua nasua</i> (Linnaeus, 1766)	South American Coati	VO, CT, T			
<i>Potus flavus</i> (Schereber, 1774)	Kinkajou	VO, CT			
<i>Procyon cancrivorus</i> (G. [Baron] Cuvier, 1798) ³	Crab-eating Raccoon	VO, I			
Order Cetartiodactyla					
Family Delphinidae					
<i>Sotalia fluviatilis</i> (Gervais & Deville, 1853)	Tucuxi	VO	DD		
Family Iniidae					
<i>Inia geoffrensis</i> (Blainville, 1817)	Amazon River Dolphin	VO	DD	EN	
Family Tayassuidae					
<i>Pecari tajacu</i> (Linnaeus, 1758)	Collared Peccary	VO, CT, T			
<i>Tayassu pecari</i> (Link, 1795)	White-lipped Peccary	VO, CT, T	VU	VU	
Family Cervidae					
<i>Mazama americana</i> (Erxleben, 1777)	Red Brocket Deer	VO, CT, T, F	DD		
<i>Mazama gouazoubira</i> (G. Fisher, 1814)	Gray Brocket Deer	VO, CT, T, F			

Continuation Table 2.

TAXON	COMMON NAME	TYPE OF RECORD	CONSERVATION STATUS		
			Global	National	Regional
<i>Mazama nemorivaga</i> (F. Cuvier, 1817)	Amazonian Brown Brocket Deer	VO, CT			
<i>Odocoileus virginianus</i> (Zimmermann, 1780) ³	White-tailed Deer	I, T			
Order Perissodactyla					
Family Tapiridae					
<i>Tapirus terrestris</i> (Linnaeus, 1758)	Lowland Tapir	VO, CT, F, T	VU	VU	
Order Sirenia					
Family Trichechidae					
<i>Trichechus inunguis</i> (Natterer, 1883)	Amazonian Manatee	VO, F	VU	VU	EN
Order Rodentia					
Family Caviidae					
<i>Hydrochoerus hydrochaeris</i> (Linnaeus, 1766)	Capybara	VO, F			
Family Cricetidae					
<i>Euryoryzomys macconnelli</i> (Thomas, 1910)	Macconnell's Rice Rat	LT, PT			
<i>Hylaeamys megacephalus</i> (Fischer, 1814)	Large-headed rice rat	LT, PT			
<i>Nectomys rattus</i> (Pelzen, 1883)	Small-footed Bristly Mouse	PT			
<i>Oecomys bicolor</i> (Thomas, 1860)	Bicolored Arboreal Rice Rat	LT, PT			
<i>Rhipidomys nitela</i> (Thomas, 1901)	Splendid Climbing Mouse	LT, PT			
<i>Zygodontomys brevicauda</i> (Allen & Chapman, 1893)	Short-tailed Cane Mouse	LT, PT			
Family Cuniculidae					
<i>Cuniculus paca</i> (Linnaeus, 1766)	Spotted Paca	VO, CT, T, F			
Family Dasyproctidae					
<i>Dasyprocta leporina</i> (Linnaeus, 1758)	Red-rumped Agouti	VO, CT, T, F, V			
<i>Myoprocta acouchy</i> (Erxleben, 1777)	Red Acouchi	VO, CT, T, V			
Family Erethizontidae					
<i>Coendou prehensilis</i> (Linnaeus, 1758)	Brazilian Porcupine	VO, CT, C			
Family Echimyidae					
<i>Echimyus chrysurus</i> (Zimmermann, 1780)	White-faced Tree Rat	C			
<i>Isothrix pagurus</i> Wagner, 1845	Plain Brush-tailed Rat				
<i>Mesomys hispidus</i> (Desmarest, 1817)	Spiny Tree Rat	PT			
<i>Proechimys cuvieri</i> (Petter, 1978)	Cuvier's Spiny Rat	LT, PT			
Family Sciuridae					
<i>Guerlinguetus aestuans</i> (Linnaeus, 1766)	Gianan Squirrel	VO, CT, LT			
Order Lagomorpha					
Family Leporidae					
<i>Sylvilagus brasiliensis</i> (Linnaeus, 1758) ³	Tapeti	I			

* Random Record; ¹ From Oliveira et al. 2006; ² From Oliveira et al. 2009; ³ From STCP, 2008.

Mammals of Saracá-Taquera, Brazil

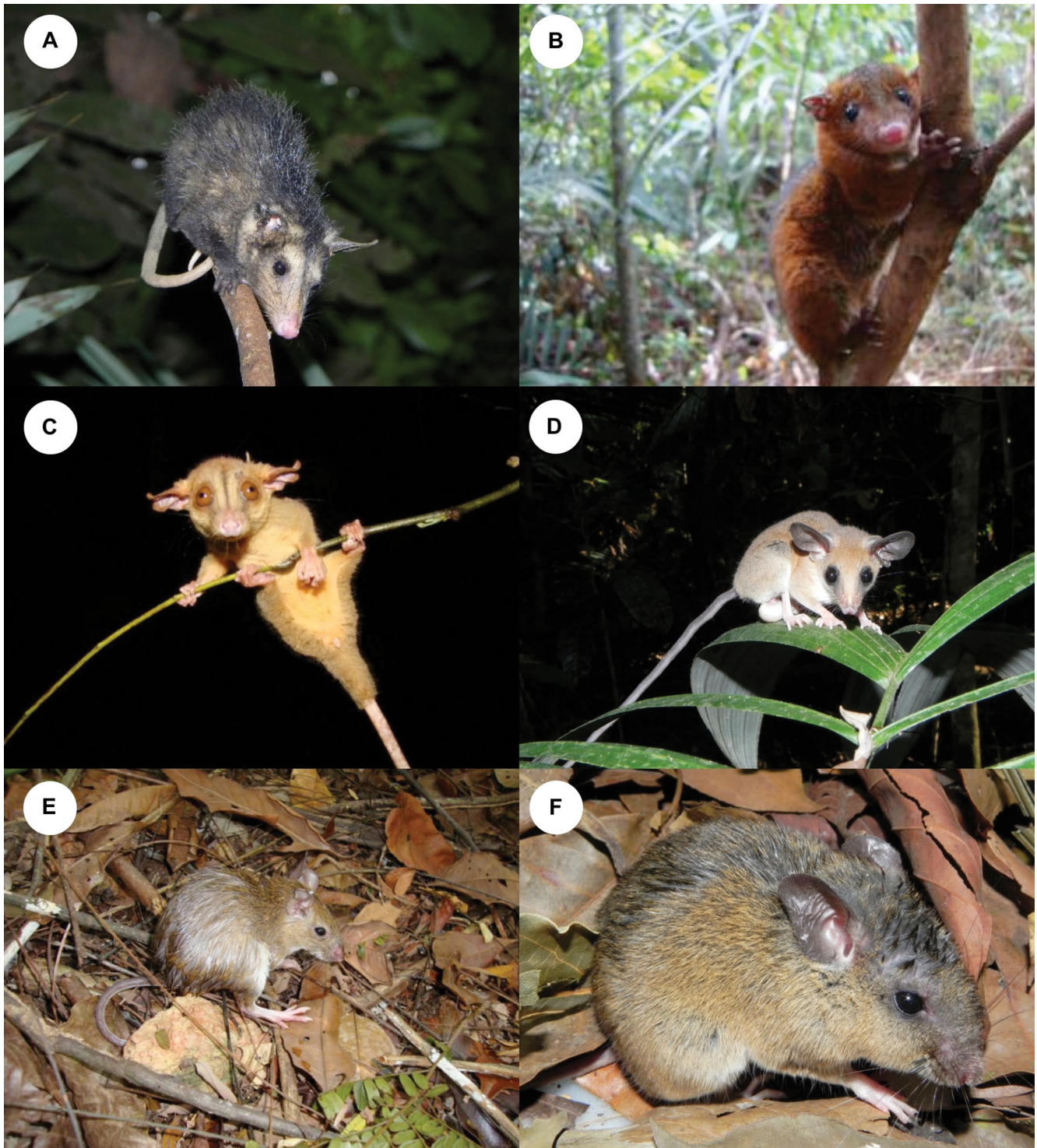


Figure 2. Small non-volant mammals recorded in the Saracá-Taquera National Forest, Pará, Brazil: A) *Didelphis marsupialis*; B) *Monodelphis arlindoi*; C) *Marmosops parvidens*; D) *Caluromys philander*; E) *Marmosa demerarae*; F) *Hylaeamys megacephalus*; G) *Proechimys cuvieri*.

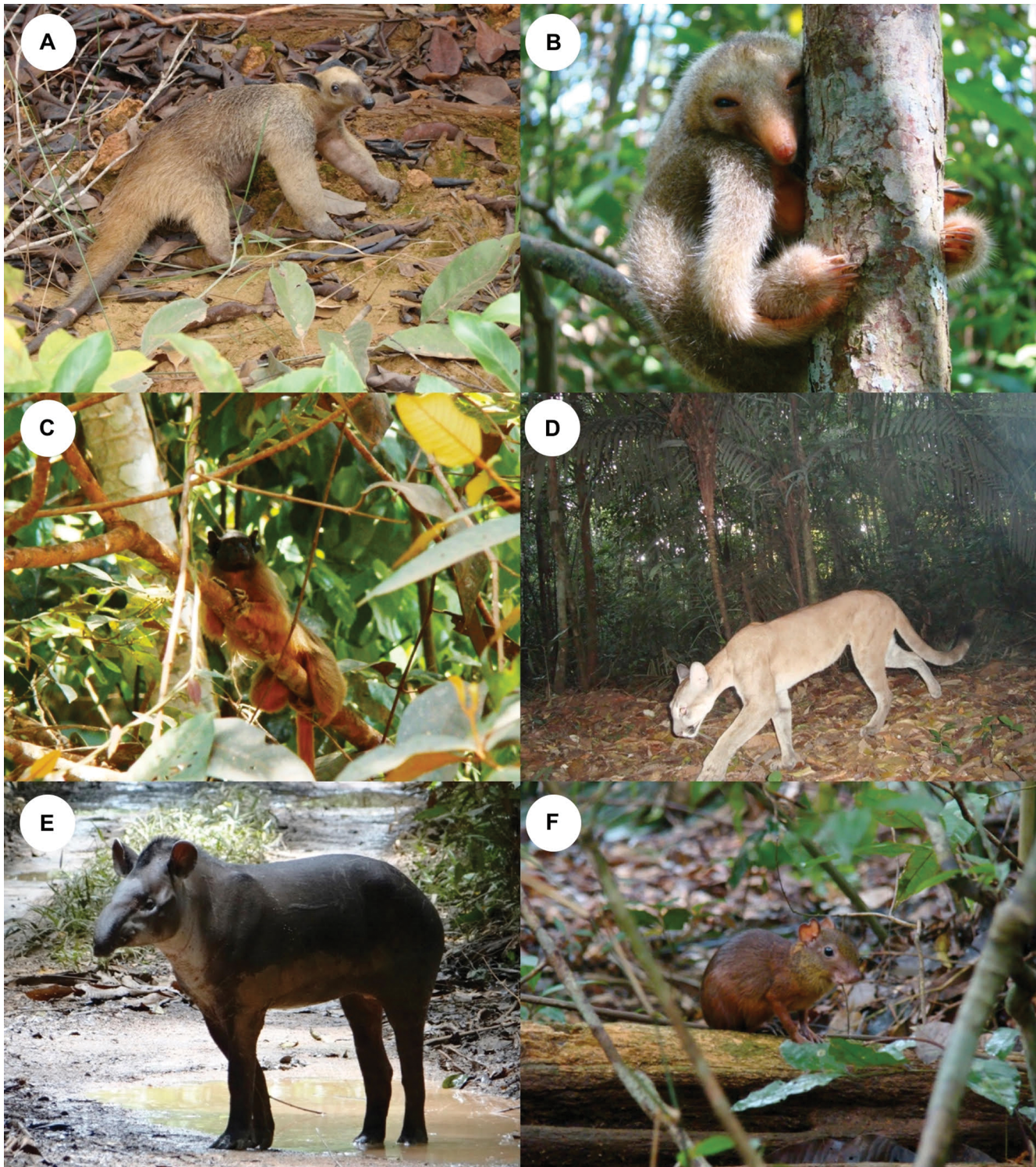


Figure 3. Medium and large mammals recorded in the Saracá-Taquera National Forest, Pará, Brazil: A) *Tamandua tetradactyla*; B) *Cyclopes didactylus*; C) *Saguinus martinsi*; D) *Puma concolor*; E) *Tapirus terrestris*; F) *Myoprocta acouchy*.

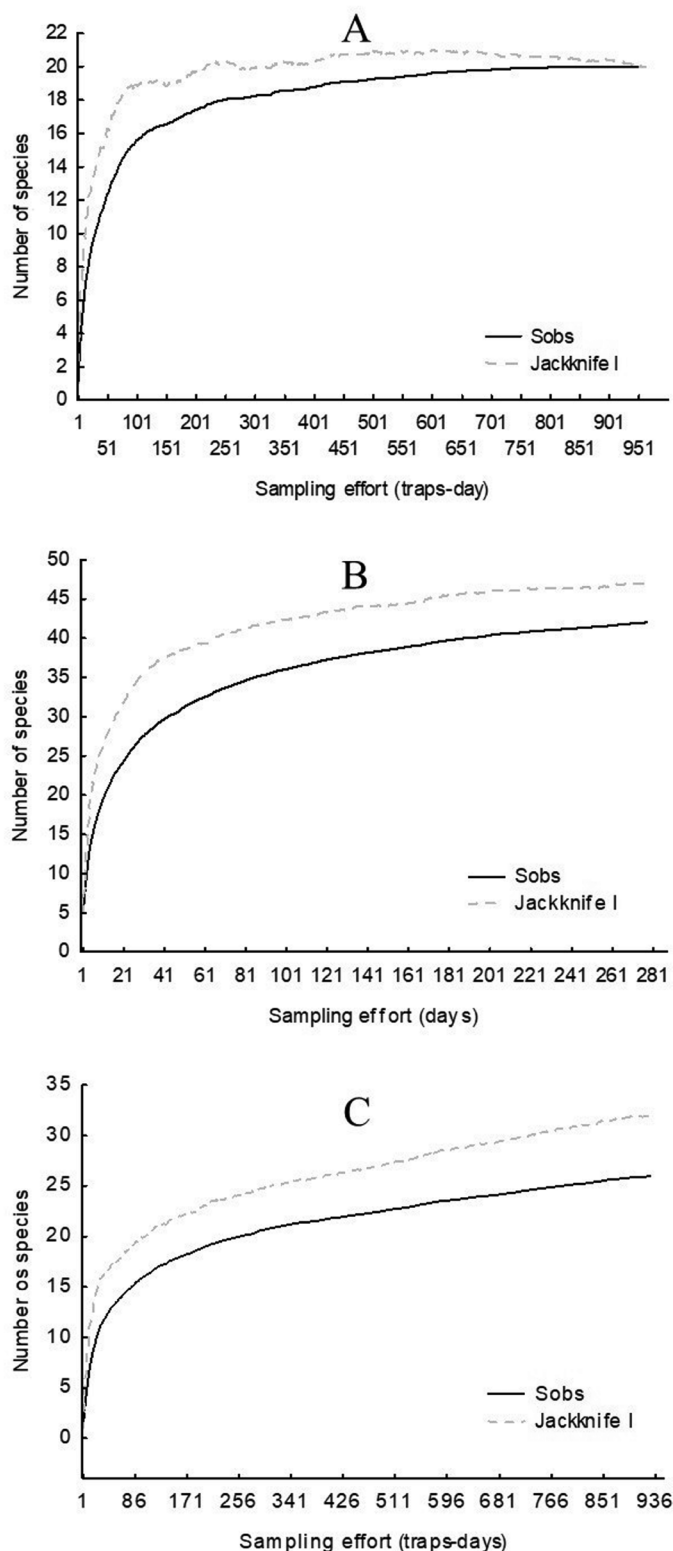


Figure 4. Species accumulation curve for small mammals (A), and medium and large mammals recorded by linear transect (B) and cameras trapping (C) in the Saracá-Taquera National Forest, Pará, Brazil.

only by interviews and published records (Oliveira et al. 2009). The wedge-capped capuchin, *C. olivaceus*, has been recorded from the left margin of the Trombetas River (Oliveira et al. 2009), although the STNF is located on the right margin. In the Amazon, rivers typically act as geographic barriers to primates (Peres et al. 1996; Boubli et al. 2015). In other cases, such as that of the northern tiger cat (*Leopardus tigrinus*), the species can easily be confused with other small-medium felines, especially by non-expert observers, and Payan & Oliveira (2016) concluded that this species is rare or absent from large areas of the Amazon basin. In addition to these four species, the tapeti (*Sylvilagus brasiliensis* (Linnaeus, 1758)), while widely-distributed in South America, has never been recorded in the current study area. While the lack of records of these five species may reflect their local rarity, we believe that continued sampling may eventually confirm their presence in the STNF and, as such, while they are included in the list of species that occur in this national forest, their presence in this protected area cannot yet be confirmed definitively.

Overall, 29 of the species recorded in the present study are considered to be endemic to the Amazon, including the marsupials (*Didelphis imperfecta* (Mondolfi & Pérez-Hernández, 1984), *Gracilinanus emiliae* (Thomas, 1909), *Marmosops parvidens* (Tate, 1931), and *Monodelphis arlindoi* (Pavan et al., 2012), the greater long-nosed armadillo (*Dasybus kappleri* (Krauss, 1982), two species of sloths (*Bradypus tridactylus* (Linnaeus, 1758) and *Choloepus didactylus* Linnaeus, 1758)), all the ten primate species recorded in the present study (see Table 1), the deer *Mazama nemorivaga* and *Odocoileus virginianus*, the Amazonian manatee (*Trichechus inunguis* (Natterer, 1883)), and the rodents *Euryoryzomys macconnelli* (Thomas, 1910), *Rhipidomys nitela* (Thomas, 1901), *Zygodontomys brevicauda* (Allen, 1897), *Myoprocta acouchy* (Thomas, 1903), *Echimys chrysurus* (Zimmermann, 1780), *Isothrix pagurus* (Wagner, 1845), *Mesomys hispidus* (Desmarest, 1817), *Proechimys cuvieri* (Petter, 1978), and *Guerlinguetus aestuans* (Linnaeus, 1766) (Bonvicino et al. 2008; Paglia et al. 2012; Patton et al. 2015). *Monodelphis arlindoi* was recently described by Pavan et al. (2012), and is endemic to the study region (see Figure 2B). No other species of mammal recorded in the present study is endemic to the Saracá-Taquera National Forest, Martin's bare-face tamarin (*Saguinus martinsi* (Thomas, 1912)) is protected only by this conservation unit.

Fourteen of the species recorded here are also included in one or more of the lists of species threatened with extinction published by the International Union for Conservation of Nature (IUCN 2017), the Brazilian Ministry of the Environment (MMA 2014), and Pará state resolution 054/2007 (Table 1). A number of these threatened species are extremely sensitive and have undergone population decline throughout most of their geographic ranges, due primarily to habitat loss and fragmentation, hunting pressure, wildfires, and roadkill (Chiarello et al. 2008; Naveda et al. 2008; Medici et al. 2012), although some, such as the tapir, the white-lipped peccary, and the jaguar, may be relatively tolerant of disturbed environments (Naveda et al. 2008; Keuroghlian et al. 2013; Quigley et al. 2017).

The most abundant of the ten marsupial species recorded in the Saracá-Taquera National Forest were *Marmosa demerarae* (Thomas, 1905) and *Marmosops parvidens* (Tate, 1931), which were both widely distributed in all the environments sampled. *Marmosa demerarae* (Thomas, 1905) was captured primarily in Sherman traps and, despite being arboreal, it was commonly captured on the ground and in the pitfall traps, as observed by Voss (2001). By contrast, the rarest marsupials were *Philander opossum* (Linnaeus, 1758) (N = 1), *Gracilinanus emiliae* (N = 2) and *Didelphis imperfecta* (Mondolfi & Pérez-Hernández, 1984) (N = 3). *Philander opossum* is recorded commonly in the Amazon (Patton et al. 2000), although only one individual was trapped in the present study. While this may reflect the local rarity of the species, limitations of the sampling effort cannot be ruled out. Two marsupials, *D. imperfecta* and *Echimyus chrysurus* (Zimmermann, 1780), were recorded in the region for the first time, extending their known geographical distributions (Faria and Melo 2017).

A majority of the species of the orders Cingulata and Pilosa were distributed homogeneously among the areas surveyed, with the nine-banded armadillo (*Dasybus novemcinctus* (Linnaeus, 1758)) and the greater long-nosed armadillo (*Dasybus kappleri* (Krauss, 1862) being the most frequent. The silky anteater (*Cyclopes didactylus* (Linnaeus, 1758)) was the rarest member of the Pilosa, which is probably related to the fact that this species is extremely difficult to locate, due to its cryptic, nocturnal and arboreal behavior, and the fact that it rarely descends to the ground (Medri et al. 2011). These characteristics, together with the dense vegetation of most of the STNF, may have limited visibility in the extreme, although the species was encountered in riverside habitats (Moura and Sapucaá), where much of the forest is regenerating.

Sloths were also recorded rarely, being found primarily during wildlife rescue operations, prior to planned deforestation for mining. Some sloths have also been rescued from the railroad track that crosses part of the natural forest. This scarcity of records reflects the cryptic coloration and behavior of the sloths, which may be difficult to spot in the high canopy of STNF, despite their relatively large size (for an arboreal mammal).

The diversity of Amazonian primates is among the greatest in the world (Rylands and Mittermeier 2009; Mittermeier et al. 2013), and more than half the biome's primate genera are found in the Saracá-Taquera National Forest. The bearded saki (*Chiropotes sagulatus*), bearded capuchin (*Sapajus apella*), Guianan red howler monkey (*Alouatta macconnelli* (Elliot, 1910)) and the Guianan spider monkey (*Ateles paniscus* (Linnaeus, 1758)) were the species encountered most frequently. The ecology of the bearded saki and Martin's bare-face tamarin (*Saguinus martinsi* (Thomas, 1912)) has been monitored in STNF since 2009, and a number of important findings in the area have already been published (Barnett et al. 2012; Melo et al. 2013; Boyle et al. 2015; Shaffer et al. 2015).

The order Carnivora had the largest number of endangered species. The bush dog (*Speothos venaticus* (Lund, 1842)) was the rarest carnivore in the region, being visualized on only a few occasions by other research teams working in STNF. While the bush dog has an ample distribution and is considered to be a habitat generalist, it appears to be naturally rare in most areas in which it is found (Dematteo et al. 2011). The top predators, the jaguar (*Panthera onca* (Linnaeus, 1758)) and the cougar (*Puma concolor* (Linnaeus, 1771)),

were recorded on most of the plateaus surveyed, including areas of habitat recuperation. The other carnivore species had a more irregular distribution within the study area.

Aquatic mammals of the orders Cetardiodactyla and Sirenia were recorded mainly during transit to the sampling points at Moura and Sapucaá, during the 2009–2010 survey. In 2011, in addition, the Amazonian manatee was monitored more directly at these sites, in particular Sapucaá Lake. At the same time, conflicts were observed between members of the local riverside communities and the dolphins, due to their attempts to retrieve fish caught in fishing nets, a behavior also observed in other regions (Loch et al. 2009).

Ungulates (orders Perissodactyla and Cetartiodactyla) were common in the study area, and were abundant in areas of habitat recuperation. The Amazonian brown brocket deer (*Mazama nemorivaga* (Cuvier, 1817)) was recorded recently in the region, with its presence being confirmed by experts, indicating the need for a taxonomic review of this and a number of other species (mainly rodents) recorded in STNF. Other ungulates, such as the peccaries (*Pecari tajacu* (Linnaeus, 1758) and *Tayassu pecari* (Link, 1795)), were recorded on a number of different plateaus and, together with the tapir (*Tapirus terrestris* (Linnaeus, 1758)), may play a unique, and vitally important functional role in the local ecosystem (Calaça 2014).

The order Rodentia was represented by some of the most abundant species found in the study area, such as the red-rumped agouti (*Dasyprocta leporina* (Linnaeus, 1758)) and the red acouchi (*Myoprocta acouchy* (Erxleben, 1777)). Both these species were common, and were recorded frequently within the study area, especially as, when they detect the presence of researchers, these animals emit a characteristic alarm vocalization before fleeing (Eisenberg and Thorington 1973; De Thoisy et al. 2008). The most common small rodents were Cuvier's spiny rat, *Proechimys cuvieri* (Petter, 1978) and the large-headed rice rat (*Hylaeamys megacephalus* (Fischer, 1814)), which were both common and widespread (Patton, et al. 2015). Other rodents were distributed more irregularly within the study area.

The order Lagomorpha, represented by a single species in Brazil, the tapeti (*Sylvilagus brasiliensis* (Linnaeus, 1758)), was only recorded in the study region through interviews, and most local residents, in particular the younger individuals, are unfamiliar with the species. Although the tapeti is common and widely distributed (Diersing 1981), it is possible that it may be very rare in the study area, or has become locally extinct.

The mammalian fauna of the Saracá-Taquera National Forest is rich and diverse, with at least as many species as most other, similar areas that have been surveyed in the Amazon biome (George et al. 1988; Calouro 1999; Marques-Aguiar et al. 2003; Pontes et al. 2008; Bergallo et al. 2012; Santos and Mendes-Oliveira 2012). While some other regions in the Amazon may have higher species richness, reinforcing their priority for conservation (Oliveira et al., 2016), the relatively high species richness recorded in the present study emphasizes the importance of this environment for the maintenance of local and regional diversity. The ecological diversity found in the present study, in terms of habitat use and feeding adaptations, is vitally important for complementary coexistence at the community level. This diversity is essential for balanced community structure and efficient ecosystem functioning (Walker 1992).

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Author Contributions

Analice Calaça: Substantial contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation.

Michel Barros Faria: Substantial contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation.

Diego Afonso Silva: Contribution to data collection; Contribution to manuscript preparation.

Áquila Oliveira Fialho: Contribution to data collection; Contribution to manuscript preparation.

Fabiano Melo: Substantial contribution in the concept and design of the study; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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