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# Medium to large size mammals of southern Serra do Amolar, Mato Grosso do Sul, Brazilian Pantanal

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**ABSTRACT:** Serra do Amolar (Amolar Mountain Ridge) is considered a Priority Area for biodiversity conservation in the Pantanal biome according to the Environmental Ministry of Brazil. Despite this fact, it is a little-studied area, lacking basic information such as species inventories. In this study, we provide a list of the medium- to large-sized mammals that inhabit the southern Serra do Amolar. We carried out a survey at Engenheiro Eliezer Batista Private Natural Heritage Reserve and Santa Tereza ranch from March 2009 to May 2013. We used non-invasive methods to generate a list of 33 mammal species from 18 families, including Endangered species such as the giant otter (*Pteronura brasiliensis*), Vulnerable species such as the lowland tapir (*Tapirus terrestris*), and Near Threatened species such as the jaguar (*Panthera onca*), highlighting the importance of this area for mammal conservation in a regional context.

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## INTRODUCTION

The Pantanal is one of the largest continuous wetlands of the world and it covers around 210,000 km<sup>2</sup> (Mittermeier *et al.* 2002) in Brazil, Bolivia and Paraguay. This biome is known for its unique abundance of wildlife (Trolle 2003), which results from seasonal changes in feeding and reproductive niches (Alho 2008; Alho *et al.* 2011). Despite this fact, the mammalian fauna of the Pantanal is still poorly known (Rodrigues *et al.* 2002; Desbiez *et al.* 2010). The threats to the biome are increasing, mainly due to changes in cattle production in the floodplains (particularly through the use of more nutritious pasture) and agriculture on the plateau, both leading to an increase in deforestation and loss of natural habitat (Desbiez *et al.* 2009a; Desbiez *et al.* 2009b; Alho and Sabino 2011). Since the early 1970s, ranchers have been clearing land, mainly through the use of fire, and planting pastures of exotic grasses to improve the carrying capacity for livestock (Desbiez *et al.* 2011). Approximately 17% of the Pantanal has been deforested through the use of fire (Alho 2008) and private ranches, whose main economic activity is beef production, occupy approximately 95% of the Brazilian Pantanal (Harris *et al.* 2005). Other threats are caused by non-sustainable practices of socio-economic development, such as illegal fishing and hunting, unplanned tourism, and pollution by pesticides, leading to a progressive deterioration of natural habitats (Alho 2008; Alho and Sabino 2011).

Within the vulnerability scenario of the Pantanal (Harris *et al.* 2005; Alho and Sabino 2011), species surveys and inventories provide the essential baseline data for monitoring impacts on wildlife, caused by factors such as habitat conversion and climate change, and for determining conservation priorities (Tobler *et al.* 2008). In this context, knowledge of the biodiversity of the region

is critical since it is the basis for improving integrated management of the entire biome.

Regarding mammal biodiversity, several inventories conducted since the 1980s have identified a total of 174 species in the Brazilian Pantanal (Schaller 1983; Alho *et al.* 1987; Rodrigues *et al.* 2002; Trolle 2003; Alho 2008; Alho *et al.* 2011). In a recent update, Carmignotto *et al.* (2012) asserted that 79 species of mammals are shared between Cerrado, Caatinga, Amazonian and Atlantic rainforest. Faunal or floral endemism is virtually absent in the Pantanal (Harris *et al.* 2005; Junk *et al.* 2006).

Although mammal occurrence and distribution in the Pantanal is considered poorly documented (Rodrigues *et al.* 2002; Trolle 2003; Junk *et al.* 2006; Desbiez *et al.* 2010), there is a consensus that this biome serves as a refuge for the largest populations of several threatened and endangered species, such as the marsh deer *Blastocercus dichotomus* (Illiger, 1815), the giant otter *Pteronura brasiliensis* (Gmelin, 1788), the giant anteater *Myrmecophaga tridactyla* (Linnaeus, 1758), the jaguar *Panthera onca* (Linnaeus, 1758), the giant armadillo *Priodontes maximus* (Kerr, 1792), and many others as pointed out by Harris *et al.* (2005) in their appraisal of Pantanal diversity. Considering this point, increased knowledge on the distributions of mammals and their conservation status in the Pantanal can contribute to the improvement of conservation strategies for these species, since the biome is currently facing changes in its landscape (Desbiez *et al.* 2009a; Desbiez *et al.* 2010). Thus, the goal of this study is to provide a list of medium- and large-sized mammals found in southern Serra do Amolar, situated in the Pantanal of Brazil, and to assess capture rates based on camera trapping surveys.

## MATERIALS AND METHODS

The study was carried out at Serra do Amolar region on Santa Tereza ranch (18°18'38" S, 57°30'10" W) and Engenheiro Eliezer Batista Private Natural Heritage Reserve (18°05'25" S, 57°28'24" W). Both properties are situated in the state of Mato Grosso do Sul, approximately 180 km north of Corumbá in the Upper Paraguay Basin, limited to the west by the Bolivian border and to the east by the Pantanal floodplains (Figure 1). Although considered one of the largest floodplains in the world, the Pantanal also has mountainous areas such as the Urucum Massif and Amolar Mountain Ridge (Silva *et al.* 2000). The highest point is Amolar peak at an altitude of 1000 m. This Precambrian massif establishes an abrupt ecotone with the seasonally flooded plains of the Brazilian Pantanal (Junk *et al.* 2006), working as a geological control of the water drainage. The climate of the Upper Paraguay Basin (APB) is considered seasonal and as tropical savannah (AW) according to the Köppen classification (Cadavid-Garcia 1984), with a hot and humid climate in the summer; a dry and cold climate during the winter; and an annual average precipitation of 1,300 mm (PCBAP 1997). The predominant vegetation of the Serra do Amolar region is composed of gallery forest and riparian forest along watercourses and the Paraguai River, dry and humid savannahs, seasonal deciduous forest and seasonal semi-deciduous forest, and occasional rocky fields (approximately 1%) (Sá Arruda *et al.* 2012; Carmignotto *et al.* 2012).

The first area surveyed was Engenheiro Eliezer Batista Private Natural Heritage Reserve (EEB), covering a total

area of 20,268 ha. The EEB protected area was created in 2008 by means of a private initiative to enhance the conservation efforts of the Pantanal Matogrossense National Park. The EEB protected area is shaped by mountains, swamps and seasonally flooded grasslands. The flood-prone area is comprised of water bodies that represent 58% of the EEB PNHR. A Private Natural Heritage Reserve is a category of protected area established by the Brazilian Federal Decree N°. 98914 of 1990, and updated by Decree N°. 1992 of 1996, where citizens voluntarily engage in the process of effective protection of representative Brazilian ecosystems.

Santa Tereza ranch, the second site surveyed, is in an area contiguous with EEB, and covers 63,000 ha, of which only 3% is used for cattle ranching. No other economic activity is carried out on the ranch. The forest remnants occupy an area surrounding the Baía Vermelha, one of the largest lakes of the Paraguay River basin (Calheiros and Ferreira 1997).

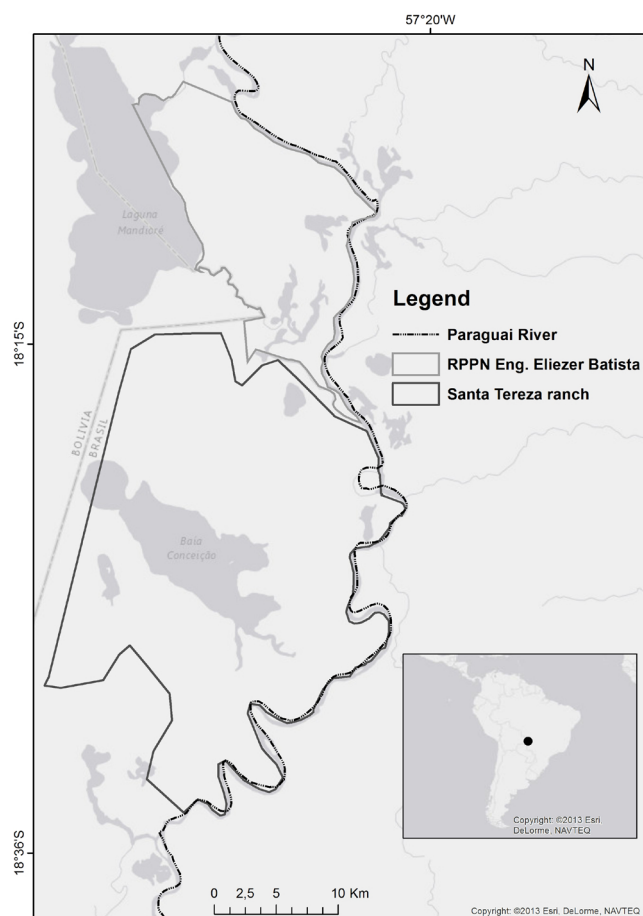
Four traditional communities (Castelo, Paraguai Mirim, Amolar and Barra do São Lourenço), with approximately 400 people, are settled in the neighborhood of the study site, and their main economic activities are associated with fishing and small-scale cattle production. Subsistence hunting is reported by some locals, and is directed at species such as capybaras *Hydrochoeris hydrochaeris* (Linnaeus, 1766), caimans *Caiman yacare* (Daudin, 1802), and peccaries *Pecari tajacu* (Linnaeus, 1758).

### Data collection

The study was carried out in seven phases: (I) from March 2009 to February 2010; (II) in March 2011; (III) from August to October 2011; (IV) from November 2011 to January 2012; (V) from February to May 2012; (VI) from August to September 2012; and (VII) from November 2012 to May 2013. We used a range of non-invasive methodologies to conduct the surveys, including camera trapping, track census, and direct observations (Silveira *et al.* 2003; Trolle 2003; Lyra-Jorge *et al.* 2008). Camera trapping was the main method employed, with the other methods complementing the species list.

Paths, dirt roads, sand banks and watercourse margins were followed during phases I and II in order to record the presence of mammals based on track census and direct observations - this latter particularly for arboreal species at Engenheiro Eliezer Batista Protected Area. Tracks were identified based on Lima-Borges and Tomas (2004). In the other phases, several camera trapping surveys were carried out at Engenheiro Eliezer Batista Protected Area and Santa Tereza ranch (Table 1). The cameras were installed in different habitats, such as gallery forests, savannahs, and deciduous and semi-deciduous forests. All cameras were programmed to operate continuously (24 h/day) and to take pictures at an interval of 30 seconds for the digital models (Bushnell Trophy Cam and Panthera Camera Trap V4), and intervals of five minutes for the analogical equipment (Tigrinus Conventional 6C). The geographic coordinates of camera traps, photographic captures, presence signs, and observations were recorded using a GPS navigator.

Camera trap sampling effort was determined by multiplying the number of camera traps by the number of



**FIGURE 1.** Map of the study site located at the Engenheiro Eliezer Batista Private Natural Heritage Reserve, and Santa Tereza ranch, Pantanal of Brazil.

sampling days (1d=24 hours), as seen in Srbeek-Araujo and Chiarello (2005). Food scraps and cat urine were used to attract the animals. Camera trap records were identified according to Lima-Borges and Tomas (2004) and by drawings in Eisenberg and Redford (1999). Nomenclature followed Wilson and Reeder (2005).

To estimate the relative abundance of the terrestrial mammals, we used the Relative Abundance Index (RAI) (Carbone *et al.* 2001), which is calculated using the number of independent pictures from each species divided by the sampling effort. We used an interval of 24 h between pictures of the same species to guarantee independence between them (Tobler *et al.* 2008). A species accumulation curve was obtained through randomizations (with 1000 runs) of different sized samples using the software R version 2.15.3. We treated each survey day as a sample, following Tobler *et al.* (2008).

## RESULTS

With a total sampling effort for track census and direct observations equivalent to 378.5 km over 45 field days, and a camera trapping sampling effort of 11,414 camera-days (Table 1), we recorded 33 species from 18 families (Table 2 and Figures 2 and 3). Carnivora was the richest mammalian order in our inventory (Table 2).

During the surveys we found four primate species (Figure 4), and all the species identified by tracks also had a camera trapping record (Table 2). The agouti *Dasyprocta azarae* Lichtenstein, 1823, crab-eating fox *Cerdocyon thous* (Linnaeus, 1766), and gray brocket deer *Mazama gouazoubira* (Fischer, 1814) were the species most recorded by the camera traps, while the six banded armadillo *Euphractus sexcinctus* (Linnaeus, 1758), the giant armadillo, the southern tamandua *Tamandua tetradactyla* (Linnaeus, 1758), the white-lipped peccary *Tayassu pecari* (Link, 1795) and the marsh deer *Blastocerus dichotomus* (Illiger, 1815) were the least recorded, and therefore showed the lowest RAIs (Figure 5). The species accumulation curve obtained considering only the camera trapping records presented an asymptotic tendency (Figure 6).

## DISCUSSION

One of the first inventories in the Pantanal that included a broad multi-taxa sampling effort was conducted by Schaller (1983) on the Acurizal Ranch, which identified 64 species, of which 43 were non-flying mammals. In the Nhecolândia sub-region of the Pantanal, Alho *et al.* (1987) identified 33 mammal species, excluding bats, while Desbiez *et al.* (2010) observed 25 medium- to large-sized mammal species in the same area as Alho *et al.* (1987)

through direct observations, evidence from tracks or fresh burrows. In the southeastern part of the Pantanal, Trolle (2003) recorded 30 species of medium- to large-sized mammals, while Rodrigues *et al.* (2002) recorded 93 species for the entire floodplain. The PCBAP (Plano de Conservação da Bacia do Alto Paraguai – Conservation Plan for the Upper Paraguay River Basin - Brasil 1997) also provides one of the most complete lists that have been published for the mammals that inhabit the region, listing 75 species, and acts as a reference for the Pantanal region (Rodrigues *et al.* 2002). Until recently, it was believed that 132 mammal species occurred in the Pantanal (Alho 2008). However, in a recent update, Alho *et al.* (2011) cited 174 mammal species inhabiting the Brazilian Pantanal.

In this study, we recorded 33 of the 43 non-flying mammal species believed to inhabit the region of our study area according to Schaller (1983). In fact, we recorded similar species to those observed by that author on Acurizal Ranch, which is located 30 km north of our study area in the northern side of Amolar Mountain Ridge. Although we used multiple methods to generate our inventory, we did not register some species observed by Schaller (1983), such as the maned wolf *Chrysocyon brachyurus* (Illiger, 1815), and some arboreal species such as the prehensile-tailed porcupine *Coendou prehensilis* (Linnaeus, 1758). Schaller's study was carried out at the end of 1970s and, by that time, these species were already considered extremely rare or difficult to detect (Schaller 1983).

The differences concerning RAIs seem to reflect the behavior and abundance of the terrestrial species. Clearly, the placement of the camera traps near the ground, and the sensitivity of the sensor biased our results in favor of medium- to large-sized ground-dwelling mammals, especially those species that frequently use roads, where camera traps were preferentially installed (Harmsen *et al.* 2010). That said, we did capture some small mammal species with this method, such as *Thrichomys pachyurus* (Wagner, 1845) and *Philander opossum* (Linnaeus, 1758) which has two spots over the eyes, a prehensile tail with less than 20% of the basal portion covered with fur, the rest of which is naked, black in 2/3 basal portion and discolored in 1/3 distal portion as described in Rossi and Bianconi (2011) (Figure 3). Since different species have different probabilities of being detected by camera traps due to distinct behavioral traits, it is important to emphasize that this index is an estimation of species abundance relative to the abundance of all other species identified by the method, and cannot be used as a population size estimator (Walker *et al.* 2000; Eduardo and Passamani 2009). The dense vegetation and the

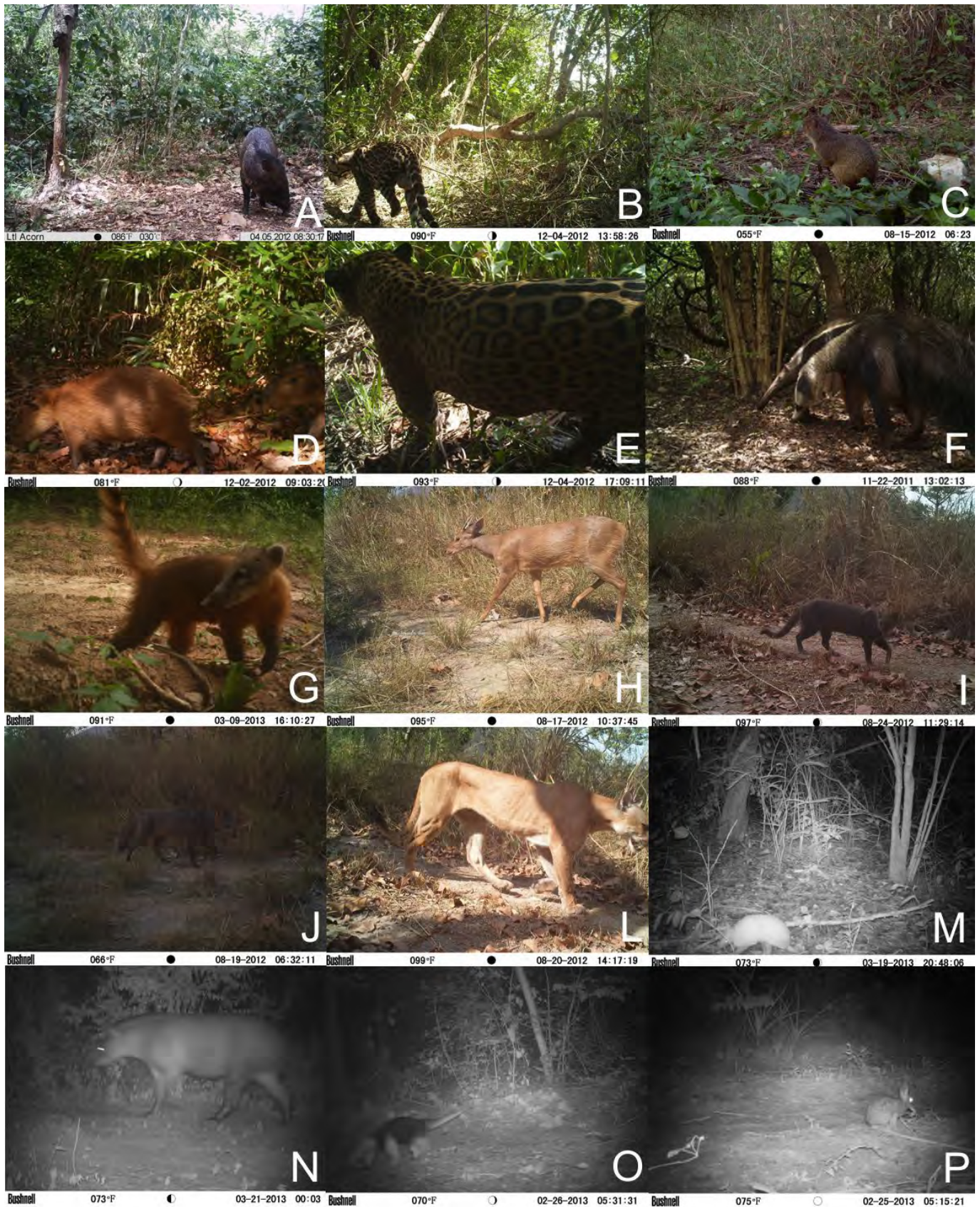
**TABLE 1.** Data from camera trapping campaigns carried out in Engenheiro Eliezer Batista Private Natural Heritage Reserve, and Santa Tereza ranch from August 2011 to May 2013.

STUDY PHASE	NO. OF CAMERA TRAPS	AVERAGE DISTANCE BETWEEN CAMERAS (M)	SURVEY DAYS	SAMPLING EFFORT (CAMERA-DAYS)
III	23	500	62	1,426
IV	12	1,500	58	696
V	20	1,500	95	1,900
VI	14	500	30	420
VII	42	2,000	166	6,972
<b>Total</b>	<b>110</b>		<b>414</b>	<b>11,414</b>



flooded fields restricted our movements while surveying the area and, due to these difficulties, we consider these results only as a rough estimate. We agree with Sberk-Araujo and Chiarello (2005) that camera traps are a relatively practical and non-intrusive method, especially

for surveying nocturnal, rare and cryptic mammals. Although some expected species were not recorded by the camera traps, our species accumulation curve showed an asymptotic tendency, demonstrating that we succeeded in recording the vast majority of the medium-to large-



**FIGURE 2.** Mammal species detected at southern Amolar Mountain Ridge (Engenheiro Eliezer Batista Private Natural Heritage Reserve and Santa Tereza ranch) through camera trapping surveys carried out from August 2011 to May 2013. A. *Pecari tajacu*; B. *Leopardus pardalis*; C. *Dasyprocta azarae*; D. *Hydrochoerus hydrochaeris*; E. *Panthera onca*; F. *Myrmecophaga tridactyla*; G. *Nasua nasua*; H. *Mazama gouazoubira*; I. *Puma yagouaroundi*; J. *Cercodyon thous*; L. *Puma concolor*; M. *Tolypeutes matacus*; N. *Tapirus terrestris*; O. *Tamandua tetradactyla*; P. *Sylvilagus brasiliensis*.





**FIGURE 3.** Mammal species detected at southern Amolar Mountain Ridge through camera trapping surveys and direct observations carried out from August 2011 to May 2013. A. *Blastocercus dichotomus*; B. *Mazama americana*; C. *Priodontes maximus*; D. *Urosciurus spadiceus*; E. *Eira barbara*; F. *Dasypus novemcinctus*; G. *Thrichomys pachyurus*; H. *Tayassu pecari*; I. *Philander opossum*.

sized ground-dwelling mammals that are expected for the area, only missing those that might be extinct in the area, that occur in low population densities or those that the methodology was unlikely to capture (Voss and Emmons 1996).

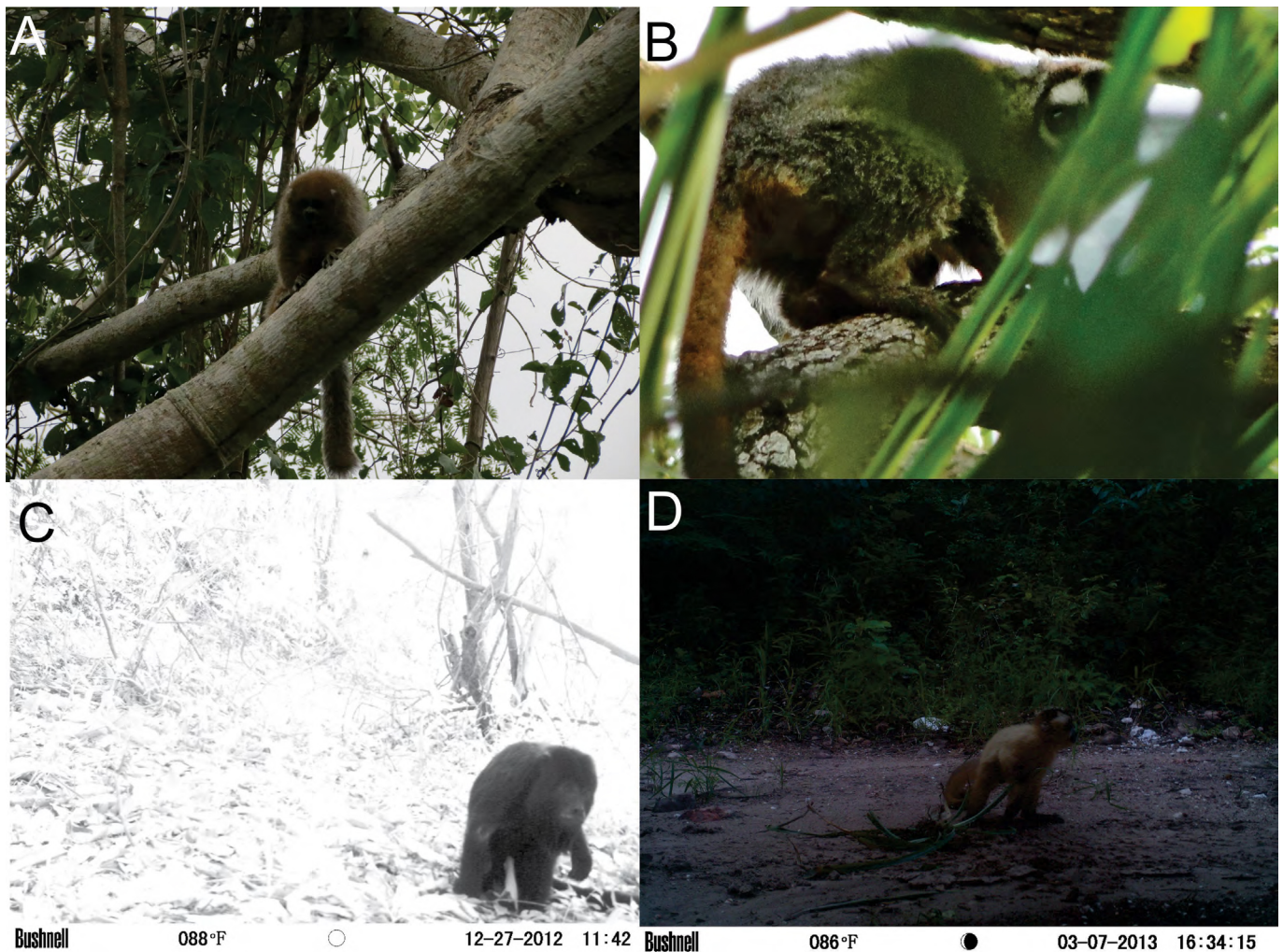
Several threatened species inhabit EEB PHNR and Santa Tereza ranch. Among them, we recorded Endangered species such as the giant otter, which according to Schaller (1983) was considered virtually exterminated in the area due to intensive hunting; Vulnerable species such as the lowland tapir, the marsh deer, and the giant armadillo, with the first camera trapping record for this latter species reported for Serra do Amolar at Engenheiro Eliezer Batista Protected Area in 2012 (Porfirio *et al.* 2012), and Near Threatened species such as the jaguar. In Brazil, the persecution of jaguars, as well as other wildlife species, is illegal, but there are still cases of jaguars being shot in an attempt to minimize the damage caused by livestock predation (Marchini and Macdonald 2012). Human occupancy around the reserve is primarily by traditional communities that focus on fishing activities, but there are also small-scale cattle-raising systems. Hence, a single cattle depredation event by a native predator is treated as a significant loss that can lead to negative perceptions and attitudes towards these animals. So, in this context,

it is quite important to gather all possible data on jaguar presence and abundance in order to apply consistent measures that can minimize these losses.

The white-lipped peccary *Tayassu pecari* (Link, 1795), which is one of the most important prey of the jaguar (Taber *et al.* 1997; Weckel *et al.* 2006) and is a Vulnerable species (IUCN 2013), was recorded only once by camera trap in May 2013, although a medium-sized group of approximately 20 individuals was observed in November 2006 at Santa Tereza ranch (GP, personal observation). The white-lipped peccary is a widespread fruit-eating mammal in Neotropical rainforests (Bodmer 1990), which strongly associates with forested areas (Desbiez *et al.* 2009b). Although the main threats to the species are related to habitat loss and hunting pressure (Carrillo *et al.* 2002), we believe that the species may occur in low densities in the study site, as is also the case in the floodplains, because of the unsuitability of the study area habitat. In another study area in the central Pantanal, Desbiez *et al.* (2009a) found that white-lipped peccary densities were higher in forested landscapes when compared to the floodplain, where the species was rarely sighted.

The southern three-banded armadillo *Tolypeutes matacus* (Desmarest, 1804), another Near Threatened species found in our inventory, had already been recorded





**FIGURE 4.** Primates observed at southern Amolar Mountain Ridge, Pantanal of Brazil. A. *Callicebus pallescens* picture by Erison Monteiro; B. *Aotus azarae* picture by Claudenice Faxina; C. *Allouata caraya*; D. *Sapajus cay*.

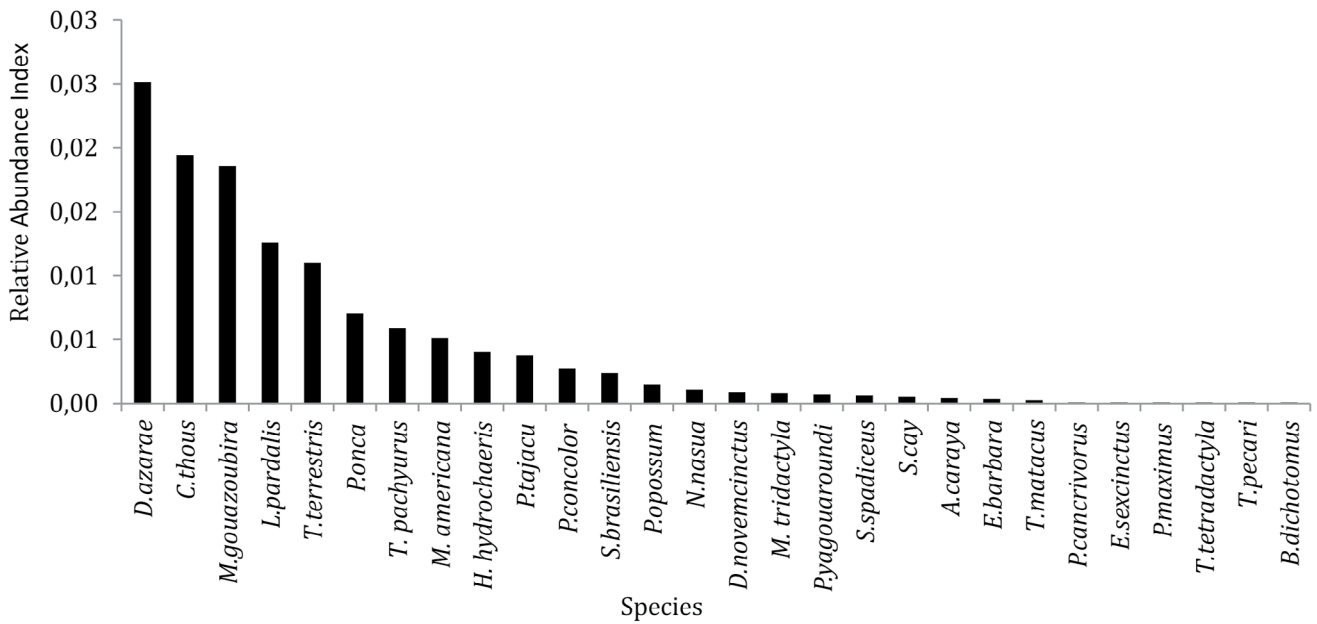
in the Serra do Amolar (Schaller 1983) and in the Pantanal of Nhecolândia (Alho *et al.* 1987). This species is distributed from southeastern Bolivia and Mato Grosso, Brazil, through the Paraguayan Chaco to the Province of Buenos Aires in Argentina (Wetzell 1985). Considered an opportunistic insectivore (Bolkovic *et al.* 1995), this species is probably facing a significant decline due to widespread habitat loss through much of its range, and because of exploitation for food (Abba and Superina 2010).

Considering the lack of information for this region, it is also important to highlight the detection of some species categorized as Data Deficient according to the IUCN Red List (2013), for example: the river otter *Lontra longicaudis* (Olfers, 1818), the agouti *Dasyprocta azarae* (Lichtenstein, 1823), and the red brocket deer *Mazama americana* (Erxleben, 1777). These species have been reported in other inventories carried out in the Pantanal (Trolle 2003; Desbiez *et al.* 2010) and records such as these are essential for mammal conservation at a regional scale, since the presence or absence of a particular species provides the basic information necessary to assess its ecological requirements.

We recorded four of the six primate species reported for the Pantanal according to Rodrigues *et al.* (2002) and Melo *et al.* (2009), and these species seem to exhibit a fragmented distribution, except for *Alouatta caraya* (Humboldt, 1812), which is typically registered over

extensive areas. For example, *Mico melanura* (É. Geoffroy, 1812), occurs only in small isolated and elevated areas such as Urucum Massif (Vivo, 1991), and there is a considerable lack of information of its status in the Pantanal floodplain (Rodrigues *et al.* 2002). The remaining primate species seem to be associated with specific vegetation types. For example, Azara's night monkey *Aotus azarae* (Humboldt, 1811), seems to occur in transitional vegetation zones, and on ridges (Rodrigues *et al.* 2002; Cáceres *et al.* 2008). Although *Aotus azarae* is typically nocturnal (Fernandez-Duque and Erkert 2006), it was twice seen during the day in the EEB PNHR. According to Schaller (1983), this species also occasionally calls in the daytime, and Fernandez-Duque and Erkert (2006) found that this species may be more active during the day if unfavorable lightning or temperature conditions prevail during the night. *Callicebus pallescens* (Thomas, 1907) was identified through direct observation and vocalization. According to Hershkovitz (1990), *C. pallescens* occurs within the study area, but there is little information about this primate species for the Pantanal overall, and Tomas *et al.* (2010) has challenged the validity of this species' taxonomic rank.

Deer are represented by four species in the Pantanal: *Blastocerus dichotomus*, *Mazama americana*, *Mazama gouazoubira* and *Ozotoceros bezoarticus* (Linnaeus, 1758). The first species is associated with marshy and flooded areas, while species from the genus *Mazama* can be found



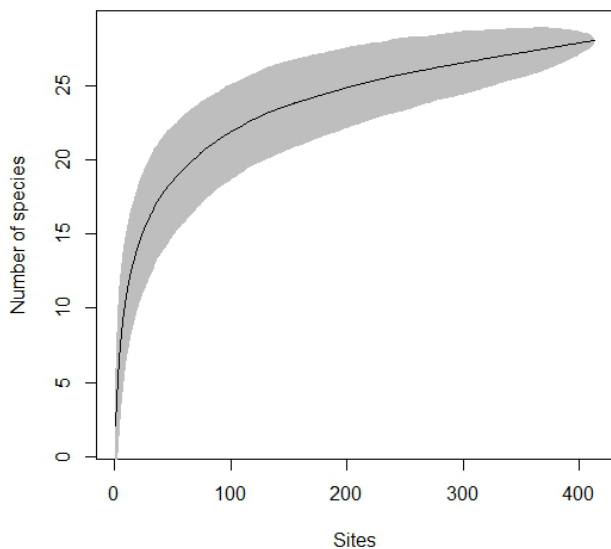
**FIGURE 5.** Index of Relative Abundance (RAI) obtained by the number of records of each mammal species registered by camera trapping at the Engenheiro Eliezer Batista Private Natural Heritage Reserve and the Santa Tereza Ranch (Amolar Mountain Ridge, Pantanal of Brazil), carried out from August 2011 to May 2013.

over the entire floodplain. *Ozotoceros bezoarticus*, which was not recorded in this study, mainly inhabit field areas (Rodrigues *et al.* 2002) and, since little of this habitat type is found within the reserve, this could probably explain the absence of the species from our inventory.

The richness of carnivores found in our study site followed a pattern close to that observed in other mammal studies carried out in the Pantanal (Trolle 2003; Desbiez

*et al.* 2010). We registered 50% of the carnivore species that occur in the Pantanal according to Alho *et al.* (2011). The presence of such a high number of species suggests that the study area presents sufficient habitat integrity and abundant prey, the most important ecological requirements for carnivores (Pierce *et al.* 2000).

The importance of the EEB PNHR and Santa Tereza ranch for the conservation of biodiversity is based not only on the presence of endangered and threatened species, but also on the diversity of habitats as a result of the influence of neighboring biomes such as the Chaco, Amazon Forest and Cerrado. Additionally, the EEB PNHR and Santa Tereza ranch are located in a strategic geographical position, i.e. in the corridor formed by the Pantanal Matogrossense National Park and four other Private Natural Heritage Reserves that together comprise the Network for Protection and Conservation of the Serra do Amolar (“Rede de Proteção e Conservação da Serra do Amolar”), a multi-organizational conservation framework for the Serra do Amolar that legally protects 209,000 hectares of Pantanal biome (Bertassoni *et al.* 2012). Furthermore, our study applies the recommendations of the Environment Ministry of Brazil (MMA 2007) to establish, as a priority, biodiversity inventories for the Serra do Amolar region, since it is classified as an area of extremely high importance for conservation. The results obtained from this study reveal the need to concentrate conservation initiatives in this region, both in public and private areas, since it plays an important role as a refuge for the mammalian fauna in the western floodplains of the Pantanal.



**FIGURE 6.** Species accumulation curve obtained through randomizations (with 1000 runs) considering the camera trapping surveys carried out at the Engenheiro Eliezer Batista Private Natural Heritage Reserve and the Santa Tereza ranch (Amolar Mountain Ridge, Pantanal of Brazil), from August 2011 to May 2013.



**TABLE 2.** List of species, common name, habitat type, conservation status according to IUCN Red List (2013), and type of record of mammals identified in Engenheiro Eliezer Batista Private Natural Heritage Reserve and Santa Tereza ranch between March 2010 and May 2013. GF= Gallery Forest, RF= Riparian Forest, DS= Dry Savannah, HS= Humid Savannah, SDF= Seasonal Deciduous Forest, SSF= Seasonal Semi-deciduous Forest, RF= Rocky Field, R=River, T= Tracks, CT= Camera trap, DO= Direct Observation, B= Burrow, LC= Least Concern, DD= Data Deficient, V= Vulnerable, NT = Near Threatened, E=Endangered.

TAXON AND SCIENTIFIC NAME	COMMON NAME	HABITAT TYPE	CONSERVATION STATUS	TYPE OF RECORD
<b>Cervidae</b>				
<i>Mazama gouazoubira</i> (Fischer, 1814)	Gray brocket deer	GF, RF, SDF, SSF	LC	T/CT
<i>Mazama americana</i> (Erxleben, 1777)	Red brocket deer	GF, RF, SDF, SSF	DD	CT/DO/T
<i>Blastocerus dichotomus</i> (Illiger, 1815)	Marsh deer	HS	V	T/CT/DO
<b>Tayassuidae</b>				
<i>Pecari tajacu</i> (Linnaeus, 1758)	Collared peccary	GF, DS, SSF	LC	CT/T
<i>Tayassu pecari</i> (Link, 1795)	White-lipped peccary	SSF, GF	V	CT/T
<b>Didelphidae</b>				
<i>Philander opossum</i> (Linnaeus, 1758)	Gray four-eyed opossum	RF, SSF	LC	CT
<b>Canidae</b>				
<i>Cerdocyon thous</i> (Linnaeus, 1758)	Crab-eating fox	GF, DS, SDF, SSF	LC	T/CT/DO
<b>Felidae</b>				
<i>Leopardus pardalis</i> (Linnaeus, 1758)	Ocelot	GF, RF, DS, HS, SDF, SSF	LC	T/CT
<i>Puma yagouaroundi</i> (É. Geoffroy, 1803)	Jaguarundi	SSF	LC	T/CT
<i>Puma concolor</i> (Linnaeus, 1771)	Puma	SDF, SSF	LC	T/CT
<i>Panthera onca</i> (Linnaeus, 1758)	Jaguar	RF, GF, HS, SSF	NT	T/CT/DO
<b>Mustelidae</b>				
<i>Eira barbara</i> (Linnaeus, 1758)	Tayra	SDF, SSF	LC	CT/DO
<i>Lontra longicaudis</i> (Olfers, 1818)	Neotropical otter	RF, R	DD	DO
<i>Pteronura brasiliensis</i> (Gmelin, 1788)	Giant otter	RF, R	E	DO
<b>Procyonidae</b>				
<i>Nasua nasua</i> (Linnaeus, 1766)	South America Coati	DS, SDF, SSF	LC	T/CT
<i>Procyon cancrivorus</i> (C.[Baron] Cuvier, 1798)	Crab-eating raccoon	SSF	LC	CT
<b>Sciuridae</b>				
<i>Urosciurus spadicus</i> Olfers, 1818	Southern Amazon Squirrel	SDF, SSF	LC	DO/CT
<i>Dasyprocta azarae</i> Lichtenstein, 1823	Azara's agouti	RF, SSF	DD	T/CT/DO
<b>Caviidae</b>				
<i>Hydrochoeris hydrochaeris</i> (Linnaeus, 1766)	Capybara	GF, RF, HS	LC	T/CT/DO
<b>Echimyidae</b>				
<i>Thrichomys pachyurus</i> (Wagner, 1845)	Sauá	SDR, RF	LC	DO/CT
<b>Tapiridae</b>				
<i>Tapirus terrestris</i> Linnaeus, 1758	Lowland tapir	GF, RF, DS, SDF, SSF	V	T/CT
<b>Cebidae</b>				
<i>Sapajus cay</i> (Illiger, 1815)	Azara's capuchin	GF, SSF	LC	DO/CT
<i>Mico melanura</i> (É. Geoffroy, 1812)	Silvery marmoset	SDF, SSF	LC	DO
<b>Aotidae</b>				
<i>Aotus azarae</i> (Humboldt, 1811)	Azara's night monkey	SDF, SSF	LC	DO
<b>Atelidae</b>				
<i>Alouatta caraya</i> (Humboldt, 1812)	Black howler monkey	RF, SDF, SSF	LC	DO/CT
<b>Pitheciidae</b>				
<i>Callicebus pallescens</i> (Thomas, 1907)	Chacoan Titi monkey	SDF, SSF	LC	DO
<b>Dasypodidae</b>				
<i>Dasyopus novemcinctus</i> Linnaeus, 1758	Nine-banded armadillo	GF, SSF	LC	CT
<i>Priodontes maximus</i> (Kerr, 1792)	Giant armadillo	SSF	V	T/B/CT
<i>Euphractus sexcinctus</i> (Linnaeus, 1758)	Six-banded armadillo	DS, SSF	LC	CT
<i>Tolypeutes matacus</i> (Desmarest, 1804)	Southern three-banded armadillo	SSF	NT	CT
<b>Myrmecophagidae</b>				
<i>Myrmecophaga tridactyla</i> Linnaeus, 1758	Giant anteater	DS, HS, SSF	V	CT
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)	Southern tamandua	SSF	LC	CT
<b>Leporidae</b>				
<i>Sylvilagus brasiliensis</i> (Linnaeus, 1758)	Tapeti	SDF, SSF	LC	CT

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## LITERATURE CITED

- Abba, A.M. and M. Superina. 2010. The 2009/2010 armadillo Red List assessment. *Edentata* 11: 135–184 (doi: 10.5537/020.011.0201).
- Alho, C.J.R., T.E.J.R. Lacher, Z.M.S. Campos and H.C. Gonçalves. 1987. Mamíferos da Fazenda Nhumirim, Sub-região da Nhecolândia, Pantanal de Mato Grosso do Sul: Levantamento preliminar de espécies. *Revista Brasileira de Biologia* 48(2): 213–225 (doi: 10.1590/S0101-81751987000200007).
- Alho, C.J.R. 2008. Biodiversity of the Pantanal: response to seasonal flooding regime and to environmental degradation. *Brazilian Journal of Biology* 68(4): 957–966 (doi: 10.1590/S1519-69842008000500005).
- Alho, C.J.R., G. Camargo and E. Fischer. 2011. Terrestrial and aquatic mammals of the Pantanal. *Brazilian Journal of Biology* 71(1): 297–310 (doi: 10.1590/S1519-69842011000200009).
- Alho, C.J.R. and J. Sabino. 2011. A conservation agenda for the Pantanal's biodiversity. *Brazilian Journal of Biology* 71(1): 327–335 (doi: 10.1590/S1519-69842011000200012).
- Bertassoni, A., N.L. Xavier-Filho, F.A. Rabelo, S.P.S. Leal, G.E.O. Porfírio, V.F. Moreira and A.P.C. Rabelo. 2012. Paraguay River Environmental Monitoring by Rede de Proteção e Conservação da Serra do Amolar, Pantanal, Brazil. *Pan-American Journal of Aquatic Sciences* 7(2): 77–84 ([http://www.cesam.ua.pt/files/PANAMJAS\\_7\(2\)\\_77-84.pdf](http://www.cesam.ua.pt/files/PANAMJAS_7(2)_77-84.pdf)).
- Bodmer, R.E. 1990. Responses of ungulates to seasonal inundation in the Amazon floodplain. *Journal of Tropical Ecology* 6: 191–201 (doi: 10.1017/S0266467400004314).
- Bolkovic, M.L., S.M. Caziani and J.J. Protomastro. 1995. Food habits of three-banded armadillo (*Xenarthra*: Dasypodidae) in the dry Chaco, Argentina. *Journal of Mammalogy* 76: 1199–1204 (<http://www.jstor.org/stable/1382612>).
- Cáceres, N.C., A.P. Carmignotto, E. Fischer and C.F. Santos. 2008. Mammals from Mato Grosso do Sul, Brazil. *Check List* 4(3): 321–335 (<http://www.checklist.org.br/getpdf?SL600-07>).
- Cadavid-Garcia, E.A. 1984. *O clima no Pantanal Mato-grossense*. Corumbá: Embrapa-CPAP. 42 pp.
- Calheiros, D.F. and C.J.A. Ferreira. 1997. *Alterações limnológicas no rio Paraguai ("dequada") e o fenômeno natural de mortandade de peixes no Pantanal Mato-grossense – MS*. Corumbá: Embrapa-CPAP. 51 pp.
- Carbone, C., S. Christie, T. Coulson, N. Franklin, J. Ginsberg, M. Griffiths, J. Holden, K. Kawanishi, M. Kinnard, R. Laidlaw, A. Lynam, D.W. Macdonald, D. Martyr, C. McDougal, L. Nath, T. O'Brien, J. Seidensticker, D. Smith, M. Sunquist, R. Tilson and W.N. Wan Shahruddin. 2001. The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Conservation* 4: 75–79 (doi: 10.1017/S1367943001001081).
- Carmignotto, A.P., M. Vivo and A. Langguth. 2012. Mammals of the Cerrado and Caatinga: distribution patterns of the tropical open biomes of Central South America; pp. 307–350, in: B.D. Patterson and L.P. Costa (ed.). *Bones, clones, and biomes: the history and geography of recent Neotropical mammals*. Chicago: University of Chicago Press.
- Carrillo, E. J., C. Saenz and T.K. Fuller. 2002. Movements and activities of white-lipped peccaries in Corcovado National Park, Costa Rica. *Biological Conservation* 108: 317–324 (doi: 10.1016/S0006-3207(02)00118-0).
- Desbiez, A.L.J., R.E. Bodmer and S.A. Santos. 2009a. Wildlife habitat selection and sustainable resources management in a Neotropical wetland. *International Journal of Biodiversity and Conservation* 1(1): 11–20 (<http://www.academicjournals.org/ijbc>).
- Desbiez, A.L.J., S.A. Santos, A. Keuroghlian and R.E. Bodmer. 2009b. Niche partitioning among White-lipped peccaries (*Tayassu pecari*), collared peccaries (*Pecari tajacu*), and feral pigs (*Sus scrofa*). *Journal of Mammalogy* 90(1): 119–128 (doi: 10.1644/08-MAMM-A-038.1).
- Desbiez, A.L.J., R.E. Bodmer and W.M. Tomas. 2010. Mammalian densities in a Neotropical Wetland subject to extreme climatic events. *Biotropica* 42(3): 372–378 (doi: 10.1111/j.1744-7429.2009.00601.x).
- Desbiez, A.L.J., S.A. Santos, A. Keuroghlian, J.M. Alvarez and W.M. Tomas. 2011. Forage use in domestic cattle (*Bos indicus*), capybara (*Hydrochoerus hydrochaeris*) and pampas deer (*Ozotoceros bezoarticus*) in a seasonal Neotropical wetland. *Mammalian Biology* 76: 351–359 (doi: 10.1016/j.mambio.2010.10.008).
- Eduardo, A.A. and M. Passamani. 2009. Mammals of medium and large size in Santa Rita do Sapucaí, MG, Southeastern Brazil. *Checklist* 5(3): 399–404 (<http://www.checklist.org.br/getpdf?SL118-08>).
- Eisenberg, J.F. and K.H. Redford. 1999. *Mammals of the Neotropics – The Central Neotropics (Ecuador, Peru, Bolivia, Brazil)*. Chicago: University of Chicago Press. 609 pp.
- Fernandez-Duque, E. and H.G. Erkert. 2006. Cathemerality and lunar periodicity of activity rhythms in owl monkeys of the Argentinian Chaco. *Folia Primatologica* 77: 123–128 (doi: 10.1159/000089699).
- Harmsen, B.J., R.J. Foster, S. Silver, L. Ostro and P. Doncaster. 2010. Differential use of trails by forest mammals and the implications for camera trap studies: a case study from Belize. *Biotropica* 42(1): 126–133 (doi: 10.1111/j.1744-7429.2009.00544.x).
- Harris, M., W.M. Tomas, G. Mourão, C.J. Silva, E. Guimarães, F. Smoda and E. Fachim. 2005. Desafios para proteger o Pantanal Brasileiro: ameaças e iniciativas em conservação. *Megadiversidade* 1(1): 156–164 ([http://www.conservacao.org/publicacoes/files/21\\_Harris\\_et\\_al.pdf](http://www.conservacao.org/publicacoes/files/21_Harris_et_al.pdf)).
- Hershkovitz, P. 1990. Titis, New World monkeys of the genus *Callicebus* (Cebidae, Platyrrhini): a preliminary taxonomic review. *Fieldiana, Zoology (New Series)* 55: 1–109 (<https://archive.org/stream/titisnewworldmon55hers/titisnewworldmon55hers.djvu.txt>).
- IUCN. 2013. IUCN Red List of Threatened Species. Version 2013.2. Electronic Database accessible at <http://www.iucnredlist.org>. Captured on 27 March 2014.
- Junk, W.J., C.N. Cunha, K.M. Wantzen, P. Petermann, C. Strussmann, M.I. Marques and J. Adis. 2006. Biodiversity and its conservation in the Pantanal of Mato Grosso, Brazil. *Aquatic Sciences* 68: 278–309 (doi: 10.1007/s00027-006-0851-4).
- Lima-Borges, P.A. and W.M. Tomas. 2004. *Guia de rastros e outros vestígios de mamíferos do Pantanal*. Embrapa/Pantanal/Sebrae/ Fundação Pantanal com Ciência. 148 pp.
- Lyra-Jorge, M.C., G. Ciocheti, V.R. Pivello and S.T. Meirelles. 2008. Comparing methods for sampling large and medium sized mammals: camera traps and track plots. *European Journal of Wildlife Research* 54: 739–744 (doi: 10.1007/s10344-008-0205-8).
- Marchini, S. and D.W. Macdonald. 2012. Predicting rancher's intention to kill jaguars: case studies in Amazonia and Pantanal. *Biological Conservation* 147: 213–221 (doi: 10.1016/j.biocon.2012.01.002).
- Melo, F., G. Buss, M.M.A. Jardim, R.C. Printes, J.S. Silva Júnior, M.M. Oliveira, J. Rímoli, M.G. Talebi, A. Hirsch and Z.M.B. Hirano. 2009. Primates; pp. 249–270, in: R.M. Rocha and W.A. Boeger (org.). *Estado da Arte e Perspectivas para a Zoologia no Brasil*. Curitiba: Ed. UFPR.
- Mittermeier, R.A., C.G. Mittermeier, T.M. Brooks, J.D. Pilgrim, W.R. Konstant, G.A.B. Fonseca and C. Kormos. 2002. Wilderness and biodiversity conservation. *Proceedings of the National Academy of Sciences* 100(18): 10309–10313 (<http://www.pnas.org/content/100/18.toc>).
- Ministério do Meio Ambiente-MMA. 2007. *Áreas prioritárias para a Conservação, Uso Sustentável, e Repartição de Benefícios da Biodiversidade Brasileira*. Brasília: MMA. 301 pp.
- Pierce, B.M., V.C. Bleich and R.T. Bowyer. 2000. Social organization of mountain lions: Does a land-tenure system regulate population size? *Ecology* 91: 1533–1543 (doi: 10.1890/0012-9658(2000)081).
- Plano de Conservação da Bacia do Alto Paraguai - PCBAP. 1997. Ministério do Meio Ambiente dos Recursos Hídricos e da Amazônia legal. Brasília: Ministério do Meio Ambiente. 433 pp.
- Porfírio, G.E.O., P. Sarmiento, N.L. Xavier-Filho, S.P.S. Leal, V.F. Moreira, F.A. Rabelo, J. Cruz and C. Fonseca. 2012. New records of giant armadillo *Priodontes maximus* (Cingulata: Dasypodidae) at Serra do Amolar, Pantanal of Brazil. *Edentata* 13: 72–75 (<http://www.xenarthrans.org/recursos/bibliography/16Edentata%2013.pdf>).
- Rodrigues, F.H.G., I.M. Medri, W.M. Tomas and G. Mourão. 2002. Revisão do conhecimento sobre ocorrência e distribuição de mamíferos do Pantanal. Embrapa Pantanal - *Documentos* 38: 1–41.
- Rossi, R.V. and G.V. Bianconi. 2011. Ordem Didelphimorphia; pp. 31–69, in: N.R. Reis, A.L. Peracchi, W.A. Pedro and I.P. Lima (org.). *Mamíferos do Brasil*. Londrina: Nélio R. dos Reis.
- Sá Arruda, W., M.V.S. Urquiza, I.H. Ishii, G.A. Damasceno-Junior, and R.C.V. Galharte. 2012. Aspectos dinâmicos da flora e criação da coleção de material botânico da Reserva Particular do Patrimônio Natural Engenheiro Eliezer Batista, Serra do Amolar, Corumbá-MS; pp. 62–81, in: A.P.C. Rabelo, V.F. Moreira, A. Bertassoni and C. Aoki (org.). *Descobrimo o Paraíso*. Rio de Janeiro: Instituto Homem Pantaneiro.
- Schaller, G.B. 1983. Mammals and their biomass on a Brazilian ranch. *Arquivos de Zoologia* 31(1): 1–36.
- Silva, J.S.V. 2000. *Zoneamento ambiental da borda oeste do Pantanal: Maciço do Urucum e adjacências*. Brasília: Embrapa Informação e Tecnologia. 365 pp.
- Silveira, L., A.T.A. Jácomo and A.F. Diniz-Filho. 2003. Camera trap, line transect census and track surveys: a comparative evaluation. *Biological Conservation* 114: 351–355 (doi: 10.1016/S0006-3207(03)00063-6).
- Srbek-Araujo, A.C. and A.G. Chiarello. 2005. Is camera-trapping an efficient method for surveying mammals in Neotropical forests? A case study in south-eastern Brazil. *Journal of Tropical Ecology* 2(1): 1–5 (doi: 10.1017/S0266467404001956).
- Taber, A.B., A.J. Novaro, N. Neris and F.H. Colman. 1997. The food habits of sympatric jaguar and puma in the Paraguayan Chaco. *Biotropica* 29: 204–213 (doi: 10.1111/j.1744-7429.1997.tb00025.x).
- Tobler, M.W., S.E. Carrillo-Percastegui, R.L. Pitman, R. Mares and G. Powell. 2008. Further notes on the analysis of mammal inventory data collected with camera traps. *Animal Conservation* 11: 187–189 (doi: 10.1111/j.1469-1795.2008.00169.x).



- Tomas, W.M., N.C. Caceres, A.P. Nunes, E.A. Fischer, G. Mourão and Z. Campos. 2010. Mammals in the Pantanal wetland, Brazil; pp. 563–595, in: Junk, W.J., C.J. da Silva, Cunha, C.N. and K.M. Wantzen (ed.). *The Pantanal: Ecology, biodiversity and sustainable management of a large Neotropical seasonal wetland*. Sofia: Pensoft Publishers.
- Trolle, M. 2003. Mammal survey in the southeastern Pantanal, Brazil. *Biodiversity and Conservation* 12(4): 823–836 (doi: 10.1023/A:1022489426920).
- Vivo, M. 1991. *Taxonomia de Callithrix Erxleben, 1777 (Callithricidae, Primates)*. Belo Horizonte: Fundação Biodiversitas para Conservação da Diversidade Biológica. 105 pp.
- Voss, R.S and L.H. Emmons. 1996. Mammalian diversity in Neotropical lowland rainforests: a preliminary assessment. *Bulletin of the American Museum of Natural History* 230: 1–115 (<http://hdl.handle.net/2246/1671>).
- Walker, R.S., A.J. Novaro and J.D. Nichols. 2000. Consideraciones para la estimacion de la abundancia de poblaciones de mamíferos. *Journal of Neotropical Mammalogy* 7(2): 73–80 (<http://www.journals4free.com/link.jsp?l=624444>).
- Weckel, M., W. Giuliano and S. Silver. 2006. Jaguar (*Panthera onca*) feeding ecology: Distribution of predator and prey through time and space. *Journal of Zoology* 270: 25–30 (doi: 10.1111/j.1469-7998.2006.00106.x).
- Wetzel, R.M. 1985. Taxonomy and distribution of armadillos. Dasypodidae; pp. 23–46, in: G.G. Montgomery (ed.). *The evolution and ecology of sloths, armadillos and vermilinguas*. Washington: Smithsonian Institution Press.
- Wilson, D.E and D.M. Reeder. 2005. *Mammal Species of the World. A Taxonomic and Geographic Reference* (3<sup>rd</sup> ed). Accessible at <http://www.press.jhu.edu/>. Captured on 31 March 2014.

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