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ACCESSIBILITY DO NOT EXPLAIN ABUNDANCE OF MEDIUM AND LARGE-SIZED MAMMALS IN TERRA DO MEIO, ALTAMIRA, PARÁ, BRAZIL

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ABSTRACT. The aim of this study was to evaluate the effects of accessibility on hunting pressure by considering the mammal abundance and biomass of two protected areas belonging to different conservation categories -indigenous land and Ecological Station- in the Xingu River basin, eastern Amazon. For doing so, we used linear transection methods (total effort 240 km, in four tracks), camera traps (487 days) and complementary records. We also developed an accessibility coefficient based on the distance between navigable rivers and roads, and the center point of the sampled trails. We used the Simple linear regression test to analyze the effects of this accessibility on the biomass of the sighted species, gathering them in orders. We found 34 species belonging to seven families and six orders. We found no relation between mammal biomass and our accessibility index, which suggests that hunting pressure affects even the most distant studied areas.

Key words: Hunting; environmental disturbance; Eastern Amazon; conservation; mastofauna

RESUMO. Nosso objetivo foi analisar os efeitos da acessibilidade sobre a pressão de caça refletida na abundância e biomassa de mamíferos em duas áreas protegidas de diferentes categorias de conservação. Terra indígena e Estação Ecológica, na bacia do rio Xingu, no leste da Amazônia. Para tal, usamos os métodos de transição linear (esforço de 240 km), armadilhas fotográficas (487 dias) e registros complementares. Adicionalmente, desenvolvemos um coeficiente de acessibilidade com base na distância dos rios e estradas navegáveis para o ponto central das trilhas percorridas. Utilizamos regressão linear simples para analisar os efeitos da acessibilidade sobre a biomassa das espécies avistadas (agrupadas em ordens). Encontramos 34 espécies pertencentes a 07 famílias. Não encontramos relação entre a biomassa de mamíferos e nosso índice de acessibilidade, sugerindo que a pressão de caça afeta a área estudada a uma maior distância.

Palavras chave: Caça; distúrbios ambientais; reserva ambiental; Amazônia oriental; conservação; mastofauna

INTRODUCTION

Variations in hunting pressure explain differences in medium and large-sized vertebrate densities in tropical rain forests worldwide (Peres, 2000; Levi *et al*., 2009; De Andrade Melo *et al*., 2015; Constantino, 2016). It is generally considered that such variation is intrinsically connected to the accessibility to hunting areas, which depends on factors such as the distance to rivers, roads and human settlements which influence the walking distance covered by hunters to the hunting area (De Souza-Mazurek *et al*., 2000; Peres & Lake, 2003). Accessibility also negatively affects refuge areas, which are sources of wildlife, impoverishing local biological communities (Espinosa *et al*., 2014; Fragoso *et al*., 2000; Harrison, 2011).

In the Tropics, road expansion is associated with increases in hunting pressure as road networks expand and the area of forest accessible to hunters increases (Laurance *et al*., 2009, Espinosa *et al*., 2014). Studies of the impact of roads and hunting on Tropical Rainforest Mammals found different responses, for example, in Congo Basin, hunting had the greatest impact on Cetartyodactyla and a lower impact on Carnivores. Monkey species showed little response to roads or hunting, whereas some rodents increased in abundance (Laurance *et al*., 2006). In the Neotropics, the first to become rare or extinct from impacted areas are the large-bodied, terrestrial mammals such as the white-lipped peccary, jaguar, giant ant-eater, tapir, puma and collared peccary (Azevedo & Conforti, 2008; Naranjo & Bodmer, 2007; Melo *et al*., 2015, Meyer *et al*., 2015, Luna *et al*., 2017). The differentiated responses of the mammals to hunting depend on biological factors such as: their higher energetic demands, larger home ranges, slower reproductive rates, and densities (Peres, 2000; Brown & Brown, 1992) and the cultural factors of the hunters, such as their ethnic origin and dietary preferences (Peres, 2000), taboos and hunting practices (Levi *et al*., 2009, Alvard, 1993).

Hunting by subsistence hunters are concentrated around settlements and near the margins of rivers and roads (Sirén *et al*., 2006; Levi *et al*., 2009; Espinosa *et al*., 2014), as described by central place foragers. On the other hand, there is a pattern related to depletion near settlements that tend to have lower capture per unit of effort than remote hunting sites (Fragoso, 1998).

The aim of this study was to investigate the effects of accessibility on the abundance of mammals in two protected areas in the Xingu River Basin, in the State of Pará, Brazil.

MATERIALS AND METHODS

Study area. This study was developed in two adjacent protected areas in the Xingu River basin eastern Amazon (Fig. 1): The Terra do Meio Ecological Station (TMES) area is located in the South-Central region of the State of Pará, covering an area of 3,373,110 ha. The TMES is surrounded by other protected areas (Velásquez, 2007). Nowadays, 15 families are authorized to live in this area, performing traditional activities such as subsistence fishing and extractivism (ICMBio, 2015). It is composed of dense evergreen forest (18%) and open forest (82%) (MMA, 2007).

The Cachoeira Seca Indigenous Land (CSIL) was officially created on 2008 and is located in the South-Central region of Pará, covering an area of 734,027 ha. It is inhabited by 87 Native American people from the Arara ethnicity and, illegally, by more than one thousand settlers, making each a region of inter-ethnic conflict (Doblas, 2015). The CSIL is also composed of dense evergreen forest (32%) and open forest (68%) (ISA, 2016).

Sampling. These trails were explored with an average speed between 1.2 and 2 km/h, registering the presence of mammals from the target group (Burnham *et al*., 1980; Peres & Cunha, 2011). The transect sections were explored by a researcher and an auxiliary between 6:30 am and 6 pm from May 2015 to June 2016. To each animal or group of animals visualized during the census, the following information was registered in field sheets: species, group size, perpendicular distance, time and location in the transect, among other data. In cases of climate adversities such as little visibility, rain or wind, the census could be temporarily interrupted and restarted in conditions which do not compromise the sighting (Peres & Cunha, 2011). In the data collection, a special effort was made to fulfill the four methodological premises provided by Burnham *et al*. (1980), assuring the reliability of the results.

The traps were installed perpendicular to the line transect, in alternative trails and along the banks of the Novo and Iriri Rivers during fieldwork. The spots were selected by an experienced fieldwork auxiliary. The 14 camera traps (nighthawk 35 mm and digital trap camera Canon® PowerShot A470) were individually set on trees at a height of 30 to 40 centimeters from the ground and with a minimum distance of 500 meters between them. The traps available for the present study were set to work throughout the whole fieldwork time, with total effort of the 487 camera days.

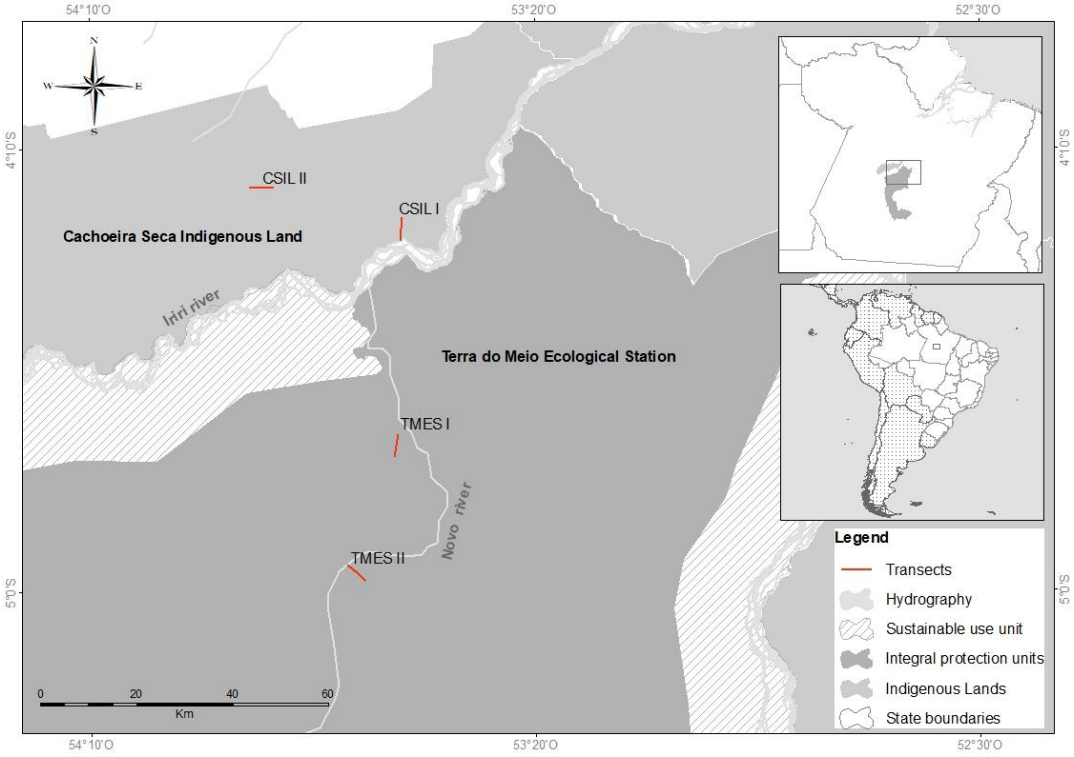

Figure 1. Conservation units and Indigenous Land constituting the *Terra do Meio* mosaic.

Another method used to make the mammal species list of this study was based on the occurrence signs of the target species (footprints, feces, vocalizations, anatomical parts and occasional encounters) during the activities in the field (installation and monitoring of the transects and trap cameras; Fragoso *et al*., 2016).

The studies in the protected areas were performed under the authorizations nº 48195-2 MMA/ICMBio and nº 022/AAEO/PRES/2016 FUNAI.

The taxonomic nomenclature of the 52 expected species in these areas of study followed the instructions proposed by Wilson & Reeder (2005) and by Reis *et al*. (2010). Due to the difficulties in determining a reliable taxonomic identification, some families of medium-sized species, from the order Rodentia, such as Muridae and Echimyidae, as well as from the order Didelphimorphia, Didelphidae, were omitted. The inclusion of small species, such as *Guerlinguetus aestuans* and *Mico argentatus*, is usual in studies because of the similarity between the registration methods of medium and large species (Santos & Mendes-Oliveira, 2012; Costa-Pereira *et al*., 2013; Benchimol & Peres, 2015).

Data Analysis. The biomass of adult species sighted (biomass/5 km covered) by area was set by multiplying the number of adults sighted at every 5 km by its body weight. According to De Andrade Melo *et al*. (2015), the arithmetic average of mass reported by Eisenberg and Redford (1999), Emmons & Feer (1997) and Reis *et al*. (2010) was considered in the body weight.

The accessibility coefficient was established by calculating the average proportions of the distances from navigable rivers and trafficable roads to the central spot of the covered trails (Table 1). We used simple linear regression and the logarithmic transformation in the biomass variable was applied so that the residuals of the model had normal distribution (Zar, 1974) in the R program (R Core Team, 2018).

Table 1. Effort distances from rivers, roads and settlements in analyzed transects.

Transect	Length (km)	Effort (km)	Distance from the river (km)	Distance from road (km)	Distance from the settlement (km)
CSIL I	5	81.75	2	10	8
CSIL II	5	38.25	18	2	23.4
TMES I	5	65	32	41	41
TMES II	5	55	54	64	64

RESULTS

In this study, we confirmed the presence of 34 of the 52 species of medium and large-size mammals expected to be found in the studied region according to the literature (Reis *et al*., 2010; Emmons & Feer, 1997; IUCN, 2016).

The linear transect method registered the presence of 19 species (Table 2); the camera trap, 19 (Table 3); and the complementary register, 29. Most of the records of the species were shared by the three methods; however, the species *Chiropotes albinasius* and *Guerlinguetus aestuans* were exclusive to the first method, *Procyon cancrivorous* to the second, and *Lontra longicaudis*, *Pteronura brasiliensis*, *Coendou preensilis*, *Hydrochaeris hydrochaeris* and *Aotus infulatus* to the occurrence signs method.

The linear effect of accessibility on the biomass of orders in the studied areas was not significant ($F = 0.885$; $p > 0.05$; $df = 46$).

DISCUSSION

We show that facilitation of hunter access to a natural landscape can lead to a development-induced impact on the abundance of mammals and that the effect of hunting affects at distances greater than 10 km from the transects to the trafficable roads and navigable rivers. In a theoretic study of hunted areas (Benítez-López *et al*., 2017), it was found that birds and mammals were depleted within 7 and 40 kilometers from the hunters' access points (roads and settlements). In other studies, it was neither found a significant

difference in the levels of accessibility, abundance of orders and biomass of adult animals (De Andrade Melo *et al*., 2015; Antunes *et al*., 2016). Although the density of residents is 1 inhab/km^2 (Harrison, 2011), it is possible that the whole area is influenced by poachers from Uruará and elsewhere. Traditionally, it is known that humans living in or adjacent to national parks threaten the preservation of some parks and reserves by hunting, building settlements, and other human activities (Pimentel *et al*., 1992) and, in Terra do Meio, this is not the exception.

Table 2. Orders and species registered by the line transect method in the TMES and CSIL during the period of May 2014 and May 2016.

	TMES I		**TMES II**		**CSILI**		**CSILII**	
	(65 Km)		**(55 Km)**		**(81,75 Km)**		**(38,25 Km)**	
Taxon	**Sights**	**Rate**	**Sights**	**Rate**	**Sights**	**Rate**	**Sights**	**Rate**
Artiodactyla	**4**	**0.62**	**7**	**1.27**	**7**	**0.86**	0	0
Mazama americana	1	0.15	5	0.91			0	0
Pecari tajacu	3	0.46	1	0.18	5	0.61	0	0
Tayassu pecari			1	0.18	2	0.24	0	0
Carnivora	**2**	**0.31**	**3**	**0.55**	**2**	**0.24**	0	0
Eira barbara	1	0.15			1	0.12	0	0
Leopardus wiedii	1	0.15						
Nasua nasua			2	0.36	1	0.12	0	0
Puma concolor			1	0.18			0	0
Perissodactyla			**1**	**0.18**			0	0
Tapirus terrestris			1	0.18			0	0
Pilosa	**1**	**0.15**	**1**	**0.18**	**1**	**0.12**	**1**	**0.26**
Bradypus variegatus							1	0.26
Tamandua tetradactyla	1	0.15	1	0.18	1	0.12		
Primates	**36**	**5.54**	**27**	**4.91**	**29**	**3.55**	**30**	**7.84**
Alouatta discolor					1	0.12		
Ateles marginatus	2	0.31	2	0.36	1	0.12	1	0.26
Callicebus moloch	12	1.85	6	1.09	7	0.86	7	1.83
Chiropotes albinasus					1	0.12	1	0.26
Mico argentatus					2	0.24	4	1.05
Sapajus apella	16	2.46	15	2.73	11	1.35	15	3.92
Saimiri sciureus	6	0.92	4	0.73	6	0.73	2	0.52
Rodentia	**25**	**3.85**	**48**	**8.73**	**27**	**3.3**	**17**	**4.44**
Dasyprocta leporina	18	2.77	30	5.45	22	2.69	12	3.14
Guerlinguetus aestuans	7	1.08	18	3.27	5	0.61	5	1.31
Total	**68**	**10.46**	**87**	**15.82**	**66**	**8.07**	**48**	**12.55**

Rate = nº of sightings/10 km; Sight.= sightings

These results may even corroborate the idea that hunting, despite low levels, has an impact on the impoverishment of communities (Peres, 2000; Parry *et al*., 2009). It is possible to even associate this situation with the fact that most parts of protected areas in the Amazon are accessible because of its large watershed (Pere**s** & Lake, 2003; Antunes *et al*., 2016). This impact may be increased by the use of firearms, which is different from the results obtained by most studies of traditional hunting in indigenous tribes (Endo *et al*., 2010; Espinosa *et al*., 2014).

The confirmation of the presence of 2/3 of the 52 expected species in the studied region indicates that the methods used in this survey of species richness are satisfactory and highlights the importance of complementary registers in inventories of mammals (Fragoso *et al*. 2016). In the analysis of abundance, the

line transects method and camera traps are essential. Moreover, these tools complement each other in the study of the groups of registered mammals, as shown in the Santos and Mendes-Oliveira (2012) research. Line transects are efficient to register diurnal fauna, especially that of Primates. However, this demands a great sampling effort for the detection, and calculation of species density (Fragoso *et al*. 2016). Camera traps are more efficient to register nocturnal animals with discrete habits, such as the carnivores (Silveira *et al*. 2003).

The protected areas studied have an important role in biological conservation, not only for those communities of mammals, but also for harboring endangered and vulnerable species of the mastofauna. The absence of *Chiropotes albinasus* and *Mico argentatus* on the right bank of the Iriri River confirms the geographical distribution proposed by Reis *et al*. (2010). Nevertheless, not detecting *Mico emiliae* in this same area is intriguing because this species was registered in the Nacional Park Serra do Pardo, located 100 km east of the TMES (Portella *et al*. 2018). The absence of some expected species in the area may be related to factors such as cryptic and nocturnal habits, naturally low population densities and behavioral changes in response to anthropic actions (Fragoso *et al*. 2016).

Table 3. Orders and species registered by the camera trap method in the TMES and CSIL during the period of May 2014 and May 2016.

	TMES I (3.064h)		**TMES II (3.120h)**		**CSILI (4.117 h)**		**CSILII (1.421 h)**	
Taxon	**Reg**	**R/SE**	**Reg**	**R/SE**	**Reg**	**R/SE**	**Reg**	**R/SE**
Artiodactyla	**8**	**0.063**	**28**	**0.215**	**30**	**0.175**	**1**	**0.017**
Mazama americana	1	0.008	13	0.100	22	0.128		
Mazama nemorivaga	1	0.008	7	0.054				
Pecari tajacu	5	0.039	7	0.054	5	0.029	1	0.017
Tayassu pecari	1	0.008	1	0.008	3	0.017		
Carnivora	**2**	**0.02**	**11**	**0.085**	**17**	**0.099**	**2**	**0.034**
Cerdocyon thous			1	0.008	1	0.006		
Eira barbara							1	0.017
Leopardus pardalis	2	0.016	5	0.038	10	0.058	1	0.017
Leopardus wiedii			1	0,008				
Nasua nasua					2	0.012		
Panthera onca			2	0,015	1	0.006		
Procyon cancrivorus					2	0.012		
Puma concolor			2	0.015	1	0.006		
Cingulata	**1**	**0.01**	**2**	**0.015**	**11**	**0.064**	**2**	**0.034**
Dasypus kappleri					1	0.006	2	0.034
Dasypus novemcinctus	1	0.008	2	0.015	9	0.052		
Priodontes maximus					1	0.006		
Perissodactyla	**29**	**0.227**	**12**	**0.092**	**9**	**0.052**		
Tapirus terrestris	29	0.227	12	0.092	9	0.052		
Pilosa					**1**	**0.006**		
Myrmecophaga tridactyla					1	0.006		
Rodentia	**16**	**0.13**	**135**	**1.038**	**36**	**0.210**	**6**	**0.101**
Cuniculus paca	3	0.023	37	0.285	23	0.134		
Dasyprocta leporina	13	0.102	98	0.754	13	0.076	6	0.101
Total	56	0.439	188	1.466	104	0.606	11	0.186

Reg = Registers; SE = Sample effort.

The higher rate of sightings compared to other studies in the region may be associated with the fact that this is an area of permanent preservation, which was also observed in similar studies (Ravetta 2001;

Sampaio *et al.* 2010). Besides this, the difference observed in the Chi-Square test among the sampled transects leads us to infer that the differences in the composition of communities of an area may not be explained by the analysis of one or two factors, but by the interaction of several variables (Tardio & Da Silveira 2015).

Terra do Meio proved to be an area with good conditions for conservation, as it can be observed in the presence of predators and large cynegetic mammals. However, the increase in hunting activities, forest exploitation and deforestation, can lead, in the short term, to a reduction in the densities of some populations and even to local extinctions.

Finally, Terra do Meio proved to be an area with good conditions for conservation. However, the increase in hunting activities, forest exploitation and deforestation, can lead, in the short term, to a reduction in the densities of some populations and even to local extinctions as reported in some studies (Fialho 2007; Travassos 2011). This also emphasizes the need to increase the monitoring of peripheral areas of units of conservation so that these units fulfill their roles in the conservation once there is a lack of efficient conservation policies in the region.

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