Medium and large sized mammals of the Cerrado domain of Tocantins state, Brazil

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Abstract

The Tocantins state is the youngest in Brazil. It is largely occupied by the Cerrado domain, a biodiversity hotspot. Despite estimates of the number of medium and large sized mammals, few studies cover the entire state broadly. In face of the threat that these animals has been suffering from the expansion of agro-pastoral and urban activities, here is presented a high mammal richness that was found on a wide geographic scale in 10 areas, which are distant at least 60 kilometers from each other, from the southern to the northern end of the state, data obtained over 10 years (2001-2011). Two methodologies were used for this study: the Irregular Path Methods and cameras-trap. Were recorded 47 mammal species, from which 14 species are considered in threat. Records of common species associated with endangered species reinforce the need for further studies to increase knowledge and understanding of the distribution of the mammal community by creating technical and scientific arguments for the development of effective conservation measures and even for the selection of protected areas to wildlife.

Keywords: Conservation. Phytophysiognomies. Biodiversity hotspot. *Panthera onca*. *Chrysocyon brachyurus. Pteronura brasiliensis*.

Introduction

The state of Tocantins has 91.0 % of its territory covered by Cerrado (IBGE, 2007). This extension includes several phytophysiognomic types, such as savanna and forest formations (RIBEIRO; WALTER, 1998), reflecting in high faunistic richness. Considering the 6,977 species of fish, amphibians, reptiles, birds (LEWINSOHN; PRADO, 2005) and mammals (PAGLIA et al., 2012) from Brazil, 2,486.0 or 35.7% of the species, have its occurrence confirmed in the Cerrado domain (MMA, 2015).

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At the same time that it stands out as a center of faunistic diversity, the *Cerrado* has undergone severe changes in its original vegetation cover. Estimates indicate that 55.0 % of its original vegetation has already been replaced by different forms of land use and occupation (KLINK; MACHADO, 2005). Specifically in the *Cerrado* of the Tocantins state, 31.0 % of its original vegetation was replaced by pastures (8 million hectares), temporary crops (731 thousand hectares) and permanent crops (9,400 hectares) (IBGE, 2013), with no estimates for other forms of use and occupation of the territory of the state.

The impacts of suppression and replacement of original vegetation implies loss of habitat, threatening the survival of ecological communities (FAHRIG, 2003; LAURANCE et al., 2011), including medium and large sized mammal communities. Theses mammals are animals above of one kilogram. Theoretical and empirical evidence indicates that the higher energetic demand of mammal species of higher body weight, the lowest densities, larger living areas and, consequently, a greater probability of extinction, particularly during the more advanced stages of habitat alteration (PURVIS et al., 2000; OLIFIERS et al., 2004; GRELLE et al., 2006).

Studies of medium and large sized mammals' communities in the state of Tocantins are scarce and punctual (LIMA et al., 2005; CARMIGNOTTO; AIRES, 2011; NOGUEIRA et al., 2011). Therefore, there is a lack of papers dealing with species list and related to ecological issues from a conservationist perspective. Based on this scenario, this study presents the richness and composition of medium and large sized mammals, presenting an updated mammal species list for Tocantins state.

Material and methods

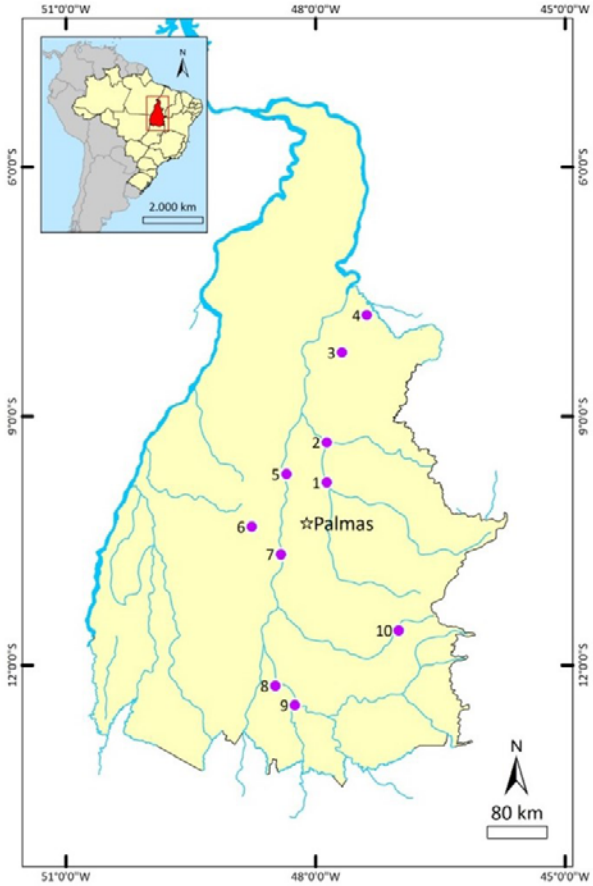
Study area

The study was conducted in the Cerrado domain in the state of Tocantins, Central-West, Brazil. The average annual precipitation in this area is approximately 1,500.0 mm, and the average temperature is 24.0 °C (LEEMANS; CRAMER, 1991). The dominant climate is semi-humid Tropical of Central Brazil (Aw, according to Köppen Classification) (ALVARES et al., 2014). The relief is characterized by being corrugated, with plateaus and small hills (MAMEDE et al., 2002).

For the present study, 10 areas were selected, which are distant at least 60.0 kilometers from each other, from the southern to the northern end of the state. These areas were chosen for the presence of phytophysiognomies representative of the Brazilian Cerrado, including Riparian Forest; Gallery Forests; Cerradões; Typical Cerrado; Dense Cerrado; Dirt Fields; and Vereda (Figure 1, Supplementary Material 1).

All areas had suffered from human influence, and their conservation status has not been assessed. The riparian forest and gallery forest are closely linked to rivers, lakes, and others, protecting the main course. The Cerradões are a forest phytophysiognomy on well-drained land, without association with water courses. The typical Cerrado, dense Cerrado and Vereda are savanical formations, where there is the presence of the defined tree and shrub-herbaceous strata, with the trees randomly distributed over the ground in different densities, without forming a continuous canopy. Finally, the Dirt Fields are characterized by the evident presence of shrubs and sub-shrubs, interspersed in the shrub-herbaceous layer (RIBEIRO; WALTER, 1998).

Figure 1 – Location of the study's selected areas of the Cerrado domain of the Tocantins state, Brazil.



Source: Elaborated by the authors (2020).

Sampling of mammals

This study brings a compilation of information collected between February 2001 and December 2011. Two methodologies were applied: the first consisted of Irregular Path Methods (IPM) similar to Machado et al. (2016). In this method, the pre-existing nonlinear tracks are traversed at a speed of approximately 1 km h-1, to obtain qualitative and quantitative data. The procedure records the number of individuals of each species that can be accurately identified when moving slowly along the route through the environment.

The second methodology consisted of the use of cameras-trap, performed with photographic traps arranged equidistant between each other by 250.0 meters, on average. It was used as a criterion the setting of camera traps on pre-existing trails, because medium and large mammals have the habit of use them. Photographic records were considered independent when the interval between photographs of the same photographic trap for the same species was one hour or longer (SRBEK-ARAUJO; CHIARELLO, 2013). Records were established according to the times of the photographic events in a 24-hour period.

The sample effort was obtained in two different ways for each methodology. These efforts between areas varied, and their demonstrations by area are presented in Supplementary Material 2. For the cameras-trap, the effort is in agreement with the formula used by Srbek-Araujo and Chiarello (2005), and presented a total of 3,464 traps per day.

Data analysis

Estimates of the richness of medium and large mammals in the study areas were carried out from the species list. A presence-absence matrix was used to estimate richness and their respective confidence intervals, using the first-order Jackknife estimator. The software used was the *EstimateS Win 820* (COLWELL, 2009), with 1000 randomizations without replacement.

Confidence intervals were calculated for the richness estimator (Jackknife of first order) in order to verify whether the differences between the estimated richness among the physiognomic types of vegetation were significant. Decision-making was done by confidence interval inference ($p < 0.05$) (ZAR, 1984). The 95% confidence intervals were used for the statistical comparison of the observed richness among vegetation types. The software used was *Statistica 7.0 Release* (STATSOFT INCORPORATION, 2005). In addition, it was estimated the sample efficiency in percentage.

The nomenclature and taxonomic classification follow Paglia et al. (2012). Recent taxonomic revisions were adopted, including Cebus/Sapajus (LYNCH-ALFARO et al., 2012) and Leopardus (TRIGO et al., 2013), as well as information on species and subspecies available in Gutiérrez and Marinho-Filho (2017).

Results

Forty seven mammal species of medium and large size were recorded, belonging to nine orders, 19 families and 35 genera. The most representative order was *Carnivora* (17 species), followed by *Rodentia* (6), *Artiodactyla* (5), *Cingulata* (5) and *Primates* (4). The family with the highest number of genera was *Dasypodidae* (four genera and six species), followed by *Canidae* and *Mustelidae* (four genera and four species each), *Felidae* (three genera and six species), *Didelphimorphia* and *Procyonidae* (three genera and three species each), *Cervidae* (two genera and three species), *Myrmecophagidae* and *Tayassuidae* (two genera and two species each), *Dasyproctidae* (one genus and four species) and *Tapiridae*, *Aotidae*, *Alouatta*, *Callithrichidae*, *Cebidae*, *Leporidae*, *Caviidae*, *Cuniculidae* and *Erethizontidae* (one genus and one species each) (Table 1 and some records in Supplementary Material 3).

Table 1 – List of species, physiognomic type of record, type of record and conservation category, according to MMA and IUCN (CO = *Cerradão*, CT = Typical *Cerrado*, MC = Riparian Forest, CD = Dense *Cerrado*, MG = Gallery forest, CS = Dirt Fields, VE = *Vereda*, PT = Camera Trap, OD = Direct Observation, RE = Rescue, T = Traces).

Taxon	Common name	Physiognomic types	Record	MMA	IUCN
DIDELPHIMORPHIA					
DIDELPHIDAE					
Didelphis albiventris Lund, 1840	White-eared opossum	MC, CO, CD, CT	AF, OD, RE		
Didelphis marsupialis Linnaeus, 1758	Common opossum	MC, CO	AF, OD, RE		
Didelphis sp.	Opossum	MC, CO, CT	OD, VE		
PILOSA					
MYRMECOPHAGIDAE					

(continue...)

Table 1 – Continuation

Taxon	Common name	Physiognomic types	Record	MMA	IUCN
Myrmecophaga tridactyla Linnaeus, 1758	Giant anteater	MC, CO, CD, CT, CS, VE	AF, OD, RE	Vulnerable	Vulnerable
Tamandua tetradactyla (Linnaeus, 1758)	Southern tamandua	MC, MG, CS, CD, CT	AF, OD, RE		
CINGULATA					
DASYPODIDAE					
Cabassous unicinctus (Linnaeus, 1758)	Southern naked-tailed armadillo	CO, CD, CT	OD		
Euphractus sexcinctus (Linnaeus, 1758)	Six-banded armadillo	CO, CD, CT, CS	AF, OD, RE		
Dasypus novemcinctus Linnaeus, 1758	Nine-banded armadillo	MG, CO, CD, CT, CS	AF, OD, RE		
Dasypus septemcinctus Linnaeus, 1758	Seven-banded armadillo	MG, CO, CD, CT	AF, OD, RE		
Dasypus sp.	Armadillo	CO	VE		
Priodontes maximus (Kerr, 1792)	Giant armadillo	CT	OD	Vulnerable	Vulnerable
PERISSODACTYLA					
TAPIRIIDAE					
Tapirus terrestris (Linnaeus, 1758)	South American tapir	MC, CO, CT	OD	Vulnerable	Vulnerable
ARTIODACTYLA					
CERVIDAE					
Blastocerus dichotomus (Illiger, 1815)	Marsh deer	VE	OD, RE	Vulnerable	Vulnerable
Mazama americana (Erxleben, 1777)	Red brocket	MC, CO, CD, CT	AF, OD, RE		
Mazama gouazoubira (G. Fischer, 1814)	Gray brocket	CO, CD, CT, CS	AF, OD, RE		
Mazama sp.		CO, CD, CT	OD		
TAYASSUIDAE					
Pecari tajacu (Linnaeus, 1758)	Collared peccary	MC, CO, CD, CT, CS	AF, OD, RE		
Tayassu pecari (Link, 1795)	White-lipped peccary	CO, CT	OD	Vulnerable	
PRIMATES					
AOTIDAE					
Aotus infulatus (Kuhl, 1820)	Night monkey	MC	RE		
ALOUATTA					

(continue...)

Table 2 – Continuation

Taxon	Common name	Physiognomic types	Record	MMA	IUCN
Alouatta caraya (Humboldt, 1812)	Black howler	MC, MG	AF, OD, RE		
CALLITRICHIDAE					
Callithrix penicillata (É. Geoffroy, 1812)	Black-tufted marmoset	MC, MG, CO	AF, OD, RE		
CEBIDAE					
Sapajus libidinosus (Spix, 1823)	Black-striped capuchin	MC, MG, CO	AF, OD, RE		
CARNIVORA					
CANIDAE					
Cerdocyon thous (Linnaeus, 1766)	Crab-eating fox	MC, CO, CD, CT, VE, CS	AF, OD, RE		
Chrysocyon brachyurus (Illiger, 1815)	Maned wolf	CT, VE, CS	OD, RE	Vulnerable	Near Threatened
Lycalopex vetulus (Lund, 1842)	Hoary fox	CO, CT	OD	Vulnerable	
CANIDAE					
Speothos venaticus (Lund, 1842)	Bush dog	CT	OD, VE	Vulnerable	Near Threatened
FELIDAE					
Leopardus braccatus (Cope, 1889)	Pantanal cat	MC	OD, RE	Vulnerable	
Leopardus pardalis (Linnaeus, 1758)	Ocelot	MC, CO, CT	OD, RE		
Leopardus tigrinus (Schreber, 1775)	Oncilla	MC, CO, CT, CD	OD, RE	In danger	Vulnerable
Panthera onca (Linnaeus, 1758)	Jaguar	CO	OD	Vulnerable	Near Threatened
Puma concolor (Linnaeus, 1771)	Cougar	CO	OD	Vulnerable	
Puma yagouaroundi (É. Geoffroy, 1803)	Jaguarundi	CO	OD, RE	Vulnerable	
MUSTELIDAE					
Eira barbara (Linnaeus, 1758)	Tayra	MC, MG, CO	OD		
Galictis vittata (Schreber, 1776)	Greater grison	MC, CO	OD, RE		
Lontra longicaudis (Olfers, 1818)	Neotropical otter	MC	OD		Near Threatened
Pteronura brasiliensis (Gmelin, 1788)	Giant otter	MC	OD	Vulnerable	Endangered
PROCYONIDAE					
Nasua nasua (Linnaeus, 1766)	South American coati	MC, MG, CO, CD, CT	AF, OD, RE		
Potos flavus (Schreber, 1774)	Kinkajou	MC	AF, OD, RE		

(continue...)

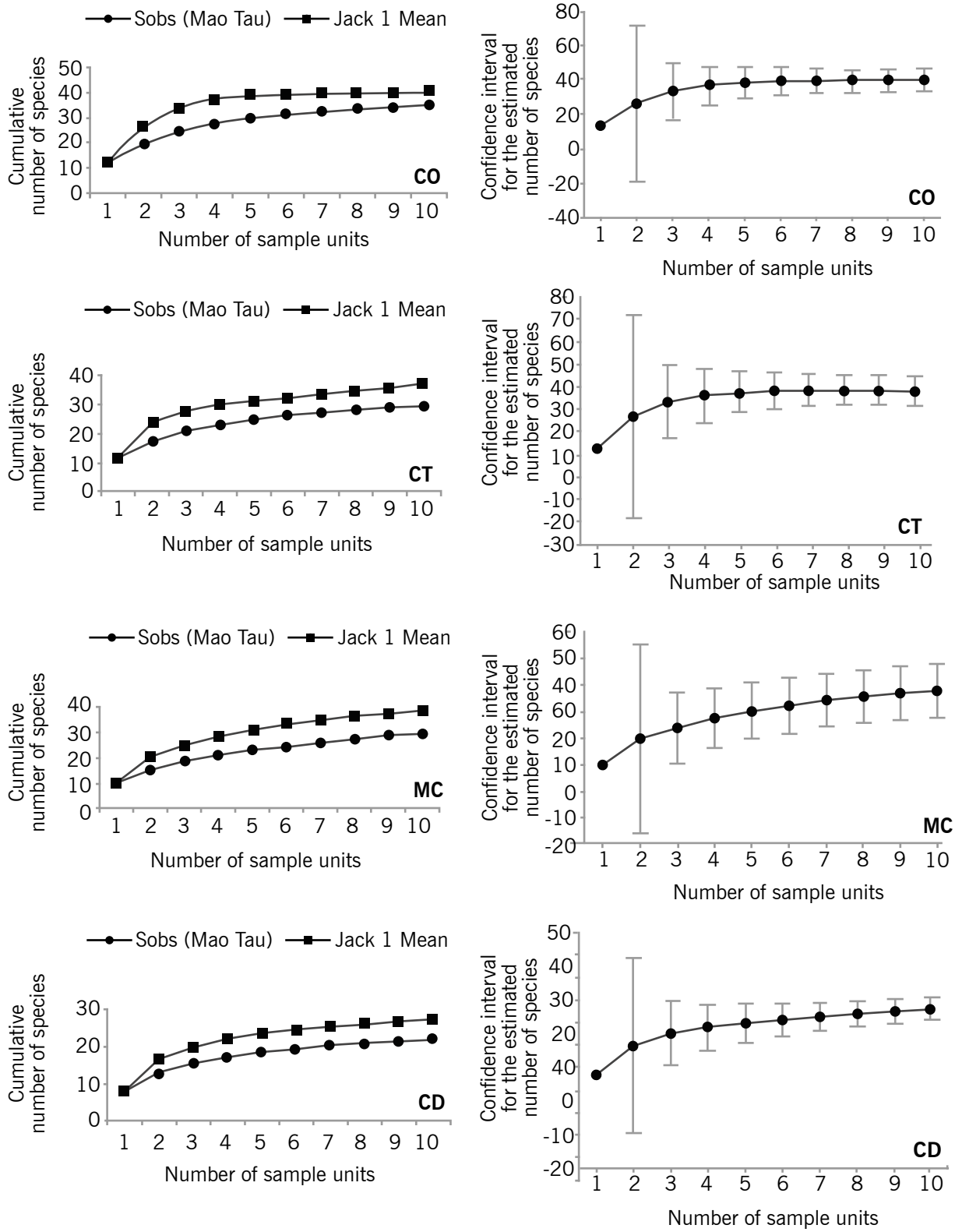
Table 2 – Continuation

Taxon	Common name	Physiognomic types	Record	MMA	IUCN
Procyon cancrivorus (G. Cuvier, 1798)	Crab-eating raccoon	MC, MG, CO, CD, CT	AF, OD, RE		
LAGOMORPHA					
LEPORIDAE					
Sylvilagus brasiliensis (Linnaeus, 1758)	Tapeti	CO, CD, CT, CS	OD, RE		
RODENTIA					
CAVIIDAE					
Hydrochoerus hydrochaeris (Linnaeus, 1766)	Capybara	MC, MG	AF, OD		
CUNICULIDAE					
Cuniculus paca (Linnaeus, 1766)	Lowland paca	MC, MG, CO, CD, CT	AF, OD, RE		
DASYPROCTIDAE					
Dasyprocta azarae Lichtenstein, 1823	Azara's agouti	CO, CD, CT	AF, OD, RE		
Dasyprocta leporina (Linnaeus, 1758)	Red-rumped agouti	CO, CD, CT, CS	AF, OD, RE		
Dasyprocta prymnolopha Wagler, 1831	Black-rumped agouti	MC, CO, CD, CT	AF, OD, RE		
Dasyprocta sp.	Agouti	CO, CD, CT	OD		
ERETHIZONTIDAE					
Coendou prehensilis (Linnaeus, 1758)	Brazilian porcupine	MC, MG, CO, CD, CT	AF, OD, RE		

Source: Elaborated by the authors (2020).

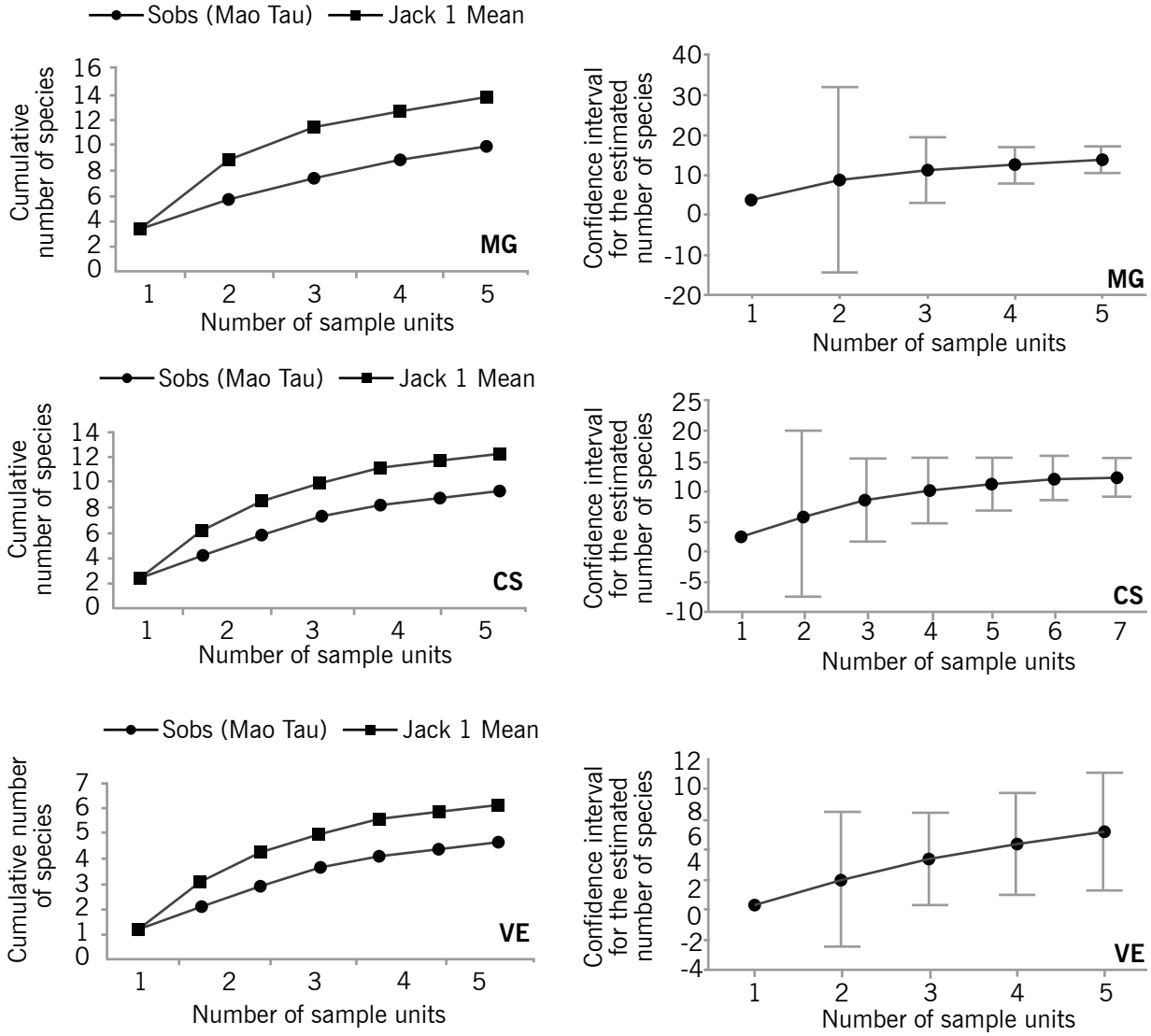
Fourteen species of medium and large sized mammals are considered in threat categories, according to the MMA (2014); and 10, according to IUCN (2017) (Table 1). Figures 2 and 3 present cumulative species curves for observed richness (Sobs) and estimated richness (Jackknife of 1st order), and the estimated richness with their respective confidence intervals for medium and large sized mammal species, recorded in each of the seven physiognomic types of the studied vegetation. These curves show the accumulated number of new species collected as the sample effort increases, therefore, showing curves that do not reach the asymptotes.

Figure 2 – Cumulative species curves for the observed and estimated richness by means of the 1st order Jackknife estimator, with its respective confidence interval (right), for medium and large sized mammal species (CO = Cerradão, CT = Typical Cerrado, MC = Riparian Forest, CD = Dense Cerrado).



Source: Elaborated by the authors (2020).

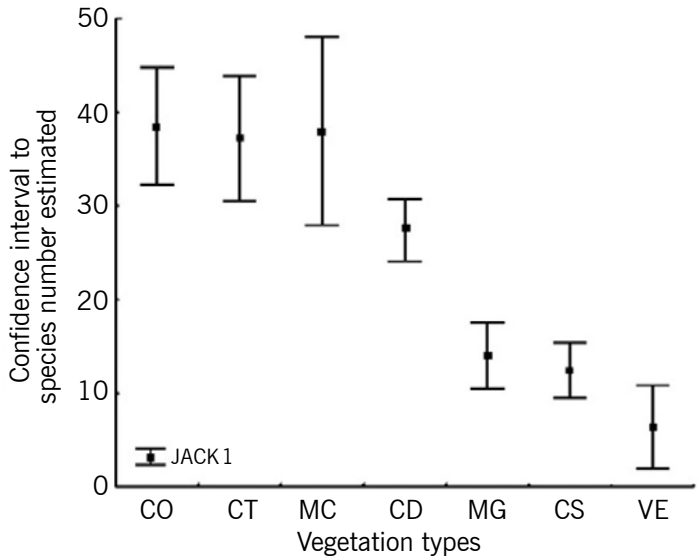
Figure 3 – Cumulative species curves for the observed and estimated richness using the 1st order Jackknife estimator, with its respective confidence interval (right), for medium and large sized mammal species (MG = Gallery Forest, CS = Dirt field, VE = Vereda).



Source: Elaborated by the authors (2020).

Figure 4 shows the comparison between the confidence intervals for the estimates of richness of medium and large sized mammals, obtained by the non-parametric 1st order Jacknife estimator for each of the seven physiognomic types. The physiognomic types of vegetation *Cerradão*, Typical *Cerrado* and Riparian Forest did not present statistically significant differences of richness when compared to each other, but they showed statistically significant differences when compared to the following vegetation types: Gallery forest, Dirt field and *Vereda*, that presented the lowest values. These last three phytophysiognomies did not differ statistically from each other.

Figure 4 – Graphical comparison of the confidence intervals for the richness estimated by the non-parametric 1st order Jacknife estimator for the medium and large mammal species in seven vegetation types of *Cerrado* (CO = *Cerradão*, CT = Typical *Cerrado*, MC = Riparian Forest, CD = Dense *Cerrado*, MG = Gallery forest, CS = Dirt field, VE = *Vereda*).



Source: Elaborated by the authors (2020).

Discussion

The *Cerrado* region in the Tocantins state presents potentialities as a center of biodiversity. Studies in the *Cerrado* of Central Brazil have shown that the records of species vary between 14 and 32 species, with the use of different methodologies (STALLINGS et al., 1991; SCHNEIDER et al., 2000; ZAHER et al., 2001; RODRIGUES et al., 2002; SANTOS-FILHO; SILVA, 2002; SILVA JÚNIOR et al., 2007; OLIVEIRA et al., 2009; BOCCHIGLIERI et al., 2010; NUNES et al., 2012; RIBEIRO; MELO, 2013; ALVES et al., 2014). According to Marinho-Filho et al. (2002), the *Cerrado* and its physiognomic types of vegetation presents 184 species of mammals, of which 51 species are categorized as medium and large sized.

One of the first studies on medium and large sized mammal fauna was conducted by Lima et al. (2005), in which there was founded 36 species in the Jalapão State Park, in the Tocantis state. Later, Carmignotto and Aires (2011) found 24 species of small size and 17 of medium and large size in the Estação Ecológica Serra Geral do Tocantins. Considering these studies, 42 mammal species of medium and large size have been currently recorded (LIMA et al., 2005; CARMIGNOTTO; AIRES, 2011; NOGUEIRA et al., 2011; NEGRÕES et al., 2011).

In this study, 47 species were recorded, representing an expressive contribution to the knowledge of the mammalian fauna, since it adds five species to the state's list. The species recorded in this study that were not observed in previous studies (LIMA et al., 2005; CARMIGNOTTO; AIRES, 2011; NOGUEIRA et al., 2011; NEGRÕES et al., 2011) are: *A. infulatus*; *L. braccatus*; *P. flavus*; *S. brasiliensis* and *D. prymnolopha*.

The species of this study corresponded to 92.0 % of all medium and large sized mammal species for the *Cerrado* domain (MARINHO-FILHO et al., 2002). The extensive list of species obtained

in the present study was due to three factors. The first one regards the geographical area where the study was conducted, that totalized ten areas, which ranged from approximately 530.0 kilometers on the longitudinal axis and 144.0 kilometers on the latitudinal axis. The second one regards the use of differentiated and complementary methodologies. According to Zanzini et al. (2008), the survey of mammals of medium and large size is defined as the simultaneous use of different methodologies of records of the species in order to obtain a list as complete as possible. Finally, the third factor is related to the current stage of scarcity of scientific studies on the fauna of the state of Tocantins (as mentioned by CARMINGNOTTO; AIRES, 2011; NOGUEIRA et al., 2011; NEGRÕES et al., 2011).

A total of 14 medium and large sized mammal species classified as threatened (MMA, 2014) were registered. These records of species in categories of threat corroborate to other studies carried out in the state of Tocantins (LIMA et al., 2005; CARMIGNOTTO; AIRES, 2011; NOGUEIRA et al., 2011) and demonstrate the imminent need for effective conservation work for these species. Some of the main forms of conservation and management *in locus* of these endangered mammals is landscape management, because the increase of natural (recovery) areas generates an increase in habitat availability and connectivity (COSTA et al., 2005). In addition, new wildlife conservation areas are suggested (COSTA et al., 2005), also based on the mammal composition (LIMA et al., 2005; CARMIGNOTTO; AIRES, 2011; NOGUEIRA et al., 2011).

The estimated richness was higher than the observed richness, which was expected, considering the occurrence of species (COLWELL; CODINGTON, 1994). The total sample efficiency was 89.7%. For each collection site, efficiency ranged from 62.5% to 86.7%, with a mean of 74.9%. This value is considered high when compared to other studies conducted in the *Cerrado* domain (BOCCHIGLIERI et al., 2010; CARMINGNOTTO; AIRES, 2011; RIBEIRO; MELO, 2013; SANTOS et al., 2013; NEGRÕES et al., 2011). The comparative analysis of the confidence intervals for the estimates showed that the physiognomic types *Cerradão*, Typical *Cerrado* and Riparian forest presented the highest values. Specifically, they reflect their structural complexity, which presents with higher canopy height, greater vertical stratification, greater tree cover and presence of water, in the case of Riparian forest (RIBEIRO; WALTER, 1998).

August (1983), when assessing the role of structural complexity on mammalian communities, found a positive correlation between mammalian richness and structural complexity. Fonseca (1989) and Sttaling et al. (1990) considered that the structural complexity of vegetation exerts influence on the richness in animal species, since it promotes the supply of a great variety of resources to be explored, a fact that allows the coexistence of a wide variety of species.

Studies conducted in the *Cerrado* of Central Brazil indicate that forest environments tend to maintain greater stability to climatic and microclimatic variations, especially in the dry seasons, when there are drastic reductions of available resources in open vegetation physiognomic types, a fact that determines the species (MARES; ERNST 1995; JOHNSON et al., 1999), increasing diversity. In this study, high richness was observed in medium and large sized mammal species for the Typical *Cerrado*, which is a type of savanna vegetation that presents as xeromorphic vegetation with tortuous trees, reaching up to seven meters, and tree cover varying between 20.0 % and 50.0 % (EITEN, 1994; RIBEIRO; WALTER, 1998). By these characteristics, it can be considered that the Typical *Cerrado* presents less complexity when compared to *Cerradão*, Dense *Cerrado* and Riparian Forest. Probably, the high richness of medium and large sized mammal species observed for the Typical *Cerrado* was due to the great territorial extension that this physiognomic type of vegetation occupies in relation to the other savanna formations of the *Cerrado* domain (EITEN, 1994).

A contrasting result obtained in the present study was the low diversity in medium and large mammal sized species observed for the Gallery forest. Studies conducted in Gallery forests of the *Cerrado* domain have shown that this phytophysiognomic type plays a major role in the diversity of the *Cerrado* fauna. In addition to acting as movement corridors for fauna, they also constitute environments of climatic and microclimatic stability, high structural complexity and provide shelter, food and water during the long dry season (REDFORD; FONSECA, 1986; SANTOS-FILHO; SILVA, 2002; RIBEIRO; MARINHO-FILHO, 2005; RIBEIRO; MELO, 2013).

The current conservation status of the *Cerrado* domain is worrying, since half of the original 2 million km^2 of *Cerrado* were transformed into planted pastures, annual crops and other types of land use (KLINK; MACHADO, 2005). Finally, the results of this compilation demonstrate that this expansion of agroforestry borders may endanger the diversity of medium and large sized mammals, since these species require large living areas for survival. For this reason, it is suggested that more studies are carried out for a better knowledge about this mammal diversity, as well as the creation of connected protected areas for conservation and preservation of the fauna described in this article.

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Mamíferos de médio e grande porte do domínio do Cerrado do estado do Tocantins, Brasil

Resumo

O Tocantins é o estado mais jovem do Brasil. É amplamente ocupado pelo domínio do Cerrado, um *hotspot* mundial de biodiversidade. Apesar das estimativas do número de mamíferos de médio e grande porte, poucos estudos abrangem todo o estado de forma ampla. Diante da ameaça que esses animais vêm sofrendo com a expansão das atividades agropastoris e urbanas, aqui se apresenta uma grande riqueza de mamíferos que foi encontrada em larga escala geográfica em 10 áreas, distantes pelo menos 60 quilômetros de cada uma, do extremo sul ao extremo norte do estado, e com dados obtidos ao longo de 10 anos (2001-2011). Duas metodologias foram utilizadas para este estudo: o método de trajetos irregulares e armadilhas fotográficas. Foram registradas 47 espécies de mamíferos, das quais 14 espécies estão ameaçadas. Registros de espécies comuns associadas a espécies ameaçadas de extinção reforçam a necessidade de novos estudos para aumentar o conhecimento e a compreensão da distribuição da comunidade de mamíferos, criando argumentos técnicos e científicos para o desenvolvimento de medidas eficazes de conservação e até mesmo para a seleção de áreas protegidas para a vida selvagem.

Palavras-chave: Conservação. Fitofisionomias. *Hotspot* de biodiversidade. *Panthera onca. Chrysocyon brachyurus. Pteronura brasiliensis.*

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