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Species composition and frequency of habitat use by medium and large-sized mammals in the Brazilian Cerrado Biome, State of Tocantins

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ABSTRACT. The Cerrado biome is the second largest natural vegetation type existing in Brazil after the Amazon, covering 91% of the State of Tocantins, with 30% of the territory changed as a result of the expansion of economic development areas. The substitution of natural vegetation means habitat loss on species, and may put the survival of medium and large-sized mammal species under extinction risk. These species represent significant energy demands and high requirements of area within the habitat. This study aims to assess the species composition and the frequency of use of physiognomic types of vegetation by medium and large-sized mammals. The study was conducted from 2001 to 2011 using a set of complementary and alternative techniques in fragments of seven different physiognomic types of vegetation. Fourth-seven medium and large-sized mammals were registered. This record corresponds to 92% of species already described within the biome, and five additional species to those registered in the data base of the State of Tocantins. Fourteen of these species are at certain degree of threat of extinction. The most used physiognomic types of vegetation in terms of canopy cover were Cerradao, Typical Cerrado, Riparian Forest and Dense Cerrado, and the less used were Gallery Forest, Campo Sujo and Vereda.

Keywords: utilization of habitat; phytophysiognomies; diversity.

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Introduction

Cerrado is the second largest of Brazil's major habitat types, after the Amazonian rainforest, and accounts 24% of the country's land area (*Instituto Brasileiro de Geografia e Estatística* [IBGE], 2004; 2012). Estimates show that this biome consists of various physiognomic types of vegetation, and covers 91% of the territory of the State of Tocantins. This is the only one of four States fully included in the implementation region of the Matopiba Plan for Farming Development, which is found to be the greater border for the expansion and intensification of the agricultural production in Brazil (Buainain, Garcia, & Vieira-Filho, 2015).

The impacts of suppression and substitution of natural vegetation mean habitat loss on species, and fragmentation, putting the survival of ecological communities under destruction and/or degradation risk (Fahrig, 2003), including medium and large-sized mammals. Theoretical and empirical evidences show that the greater energy demand of mammalian species with greater body weight means lesser density, greater life areas and, consequently, greater probability for extinction especially during the most advanced degradation stages of the habitat (Grelle, Paglia, & Silva, 2006).

The spatial variation of Cerrado, which is shown as a mosaic of vegetation types such as plantations, savannas and forestry (Ribeiro & Walter, 1998), constitutes a great diversity of habitats, a determining factor for a remarkable alternation of species, which may create conditions for studies on habitats utilization rates by animals. Considering that studies on use of Cerrado habitats by medium and large-sized mammal are scarce and punctual (Fonseca & Redford, 1984; Redford & Fonseca, 1986; Johnson, Saraiva, & Coelho, 1999; Santos-Filho & Silva, 2002; Bocchiglieri, Mendonça, & Henriques, 2010; Carmignotto & Aires, 2011), and constitute important subsidies for the preservation of species and types of vegetation, this

study was developed aiming to assess the species composition and the frequency of habitat use in the Cerrado biome of the State of Tocantins, Brazil.

Material and methods

Area of study

The study was developed in the Cerrado biome of the State of Tocantins, Central-West Region of Brazil. The typical climate of this biome is hot and semi-humid, with pronounced seasonal variation marked by a dry winter (Aw - Köppen climate classification). Precipitation levels in the State vary widely. However, the mean annual rainfall is 1,500 mm, and the mean temperature is 24ºC.

Ten locations were sampled at North - South longitudinal axis of the State of Tocantins. Then, representative areas of fragments of Riparian Forest, Gallery Forest, Cerradao, Dense Cerrado, Typical Cerrado, Campo Sujo and Vereda, were selected as outlined in Ribeiro and Walter (1998). Figure 1 shows locations selected to the study, and Table 1 describes physiognomic types of vegetation under study.

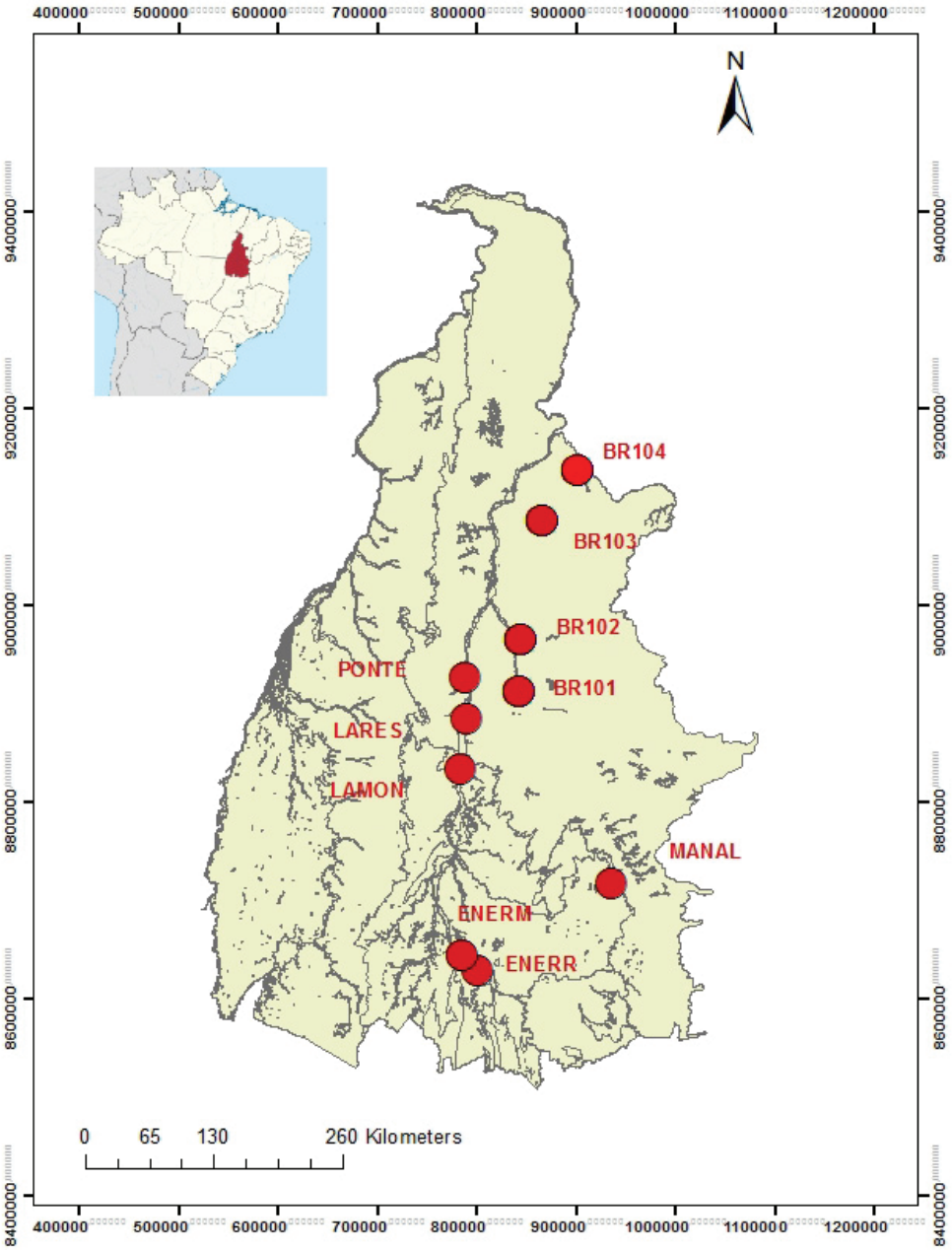

Figure 1. Areas sampled in the Cerrado biome of the State of Tocantins, Brazil.

Table 1. Locations sampled to the study and physiognomic types of vegetation selected according to Ribeiro and Walter (1998).

Sampled area and coordinates	Types of vegetation
BR104 – 07º 47' S 47º 23' W	Riparian Forest, Cerradao, Dense Cerrado, Typical Cerrado and Campo Sujo
BR 103 – 08º 14' S 47º 41' W	Riparian Forest, Cerradao, Dense Cerrado, Typical Cerrado and Campo Sujo
BR 102 – 09º 19' S 47º 52' W	Riparian Forest, Cerradao, Dense Cerrado, Typical Cerrado and Campo Sujo
BR 101 – 09º 48' S 47º 52' W	Riparian Forest, Cerradao, Dense Cerrado, Typical Cerrado and Campo Sujo
PONTE – 09º 42' S 48º 21' W	Riparian Forest, Cerradao, Dense Cerrado and Typical Cerrado
LARES – 11º 00' S 48º 33' W	Riparian Forest, Cerradao, Dense Cerrado, Typical Cerrado and Vereda
LAMON – 09° 53' S 48° 21' W	Riparian Forest, Gallery Forest, Cerradao, Dense Cerrado, Typical Cerrado, Vereda and Campo Sujo
MANAL – 11º 35' S 47º 00' W	Riparian Forest, Gallery Forest, Cerradao, Dense Cerrado, Typical Cerrado and Vereda.
ENERM – 12º 14' S 48º 23' W	Riparian Forest, Gallery Forest, Cerradao, Dense Cerrado and Typical Cerrado.
ENERR – 12º 38' S 47º 52' W	Riparian Forest, Gallery Forest, Cerradao, Dense Cerrado, Cerrado Típico and Campo Sujo

Sampling of mammals

The present study shows data collected from February 2001 to December 2011. Two methods were used for data collection as follows: (i) transect walk (Cullen Jr, Rudran, & Valladares-Padua, 2004), covering preexisting traces on sampling areas at 1 km hour^{-1}, for data collection on species by means of direct observation and observation of vestiges (indirect method); and (ii) camera traps placed on the best spots, where animal usually pass through, to capture unique images of wildlife 24 hours a day.

The sampling effort varied according to the sampling method used for data collection. The sampling effort was 1,245 hours for transect walk, and 3,646 traps a day for camera traps method (Srbek-Araujo & Chiarello, 2005).

Data processing and analysis

Species richness estimates for medium and large-sized mammal were carried out from the listing of species. The presence-absence matrix was then developed and used to estimate the species richness observed and its confidence intervals. The Jackknife estimator of species richness was used, and the EstimateS 9.1.0 (Colwell, 2013) was run based on 1,000 random samples without replacement.

The chi-squared test (χ^2) was carried out in PAST software (Hammer, Harper, & Ryan 2001) to compare the utilization frequency of physiognomic types of vegetation by medium and large-sized mammal species at 5% significance, assuming that p-values lesser than 0.05 show strong evidence against the null hypothesis (Triola, 1999).

The association between medium and large-sized mammal species and physiognomic types of vegetation was assessed by means of Principal Component Analysis (PCA), based on the number of records on the occurrence of species within each sampled type of vegetation. The Multivariate Statistical Package (Kovach, 2013) was used for PCA.

Results and discussion

The species composition and the frequency of use of physiognomic types of vegetation by medium and large-sized mammals were assessed. Fourth-seven mammals belonging to 9 Orders, 19 Families and 35 Genus were registered. Results show that the most representative Order was Carnivora (36.1%), followed by Rodentia (14.9%), Artiodactyla and Cingulata (12.8% each), Primates (8.5%), Didelphimorphia (6.4%), Pilosa (4.2%), and Lagomorpha and Perissodactyla (2.1% each). The Family with the greater number of Genus was Dasypodidae, which comprised four Genus and six species. This was followed by Canidae and Mustelidade (4 Genus and 4 species each), Felidae (3 Genus and six species), Didelphidae and Procyonidae (3 Genus and 3 species), Cervidae (2 Genus and 4 species), Myrmecophagidae and Tayassuidae (2 Genus and 2 species), Dasyproctidae (one Genus and 4 species), and Tapiridae, Aotidae, *Alouatta*, Callithrichidae, Cebidae, Leporidae, Cavidae, Cuniculidae and Erethizontidae, with one Genus and one specie each.

Table 2 describes 14 species of medium and large-sized mammals under study, which are at certain degree of threat of extinction or level of vulnerability obtained according to the Ministry of the Environment (Brasil, 2014), namely: *Myrmecophaga tridactyla*, *Priodontes maximus*, *Tapirus terrestris*, *Blastocerus dichotomus*, *Tayassu pecari*, *Chrysocyon brachyurus*, *Lycalopex vetulus, Speothos venaticus*, *Leopardus braccatus*, *Leopardus tigrinus*, *Panthera onca*, *Puma concolor*, *Puma yagouaroundi* and *Pteronura brasiliensis*.

Table 2. List of species, common names, types of habitats, endemicity, registration form, and conservation categories, Ministry of the Environment (Brasil, 2014). (RP = Riparian Forest, GF = Gallery Forest, CO = Cerradao, DC = Dense Cerrado, TC = Typical Cerrado, CS = Campo Sujo, VE = Vereda, PT = Photographic Trap, DV = Direct Visualization, TE= Trace Elements). The nomenclature of species was done according to the Annotated Checklist of Brazilian Mammals (Paglia et al., 2012).

Taxon	Place of registration	Registration form	Conservation category
DIDELPHIMORPHIA			
DIDELPHIDAE			
Didelphis albiventris (Lund, 1840)	RF, CO, DC, TC	PT, DV	
Didelphis marsupialis (Linnaeus, 1758)	RF, CO	PT, DV	
Didelphis sp.	RF, CO, TC	DV, TE	
PILOSA			
MYRMECOPHAGIDAE			
Myrmecophaga tridactyla (Linnaeus, 1758)	RF, CO, DC, TC, CS, VE	PT, DV	Vulnerable
Tamandua tetradactyla (Linnaeus, 1758)	RF, GF, CO, DC, TC	PT, DV	
CINGULATA			
DASYPODIDAE			
Cabassous unicinctus (Linnaeus, 1758)	CO, DC, TC	DV	
Euphractus sexcinctus (Linnaeus, 1758)	CO, DC, TC, CS	PT, DV	
Dasypus novemcinctus (Linnaeus, 1758)	RF, CO, DC, TC, CS	PT, DV	
Dasypus septemcinctus (Linnaeus, 1758)	RF, CO, DC, TC	PT, DV	
Dasypus sp.	CO	TE	
Priodontes maximus (Kerr, 1792)	TC	DV	Vulnerable
PERISSODACTYLA			
TAPIRIIDAE			
Tapirus terrestris (Linnaeus, 1758)	RF, CO, TC	DV	Vulnerable
ARTIODACTYLA			
CERVIDAE			
Blastocerus dichotomus (Illiger, 1815)	VE	DV	Vulnerable
Mazama americana (Erxleben, 1777)	RF, CO, DC, TC	PT, DV	
Mazama gouazoubira (G. Fischer, 1814)	CO, DC, TC, CS	PT, DV	
Mazama sp.	CO, DC, TC	DV	
TAYASSUIDAE			
Pecari tajacu (Linnaeus, 1758)	RF, CO, DC, TC, CS	PT, DV	
Tayassu pecari (Link, 1795)	CO, TC	DV	Vulnerable
PRIMATES			
AOTIDAE			
Aotus infulatus (Kuhl, 1820)	RF	DV	
ALOUATTA			
Alouatta caraya (Humboldt, 1812)	RF, GF	PT, DV	
CALLITRICHIDAE			
Callithrix penicillata (É. Geoffroy, 1812)	RF, GF, CO	PT, DV	
CEBIDAE			
Cebus Sapajus libidinosus (Spix, 1823)	RF, GF, CO	PT, DV	
CARNIVORA			
CANIDAE			
Cerdocyon thous (Linnaeus, 1766)	RF, CO, DC, TC, VE, CS	PT, DV	
Chrysocyon brachyurus (Illiger, 1815)	TC, VE, CS	DV	Vulnerable
Lycalopex vetulus (Lund, 1842)	CO, TC	DV	Vulnerable
Speothos venaticus (Lund, 1842)	TC	DV, TE	Vulnerable
FELIDAE			
Leopardus braccatus (Cope, 1889)	RF	DV	Vulnerable
Leopardus pardalis (Linnaeus, 1758)	RF, CO, TC	DV	
Leopardus tigrinus (Schreber, 1775)	RF, CO, TC, DC	DV	Under risk
Panthera onca (Linnaeus, 1758)	CO	DV	Vulnerable
Puma concolor (Linnaeus, 1771)	CO	DV	Vulnerable
Puma yagouaroundi (É.Geoffroy, 1803)	CO	DV	Vulnerable
MUSTELIDAE			
Eira barbara (Linnaeus, 1758)	RF, GF, CO	DV	
Galictis vittata (Schreber, 1776)	RF, CO	DV	
Lontra longicaudis (Olfers, 1818)	RF	DV	
Pteronura brasiliensis (Gmelin, 1788)	RF	DV	Vulnerable
PROCYONIDAE			
Nasua nasua (Linnaeus, 1766)	RF,GF, CO, DC, TC	PT, DV	
Potos flavus (Schreber, 1774)	RF	PT, DV	
Procyon cancrivorus (G. Cuvier, 1798)	RF, GF, CO, DC, TC	PT, DV	

Taxon	Place of registration	Registration form	Conservation category
LAGOMORPHA			
LEPORIDAE			
Sylvilagus brasiliensis (Linnaeus, 1758)	CO, DC, TC, CS	DV	
RODENTIA			
CAVIIDAE			
Hydrochoerus hydrochaeris (Linnaeus, 1766)	RF, GF	PT, DV	
CUNICULIDAE			
Cuniculus paca (Linnaeus, 1766)	RF, GF, CO, DC, TC	PT, DV	
DASYPROCTIDAE			
Dasyprocta azarae (Lichtenstein, 1823)	CO, DC, TC	PT, DV	
Dasyprocta leporina (Linnaeus, 1758)	CO, DC, TC, CS	PT, DV	
Dasyprocta prymnolopha Wagler, 1831	RF, CO, DC, TC	PT, DV	
Dasyprocta sp.	CO, DC, TC	DV	
ERETHIZONTIDAE			
Coendou prehensilis (Linnaeus, 1758)	RF, GF, CO, DC, TC	PT, DV	

Mammal species registered in this study, i.e., *Aotus infulatus* (Kuhl, 1820), *Leopardus braccatus* (Cope, 1889), *Potos flavus* (Schreber, 1774), *Sylvilagus brasiliensis* (Linnaeus, 1758) and *Dasyprocta prymnolopha* (Wagler, 1831), correspond to 92% of species already described within the Cerrado biome (Marinho-Filho, Rodrigues, & Juarez, 2002), and five additional species to those reported in other studies (Fonseca & Redford, 1984; Redford & Fonseca, 1986; Johnson et al., 1999; Marinho-Filho et al., 2002; Santos-Filho & Silva, 2002; Lima, Hidasi, & Veiga, 2005; Silva Jr et al., 2007; Juarez, 2008; Nobre et al., 2009; Oliveira, Câmara, & Oliveira, 2009; Bocchiglieri et al., 2010; Carmignotto & Aires, 2011; Nunes, Scoss, & Lessa, 2012). These records extended the geographic distribution of species especially due to the accuracy of methods used for data collection, duration of the study and extent of the area of study.

The Species-sampling effort curve obtained from the species richness and the Jackknife estimator of species richness showed a stabilization trends with 82.4% sampling efficiency. This achievement was expected once the study lasted long and was developed in a wide study area, using a set of complementary and alternative sampling techniques (Figure 2).

Fourth-seven medium and large-sized mammalian species were registered. Thirty-five of 47 species were registered in the Cerradao, 30 in the Typical Cerrado, 29 in the Riparian Forest, 22 in the Dense Cerrado, 10 in the Gallery Forest, 9 in the Campo Sujo and 4 in the Vereda. These data show that the species under study have using all the existing physiognomic types of vegetation, however, at different utilization rates.

Figure 3 shows the Principal Component Analysis (PCA) for medium and large-sized mammal species, in which the number of records was sufficient for the analysis. The total variance in the set of variables under study was 72.5, where 43.7% for the axis 1 and 28.8% for the axis 2. Thus, the two-dimensional perceptual graph generated by the PCA was found to be appropriate to assess relationships between variables (Rencher, 2002; Hongyu, Sandanielo, & Oliveira-Jr, 2016).

The axis 1 describes positive relationships existing with species occurred in savannas such as Cerradao, Dense Cerrado, Typical Cerrado and Campo Sujo, as follows: *Cabassous unicinctus* (*Cn*), *Cerdocyon thous* (*Ct*), *Chrysocyon brachiurus* (*Cb*), *Cuniculus paca* (*Cp*), *Dasyprocta azarae* (*Da*), *Dasyprocta leporina* (*Dl*), *Dasypus novencinctus* (*Dn*), *Dasypus septencinctus* (*Ds*), *Didelphis albiventris* (*Di*), *Mazama americana* (*Ma*), *Mazama gouazoubira* (*Mg*), *Myrmecophaga tridactyla* (*Mt*), *Nasua nasua* (*Nn*), *Pecari tajacu* (*Pt*), *Tamandua tetradactyla* (*Tm*) and *Procyon cancrivorus* (*Pc*).

The axis 2 consisted of positive contribution of species occurred in forest formations such as Riparian Forest and Gallery Forest, namely: *Alouatta caraya* (*Ac*), *Callithrix penicillata* (*Ca*), *Coendou prehensilis* (*Co*), *Didelphis marsupialis* (*Dm*), *Eira barbara* (*Eb*), *Hydrochoerus hydrochaeris* (*Hh*), *Sapajus libidinosus* (*Sl*) and *Tapirus terrestris* (*Tt*).

The following species did not have sufficient number of records for PCA or assessment of associations between species and physiognomic types of vegetation: *Aotus infulatus* (*Ai*), *Blastocerus dichotomus* (*Bd*), *Dasyprocta primnolopha* (*Dp*), *Euphractus sexcinctus* (*Es*), *Galictis vitata* (*Gv*), *Leopardus braccatus* (*Lb*), *Leopardus pardalis* (*Lp*), *Leopardus tigrinus* (*Lt*), *Lontra longicaudis* (*Ll*), *Lycalopex vetulus* (*Lv*), *Panthera onca* (*Po*), *Potos flavus* (Pt), *Priodontes maximus* (Pm), *Pteronura brasiliensis* (*Pb*), *Puma concolor* (*Pu*), *Puma yagouaroundi* (*Py*), *Sylvilagus brasiliensis* (*Sb*), *Speothus venaticus* (*Sv*) and *Tayassu pecari* (*Tp*).

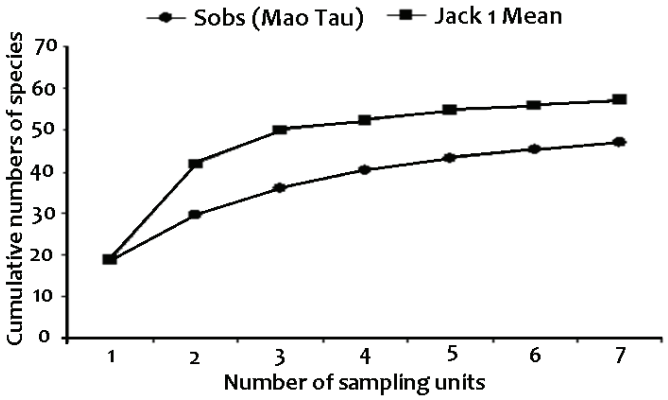

Figure 2. Accumulation curve of medium and large-sized mammal species obtained by means of the Jackknife estimator of species richness for seven physiognomic types of vegetation sampled in the Cerrado biome of the State of Tocantins.

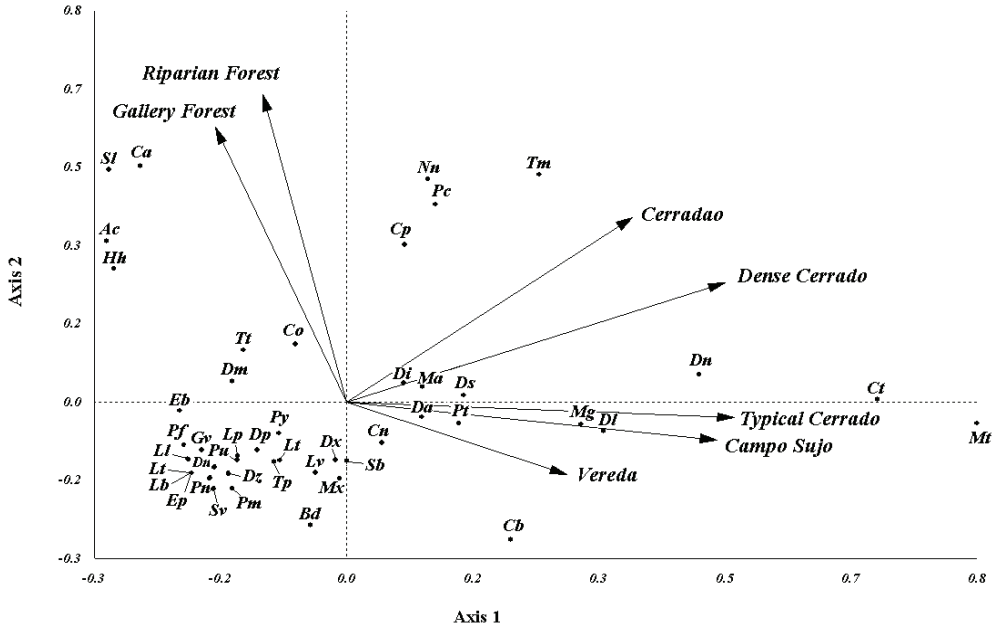

Figure 3. Two-dimensional perceptual map generated by the Principal Component Analysis for physiognomic types of vegetation and medium and large-sized mammal species assessed in the Cerrado biome of the State of Tocantins.

The chi-squared test showed that there are no statistically significant differences regarding the use of Riparian Forest, Typical Cerrado and Dense Cerrado by medium and large-sized mammals ($0.02 \leqslant \chi^2 \leqslant 2.96$, and $1.00 \geqslant$ p-value $\geqslant 0.11$). These were the most used habitats by mammal species under study. The Gallery Forest, Campo Sujo and Vereda were habitats with lesser frequency use when compared with other types of vegetation sampled in the study area ($4.50 \leqslant \chi^2 \leqslant 19.88$, and $0.04 \geqslant$ p-value $\geqslant 0.01$).

The lower richness of medium and large-sized mammalian species observed in the Gallery Forest differ from those found in studies conducted in the Cerrado, which have showed that this type of vegetation contributes significantly to changes of fauna diversity in the Cerrado once is used as wildlife movement corridor, climate stability environment and high structural complexity. In addition, this habitat provides shelter, fodder and water in prolonged period of time with little or no rain (Redford & Fonseca, 1986; Johnson et al., 1999; Santos-Filho & Silva, 2002; Ribeiro & Marinho-Filho, 2005; Ribeiro & Melo, 2013). A putative explanation on this contradictory finding may be related to the number of fragments sampled in each of physiognomic type of vegetation under study. A set of ten fragments was sampled in each of Riparian Forest, Cerradao, Dense Cerrado and Typical Cerrado habitats, and four fragments were sampled in the Gallery Forest. The same may have determined the lower species richness observed for Campo Sujo and Vereda habitats, in which the species-sampling effort comprised six and three fragments, respectively. Besides, these types of vegetation are found to be habitats with lower structural complexity, therefore, with lower richness of mammalian species (Ribeiro & Marinho-Filho, 2005).

Conclusion

The species composition and frequency of habitat use by medium and large-sized mammals in the Brazilian Cerrado biome varied widely. Most species under study are already described within the biome and five are registered in the data base of the State of Tocantins. Fourteen of 47 species registered are at certain degree of threat of extinction.

Medium and large-sized mammalian species showed preference to a certain physiognomic type of vegetation such as Cerradao, Typical Cerrado, Dense Cerrado and Riparian Forest. Beyond this inference, it points out that lesser frequency of species in habitats such as Gallery Forest, Campo Sujo and Vereda was observed.

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