Journal of Threatened Taxa | www.threatenedtaxa.org | 26 November 2013 | 5(15): 4994–5001

ISSN
Online 0974–7907
Print 0974–7893

OPEN ACCESS

Diversity of medium and large sized mammals in a Cerrado fragment of central Brazil

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Abstract: Studies related to community ecology of medium and large mammals represent a priority in developing strategies for conservation of their habitats. Due to the significant ecological importance of these species, a concern in relation to anthropogenic pressures arises since their populations are vulnerable to hunting and fragmentation. In this study, we aimed to analyze the diversity of medium and large mammals in a representative area of the Cerrado biome, located in the National Forest of Silvânia, central Brazil, providing insights for future studies on the biodiversity and conservation of Cerrado mammals. Sampling was carried out by linear transects, search for traces, footprint traps and camera traps. We recorded 23 species, among which three are listed in threat categories (e.g., *Myrmecophaga tridactyla*, *Chrysocyon brachyurus* and *Leopardus tigrinus*). We registered 160 records in the study area, where the most frequently recorded species were *Didelphis albiventris* (30 records) and *Cerdocyon thous* (28 records). Our results indicated that a small protected area of Cerrado can include a large and important percentage of the diversity of mammals in this biome, providing information about richness, abundance, spatial distribution and insights for future studies on the biodiversity and conservation of these biological communities.

Keywords: Brazil, Cerrado, conservation, medium and large mammals, threatened species.

Portuguese Abstract: Resumo: Estudos relacionados à comunidade ecológica dos mamíferos de médio e grande porte são prioritários no desenvolvimento de estratégias para conservação de seus habitats. Devido à grande importância ecológica dessas espécies, uma preocupação em relação às pressões antropogênicas surge, uma vez que suas populações são vulneráveis à caça e fragmentação. O objetivo do presente estudo foi analisar a diversidade de mamíferos de médio e grande porte em uma área do bioma Cerrado, localizada na Floresta Nacional de Silvânia, Brasil central, proporcionando informações para futuros estudos sobre biodiversidade e conservação de mamíferos no Cerrado. As coletas foram realizadas através de transectos lineares, busca por vestígios, armadilhas de pegadas e armadilhas fotográficas. Registramos 23 espécies, entre as quais três estão listadas em categorias de ameaça (*Myrmecophaga tridactyla*, *Chrysocyon brachyurus* e *Leopardus tigrinus*). Foram obtidos 160 registros para a área de estudo, sendo que as espécies mais frequentes foram *Didelphis albiventris* (30 registros) e *Cerdocyon thous* (28). Nossos resultados indicam que uma pequena área protegida do Cerrado possui uma importante porção da diversidade de mamíferos desse bioma, provendo informações sobre riqueza, abundância, distribuição espacial e subsídios para futuros estudos sobre biodiversidade e conservação destas comunidades biológicas.

DOI: http://dx.doi.org/10.11609/JoTT.o3342.4994-5001 | **ZooBank:** urn:lsid:zoobank.org:pub:663DE02A-CDBC-4E24-8EB9-890F03E5AD10

Editor: Daniel Brito, Federal University of Goiás, Goiânia, Brazil. **Date of publication:** 26 November 2013 (online & print)

Manuscript details: Ms # o3342 | Received 13 September 2012 | Final received 30 May 2013 | Finally accepted 10 October 2013

Citation: Campos, F.S., A.R.B. Lage & P.H.P. Ribeiro (2013). Diversity of medium and large sized mammals in a Cerrado fragment of central Brazil. *Journal of Threatened Taxa* 5(15): 4994–5001; http://dx.doi.org/10.11609/JoTT.o3342.4994-5001

Funding: Initial funding for this work was generously provided by the Instituto de Pesquisas Ambientais e Ações Conservacionistas (IPAAC) and the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio).

Competing Interest: None.

Author Contributions: ARBL designed and conducted the fieldworks, conceived the ideas and wrote the paper. FSC helped with the design of the project and in the conduction of the fieldworks, analysed the data and helped to write the paper. PHPR helped in the fieldworks, identified the relevant biological questions and contributed to the writing.

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Acknowledgements: We thank Caio Stuart Amorim Pereira, Rodolfo Cabral and Renato Cézar de Miranda for logistical support in the fieldworks. We are also grateful to Mirco Solé and Marilia Bilu Rodrigues for the comments and suggestions to improve this manuscript.

INTRODUCTION

The medium and large sized mammals carry a crucial influence on their ecosystems, performing important tasks as pollinators (Mora et al. 1999), seed dispersers (Fragoso & Huffman 2000; Galetti et al. 2001; Alves-Costa & Eterovick 2007) and predators (Bodmer 1991; Pedó et al. 2006; Weckel et al. 2006), maintaining the balance of populations and communities associated with them (Asquith et al. 1999; Herrerias-Diego et al. 2008).

Brazil has the richest mammal fauna in the world, represented by 701 species (Paglia et al. 2012). In Brazilian Cerrado, the occurrence of around 250 species of mammals has already been registered, of which 32 are endemic and 17 are included in the Red Book of Threatened Brazilian Fauna (Machado et al. 2008).

Due to the significant ecological importance that these species have, a concern in relation to anthropogenic pressures arises since they are vulnerable to hunting and population fragmentation (Cullen Jr. et al. 2000). These factors directly influence the requirements of these species in terms of living space, food, shelter and specialized modes of reproduction (Henle et al. 2004).

The study of these animals involves a different set of techniques that can be direct or indirect (Cullen Jr. et al. 2000). Direct techniques are often unfeasible due to crepuscular and nocturnal habits (Pardini et al. 2003). Indirect techniques (e.g., tracks, vocalizations and other sounds, bones and feces) are widely used because they provide a precise indication of medium and large mammals and their use of habitats (Smallwood & Fitzhugh 1993; Becker & Dalponte 1999; Scoss et al. 2004).

Available information on the ecology of various mammalian species emphasizes the importance of these animals in a series of ecological processes related to the dynamics of natural environments (Cardillo et al. 2006). Herbivorous mammals such as deer, tapirs, peccaries, collared peccaries and large rodents perform important roles in maintaining the diversity of plants via seed dispersal and eating seedlings (De-Steven & Putz 1984; Dirzo & Miranda 1990; Fragoso 1994). Carnivores regulate populations of herbivores (Redford 1992), and they serve as key indicators of habitat quality (Schonewald-Cox et al. 1991). Thus studies related to community ecology of medium and large mammals are central to developing strategies for the conservation of species and habitats (Loyola et al. 2009).

This study aimed to analyze the species composition of the community of medium and large mammals that inhabit a representative area of the Cerrado biome in different environmental situations, covering both well preserved areas, such as areas potentially affected by the advancement of human activities, providing information about richness, abundance, types of baits used to attract species and insights for future studies on the biodiversity and conservation of Cerrado mammals.

MATERIALS AND METHODS

Study area

The National Forest of Silvânia (16^{0}39'32"S & 48^{0}36'29"W, 900m), located in the municipality of Silvania, state of Goiás, central Brazil (Fig. 1). This is an area of environmental protection with sustainable use (IUCN Protected Area Category VI) of 466.55ha, managed by Chico Mendes Institute for Biodiversity Conservation (ICMBio), located entirely in the Cerrado biome. However, some anthropogenic changes observed in other portions of this biome (see Machado et al. 2004) are found around this National Forest, highlighting mainly pastures and fields of soybeans and corn.

Following the Köppen classification system (see Lutgens & Tarbuck 1995), the regional climate is classified as tropical savanna (Aw), with two well defined seasons, one wet and one dry. According to Eiten (1993) and Oliveira-Filho & Ratter (2002), the Cerrado "sensu lato" is composed of different types of vegetation. Ribeiro & Walter (2008) identified 25 different vegetation types for this biome. In the National Forest of Silvânia can be found two of these vegetation types (i.e., Cerrado "sensu strict" and Gallery Forests), as well as anthropogenic environments with invasive species like *Pinus sp*. (pine), *Eucalyptus* sp. and *Melinis minutiflora* (Poaceae).

Sampling design

Six areas were selected inside the National Forest of Silvânia and a number was used to represent each diferent vegetation type within the study area, where the Cerrado "sensu stricto" areas were represented by the numbers 1 and 4, the Gallery forest areas by the numbers 2 and 5, the anthropogenic environments by the number 3 and the transition areas between Cerrado "sensu stricto" and Gallery forest number 6 (see Fig. 1). Four sampling methods were used to record the species of medium and large mammals in the study area, which were carried out by linear transects, search for traces (i.e., tracks, trails, feces, etc.), footprints traps and camera traps (Images 1–3).

Data collection through the linear transect methods was performed according to the model proposed by

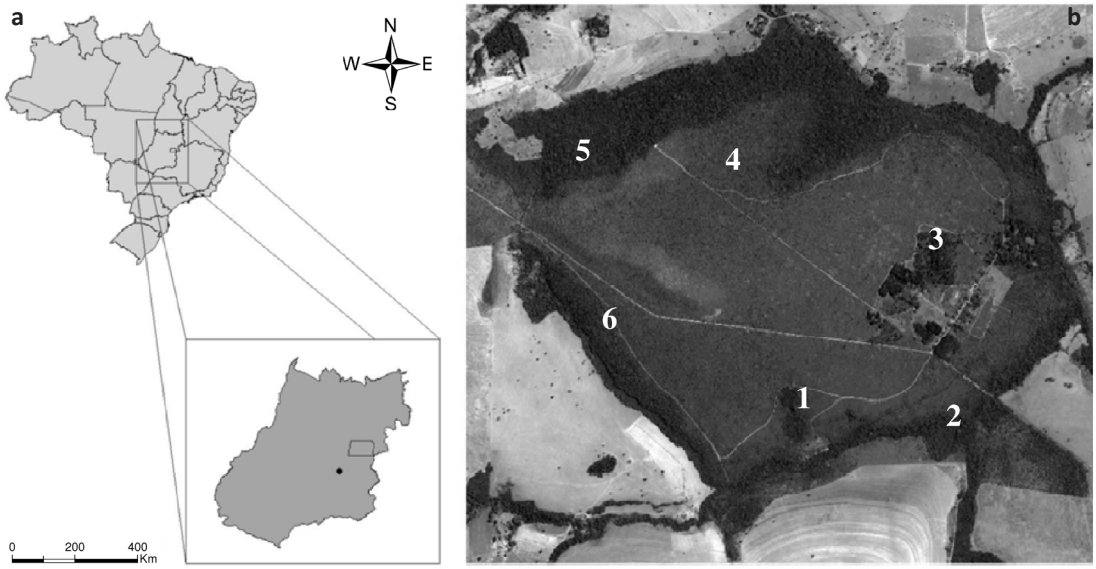

Figure 1. (a) Location of the municipality of Silvânia in the state of Goiás, Central Brazil. (b) Aerial view of the National Forest of Silvânia (Source: Erdas Viewfinder). The Cerrado "sensu stricto" areas were represented by the numbers 1 and 4, the gallery forest areas by the numbers 2 and 5, the anthropogenic environments by the number 3 and the transition areas between Cerrado "sensu stricto" and Gallery forest by the number 6.

Image 1. Footprints trap (sand plots).

Image 2. Camera trap installation.

Image 3. Linear transect in a Gallery Forest.

Burnham et al. (1980), recording the species names, the number of individuals and location of the sighting for each animal seen. Transects traveled about 30km per sampling day, which corresponds to 5km per each one of the six sampled areas. During the fieldwork, various types of environments were inspected in order to identify the species of mammals in the region and analyze their ecological aspects, through indirect data such as footsteps, feces, sounds, tracks, trails and damage that could lead to the diagnosis of the local species.

The footprints were obtained by the method of sand plots, represented by 60 wooden boxes with dimensions of 1m² filled with fine sand (2–4 cm), which were

baited daily with salt, pineapple, banana and bacon, and distributed in equitable proportions among the six different sampling areas defined in the study area, with each area containing 10 plots with a distance of 10m among them. The baits were put separately among the sand plots, so that each sampled area had two plots without bait, two with salt, two with pineapple, two with banana and two with bacon.

In addition to the linear transect methods and sand plots, six camera traps (TIGRINUS Conventional 6.0c) were installed in each of the six sampled areas in the study area to carry out the record of the species. For the independent records of camera traps, the records with one hour of interval were used, avoiding the same animal records (see Silveira et al. 2003; Srbek-Araujo & Chiarello 2007).

We carried out eight samplings between October 2008 and August 2009, contemplating the dry and rainy periods, providing a total of 24 sampling days over eight months. The field trips lasted three days per trip, where were established 72 hours of exposure to footprints traps and camera traps in each trip. The field observations were conducted during eight hours a day and four hours at night, comprising 12 hours per sampling day. During the night, the environments were inspected with the aid of powerful flashlights, thus enabling a better view of the nocturnal animals. The sampling effort was conducted by two researchers and focussed only on medium and large mammals (>1kg), thus disregarding the presence of small mammals (<1kg), such as bats, small rodents and small marsupials.

Data Analysis

To estimating the number of records of mammal species, we used a Jackknife 1 procedure (Colwell & Coddington 1994), that corrects the sub-sample inclination, allowing estimation of confidence intervals, and hypothesis testing. We evaluated the Jackknife 1 using the EstimateS program (Colwell 2006), which also produced a collector curve from the output of the Jackknife analysis.

To check what type of bait attracted the largest number of species, was performed similarity analysis between the types of baits used in the sand plots through the Jaccard coefficient (Magurran 1988), generated by the software "Biodiversity Professional", version 2.0. (McAleece et al. 1997). In addition, we also analyzed the frequency of records obtained for each kind of bait.

Specimens were monitored under collecting permit No. 15458-2 ICMBio/SISBIO (Instituto Chico Mendes de Conservação da Biodiversidade/Sistema de Autorização e Informação em Biodiversidade). No voucher specimens were collected. Nomenclature of mammal species followed Wilson & Reeder (2005).

RESULTS

We found 23 mammals species in National Forest of Silvânia classified in eight orders, among which included three species that are listed in threat categories (e.g., *Myrmecophaga tridactyla*, *Chrysocyon brachyurus* and *Leopardus tigrinus*; Table 1). We registered 160 records in the study area, where the most frequently recorded species were *Didelphis albiventris* (30 records) and *Cerdocyon thous* (28 records).

The total sampling effort was 144 traps/day for the sand plots, 144 traps/day for the camera traps and 280km transected inside the National Forest. The curve constructed from data collected shows that the collection method shows the same tendency of the richness accumulation curve observed to the Jackknife 1 diversity estimator. The template bit upward, with a low slope is a robust indication that the curve has a stabilization tendency (Fig. 2).

Comparing the species records/bait type by pairwise relationships were found the following results: 60% of similarity between the pairs salt-none and pineapple-none; 50% of similarity between the pair banana-none; 55% of similarity between the pair bacon-none; 75% between the pair pineapple-salt; 62,5% between banana-salt; 33% between the pairs bacon-salt and pineapple-bacon; 44% between the pair banana-

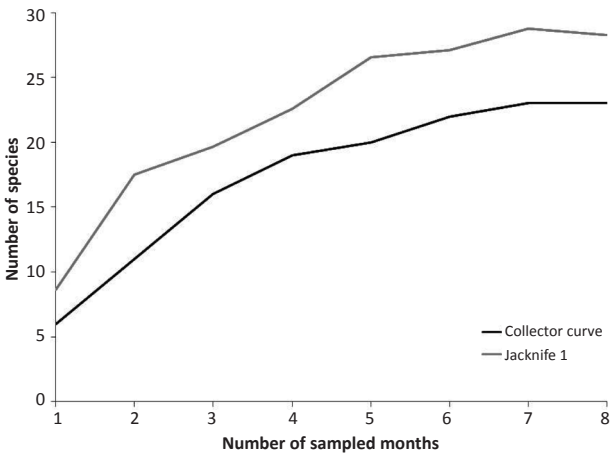

Figure 2. Cumulative number of mammal species observed and estimated by Jackknife 1 procedure built from the months sampled in the National Forest of Silvânia, state of Goiás, Brazil.

Table 1. Record types, IUCN Red List categories and population trends of the medium and large mammals recorded in the National Forest of Silvânia, state of Goiás, Brazil.

Taxon	Record types	Red List categories	Population trends
Order Didelphiomorphia			
Chironectes minimus	Sightings	Least Concern	Decreasing
Didelphis albiventris (Image 4)	Sightings/ Footprints	Least Concern	Stable
Order Pilosa			
Myrmecophaga tridactyla (Image 5)	Sightings/ Footprints/ Camera trap	Vulnerable	Decreasing
Tamandua tetradactyla	Sightings	Least Concern	Unknown
Order Cingulata			
Euphractus sexcinctus	Sightings/ Footprints	Least Concern	Stable
Dasypus novemcinctus	Sightings/ Footprints	Least Concern	Increasing
Cabassous unicinctus	Sightings/ Footprints	Least Concern	Unknown
Order Primates			
Callithrix penicillata (Image 6)	Sightings	Least Concern	Increasing
Sapajus libidinosus	Sightings	Least Concern	Decreasing
Alouatta caraya	Sightings	Least Concern	Decreasing
Order Lagomorpha			
Sylvilagus brasiliensis	Sightings	Least Concern	Unknown
Order Carnivora			
Chrysocyon brachyurus	Sightings/ Footprints	Near Threatened	Unknown
Procyon cancrivorus	Footprints	Least Concern	Decreasing
Eira Barbara	Footprints	Least Concern	Decreasing
Cerdocyon thous (Image 7)	Sightings/ Footprints/ Camera trap	Least Concern	Stable
Puma concolor	Footprints	Least Concern	Decreasing
Conepatus semistriatus	Footprints	Least Concern	Decreasing
Nasua nasua (Image 8)	Sightings/ Footprints	Least Concern	Decreasing
Puma yagouaroundi	Sightings	Least Concern	Decreasing
Leopardus tigrinus	Sightings/ Footprints	Vulnerable	Decreasing
Order Artiodactyla			
Mazama americana	Sightings/ Camera trap	Data Deficient	Unknown
Mazama gouazoubira	Sightings/ Footprints	Least Concern	Decreasing
Order Rodentia			
Coendou prehensilis	Sightings/ Footprints	Least Concern	Stable

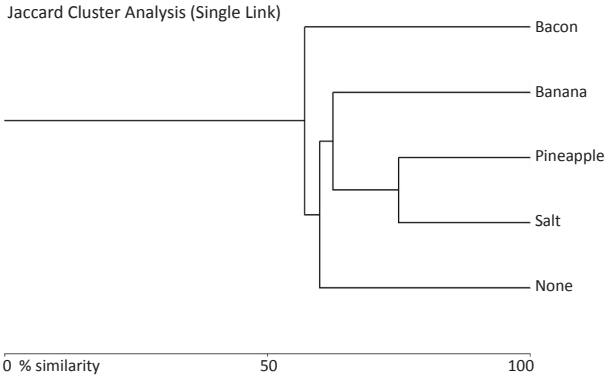

Figure 3. Similarity dendrogram between the bait types used in the sand plots sampled in the National Forest of Silvânia, state of Goiás, Brazil

pineapple and 57% between the pair banana-bacon (Fig. 3).

DISCUSSION

The predominantly nocturnal habits of the most mammalian species, associated to the low population densities and very extense home ranges, hamper the study of many species of medium and large mammals (Pardini et al. 2003). However, our results indicated that a small protected area of Cerrado can include a large and important percentage of the diversity of medium and large mammals of this biome. The species recorded in the National Forest of Silvânia corresponds to about 40% of all species of medium and large mammals distributed in the Brazilian Cerrado, which total is 52 species (see Paglia et al. 2012). Among the sampled mammals, three species (*Myrmecophaga tridactyla, Leopardus tigrinus* and *Chrysocyon brachyurus*) are mencioned in the IUCN Red List of Threatened Species (IUCN 2012) and the Brazilian Red Book of Threatened Fauna (Machado et al. 2008), which further emphasizes the importance of this region for the conservation of mammals in the Brazilian Cerrado.

The number of species detected (i.e., 23) can be considered high when compared to the small size of the National Forest of Silvânia (i.e., only 466ha), which indicated that a small protected area of Cerrado can include a large and important percentage of the richness of mammals of this biome, in this case, corresponding to about 40% of all species of medium and large mammals that occur in the Brazilian Cerrado (see Paglia et al. 2012).

In regard to the use of baits for the studies of

Image 4. *Didelphis albiventris* (Lund, 1840).

Image 5. *Myrmecophaga tridactyla* (Linnaeus, 1758).

Image 6. *Callithrix penicillata* (É. Geoffroy, 1812).

Image 7. *Cerdocyon thous* (Linnaeus, 1766).

medium and large mammals, we suggest the use of bacon, pineapple and banana as baits. These presented the lowest similarity values when compared pair to pair. According to Astúa et al. (2006), many factors may be considered before choosing the best bait type, including weather conditions, durability, local availability and invertebrate attacks. Bacon, pineapple and banana probably attract mammals due to their strong odor, which also attracts many invertebrates. If this type of bait is chosen, we recommend the researcher to replace the bait daily or make it inaccessible to invertebrates. Pineapples and bananas lose their odor quickly when exposed to sunlight in open areas and dry weather, so the ideal is put these baits in shaded places for a better sampling effect.

The value attributed to mammal fauna by society in general and people who have direct contact with nature (e.g., as farmers) largely depends on their perceived relationship with these animals. One way to obtain support from communities surrounding protected areas in species conservation is to demonstrate how mammals contribute to the maintenance of environmental balance, and how this is favorable and profitable. This can be done via local environmental education programs, dealing with issues such as damage caused by carnivores to farm animals. *Puma concolor* generally attacks cattle, horses and goats, while species like *Cerdocyon thous*, *Chrysocyon brachyurus* and *Leopardus tigrinus* are responsible for attacks against chickens and smaller animals. Simple prevention measures could be taken by land owners and could extirpate or considerably reduce the damage caused by wild mammals (see Pitman et al. 2002).

Another important measure for the management and preservation of wild mammals is to control the use of fire. It is known that prolonged periods without passage of fire in the Cerrado can cause an excessive increase in leaf litter or native pasture and the accumulation of

Image 8. *Nasua nasua* (Linnaeus, 1766).

organic material can cause very harmful fires to wildlife and also the restoration of the original flora due to high temperatures and speed dispersion achieved by fire (Klink & Moreira 2002). That is why a strategy to control the fire within the area of the conservation area is very important. It is necessary to construct fire breaks in certain places, conducting controlled burns and also opening strategic roads that can serve to shift fire brigade. Such measures are likely to avoid disastrous events as the burning of 1994 happened in the Emas' National Park that devastated almost the entire park, as can be seen in França & Setzer (1997) and França & Setzer (1999).

Being one of the smallest protected areas in Brazil (ICMBio 2013), the National Forest of Silvânia shelters mammal species that have great need for living area such as *Puma concolor* and *Chrysocyon brachyurus*, which require a living area greater than that existing in this forest. This reinforces the importance of the maintenance of the native forest even in small conservation units, which need to maintain the areas of legal reserve and permanent preservation areas of neighboring farms, which also are used by the native mammal species.

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