Detection and monitoring of the fauna of medium and large mammals using camera traps in a forest remnant area in the municipality of Água Fria de Goiás, Brazil – A tool for nature conservation

Estudo de levantamento e monitoramento, através de armadilhas fotográficas, da fauna de médios e grandes mamíferos em remanescente florestal, município Água Fria de Goiás, Brasil – Uma ferramenta para a conservação

Estudio de relevamiento y monitoreo, a través de cámaras trampa, de fauna de mamíferos medianos y grandes en un remanente de bosque, municipio de Água Fria de Goiás, Brasil – Una herramienta para la conservación

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Abstract
Despite the growing amount of information available, biodiversity is still under threat. Wildlife plays a crucial role in maintaining the ecological balance, and it is of logical and strategic importance to promote the further development of fauna recording and monitoring processes, emphasizing the need to strengthen the relationship between humans and nature. The aim was to record the species of medium and large mammals using camera traps. The study was conducted in the EcoCerrado Reserve in the municipality of Água Fria de Goiás, Brazil, between December 2020 and December 2022, using two camera traps in three different phytophysiognomies. 17 mammal species were recorded in 149 camera trap records, including species in the threatened category, such as Myrmecophaga tridactyla, Tapirus terrestrials, Chrysocyon brachyurus, Lycalopex vetulus, Panthera onca and Alouatta caraya. The mammal fauna observed in the study shows that this ecosystem can support populations of native species even in a modified landscape. This finding strengthens the basis for future initiatives aimed at environmental education, ecotourism, and more comprehensive legal protection for this region and other remnants of native vegetation in the Cerrado.
Keywords: Conservation; Monitoring; Fauna; Mammals; Camera trap; Cerrado; Detection.

Resumo
Apesar da quantidade crescente de informação disponível, a biodiversidade continua sofrendo ameaças. A mastofauna desempenha um papel crucial na preservação do equilíbrio ambiental, sendo de importância lógica e estratégica promover o avanço dos processos de levantamento e monitoramento da fauna, destacando a necessidade de fortalecer os laços entre as pessoas e a natureza. O objetivo foi realizar o levantamento das espécies de médios e grandes mamíferos, usando armadilhas fotográficas. O estudo foi realizado na Reserva EcoCerrado, no município de Água Fria de Goiás, Brasil, durante dezembro de 2020 e dezembro de 2022, utilizando duas armadilhas fotográficas em três fitofisionomias distintas. Foram registradas 17 espécies de mamíferos em 149 registros feitos pelas armadilhas fotográficas, incluindo espécies em categoria de ameaça como: Myrmecophaga tridactyla, Tapirus terrestres,

Chrysocyon brachyurus, Lycalopex vetulus, Panthera onca e Alouatta caraya. A mastofauna observada no estudo evidência que mesmo em meio a uma paisagem alterada, este ecossistema consegue sustentar populações de espécies nativas. Essa constatação fortalece a base para futuras iniciativas visando à educação ambiental, o ecoturismo além de uma proteção legislativa mais abrangente para esta região e outros remanescentes de vegetação nativa do Cerrado.
Palavras-chave: Conservação; Monitoramento; Fauna; Mamíferos; Armadilha fotográfica; Cerrado; Detecção.

Resumen
A pesar de la creciente cantidad de información disponible, la biodiversidad continúa enfrentándose a amenazas. La vida silvestre juega un papel crucial en la preservación del equilibrio ambiental, y resulta de importancia lógica y estratégica promover el avance de los procesos de estudio y monitoreo de la fauna, resaltando la necesidad de fortalecer los vínculos entre las personas y la naturaleza. El objetivo era estudiar especies de mamíferos medianos y grandes, utilizando cámaras trampa. El estudio se realizó en la Reserva EcoCerrado, en el municipio de Água Fria de Goiás, Brasil, durante diciembre de 2020 y diciembre de 2022, utilizando dos cámaras trampa en tres fitofisonomías diferentes. Se registraron 17 especies de mamíferos en 149 registros realizados mediante cámaras trampa, incluyendo especies en la categoría de amenaza como: Myrmecophaga tridactyla, Tapirus terrestres, Chrysocyon brachyurus, Lycalopex vetulus, Panthera onca y Alouatta caraya. La fauna de mamíferos observada en el estudio muestra que incluso en medio de un paisaje cambiado, este ecosistema puede sustentar poblaciones de especies nativas. Este hallazgo fortalece la base para futuras iniciativas dirigidas a la educación ambiental, el ecoturismo, así como una protección legislativa más integral para esta región y otros remanentes de vegetación nativa en el Cerrado.
Palabras clave: Conservación; Monitoreo; Fauna; Mamíferos; Cámara trampa; Cerrado; Detección.

1. Introduction

The increasing conversion of natural areas to pasture, agriculture and urban areas is leading to habitat and species loss (Dirzo et al., 2014). Thus, the alarming decline in biodiversity, combined with people's inability to recognize it, lays the foundation for a dangerous negative feedback loop in which biodiversity loss occurs without people noticing or giving it the attention, it deserves (Schuttler et al. 2018, 2019).

The fragmentation and destruction of habitats have an impact on the migration and recolonization of fragments, which are thereby restricted. These processes can lead to an imbalance in the trophic chain (Andreazzi et al., 2009), such as an increase in the densities of small mammals due to the lack of predators and competitors (Pianca, 2004), and increase the possibility of these populations being driven to extinction (Reis et al., 2006).

Mammal fauna is important for maintaining the balance of the environment, for participating in ecological processes, and for the conservation and regeneration of forests. Some mammal species can be considered key species for structuring communities, as they are essential for indicating environmental impacts of different kinds and also contribute to the establishment of protected areas and the implementation of their management plans (Dotta & Verdade, 2007; Kasper et al., 2007; Abreu & Köhler, 2009).

Medium and large mammals are good indicators of environmental quality as they are among the vertebrate communities most affected by changes in environmental conditions. Most species in this group are sensitive to changes in the surrounding forest remnants. Therefore, the disturbance of medium and large mammal communities is of concern, as the absence or low abundance of species of this group in forest fragments leads to changes in the spatial pattern of regeneration and vegetation composition (Cuarón, 2000; Galetti et al., 2003).

The development of methods to survey and monitor fauna and their habitats is of logical and strategic importance, as they aid in management decisions and provide evidence of important issues that need to be researched and managed (Buckland, et al., 2005; Butchart, et al., 2010; Ahumada, et al., 2013; Dirzo, et al., 2014; Martins, et al., 2019).

It is also important to emphasize the importance of strengthening the links between people and nature. Projects that engage multiple audiences in the natural sciences increase participants' awareness of biodiversity in their environment and lead to behavioral changes and pro-environmental attitudes through their observations (Cosquer, et al., 2012; Toomey and Domroese, 2013; Johnson, et al., 2014; Forrester, et al., 2016; Schuttler et al., 2018). Thus, with more knowledge and

awareness of local biodiversity, people are beginning to notice changes and patterns in the natural world in which they live (Cosquer, et al., 2012) and break the cycle of indifference and destruction. However, programs targeting youth can reach more receptive participants and lead to sustainable results. During their childhood and adolescence, they are in the process of forming their values and connections (Chawla, 1999; Haywood, et al., 2016).

With this in mind, the aim of this research was (i) to conduct a survey of medium and large mammal species using camera trapping as a methodological technique. Based on the results, we hope to (ii) promote environmental awareness among the surrounding population and highlight the impact that knowledge of wildlife and human contact with nature can have on the conservation of species and protected areas.

2. Methodology

2.1 Study area

The study was conducted in the EcoCerrado Reserve (14º52'06"S, 47º53'42"W), located in the municipality of Água Fria de Goiás, Goiás, with a sampling period between December 2020 and December 2022. The study area is a remnant of the Cerrado and is located on a frontier of interest to agribusiness and illegal hunting (Figures 1 and 2). There are different types of vegetation in the reserve, such as forest, savannah, and grassland. The climate is limited to rainy summers and dry winters. About 95% of the rain that falls every year is recorded between October and April and the least rainy period is from May to September. Average temperatures vary between 20ºC and 34ºC, with the coldest period of the year covering the months of June and July and reaching 12ºC (IBGE, 2023).

2.2 Field and sampling procedures

To survey species of medium and large mammals (> 1 kg), three points (sampling units) were distributed throughout the reserve. The points were outlined on a system of predetermined paths. The minimum distance between the nearest points was 700 m and the maximum distance was 1000 m (Figure 1). A camera trap was installed at each point. Due to equipment limitations, not all sampling points were sampled simultaneously.

2.3 Camera trap

Two camera traps (Bushnell) were used to record images of the animals both during the day and at night, with the date and time of each recording being recorded. The traps were fixed (trees, poles) so that all mammal species included in this study could be recorded. The traps were installed in the study areas over a period of 40 days (39 nights) and operated continuously for 24 hours. The devices were programmed to record videos with a minimum interval of 1 second between each recording and to operate continuously. This automatic operation eliminated the need for researchers to visit the site daily, minimizing potential disturbance to the fauna. At the end of each observation period, the camera's memory card (micro SD) was removed to identify the recorded images and replaced with a blank card.

They were distributed at three different points (P1, P2, P3). The areas were covered on foot by the group of researchers, the trap installation points were decided according to the existence of evidence or diversification of points of view where footprints, tracks and traces were identified (Figure 1).

Figure 1 - Study area and points of the Traps Camera installations.
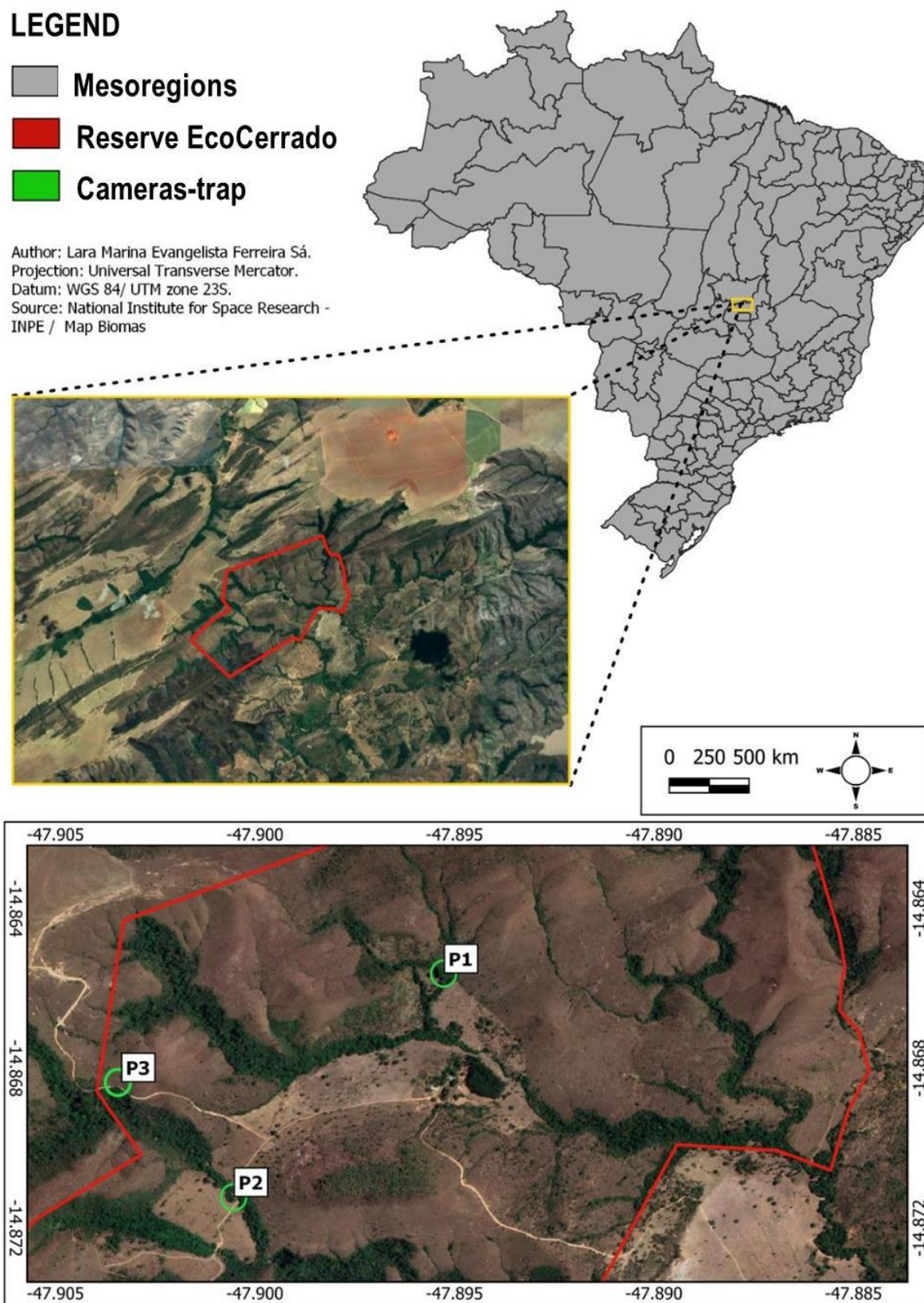
Source: Authors.

Figure 2 - Surrounding study area.
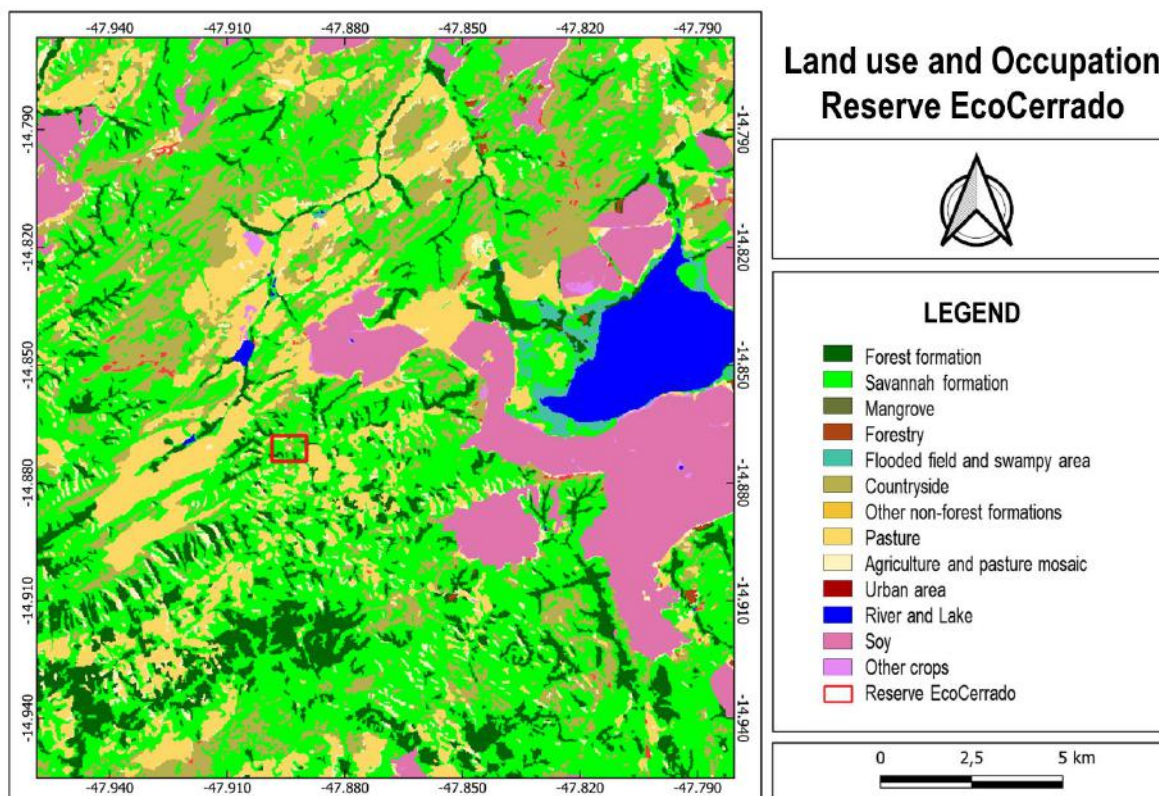
Source: Authors.

To ensure temporal independence between recordings in "the camera trap data, "sequential videos" were excluded from the analyses, i.e., videos of the same species with an interval of less than one hour between one video and another, in the same trap. Videos of the traps when they were set and of pets were also excluded from the analysis (Burton, et al., 2015; Sollmann, et al., 2013; Ponce-Martins, et al., 2022).

2.4 Search for tracks and signs

The trails created to reach the camera trap points were used as nonlinear transects, i.e., a daytime censoring procedure similar to that described by Peres and Cunha (2011) and Ponce-Martins. In addition to the procedures described by Peres and Cunha (2022) and Ponce-Martins (2022), in which tracks and signs were actively searched for, these procedures were carried out in pairs. It was taken into account that the tracks were created when the camera traps were set up or by the constant passage of animals or roads and that these tracks do not have a fixed width.

2.5 Data analysis

The sampling effort for the camera trap was defined as the number of camera traps × the number of sampling days, and the sampling success was expressed as a percentage, calculated by relating the number of records to the sampling effort × 100 (Table 2) and imposing a one-hour interval for independence between camera trap detection events (Beaudrot, et al., 2016). Species richness was estimated using rarefaction and extrapolation curves (Colwell, et al., 2012; Chao, et al., 2014), using the INEXT online program (Chao, et al., 2016).

The animals were identified to the lowest taxonomic level (Table 1), using Reis et al. (2006) in Mammals of Brazil as

a reference. Subsequently, the presence of endangered species was ascertained based on Normative Instruction MMA No. 03, of May 27, 2003, Book of Endangered Fauna in the State of São Paulo: Vertebrates (SMA, 2009) and CITES List of Wild Flora and Fauna in Danger of Extinction (2011), and on the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN, 2022).

3. Results

Seventeen species of medium and large mammals were documented, with a total of 149 records from the two camera traps, for a sampling effort of 720 traps/day, resulting in an overall sampling success of 20.69% (Table 1). The number of species and sampling success (Table 1) varied among the three sampling points studied, with 83 records found in the gallery forest (P1), for a sampling effort of 240 traps/day, achieving a success rate of 34.58%; in the stream area (P2), 43 records were made, with an effort of 240 traps/day and a success rate of 17.91%; the point located on the road (P3) had 9 records, a sampling effort also of 240 traps/day and a success rate of 3.75%.

The total number of species recorded (Table 1) was identical at points 1 and 2 (14 species), however, the number of species sampled on the road (P3) was significantly smaller compared to the gallery and stream forest (P1 and P2). The presence of four species was confirmed with records found at all three sampling points. Three species were exclusively detected in the gallery forest, two in the stream, and one on the road (Table 1). The species with the highest number of records was the giant anteater (*Myrmecophaga tridactyla*), being detected in three sampling attempts (28 detections). The species with the fewest detections (one record) were the Moorish cat (*Puma yagouaroundi*), Little anteater (*Tamandua tetradactyla*), and Black howler monkey (*Alouatta caraya*).

Table 1 - Mammal species and number of records, sampling effort (camera days) and detection rates of species recorded in the EcoCerrado Reserve, according to the sampled environment.

Species	Gallery Forest (P1)	Stream (P2)	Road (P3)	Total
Chrysocyon brachyurus	1	5	1	7
Lycalopex vetulus	2	1	0	3
Leopardus pardalis	4	1	0	5
Puma concolor	1	1	0	2
Panthera onca	9	0	0	9
Herpailurus yagouaround	0	1	0	1
Eira barbara	3	4	0	4
Procyon cancrivorus	4	5	0	9
Nasua nasua	10	3	0	13
Mazama americana	8	7	1	16
Tapirus terrestris	14	2	0	16
Dasypus novemcinctus	2	6	0	8
Myrmecophaga tridactyla	19	4	5	28
Tamandua tetradactyla	0	0	1	1
Dasyprocta azarae	4	1	0	5
Sapajus apella	3	0	0	3
Alouatta caraya	0	1	0	1
Total de records	83	43	9	149
Sample success (%)	34,58	17,91	3,75	20,69
Total species	15	14	4	18

Source: Authors.

Figure 3 shows that the observed species richness is close to what would be expected in the gallery forest area (P1), as the rarity curves tend to stabilize. The number of species recorded (15 species) does not differ significantly from the number of species extrapolated for this phytophysiognomy (16 species), indicating that the sampling effort was sufficient to record most species in this area. In the area of the stream (P2), there is a possibility that more species would have been recorded with a slightly greater sampling effort. The number of species found (14) was lower than that extrapolated for the region (17 species), as evidenced by the rarity curve. At the sampling point by the road (P3), on the other hand, the sampling effort proved to be insufficient for the area, as evidenced by the rarity curve.

Figure 3 - Species richness by sampled phytophysiognomy, based on camera trap records. P1= Gallery Forest, P2= Stream, P3= Road.
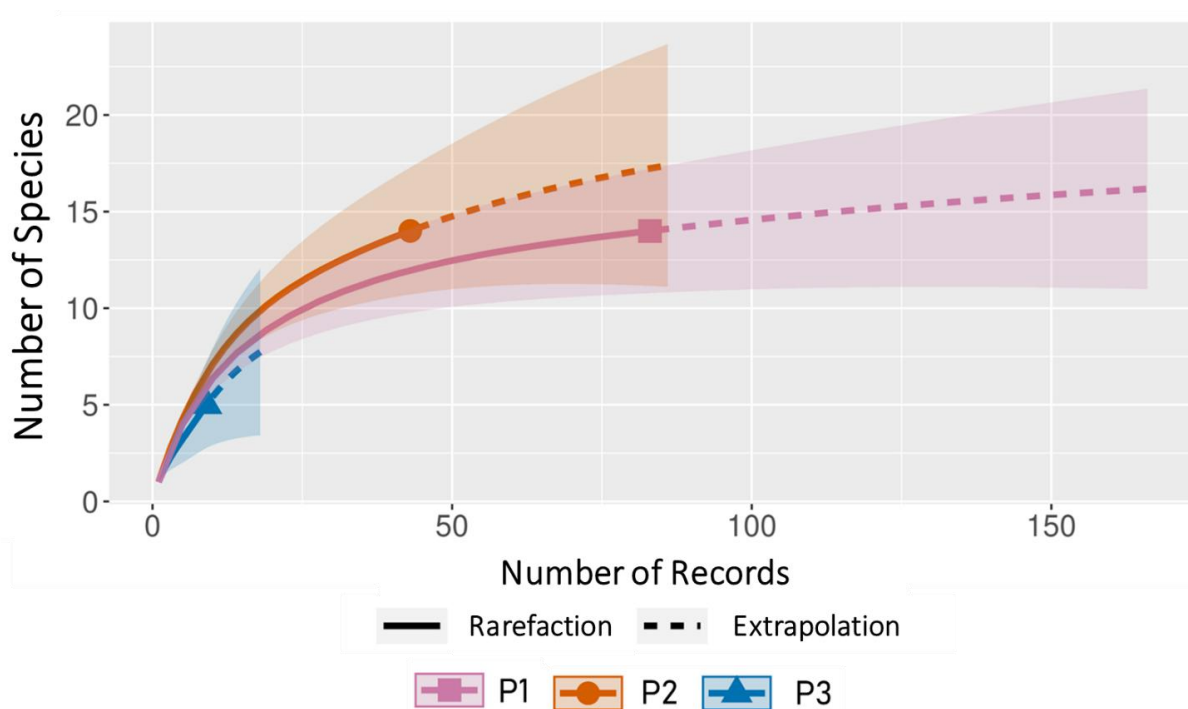
Source: Authors.

Among the 17 species of medium-sized and large mammals recorded (Table 2 and Figure 4), the carnivore order (Carnivora) was the most represented with 52.94% (9 species) and accounted for more than half of the species recorded. The tapir (*Tapirus terrestris*) and the giant anteater (*Myrmecophaga tridactyla*) are classified as vulnerable. The maned wolf (*Chrysocyon brachyurus*), the little fox (*Lycalopex vetulus*), the jaguar (*Panthera onca*) and the black howler monkey (*Alouatta caraya*) are classified as Near Threatened on the Global List of Threatened Species (IUCN, 2022-1).

Table 2 - Rate (order, family and species) of large and medium-sized mammal species found in the EcoCerrado Reserve, Água Fria de Goiás (GO), and classification on the list of threatened animals.

TAXA	SPECIES	IUCN (2022)
Carnivora		
Family Canidae	*Chrysocyon brachyurus*	Near threatened
	Lycalopex vetulus	Near threatened
Family Felidae	*Leopardus pardalis*	Least concern
	Puma concolor	Least concern
	Panthera onca	Near threatened
	Herpailurus yagouaround	Least concern
Family Mustelidae	*Eira barbara*	Least concern
Family Procyonidae	*Procyon cancrivorus*	Least concern
	Nasua nasua	Least concern
Artiodactyla		
Family Cervidae	*Mazama americana*	Insufficient Data
Perissodactyla		
Family Tapiridae	*Tapirus terrestris*	Vulnerable
Cingulata		
Family Dasypodidae	*Dasypus novemcinctus*	Least concern
Pilosa		
Family Mirmecophagidae	*Myrmecophaga tridactyla*	Vulnerable
	Tamandua tetradactyla	Least concern
Rodentia		
Family Dasyproctidae	*Dasyprocta azarae*	Insufficient Data
Primates		
Family Cebidae	*Sapajus apella*	Least concern
Family Atelidae	*Alouatta caraya*	Near threatened

Source: Authors.

Figure 4 - Example of species recorded during the survey. A. Giant anteater (*Myrmecophaga tridactyla*); B. Forest deer (*Mazama americana*); C. Tapir (*Tapirus terrestris*); D. Jaguar (*Panthera onca*).

Source: Authors.

4. Discussion

The present study has shown the importance of sampling in different phytophysiognomies in a given study area. It has also shown that longer sampling periods (not less than 250 camera days) are useful when aiming for a more complete coverage of the medium and large mammal community.

Collecting samples in different habitats was essential to increase the number of records and the diversity of species observed. This approach reveals differences in community composition between the environments sampled, particularly in terms of the absolute number of species identified. For example, 15 species were recorded in the gallery forest area (P1). In the road area (P3), only five species were identified. Some species were recorded more frequently in certain environments, highlighting the importance of collecting data on different phytophysiognomies to ensure a more comprehensive survey of the community as a whole. Furthermore, the results suggest that camera traps are a suitable tool for studies investigating species' habitat preferences, as required by regulations (Srbek-Araujo & Chiarello, 2007).

The results of the study highlight how important it is for the conservation of mammals in the Cerrado areas to preserve the mosaic of different native formations and environments, as there are species that cover all formations, others that are more selective, and some that are exclusive to a particular physiognomy, as previously mentioned and demonstrated in

other studies in the field (Cáceres, et al., 2008; Ferreira, 2008; Alves, et al., 2012).

In addition to the relationship between the intensity of sampling and the effectiveness of detection, it is also important to consider that factors related to the environment in which the device is installed can also influence the collection of data. According to Srbek-Araujo & Chiarello (2007), if the aim is to capture a larger number of species, it is necessary to carry out a trapping effort of more than 250 traps per day. In the present study, we achieved a total sampling effort of 720 traps/day. However, the effort per sampling site was 240 traps/day, which is below the value reported in previous studies and could explain the low number of records in area P3.

Silva Luiz, et al. (2019) emphasized the importance of observing footprints as an aid in identifying different species. However, the present study focused exclusively on photographic records, without looking at footprints or other remains. It is important to emphasize that there was no food supply in the vicinity of the cameras used to take the photographs.

As already mentioned by Srbek-Araujo and Chiarello (2005, 2007), it is difficult to compare the data of the studies conducted in Brazil due to the inconsistency of the sampling designs used. In addition, it should be noted that the differences in the effectiveness of mammal sampling between the different brands and models of equipment are a limitation for the comparison of research.

In fragmented landscapes, the frequent presence of the Carnivora group is common, as most of its species have high mobility and the necessary skills to explore environments affected by human activities, as long as these environments are close to areas with native vegetation, as shown by Lyra-Jorge, et al. (2008, 2010). This finding confirms the results observed in the study area, where the majority of detections corresponded to the order Carnivora, with a total of nine species represented.

As can be seen in Figure 2, in one study area there is an intensive agricultural activity that covers the native vegetation and penalises small species and those that have a restrictive diet. According to Santos (2009), the edge effect leads to the isolation of these species, resulting in a decrease in genetic variability and an increase in the risk of extinction. Although the carnivore order (Carnivora) is the most abundant, species such as *Herpailurus yagouaround* and *Puma concolor* were observed in low numbers in the study area. These data are consistent with the study by the authors Bocchiglieri, et al. (2010) and are an indication of the migration or decline of these populations in the Cerrado.

According to Moura, et al. (2021), fauna monitoring is an important tool for understanding species and their ecological importance. The cataloging of species and their habits helps in the creation of programs for the recovery of degraded areas and conservation through public policies and environmental education, because environmental education is a pillar for the preservation of the environment, making the population aware of the importance of an ecologically balanced environment for humans and all other living beings.

5. Final Considerations

The study of the local fauna shows that the nature reserve is a habitat for near threatened and vulnerable species, which reinforces the idea of preservation, discussion and understanding of the importance of this ecosystem to the community.

It was noted that the nature reserve not only provides the opportunity to conduct research, but also supports educational initiatives that promote learning in unconventional environments, which could play a crucial role in promoting behavioral changes and attitudes in favor of the conservation of future species.

The implementation of environmental education activities involving local communities should be introduced as a way to minimize the disturbance caused by the expansion of human activities. In addition to carrying out an inventory showing the presence of these mammals in the fragment, with the aim of developing conservation strategies and awareness of the Cerrado biome.

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