Santiago W.T.V. at al. Activity pattern for medium and large mammals from the Cerrado domain. Natureza online 17 (2): 016-025

Submetido em: 18/05/2018 Revisado em: 19/02/2019 Aceito em: 09/05/2019

natureza online
ESFA ISSN 1806-7409

Activity pattern for medium and large mammals from the Cerrado domain

Padrão de atividade para mamíferos de médio e grande porte do domínio Cerrado

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Resumo O Cerrado, uma vasta ecorregião de savana tropical do Brasil, é considerado um hotspot de biodiversidade e as altas taxas de destruição vêm mudando seus ambientes naturais. As ações de conservação da fauna silvestre são complexas porque algumas espécies alteram seus padrões de atividade quando enfrentam distúrbios antropogênicos, a fim de maximizar seu uso de energia. Essa mudança gera alta aptidão e persistência no ambiente. Portanto, o presente trabalho mostra que três espécies, *Dasyprocta leporina*, *Dasyprocta prymnolopha* e *Nasua nasua,* apresentaram hábitos diurnos predominantes, enquanto duas espécies, *Cerdocyon thous* e *Didelphis albiventris*, apresentaram hábitos noturnos. Além disso, *Didelphis marsupialis* é predominantemente noturno e *Mazama gouazoubira* apresenta um hábito "catemeral". Esses padrões estão relacionados às mudanças ambientais e suas consequentes ameaças, que influenciam os padrões de comportamento para proteção contra predadores e pressão de caça, uma vez que o hábito noturno era evidente para quatro das sete espécies.

Palavras-chave: Comportamento, padrão de atividade uni ou bimodal, atividade funcional.

Abstract The Cerrado, a vast tropical savanna ecoregion of Brazil, is considered a biodiversity hotspot and the high rates of destruction have been changing its natural environments. Conservation actions for wildlife are complex because some species change their activity patterns when facing anthropogenic disturbances in order to maximize their energy use. This change generates high fitness and persistence in the environment. Therefore, the present work shows that three species, *Dasyprocta leporina*, *Dasyprocta prymnolopha* and *Nasua nasua*, presented predominant diurnal habits, while two species, *Cerdocyon thou*s and *Didelphis albiventris*, presented nocturnal habits. Furthermore, *Didelphis marsupialis* is predominantly nocturnal and *Mazama gouazoubira* presents a "catemeral" habit. These patterns are related to environmental changes and its consequent threats, which influence behavior patterns for protection against predators and hunting pressure, since nocturnal habit was evident for four of the seven species.

Keywords: Behavior, uni- or bimodal activity pat-

tern, functional activity.

Introduction

The period of activity is used to describe circadian patterns (FERREIRA; VIEIRA, 2014), intraguild competition, temporal segregation (LUCHERINI et al. 2009), co-occurrence of populations (LADINE; 1997), among others. Several abiotic factors (such as light and temperature - e.g. PATTERSON et al., 1999) and biotic factors (such as body mass or competition - e.g. O'DONOGHUE et al. 1998) modify the pattern of activity. In order to minimize possible energy losses, the animals modify their strategies and obtain by reducing the activity, cease or modify it for other periods (FITCH & SHIRER 1970, MCMANUS 1971, VIEIRA et al. 2017). For this reason, each species presents its specific activity pattern in order to maximize this energetic use in reproductive behaviors, reduce the risk of predation, minimize physiological stress, among other demands for a high fitness and its persistence in the environment.

It is of great importance to know when animals are active in order to understand their ecological niches and develop conservation plans (HWANG; GARSHELIS, 2007), mainly because some species change their activity patterns when facing anthropogenic disturbances. Species can run away (Collared Peccary, *Pecari tajacu* – GRIFFITHS; VAN SCHAIK, 1993), can show behavioral plasticity at different levels of impact (*Cuniculus paca* – MICHALSKI; NORRIS, 2011), or even alter activity patterns in face of hunting pressure (*Tapirus terretris* - WALLACE et al., 2012).

Studies focusing on periodic activity for Brazilian species are incipient and the few studies already conducted are highly specific (e.g. small terrestrial mammals in VIEIRA; BAUMGARTEN, 1995). The situation is even more complicated for the Cerrado domain, which is one of the most threatened domains in the world and considered a biodiversity hotspot (MYERS et al., 2000). The rate of destruction is one of the highest in Brazil with average deforestation of 40,000 km² per year (KLINK; MACHADO, 2005) and changes in the environment hinder conservation actions, which in turn can lead to local or regional extinctions.

In view of this panorama, the objective of this study was to analyze pattern of the periods of activities of medium and large mammals. The animals herein studied were: *Didelphis marsupialis*; *Cerdocyon thous*; *Dasyprocta leporina*; *Dasyprocta prymnolopha*; *Didelphis albiventris*; *Mazama gouazoubira*; and *Nasua nasua*.

Material and Methods

Study area

The study was conducted in the Cerrado domain in the state of Tocantins, Central-West, Brazil. The mean annual rainfall is approximately 1,500 mm and the average temperature is 24 ° C (LEEMANS; CRAMER, 1991), the dominant climate is tropical semi-humid of Central Brazil (Aw according to Köppen). The relief is characterized by being corrugated, with plateaus and testimonial hills (MAMEDE et al., 2002).

For the present study seven areas distant at least 60 kilometers from each other were selected from its extreme south to the extreme north of the state. The area was chosen considering the presence of phytophysiognomies, which is representative of the Brazilian Cerrado and include riparian forest; gallery forests; cerradões; typical cerrado; dense cerrado; fields; and veredas (Table 1, Figure 1).

Methodology and data analysis

In order to evaluate the period of activity, Camera-traps were arranged in preexisting trails equidistant from each other 250 meters on average. The sampling effort between the areas varied and the sample effort per area is in Table 2. The calculation of the sample effort was performed according to the formula used by Srbek-Araujo and Chiarello (2005). The success of the sampling was expressed in percentage; it was calculated by the ratio of the number of records per capture effort. The sample effort was 3,464 traps/day.

Photographic records were considered independent when the interval between photographs of the same photographic trap for the same species was one hour or more (SRBEK-ARAUJO; CHIARELLO, 2013). Records were established according to the times of the photographic events in a 24-hour period.

Table 1. Relation of the selected areas of study with their respective physiognomic types of vegetation according to Ribeiro and Walter (1998). The geographical coordinates are in the "Location" column. The numbers in this Table refer to the same numbers as in Figure 1.

Location	**Description**
1- 09º48'S 47º 52'W	Riparian forest, Cerradão, Dense cerrado, Typical cerrado and Campo Sujo
2- 09º19'S 47º 52'W	Riparian forest, Cerradão, Dense cerrado, Typical cerrado, Campo Sujo
3- 8º14'S 47º41'W	Riparian forest, Cerradão, Dense cerrado, Typical cerrado, Campo Sujo
4- 07º47'S 47º23'W	Riparian forest, Cerradão, Dense cerrado, Typical cerrado, Campo Sujo
5- 09º42'S 48º 21'W	Riparian forest, Cerradão, Dense cerrado, Typical cerrado
6- 11º35'S 47º00'W	Riparian forest, Gallery forests, Cerradão, Dense cerrado e Typical cerrado, Campo Sujo
7- 12º54'S 46º45'W	Riparian forest, Cerradão, Dense cerrado, Typical cerrado e Vereda

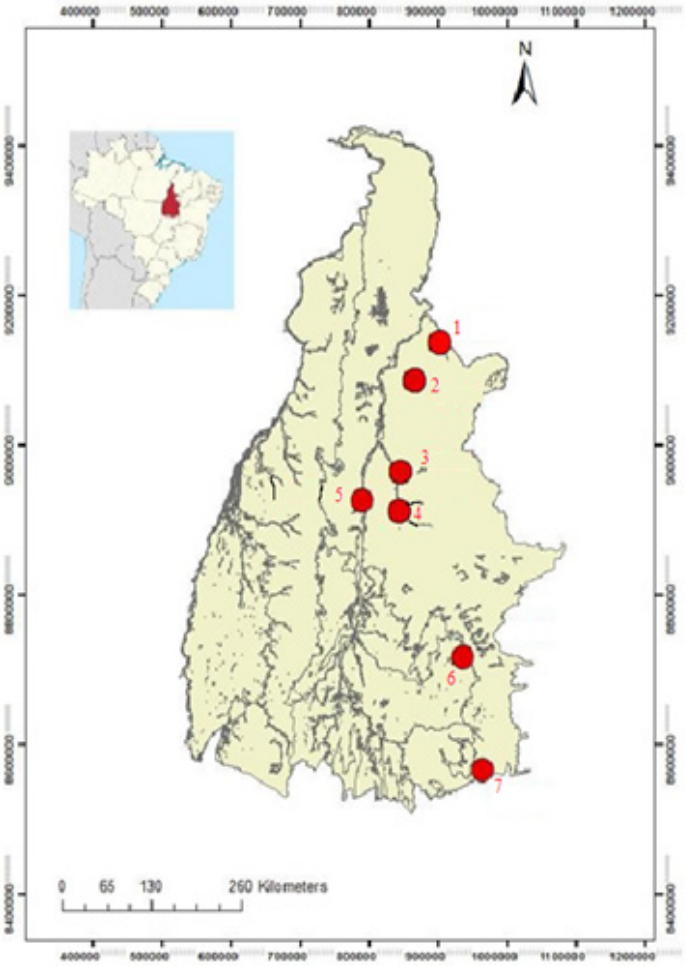

Figure 1. Location of the selected areas of study in the Cerrado of the State of Tocantins, Brazil. (Source: Atlas do Tocantins: Secretariat for Planning and Modernization of Public Management - SEPLAM, 2012).

Table 2. Localities and sample effort by area of activity period of species of the Cerrado of the State of Tocantins, Brazil.

Locality	Sample effort (traps/day)
1	465
2	465
3	465
4	465
5	624
6	520
7	460

The classification of mammal species of medium and large size in relation to the period of activity was performed according to the recommendations of Gomez et al. (2005). This characterizes them in relation to the period of activity according to the following criteria: (1) less than 10% of nocturnal records are "diurnal species"; (2) with 10 to 30% of nocturnal records are "predominantly diurnal" species; (3) with 30 to 70% of nocturnal records are species that are active during the day and during the night, also called "catemerals"; (4) from 70 to 90% of the nocturnal records are considered "predominantly nocturnal"; (5) with more than 90% nocturnal records are "nocturnal species".

To evaluate the distribution of the photographic records, the Watson Test (U^2) with significance of 5% was used, where the null hypothesis is rejected when the photographic records of the species are evenly distributed by the circular-linear graph. The length of vector r, which characterizes how concentrated the activity period is, was also calculated and values close to 0 indicate a more homogeneous pattern, while values close to 1 indicate that the activities are more concentrated in the circular mean interval (DI BITETTI et al., 2010). Analyzes were performed using the Oriana 4.0 program (Kovach Compute Service – KOVACH, 2011).

Results

The following species were registered for study area: *Didelphis marsupialis*, *Cerdocyon thous*, *Dasyprocta leporina*, *Dasyprocta prymnolopha*, *Didelphis albiventris*, *Mazama gouazoubira* and *Nasua nasua*. The species with the highest number of photographic records was *Cerdocyon thous*, with 75 records, followed by *Dasyprocta leporina*, with 45 records, *Nasua nasua*, with 24 records, *Dasyprocta prymnolopha*, with 22 records, *Didelphis marsupialis*, with fourteen records, *Mazama gouazoubira*, with ten records, and *Didelphis albiventris* with 13 records.

Table 3 shows the relation of species whose number of photographic records allowed the elaboration of circular-arc graphs with their respective statistical parameters and tests of statistical significance.

Table 3. Number of records, distribution of records between periods of the day, classification of period of activity and uniformity in the distribution of photographic records (Watson's U2 test) observed for medium and large mammal species obtained from traps in the Cerrado, Central-West, Brazil.

Species	**Records**	**Day records**	**Night records**	**Classification of the activity period**	**Vector *r***	**Watson test (U2)**
Cerdocyon thous	75	5	70	Nocturnal	0.235	$p < 0.005$
Dasyprocta leporina	45	36	9	Predominantly Diurnal	0.292	$p < 0.005$
Dasyprocta prymnolopha	22	15	7	Predominantly Diurnal	0.118	$p < 0.005$
Didelphis albiventris	13	1	12	Predominantly Nocturnal	0.487	$p < 0.005$
Didelphis marsupialis	14	0	14	Nocturnal	0.872	$p < 0.005$
Mazama gouazoubira	16	11	5	Catemeral	0.251	$p > 0.05$
Nasua nasua	24	19	5	Predominantly diurnal	0.284	$p < 0.005$

The species *C. thous* and *D. marsupialis* had nocturnal periods of activity (p value <0.005). The *D. albiventris* species showed a period of predominantly nocturnal activity (p value <0.005). The species *D. leporina*, *D. prymnolopha* and *N. nasua* presented periods of activities predominantly diurnal (value p <0.005). The species *M. gouazoubira* presented a period of activity considered to be catemeral, showing activity at both night and day periods, without distinction (value p >0.05).

Figures 2, 3 and 4 show activity peaks for seven medium and large mammal species recorded by Camera-traps in the Cerrado domain of the state of Tocantins, Brazil. Four species of medium and large mammals presented bimodal activity peaks: *Cerdocyon thous*, *Didelphis albiventris*, *Didelphis marsupialis* with activity peaks between 0:00 a.m. and 10:00 p.m., and *Dasyprocta prymnolopha* with activity peaks at 6:00 p.m. and 7:00 p.m. Dasyprocta leporina showed a peak activity at 7:00 p.m. The *Nasua nasua* species presented activity peaks at 5:00 p.m. and 6:00 p.m. The *Mazama gouazoubira* species showed a peak activity at 6:00 p.m.

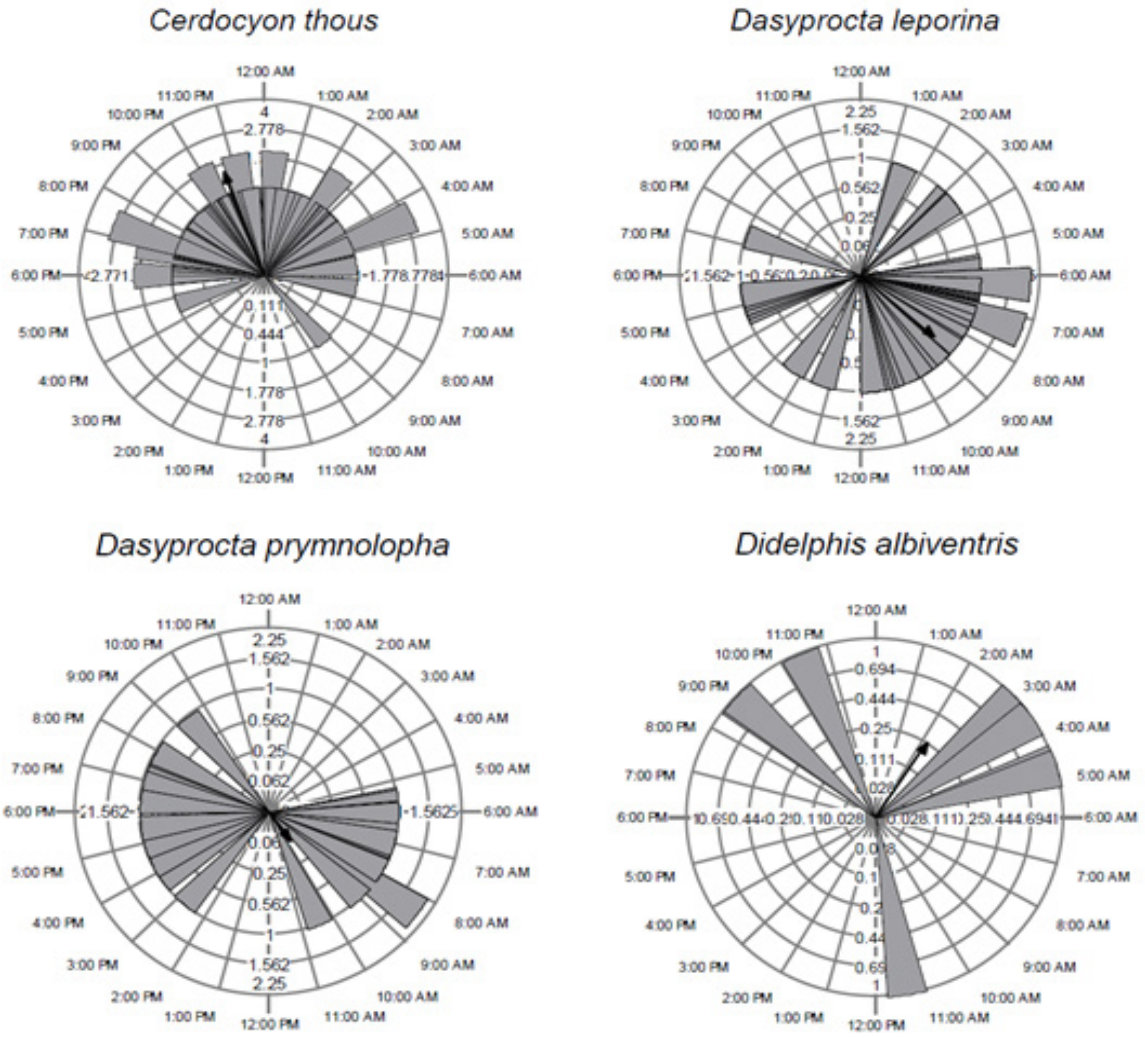

Figure 2. Circular-arc graphs with the records of daily activities of *Cerdocyon thous*, *Dasyprocta leporina*, *Dasyprocta prymnolopha* and *Didelphis albiventris* species obtained from Camera-traps in the Cerrado, Central-West, Brazil.

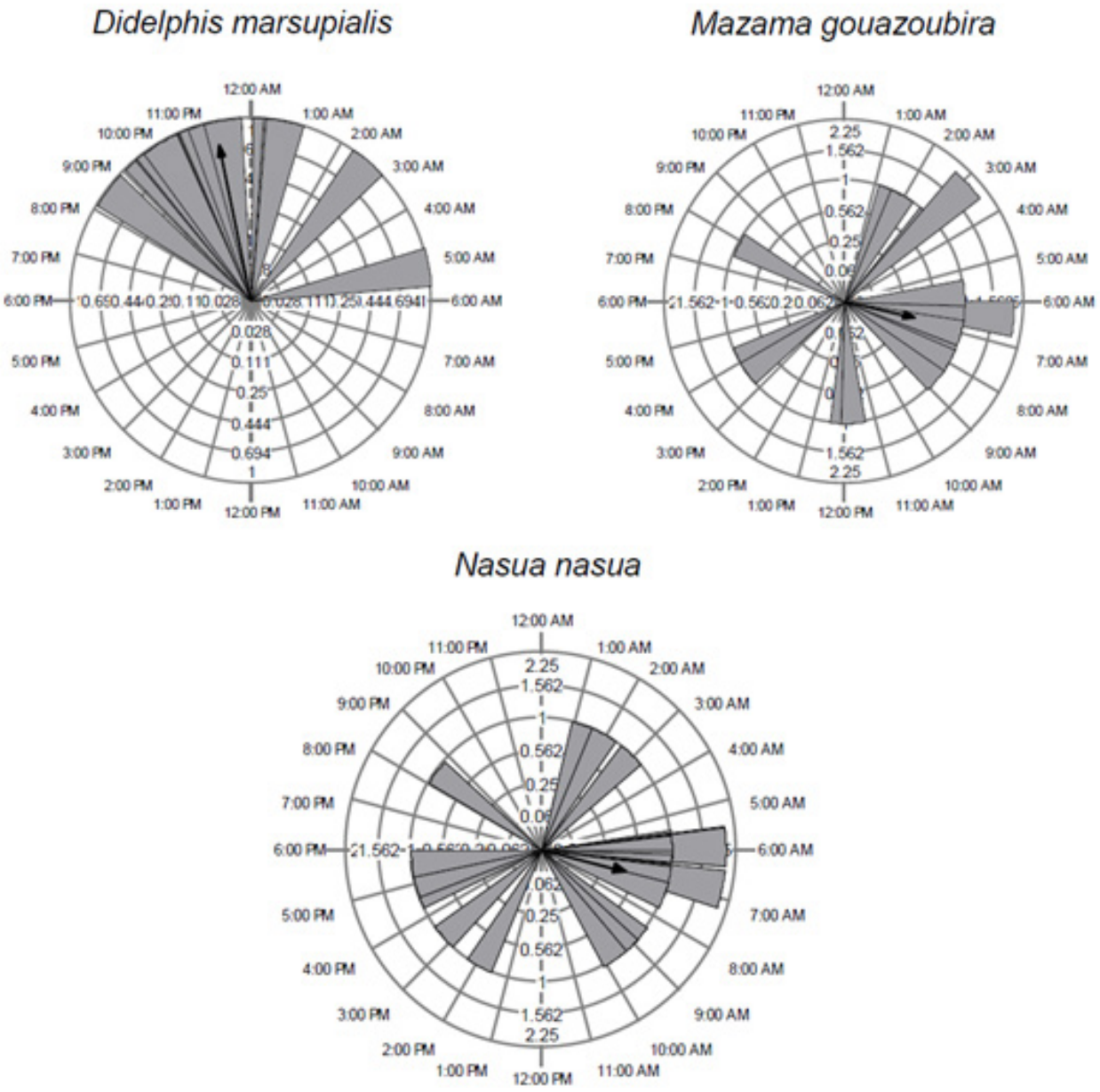

Figure 3. Circular-arc graphs with records of daily activities of the species *Didelphis marsupialis*, *Mazama gouazoubira* and *Nasua nasua* obtained from Camera-traps in the Cerrado, Central-West, Brazil.

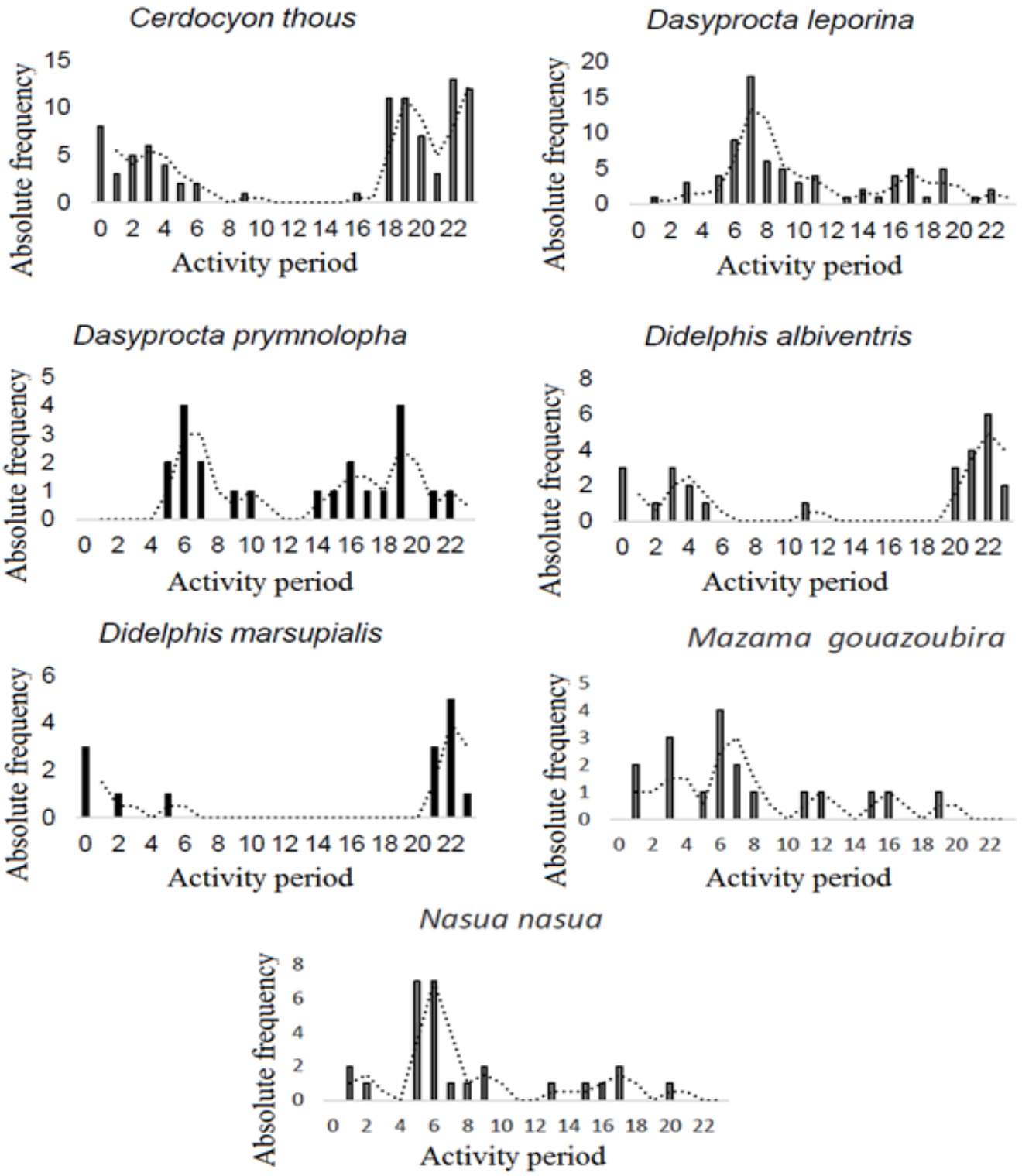

Figure 4. Records of activity periods for mammal species of medium and large size, obtained through the use of Camera-traps in seven study areas in the Cerrado, Tocantins state, Brazil.

Discussion

The periods of activity were similar to those of studies carried out in different locations in South America (GÓMEZ et al., 2005; VIEIRA; PORT, 2007; TOBLER et al., 2009; DI BITETTI et al., 2009; DI BITETTI et. al., 2010; FARIA-CÔRREA et al. 2009; MICHALSKI; NORRIS, 2011; CORTÉS--MARCIAL; BRIONES-SALAS, 2014; JAX et al., 2015), but the present studypresents some peculiarities.

Among the seven species of medium and large mammals, three species (*D. leporina*, *D. prymnolopha* and *N. nasua*) presented periods of activity predominantly diurnal. Two species (*C. thous* and *D. albiventris*) showed periods of nocturnal activity and one species (*D. marsupialis*) predominantly nocturnal. One species, *M. gouazoubira*, presented period of catemeral activity. Body size influences this pattern of species activity, with lower body weight mammals tending to be predominantly nocturnal or nocturnal as an anti-predation strategy. Nevertheless, larger mammals tend to be catemeral because they have higher energy requirements (SCHAIK; GRIFFITHS, 1996; GÓMEZ et al., 2005; OLIVEIRA--SANTOS et al.. 2013).

A bimodal pattern of activity was observed for *C. thous*, *D. marsupialis*, *D. albiventris* and *D. prymnolopha*. This type of activity is a result of the intrinsic circadian rhythm, which is usually bimodal (ASCHOFF, 1966) and occurs in different groups of rodents, carnivores and marsupials (e.g. BACIGALUPE et al., 2003; FERREIRA; VIEIRA, 2014). This pattern maximizes the energy expenditure for daily activities by avoiding periods with intense heat and encounters with top-chain predators that are more active by the high-energy requirement.

The daytime behavior for *N. nasua* was similar to that observed in other studies conducted by other authors who found individuals foraging for the capture of invertebrates and small vertebrates. This activity was concentrated between 7 a.m. and 6 p.m., which is a pattern similar to that of this paper (EMMONS, 1997; ALVES; ANDRIOLO, 2005).

Considering the genera *Dasyprocta* and *Mazama*, Gomez et al. (2005) observed periods of activity similar to that observed in this study for *Dasyprocta* and differentiated for *Mazama*, pointing to this species a period of predominantly nocturnal activity with a low frequency of activity in the diurnal period. The differentiated pattern for *Mazama* is a result of hunting pressure. Some species of the genus *Mazama* are able to change their patterns due to hunting, becoming nocturnal in areas with high pressure in response to periods of constant activity of people or other animals (DI BILLETI et al., 2008). Deer hunting has become common in the state of Tocantins (SSP, 2016; G1, 2016) due to the high population density.

It is concluded that three species of medium and large mammals presented predominant diurnal habits; two species had nocturnal habits, one predominantly nocturnal, and a catemeral habit. The predominant characteristics are nocturnal habits, which are adaptive behaviors of protection against predators and hunting pressure. In addition, the present report is the first to present the activity pattern for the species *Dasyprocta prymnolopha* in natural environments.

It is reiterated that the domain in which these species are inserted is threatened, despite its high diversity (MYER et al., 2000). The constant environmental changes (KLINK et al., 2005) generate changes in the microstructure habitat and force the change of periods of activity. The difficulty of precisely defining standards hinders conservationist actions and the situation is even more complicated when considering the current Brazilian political situation. Endangered domains still suffer from strong anthropogenic pressure and current legislation (e.g. 2012 Forest Code, among others) neglects its biological importance. Furthermore, the patterns presented in this work are susceptible to change due to strong human action on the Brazilian Cerrado.

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