

## Private forest reserves can aid in preserving the community of medium and large-sized vertebrates in the Amazon arc of deforestation

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**Abstract** Due to the advancing agricultural frontier in the Brazilian Amazon, the present rate of deforestation engenders a pessimistic scenario for vertebrate diversity in the area. Protected areas are an essential conservation tool to limit biodiversity loss, but their efficiency have yet to be proven. Here, we used camera-trap data on the presence of medium and large-size vertebrates in a protected area (Cantão State Park) and a neighbouring private forest reserve (Santa Fé Ranch) to evaluate their effectiveness in protecting biodiversity. We also gathered information on seasonality and activity patterns. A total sampling effort of 7929 trap-nights revealed a diverse vertebrate fauna in the region. A total of 34 mammal species, belonging to 8 different orders was detected in the study area, some of which have a high level of conservation interest and value. The photographic index showed that diversity was more abundant outside the protected area of Cantão State Park, where seasonality could play a major role in vertebrate occurrence. Overall, the influence of seasonality on distribution appears to be species-specific. During the wet season around 40% of the common species were not detected inside the park, whereas in Santa Fé Ranch most species (62.5%) suffered only a slight decrease in relative abundance probably due to changes in the availability of food resources. Our results highlight the importance of private land for vertebrate conservation in the Amazon and alert to the need for increased law enforcement in these areas to secure biodiversity preservation.

**Keywords** Camera-trapping · Tropical mammals and birds · Amazon · Activity period

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## Introduction

With a growing human population and a higher demand for natural resources, protected areas represent one of the main conservation measures used to avoid species extinction and habitat loss (Cardillo et al. 2004; Joppa et al. 2009). Despite covering over 12% of earth's terrestrial surface, there are still some issues concerning the efficiency of protected areas in securing species richness preservation (Parrish et al. 2003). One of the questions that remain open is the usefulness of private reserves in preserving the extraordinary biodiversity of tropical forests, such as in the Amazon. In Brazil, the agricultural frontier is quickly advancing, with a concomitant fragmentation of the Amazon forest. By law, new farms and ranches must establish a private forest reserve that covers 80% of the private land accessioned. In theory, this legal requirement preserves, by far, much more land than the more traditional public protected areas. However, it is not clear how useful they are in preserving biodiversity because most of our conservation and scientific efforts are focused towards public reserves.

The Amazon basin represents one of the most important regions in the world in terms of biodiversity (Costa et al. 2005; Stone et al. 2009). This, the largest rainforest on the planet, harbours the greatest number of endemic species per unit area and one of the highest diversities of vertebrates (IUCN et al. 2008). Habitat loss is the most important threat to vertebrate species and, even if relatively well known, only a small number of studies provide information on their status in this tropical forest (Voss and Emmons 1996; Fonseca et al. 1999). The rate of deforestation of Brazilian Amazonia has reached considerably high rates in recent years and it is estimated that the advance of the agricultural frontier over the region could cause a reduction by 50% of its forest cover in a few decades and, with it, the majority of its vertebrate diversity (Laurence et al. 2001; Azevedo-Ramos et al. 2006). This scenario highlights the imperativeness of establishing an effective network of protected areas (Schulman et al. 2007). In particular, within the “arc of deforestation” the eastern/south-eastern region of the Amazon, where increased human pressure results in a highly fragmented landscape of agricultural farms and forest patches, evaluation of the conservation value of the remaining forest fragments is needed (Lopes and Ferrari 2000; Morton et al. 2006).

There has been an increase in research on the distribution and ecology of medium and large-sized mammals and birds in the tropics, but their biological characteristics (nocturnal, low density and cryptic) make them difficult to census and study (Silveira et al. 2003; Lyra-Jorge et al. 2008). The use of camera trapping in surveys has been intensified recently due to the advantages of being cost-effective for detecting animals with inconspicuous habits and its reduced disturbance (Zielinski et al. 1995; Kelly 2008; Rowcliffe and Carbone 2008). It constitutes a non-invasive method that provides considerable information on occurrence, population density and other biological parameters (sociality, activity or reproduction) of target and non-target species (Silveira et al. 2003; Gómez et al. 2005; Stein et al. 2008).

This research is part of a long-term monitoring programme for jaguar density. Our intensive sampling effort over several years has resulted in a considerable number of photos of medium to large-sized vertebrates (mostly mammals, and to a limited extent birds) within Cantão State Park (CS-Park) and the adjacent Santa Fé Ranch (SF-Ranch). We use this information to report on vertebrate species richness, their activity patterns and the influence of seasonality and flooding both in a public reserve (CS-Park) and in a private forest fragment within a cattle ranch (SF-Ranch) in the Amazon arc of deforestation.

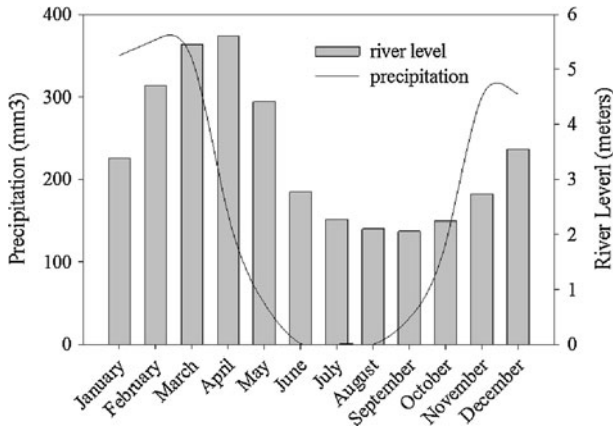
## Materials and methods

### Study area

The study was carried out in the middle Araguaia river basin in two areas on opposite sides of the river: the Cantão State Park (CS-Park) on the right river bank and the Santa Fé Ranch (SF-Ranch) on the left river bank (Fig. 1). Cantão State Park (09°36' S, 50°03' W) is an 89,000 ha conservation unit situated in the transitional area between the Amazon and *Cerrado* biomes. Water abundance undergoes dramatic cyclical changes due to an extended network of rivers, canals and lakes. The dynamics created by the wet season (November–March) and the prolonged dry season (April–October) influences vegetation structure (SPMA 2000; Vitt et al. 2007). With an annual average precipitation of 1,710 mm/year and a difference of more than 4 m in river level between seasons (data from Santa Fé Ranch), flooding conditions influence available resources (food and shelter) for the fauna (Fig. 2). The vegetation, mainly represented by secondary growth tropical rainforest with some small grassland areas, suffers partial flooding during the wet season.



**Fig. 1** Study area showing the Santa Fé Ranch and Cantão State Park and their ecotonal location in the Brazilian biomes of the Amazon and *Cerrado*



**Fig. 2** Average precipitation and river level recorded for the Cantão State Park region, central Brazil (data from Santa Fé Ranch)

Santa Fé Ranch (09°34' S, 50°21' W) is a 65,000 ha beef cattle ranch in southeast Pará State, bordering the Araguaia River. Around 65% of the ranch represents a continuous, semi-deciduous seasonal tropical forest (similar as the CS-Park) patch that extrapolates the farm boundaries, while the other 35% is occupied almost entirely by pastures.

#### Field methods

We conducted five camera trap surveys between July 2005 and November 2007 during both the dry (three surveys) and wet (two surveys) seasons. A variable number of stations (from 10 to 22) were established throughout each study area, with a distance of 1–3 km between stations (Rabinowitz and Nottigham 1986; Karanth and Nicholds 2002; Silver et al. 2004). One passive infra-red camera was placed approximately 50–70 cm above ground on dirt roads or trails (animal or human made) at each station, except during the 2007 dry season survey at SF-Ranch when two cameras per station were used (Silver 2004). Two different camera types were used: Camtrakker® (Cam Trakker, Watkinsville, USA) and C1-BU® (Vibrashine Inc., Taylorsville, MS 3968, USA). Each camera was programmed to take photographs 24 h/day with a 5-min interval between photos. All stations were checked on a regular basis (5–20 days) throughout all surveys for maintenance. In addition to camera trapping, field observations contributed data on the occurrence of primates and aquatic mammals during the expeditions for camera installation and monitoring.

#### Data analysis

Species identification, number of individuals, sex, age, date and hour were determined, where possible, for each photograph. Following O'Brien et al. (2003), photos were considered independent events only if they met at least one of three criteria: consecutive photographs of different individuals of the same or different species; consecutive photographs of individuals of the same species taken more than 1 h apart; non-consecutive photos of individuals of the same species.

The relative abundance index (RAI) was determined for all species by dividing the number of independent photo captures, by effort (trap-nights) times 100 (O'Brien et al. 2003; Kawanishi and Sunquist 2004). A photographic base index of abundance is considered a consistent method to infer the relative abundance of cryptic mammals, assuming that the cameras did not affect the rates of movement of animals (Carbone et al. 2001; Goulart et al. 2009). The criteria used to set-up the cameras was always to maximise jaguar detection and, therefore, we assume that the same bias in species detection occurs across the entire study area, making the data comparable between sites and over time (Stein et al. 2008).

We anticipated that populations would remain relatively stable during our short study period (3 years) and also within seasons in the absence of any catastrophic phenomenon (Krebs 1994; Harmsen 2006). Taking this into account, results from different surveys were pooled and we compared RAI for the most frequent species between seasons (dry and wet) for both areas (SF-Ranch and CS-Park) using Mann–Whitney tests.

### Factors affecting diversity and species detection

Using generalised linear mixed models (GLMM), we evaluated the factors that could affect species richness according to sampling features (year, season, area: CS-Park vs. SF-Ranch) and environmental predictors (distance to water, distance to pasture, camera location i.e. road vs. trail), considering the number of different species as the dependent variable and trap station included as a random variable. We also analysed the factors affecting RAI according to some species characteristics: weight, conservation status, trophic niche (predator vs. prey) and social behaviour (solitary vs. group-living), using RAI as the dependent variable. We used R v.8.2 free statistical software and the Lme4 package for mixed models (Bates and Sarkar 2006) to fit the statistical models.

### Activity patterns

We generated the activity pattern in 1-h intervals for those species with more than 10 independent photographic events. We used Chi-square tests to compare data from CS-Park and SF-Ranch, pooling them for further analysis if they were not significantly different ( $P > 0.05$ ). Then, each capture was classified into three categories: nocturnal (18:31–05:00 h), diurnal (06:31–17:00 h), and crepuscular (17:01–18.30 and 05:01–06:30 h) (Schaik and Griffiths 1996).

## Results

### Species richness

A total sampling effort of 7929 trap-nights were conducted over several, continuous, two-month periods (average 61 days), with a variable number of camera stations (average 15; range 10–22) and trap nights (965 trap-nights; 525–1681) at each site (Table 1). Camera trap effort on CS-Park was lower (3183 trap nights) than in SF-Ranch (4746 trap nights), but sampling season lasted on average 61 days in both areas, and the average number of camera stations established on each site was slightly higher in CS-Park (18) than in SF-Ranch (15). In 2007 we only sampled SF-Ranch.

**Table 1** Sampling effort (No. stations, No. trap-nights, average number of days of effective camera use), total number of photos and number of photos (and percentage) for main vertebrate Classes in Cantão State Park and Santa Fé Ranch in central Brazil, as determined from camera traps

	Cantão State Park				Santa Fé Ranch					
	2005		2006		2005		2006		2007	
	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain
No. stations	21	10	22	14	12	14	17	11	21	
Total effort (Trap-nights)	1390	626	1167	662	764	662	1114	525	1681	
Mean no. of days	66	63	53	47	64	47	66	48	80	
No. photos	136	37	94	80	136	80	220	100	724	
Mammals	60 (44.12)	20 (54.05)	39 (41.49)	62 (77.5)	76 (58.9)	62 (77.5)	165 (75.0)	70 (70.0)	505 (70.0)	
Birds	75 (55.88)	17 (45.95)	52 (55.32)	17 (21.30)	47 (35.70)	17 (21.30)	46 (20.90)	30 (30.00)	215 (29.80)	
Reptiles	0	0	3 (3.19)	1 (1.30)	7 (5.40)	1 (1.30)	9 (4.10)	0	1 (0.10)	
Not identified	0	0	0	0	7 (5.40)	0	0	0	3	

*Italicized values are percentage of photos has stated in figure heading*

Mammals constituted the greater proportion of the utilised photos (65.7%), followed by birds (32.9%) and reptiles (1.4%). This proportion nevertheless changes, when the two study areas are considered separately. In CS-Park, 53.9% of the photo captures were of birds, compared to 44.6% for mammals and 1.1% for reptiles. On SF-Ranch, mammals were the most frequently captured group (70.2%), followed by birds (28.4%) and reptiles (1.4%).

A total of 34 mammal species, belonging to eight different orders was detected in the study area during the course of the survey period (Table 2). We registered more mammal species in the SF-Ranch forest reserve ( $N = 30$ ) than in CS-Park ( $N = 16$ ), where some common species like brocket deer (*Mazama* spp.), peccaries (*Tayassu pecari* and *Pecari tacaju*), crab-eating fox (*Cerdocyon thous*) and armadillos (*Priodontes maximus* and *Dasybus novemcinctus*) were absent, contrary to a previous census carried out in the park (Silveira 2004).

In terms of conservation status, we emphasise the presence of two endangered species (EN), Giant Otter (*Pteronura brasiliensis*) and Uta Hick's Bearded Saki (*Chiropotes utahickae*); and three species classified as vulnerable (VU) according to IUCN (2008), Brazilian Tapir (*Tapirus terrestris*), Marsh Deer (*Blastocerus dichotomus*) and Giant Armadillo (*Priodontes maximus*) (Table 2) in the studied areas. Two aquatic species, the Pink River Dolphin (*Inia geoffrensis*) and the Giant Otter (*Pteronura brasiliensis*) were only present in CS-Park. Thus, comparing the two sampled areas, we recorded four species classified under Threatened Categories (EN or VU) from SF-Ranch, whereas only three were recorded from CS-Park (Table 2).

#### Photo capture rate differences between places and seasons

All the species seem to be more abundant in SF-Ranch than in the CS-Park, with the exception of *Cuniculus paca* and *Crax fasciolata* (Table 3). When comparing RAI between seasons we can verify the absence of some species during the wet season, such as *Puma concolor*, *Mazama americana*, *Hydrochaeris hydrochaeris* and *Penelope* spp. inside CS-Park and *Mazama gouazoupira*, *Didelphis* spp., *Hydrochaeris hydrochaeris* and *Mitu tuberosum* in SF-Ranch. For CS-Park, some species show a reduction (*Leopardus pardalis*, *Didelphis* spp. and *Crax fasciolata*) or increase (*Tapirus terrestris*, *Panthera onca* and *Cuniculus paca*) in RAI from the dry to the wet season, but the difference is only significant for the jaguar (Mann–Whitney  $W = 32$ ;  $P < 0.001$ ). The majority of the species that occur in SF-Ranch reveal a fluctuation in capture rates from the dry to the wet season. However, only the reduction of *Mazama americana*, *Pecari tacaju*, *Cerdocyon thous*, *Leopardus pardalis*, *Dasyprocta azarae*, *Penelope* spp. and *Crax fasciolata* were significant (Mann–Whitney test  $P < 0.05$  for all comparisons).

#### Biological and sampling factors affecting RAI

GLMM analysis revealed that the number of species detected at each station was significantly higher outside the park than inside (Table 4). Also RAI increased with the number of days of sampling during the study years and revealed a negative correlation with season (lower richness during the wet season). Camera location seemed to be of importance, resulting in a higher number of species photographed on roads compared to trails.

The relationship between the photographic rate (RAI) and some species characteristics reveal that detection was positively and strongly dependent on animal body mass (favouring larger species) and aggregation (species that moved in groups) (Table 4). Considering that threatened level is directly associated with abundance, it is logical that

**Table 2** Summary of mammal species recorded in Cantão State Park and Santa Fé Ranch using camera trapping and occasional observations, together with their respective conservation status (IUCN 2008) and Brazilian National Red List (2005) status

Species	Common name	IUCN status (2008)	Brazil National Red List (2005)	Cantão State Park		Santa Fé Ranch
				2002/2003 <sup>a</sup>	2005/2006	2005–2007
<i>Blastocerus dichotomus</i>	Marsh Deer	VU	VU		X	X
<i>Mazama Americana</i>	Red Brocket Deer	LC		X		X
<i>Mazama gouazoupira</i>	Gray Brocket Deer	LC		X		X
<i>Pecari tajacu</i>	Collared Peccary	LC		X		X
<i>Tayassu pecari</i>	White-lipped Peccary	NT		X		X
<i>Inia geoffrensis</i>	Pink River Dolphin	DD		X	X	
<i>Cerdocyon thous</i>	Crab-eating fox	LC				X
<i>Speothos venaticus</i>	Bush Dog	NT	VU			X
<i>Puma yagouaroundi</i>	Jaguarundi	LC		X	X	X
<i>Leopardus pardalis</i>	Ocelot	LC		X	X	X
<i>Leopardus wiedii</i>	Margay	NT	VU	X		X
<i>Panthera onca</i>	Jaguar	NT	VU	X	X	X
<i>Puma concolor</i>	Puma	LC		X	X	X
<i>Eira Barbara</i>	Tayra	LC		X		X
<i>Pteronura brasiliensis</i>	Giant Otter	EN	VU	X	X	
<i>Nasua nasua</i>	South American Coati	LC		X	X	X
<i>Procyon cancrivorus</i>	Crab-eating Raccoon	LC				X
<i>Didelphis albiventris</i>	White-eared Opossum	LC		X	X	
<i>Didelphis marsupialis</i>	Black-eared Opossum	LC		X	X	X
<i>Tapirus terrestris</i>	Brazilian Tapir	VU		X	X	X
<i>Alouatta caraya</i>	Black Howler Monkey	LC				X
<i>Cebus apella</i>	Black-capped Capuchin	LC		X	X	X
<i>Saimiri sciureus</i>	Common Squirrel Monkey	LC				X
<i>Callicebus moloch</i>	Red-bellied Titi Monkey	LC				X
<i>Aotus azarae</i>	Azara's night monkey	LC			X	
<i>Chiropotes utahickae</i>	Uta Hick's Bearded Saki	EN	VU			X
<i>Cuniculus paca</i>	Spotted Paca	LC		X	X	X
<i>Dasyprocta azarae</i>	Azara's Agouti	DD		X		X
<i>Coendou prehensilis</i>	Brazilian porcupine	LC			X	X
<i>Hydrochaeris hydrochaeris</i>	Capybara	LC		X	X	X
<i>Dasybus novemcinctus</i>	Nine-banded Armadillo	LC				X
<i>Priodontes maximus</i>	Giant Armadillo	VU	VU			X
<i>Myrmecophaga tridactyla</i>	Giant Anteater	NT	VU			X
<i>Tamandua tetradactyla</i>	Collared Anteater	LC		X		X
Total Species	34			21	16	30

<sup>a</sup> Data from Silveira (2004)



**Table 3** Photo capture rates (photos/100 camera-trap nights) for the main mammal species in Cantão State Park and Santa Fé Ranch during the wet and dry seasons and variation relative to dry season (↑ increase; ↓ decrease; X no detection)

	CS-Park			SF-Ranch		
	Dry	Wet		Dry	Wet	
<i>Tapirus terrestris</i>	1.136 (±0.284)	1.608 (±0.651)	↑	2.582 (±0.585)	1.573 (±0.646)	↓
<i>Mazama gouazoupira</i>				0.461 (±0.134)		X
<i>Mazama americana</i>	0.097 (±0.096)		X	2.207 (±0.391)	1.061 (±0.451)	* ↓
<i>Pecari tacaju</i>				1.389 (±0.414)	0.066 (±0.066)	* ↓
<i>Cerdocyon thous</i>				3.709 (±1.100)	0.197 (±0.144)	* ↓
<i>Leopardus pardalis</i>	0.583 (±0.299)	0.154 (±0.154)	↓	1.012 (±0.264)	0.191 (±0.132)	* ↓
<i>Puma concolor</i>	0.095 (±0.053)		X	2.216 (±0.647)	2.064 (±0.553)	↓
<i>Panthera onca</i>	0.173 (±0.074)	0.308 (±0.205)	* ↑	4.957 (±0.738)	4.123 (±0.787)	↓
<i>Didelphis spp.</i>	0.373 (±0.138)	0.154 (±0.154)	↓	0.111 (±0.065)		X
<i>Cuniculus paca</i>	0.426 (±0.183)	1.072 (±0.562)	↑	0.213 (±0.093)	0.301 (±0.226)	↑
<i>Dasyprocta azarae</i>				3.209 (±1.304)	0.364 (±0.364)	* ↓
<i>Hydrochaeris hydrochaeris</i>	0.297 (±0.228)		X	0.339 (±0.140)		X
<i>Priodontes maximus</i>				0.275 (±0.088)	0.358 (±0.303)	↑
<i>Penelope spp.</i>	0.718 (±0.313)		X	1.868 (±0.510)	0.501 (±0.278)	* ↓
<i>Crax fasciolata</i>	4.492 (±0.889)	3.076 (±1.029)	↓	4.127 (±1.015)	1.724 (±0.813)	* ↓
<i>Mitu tuberosum</i>				1.564 (±0.344)		X
Camera trap effort	2557	626		3412	1187	

Bold values highlight relevant conservation status

\*Significant differences determined using Mann-Whitey tests ( $P < 0.05$ )

vulnerable species were less frequently captured than less threatened ones, which was confirmed by a negative correlation. Trophic niche, on the other hand, did not present a significant association with RAI.

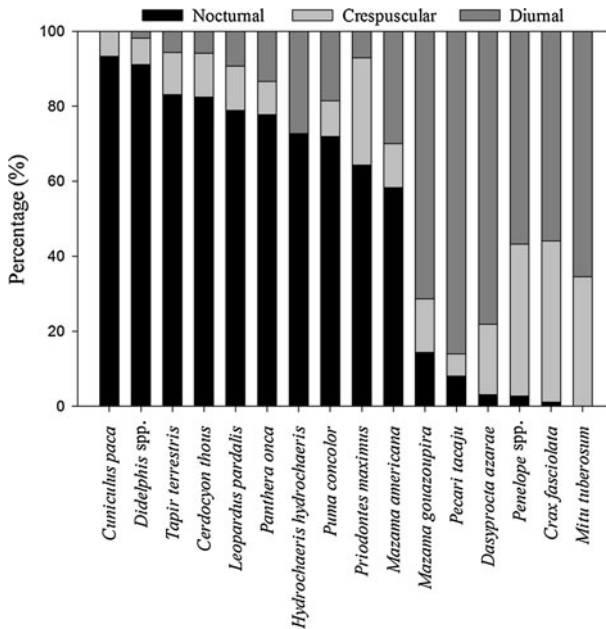
### Activity patterns

We determined the activity pattern for 16 species of mammals and birds. Most were nocturnal, with the exception of the gray brocket deer (*Mazama gouazoupira*), collared

**Table 4** Estimated coefficients and standard error (SE) for variables that influence species richness (total number of species) (model 1) and photographic rate (no. photos/100 camera-trap nights) (model 2) using GLMM analysis

		Estimate (±SE)
Model 1		
(Intercept)		-0.0857 (±0.0157)***
Days		0.0119 (±0.0031)***
Area	<i>SF-Ranch</i>	0.3975 (±0.1705)*
Year		0.4276 (±0.0784)***
Season	<i>Wet</i>	-0.7521 (±0.141)***
Place	<i>Trail</i>	-0.4230 (±0.1434)**
Model 2		
(Intercept)		-0.0199 (±0.1697)
Weight		0.0092 (±0.0006)***
Status	LC	-0.8340 (±0.0948)***
	NT	-0.4166 (±0.1079)***
	VU	-1.9013 (±0.1714)***
Trophic Niche		0.0071 (±0.0538)
Territorial Behaviour		-0.4908 (±0.0554)***

\*Parameter estimate significant at 0.05; \*\* 0.01; \*\*\* 0.001 levels



**Fig. 3** Activity patterns of some mammal and bird species in the study area in central Brazil, recorded by camera trapping (nocturnal 18:31–05:00 h, diurnal 06:31–17:00 h and crepuscular 17:01–18.30 and 05:01–06:30 h)

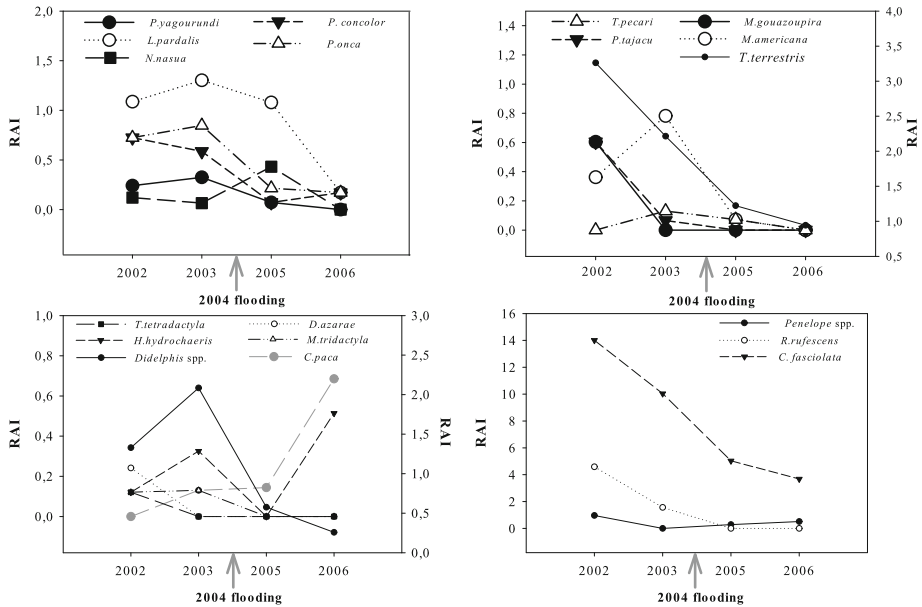
peccary (*Pecari tajacu*) and agouti (*Dasyprocta azarae*) (Fig. 3). All of the bird species presented crepuscular/diurnal behaviour. The jaguar was significantly more diurnal inside the park than in SF-ranch ( $\chi^2 = 55.71$ ,  $DF = 22$ ,  $P < 0.001$ ). There were no differences in the activity patterns of the other common species between both areas.

## Discussion

Photo capture rates are biased towards animals that spend most of the time on the ground and, since cameras were set to detect and evaluate jaguar density, it is also biased towards larger and more abundant animals, making the inventory of mammal species present in the area incomplete. Nevertheless, it contributes important information concerning the occurrence of mammals with different conservation status along the Amazonian agricultural frontier where there is no room for complacency about the security of species not currently considered globally threatened (Cardillo et al. 2004). For the majority of the mammal species the activity patterns found in our study area are similar to those described in the literature, with a typical predominance of nocturnal species (Gómez et al. 2005). Nevertheless, as occurs in CS-Park, jaguar can be considerably active in the daytime in areas of the Amazon and in the Pantanal, which could be associated with main prey species activity (Schaller and Crawshaw 1980; Crawshaw and Quigley 1991; Gómez et al. 2005; Weckel et al. 2006).

CS-Park is influenced by a strong seasonal environment: the flooding regime during the winter season covering around 70% of its area between the Araguaia and Côco Rivers (SMPA 2000), making it very susceptible to catastrophic flooding or, at other times, even droughts. The consequences in terms of habitat availability for terrestrial species are evident, forcing animals to move in search of more suitable habitat and causing seasonal differences in species occurrence and abundance inside the park. Comparing the results on species richness in CS-Park with a previous inventory done by Silveira (2004) using the same methodological approach, we show that 42.3% ( $N = 21$ ) of the mammal species previously reported in the area were not detected in our three subsequent sampling periods. The number of mammal photos actually decreased from 8–10 photos/100 trap nights to 3–4 photos/100 trap nights from 2002–2003 to 2005–2006, respectively. Also, a decreased pattern can be observed in RAI from 2002–2003 to 2005–2006 for almost all the species, despite a superior sampling effort (2615 camera-nights for 2002–2003 and 3183 camera-nights for 2005–2006) (Fig. 4). These differences can be explained by the extremely wet 2004 season that flooded almost the entire park as a result of elevated precipitation and the consequent increase in river water levels (Brazilian National Water Agency data). During the 2004 flooding many populations of terrestrial mammals probably dispersed from CS-Park in search of more suitable dry land, which is mainly available in the areas surrounding the park. We heard several anecdotal accounts of abnormal numbers of drowned animals and considerable numbers of animals crossing the river during that period. If reductions in the mammal population occur inside the park during wet seasons, the re-colonisation process totally depends on the level of habitat preservation in the surrounding areas, which is mainly occupied by agricultural farms (with their forest reserves) and human rural settlements. Some species with higher mobility, like *Panthera onca* and *Tapirus terrestris*, may continue to use CS-Park during the wet season, exploiting the small areas that remain above water. Due to the reduced areas of dry land, a concentration of activity in these areas could result in the increased capture rates (RAI) of these species. In contrast, due to the severe flood in 2004, other species may have been extirpated from the CS-Park area and have not managed to reoccupy the park since. Only *Cuniculus paca*, *Nasua nasua* and *Hydrochaeris hydrochaeris* showed an increase in RAI after 2003.

The forested reserve in SF-Ranch is less effected by river flooding and, thus, animal distribution throughout the seasons should be based on other resource availability; namely food (Bodmer 1990). In fact, the majority of species demonstrated a decrease in relative abundance, especially the large herbivorous such as *Mazama* spp., *Pecari tacaju*, *Tapirus*



**Fig. 4** Photographic rate fluctuation between different years of sampling in Cantão State Park for the most common mammal and bird species (2002–2003 data from Silveira 2004)

*terrestris*. Mendes Pontes and Chivers (2007) observed how, in an area in central Amazonia, fluctuations in food supply regulated forest use by peccary species and consequently conditioned jaguar and puma whereabouts. With widely distributed food resources during the wet season, peccaries exploited forested areas less frequently and presented broader spatial use. Our results concerning RAI variation for herbivorous species within seasons supports this. In order to understand the influence of seasonality on mammal movement in forested areas in central Brazil further research should be performed, enlarging the scale beyond forest limits, supported by a carefully structured sampling design and taking into account food availability measures.

Our camera trapping research revealed mammal diversity in a region covering both a protected and private area within the “arc of deforestation”. The results highlight the importance of private forest reserves for mammal conservation and the misleading idea that nature reserves per se can secure species richness. On the other hand, private forest reserves can be more susceptible to pressure (e.g. deforestation and hunting) due to lower law enforcement, especially in the Amazonian agricultural frontier (Cardillo et al. 2004). In this region, for conservation measures to succeed, combined action within protected and private areas should be established.

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