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ORIGINAL PAPER

Monitoring mammals in the Caxiuanã National Forest, Brazil – First results from the Tropical Ecology, Assessment and Monitoring (TEAM) program

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Abstract The need for long-term biodiversity monitoring using standardized protocols led to the creation of the Tropical Ecology, Assessment and Monitoring (TEAM) initiative. At some 50 field stations in tropical forests around the world, TEAM will monitor various taxa such as ants, birds, butterflies, medium and large terrestrial mammals, primates, litter fall, and trees, as well as landscape change in nine tropical biodiversity hotspots and three tropical wilderness areas. The TEAM terrestrial mammal program calls for using a grid of camera phototraps to monitor long-term trends in densities and occupancy rates of species that can or cannot be uniquely identified, respectively. We describe the TEAM camera phototrapping program and provide results for the first TEAM site–Caxiuanã National Forest in northern Brazil. An intensive one year camera trapping effort was carried out to determine which months were most suitable for long-term monitoring. Fifteen species of medium and large terrestrial mammals and two large birds were recorded, including three xenarthrans, five carnivores, one perissodactyle, three artiodactyles, two rodents, and one marsupial. The medium and large terrestrial mammal diversity was well represented during two consecutive wet and dry months, respectively. We also recorded activity patterns for all species photographed by our camera traps more than 10 times.

Keywords Brazil · Camera trapping · Monitoring · TEAM program · Tropical rainforest

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Introduction

At the Rio Earth Summit in 1992 over 150 heads of state from around the world signed the Convention on Biological Diversity (CBD). The CBD was the world's first comprehensive international agreement committing governments to sustainable use and conservation of biological resources. More than 175 governments have now ratified the CBD that obligates the Parties to slow biodiversity loss by (1) establishing a system of protected areas giving special consideration to threatened species and ecosystems, (2) creating economic incentives for sustainable use of biodiversity, (3) evaluating development projects to understand their impacts on biodiversity, and (4) protecting indigenous people's rights to traditionally utilize and manage their natural resources.

To effectively evaluate progress in satisfying CBD goals monitoring biodiversity is critical. In 1996 CBD Parties were encouraged to set measurable targets to achieve conservation and sustainable use objectives. Formal agreement was reached to establish a core set of biodiversity indicators that could be monitored. To track biodiversity trends and threats that may be national or global in scope requires a long-term biodiversity monitoring program that has at its heart a standardized monitoring procedure for collecting quantitative data.

Monitoring natural populations, habitats, and threats is vital to assessing impacts on natural landscapes (Balmford et al. 2003; Kremen et al. 1994; ter Keurs and Meelis 1986). Monitoring is the repeated collection of data in the same area for the same time period to analyze changes in species' populations (Comiskey et al. 2001; Thompson et al. 1998). Monitoring can serve as an early warning system to alert managers that changes in biodiversity may require changes in management schemes to promote the long-term maintenance of biodiversity (Balmford et al. 2003; Yoccoz et al. 2001; Hellawell 1991). To be effective, field data must be collected in a rigorous, consistent manner according to standard, accepted protocols (Comiskey et al. 2001; Debinski and Humphrey 1997). Recently, increased emphasis has been placed on the standardization of data collection methodologies to enable comparisons between different projects (Henschel and Ray 2003). The need for a network of long-term biodiversity monitoring sites using standardized protocols led to the creation of the Tropical Ecology, Assessment and Monitoring, or TEAM, program.

TEAM was established in 2002 with a grant from the Gordon and Betty Moore Foundation to Conservation International. TEAM's mission is to monitor long-term trends in biodiversity through a network of 50 or more tropical forest field stations located in nine tropical forested hotspots (Atlantic Forest, East and West Africa, Indonesia, Madagascar, Philippines, MesoAmerica and Caribbean, Southeast Asia, and Tropical Andes, and three wilderness areas (Amazônia, Central Africa, and Papua New Guinea) (Myers et al. 2000), TEAM will provide an early warning system on the status of biodiversity that can effectively guide conservation actions. The primary goal of monitoring a broad range of biodiversity indicators is to detect changes and trends that differ significantly from normal and natural fluctuation.

In addition to the list of standard variables to be monitored across all sites, each TEAM field station is also be expected to monitor site-specific variables that are of local or regional importance. These variables include, for example, threatened or endangered species, economically important species, and rare and unique habitat types. Currently, TEAM monitoring protocols are being implemented at 3 sites in the Amazon wilderness of Brazil, and one site each in the Atlantic Forest and MesoAmerica hotspots.

TEAM is a ten-year program that will hopefully function in perpetuity once results show the value of long-term globally collected, standardized data analyzed by local professional biologists and other scientists. TEAM has chosen to work in already established research stations in tropical forests managed primarily for the conservation of biodiversity. However, TEAM might also serve as a model monitoring program for other tropical CBD Parties as one step towards satisfying the 1996 agreements. The goal of implementing standardized protocols for monitoring biodiversity globally could thus be realized.

Monitoring medium and large terrestrial mammals

Monitoring is the application of a systematic data collection program repeatedly executed in the same place during a specific time. A statistically robust methodology that gives repeatable results under the same conditions is essential. The number of individuals of all species using a certain area within each habitat type is a powerful measure of biodiversity but is generally and practically unattainable. However, when the number of individuals of certain focal species within a specific area can be statistically estimated year after year population trends above background noise can be recognized and documented (Karanth and Nichols 1998). For other species occupancy rates can be computed (MacKenzie et al. 2006).

Because every component of biodiversity cannot be monitored, TEAM, with help from international scientists, chose to monitor several core components of biodiversity in tropical evergreen forests. Often socio-economic factors lead to unsustainable pressure on certain terrestrial medium and large mammals. Thus, TEAM's monitoring program does not involve all mammal fauna but instead targets medium and large mammals most likely to respond to specific threats such as landscape scale changes, direct and indirect hunting pressure, or changes in ecological processes such as fire and climate change (Lambeck 1997). Some species lend themselves to individual identification and also serve as focal species for monitoring programs (Lambeck 1997). Spotted cats of various sizes, and large herbivores such as tapirs and elephants serve as focal species since they are sensitive to a variety of threats. Ideal for monitoring are threatened mammal species, particularly those on the IUCN Red List (Lawler et al. 2003).

No method can provide a measure of density, i.e., the number of individuals per unit area, unless (1) individuals can be identified, and (2) the size of the area being sampled can be determined. Determining the size of the area sampled depends upon knowledge of the home range of the species under study, and this requires validation by fieldwork (Wemmer et al. 1996). Because individuals of the focal species chosen by TEAM can be uniquely identified their population densities can be monitored through time (Karanth and Nichols 1998; Trolle and Kéry 2003). Data on non-focal species can be used to estimate siteoccupancy rates (MacKenzie et al. 2006).

For large areas with focal species the entire area generally cannot be monitored simultaneously in its entirety. In addition, individuals have different probabilities of being detected within the sampled area during a specific time interval and not all individuals are detected during each time interval. Thus, a subset of the entire area must be monitored and inferences about densities and abundances of the entire area can be inferred using appropriate, well documented, and proven mathematical software (Karanth and Nichols 2002; MacKenzie et al. 2006). Moreover, monitoring continuously in time is unnecessary. If detection rates are low then species' relative abundances can be estimated.

Major challenges must be overcome to monitor carnivores and other shy species. Carnivores, particularly those in tropical forests, are usually elusive and not easily observed by humans. Some are nocturnal or move about the landscape using dense cover. Typically, carnivores range widely and occur infrequently over large parts of their home range (Sunquist and Sunquist 2001). Their population densities are usually low making direct observation methodologies unreliable. The basic ecology of carnivores makes their populations inherently difficult to monitor. However, despite these challenges, population and habitat information on carnivores provides robust information on biodiversity (Balmford et al. 2003).

Camera phototrapping

Automatic cameras have been used to capture photographs of wildlife for at least 100 years (Chapman 1927; Nesbit 1926; Shiras 1906). Remote surveying and monitoring of terrestrial and some arboreal mammals has been enabled by a new generation of camera phototraps and well developed capture-recapture models (Trolle 2003; Karanth and Nichols 2002; Jones and Raphael 1993; Mace et al. 1990; Joslin 1977). Population estimates can now be made for individually identifiable species by photographing both sides of individuals simultaneously and occupancy rates can be calculated for other species (MacKenzie et al. 2006). For instance, Karanth and Nichols (2002) estimated tiger densities in four national parks in India, and Trolle and Kéry (2003) estimated ocelot densities in an area of the Pantanal, Brazil. Carbone et al. (2001) suggested that camera phototraps and home range information could be used to estimate densities of animals that cannot be individually identified but this remains contraversial. Concurrently, prey populations can also be monitored with camera phototraps.

The first TEAM station was established in the Caxiuanã National Forest, an important Conservation Unit in the Xingu-Tocantins basin, in December, 2002. Caxiuanã National Forest is also a RAINFOR site where important ecological and biogeochemical consequences of environmental change are being monitored to understand their effects on forest biomass and dynamics (Malhi et al. 2002). The results obtained by RAINFOR and TEAM are complementary and comprehensive, potentially allowing environmental impacts to be understood more thoroughly. Here we report on the first year of camera trapping results obtained at Caxiuanã National Forest.

Methods

Study area

Located in Melgaço, Pará, Brazil, Caxiuanã National Forest is 330,000 ha, the largest protected area between the Tocantins and Xingu rivers. The landscape is primary rainforest with 85% terra firme, 12% flooded igapó and várzea, and 3% secondary forest (Lisboa et al. 1997). The forest is dominated by Sapotaceae (72 spp.), Chrysobalanaceae (59 spp.), and Lauraceae (46 spp.) (Silva and Almeida, personal communication). The Ferreira Penna Scientific Station, located at 1°42′30″ S, 51°31′45″ W, has an area of 33,000 ha operated by IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) and Museu Paraense Emílio Goeldi, Belém (Lisboa 1997).

The climate is humid tropical with two seasons: dry (June–December) and wet (January–May). The medium annual temperature is 26°C (Oliveira et al. 2002). Rainfall peaks in March with 379.8 mm and declines to a minimum of 50.7 mm October. Total yearly rainfall is approximately 1400 mm (Costa and Moraes 2002).

Serveral groups of vertebrates including reptiles (Ávila-Pires and Hoogmoed 1997; Bernardi et al. 2002; Estupiñán-T et al. 2002), birds (Silva et al. 2001; Silva and Pimentel Neto 1997), bats (Marques-Aguiar and Aguiar 2002), and primates (Jardim 1997; Veracini 2002, 1997; Bobadilla 1998; Pina 1999; Souza 1999; Tavares 1999) have been the subject of previous studies.

The local population of about 283 people (2003) is distributed in three villages within the reserve (Silveira et al. 2002). People live simply subsisting on small-scale farming, forest extraction, fishing, and hunting (Ferraz et al. 2002). The impact on the natural environment has not been investigated.

Time and equipment

From December 2002–November 2003 we placed a pair of camera traps at 12 sites 3–4 km apart to cover approximately 70 km^2. Sites chosen were active animal paths and locations with a significant number of animal tracks. Each of 24 camera traps was run continuously, day and night, for 12 mon or until it failed. After taking a photograph, each camera trap was forced to wait 20 s (the so-called *latency time*) before another photograph could be taken.

We used Cam Trakker^{TM} passive camera traps (CamTrak South, Inc., Watkinsville, GA 30667, USA, http://www.camtrakker.com). The passive system is activated by heat-in-motion within an opportunity cone that begins at the camera trap in a 4 cm circle that widens to a 2 m circle 8 m from the camera trap. The 35 mm camera with automatic focus within the camera trap photographed a larger frame that was encompassed by the opportunity cone of the sensor. When the heat-in-motion censor was trigger, a 35 mm camera took a photograph 0.6 s later so that most subjects were properly centered. Day and time were recorded on each photograph.

Data analysis

For those species whose individuals can be uniquely identify, density estimates are possible. For others site occupancy rates can be estimated. If detection probabilities are low then estimating relative abundances must be considered. To estimate relative abundance of medium and large terrestrial mammals and terrestrial birds, we analyzed the camera trapping data in three different ways. First, we assumed that only one individual male or female per species (or group in the case of peccarys, coatimundis and birds) could be photographed at each camera location during a 24 h period beginning at midnight (unless we could determine without doubt otherwise). That is, if a deer of unknown sex was photographed at a single site 3 times during a

24 h period beginning at midnight then this was counted as a single photograph of the same deer.

We identified all felids uniquely from their spot patterns or unique body characters (Karanth and Nichols 1998; Trolle and Kéry 2003). We used this information to re-estimate relative abundance.

The most conservative estimate of relative abundance is to count the photograph of a single species at each camera trap site once and only once for the length of the study. This redefines a camera trapping occasion to be the length of the study. That is, if paca were photographed at each of 8 sites multiple times during the study then each of 8 sites was recorded to have photographed a single paca during the length of the study. Thus, no camera trap could record more than one occurrence of a species unless individuals could be determined.

For each species we recorded the total number of pictures, the number of pictures per day, and the relative percent number of pictures of each species as surrogate for the percent relative abundance of each species. We also recorded activity patterns for those species photographed at least 10 times (Fig. 1).

Results of continuous monitoring were used to determine which months were most representative of the mammalian fauna so that monitoring could continue during just those months, thus reducing the cost of the monitoring program.

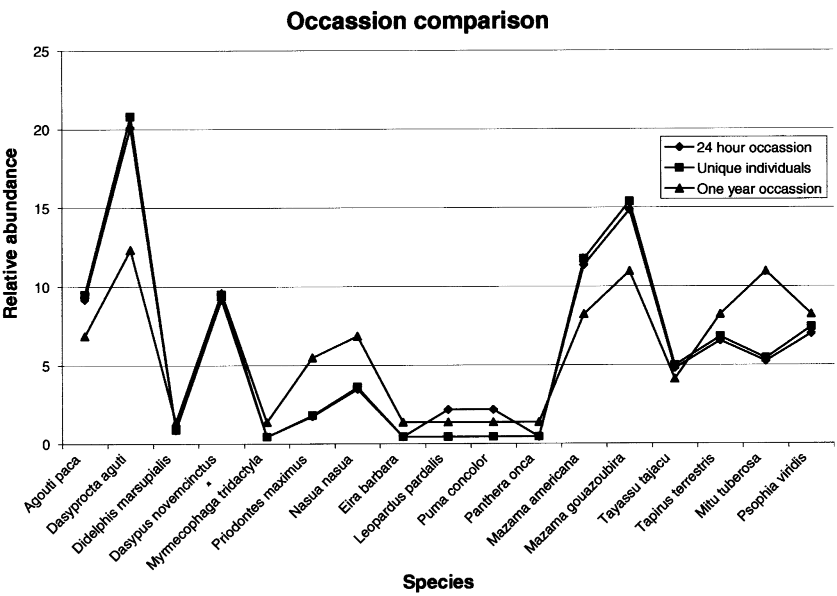

Fig. 1 The number of days in a camera trapping occasion (the number of days used to record detection or non-detection) did not effect the relative abundance of species. With several species were we able to identify individuals and thus avoid repeatedly counting them but this also had little effect on relative abundance. Shown is a comparison of the relative abundance of each species using a 24 h camera trapping occasion, non-repeated counting of unique individuals, and a one year camera trapping occasion

Results

During one year of camera trapping at 12 sites, 348 photographs were recorded. Of these photographs 12 days or times could not be deciphered leaving 336 useful photographs. Approximately 1/3 of the photographs taken at each site during a 24 h period beginning at midnight (a camera trapping *occasion* of 24 h) were of the same species. Assuming that repeated photographs of the same species during an occasion were the same individual (unless we could determine otherwise) 236 photographs of 15 medium and large mammals in six orders and 2 terrestrial birds were recorded during 2838.35 camera trap days (Table 1). Detection rates at our camera traps was less than 2/3 animal per day for all 12 camera trapping sites thus precluding the estimation of reasonably low variance occupancy rates.

Using each focal species unique marks and body characteristics we recorded one photograph of a male jaguar, three photographs of the same male puma, and five photographs of the same male ocelot.

Relative abundances did not change significantly when an occasion was defined as a 24 h period beginning at midnight (Table 1), when individuals could be determined (Table 2), or most conservatively when an occasion was defined as the entire study period (Table 3–4).

Activity patterns for species recorded at least 10 times revealed that *Agouti paca* and *Dasypus novemcinctus* were nocturnal, *Dasyprocta leporina, Tayassu tajacu* and

Table 1 During one year of camera trapping at 12 sites, 336 useful photographs were recorded

Species	Common name	Total	24 h	Pics/day	Pct. rel.
Agouti paca	paca	23	21	0.0074	9.17
Dasyprocta aguti	red-romped aguti	65	46	0.0162	20.09
Didelphis marsupialis	common opossum	2	2	0.0007	0.87
Dasypus novemcinctus	nine-banded armadillo	24	21	0.0074	9.17
Dasypus sp.	unknown armadillo	4	3	–	–
Myrmecophaga tridactyla	giant anteater	1	1	0.0004	0.44
Priodontes maximus	giant armadillo	4	4	0.0014	1.75
Nasua nasua	South American coati	22	8	0.0028	3.49
Eira barbara	tayra	1	1	0.0004	0.44
Leopardus pardalis	ocelot	6	5	0.0018	2.18
Puma concolor	puma	5	5	0.0018	2.18
Panthera onca	jaguar	1	1	0.0004	0.44
Mazama americana	red brocket deer	35	26	0.0092	11.35
Mazama gouazoubira	gray brocket deer	42	34	0.0120	14.85
Tayassu tajacu	collared peccary	24	11	0.0039	4.80
Tapirus terrestris	brazilian tapir	25	15	0.0053	6.55
Mitu tuberose	razor-billed curassow	29	12	0.0042	5.24
Psophia viridis	grey-winged trumpeter	23	16	0.0056	6.99
		336	232	0.0807	100

Approximately 1/3 of the photographs taken at a single site during a 24 h period beginning at midnight (a camera trapping *occasion*) were of the same species. Assuming that repeated photographs of the same species during an occasion were the same individual (unless we could determine otherwise) 232 photographs of 16 medium and large mammals and 2 terrestrial birds were recorded. In four photographs we were unable to identify which species of armadillo was present. The relative abundance of each species was determined by dividing the total number of each species photographed by the total number of all species photographed during a 24-h occasion. Total pictures per day (Pics/day), and percent relative abundance (Pct. rel.) for each species are given. All 12 camera trap sites recorded approximately one photograph each day.

Table 2 For each of three species of felids we were able to individually identify each individual

Species	Total pictures	Pics/day	Pct. rel. abd.
Agouti paca	21	0.0074	9.50
Dasyprocta aguti	46	0.0162	20.81
Didelphis marsupialis	2	0.0007	0.90
Dasypus novemcinctus	21	0.0085	9.50
Myrmecophaga tridactyla	1	0.0004	0.45
Priodontes maximus	4	0.0014	1.81
Nasua nasua	8	0.0028	3.62
Eira barbara	1	0.0004	0.45
Leopardus pardalis	1	0.0004	0.45
Puma concolor	1	0.0004	0.45
Panthera onca	1	0.0004	0.45
Mazama Americana	26	0.0092	11.76
Mazama gouazoubira	34	0.0120	15.38
Tayassu tajacu	11	0.0039	4.98
Tapirus terrestris	15	0.0053	6.79
Mitu tuberosa	12	0.0042	5.43
Psophia viridis	16	0.0056	7.42
	221	0.0779	100

This reduced the relative abundance of each felid species and increased the relative abundance of all other species. Total pictures, pictures per day (Pics/day), and percent relative abundance (Pct. rel. abd.) for each species are given

Table 3 The most conservative estimate of relative abundance is to assume that if at each site a species was photographed then the same individual of that species was photographed repeatedly (unless we could determine otherwise) during the entire camera trapping period

Species	Total	Pics/day	Pct. rel. abd.
Agouti paca	5	0.0018	6.85
Dasyprocta aguti	9	0.0032	12.33
Didelphis marsupialis	1	0.0004	1.37
Dasypus novemcinctus	7	0.0025	9.59
Myrmecophaga tridactyla	1	0.0004	1.37
Priodontes maximus	4	0.0014	5.48
Nasua nasua	5	0.0018	6.85
Eira barbara	1	0.0004	1.37
Leopardus pardalis	1	0.0004	1.37
Puma concolor	1	0.0004	1.37
Panthera onca	1	0.0004	1.37
Mazama americana	6	0.0021	8.22
Mazama gouazoubira	8	0.0028	10.96
Tayassu tajacu	3	0.0011	4.11
Tapirus terrestris	6	0.0021	8.22
Mitu tuberosa	8	0.0028	10.96
Psophia viridis	6	0.0021	8.22
	73	0.0257	100

For instance, this assumption says that no more than 12 A. *paca* (one per camera trap site) could be photographed during the entire period. This assumption significantly reduces the number of unique photographs but does not alter significantly percent relative abundance. Total pictures, pictures per day (Pics/day), and percent relative abundance (Pct. rel. abd.) for each species are given

the two bird species *Mitu tuberosa*, and *Psophia viridis* were diurnal, and *Mazama americana* and *M. gouazoubira* were continuously active. *Tapirus terrestris* were active nearly continuously but no photographs were obtained between 8:30 and noon

Table 4 Using a 24 h camera trapping occasion, activity patterns for species photographed at least 10 times are given as the number of photographs in each two hour period beginning at midnight

Time	*A. paca*	*D. aguti*	*D. nov.*	*M. amer.*	*M. gou.*	*T. terrestris*	*T. tajacu*	Birds
0–2	1		4	2	1	2		
2–4	6		5	3	3			
4–6	2		3	4		2		
6–8		12		3	11		2	10
8–10		9	1	1	4	1	2	3
10–12		2			5			3
12–14		4		2	4	1	2	4
14–16		5		1	3	1	2	3
16–18		7	1		2		1	5
18–20	6	7	2	4	1	2	2	
20–22	4		4	5		5		
22–24	2		1	1		1		

D. nov. ≡ Dasypus novemcinctus, *M. amer.* ≡ Mazama americana, *M. gou.* ≡ *M. gouzaoubira. Mitu tuberosa* and *Psophia viridis* showed similar activity patterns and so are combined into Birds. Note that *A. paca* began their nocturnal foraging at 19:16 and *D. aguti* were active until 18:49 so that these species showed no activity overlap. With some exceptions, activity patterns are generally clear

Table 5 For each month (J ≡ January, etc.) and for each species the total number of photographs using a 24 h camera trapping occasion is given

Species	N	D	J	F	M	A	M	J	J	A	S	O	N	D	Sum
Agouti paca		1	3		3		6	5	2	1					21
Dasyprocta agouti		4	5	1	12	6		7	4	1	1	3	2		46
Dasypus novemcinctus	2				8	4				1			3	3	21
Didelphis marsupialis								2							2
Eira Barbara													1		1
Leopardus pardalis			1	1			2	1							5
Mazama americana			5	1	4	1	3	2	4	1	3	1		1	26
Mazama gouazoubira	1	2	10	1	2	5	1			3		5	3	1	34
Myrmecophaga tridactyla					1										1
Nasua nasua	1	1	2	2			1							1	8
Panthera onca											1				1
Priodontes maximus		1	1	1								1			4
Puma concolor					2	2	1								5
Tapirus terrestris			2	1	2		2	1	1	4			1	1	15
Tayassu tajacu				1	7	1						1		1	11
Mitu tuberosa	1	2	3	2	1		1							2	12
Psophia vividis	1	4		1	5	1	1	1	1	1					16
Total records	6	15	32	12	47	20	18	19	12	12	5	11	10	10	229
Richness	5	7	9	10	11	7	9	7	5	7	3	5	5	7	17

Camera traps recorded the most photographs and highest species richness in March during the wet season and the lowest number in September during the dry season. Note that two terrestrial bird species, *Mitu tuberosa* and *Psophia vividis* were not detected in the dry season. The wet months of mid March through mid May, and the dry months of mid September to mid November were selected for long-term monitoring. Only *Didelphis marsupialis* was not recorded during either of these seasons suggesting that a resting period, perhaps at a wallow, might occur during this time (Table 4).

Based on the number of photographs and the diversity of species, two wet months and two dry months were selected for future long-term monitoring (Table 5).

Discussion

Despite being one of the largest protected areas in oriental Amazônia, much information regarding Caxiuanã National Forest remains unknown. Of the mammalian fauna, order Chiroptera was sampled reasonably well by Marques-Aguiar and Aguiar (2002), order primates has received greater attention (Bobadilla 1998; Bobadilla and Ferrari 2000; Jardim 1997; Jardim and Oliveira 1997, 2002; Moegenburg and Jardim 2002; Pina 1999; Pina et al. 2002; Souza 1999; Souza et al. 2002; Tavares 1999; Tavares and Ferrari 2002), and other mammals have been inferred to be present based on interviews and observations of hunters (Lisboa et al. 2002; Santana and Lisboa 2002). As a result of the present study the presence of 11 non-volant mammal species has been confirmed. Moreover, four additional non-volant mammals have been added to the list of mammals: ocelot *(Leopardus pardalis)* and giant armadillo *(Priodontes maximus)* were recorded for the first time, and two deer species *(Mazama americana* and *M. gouazoubira)* were positively identified. According to IBAMA (2003), five of the photographed species are vulnerable: *Myrmecophaga tridactyla, P. maximus, L. pardalis, Puma concolor* and *Panthera onca*.

Our results did not offer any surprises in medium and large mammalian species composition. Voss and Emmons (1996) suggested that xenarthran, carnivore, and ungulate faunas are remarkably uniform throughout greater Amazônia. For these taxa, the species present in our area were a subset of those from 10 other sites in Amazônia. What is surprising is the relatively low number of photographs and the relatively low *apparent* densities we recorded. For instance, we expected to record species such as deer, pacas, and agutis at each camera trap site. In fact, deer, pacas, and agutis were recorded at 5, 7, and 9 sites, respectively, out of 12 possible sites. Moreover, at sites that successfully recorded these species, the number of records was relatively low suggesting these species were foraging widely. Supporting evidence of this hypothesis comes from recording only 3 individual cats, one each of 3 species, during the entire year in our study area of 70 km^2. In contrast, in a three month study in Brazil's Pantanal Trolle and Kéry (2003) obtained 54 pictures of approximately 11 ocelots in 10 km^2.

Species' relative abundance did not vary greatly when the number of days in a camera trapping occasion was changed from a single 24-h period to one year (Tables 2–5). We do not recommend defining a camera trapping occasion as one year because this would preclude density studies. Our point is that relative abundances are fairly robust to changes in the number of days used to define a camera trapping occasion.

Because we only recorded one individual each of three focal species where we could identify individuals we were not able to estimate densities for these species. Indeed, carnivores and many other species appeared to be relatively sparse at Caxiuanã National Forest compared to other habitats e.g. Pantanal (Trolle and Kéry 2003); and Espírito Santo (Srbek-Araujo and Chiarello 2005) in Brazil. More data on rainfall, seasonal flooding, tree growth rates, hunting pressure, and continued monitoring of the medium and large mammals will help us determine why the mammalian fauna is apparently sparse.

As expected the two terrestrial birds, *Mitu tuberosa* and *Psophia viridis*, as well as peccary and aguti were exclusively diurnal. The paca was crepuscular. Moreover, paca and aguti were photographed at the same camera trap sites but during periods of the day. Closer analysis of the 2 h period from 1800 to 2000 showed that no agutis were active after 18:49 while no pacas were active before 19:16. This evidence suggests these guild members were avoiding competing for resources.

The TEAM camera trapping monitoring effort at Caxiuanã National Forest is a continuing effort that will enable year-to-year comparisons of richness, relative abundance, activity patterns, and rates of change in site occupancy (MacKenzie et al. 2003, 2006). Individual carni vores that were identified were too few in number to permit density estimates (Karanth and Nichols 1998). That such low numbers of carnivores might persist remains to be discovered.

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