



Medium-sized and large mammals from Quedas do Rio Bonito Ecological Park, Minas Gerais, Brazil

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Abstract: Information about the occurrence of medium-sized and large mammals in the Cerrado and the Atlantic Forest is essential for monitoring the conservation status of these species in such biodiversity hotspots. This study presents the results of a survey of medium-sized and large mammals from Quedas do Rio Bonito Ecological Park, located in an ecotone between Cerrado and Atlantic Forest in Southeastern Brazil. Four sampling methods were used: sand plots, camera traps, line transects and tomahawk traps. We recorded 20 species belonging to 12 families and 7 orders, with a high occurrence of Carnivora (50%). We highlight the occurrence of five endangered species: *Chrysocyon brachyurus*, *Leopardus pardalis*, *L. guttulus*, *Puma yagouaroundi* and *P. concolor*. The species with the highest frequencies of occurrence were *P. concolor* (27%), *C. brachyurus* (17%), and *Sylvilagus brasiliensis* (13%). Our results confirm that, despite their small size, forest fragments are essential for “top-of-the-chain” species conservation in the region.

Key words: Atlantic Forest; carnivores; Cerrado; mammalian survey; Minas Gerais

INTRODUCTION

Brazil houses one of the most diverse mammalian faunas in the world, with more than 700 species currently recorded, including marine and continental mammals (Paglia et al. 2012). The Cerrado and the Atlantic Forest biomes—two hotspots in critical conservation status (Myers et al. 2000; Mittermeier et al. 2005)—shelter together 392 species of mammals, 74 of which are at risk of extinction (Reis et al. 2011; MMA 2014). Among these threatened species, 64 are medium-sized or large terrestrial mammals, comprising primates of all sizes and other mammals weighing more than 1 kg (Chiarello 2000), which demonstrates the high degree of vulnerability of this group. Habitat loss and degradation, poaching and low reproductive rates are

the key factors that contribute to a drastic population reduction of these species in such biomes (Robinson and Redford 1991; Chiarello 1999; Crooks 2002; Negrão and Valladares-Padua 2006; Paglia et al. 2012). On the other hand, there is a lack of information on the biological and ecological aspects of most Brazilian mammals, such as reproductive habits, distribution and habitat preferences, hindering the development of conservation plans for these species (Voss and Emmons 1996; Emmons and Feer 1997). Presenting predominantly nocturnal habits, relatively large home ranges, and naturally low population densities, medium-sized and large mammals are particularly difficult to study (Pardini et al. 2003), requiring a long period of data sampling in the field and comprehensive research methodology. Inventories of fauna constitute an important tool, enabling direct access to local diversity and providing primary data essential for decision-making regarding the management of natural areas (Silveira et al. 2010). In this context, the state of Minas Gerais, which has lost most of its natural areas of Cerrado and Atlantic Forest (Rizzini 1997; SOS Mata Atlântica 2013), has many areas requiring studies on various biological groups. Aiming to contribute to the knowledge of the local biodiversity, here we present a survey of medium-sized and large mammals in the Quedas do Rio Bonito Ecological Park, located in the south of Minas Gerais, Brazil.

MATERIALS AND METHODS

Study site

This study was conducted in a forest fragment within the limits of the Quedas do Rio Bonito Ecological Park (QRBEP), a private property with an area of 235 ha located on the slopes of the Serra do Carrapato, in the municipality of Lavras, Minas Gerais, Brazil (Figure 1; coordinates: 21°19'45" S, 044°59'00" W). Altitude ranges between 984 and 1,235 m. Due to the history of forest fires and the removal of wood in the past, there is a mix of native vegetation in different successional stages. The QRBEP is located in an ecotone with phytophysionomies

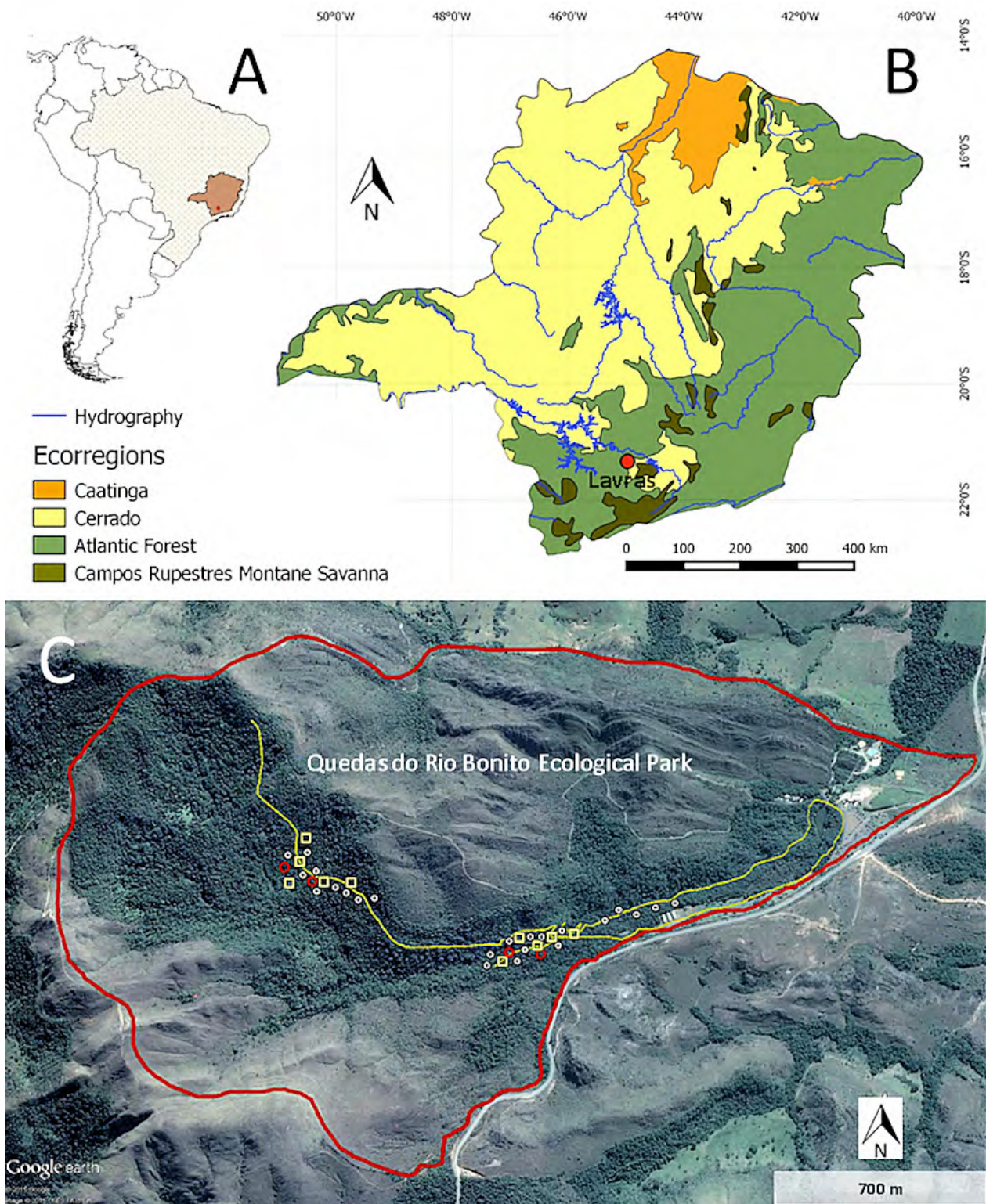


Figure 1. Location of the study site in South America (A) and Minas Gerais state (B). The satellite image (C) shows the limits of Quedas do Rio Bonito Ecological Park and the location of the sand plots (white frames), camera traps (red circles), tomahawk traps (white circles), and active searches transects (yellow line). Ecorregions following Olson et al. (2001). Source of image C: Google Earth™ software.

of both biomes: Alluvial Semideciduous Forest, Montane Semideciduous Stationary Forest, Cerrado, Candeia, Rupestrian fields, and Altitude fields (Oliveira-Filho and Fluminhan-Filho 1999). The climate of the region is of type Cwa according to the Köppen classification, rainy temperate, with average annual precipitation of 1,460 mm (the largest rainfall occurring between November

and February), and average annual temperatures about 20.4°C (Dantas et al. 2007; Sá Júnior et al. 2012).

Data collection

Fieldwork was carried out over four expeditions, two for each season (dry and rainy), conducted from June 2012 to May 2013, totaling 121 days of sampling.

Four different sampling methods were used: sand plots, camera traps, active searches (line transects) and tomahawk traps. Footprints were recorded using 10 sand plots of 75 × 75 cm, filled with fine sand, sieved and moistened, composing a layer of 4 cm in thickness. The plots, equidistant about 100 m from each other, were distributed in two line transects (five plots per transect), using a narrow trail and a deactivated road, commonly used by animals in their movements (Crawshaw-Jr 1997; Goulart et al. 2009). Baits consisting of bacon, banana, apple and cassava were put in the center of the sand plots. These sand plots were checked in a daily basis during five consecutive days in each expedition, totaling 200 sand plots/day and 4,800 h of sampling effort. Footprints were photographed in scale and identified following Becker and Dalponte (1991) and Carvalho-Jr and Luz (2008). For the analyses, one or more tracks from the same species registered in the same plot in a range of 24 h were treated as one independent sample. We used four analogic camera traps (Tigrinus®) installed along two line transects. These cameras remained activate for an average of 27 consecutive days in each expedition, totaling 428 traps/day and 10,272 h of sampling effort. Records of each species by each camera in one-hour period were considered as one independent sample (Tobler et al. 2008). Searches in trails were carried out by visual and sound records, footprints (away from sand plots), and scats, totaling 82.5 km of trails traversed in 33 days of sampling. Tomahawk traps (45 × 20 × 20 cm) were used as a supplementary method in an attempt to capture medium-sized species. In total, 23 traps were distributed along three transects, one transect with five traps on the ground and two transects with eight traps on the ground and one trap in a platform in the canopy in each transect. The minimum distance between the traps was 20 m. The bait was a mixture of banana, ground peanuts, cornmeal and cod liver oil. The traps were checked daily in the morning and baits replaced when necessary. The trapping was conducted during 24 days totaling 552 traps/night of capture effort. To compose the species list, we also took into account records resulting from opportunistic observations made by one of the authors (KKS) in previous years, as well as records made by other researchers and photographs taken by park goers. These records were treated as “occasional records” in Table 1. Domestic species were not included in the count of species in Table 3 to enable a comparison between studies, since some authors include such species while others do not.

Data analysis

Species accumulation curve was made using EstimateS 9.1 and Sigma Plot 3.0. Taxonomic nomenclature follows Paglia et al. (2012) and Trigo et al. (2013) for *Leopardus guttulus*. The global, national and local threat status for

each species was defined based on the IUCN Red List (2015), Brazilian Red List (MMA 2014) and Minas Gerais Red List (COPAM 2010), respectively.

RESULTS

In total, 20 species of medium-sized and large mammals belonging to seven orders and 12 families were recorded in QRBEF (Table 1). Sampling for sand plots resulted in 21 records of nine species, of which *Sylvilagus brasiliensis* was the most frequent (38%) (Table 2). Camera traps obtained 88 records from ten species (Figure 2), of which the most frequent was *Puma concolor* (30%) (Table 2). Six species were recorded

Table 1. Medium- and large-sized mammals recorded in Quedas do Rio Bonito Ecological Park. Abbreviations: capture (ca); photograph (ph); feces (fe); footprints (fo); observation (ob); occasional records (oc); vocalization (vo); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Not Evaluated (NE).

Taxon	Record type	Conservation status		
		MG	Brazil	IUCN
DIDELPHIMORPHIA				
Didelphidae				
<i>Didelphis aurita</i> Wied-Neuwied, 1826	oc	LC	LC	LC
<i>Didelphis albiventris</i> Lund, 1840	ca	LC	LC	LC
PILOSA				
Myrmecophagidae				
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)	oc	LC	LC	LC
CINGULATA				
Dasypodidae				
<i>Dasybus novemcinctus</i> Linnaeus, 1758	fo, ph	LC	LC	LC
<i>Euphractus sexcinctus</i> (Linnaeus, 1758)	oc	LC	LC	LC
PRIMATES				
Callitrichidae				
<i>Callithrix penicillata</i> (É. Geoffroy, 1812)	ob, vo	LC	LC	LC
Pitheciidae				
<i>Callicebus nigrifrons</i> (Spix, 1823)	ob, vo	LC	LC	NT
CARNIVORA				
Canidae				
<i>Cercopithecus thous</i> (Linnaeus, 1766)	oc	LC	LC	LC
<i>Chrysocyon brachyurus</i> (Illiger, 1815)	fo, ph, fe	VU	VU	NT
<i>Canis lupus familiaris</i> Linnaeus, 1758	fo, ph	LC	LC	LC
Felidae				
<i>Leopardus pardalis</i> (Linnaeus, 1758)	fo, ph	VU	LC	LC
<i>Leopardus guttulus</i> (Hensel, 1872)	fo	VU	VU	NE
<i>Puma concolor</i> (Linnaeus, 1771)	fo, ph, fe	VU	VU	LC
<i>Puma yagouaroundi</i> (É. Geoffroy, 1803)	oc		VU	LC
Mustelidae				
<i>Eira barbara</i> (Linnaeus, 1758)	ph	LC	LC	LC
Procyonidae				
<i>Nasua nasua</i> (Linnaeus, 1766)	oc	LC	LC	LC
<i>Procyon cancrivorus</i> (G. Cuvier, 1798)	fo, ph	LC	LC	LC
LAGOMORPHA				
Leporidae				
<i>Sylvilagus brasiliensis</i> (Linnaeus, 1758)	fo, ph	LC	LC	LC
RODENTIA				
Caviidae				
<i>Hydrochoerus hydrochaeris</i> (Linnaeus, 1766)	fo, ph	LC	LC	LC
Cuniculidae				
<i>Cuniculus paca</i> (Linnaeus, 1766)	fo, ph	LC	LC	LC



Figure 2. Species recorded in Quedas do Rio Bonito Ecological Park by camera traps: *Puma concolor* (A); *Leopardus pardalis* (B); *Chrysocyon brachyurus* (C); *Canis l. familiaris* (D); *Hydrochoerus hydrochaeris* (E); *Eira barbara* (F); *Cuniculus paca* (G); *Procyon cancrivorus* (H); *Sylvilagus brasiliensis* (I); *Dasypus novemcinctus* (J).

through active searches, with 22 direct and indirect records, and the most frequent species was *Callicebus nigrifrons* (41%) (Table 2). In addition to the species registered through these methodologies, we identified the occurrence of other six species in the area of QRBEP, whose records resulted from opportunistic observations (*Tamandua tetradactyla*; *Euphractus sexcinctus*; *Cerdocyon thous*; *Puma yagouaroundi*), sampling made by other researchers (*Didelphis aurita*) and photos taken by QRBEP goers (*Nasua nasua*).

DISCUSSION

Sampling through sand plots and camera traps enabled the greatest number of records, with both methods showing similar results. Sand plots showed the best performance in the short term (Figure 3), which probably is due to the use of a larger number of unities in comparison with camera traps, covering a larger sampling area. A similar result was observed by

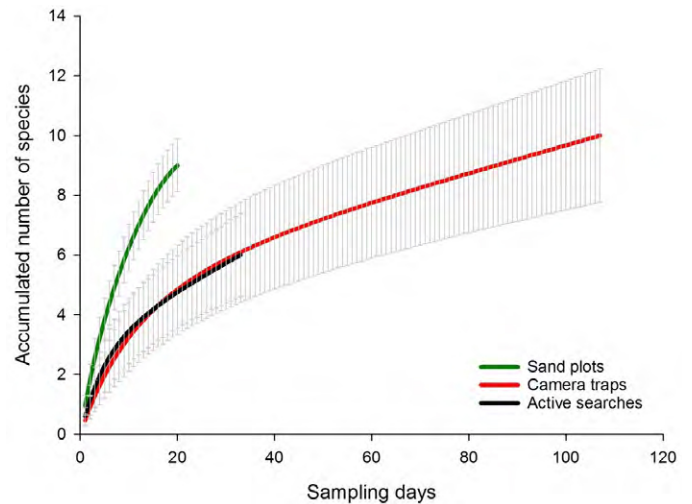


Figure 3. Randomized species accumulation curve (95% confidence interval) for the main methods used in this study to sampling the medium and large mammal assemblage in Quedas do Rio Bonito Ecological Park.

Table 2. Frequences occurrence distribution of records by four sampling methods used in this study (sand plots, camera trap, transects and tomahawk traps). Abbreviations: Absolute frequency (fo); relative frequency (fr); general relative frequency (Fr).

Species	Methodology								Records	Fr (%)
	Sand plots		C. trap		Transects		T. traps			
	fo	fr (%)	fo	fr (%)	fo	fr (%)	fo	fr (%)		
<i>D. albiventris</i>	-	-	-	-	-	-	1	100	1	0.7
<i>D. novemcinctus</i>	2	9.5	1	1.1	1	4.5	-	-	4	3.0
<i>C. penicillata</i>	-	-	-	-	3	13.5	-	-	3	2.2
<i>C. nigrifrons</i>	-	-	-	-	9	41.0	-	-	9	7.0
<i>C. brachyurus</i>	2	9.5	20	22.7	1	4.5	-	-	23	17.4
<i>C. l. familiaris</i>	1	4.8	15	17.0	-	-	-	-	16	12.1
<i>L. pardalis</i>	2	9.5	11	12.5	-	-	-	-	13	10.0
<i>L. guttulus</i>	1	4.8	-	-	-	-	-	-	1	0.7
<i>P. concolor</i>	2	9.5	26	29.5	7	32.0	-	-	35	26.5
<i>E. barbara</i>	-	-	1	1.1	-	-	-	-	1	0.7
<i>P. cancrivorus</i>	1	4.8	3	3.4	-	-	-	-	4	3.0
<i>S. brasiliensis</i>	8	38.1	9	10.2	-	-	-	-	17	13.0
<i>H. hydrochaeris</i>	-	-	1	1.1	1	4.5	-	-	2	1.5
<i>C. paca</i>	2	9.5	1	1.1	-	-	-	-	3	2.2
Total of records	21		88		22		1		132	

Espartosa et al. (2011) in their evaluation of the efficiency of these two methods in sampling large mammals in remnants of Atlantic Forest in the state of São Paulo. The searches in trails were particularly effective in the detection of arboreal and diurnal species such as the marmoset (*Callithrix penicillata*) and the masked titi monkey (*C. nigrifrons*), both recorded exclusively by this method. Tomahawk traps obtained low capture success (<0.1%) but allowed the unique record of *Didelphis albiventris* obtained in this study. Even though we have noted differences between the performances of the methods applied, they were complementary, with unique species reported from one or another, which consistently increased our results. Our results corroborate recommendations to join multiple methods in samplings of medium-sized and large mammals in Brazilian biomes, due to behavioral differences in the assemblage (Voss and Emmons 1996; Santos 2003; Srbek-Araujo and Chiarello 2005; Espartosa et al. 2011). It is noteworthy that the species accumulation curve showed no tendency to stabilisation for any methods (Figure 3), suggesting that a larger number of species could be registered with a longer sampling period.

The species richness found in QRBEF can be considered high, if compared with that found in other studies conducted on Cerrado and Atlantic Forest remnants with up to 400 ha (Table 3), where the average richness is around 17 species (± 4.81). However, we highlight the absence of a standardization of methodology and sampling time between these studies and that some authors follow subjective criteria for the classification of species in the category of medium-sized and large mammals (Prado et al. 2008; Abreu-Jr and Köhler 2009; Eduardo and Passamani 2009; Silva and Passamani 2009; Magioli et al. 2014; Reale et al. 2014), including in their lists species of *Chironectes*, *Callithrix*, *Guerlinguetus* and *Cavia*, whose body mass is less than 1 kg. Comparing the results of our study with those obtained by Silva and Passamani (2009), which sampled the mammalian fauna in five small forest fragments in the serra do Carrapato, surrounding area of the QRBEF, we note

remarkable differences in the richness and composition of mammal assemblages of both sites. In that study, 17 species were recorded, four of which are domestic, with a high rate of occurrence of *Didelphis* spp. (92.7% of records) and a proportionally smaller representation of the order Carnivora (29.0%). Three native species found in that study were not found in the QRBEF (*Conepatus semistriatus*, *Cabassous unicinctus* and *Sphigurus* sp.), although the occurrence of these species in the park should be presumed. The order Carnivora was the most representative, corresponding to 50% of the recorded species, followed by Didelphimorphia (10%), Cingulata (10%), Primates (10%), Rodentia (10%), Pilosa (5%) and Lagomorpha (5%). The predominance of species of the order Carnivora also has been observed in other studies conducted in Brazil in fragments of the Atlantic Forest and Cerrado (Modesto et al. 2008; Prado et al. 2008; Abreu-Jr and Köhler 2009; Eduardo and Passamani 2009; Silva and Passamani 2009; Wolfart et al. 2013; Magioli et al. 2014; Reale et al. 2014), with *C. thous*, *N. nasua* and *P. cancrivorus* the most frequent species. These species are generalists for diet and habitat are tolerant to modified habitats. Therefore, they can occupy anthropogenic areas with high degrees of landscape fragmentation (Silva 1994; Borges and Tomás 2004; Abreu-Jr and Köhler 2009; Reis et al. 2011).

Five carnivore species found in QRBEF are included in the “vulnerable” category of the Minas Gerais and Brazilian red lists (COPAM 2010; MMA 2014 [Table 2]), and *C. brachyurus* also features in the IUCN Red List as “near threatened” (Cunha de Paula and DeMatteo 2015). One species of monkey, *C. nigrifrons*, is reported in the IUCN Red List (2015) as “near threatened”. Although *C. nigrifrons* is relatively common throughout their geographic range, its populations have been decreasing recently due to the progressive habitat loss in the Atlantic Forest of Southeastern Brazil, to where the species is restricted (Veiga et al. 2008).

Photographic records made possible some individual identifications. Two individuals of *P. concolor* and at least four individuals of *L. pardalis* were identified through

Table 3. Species richness of medium and large-sized mammals in Quedas do Rio Bonito Ecological Park compared to that found in other studies conducted on remnants of Cerrado and Atlantic Forest with areas ≤ 400 ha. Abbreviations: Sand plots (sp); camera trap (ct); transects (tr); grid traps (gt); opportunistic observations (op); interviews (in); Cerrado (CE); Atlantic Forest (AF).

Authors	Methodology	Bioma	Area (ha)	Species richness*
Santos et al. (present study)	sp, ct, tr, gt, op	CE/AF	235	19
Modesto et al. 2008	ct, tr, gp	AF	220	11
Moreira et al. 2008	tr, gt, in	CE	391	11
Prado et al. 2008	sp, ct, tr, gt	AF	384	22
Abreu-Jr and Köhler 2009	ct, tr	AF	221	16
Eduardo and Passamani 2009	sp, ct, tr	AF	300	15
Silva and Passamani 2009	sp, ct, tr	CE/AF	35	13
Wolfart et al. 2013	sp, tr	AF	220	18
Magioli et al. 2014	tr	CE/AF	173	20
Reale et al. 2014	sp, ct, tr, in	AF	190	26

* Domestic species were not included.

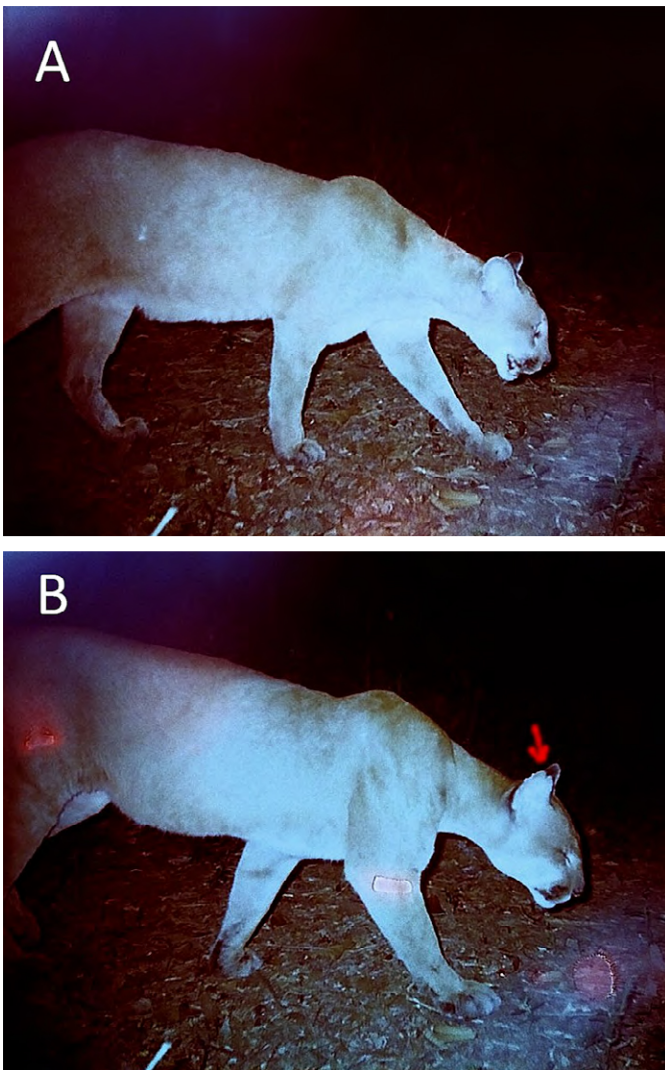


Figure 4. Morphological differences between two individuals of puma (*Puma concolor*) recorded in Quedas do Rio Bonito Ecological Park area: Photograph A was taken by camera trap at 8:46 pm in 6 March 2013, and photograph B was taken at 9:26 pm of the same day.

comparisons of scars, pattern of fur patches, and body proportions (Figures 4 and 5), following Di Bitetti (2006) and Kelly et al. (2008). Considering the relatively small size of the area and the high degree of fragmentation of the landscape, the high cat representativeness is remarkable, which included small to large predators such as the puma. Due to the fact that they are highly specialized predators and need large home range, native cats are among the most sensitive species to habitat loss. Therefore, they are more susceptible to local extinctions (Chiarello 1999; Crooks 2002; Marinho-Filho and Machado 2006; Machado et al. 2008). The presence of these species in the QRBEF can be indicative of a good environmental condition or extreme isolation since the park is one of the few forested areas in the region. However, more detailed studies are required to determine the way they use the habitat in order to identify factors that influence their permanence on site.

We also identified through photographs eleven



Figure 5. Comparison of spot patterns in four individuals of ocelot (*Leopardus pardalis*) recorded in Quedas do Rio Bonito Ecological Park by camera trap.

domestic dogs (*Canis lupus familiaris*) inside the QRBEF area, these being the only exotic species recorded in our study. According to Paschoal et al. (2012), free-ranging domestic dogs are becoming the most abundant medium-sized mammals in Atlantic Forest fragments in Southeastern Brazil. We emphasize that the constant presence of dogs in the area of QRBEF poses a threat to local fauna, since they act as predators of several native species, exerting competitive pressure on local predators (Torres and Prado 2010; Vanak and Gompper 2010; Young et al. 2011). In addition, domestic dogs are potential disseminators of viruses and other pathogens among native canid populations (Curi et al. 2010; Woodroffe et al. 2012). Another threat to the native fauna identified on site is the practice of motocross, an increasingly frequent activity in the QRBEF area and its surroundings, which can cause disturbances and fauna harassment, as well as increasing the occurrence of fires and damages to the soil (Faria 2010; SEMMADS 2013).

The results of this study demonstrate the importance of QRBEF for the conservation of medium-sized and large mammals in the south of the state of Minas Gerais, including five endangered species. Thus, we emphasize the need to preserve this area, located in a quite anthropized region, with a high degree of landscape fragmentation and absence of other protected areas.

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