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inventory

Medium and large-sized mammals of the Reserva Ecológica de Guapiaçú, Cachoeiras de Macacu, RJ

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Abstract: Medium and large-sized terrestrial mammals develop important functions in ecosystems maintenance. However, this group is the most vulnerable to local extinctions, through habitat loss or hunting. This study inventoried the community of medium and large mammals in the Reserva Ecológica de Guapiaçú (REGUA), Cachoeiras de Macacu, RJ, providing data on species composition, richness and abundance. Species were registered through the use of camera traps, sign survey and visual encounters on pre-existing trails and roads. The study was conducted from January to October 2012, with each month considered as a sample unit. An effort of 1568 cameras-day and 120 km traveled, resulted on 302 records of 22 species of medium and large-sized mammals, belonging to eight orders. This value corresponds to more than three-quarters of the richness described from this group in the Atlantic Forest of Rio de Janeiro state. Five species are under some level of regional, national or global threat. Three game species, *Pecari tajacu*, *Cuniculus paca* and *Dasyprocta leporina* were abundant in the area. The observed richness was comparable to that found in other studies conducted in rain forests. Thus, for its high number of species, including those under some degree of threat, we conclude that REGUA is an important area to mammal conservation, especially in the Atlantic Forest of Rio de Janeiro state.
Keywords: *Mammal community, endangered species, camera traps, sign survey, Atlantic Forest.*

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Resumo: Mamíferos de médio e grande porte desempenham funções importantes para a manutenção dos ecossistemas. Porém, esse grupo é um dos mais vulneráveis a extinções locais, seja pela perda de hábitat ou pela caça. Neste estudo foi inventariada a comunidade de médios e grandes mamíferos na Reserva Ecológica de Guapiaçú (REGUA), Cachoeiras de Macacu, RJ, sendo descritos dados de composição, riqueza e abundância. As espécies foram registradas através do uso de armadilhas fotográficas, busca por vestígios e visualizações diretas em trilhas e estradas pré-existentes. O estudo foi realizado de janeiro a outubro de 2012, sendo cada mês considerado uma unidade amostral. A partir de um esforço de 1568 câmeras-dia e de 120 km caminhados, obtivemos 302 registros de 22 espécies de mamíferos de médio e grande porte, pertencentes a oito Ordens. Esse valor corresponde a mais que três quartos da riqueza de espécies descrita para esse grupo na Mata Atlântica do estado do Rio de Janeiro. Cinco espécies encontram-se sob algum nível de ameaça regional, nacional ou global. Três espécies cinegéticas, *Pecari tajacu*, *Cuniculus paca* e *Dasyprocta leporina* foram abundantes na área. A riqueza observada foi comparável à encontrada em outros estudos realizados em florestas ombrófilas densas. Assim, por seu elevado número de espécies, incluindo aquelas sob algum grau de ameaça, concluímos que a REGUA é um lugar de destaque para a conservação da biodiversidade de mamíferos, especialmente na Mata Atlântica do estado do Rio de Janeiro.
Palavras-chave: *Comunidade de mamíferos, espécies ameaçadas, armadilhas fotográficas, busca por vestígios, Mata Atlântica.*

Introduction

Medium and large-sized terrestrial mammals develop important functions in ecosystems maintenance. These animals affects plant population dynamics through herbivory and physical damage (e.g. Dirzo & Miranda 1990, Keuroghlian & Eaton 2009, Beck et al. 2013), and also through their role as seed dispersers and predators (e.g. Asquith et al. 1997, Asquith et al. 1999, Galetti et al. 2006, Donatti et al. 2009, Kuprewicz 2013) contributing to plant local diversity. Acting as animal predators they also regulate herbivore populations (e.g. Terborgh 1988, Sinclair et al. 2003) affecting prey activity patterns (Lima & Dill 1990), and reducing competition by resources favoring species co-ocorrence (Miller et al. 2001). In this way, these animals favor forest complexity and heterogeneity (e.g. Miller et al. 2001). Besides that, they contribute also to the conservation of other species acting as umbrella species (e.g. Noss et al. 1996) especially by their large area requirements. These animals are also among the main flagship species (e.g. Mittermeier 1986), due to their charismatic attributes. Due to its ability to move inside habitat mosaics, these mammals have been used also as landscape species, contributing to conservation planning in larger scales (Bani et al. 2002, Sanderson et al. 2002a, Crouzeilles et al. 2010).

In spite of their importance, these animals are among the most vulnerable to local extinction following anthropogenic disturbance, due to their naturally low population densities (e.g. Cullen et al. 2005, Soisalo & Cavalcanti 2006), their large area requirements (Sanderson et al. 2002b, Cullen et al. 2005) and also because they are preferential targets to hunters (Redford 1992, Peres 1996, Cullen et al. 2001, Travassos 2011). These factors has conducted to the loss of these animals in tropical forests, promoting profound transformations in forest dynamics and threaten the maintenance of these ecosystems (Stoner et al. 2007, Jorge et al. 2013, Kurten 2013, Harrison et al. 2013).

Due to this rugged relief and edaphic characteristics, which promotes a variety of ecological conditions, the Atlantic Forest at Rio de Janeiro state harbor a high biodiversity (e.g. Bergallo et al. 2000). The unrivalled numbers of endemic species and a relentless process of post-colonial deforestation (Dean 1996) make this forest an important region inside this Brazilian *hotspot* (Myers et al. 2000). Actually, the forest cover only 19.6% of the state area (Fundação SOS Mata Atlântica & INPE 2011) in a fragmented distribution (Ribeiro et al. 2009), contributing to biodiversity loss through the reduction of suitable areas to mammal persistence, especially for the larger species (Cardillo & Bromhan 2001, Kinnaird et al. 2003, Ewers & Didham 2006). Besides that, fragmentation facilitates the access of hunters (Peres 2000), increasing the negative pressures over the populations of these animals (Chiarello 2000, Cullen et al. 2001). In this scenario, large ($>$ 100 ha), protected remnants are responsible to maintain the diversity of medium and large-sized mammals (Canale et al. 2012).

In spite of their importance and vulnerability, few studies had been carried out with this mammal group in the Atlantic Forest. The difficulties related to the study of these animals are due to their furtive habits (Reis et al. 2006, Barea-Azcón et al. 2007), and habitat requirements (Sanderson et al. 2002b, Barea-Azcón et al. 2007). Recently, the use of new tracking technologies as camera traps (e.g. Karanth & Nichols 1998, Santos-Filho & Silva 2002, Galetti et al. 2006, Srbek-Araújo & Chiarello 2007, Goulart et al. 2009, Carvalho et al. 2013), and their combined use with other sampling techniques as footprint traps, linear transects and sign surveys (Passamani et al. 2005, Negrão & Valladares-Pádua 2006, Spínola 2008, Modesto et al. 2008a, Silva & Passamani, 2009, Espartosa et al. 2011, Delciellos et al. 2012) have favored studies with this group. However, due to be a recent approach, several areas still represents knowledge gaps for this group, especially in the Rio de Janeiro state (Cunha 2004, Modesto et al. 2008a,b, Delciellos et al. 2012). Inventories of this group are still needed to a better understanding of the regional biodiversity and its ecological patterns. These studies are of fundamental importance to verify the conservation status of the species and to develop monitoring and management and strategies (Northon-Griffiths 1978, Boddicker et al. 2002, Gaidet-Drapier et al. 2006). From these information is possible to define priority areas for conservation, establish minimum areas for reserves and to understand the main treats, consolidating the conservation strategies in these areas.

This study aim to characterize the assemblage of medium and large sized mammals of a preserved area of the Atlantic Forest, the Reserva Ecológica de Guapiaçú (REGUA), situated at Cachoeiras de Macacu, RJ. More specifically, were assessed the species composition, richness and species abundance in the area.

Material and Methods

1. *Study area*

The Reserva Ecológica de Guapiaçú (REGUA, 22°22'12'' S – 22°27'18'' S and 42°42'25'' O – 42°49'19'' O) is a private area, covering 7300 ha. The vegetation is the rain forest, covering montane, sub-montane and lowland areas (Oliveira-Filho & Fontes 2000). In the last, most part of the vegetation is in initial successional stages due to the recent history of anthropogenic disturbance. The most representative botanical families in the area are Fabaceae, Rubiaceae, Myrtaceae, Lauraceae, Meliaceae, Euphorbiaceae, Sapindaceaea, Melastomataceae, Annonaceae and Sapotaceae (Azevedo 2012). The climate is classified as Am according to Köppen (Peel et al. 2007), with annual mean temperature of 22.4 °C and maximum temperatures occurring in January and February and minimum in July. The annual rainfall is 2095 mm; December and January are the rainy months and June and July the driest ones. The altitude ranges from 20 m to ca. 2000 m. The area overlaps with the Parque Estadual dos Três Picos which is the largest state conservation unit from Rio de Janeiro, covering 58.790 ha (INEA 2013). About 94.8% of REGUA is covered by forest and the remaining areas include swamp, pastureland, and agriculture.

2. *Data collection*

The study was carried out from January to October 2012, and each month was considered a sample event. The species was registered through the combined use of camera traps, sign surveys and visual encounters carried out evenly at pre-existing trails and roads during other field activities. To avoid biased sampling of the some species baits were not used.

Camera traps were set at 20 stations spaced at least 500 m among them, covering an area of ca. 1,400 ha. Stations were placed at pre-existing trails and abandoned dirty roads (2 to 8 m width), which are periodically managed to keep them open.

Table 1. Medium and large-sized mammals of the Reserva Ecológica de Guapiaçú, Cachoeiras de Macacu, RJ. Type of record: Ct = Camera trap; Fp = Footprints; Bw = Burrow; Fs = Feeding signs; Cr = Carcass; Vi = Visualization; Vo = Vocalization; Tm = Territorial marks; F = Faeces; H = Hair. Status of Threat: PT = presumably threatened; LC = least concern; NT = near threatened; VU = vulnerable; EN = endangered; CE = critically endangered. Species nomenclature followed Paglia et al. (2012).

TAXA (Order/Family/Species)	***Common Name***	***Type of record***	***Degree of threat***		
			RJ	**BR**	**IUCN**
Didelphimorphia					
Didelphidae					
Didelphis aurita (Wied-Newied, 1826)	Big-eared opossum	Ct	-	-	LC
Cingulata					
Dasypodidae					
Dasypus novemcinctus Linnaeus, 1758	Nine-banded armadillo	Ct, Fp, Bw, Fs, Cr	-	-	LC
Cabassous tatouay (Desmarest, 1804)	Greater naked-tailed armadillo	Ct, Fp, Bw	PT	-	LC
Euphractus sexcinctus (Linnaeus, 1758)	Six-banded armadillo	Ct, Bw, Fs	-	-	LC
Bradypodidae					
Bradypus variegatus Schinz, 1825	Brown-throated sloth	Vi	-	-	LC
Myrmecophagidae					
Tamandua tetradactyla (Linnaeus, 1758)	Southern tamandua	Cr	-	-	LC
Primata					
Atelidae					
Alouatta guariba (Humboldt, 1812)	Brown howler	Vo	PT	-	LC
Brachyteles arachnoides É. Geoffroy, 1806	Southern muriqui	Vi	CE	EN	EN
Cebidae					
Sapajus nigritus (Goldfuss, 1809)	Black capuchin	Vi	-	-	NT
Carnivora					
Canidae					
Cerdocyon thous (Linnaeus, 1766)	Crab-eating fox	Ct, Fp	-	-	LC
Procyonidae					
Nasua nasua (Linnaeus, 1766)	South american coati	Ct, Vi, Tm	-	-	LC
Procyon cancrivorus (G.Curvier, 1798)	Crab-eating raccoon	Fp	-	-	LC
Mustelidae					
Eira barbara (Linnaeus, 1758)	Tayra	Ct, Fp	PT	-	LC
Lontra longicaudis (Olfers, 1818)	Neotropical otter	Fs	-	-	LC
Galictis cuja (Molina, 1782)	Lesser grison	Fp	-	-	LC
Felidae					
Leopardus pardalis (Linnaeus, 1758)	Ocelot	Ct	VU	VU	LC
Puma concolor (Linnaeus, 1771)	Cougar	Ct, Fp, Tm, F	VU	VU	LC
Artiodactyla					
Tayassuidae					
Pecari tajacu (Linneaus, 1758)	Collared peccary	Ct, Fp, Fs	VU	-	LC
Rodentia					
Erethizontidae					
Coendou insidiosus (Lichtenstein, 1818)	Bahia porcupine	H	PT	-	LC
Cuniculidae					
Cuniculus paca (Linnaeus, 1766)	Lowland paca	Ct, Fp, Fs	VU	-	LC
Dasyproctidae					
Dasyprocta leporina (Linnaeus, 1758)	Red-rumped agouti	Ct, Fp, Fs	-	-	LC
Lagomorpha					
Leporidae					
Sylvilagus brasiliensis (Linnaeus, 1758)	Tapiti	Vi	-	-	LC

Even in the wider roads the canopy is closed on most points. Each station received a digital camera trap (Tigrinus 6.0 D or Bushnell Trophicam) for 7.8 ± 1.9 days (mean ± sd) at each month. Traps were active during 24 h.day^{-1} with an interval of 1 min between shots. Each picture was considered a record of occurrence; for a same species independent records where those who had at least an hour of interval among each other (Di Bitetti et al. 2006, Tobler et al. 2008, Goulart et al. 2009, Espartosa et al. 2011).

Sign surveys were carried out at the same trails and roads were the camera traps were located. Each trail was surveyed once a month, during the day, with a constant velocity of 1.5 Km/h. Recent species signs such as footprints, burrows, feeding signs, carcass, territorial marks (scratch or stripped trees),

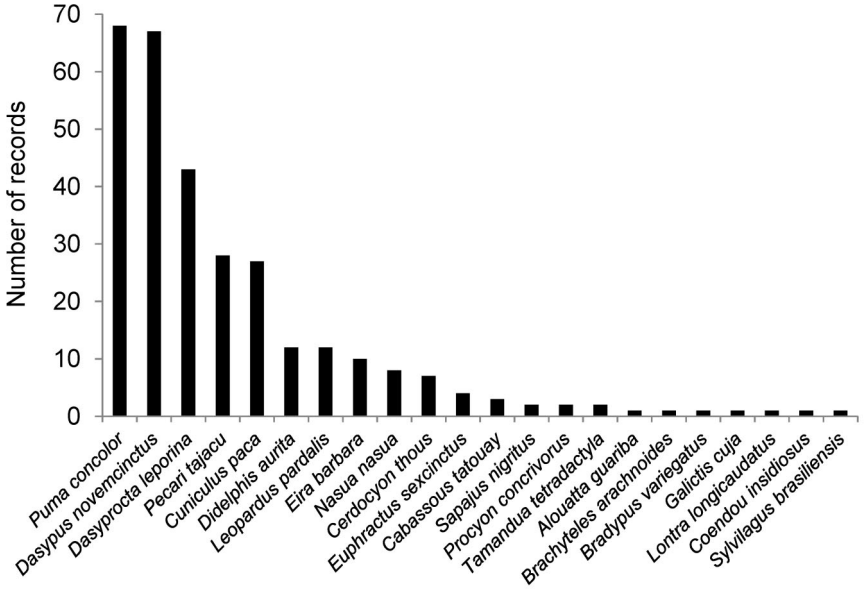

Figure 1 Number of independent records for the 22 species of medium and large-sized mammals recorded by camera traps, sign surveys and visual encounters at the Reserva Ecológica de Guapiaçú (REGUA), Cachoeiras Macacu, Rio de Janeiro.

vocalization and feces, were identified and georeferenced with a GPS. Footprints were identified based on authors knowledge and field guides (Emmons 1997, Becker and Dalponte 1999, Borges and Tomás 2008). For a same species records obtained within a same sample event were considered independent only when spaced at least 500 m among them.

Considering the independence of visual encounters, different observations of individuals or social groups of a same species in a given trail in the same day were considered as a unique record.

3. *Data analyses*

Sampling effort was evaluated using a species accumulation curve (Magurran 2004) with 1000 simulations; the curve was based on sampling events, considering each month as a sample. Expected richness was obtained through the nonparametric estimator Jackknife 2. This estimator is suitable for the analysis of communities with low evenness among species (Brose et al. 2003), which is the case of the studied group, and had a good performance in a study carried out with these mammals in the Amazon (Tobler et al. 2008). All the analyses were carried out using EstimateS 8.2.2 (Colwell 2006).

For each species we recorded the degree of threat using Bergallo et al. (2000) for the state of Rio de Janeiro, Chiarello et al. (2008) for the Brazil and the International Union for Conservation of Nature (IUCN 2012) for globally threatened species.

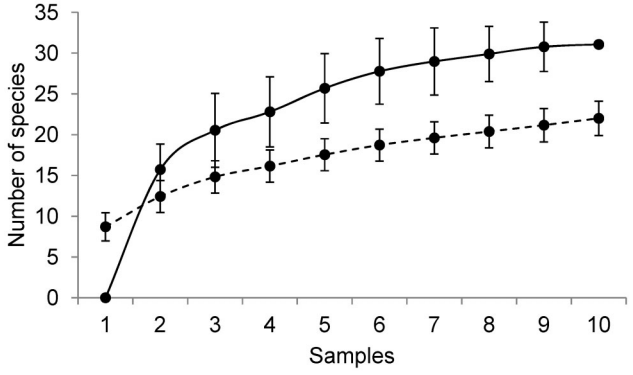

Figure 2 Species accumulation curve (dashed line) and expected richness (solid line) - obtained from the nonparametric estimator Jackknife 2 - to medium and large-sized mammals of the Reserva Ecológica de Guapiaçú, Cachoeiras de Macacu, RJ. Data obtained by camera traps, sign surveys and visual encounters. The bars indicate the standard deviation of each mean value.

Results

Considering all the methods used and an effort of 1589 cameras-days and 120 km of transects, we obtained 302 independent records from 22 species, belonging to eight orders and 15 families of medium and large-sized mammals (Table 1). Twelve species were detected using camera traps, 16 with the sign surveys and five were visual encounters. Only one species (*Nasua nasua*) was detected by the three methods. Camera traps and transects recorded 10 species in common. Two species were exclusively detected by camera traps, six in the sign surveys and four by visual encounters (Table 1).

Among the species recorded, eight were to order Carnivora (36.4%), three Cingulata (13.6%), Primates (13.6%) and Rodentia (13.6%), and two were Pilosa (9.1%). One species of family Didelphidae (4.5%), Tayassuidae (4.5%) and Leporidae (4.5%) were also registered (Table 1). Besides that, other two species of native mammals were observed; the brown-four-eyed-opossum *Metachirus nudicaudatus* (Desmarest, 1817) and the Ingram's squirrel *Guerlinguetus ingrami* (Thomas, 1906). In addition, the exotics *Callitrix jacchus* (Linnaeus, 1758) and *Canis lupus familiaris* (Linnaeus, 1758) (two individuals) were also recorded.

Considering all the types of records, the species with the higher number of observations were the cougar *Puma concolor* and the nine-banded-armadillo *Dasypus novemcinctus* (Figure 1).

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Table 2 Inventories of medium and large-sized mammals in dense Atlantic Rainforest and their respective areas of study, richness, sampling efforts and monitoring methods. LT = linear transect; VI = visualization; SS = sign surveys; CT = camera traps; IN = interviews; SP = sand plot.

State and Local	Area (ha)	Richness	Sampling effort (months)	Methods	Reference
Rio de Janeiro Reserva Ecológica de Guapiaçú (REGUA)	7300	22	10	CT SS VI LT	This study
Alagoas Usina Serra Grande	8000	22	6	VI SS CT IN	Fernandes 2003
Rio de Janeiro Parque Nacional da Serra dos Órgãos	11800	34	7	LT VI SS CT IN	Cunha 2004
Espírito Santo Anchieta	390	11	24	VI	Passamani et al. 2005
São Paulo Reserva Florestal Morro Grande	10870	14	5	SS SP LT	Negrão & Valladares-Pádua 2006
Rio de Janeiro Parque Estadual do Desengano	22400	22	1	VI SS CT	Modesto et al. 2008b
Santa Catarina Reserva Ecológica Caraguatá	4200	16	17	CT	Goulart et al. 2009
Santa Catarina Parque Estadual da Serra do Tabuleiro	5000	13	17	CT	Goulart et al. 2009
Rio de Janeiro Parque Nacional da Serra da Bocaina	104000	18	2	LT CT	Delciellos et al. 2012
Rio de Janeiro Parque Estadual da Ilha Grande	14572	11	15	CT	Lessa, 2011

Seven species (31.8%) have only one record (*Alouatta guariba*, *Brachyteles arachnoides*, *Bradypus variegatus*, *Galictis cuja*, *Lontra longicaudatus*, *Coendou insidiosus* and *Sylvilagus brasiliensis*), obtained through the signs surveys or visual encounters.

The accumulation curve did not reaches an asymptote and the expected richness was 31.1 species (Figure 2).

Considering the degree of threat, five species (22.7%) were present in the list of the threatened fauna of the Rio de Janeiro state, while three (13.6%) are in risk at Brazil and one (4.5%), the Southern muriqui *Brachyteles arachnoides*, is globally threaten (Table 1).

The species richness found at REGUA was comparable to the registered in other areas harboring the Rain Atlantic Forest, including higher protected areas (Table 2).

Discussion

Besides the 22 species found in this study, the jaguarundi *Puma yagouaroundi* (É. Geoffroy, 1803), the margay *Leopardus wiedii* (Schinz, 1821) and the capybara *Hydrochoerus hydrochaeris* (Linnaeus, 1766) were also previously detected at REGUA (Pimentel 2005, Rocha et al. 2005). Summing these three species, the area harbor 39% of the Atlantic Forest medium and large-sized mammal species and 75.7% of those from Rio de Janeiro state (Rocha et al. 2004).

A failure in the detection of the two feline species mentioned above could be due to two non-excludent reasons, (1) their naturally low population densities (Lyra-Jorge et al. 2008, Almeida et al. 2013), and (2) the high frequency of *Puma concolor* and *Leopardus pardalis* in several trails, whose presence has been negatively related to the occurrence of these species (Oliveira et al. 2010, Oliveira 2011, Oliveira-Santos et al. 2012). In addition, for *L. wiedii*, trail characteristics - which were more open, wide and managed than the preferred by the species – could have contributed to this result (Goulart et al. 2009). For *H. hydrochaeris* the absence of favorable habitats in the trails - as swampy areas - could explain why this species was not detected in this study (Ferraz et al. 2006).

The existence of non-detected species and the higher number of species registered only once (31.8%) can be responsible to the non-establishment of the rarefaction curve. These data suggest that these species are rare in the studied area. However, this result could also be due to sampling problems. The use of camera-traps outside the trails and in other habitats (in the canopy, closer to water courses, for example), and night transects in future studies are necessary to clarify this (Harmsen et al. 2010, Melo et al. 2012).

The observed richness (22 species) represented 70.8% of the estimated one (31.1 species). As the number of species known to the region is 33 (Rocha et al 2004), the use of Jacknife 2 seems to have been adequate to the studied community, corroborating the results found by other authors (Brose et al. 2003, Tobler et al. 2008).

The species with the higher number of records were *P. concolor* and *D. novemcinctus*. Both species are habitat generalists, occurring both in preserved and anthropized areas (Dickson et al. 2005, Andrade-Nuñez & Aide 2010, Mazzoli 2010, Canale et al. 2012). The large home range sizes of *P. concolor* (100–220 Km^2, Mazzoli 2010) and the difficulty of differentiate individuals (Oliveira-Santos et al. 2010), however, can have contributed to their elevated number of records. Considering *D. novemcinctus*, the foraging behavior can have inflate the number of records as a single individual moves long distances leaving several marks (Neck 1976, Mcbee & Backer 1982).

Habitat restricted species, that occur preferentially in preserved areas were well represented at REGUA. Among them are *Pecari tajacu*, *Cuniculus paca* and *L. pardalis* that are classified as vulnerable in the state and national red lists (Table 1). The first two are game species (Peres 1996, Cullen et al. 2001) that can maintain viable populations in the area due to the protection actions carried out by the owners and their employees.

Didelphis aurita, which is considered an indicator of disturbed habitats (Bergallo 1994), was less abundant here than in others studies (e.g. Gaspar 2005, Negrão & Valladares-Pádua 2006, Srbek-Araújo & Chiarello 2007). This result enhances the degree of forest conservation, as this species is generally more abundant is areas where top predators are absent (Fonseca & Robinson 1990).

The absence of the deer species (*Mazama* Rafinesque, 1817), white-lipped peccary (*Tayassu pecari* Link, 1795) and tapir (*Tapirus terrestris* Linnaeus, 1758) were the most apparent; in the last 10 years species were not detected in the area. For *T. pecari* there is an anecdotal observation by an employee recorded over 50 years, when according to him whole herds were hunted. For *Mazama* spp. and *T. terrestris*, the last records where those carried out by naturalists that visited the region in the century XIX (Miller et al. 2006). Habitat fragmentation and principally over hunting must have contributed to the local extinction of these species at the REGUA, as found in other Atlantic Forest regions (e.g. Chiarello 2000, Canale et al. 2013).

The fact that the number of medium and large-sized mammals species found at REGUA was comparable inclusive to large protected areas could be due to the formed continuum with the Parque Estadual dos Três Picos. However, the management and protection of the area by its owners is fundamental to maintain the populations of these animals. The creation of private reserves has been an important strategy for biodiversity conservation in Brazil (e.g. Schiavetti et al. 2010, Negrões et al. 2011). At REGUA, as in other private reserves, the surveillance is done generally by locals, mostly former hunters, who know the region well and are able to keep gatherers and hunters away. The number of species, including cinegetic and endangered ones makes REGUA important to the conservation of medium and large-sized mammals in the state and a stocking area to future recolonizations of regions in their surroundings.

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