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ORIGINAL PAPER

Carnivore mammals in a fragmented landscape in northeast of São Paulo State, Brazil

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Abstract São Paulo is the most developed state in Brazil and little of its native vegetation remains. In Luiz Antonio and Santa Rita do Passa Quatro municipalities, only small fragments of *cerrado* (Brazilian savanna) physiognomies (*cerradão*, *cerrado sensu stricto*) and of semideciduous forest have been left, surrounded by eucalyptus silviculture and sugar-cane agriculture. However, that vegetation mosaic still shelters large mammals, including several carnivore species. To detect the carnivores present in such a mosaic area (50,000 ha), and to find out how they use the landscape, we recorded them through 21 camera traps and 21 track plots, during 18 months. Species richness, diversity and relative frequency were evaluated according to the habitat. Ten species were recorded, some of them locally threatened to extinction (*Puma concolor*, *Leopardus pardalis*, *Chrysocyon brachyurus*). Species diversity did not significantly differ among fragments, and although most species preferred one or another habitat, the carnivore community as a whole explored all the study area regardless of the vegetation cover; eucalyptus plantations were as used by the carnivores as the native fragments. Therefore, it seems possible to maintain such animals in agricultural landscapes, where some large native fragments are left and the matrix is permeable to native fauna.

Keywords Agroecosystem · Brazilian savanna · Camera trap · Carnivores · *cerrado* · Habitat fragmentation · Mammal · Track plot

Introduction

Habitat loss is presently the highest threat to terrestrial vertebrates (Crooks 2002). The loss of the original vegetation cover may change species composition, diversity and behavior of

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the native fauna, as well as may interfere in the community structure. Some mammal species, however, benefit from agriculture or silviculture expansion (Laurance 1994; Gehring and Swihart 2003) whereas others, particularly those with large home ranges and small populations, are vulnerable to habitat fragmentation and may become locally extinct (Crooks 2002).

Habitat fragmentation may also interfere in the way species use the modified landscape. Cursorial and generalist species widely explore the environment and are less susceptible to landscape fragmentation (Chiarello 2000). Habitats more intensely used generally retain enough environmental quality to keep the transit and/or residence of species in the landscape (Garshelis 2000).

São Paulo is the most densely populated and developed state in Brazil; consequently, the natural ecosystems are highly fragmented and the native fauna faces serious pressures. Knowing how species use different habitats in anthropogenic landscapes is of great value to subsidize actions towards the maintenance of biodiversity.

With the purpose of contributing to the conservation of the carnivore assemblage of São Paulo State, this study aims to answer the following questions: (a) What are the species of carnivores present in the study area? (b) Do carnivores indistinctly use the study area regardless of the vegetation cover?

Study area

The study area comprises approximately 50,000 ha, in the Northeast of São Paulo State (Santa Rita do Passa-Quatro and Luiz Antônio municipalities: 21°31′15″ S–47°34′42″ W; 21°44′24″ S–47°52′01″ W). It is limited to the East by Anhangüera highway, and to the South by Mogi-Guaçu river (Fig. 1).

As several other regions intensely explored by men, the study region is a mosaic formed by native vegetation patches and extensive monocultures, especially sugar cane, orange and eucalyptus. The native vegetation comprises patches of semideciduous forest and of different

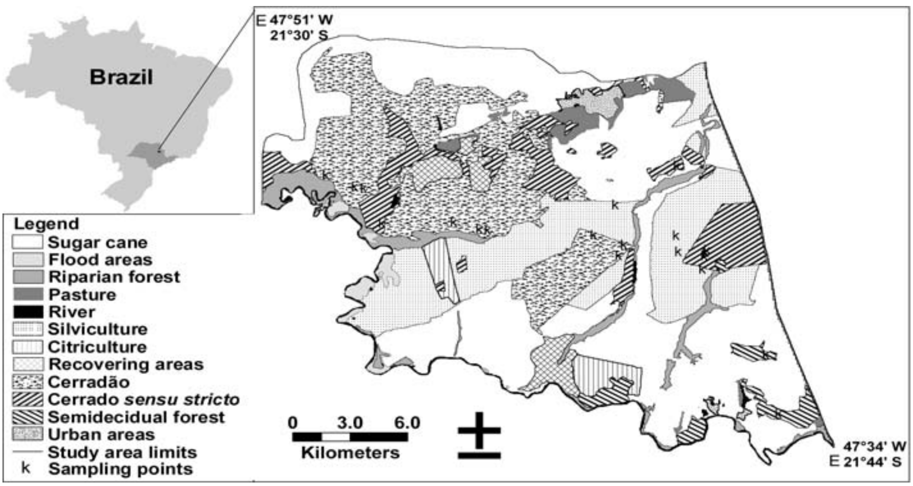

Fig. 1 The study area, in São Paulo State, Brazil

savanna physiognomies in an increasing density of trees, from *campo sujo* (grassy field with scattered trees) to *cerradão* (sclerophyllous woodland), being *cerrado sensu stricto* an intermediate form (typical *cerrado* with grasses, shrubs and many trees) (Coutinho 1978; Oliveira and Marquis 2002; Shida 2005).

Because of agriculture expansion, the region lost 60% of its original vegetation cover between 1962 and 1992 (Kronka et al. 1993); since then, agriculture and forestry are still expanding in the region but in a much lower rate. Despite this, two large fragments of cerrado still exist in the region, protected as nature preserves: Cerrado Pé-de-Gigante (1,212.9 ha) (Korman 2003) and Jataí Ecological Station (9,010.7 ha) (Decree 47.096/SP, from 18/September/2002). Four of the semideciduous forest patches are also protected, being part of the Vassununga State Partk (sizes ranging from 12.1 to 327.8 ha) (Korman 2003).

In this study, we sampled seven fragments of native vegetation (three of *cerradão*, three of *cerrado sensu stricto*, and two of semideciduous forest) as well as two others with *Eucalyptus* spp. homogeneous plantations (Fig. 1).

Methods

To estimate richness and occurrence of medium- and large-sized carnivore species, data were collected in 3-day monthly field trips, during 18 months (August/2004 to January 2006). In the field, two systematic methods were used: camera trapping and track plot recording.

The track plot recording (Lyra-Jorge 1999; Pardini et al. 2003) is based on the identification of the animal species through footprints in a plot, and allows estimating animal occurrence and richness. In this study, we randomly selected 21 sampling points from a bigger group of points which followed the requisites: (i) placed along pre-existing trails or dirt roads and (ii) with previously recorded footprints in the soil. Twenty-one track plots of $10 \text{ m} \times 2 \text{ m}$ were installed in the eucalyptus plantation and native vegetation patches; the number of plots in each patch was proportional to its size, resulting in: nine plots in *cerradão*, six in *cerrado sensu stricto*, two in semideciduous forest and four in the eucalyptus plantation (Fig. 1). The ground itself, which was sandy, was used to create each track plot. The track plots were visited every day, during each 3-day field trip, in order to identify the footprints in the soil and to clear the ground for new records. Ambiguous footprints were ignored and footprints of the same species, in the same plot, and in the same day were considered as if they were from a single individual.

The camera trapping method (Wemmer et al. 1996; Tomas and Miranda 2003) is based on the identification of the animal species through photographs taken by an automatic camera activated by the animal body heat and movement. It also permits to estimate animal occurrence and richness. To distribute the camera traps in the study area, we used the same criteria as those used to place track plots, in addition that the cameras should be protected from direct sunshine (as they would set off if exposed to intense heat). The sampling points were visited every field trip to change the films and batteries of the cameras, which remained activated in the field over the whole sampling period.

We assumed that all sampling points containing camera traps and track plots were homogeneous in detecting carnivores, and that all the carnivore species were equally detectable by both methods.

A species accumulation curve was drawn using data lumped from both methods to express carnivore richness. The curves were randomized 5,000 times through a rarefaction process (Santos 2003). Species richness was also estimated through the Bootstrap technique (Smith and Van Belle 1984; Santos 2003) with 5,000 randomizations, and using data from both methods.

The relative frequency (FR) of the carnivores recorded by camera traps and track plots was calculated according to the model (Crooks 2002): i/N, where i = number of occurrences of species I; N = total occurrences in the physiognomy.

Species records in *cerradão*, *cerrado sensu stricto*, and eucalyptus plantation were compared by Kruskal–Wallis test (Zar 1999); we removed semideciduous forest from this analysis due to the very small sample size (N = 2). The similarity in the carnivore assemblage in each vegetation form was tested through a multi-response permutation procedure (MRPP) analysis (McCune and Grace 2002) using data randomized 1,000 times and the Bray–Curtis index (Beals 1984). We used the numbers of species records in each sampling point.

Species diversity (Shannon-Wiener diversity index, Magurran 1998) was calculated from species occurrences and compared among vegetation types (except for semideciduous forest, due to small sample size) by Kruskal–Wallis test (Zar 1999).

We used the softwares EstimateS 7.0 (Colwell 2005), MVSP 3.1 (Kovach Computing Services 2006) and Statistica 6.0 (StatSoft Inc 2001) for statistical analyses.

Results

Ten carnivore species belonging to four different families were recorded in the 18 months of the study (Table 1). Nine of them were recorded by camera traps (12,960 h of exposure) and seven species were recorded in the track plots (1,864 h). Two species of small felines (*Leopardus tigrinus* and *Puma yagouaroundi*) could only be distinguished by the camera traps, as their footprints were very much alike. For that reason, they were grouped as "small felines" in the analyses.

The species accumulation curve with data from both methods approached the asymptote after 9 months of sampling, and the "obtained" species richness considered in the analyses (9.0) was similar to the value estimated by Bootstrap (9.16 $\pm$ 0.16).

Puma concolor and *Chrysocyon brachyurus* showed the highest relative frequencies regardless of the sampling method. *Leopardus pardalis* and *Cerdocyon thous* showed intermediate values of relative frequencies while the other five species showed low relative frequencies. *Procyon cancrivorus* was not registered by camera traps and was only found in the semideciduous forest, while *Nasua nasua* was not registered in the track plots (Table 1).

Although most species showed preference for some habitats—such as *L. pardalis*, *N. nasua* and *C. semistriatus* which seem to prefer cerrado physiognomies, whereas *C. thous* and *E. barbara* were more frequently found in the eucalyptus plantation (Table 1)—the distribution of all species records in the three vegetation forms compared—*cerradão*, *cerrado sensu stricto* and eucalyptus plantation—was not statistically different (Kruskal–Wallis; $P = 0{,}50$). This result was confirmed by the MRPP, which showed similarity in species composition among the different habitats ($P = 0.65$; A = −0.013; expected $\Delta = 0.51$; observed $\Delta = 0.52$). Species diversity assessed by Shannon-Wiener index also showed no significant difference among those three habitat types (Kruskal–Wallis; $P = 0.31$).

Table 1 Carnivore species registered by camera traps and in track plots

Species	Family	NR	Percentage of NR in the vegetation form				Relative frequency (%)		
			CD	SS	SF	EU	FT	FA	FC
Puma concolor (Linnaeus 1771)	Felidae	74	49	22	9	20	29.4	30.1	29.0
Leopardus pardalis (Linnaeus 1758)	Felidae	39	56	33	3	8	15.5	23.1	11.1
Small cat	Felidae	11	0	55	27	18	4.4	4.0	8.0
Chrysocyon brachyurus (Illiger 1811)	Canidae	78	47	18	8	27	31.0	24.1	32.3
Cerdocyon thous (Linnaeus 1716)	Canidae	27	37	15	7	41	10.7	3.2	12.0
Nasua nasua (Linnaeus 1766)	Procyonidae	02	50	50	0	0	0.8	5.9	0.0
Procyon cancrivorus (Cuvier 1798)	Procyonidae	03	0	0	100	0	1.2	0.0	4.1
Conepatus semistriatus (Boddaert 1784)	Mephitidae	11	64	27	0	9	4.4	6.1	1.8
Eira barbara (Linnaeus 1758)	Mustelidae	07	29	0	14	57	2.8	3.0	1.8

NR = Number of species records in all vegetation forms; CD = *cerradão*, SS = *cerrado sensu stricto*, SF = semideciduous forest, EU = eucalyptus plantation; FA = relative frequency obtained through camera trap data; FC = relative frequency obtained through track plot data; FT = relative frequency obtained through both sampling methods

Discussion

The species composition of the carnivore assemblage in the study area is in accordance with the geographic distributions found in Emmons (1997) and Eisenberg and Redford (1999) and also corroborates other surveys carried out in the region (Gargaglioni et al. 1998; Lyra-Jorge 1999; Talamoni et al. 2000). The sampling methods used here (camera trapping and track plots) showed to be adequate to survey medium- and large-sized carnivore species, since the value of species richness obtained in the field was very similar to the estimated value, and after 9 months of sampling these methods had detected the probable composition and species richness in the area.

Some carnivore species expected in the region according to the literature (Emmons 1997; Gargaglioni et al. 1998; Eisenberg and Redford 1999; Lyra-Jorge 1999; Talamoni et al. 2000) could not be detected. This fact probably indicates that either some of those species are presently rare or even extinct in the region, or the methods used to sample local richness were not directed to some types of habitats and species niches. For example, *Lycalopex vetulus* and *Leopardus wiedii*—not detected—are naturally rare species, and their population densities are usually very low (Azevedo 1996; Jácomo et al. 2004); *Lontra longicaudis* and *Galictis cuja* are species associated to aquatic habitats and their habitats or territories were not sampled (Emmons 1997; Pardini 1998); *Panthera onca* has not been found in the region for more than 50 years, and elderly local inhabitants report several hunting episodes involving this species; thus, it must be locally extinct.

The largest carnivores registered in the study area—*Puma concolor* and *Chrysocyon brachyurus*—showed the highest relative frequencies, probably because they move more in search for food, and have large home ranges (Dietz 1984; Dickson and Beier 2002). Because of that, the camera traps might have repeatedly recorded the same individuals, although we here treat each 'capture' as an independent sample. In addition, it was observed that camera traps performed better in the detection of large bodied animals (Carbone et al. 2002; Silveira et al. 2003); consequently, the large animals may have been over-analyzed by the methodology here adopted.

In the same way as found by other authors (Chinchila 1997; Oliveira 1998; Nuñez et al. 2000; Jácomo et al. 2004), our results showed that most species hold peculiar habitat preferences, however, the carnivore community all together was very similar in the whole study area. Our results corroborate the idea that large and medium carnivores in fragmented environments explore the region as a whole, and are not restricted to the native vegetation patches; they are more generalists than populations living in continuous and preserved areas (Azevedo 1996; Franklin et al. 1999; Donadio et al. 2001). Recent studies have shown that animals may adapt to modifications to their original habitats (Sánchez-Hernandez et al. 2001; Tabeni and Ojeda 2005; Morán-López et al. 2006; McDougal et al. 2006); in this study, the species *C. thous* and *E. barbara* confirmed their ability to use anthropogenic landscapes (Bisbal 1986; Jácomo et al. 2004). However, species more vulnerable to habitat fragmentation as *Panthera onca* may not have been able to adapt to habitat modifications in the study region (F. Azevedo, personal communication) and, together with hunting pressure, that could have been another reason for their local extinction.

In such a highly fragmented agricultural landscape, where few small patches of native vegetation remain, matrix permeability may be of a great importance for medium- and large-sized mammals. Highly permeable matrices connect habitats and permit animal movements throughout the landscape, maintaining processes that are essential to the persistence of carnivore populations; species with large home range are then able to use the native fragments and matrices to forage and to allow dispersal of young individuals (Elmhagen and Angerbjörn 2001; Hensen et al. 2005). Our results indicate that the eucalyptus matrix has an important function in connecting patches of native vegetation in the study area, and this may be the reason for the permanence of a still rich carnivore assemblage in such an agricultural landscape (Lyra-Jorge and Pivello 2005). Consequently, the conservation of the regional biological diversity requires the incorporation of knowledge on ecological processes to agricultural practices.

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References

Azevedo FCC (1996) Notes on behavior of the margay *Felis wiedii* in the Brazilian Atlantic forest. Mammalia 60:325–328

Beals EW (1984) Bray-Curtis ordination: an estrategy for analysis of multivariate ecological data. Adv Ecol Res 14:1–56

Bisbal FJ (1986) Food habits of some neotropical carnivores in Venezuela. Mammalia 50(3):329–339

Carbone C, Conforti C, Coulson T, Franklin N, Ginsberg JN, Griffths M, Holden J, Kinnaird M, Laidlaw R, Lynam A, Macdonald DW, Martyr D, Macdougal C, Nath L, O'Brien TO, Seidnsticker J, Smith DJ, Tilson R, Shahruddin WN (2002) The use of photograph rates to estimate densities of tigers and other cryptic mammals: response to Jannelle et al. Anim Conserv 5:121–132. doi:10.1017/S1367943002002172

Chiarello AG (2000) Conservation value of a native forest fragment in a region of extensive agriculture. Revista Brasileira de Biologia 60:237–247 (Medline). doi:10.1590/S0034-71082000000200007

Chinchila FA (1997) La dieta del jaguar (*Panthera onca*), el puma (*Felis concolor*) y el manigordo (*Felis pardalis*) em el Parque Nacional Corcovado, Costa Rica. Ver Biologica Tropical 459:1223–1229

Colwell RK (2005) EstimateS: statistical estimation of species richness and shared species from samples. Version 7.5. User's guide. http://purl.oclc.org/estimates. Accessed 10 Feb 2006

Coutinho LM (1978) O conceito de cerrado. Revista Brasileira de Botânica 1:115–117

Crooks K (2002) Relative sensitivities of mammalian carnivores to habitat fragmentation. Conserv Biol 16:488–502. doi:10.1046/j.1523-1739.2002.00386.x

Dickson BG, Beier P (2002) Home range and habitat selection by adult cougars in southern California. J Wildl Manage 66(4):1235–1245

Dietz J (1984) Ecology and social organization of the maned wolf (*Chrysocyon brachyurus*). Smithsonian Contrib Zool 392:1–51

Donadio E, Di Martino S, Aubone M, Novaro AJ (2001) Activity patterns, home range, and habitat selection of the common hog-nosed skunk, *Conepatus chinga* in northwestern Patagonia. Mammalia 65:49–54

Eisenberg JF, Redford KH (1999) Mammals of the neotropics. University of Chicago Press, USA, 609 pp

Elmhagen B, Angerbjörn A (2001) The applicability of metapopulation theory to large mammals. Oikos 94:89–100. doi:10.1034/j.1600-0706.2001.11316.x

Emmons L (1997) Neotropical rainforest mammals: a field guide. University of Chicago Press, USA, 307 pp

Franklin W, Johnson W, Sarno R, Iriarte JA (1999) Ecology of the Patagonia puma in southern Chile. Biol Conserv 19:33–40. doi:10.1016/S0006-3207(99)00008-7

Gargaglioni LH, Batalhão ME, Lapenta MJ, Carvalho MF, Rossi RV, Veruli VP (1998) Mamíferos da Estação Ecológica de Jataí, Luiz Antônio, SP. Papéis Avulsos de Zoogia 40:267–287

Garshelis DL (2000) Delusions in habitat evaluation: measuring use, selection and importance. In: Boitani L, Fuller TK (eds) Research techniques in animal ecology: controversies and consequences. Columbia University Press, New York, pp 111–164

Gehring TM, Swihart RK (2003) Body size, niche breath, and ecologically scaled responses to habitat fragmentation: mammalian predators in an agricultural landscape. Biol Conserv 109:283–295. doi:10.1016/S0006-3207(02)00156-8

Hensen A, Knight RL, Marzluff JM, Powell S Brown K, Gude P, Jones K (2005) Effects of exurban development on biodiversity: patterns mechanisms and research needs. Ecol Appl 15:1893–1905. doi:10.1890/05-5221

Jácomo AT, Silveira L, Diniz-Filho AF (2004) Niche separation between the maned wolf (*Chrysocyon brachyurus*), the crab-eating fox (*Dusicyon thous*) and the hoary fox (*Dusicyon vetulus*) in Central Brazil. J Zool Lond 262:99–106. doi:10.1017/S0952836903004473

Kovach Computing Services (2006) http://www.kovcomp.com. Accessed 30 May 2006

Korman V (2003) Proposta de interligação das glebas do Parque Estadual de Vassununga (Santa Rita do Passa Quatro, SP). MSc Thesis, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, SP, Brazil

Kronka FJN, Matsukuma CK, Nalon MA, Del Cali IH, Rossi M, Matos IFA, Shin-Ike MS, Pontinhas AS (1993) Inventário Florestal do estado de São Paulo. Instituto Florestal, São Paulo, p 199

Laurance WF (1994) Rainforest fragmentation and the structure of small mammal communities in tropical Queensland. Biol Conserv 69:23–32. doi:10.1016/0006-3207(94)90325-5

Lyra-Jorge MC (1999) Avaliação do potencial faunístico da A.R.I.E. Cerrado Pé-de-Gigante (Parque Estadual do Vassununga, Santa Rita do Passa Quatro – SP) com base na análise de habitats. MSc thesis, Instituto de Biociências, Universidade de São Paulo, São Paulo, SP, Brazil

Lyra-Jorge MC, Pivello VR (2005) Mamíferos. In: Pivello VR, Varanda EM (eds) O Cerrado Pé-de-Gigante (Parque Estadual de Vassununga, São Paulo) – Ecologia e Conservação. Secretaria de Estado do Meio Ambiente, São Paulo, pp 135–148

Magurran AE (1998) Ecological diversity and its measurement. University Press, Cambridge, p 178

McCune B, Grace JB (2002) Analyses of ecological communities. Software design, Gleneden Deach, USA

McDougal PT, Réale D, Sol D, Reader SM (2006) Wildlife conservation and animal temperament: causes and consequences of evolutionary change for captive reintroduced and wild populations. Anim Conserv 9:39–48. doi:10.1111/j.1469-1795.2005.00004.x

Morán-López R, Guzmán JM, Borrego EC, Sánchez AV (2006) Nest-site selection of endangered cinereous vulture populations affect by anthropogenic disturbance: present and future conservation implications. Anim Conserv 9:29–37. doi:10.1111/j.1469-1795.2005.00003.x

Nuñez R, Miller B, Lindzey F (2000) Food habits of jaguars and pumas in Jalisco, Mexico. J Zool Lond 252:373–379

Oliveira TG (1998) *Herpailurus yagouaroundi*. Mammal Species 578:1–6

Oliveira PS, Marquis RJ (2002) The cerrados of Brazil. Ecology and natural history of a neotropical savanna. Columbia University Press, New York, 398 pp

Pardini R (1998) Feeding ecology of the neotropical river otter *Lontra longicaudis* in an Atlantic forest stream, south-eastern Brazil. J Zool Lond 245:385–391. doi:10.1111/j.1469-7998.1998.tb00113.x

Pardini R, Ditt EH, Cullen L Jr, Bassi C, Rudran R (2003) Levantamento rápido de mamíferos terrestres de médio e grande porte. In: Cullen L Jr, Rudran R, Valladares-Pádua C (eds) Métodos de estudo em biologia da conservação e manejo de vida silvestre. Editora da UFPR; Fundação O Boticário de Proteção à Natureza, Curitiba, pp 181–202

Sánchez-Hernandez C, Romero-Almaraz ML, Colín-Martinez H, García-Estrada C (2001) Mamíferos de cuatro áreas com diferente grado de alteración em el sureste de México. Acta Zoológica del Mexico 84:35048

Santos JA (2003) Estimativa de riqueza em espécies. In: Cullen L Jr, Rudran R, Valladares-Pádua C (eds) Métodos de estudo em biologia da conservação e manejo da vida silvestre. Editora da UFPR, Curitiba, pp 19–42

Shida CN (2005) Caracterização física do cerrado Pé-de-Gigante e uso das terras na região. Evolução do uso das terras na região. In: Pivello VR, Varanda E (eds) O Cerrado Pé-de-Gigante. Parque Estadual de Vassununga. Ecologia e Conservação. SEMA, São Paulo, pp 25–47

Silveira L, Jácomo AT, Diniz-Filho JA (2003) Camera trap, line transect census and track surveys: a comparative evaluation. Biol Conserv 114:351–355. doi:10.1016/S0006-3207(03)00063-6

Smith EP, Van Belle G (1984) Non parametric estimation of species richness. Biometrics 40:119–129. doi:10.2307/2530750

Statsoft Inc (2001) STATISTICA V.6.0. www.statsoft.com. Accessed 20 Jan 2006

Tabeni S, Ojeda RA (2005) Ecology of the desert small mammals in disturbed and undisturbed habitats. J Mammal 70(2):416–420

Talamoni SA, Motta-Júnior JC, Dias MM (2000) Fauna de mamíferos da Estação Ecológica de Jataí e Estação Experimental de Luiz Antônio. In: Santos JE, Pires JSR (eds) Estudos Integrados em Ecossistemas. Estação Ecológica de Jataí. RiMa Editora, São Carlos, p 346

Tomas WM, Miranda GHB (2003) Uso de armadilhas fotográficas em estudos populacionias. In: Cullen L Jr, Rudran R, Valladares-Pádua C (eds) Métodos de estudo em biologia da conservação e manejo de vida silvestre. Editora da UFPR; Fundação O Boticário de Proteção à Natureza, Curitiba, pp 243–268

Wemmer C, Kunz T, Lundie-Jekins G, McShea W (1996) Mammalian sign. In: Wilson DE, Cole FR, Nichols JD, Rudran R, Foster MS (eds) Measuring and monitoring biological diversity. Standard methods for mammals. Smithsonian Institution Press, London, pp 157–176

Zar JH (1999) Biostatistical analysis. Prencinton Hall, New Jersey, p 409