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How does the giant anteater *Myrmecophaga tridactyla* use a landscape featuring high human disturbance and free-ranging dogs?

São José do Rio Preto
2020

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Dissertação apresentada como parte dos requisitos para obtenção do título de Mestre em Biologia Animal junto ao Programa de Pós-Graduação em Biologia Animal do Instituto de Biociências, Letras e Ciências Exatas da Universidade Estadual Paulista "Júlio de Mesquita Filho", Câmpus de São José do Rio Preto.

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To my parents who never measured efforts
so that I could get here.

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RESUMO

O tamanduá-bandeira (*Myrmecophaga tridactyla*) é uma espécie vulnerável à extinção globalmente e em diversas escalas regionais, incluindo o estado de São Paulo. Essa espécie é dependente de condições ambientais e recursos favoráveis à sua termorregulação, como áreas com alta disponibilidade de água e com fragmentos florestais. Além disso, o tamanduá-bandeira é um especialista mirmecófago que possui baixa taxa metabólica basal, sendo assim uma espécie lenta e vulnerável à caça, atropelamentos e confronto com cães. Este trabalho teve como objetivos 1) entender como as características ambientais influenciam o uso da paisagem pelo tamanduá-bandeira (*Myrmecophaga tridactyla*); 2) avaliar se há sobreposição espacial entre tamanduá-bandeira e cães domésticos e 3) avaliar o padrão de atividade diária do tamanduá-bandeira levando em consideração a temperatura do ambiente, a proximidade com áreas de maior densidade humana e a presença de cães. Para isso, realizamos a análise dos dados de armadilhas fotográficas e registradores de temperatura instalados no Parque Estadual Furnas do Bom Jesus e seu entorno, situados no norte do estado de São Paulo. Os registros compuseram matrizes de detecção/não-detecção para tamanduá-bandeira e cães. Covariáveis relacionadas aos tipos vegetacionais e de uso antrópico foram avaliadas em modelos de ocupação estação-única/espécie-única e em modelos de ocupação com probabilidade de detecção heterogênea (modelos RN). Para avaliar o padrão de atividade utilizamos o estimador de densidade von Mises kernel para dados circulares e para avaliar a sobreposição nos padrões de atividade utilizamos o coeficiente de sobreposição de densidade. Encontramos relação positiva entre o uso da paisagem pelo tamanduá-bandeira e a proximidade com a Unidade de Conservação, áreas nativas abertas, estradas não pavimentadas e frequência de cães. O uso da paisagem por cães foi influenciado positivamente pela área urbana e abundância realtiva de presas. As predições de uso da paisagem pelas duas espécies sobrepuseram espacialmente. Em relação ao padrão de atividade, o tamanduá-bandeira dispôs padrão crepuscular-noturno e nos horários de temperatura amena. Durante a estação fria a espécie teve atividade predominantemente noturna próximo às construções e estradas não-pavimentadas e crepuscular longe delas. A espécie também apresentou considerável segregação de atividade com o cachorro doméstico, o qual teve atividade predominantemente diurna. Esse trabalho abre caminhos para o entendimento de como o tamanduá-bandeira ocupa as áreas antropizadas visto a presença da espécie nessas áreas.

Palavras–chave: Espécie exótica, distúrbios antrópicos, Cerrado, Unidade de Conservação.

ABSTRACT

The giant anteater (*Myrmecophaga tridactyla*) is a mammal vulnerable to global- and regional-scale extinction, including within São Paulo State, Brazil. This species depends on areas with high water availability, forest patches, and favorable environmental conditions and resources for thermoregulation. Moreover, the giant anteater is a myrmecophagous specialist with a low basal metabolic rate and is therefore slow and vulnerable to hunters, vehicle collisions and dog attacks. The objectives of this work are 1) to understand how environmental characteristics influence landscape use by the giant anteater; 2) to evaluate whether there is spatial overlap between giant anteaters and dogs; and 3) to evaluate the giant anteater activity pattern, considering environmental temperature, proximity to areas of high human density, and the presence of dogs. For these purposes, we used camera traps and temperature data loggers, which were installed in Furnas do Bom Jesus State Park and its surroundings, located in northern São Paulo State, Brazil. The records comprised detection/nondetection data of giant anteaters and dogs. Covariates related to vegetation type and anthropogenic use were evaluated in single-species/single-season occupancy models and in occupancy models with heterogeneous detection probability (RN models). To evaluate activity pattern, we used von Mises kernel density estimation for circular data. To evaluate the overlap in giant anteater and dog activity patterns, we used the density overlap coefficient. We found a positive correlation between the giant anteater's landscape use and its proximity to Protected Areas, open native vegetation, unpaved roads and the frequency of dogs. Landscape use by dogs was influenced positively by urban area and prey relative abundance. The landscape-use predictions for both species presented evidence of spatial overlap. The giant anteater had crepuscular-nocturnal activity and was most active in mild temperatures, between 18ºC and 28ºC. During the cold season, the species' predominantly nocturnal activity occurred near buildings and unpaved roads, while its crepuscular activity occurred far from them. The species also showed a high degree of segregation from dogs, whose activity was predominantly diurnal. This work creates avenues for understanding how the giant anteater occupies the anthropized areas since the presence of this species in these areas.

Keywords: Alien species, anthropogenic disturbance, Cerrado, Protected Area.

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ABBREVIATION AND ACRONYMS LIST

AIC –	Akaike Information Criterion
AICc –	Akaike Information Criterion corrected for small samples
FBJSP –	“Furnas do Bom Jesus” State Park
QAIC –	Quasi-Akaike Information Criterion
QAICc –	Quasi-Akaike Information Criterion corrected for small samples

SUMMARY

1. GENERAL INTRODUCTION

Agricultural expansion and intensification converts large areas of native vegetation and species habitat into crops and pasture, leaving only remnants in various stages of conservation (DURIGAN; RATTER, 2006). The loss of native habitats causes resources scarcity for wildlife and changes in their habitat quality (FAHRIG, 2003). With this habitat loss and fragmentation, agricultural landscapes become relevant in wildlife conservation studies, as some animals can adapt to using these areas (CAMPOS; CHARTERS; VERDADE, 2018; DOTTA; VERDADE, 2011; MARTIN et al., 2012). In this scenario, habitat generalists can develop mechanisms of adaptation to these new environments (ROSALINO; VERDADE; LYRA-JORGE, 2014). Habitat-specialist species, however, may suffer local population declines and extinctions (CEBALLOS; EHRLICH, 2002). Understanding these processes and patterns is the key to developing effective management and conservation policies (VERDADE; PIÑA; LYRA-JORGE, 2011).

The ecological characteristics of a species or group (e.g., population, assemblage or taxon) are directly related to the evolutionary adaptation for their survival. The biological and ecological requirements of large-sized mammals generally make them more vulnerable to extinction due to habitat loss (CARDILLO et al., 2005), because they depend on large home-ranges to supply their energetic needs and have small population sizes (CHIARELLO, 1999; CROOKS et al., 2011; VYNNE et al., 2011). The giant anteater (*Myrmecophaga tridactyla*, Pilosa L. 1758) is a large-sized insectivorous mammal, with a low basal metabolic rate and reduced thermoregulation capacity (MCNAB, 1985), and is vulnerable to extinction (BRESSAN; KIERULFF; SUGIEDA, 2009; MIRANDA; BERTASSONI; ABBA, 2014; MIRANDA et al., 2015). Despite its vulnerability and its status as a flagship species for Cerrado conservation in Brazil, information about the giant anteater's ecology is scarce (DINIZ; BRITO, 2015). Furthermore, most of the published studies of free-living individuals were conducted in preserved areas of the Pantanal (CAMILO-ALVES; MOURÃO, 2006; DESBIEZ; MEDRI, 2010; MEDRI; MOURÃO, 2005; MOURÃO; MEDRI, 2007) and in protected areas such as Emas National Park (MIRANDA et al., 2006) and Serra da Canastra National Park (BERTASSONI; COSTA, 2010). Works developed in fragmented or intensely modified areas are exceptions (BERTASSONI, 2017; KREUTZ; FISCHER; LINSENMAIR, 2012; PETRAZZINI, 2019; VERSIANI, 2016).

Most available information about the giant anteater's ecological characteristics is related to demographics and habitat characteristics, and it varies between the studied populations (BRAGA, 2010; MIRANDA et al., 2006). The population density of the species varies from 1.3 to 2 individuals/km^2 (EISENBERG; REDFORD, 1999). In general, the home-ranges vary from 0.8 km^2 (MIRANDA, 2004) to 25 km^2 (MONTGOMERY, 1985) depending on the region studied (BERTASSONI; RIBEIRO, 2019). Protected areas alone are not sufficient to maintain viable populations of the giant anteater (BERTASSONI et al., 2019). Therefore, the species is expected to also occupy agricultural and pasture areas because, despite the risks, they provide various resources (BRAGA, 2010; MIRANDA, 2004; ROSALINO; VERDADE; LYRA-JORGE, 2014). An indication that there is gene flow between giant anteater populations and constant use of non-native areas comes from a study in São Paulo State, in which the populations were genetically uniform despite their presumed geographical separation by the agricultural, river and road matrix (RIBEIRO, 2016). Unpaved roads present in agricultural areas seem to be important for species movement (VYNNE et al., 2011). Moreover, places with greater habitat perturbation are known to have higher abundance of certain ant species, albeit lower richness compared to preserved areas (VASCONCELOS, 1998), and the giant anteater has demonstrated flexibility in using food resources according to availability (RODRIGUES et al., 2008).

Giant anteaters body temperature is low and they have a low basal metabolic rate when compared with other large mammals, characteristics related to their food that is based on low energy content items (MCNAB, 1985). The environmental temperature plays a vital role in their thermoregulation, and can influence their behavior, daily activity and habitat use (CAMILO-ALVES; MOURÃO, 2006; ROSA, 2007). These attributes differentiate them from other large tropical mammals in terms of environmental needs, such as a limited range of tolerated environmental temperature and heterogeneous habitats (CAMILO-ALVES; MOURÃO, 2006; ROSA, 2007). Behaviors such as covering itself with its tail to sleep on cold days to prevent loss of body heat (MEDRI; MOURÃO, 2005), or bathing on hot days to decrease body temperature (EMMONS et al., 2004), are described in the literature. Furthermore, the giant anteater uses open habitats more frequently in mild temperatures, and forested habitats more on the hottest or coldest days (CAMILO-ALVES; MOURÃO, 2006; MOURÃO; MEDRI, 2007). The species needs forested areas for the important temperature-buffering effect that this type of phytophysiognomy has in extreme temperatures— the temperature is lower in the forest than in open areas on hot days, and vice versa on cold days (MOURÃO; MEDRI, 2007). Thus, giant anteater occupancy is higher in open places that are near forested patches, indicating the importance of heterogeneous habitats (BERTASSONI; RIBEIRO, 2019). This relationship between habitat selection and environmental temperature complicates our understanding of the species' landscape use, because it is not limited to one kind of habitat. Thus, any model that describes the giant anteater's landscape occupation will be necessarily complex.

Anthropogenic disturbances, such as industry and urbanization, are negative factors for some species because they reduce many important resources such as food and shelter. In some giant anteater populations, the urban area negatively affects landscape use (MACEDO, 2008; VERSIANI, 2016). Anthropogenic actions are generally associated with native habitat loss, expansion of roads and highways, and invasion by alien species in native vegetation areas. But, recent studies have noted the adaptiveness of some species to human-driven environmental and landscape changes, thus, current populations may not respond to these changes in the same way as populations that were studied when their habitat was less disturbed (MCDONNELL; HAHS, 2015).

With the expansion of urban areas, roads have emerged as a powerful aggravating factor for many populations (COFFIN, 2007; GARRIGA et al., 2012). The construction of high-volume roads is one of the anthropogenic disturbance that most affects the dynamics of ecological processes, potentially changing the physical, chemical, and biological environments (FORMAN; ALEXANDER, 1998). Vehicle collisions are considered one of the main causes of population decline of giant anteaters (DINIZ; BRITO, 2015). In an optimistic scenario, considering a population density of 0.4 individuals/km² and a collision rate of 10%, the population is projected to be extinct within 15 years (DINIZ; BRITO, 2015). In addition, high-volume roads can be a barrier, preventing animals from crossing, and isolating populations (FORMAN; ALEXANDER, 1998). In São Paulo State, where there is an extensive road network, it is common for roads to cross or run adjacent to Conservation Units, as is the case for the Furnas do Bom Jesus State Park— the Cândido Portinari highway runs contiguous to the western boundary of the park, and the Pedregulho municipal road to the eastern boundary (BRANCO et al., 1991).

Predators, both natural and alien, are another factor that can affect a species' use of a particular habitat (LACERDA; TOMAS; MARINHO-FILHO, 2009). Alien predators alter the species' habitat, and their impact can be drastic because they cause an imbalance in the community (SALO et al., 2007). One of the best-known cases of an alien predator is that of the domestic dog (*Canis lupus familiaris*), an invasive animal species of global magnitude. Domesticated and introduced by humans, dogs are currently a widespread problem (GOMPPER, 2013). They are often found within Brazil’s Conservation Units (BIANCHI et al., 2020), and their interaction with wild animals poses threats such as competition, predation, and transmission of pathogens (LESSA et al., 2016). A study carried out in the National Park of Brasília found that giant anteaters avoid areas of the park's boundary where the occurrence probability of domestic dogs is high (LACERDA; TOMAS; MARINHO-FILHO, 2009).

The majority of the Cerrado is characterized by a mosaic of native vegetation fragments, agricultural areas, and areas containing threatening elements such as roads and domestic dogs. Understanding how the giant anteater uses such a landscape is important for the development of relevant land management strategies and species conservation plans.

REFERENCES

BERTASSONI, A. **Ecologia Espacial e Populacional de tamanduá-bndeira (*Myrmecophaga tridactyla*) em Estação Ecológica de Domínio Cerrado, São Paulo, Brasil**. 2017. 120 f. Thesis – Instituto de Biociências e Letras, Universidade Estadual Paulista "Julio de Mesquita Filho". São José do Rio Preto, São Paulo, Brazil. 2017.

BERTASSONI, A.; COSTA, C. M. L. Behavioral repertoire of giant anteater (*Myrmecophaga tridactyla*, Linnaeus 1758) in nature at Serra da Canastra National Park, MG and in captivity at Curitiba Zoo, PR, Brazil. **Revista de Etologia**, v. 9, n. 2, p. 21–30, 2010.

BERTASSONI, A.; RIBEIRO, M. C. Space use by the giant anteater (*Myrmecophaga tridactyla*): a review and key directions for future research. **European Journal of Wildlife Research**, v. 65, n. 6, p. 93–93, 2019.

BERTASSONI, A. et al. Land-use changes and the expansion of biofuel crops threaten the giant anteater in southeastern Brazil. **Journal of Mammalogy**, v. 100, n. 2, p. 435–444, 2019.

BIANCHI, R. C. et al. Dog activity in protected areas: behavioral effects on mesocarnivores and the impacts of a top predator. **European Journal of Wildlife Research**, v. 66, n. 3, 2020.

BRAGA, F. G. **Ecologia e comportamento de tamanduá-bandeira *Myrmecophaga tridactyla* Linnaeus, 1758 no município de Jaguariaíva, Paraná**. 2010. 104 f. Thesis – Universidade Federal do Paraná. Curitiba, Paraná, Brazil. 2010.

BRANCO, L. H. D. C. et al. Plano Conceitual de Manejo - Parque Estadual das Furnas do Bom Jesus, Município de Pedregulho, SP. **Revista do Instituto Florestal**, v. 3, n. 2, p. 137–155, 1991.

BRESSAN, P. M.; KIERULFF, M. C. M.; SUGIEDA, A. M. **Fauna ameaçada de extinção no Estado de São Paulo**. São Paulo: Fundação Parque Zoológico de São Paulo, Secretaria do Meio Ambiente, 2009. 645 p.

CAMILO-ALVES, C. S. P.; MOURÃO, G. M. Responses of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) to variation in ambient temperature. **Biotropica**, v. 38, n. 1, p. 52-56, 2006.

CAMPOS, B. M.; CHARTERS, J. D.; VERDADE, L. M. Diversity and distribution patterns of medium to large mammals in a silvicultural landscape in south-eastern Brazil. **iForest-Biogeosciences and Forestry**, v. 11, n. 6, p. 802, 2018.

CARDILLO, M. et al. Multiple causes of high extinction risk in large mammal species. **Science**, v. 309, n. 5738, p. 1239-1241, 2005.

CEBALLOS, G.; EHRLICH, P. R. Mammal population losses and the extinction crisis. **Science**, v. 296, n. 5569, p. 904–907, 2002.

CHIARELLO, A. G. Effects of fragmentation of the Atlantic forest on mammal communities in south-eastern Brazil. **Biological Conservation**, v. 89, n. 1, p. 71–82, 1999.

COFFIN, A. W. From roadkill to road ecology: A review of the ecological effects of roads. **Journal of Transport Geography**, v. 15, n. 5, p. 396–406, 2007.

CROOKS, K. R. et al. Global patterns of fragmentation and connectivity of mammalian carnivore habitat. **Philosophical Transactions of the Royal Society B**, v. 366, p. 2642–2651, 2011, doi:10.1098/rstb.2011.0120.

DESBIEZ, A. L. J.; MEDRI, Í. M. Density and habitat use by Giant Anteaters (*Myrmecophaga tridactyla*) and Southern Tamanduas (*Tamandua tetradactyla*) in the Pantanal Wetland, Brazil. **Edentata**, v. 11, n. 1, p. 4–10, 2010.

DINIZ, M. F.; BRITO, D. Protected areas effectiveness in maintaining viable giant anteater (*Myrmecophaga tridactyla*) populations in an agricultural frontier. **Natureza e Conservação**, v. 13, n. 2, p. 145–151, 2015.

DOTTA, G.; VERDADE, L. M. Medium to large-sized mammals in agricultural landscapes of south-eastern Brazil. **Mammalia**, v. 75, n. 4, p. 345–352, 2011.

DURIGAN, G.; RATTER, J. A. Successional changes in cerrado and cerrado/forest ecotonal vegetation in western São Paulo State, Brazil, 1962-2000. **Edinburgh Journal of Botany**, v. 63, n. 1, p. 119–130, 2006.

EISENBERG, J. F.; REDFORD, K. H. **Mammals of the Neotropics: Ecuador, Bolivia, Brazil**. Chicago and London: The University of Chicago, 1999. v. 3.

EMMONS, L. H. et al. Bathing Behavior of Giant Anteaters (*Myrmecophaga tridactyla*). **Edentata**, v. 6, n. 1, p. 41, 2004.

FAHRIG, L. Effects of Habitat Fragmentation on Biodiversity. **Annual Review of Ecology, Evolution, and Systematics**, v. 34, n. 1, p. 487–515, 2003.

FORMAN, R. T. T.; ALEXANDER, L. E. Roads and their major ecological effects. **Annual Review of Ecology and Systematics**, v. 29, n. 1, p. 207–231, 1998.

GARRIGA, N. et al. Are protected areas truly protected? The impact of road traffic on vertebrate fauna. **Biodiversity and Conservation**, v. 21, n. 11, p. 2761–2774, 2012.

GOMPPER, M. E. **Free-ranging dogs and wildlife conservation**. 1. ed. Oxford: Oxford University Press, 2013.

KREUTZ, K.; FISCHER, F.; LINSENMAIR, K. E. Timber plantations as favourite habitat for giant anteaters. **Mammalia,** v. 76, p. 137-142, 2012.

LACERDA, A. C. R.; TOMAS, W. M.; MARINHO-FILHO, J. Domestic dogs as an edge effect in the Brasília national park, Brazil: Interactions with native mammals. **Animal Conservation**, v. 12, n. 5, p. 477–487, 2009.

LESSA, I. et al. Domestic dogs in protected areas: a threat to Brazilian mammals? **Natureza e Conservação,** v. 14, n. 2, p. 46-56, 2016.

MACEDO, L. S. M. **Área de vida, atividade, uso de habitat e padrões hematológicos de tamanduá-bandeira (*Myrmecophaga tridactyla*, Linnaeus 1758) nas savanas peruibanas de Boa Vista, Roraima**. 2008. 85 f. Thesis (Master's Degree) – Universidade Federal de Roraima. Boa Vista, Roraima, Brazil. 2008.

MARTIN, P. S. et al. Terrestrial non-volant small mammals in agro-silvicultural landscapes of Southeastern Brazil. **Forest Ecology and Management**, v. 282, p. 185–195, 2012.

MCDONNELL, M. J.; HAHS, A. K. Adaptation and adaptedness of organisms to urban environments. **Annual Review of Ecology, Evolution, and Systematics**, v. 46, p. 261–80, 2015.

MCNAB, B. K. Energetics, population biology, and distribution of xenarthrans, living and extinct. In: MONTGOMERY, G. G., ed., **The evolution and ecology of armadillos sloths and vermilinguas**. Washington: Smithsonian Institution Press, 1985, p. 219-232.

MEDRI, Í. M.; MOURÃO, G. Home range of giant anteaters (*Myrmecophaga tridactyla*) in the Pantanal wetland, Brazil. **Journal of Zoology**, v. 266, n. 4, p. 365–375, 2005.

MIRANDA, F. R. et al. Avaliação do Risco de Extinção de *Myrmecophaga tridactyla* Linnaeus, 1758 no Brasil. In: Instituto Chico Mendes de Conservação da Biodiversidade, ed. **Avaliação do Risco de Extinção dos Xenartros Brasileiros**. Brasília, DF: ICMBio, 2015, p. 89–105.

MIRANDA, F.; BERTASSONI, A.; ABBA, A. M. 2014. *Myrmecophaga tridactyla*. **The IUCN Red List of Threatened Species.** 2014: e.T14224A47441961. Available in: <https://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T14224A47441961.en.> Downloaded on: 25 March 2020.

MIRANDA, G. H. B. **Ecologia e Conservação do tamanduá-bandeira (*Myrmecophaga tridactyla*, Linnaeus, 1758) no Parque Nacional das Emas**. 2004. 67 f. Thesis – Instituto de Ciências Biológicas, Universidade de Brasília. Brasília, Goiás, Brazil. 2004.

MIRANDA, G. H. B. et al. Giant anteater (*Myrmecophaga tridactyla*) population Survey in Emas National Park, Brazil – a proposed monitoring program. **Endangered Species Update**, v. 23, p. 96-103, 2006.

MONTGOMERY, G. G. Movements, foraging and food habits of the four extant species of neotropical vermilinguas (Mammalia; Myrmecophagidae). In: MONTGOMERY, G. G. ed. **The evolution and ecology of armadillos, sloths and vermilinguas**. Washington: Smithsonian Institution Press, 1985.

MOURÃO, G.; MEDRI, Í. M. Activity of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) in the Pantanal of Brazil. **Journal of Zoology**, v. 271, n. 2, p. 187–192, 2007.

PETRAZZINI, P. B. **Padrão de Ocupação e Atividade de Tamanduá-bandeira em uma Área de Proteção no Cerrado**. 2019. 83 f. Thesis (Master’s degree) – Instituto de Ciências Biológicas, Universidade de Brasília. Brasília, Goiás, Brazil. 2019.

RIBEIRO, R. C. **Genética populacional de *Myrmecophaga tridactyla* (Pilosa, Myrmecophagidae) no estado de São Paulo utilizando o gene mitocondrial CytB**. 2016. 50 f. Thesis (Master’s degree) – Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista “Julio de Mesquita Filho”. São José do Rio Preto, São Paulo, Brazil. 2016.

RODRIGUES, F. H. G. et al. Anteater Behavior and Ecology. In: VIZCAÍNO, S. F.; LOUGHRY, W. J. eds. **The Biology of the Xenarthra**. Florida: University Press of Florida, 2008, p. 257-268.

ROSA, A. M. L. **Efeito da temperatura ambiental sobre a atividade, uso de habitat e temperatura corporal do tamanduá-bandeira (*Myrmecophaga tridactyla*) na fazenda Nhumirim, Pantanal**. 2007. 32 f. Thesis (Master's degree) – Universidade Federal do Mato Grosso do Sul. Corumbá, Mato Grosso do Sul, Brazil. 2007.

ROSALINO, L. M.; VERDADE, L. M.; LYRA-JORGE, M. C. Adaptation and evolution in changing environments. In: VERDADE, L. M.; LYRA-JORGE, M. C.; PIÑA, C. I. eds. **Applied ecology and human dimensions in biological conservation**. New York: Springer, 2014, p. 53–71.

SALO, P. et al. Alien predators are more dangerous than native predators to prey populations. **Proceedings of the Royal Society**, v. 274, n. 1615, p. 1237–1243, 2007.

VASCONCELOS, H. L. Respostas das formigas à fragmentação florestal. **Série Técnica IPEF**, v. 12, n. 32, p. 95-98, 1998.

VERSIANI, N. F. **O tamanduá-bandeira (*Myrmecophaga tridactyla*) em áreas protegidas e seus entornos no Cerrado do nordeste do estado de São Paulo**. 2016. 170 f. Thesis - Faculdade de Filosofia, Ciências e Letras, Universidade de São Paulo. Ribeirão Preto, São Paulo, Brazil. 2016.

VERDADE, L. M.; PIÑA, C. I.; LYRA-JORGE, M. C. Redirections in Conservation Biology. In: VERDADE, L. M.; LYRA-JORGE, M. C.; PIÑA, C. I. eds. **Applied ecology and human dimensions in biological conservation**. New York: Springer, 2014, p. 53–71.

VYNNE, C. et al. Resource selection and its implications for wide-ranging mammals of the Brazilian Cerrado. **PLoS ONE**, v. 6, n. 12, 2011.

2. MANUSCRIPT: How does the giant anteater *Myrmecophaga tridactyla* use a landscape featuring high human disturbance and free-ranging dogs?

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ABSTRACT

In recent decades, the native landscape has been rapidly modified for human occupation and cropland. Some species were affected by these changes due to habitat loss, invasions of exotic species, roadkills and other many factors, like giant anteaters. Considering the importance of understanding how these impacts affect wildlife and the ecological requirements for the conservation of giant anteater populations, we aimed to understand which environmental characteristics influence giant anteater landscape-use in areas populated by humans and dogs. We focus specifically on an area of Cerrado and Atlantic Forest, surrounded by a mosaic of coffee plantations and pastures and close to an urban area. We also evaluated the activity pattern of the giant anteater in sites near and far from anthropogenic disturbance, and calculated its segregation from the activity patterns of dogs. We used data from 58 camera trap installed in Furnas do Bom Jesus State Park and its surroundings, located at northest São Paulo state, to model giant anteater landscape-use. To understand the effect of the presence of dogs on giant anteater landscape use, we took the frequency of dogs at each site as a covariate and also modeled dog landscape use. Our results showed that the protected area is the most important predictor, followed by open native vegetation areas, for giant anteater landscape use. We also found a positive relationship between giant anteater landscape use and frequency of dogs, but a segregation in their activity patterns, being the anteaters crepuscular-nocturnal and dogs diurnal. Human disturbance had an effect on the population of giant anteaters, resulting in a differential activity time based on the distance from the anthropized land. Giant anteaters did not avoid sites close to anthropic areas, but had only nighttime activities close to those areas, also on cold days when the temperature drops a lot at night while away from these areas on cold days the activity was higher during dusk. This work creates new avenues for understanding how this species uses areas under strong human influence, which nowadays cover large parts of the range territory of this species. Our results also reinforce the importance of strictly protected areas in maintaining giant anteaters and other species populations, recognized the strong influence of the park in the land-use by them. These findings should be considered in the development of urban expansion projects of cities near native areas.

KEY WORDS: alien species, anthropogenic disturbance, Brazilian Cerrado, Protected Area.

2.1. Introduction

Over the past century, human activities have expanded to the point of dominating some terrestrial ecosystems, especially tropical ones, with agriculture, animal grazing, infrastructure development, human settlements and urbanization, changing the land cover and reducing the native areas (MCGILL et al., 2015). The loss of native areas leads to resource scarcity for animals and changes in habitat quality, and resource availability and environmental conditions are factors in mammals populations persistence models (DINIZ; BRITO, 2015; FAHRIG, 2003). Urban expansion is also associated with an increase in roads and highways, one of the main threats to some vertebrate species, particularly for slow moving animals and those which regularly cross roads, because high volumes of traffic increases the risk of animals being hit by vehicle (COFFIN, 2007). Large mammals are generally more vulnerable to extinction due to habitat loss and vehicle collisions, because meeting their biological and ecological needs requires a large home range (CARDILLO et al., 2005; CHIARELLO, 1999; VYNNE et al., 2011).

Throughout the process of agricultural and urban expansion, humans have introduced livestock and domesticated animals into the landscape, and these animals are associated with land use changes that impact biodiversity in various ways (MCGILL et al., 2015). The most common introduced animal known in the world is the domestic dog (GOMPPER, 2013). Free-ranging domestic dogs have the potential to interact with wildlife and the consequences of this interaction are not well understood because the impacts differ according to the density of the dog population and the extent to which humans care for and control them (GOMPPER, 2013). Dogs are a potential predator and competitor of wildlife and can also be considered an edge effect in protected areas because they most frequently occupy edge areas influenced by exogenous factors, such as the density of human residences (LACERDA; TOMAS; MARINHO-FILHO, 2009; SRBEK-ARAUJO; CHIARELLO, 2008).

The giant anteater (*Myrmecophaga tridactyla* Linnaeus 1758, Mammalia: Pilosa), is one of the species which has been affected by the land-use changes (BERTASSONI et al., 2019). It is a large-sized (body mass up to 45 kg) mammal, feeds maily on ants and termites and has a low basal metabolic rate and relatively low body temperature (33ºC), which can vary from 15ºC to 36ºC due to low thermoregulatory capacity (MCNAB, 1985). Occurs in Neotropics, from Honduras to Northern Argentina and information about ecological characteristics differ between the studied populations (GAUDIN; HICKS; BLANCO, 2018) and are related to the environmental and behavioral plasticity that has been observed in the species (BRAGA, 2010; MIRANDA et al., 2006). The species seems to prefer a heterogeneous landscape, using both opened and covered native areas depending on the region where they lives and their activity timing, which can vary between seasons and according to the temperature (CAMILO-ALVES; MOURÃO, 2006; GAUDIN; HICKS; BLANCO, 2018; MOURÃO; MEDRI, 2007; QUIROGA et al., 2016). The same population studied in the Pantanal, in Brazil, for example, had different activity patterns in different seasons and daily temperatures, being mainly nocturnal in the rainy season and in the dry season its activity was closely related to the average daily temperature, being essentially diurnal on cold days (CAMILO-ALVES; MOURÃO, 2006; ROSA, 2007).

Beyond temperature requirements, environmental suitability for giant anteaters is related to the absence of anthropogenic pressures. Suitable habitats for giant anteater are in connected native vegetation patches far from areas of high human population density (BERTASSONI et al., 2019). However, giant anteaters were observed using the surroundings matrix of soybean crops and timber plantation (MIRANDA, 2004; KREUTZ; FISCHER; LINSENMAIR, 2012), but information about the use of other types of matrices is lacking and the type of matrix influences the permeability and availability of resources, such as thermal comfort and food. Although agricultural areas have lower ant and termite species richness, these areas may in fact present higher abundances of some specific species, which are adapted to disturbance (VASCONCELOS, 1998). Giant anteaters can eat a variety of species of ants and termites, and preference may be related to abundance when there is less diversity (RODRIGUES et al., 2008). Braga (2010) found *Acromyrmex* sp. between the itens consumed by giant anteaters, a typical gender found in croplands and pasture. This and other indirect founds, like roadkills near pasture with high density of ants and termites nests, indicates that giant anteater can use agricultural landscapes for foraging, crossing roads to access nests available there (FREITAS; JUSTINO; SETZ, 2014). Unpaved roads in rural and protected areas seem to be important for giant anteater movement and may be points of access to suitable habitats (VYNNE et al., 2011). São Paulo is a highly anthropized state of southest Brazil, where urbanization and agricultural expansion have largely replaced giant anteaters' native habitats, leaving only 1.6% of them within strictly protected and isolated areas (BERTASSONI et al., 2019). There are few studies of giant anteater landscape use in São Paulo and the only monitored population in this state used mostly savanna, water-related and anthropic-related areas and avoided exotic timber plantation (BERTASSONI et al., 2017; BERTASSONI; MOURÃO; BIANCHI, 2020).

Recent studies have highlighted the adaptiveness of some species in response to environmental and landscape changes, sugesting that species that currently live may not respond in the same way as individuals of populations studied when there was less impact on their habitat (MCDONNELL; HAHS, 2015; ROSALINO; VERDADE; LYRA-JORGE, 2014). A population of giant anteaters studied in a protected area within human-modified landscape selected areas near anthropogenic sites, including roads, built-up and urban areas, confirming the plasticity of habitat use by them (BERTASSONI; MOURÃO; BIANCHI, 2020). Non-evolutionary adaptive responses can also occur due to urbanization and may or may not be reversible, depending on the degree of impact and how long the response takes to develop

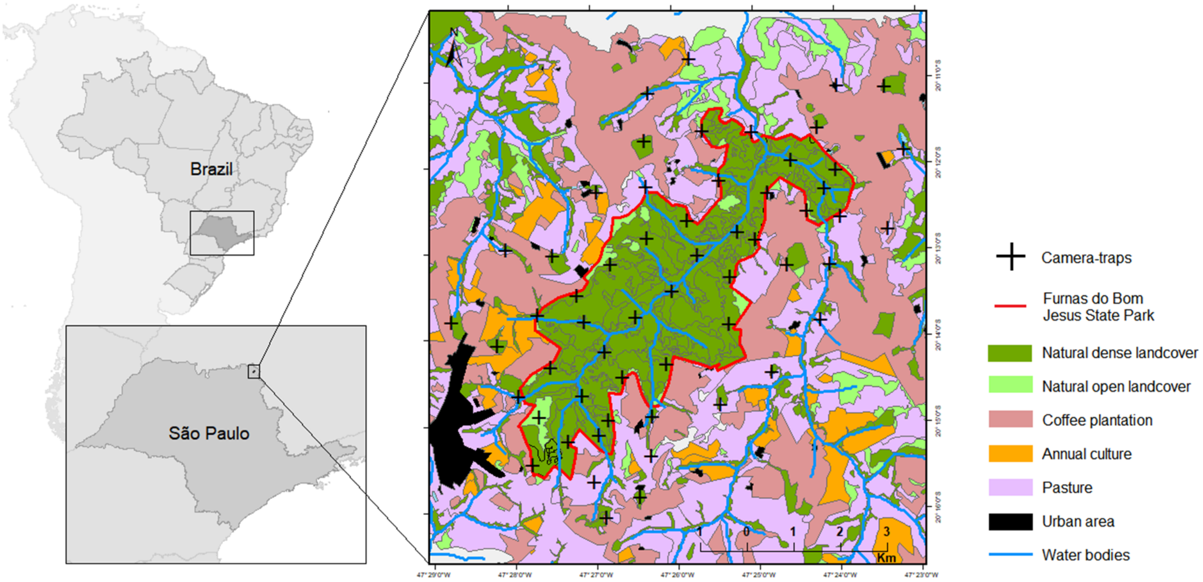
(MCDONNELL; HAHS, 2015). With this habitat loss and fragmentation, agricultural landscapes become relevant in wildlife conservation studies, as some animals can adapt to using these areas (CAMPOS; CHARTERS; VERDADE, 2018; DOTTA; VERDADE, 2011; MARTIN et al., 2012). Agricultural dominated landscapes may offer some resources but also some risks, as free-ranging dogs, thus, the species have to elect to use some areas pondering the benefits and risks. In the National Park of Brasilia, the giant anteater is considered the most susceptible species to dog attacks and seems to avoid the park's edge areas, where the occurrence of dogs is high (LACERDA; TOMAS; MARINHO-FILHO, 2009).

Our goals were to understand the giant anteater’s landscape use and activity patterns in a typical Brazilian rural landscape and the effect of free-ranging dogs and human disturbance on the anteater population. The study area comprised a protected area, containing a forest remnant and savanna, and its surrounding area composed of coffee plantation and pasture. Our predictions were that (1) giant anteaters would prefer areas near the protected area, native vegetation (savanna and forest), unpaved roads and waterbodies, and prevent pasture, coffee plantation and human disturbances (buildings construction, urban area and paved roads); (2) giant anteaters would avoid dogs, and the two species would maintain segregated landscape use and activity patterns; and (3) the activity pattern of giant anteaters would be primarily crepuscular-nocturnal, but would differ on cold and hot days and by season, according to environmental temperature.

2.2. Study area

The study area, situated in northeastern São Paulo State, Brazil, encompassed the Furnas do Bom Jesus State Park (hereafter, FBJSP; 20°11'14" to 20°16'34"S and 47°22'13" to 47°29'17" W) — a protected area covering 2,069 ha within a Brazilian Cerrado landscape — and its surroundings, comprising 4,815 ha of sampled area (Figure 1). FBJSP and the surrounding landscape is topographically rugged and dominated by the Pedregulho River basin that crosses through the center of the park. The land inside the park is characterized primarily by escarpment slopes covered with Cerrado and Atlantic Forest remnants, while the land outside the park is flat with little slope and has been mostly converted to coffee plantations and pasture lands (ESRI, 2020). In the escarpment region and the valley's riparian area, the land cover is low secondary vegetation and primary semi-deciduous seasonal forests; the higher elevations have fragments of herbaceous and shrubby savanna, grasslands and savanna *sensu stricto* (SASAKI; DE MELLO-SILVA, 2008). According to the Köppen classification, the climate is defined as tropical high (Cwb), with annual minimum, maximum and average temperatures of 13.7°C, 26.5°C and 20.1°C, respectively, and an annual average rainfall of 1,545 mm (CEPAGRI, 2016).

Figure 1. Land cover of Furnas do Bom Jesus State Park and its surroundings, located in Pedregulho, São Paulo, Brazil, and the distribution of camera traps (n=58) in the area.



Source: Prepared by author.

2.3. Methods

2.3.1. Data collection

From January to August 2017, we used unbaited camera traps (Bushnell® Trophy Cam 6.0 Mpxl and Scoutguard ® SG 550) to record the occurrence of giant anteaters and dogs at 60 sampling sites. We placed the camera traps at each intersection of a 1-km² grid extending from inside the FBJSP (n=44) to its surroundings (n=16) (Figure 1). Two of the camera traps inside the park failed, so our final sample of surveyed sites was 58. We programmed the camera traps for continuous operation (24 hours/day) and to capture three photographs per trigger event, with 10-second interval between events. We deployed camera traps for at least 60 days at each sampling point and checked camera operation every 15–20 days. We installed temperature data loggers (Novus® TagTemp) with the camera traps, programmed for continuous operation and to record data every 30 minutes. As we did not have a data logger for each camera trap, we developed a rotation system: every 15 days, we changed the location of the data loggers, so that all sites had temperature records for a 60-day period.

We generated encounter histories for giant anteaters and dogs to evaluate landscape use, recording detections and non-detections over three-day intervals. We used previous studies of the species (Appendix A) to identify environmental variables that could influence resource selection. These variables included proportions of natural covered areas (tropical forests and closed canopy savanna), natural open areas (savanna *sensu stricto*), pasture, and coffee plantations; slope; distances to water, to unpaved roads and to urban areas; distance from FBJSP; and density of human buildings (Table 1). We also included the frequency of dogs as a covariate to test whether the giant anteater avoids dogs (Table 1). As dogs may use the park as a source of food, we included prey relative abundance as a covariate. We generated the vegetation type and land use covariates using a land cover map provided by the park administration, which we verified using Sentinel-2 images (https://earthexplorer.usgs.gov/).

We summarized the proportion of each land cover metric within buffers of 100-, 250- and 500-meter radii. We also measured the linear distance between each sampling point and the closest waterbody, using the drainage system map of São Paulo State, "*Rede de Drenagem do Estado de São Paulo*" (https://www.infraestruturameioambiente.sp.gov.br/cpla/mapa-da-rede-de-drenagem-do-estado-de-sao-paulo/). We calculated the slope at each camera, using the digital elevation model "*Modelo Digital de Elevação do Estado de São Paulo*" (https://www.infraestruturameioambiente.sp.gov.br/cpla/modelo-digital-de-elevacao-mde-do-estado-de-sao-paulo/). Land cover, building density, distance from FBJSP, distance to waterbodies, and slope were estimated using ArcMap® 10.2.1 (ESRI, 2020). Distances from cameras to nearest unpaved and paved roads and to nearest urban land cover were calculated using satellite images in Google Earth Pro. The frequency of dogs was estimated by counting the number of independent records (records at 60-minute intervals) at each site, divided by the camera-trap effort of the site at which the record was obtained. Similarly, the relative abundance of prey was measured by counting the number of independent records (records at 60-minute intervals) of small- to medium-sized terrestrial mammals, reptiles and terrestrial birds (Appendix A) at each site, divided by the camera-trap effort of the site at which the record was obtained. To assess whether detectability changed seasonally, we classified sampling occasions as ordinal continuous numbers, the first occasion being 18 January 2017, numbered as 18, and the last one being 23 August 2017, numbered as 235. We also measured the mean temperature over each sampling occasion to evaluate the influence of weather on detection probability.

Table 1 - Covariates determined *a priori* for detection (p) and landscape use (Ψ or λ) of giant anteaters and dogs in the study area. The expected relationships (+ indicates a positive relationship and – indicates a negative relationship) were based on reviewed literature and on the hypothesis of this work. NA indicates that the covariate was not evaluated for the parameter in question. *Dogs were only evaluated for giant anteater landscape use. **Prey was only evaluated for dog landscape use.

(to be continued)

Covariate	**Description**	**Expected relationship (giant anteaters)**		**Expected relationship (dogs)**	
		Ψ / λ	p	Ψ / λ	p
dense500, dense250, dense100	Percentage of forestry vegetation, including deciduous/semi-deciduous/alluvial forests and closed canopy savanna inside 500-m, 250-m and 100-m radii buffers around each sampled site.	+	NA	-	NA
open500, open250, open100	Percentage of open savanna vegetation, including typical savanna, savanna *stricto sensu*, shrub savanna, open fields and Cerrado fields inside 500-m, 250-m and 100-m radii buffers around each sampled site.	+	NA	+	NA
pasture500, pasture250, pasture100	Percentage of pasture inside 500-m, 250-m and 100-m radii buffers around each sampled site.	-	NA	+	NA
coffee500, coffee250, coffee100	Percentage of coffee plantation inside 500-m, 250-m and 100-m radii buffers around each sampled site.	-	NA	+	NA
builds500, builds250, builds100	Density of buildings constructions, in square meters, inside 500-m, 250-m and 100-m radii buffers around each sampled site.	-	NA	+	NA
water	Linear distance, in meters, from each sampled site to the nearest waterbody.	-	NA	+	NA
UCdist	Linear distance, in meters, from each sampled site to the nearest edge of FBJSP. The sites inside the FBJSP had zero value.	-	NA	-	NA
urban	Linear distance, in meters, from each sampled site to urban land cover area.	+	NA	-	NA
ways	Linear distance, in meters, from each sampled site to the nearest unpaved road.	-	NA	-	NA
road	Linear distance, in meters, from each sampled site to the nearest paved road.	+	NA	+	NA
slope	Categorical index of slope, where zero corresponds to a plane ground and ten corresponds to a 90º scarp.	-	NA	-	NA
dogs*	Frequency of dogs at each site.	-	NA	NA	NA
prey**	Relative abundance of potential prey for dogs (including small unidentified mammals, repitiles and birds, *Dasyprocta azarae, Didelphis albiventris, Conepatus semistriatus, Procyon cancrívorus, Cuniculus paca, Nasua nasua, Tamandua tetradactyla, Sylvilagus brasiliensis, Euphractus sexcinctus, Cabassous sp., Dasypus sp.*). Number of independent prey records for each camera-trap, divided by the effort of the camera-trap.	NA	NA	+	NA

Table 1 - Covariates determined a priori for detection (p) and landscape use (Ψ or λ) of giant anteaters and dogs in the study area. The expected relationships (+ indicates a positive relationship and – indicates a negative relationship) were based on reviewed literature and on the hypothesis of this work. NA indicates that the covariate was not evaluated for the parameter in question. *Dogs were only evaluated for giant anteater landscape use. **Prey was only evaluated for dog landscape use.

(conclusion)

Covariate	**Description**	**Expected relationship (giant anteaters)**		**Expected relationship (dogs)**	
		Ψ / λ	***p***	**Ψ / λ**	***p***
temp	Mean temperature of each sampled occasion, represented by 3-day period.	NA	+	NA	+
day	Day of year; ordinal continuous numbers the first occasion being 18 January 2017, numbered as 18, and the last one being 23 August 2017, numbered as 235.	NA	-	NA	-

Source: Prepared by author.

To evaluate activity patterns of giant anteaters and dogs, we used the time stamp of each detection recorded by the camera traps. We counted each photographs obtained at least 60 minutes apart as independent records. To classify cold and hot seasons, we used the 3-day average temperature provided by the National Meteorology Institute (INMET). Hot season was the period from January to April and cold season from may to august. To categorize cold and hot days we used the average daily temperatures obtained from data loggers, of which hot days were days with average temperature lower than 18ºC and cold days with average temperature up to 23ºC. We obtained the minimum and maximum daily temperatures, as well as the temperature at the moment of the photographic record, from temperature data loggers from the date and site of record. In places where records were obtained in the absence of a data logger, we used the temperature record of the closest data logger installed at a site with similar environmental characteristics (vegetation, region of the study area, distance from river, distance from urban center, and slope). To discover whether the activity patterns change in the presence of human activity, we used the covariate “builds500” (density of buildings inside 500-meter buffers). We then classified the records as either inside or outside the buffers surrounding the buildings.

2.3.2. Data analysis

We used a two-stage approach to model (1) detection probabilities and (2) landscape use probabilities for giant anteaters and dogs. First we evaluated the correlation between the covariates by Spearman test, considering correlated covariates with |>0.60|. The correlated covariates was not added in the same model. To model landscape use, we used single-species single-season occupancy models (MACKENZIE et al., 2017) and single-species single-season occupancy models with heterogeneous detection (hereafter, RN models; ROYLE; NICHOLS, 2003). The model considered most adequate to describe the species' landscape use would show the best fit for both giant anteaters and dogs. We used *occu* and *occuRN* function for single-species occupancy and RN occupancy models, respectively, in *Unmarked* package (FISKE; CHANDLER, 2011) from RStudio (RSTUDIO TEAM, 2015). We ranked models based on their Akaike's Information Criterion adjusted for small sample size (AICc) and model weights (w) (BURNHAM; ANDERSON, 2002). We interpreted the top-ranked models with 0.90 cumulative w (i.e., the 90% confidence set) that did not add uninformative parameters (ARNOLD, 2010). We standardized all covariates to z-scores prior to analysis and interpreted model β coefficients as the change in the log-odds ratio relative to 1 standard deviation. We considered covariates with standard errors (SE) less than the estimated value of β coefficients to have the strongest support.

When modeling detection probabilities, we held the occupancy parameter constant (i.e., intercept only) and retained the top-ranked detection model's structure to model occupancy. For each species, we fitted the detection models with "day", "temperature" and additive combinations of those covariates for detection. Then, we fitted the univariate models with our covariates of interest for occupancy (Table 1). Additive models were generated stepwise, with uncorrelated combinations of metrics that ranked above the null (intercept only) model. The additive occupancy models for each species included various combinations of land cover variables. To check the goodness of fit, we generated a bootstrap of 10,000 repetitions to assess the overdispersion index, ĉ (MACKENZIE; BAILEY, 2004), using *mb.gof.test* function in the *AICcmodavg* package (MAZEROLLE, 2019) from RStudio (RSTUDIO TEAM, 2015). In cases of multiple models in the candidate set, we calculated model-averaged estimates of the best-ranked models, using *modavg* function in *AICcmodavg* package (MAZEROLLE, 2019).

To compare the land-use by giant anteaters and dogs and visualize if they overlapped, the predictions of landscape-use by both species were plotted on a map using the Kernel Density Estimation in ArcMap® 10.2.1 (ESRI, 2020).

For activity analysis, we first estimated the giant anteater activity patterns using the von Mises kernel density, a non-parametric estimator for circular data (RIDOUT; LINKIE, 2009; SCHMID; SCHMIDT, 2006). Second, we sought to understand if there was (a) seasonal difference in giant anteater activity patterns; (b) overlap of giant anteater activity patterns with the minimum and maximum daily temperatures; (c) temporal segregation between giant anteaters and dogs; and (d) differences between the giant anteater activity patterns near and distant from humans presence. To answer these questions, we estimated the overlap of activity patterns using the overlap coefficient (Δ) as well as the same von Mises kernel density estimator from the first step. The overlap coefficient (Δ) is a value ranging from 0 to 1 and is defined as the area under the curve, formed by taking the smaller of two density functions at each time point (RIDOUT; LINKIE, 2009). All activity analyses were made using the package *Overlap* (MEREDITH; RIDOUT, 2018) from RStudio (RSTUDIO TEAM, 2015). We inferred human activity considering the 500-m radius buffer, with and without human-built constructions, and the distance from unpaved roads, as these roads are used by humans mostly during business hours (6 a.m. to 6 p.m.).

2.4. Results

The camera-trap surveys resulted in a total sampling effort of 4,699 trap-days and 151 records of giant anteaters, of which 104 were from inside the FBJSP and 47 from outside. We obtained 85 records of dogs, 50 inside and 35 outside the FBJSP and 1888 records of prey, 737 inside and 1158 outside the park, resulting in a 0.41 prey/trap-night. Our 58 camera traps detected giant anteaters at 42 sites and dogs at 28 sites, resulting in 72% and 48% naïve occupancy, respectively. We recorded 37 sequences dog-anteater, 5 in “Furnas”, 27 in “Edge” and 5 in the “Surroundings”; and, 10 records of dog-tayra sequences, 3 in “Furnas”, 6 in “Edge” and 1 in “Surroundings”.

Twenty-two correlations were observed (Appendix B); thus, these covariates were not combined in the additive models. In the single-species single-season models for giant anteaters, beginning with the global model, the goodness of fit showed a high overdispersion ($\hat{c}$ =41.78, p=0.003), making it impossible to adjust the models by QAICc. We fitted subglobal models to investigate whether the overdispersion was caused by overparameterization, but all of them also showed high overdispersion. For detection, only the model with temperatures and days converged and was ranked better by AICc (Appendix C). Six occupancy models converged and were ranked by AICc, but distance from unpaved roads was the only occupancy covariate for which the confidence interval did not exceeded the β-value (β= -0.72±0.38); therefore, we could not match covariates to create other models. The top-ranked model suggested that giant anteater landscape use decreases with increasing distance from unpaved roads, i.e., their landscape use is higher near unpaved roads.

For the giant anteater, RN models had a good fit ($\hat{c}$=0.02, p=0.18). For detection, day of year was the top-ranked occupancy model (Appendix D) and showed decreasing detection of giant anteater throughout the year (β= -0.74±0.12). Among the top-ranked landscape use models, a total of 44 models converged and were better than the intercept-only model (Appendix D).

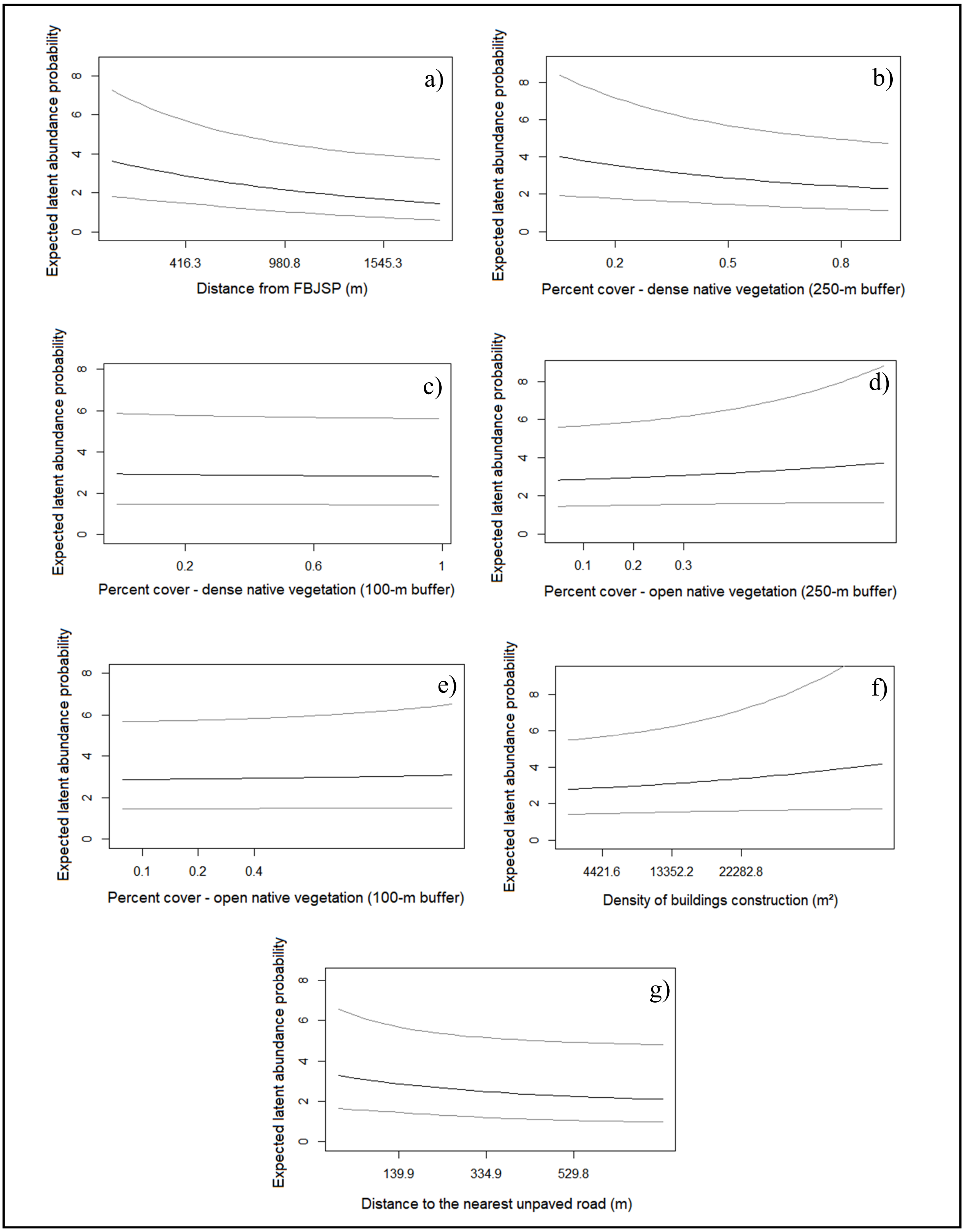
Distance from FBJSP had the highest weight in all the models that included it (ΣAICcWt = 0.68, Table 2), showing a decrease in landscape use as the distance from FBJSP increased (β= -0.43±0.16, Figure 2.a.). Giant anteaters also used dense native vegetation areas less frequently (β = -0.45±0.14 for 250-m radius and β = -0.23±0.12 for 100-m radius; Figure 2.b and 2.c, respectively) and used open native vegetation areas more frequently (β = 0.15±0.07 for 250-m radius and β = 0.11±0.08 for 100-m radius; Figure 2.d and 2.e, respectively). The anthropogenic covariates also appeared in the top-ranked models. Giant anteaters showed increased landscape use near buildings (β= 0.24±0.11 for 500-m radius; Figure 2.f) and unpaved roads (β= 0.54±0.22; Figure 2.f), and they seemed to use sites also frequented by free-ranging dogs (β= 0.17±0.08; Figure 3).

Table 2 - Summation of covariate AICc cumulative weights at 90% confidence and the relationship with giant anteater landscape use.

Covariate	Summation of AICc Cumulative weights (90%)	Relation
Ucdist	0.6819	-
Dogs	0.4807	+
ways	0.3649	+
dense250	0.3564	-
builds500	0.2277	+
open250	0.2001	+
slope	0.1168	+
open100	0.0726	+
dense100	0.0444	-
pasture100	0.0386	+

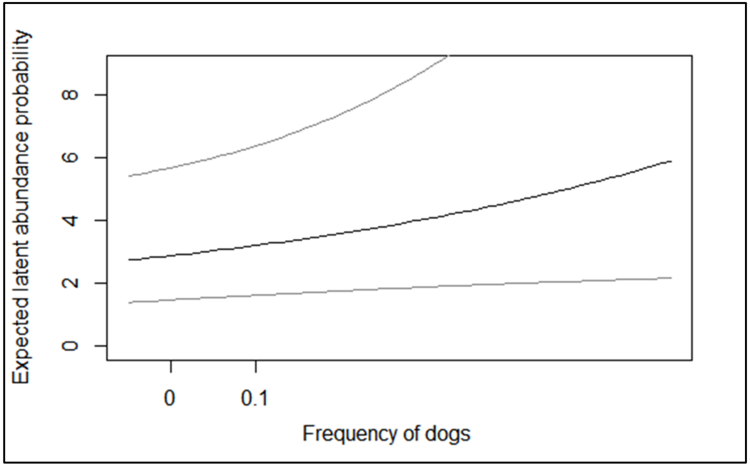
Source: Prepared by author.

Figure 2 - Expected latent abundance probabilities based on the average of giant anteater RN models (AICc cumulative weight up to 90%) as a function of (a) distance from FBJSP; (b) percent cover of dense native vegetation in 250-m buffer; (c) percent cover of dense native vegetation in 100-m buffer; (d) percent cover of open native vegetation in 250-m buffer; (e) percent cover of open native vegetation in 100-m buffer; (f) density of buildings in a 500-m buffer; and (g) distance to the nearest unpaved road. Here, the expected latent abundance probability is interpreted as landscape use. Study conducted using camera traps in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017.



Source: Prepared by author.

Figure 3 - Expected occupancy probability of giant anteater in the best single-species single-season occupancy model as a function of frequency of dogs. Here, the expected occupancy probability is interpreted as landscape use. Study conducted using camera traps in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017.



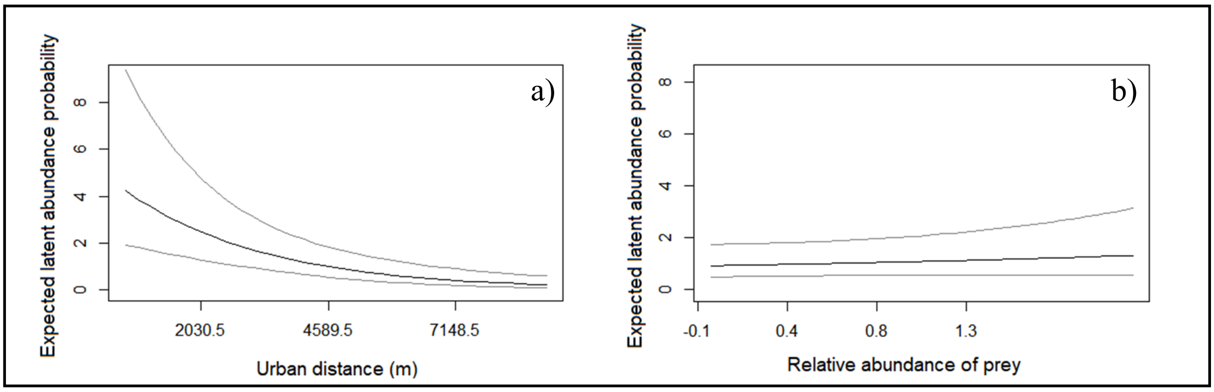
Source: Prepared by author.

For dogs, the single-species single-season model also had a strong fit (ĉ was higher than 1000, p=0), and no model converged. Then, we modeled dog occupancy using the RN model.

The RN model fitted well with a ĉ-value of 1.8 (p=0.007), so we adjusted the ranked models by QAICc. The detection modeling showed day of year as an important covariate with negative influence (QAICc weight= 0.39; β = -0.17, SE = 0.14; Appendix E), with almost the same weight as the best-ranked intercept-only (null) model (QAICc weight= 0.29; β = -2.92, SE = 0.22; Appendix E); therefore, we estimated occupancy with both null detection and day of year.

Four models ranked better than the null model. Distance to urban area was present in all the models with some QAICc weight (β = -0.94; SE= 0.21; Appendix E, Figure 4.a.), showing a negative relationship with dog landscape use; in other words, dogs use areas near the urban perimeter more frequently. Prey appeared as the second most important covariate for dogs, with positive influence (β = 0.14; SE= 0.11; Appendix E, Figure 4.b.).

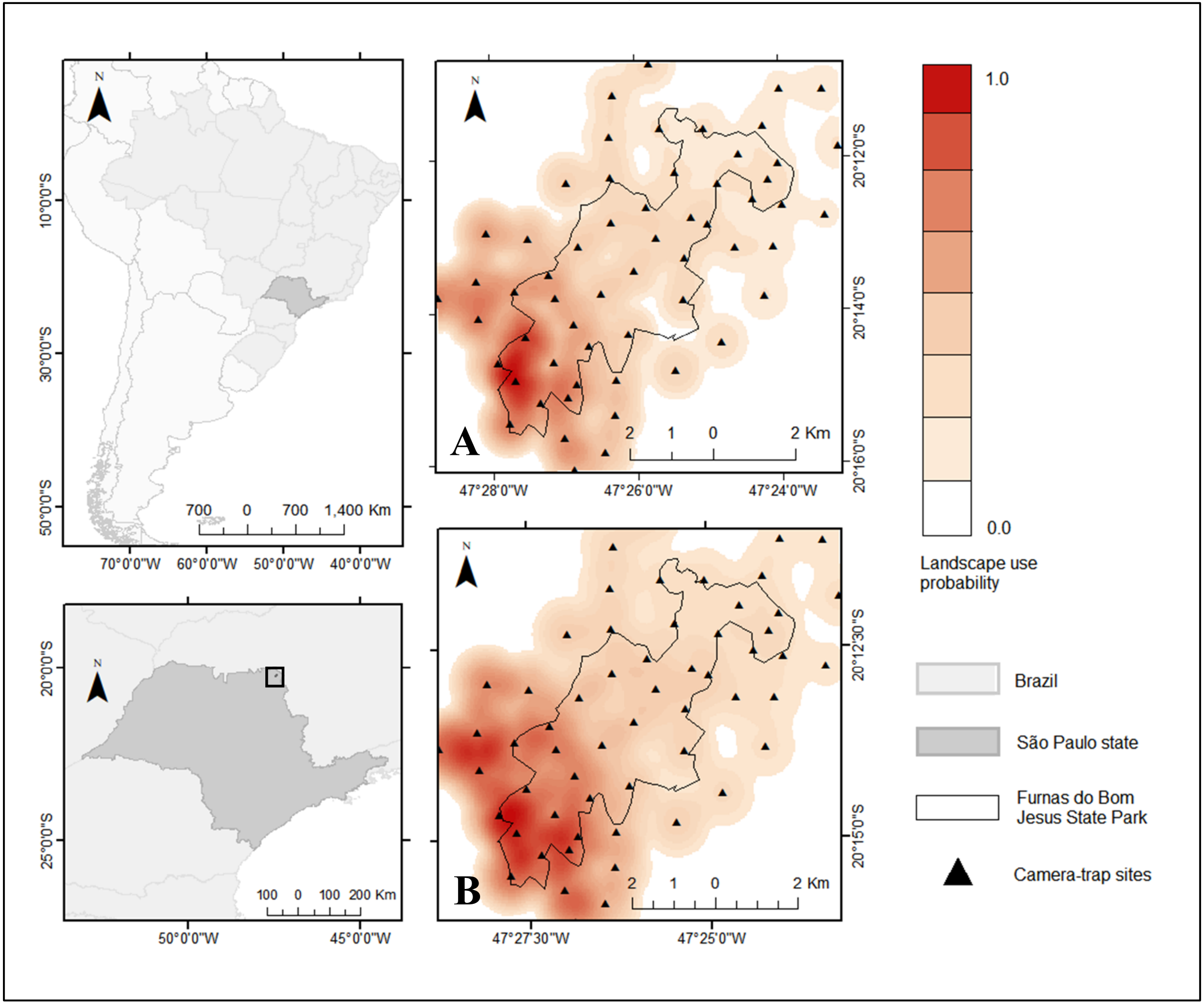
Figure 4 - Expected latent abundance probability of the best dog RN model as a function of (a) urban distance and (b) relative abundance of prey. Here, the expected latent abundance probability is interpreted as landscape use. Study conducted using camera traps in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017.



Source: Prepared by author.

The prediction map showed high overlap between the landscape-use by giant anteaters and dogs (Figure 5), suggesting they use frequently the same area.

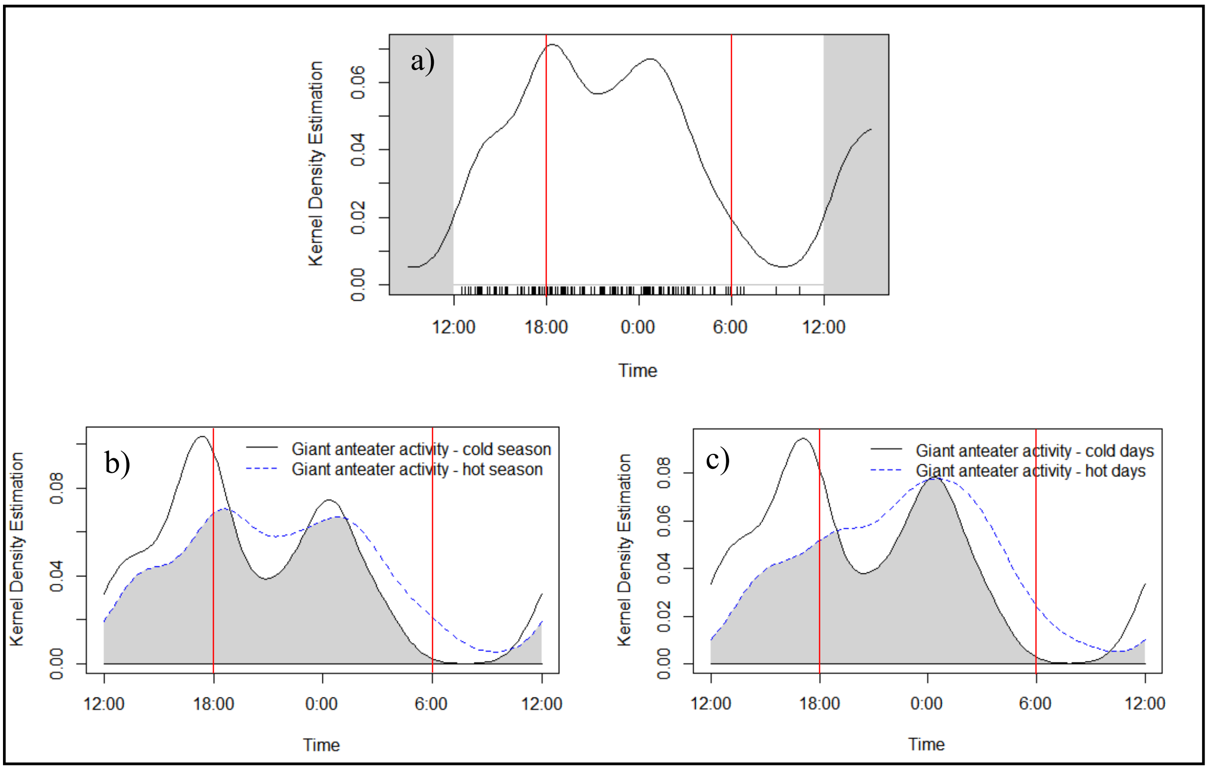
Figure 5 - Landscape use predictions for (A) giant anteaters and (B) dogs, according to data recorded by camera traps in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017.



Source: Prepared by author.

The giant anteater showed a crepuscular-nocturnal activity pattern (Figure 6.a). There was a high overlap between the giant anteater activity patterns in the cold and hot seasons (Δ=0.74, IC= -0.66 +0.93; Figure 6.b), on both the hottest and coldest days (Δ= 0.69, IC= -0.57 +0.90; Figure 6.c).

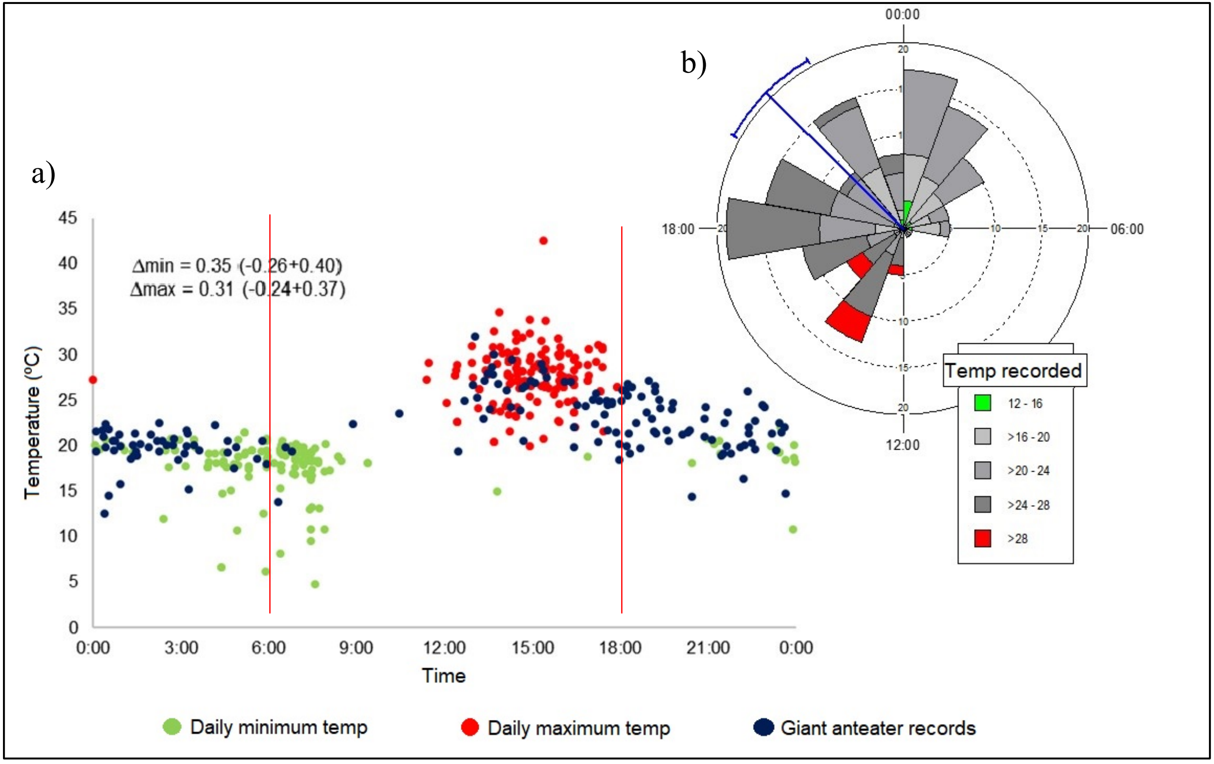
Figure 6 - Kernel Density estimation of giant anteaters activity patterns (a) throughout the study period, (b) separately in cold and hot seasons, and (c) on the hottest (average temp. > 23°C) and coldest days (average temp. <15°C). Study conducted using camera traps in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017. Red lines indicate the average time of sunset and sunrise in the sampling period.



Source: Prepared by author.

The temperatures over the study period ranged from 3.8ºC to 42ºC, but the minimum and maximum temperatures associated with giant anteater detection were 12.6ºC and 32ºC, respectively. This suggests that the majority of anteater activity occurred after the daily maximum temperature, with little overlap of the maximums (Δmax = 0.31, IC= -0.24 +0.37; Figure 7), and before the daily minimum temperature, with little overlap of the minimums (Δmin = 0.35, IC= -0.26 +0.40; Figure 7).

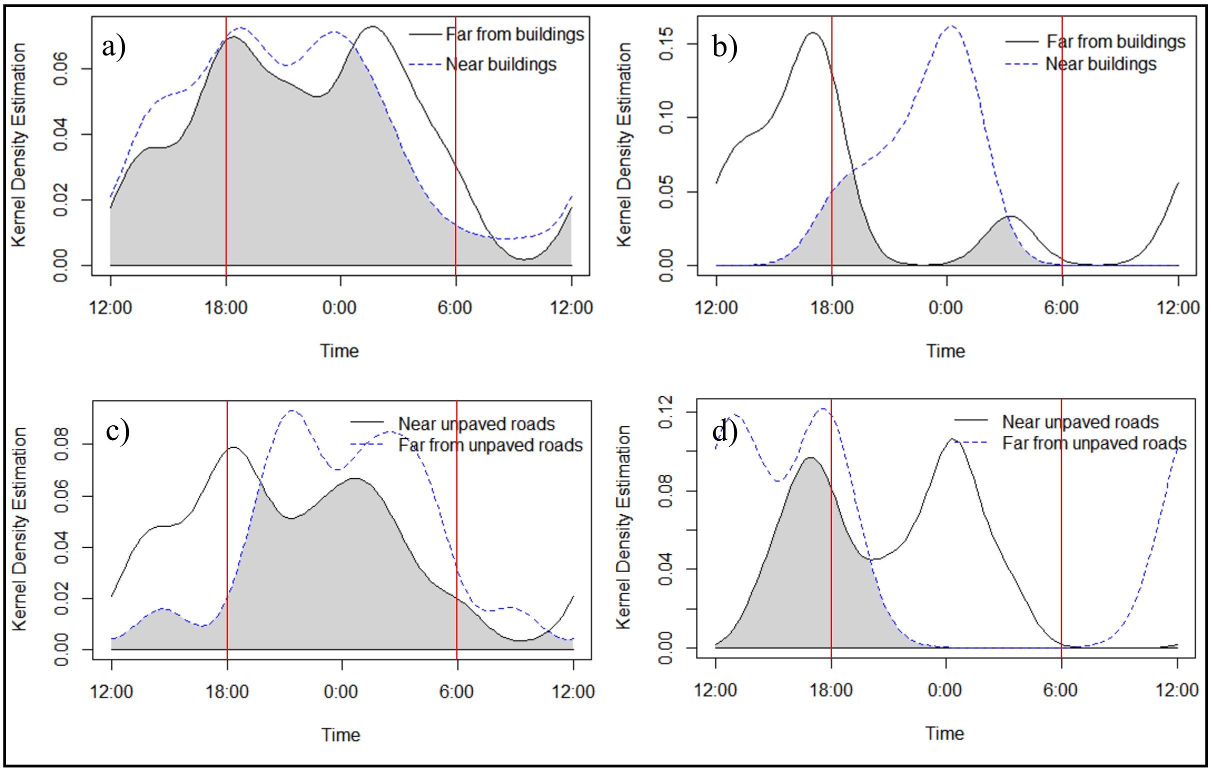
Figure 7 - Relationship between activity time and temperature, where (a) indicates the giant anteater activity patterns and its relationship with the minimum and maximum daily temperature, and (b) the association between the time of giant anteater records and the temperature recorded at the moment of the record. The photo and temperature records were obtained with camera traps and dataloggers, respectively, in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017. Red lines indicate the average time of sunrise and sunset in the sampling period.



Source: Prepared by author.

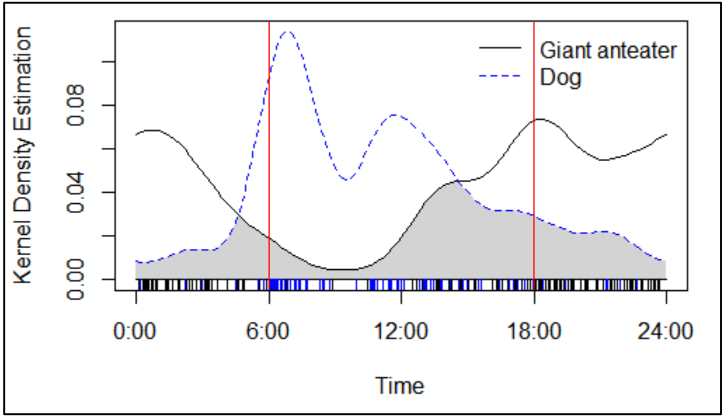
Giant anteaters showed both a crepuscular and nocturnal activity pattern during the hot season, both near and far from buildings (Δ=0.82, IC= +0.94 -0.77; Figure 8.a). In the cold season, however, their activity was only crepuscular in areas far from buildings and nocturnal in areas near buildings (Δ=0.25, IC= +0.53 -0.02; Figure 8.b). The same pattern was observed in areas near and far from unpaved roads in both the hot season (Δ=0.67, IC= +0.83 -0.53; Figure 8.c) and cold season (Δ=0.46, IC= +0.76 -0.18; Figure 8.d). Dogs had a diurnal activity pattern and low overlap with giant anteater activity at dawn and twilight (Δ=0.49, IC= +0.58 -0.37, Figure 9).

Figure 8 - Overlap estimation of giant anteaters near and far from buildings in (a) hot season and (b) cold season; and near and far from unpaved roads in (c) hot season and (d) cold season. Red lines indicate the average time of sunset and sunrise in the sampling period. Study conducted using camera traps in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017.



Source: Prepared by author.

Figure 9. Overlap estimation between giant anteater and dog activity patterns in Furnas do Bom Jesus State Park and its surroundings, São Paulo, Brazil, from January to August 2017. Red lines indicate the average time of sunrise and sunset in the sampling period.



Source: Prepared by author.

2.5. Discussion

This study provides the first information about the giant anteater population of FBJSP and its surroundings. We found a high naïve occupancy of giant anteaters inside and near

FBJSP, having detected the giant anteater in almost the entire study area. Our measured covariates did not model detection heterogeneity, and probably caused the overdispersion in the single-species single-season model, indicating the model's lack of fit. Therefore, we considered the single-species model as unsuitable for making inferences about giant anteater landscape use. The RN occupancy model had better fit, showing a heterogeneous abundance of giant anteaters among the sampled sites (ROYLE; NICHOLS, 2003).

The most supported covariate for giant anteater was distance from the FBJSP, validating the importance of protected areas for the population studied here. A study conducted in twenty patches of remnant Cerrado in São Paulo State showed that, at the regional scale, the native patch size and the percent cover of native vegetation were the most important covariates for giant anteater occurrence (ZANIRATO, 2017). These results evidence the effectiveness of protected areas in maintaining populations. Well-managed protected areas reduce rates of habitat loss and maintain species population levels better than other management approaches, particularly for threatened species (BUTCHART et al., 2012; GELDMANN et al., 2013). However, within protected areas in São Paulo, only 13.1% of the landscape constitutes suitable habitat for the giant anteater, and only 1.6% of this habitat is in the strictly protected category (BERTASSONI et al., 2019).

The FBJSP is characterized mainly by forests and closed canopy savanna, and the giant anteater is present throughout the entire area. Yet despite that, the prediction of the species' landscape use showed greater usage of the few open native vegetation areas available in the study area, mostly at the edge of the park, and less usage of the dense native areas, which lie mostly in the protected area's interior. The same positive relationship with open native vegetation was observed in other Cerrado areas (BRAGA, 2010; BERTASSONI et al., 2017; MIRANDA, 2004; VERSIANI, 2016), in a savanna area of Amazonia (MACEDO, 2008), and in the Pantanal (DESBIEZ; MEDRI, 2010; MOURÃO; MEDRI, 2007). The Cerrado is the most important Brazilian domain for giant anteater conservation and is home to probably the largest fraction of the species' population (MIRANDA et al., 2015). The Cerrado domain in São Paulo State (which includes not only savannas but also riparian forests and closed canopy formations RIBEIRO; WALTER, 2008) currently comprises less than 7% of its original coverage and has been divided into small patches (DURIGAN; SIQUEIRA; FRANCO, 2007). Within these remaining Cerrado patches, savannas habitats compose a small percentage of the landscape. The expansion of monocultures has converted savanna habitats into agricultural landscapes and diminished the environmental suitability for the species (BERTASSONI et al., 2019). The giant anteater's dependence on open native vegetation and protected areas underscores the importance of preserving them, and especially savanna remnants, to support the species' conservation.

We found a positive relation between giant anteater landscape use and some anthropogenic covariates. The species frequently used areas near buildings and unpaved roads. These results are worrisome from the conservation viewpoint, because vehicle collisions, habitat fragmentation and hunting are the major threats to giant anteater populations (MIRANDA et al., 2015). Landscape use near anthropogenic areas might be related to movement between suitable habitat areas, since the urban area of Pedregulho lies between the park and other areas that are apropriate for giant anteaters. Land-use changes associated with agriculture and urbanization force wildlife to move into or around these anthropized areas, putting pressure on giant anteater populations (BERTASSONI et al., 2019). At Emas National Park, roads were an important covariate showing negative influence on the giant anteater; however, when combined with non-cropland, roads had a positive effect (VYNNE et al., 2011). This probably occurred because giant anteaters used dirt roads to move between croplands, a behavior that may have been revealed had paved and unpaved roads been treated as two distinct covariates. Giant anteaters were observed using unpaved roads in animal GPS-monitoring and studies in which camera traps were placed both on and off unpaved roads (BRAGA, 2010; VERSIANI, 2016). FBJSP is surrounded by unpaved roads and crossed by firebreaks, both of which may facilitate access to areas containing important resources such as ant and termite nests. A long-term study that monitored a large area, including our study area as well as Serra da Canastra National Park, showed that giant anteater roadkills were related to open native areas and had a negative relationship with traffic volume (FREITAS; JUSTINO; SETZ, 2014). The authors found that giant anteater's killed on road were associated with foraging sites, since termitaries or ant nests were present adjacent to all the roadkill sites, showing signs of feeding (FREITAS; JUSTINO; SETZ, 2014).

Taking all the covariates together, we found that giant anteaters used mostly the edge of the FBJSP (Figure 5). The positive relationship between landscape use and slope supports the frequent use of the park's edge, where the escarpments skirt the park, parallel to the edge. The edge features the characteristics most important for giant anteater use (i.e. proximity to protected area, open savanna), and it has a high number of unpaved roads that allow movement between the park and other protected areas within farms (i.e. Legal Reserves and Permanent Protected Areas) and grasslands.

Unexpectedly, the frequency of free-ranging dogs showed a positive relationship with giant anteater landscape use. Dogs are considered a significant threat to wildlife communities, because they often occur in high abundances and are free-ranging, interacting with wildlife as predators, prey, competitors or disease vectors (GOMPPER, 2014; HUGHES; MACDONALD, 2013; VANAK; GOMPPER, 2009). Although free-ranging dogs are considered among the major threats to giant anteater populations (MIRANDA et al., 2015) giant anteaters are not preventing places with the presence of dogs. In some communities, giant anteaters are recognized by the local community as a threat to people and dogs (BERTASSONI, 2012), which generates avoidance by the species, and are sometimes killed by poachers (KOSTER, 2008). While giant anteater hunting has never been reported for the FBJSP region, it has for other areas of São Paulo State (BERTASSONI et al., 2017). Usually, free-ranging dogs attack small- to medium-sized mammals, but they are able to kill a giant anteater when they attack as a group.

The landscape use model for dogs showed proximity to urban areas and relative abundance of prey as the only important covariates. When plotted on a map (Figure 5), the predicted distribution of dog landscape use was almost the same as that of the giant anteater (though probably for different reasons). This overlap is explained by the fact that the largest portion of savanna *stricto sensu* is at the edge of the FBJSP and is near to the urban area (Figure 1). In addition to having the only patches of open savanna, the edge and surroundings of FBJSP are also plains favorable to agriculture and residential development. Dogs probably use this anthropized area in search for shelter and food, since, unlike wild predators, they depend not only on wild prey but also on human-provided resources (VANAK; GOMPPER, 2009). Yet, while the same area may provide the giant anteaters with savanna habitat, termitaries and ant nests, and a means of thermoregulation, its proximity to such a high-risk environments reduces its environmental suitability (BERTASSONI et al., 2019).

Brasília National Park is unlike FBJSP in that the availability of open native vegetation is high inside the park, and, the giant anteater is therefore able to avoid the edge areas, where the probability of dog occurrence is high (LACERDA; TOMAS; MARINHO-FILHO, 2009). In the FBJSP, however, the giant anteaters' need for open areas seems to outweigh the threats they could encounter in the park's edge areas. Another hypothesis for the spatial overlap between giant anteaters and dogs is that, once no attacks have been reported for the area, the dogs here may not be as aggressive as in other areas. Dogs showed no influence on mesocarnivores in FBJSP (BIANCHI et al., 2020), and this seems to be happening with giant anteaters too. However, our understanding of how dogs interact with these mammals is still poorly developed.

Giant anteaters showed a crepuscular-nocturnal activity pattern that did not differ between seasons and hot or cold days. Greater activity occurred during mild temperatures and was lower during extreme temperatures (Figure 7). The amplitude of daily environmental temperature was high, with hottest temperatures occurring between 12 noon and 6 p.m., when giant anteaters were least activity, and the coldest occurring between 3 a.m. and 8 a.m., a period of reduced activity. We observed some indication of adjustment in activity as a function of temperature on the coldest and hottest days. There was some displacement of activity between the season evaluated. There was a slight increase in activity during the morning on hot days that reflected on hot season (also called rainy season) and a peak in late afternoon which only occurred on cold days, consequently, on cold season (also called dry season) (Figure 6.a. and 6.b.). On cold days, when the average temperature dropped by up to 10ºC, giant anteaters were recorded more frequently at sunset, when temperatures were still close to the maximum. Giant anteaters probably change their activity to take advantage of more comfortable temperatures.

This is the first study to evaluate the influence of environmental temperature on the activity pattern of giant anteaters, using camera traps. The activity of Xenarthra is closely correlated with environmental temperature because of their low thermoregulatory capacity (MCNAB, 1985). Studies that monitored giant anteaters in the Pantanal— where the climatic conditions differ greatly between dry and rainy seasons, and the thermal amplitude can range from 0ºC to 48ºC— showed that their body temperature oscillated according to the environmental temperature (ROSA, 2007), and they changed their habitat use (in covered and open areas) and activity pattern in response to climatic conditions (CAMILO-ALVES; MOURÃO, 2006; MOURÃO; MEDRI, 2007; ROSA, 2007). Although covered areas were used less often, they were an important habitat on days with extreme temperatures (MOURÃO;

MEDRI, 2007; ROSA, 2007). Therefore, heterogeneous environments seem necessary for the maintenance of body temperature in giant anteaters.

Predictions of giant anteater activity differed for areas near and far from buildings and unpaved roads only in the cold season (Figure 9.b. and 9.d.). We expected that, on cold days, when the average environmental temperature drops below 15ºC at night, anteater activity would be strictly crepuscular. However, their activity was in fact more nocturnal near anthropized sites such as houses, farms and industrial areas, while crepuscular activity occurred far from buildings, spiking at around 5 p.m. (Figure 9.b.). A similar displacement was observed near and far from unpaved roads (Figure 9.d.). This may indicate anthropic disturbance and the giant anteater's avoidance of interactions with humans. Urbanization poses a serious threat to wildlife populations, including the giant anteater, that inhabit native vegetation remnants surrounded by the expanding urban and suburban sprawl (DINIZ; BRITO, 2013). Urban expansion, as an edge effect, is a significant factor in wildlife population decline (WOODROFFE; GINSBERG, 1998), and the city of Pedregulho is located only about one kilometer from the site used most by the giant anteater.

Although landscape use of giant anteaters and dogs overlapped, the activity patterns evidenced substantial segregation. Giant anteaters had crepuscular-nocturnal activity, whereas dogs were diurnal (Figure 8). The models predicted some overlap at dusk, declining at night when giant anteaters initiate their activity. This probably occurred because dogs are generally active when humans are (BIANCHI et al., 2020), between 6 a.m. and 6 p.m. However, some dogs were free-ranging strays, which may explain why some dogs were recorded at dusk. The landscape use analysis showed prey as weak influence on dogs' use, suggesting that free-ranging strays dogs maybe prey on some native and alien vertebrates living in the park. This is a problem if they compete compete for food resources with the carnivores native to the FBJSP (VANAK; GOMPPER, 2009). In some places, mammals showed altered activity patterns and lower abundance in sites where dogs were present, than in sites where they were not (ZAPATA-RÍOS; BRANCH, 2016). The segregation of activity patterns observed here could be attenuating the pressure dogs put on the giant anteater population, since there are probably few antagonistic encounters even though they use the same environments (ZAPATA-RÍOS; BRANCH, 2016). Furthermore, considering the landscape use and activity pattern results, thermoregulation seems to be highly important to giant anteaters, driving their continued use of these open areas despite the presence of dogs (CAMILO-ALVES; MOURÃO, 2006; VYNNE et al., 2011).

2.6. Conclusions

Our findings support the importance of "Furnas do Bom Jesus" State Park and its few patches of savanna *sensu stricto* for the giant anteater population that lives there. We also highlight the importance of considering these findings in the planning of urban expansion projects for Pedregulho, because the city is very close to the areas considered suitable for giant anteaters. Management plans for the area should also consider the high density of free-ranging dogs, which occur throughout the protected area and can prey on native species and compete with native predators. The differences observed in the giant anteater's activity patterns near anthropized environments may be evidence of anthropogenic pressure on the population. The species' activity pattern is closely related to ambient temperature, but it is also influenced by human presence, avoiding places at times when encounters with humans are likely.

2.7. Acknowledgments

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3. FINAL CONSIDERATIONS

Our findings support the importance of Protected Areas for giant anteater conservation, particularly those with savanna habitats in São Paulo State, which is the highest anthropized state in Brazil. We also highlight the importance of considering these findings in the planning of urban expansion projects situated close to native areas, particularly those that are unprotected, as the majority of areas suitable for giant anteaters are not protected. The giant anteater seems to change its behavior near anthropized environments and places of human activity, which may be evidence of human pressure on the population. The species' activity pattern is closely related to ambient temperature, but it is also influenced by human presence, avoiding places at times when encounters with humans are likely. Management plans for the area should also consider the high density of free-ranging dogs, which occur throughout the protected area, can prey on native species and compete with native predators. We recommend that future studies model the interaction between giant anteaters and dogs to better understand how anteater populations are affected by, and respond to, this pressure.

REFERENCES

ARNOLD, T. W. Uninformative Parameters and Model Selection Using Akaike's Information Criterion. **The Journal of Wildlife Management**, v. 74, n. 6, p. 1175–1178, 2010.

BERTASSONI, A. Perception and Popular Reports About Giant Anteaters (*Myrmecophaga tridactyla* Linnaeus, 1758) by Two Brazilian Traditional Communities. **Edentata**, v. 13, n. 1, p. 10–17, 2012.

BERTASSONI, A. et al. Movement patterns and space use of the first giant anteater (*Myrmecophaga tridactyla*) monitored in São Paulo State, Brazil. **Studies on Neotropical Fauna and Environment**, v. 52, n. 1, p. 68–74, 2017.

BERTASSONI, A. et al. Land-use changes and the expansion of biofuel crops threaten the giant anteater in southeastern Brazil. **Journal of Mammalogy**, v. 100, n. 2, p. 435–444, 2019.

BIANCHI, R. C. et al. Dog activity in protected areas: behavioral effects on mesocarnivores and the impacts of a top predator. **European Journal of Wildlife Research**, v. 66, n. 3, 2020.

BRAGA, F. G. **Ecologia e comportamento de tamanduá-bandeira *Myrmecophaga tridactyla* Linnaeus, 1758 no município de Jaguariaíva, Paraná**. 2010. 104 f. Thesis – Universidade Federal do Paraná. Curitiba, Paraná, Brazil. 2010.

BREITENMOSER, U.; BREITENMOSER-WÜRSTEN, C.; BOITANI, L. Assessing conservation status and units for conservation. In: BOITANI, L.; POWELL, L. A. eds. **Carnivore Ecology and Conservation: A Handbook of Techniques**. New York: Oxford Press, 2012, p. 362–378.

BURNHAM, K. P.; ANDERSON, D. **Model Selection and Multimodel Inference: A Practical Information-theoretic Approach**. 2. ed. New York: Springer-Verlag, 2002.

BUTCHART, S. H. M. et al. Protecting Important Sites for Biodiversity Contributes to Meeting Global Conservation Targets. **PLoS ONE**, v. 7, n. 3, e32529, doi:10.1371/journal.pone.0032529, 2012.

CAMILO-ALVES, C. S. P.; MOURÃO, G. M. Responses of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) to variation in ambient temperature. **Biotropica**, v. 38, n. 1, p. 52-56, 2006.

CAMPOS, C. B. et al. Diet of free-ranging cats and dogs in a suburban and rural environment, south-eastern Brazil. **Journal of Zoology**, v. 273, n. 1, p. 14-20, 2007.

CARDILLO, M. et al. Multiple causes of high extinction risk in large mammal species. **Science**, v. 309, n. 5738, p. 1239-1241, 2005.

CEPAGRI. **Clima dos municípios paulistas**. Available in: <http://www.cepagri.unicamp.br/outras-informacoes/clima-dos-municipios paulistas.html>. Downloaded on: . 10 November 2018.

CHIARELLO, A. G. Effects of fragmentation of the Atlantic forest on mammal communities in south-eastern Brazil. **Biological Conservation**, v. 89, n. 1, p. 71–82, 1999.

COFFIN, A. W. From roadkill to road ecology: A review of the ecological effects of roads. **Journal of Transport Geography**, v. 15, n. 5, p. 396–406, 2007.

DESBIEZ, A. L. J.; MEDRI, Í. M. Density and habitat use by Giant Anteaters (*Myrmecophaga tridactyla*) and Southern Tamanduas (*Tamandua tetradactyla*) in the Pantanal Wetland, Brazil. **Edentata**, v. 11, n. 1, p. 4–10, 2010.

DINIZ, M. F.; BRITO, D. Threats to and viability of the giant anteater, *Myrmecophaga tridactyla* (Pilosa: Myrmecophagidae), in a protected cerrado remnant encroached by urban expansion in central Brazil. **Zoologia**, v. 30, n. 2, p. 151–156, 2013.

DINIZ, M. F.; BRITO, D. Protected areas effectiveness in maintaining viable giant anteater (*Myrmecophaga tridactyla*) populations in an agricultural frontier. **Natureza e Conservação**, v. 13, n. 2, p. 145–151, 2015.

DURIGAN, G.; SIQUEIRA, M. F.; FRANCO, G. A. D. C. Threats to the Cerrado remnants of the State of São Paulo, Brazil. **Scientia Agricola**, v. 64, n. 4, p. 355–363, 2007.

ESRI. **ArcMap | Documentation**. Available in: <https://desktop.arcgis.com/en/arcmap/>. Downloaded on: 10 may 2020.

FAHRIG, L. Effects of Habitat Fragmentation on Biodiversity. **Annual Review of Ecology, Evolution, and Systematics**, v. 34, n. 1, p. 487–515, 2003.

FISKE, I. J.; CHANDLER, R. B. Unmarked: An R Package for Fitting Hierarchical Models of Wildlife Occurrence and Abundance. **Article in Journal of statistical software**, v. 43, 2011.

FREITAS, C. H.; JUSTINO, C. S.; SETZ, E. Z. F. Road-kills of the giant anteater in south-eastern Brazil: 10 years monitoring spatial and temporal determinants. **Wildlife Research**, v. 41, n. 8, p. 673-680, 2014.

GAUDIN, T. J.; HICKS, P.; BLANCO, Y. *Myrmecophaga tridactyla* (Pilosa: Myrmecophagidae). **Mammalina Species,** v.50, n. 956, p. 1-13, 2018.

GELDMANN, J. et al. Effectiveness of terrestrial protected areas in reducing habitat loss and population declines. **Biological Conservation**, v. 161, p. 230-238, 2013.

GOMPPER, M. E. **Free-ranging dogs and wildlife conservation**. 1. ed. Oxford: Oxford University Press, 2013.

HUGHES, J.; MACDONALD, D. W. A review of the interactions between free-roaming domestic dogs and wildlife. **Biological Conservation.** v. 157, p. 341-351, 2012.

KOSTER, J. M. Giant Anteaters (*Myrmecophaga tridactyla*) killed by hunters with dogs in the Bosawas Biosphere Reserve, Nicaragua. **The Southwestern Naturalist**, v. 53, n. 3, p. 414–416, 2008.

KREUTZ, K.; FISCHER, F.; LINSENMAIR, K. E. Timber plantations as favourite habitat for giant anteaters. **Mammalia,** v. 76, p. 137-142, 2012.

LACERDA, A. C. R.; TOMAS, W. M.; MARINHO-FILHO, J. Domestic dogs as an edge effect in the Brasília national park, Brazil: Interactions with native mammals. **Animal Conservation**, v. 12, n. 5, p. 477–487, 2009.

MACEDO, L. S. M. **Área de vida, atividade, uso de habitat e padrões hematológicos de tamanduá-bandeira (*Myrmecophaga tridactyla*, Linnaeus 1758) nas savanas peruibanas de Boa Vista, Roraima**. 2008. 85 f. Thesis (Master's Degree) – Universidade Federal de Roraima. Boa Vista, Roraima, Brazil. 2008.

MACKENZIE, D. I. et al. **Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence**. 2. ed. Oxford: Elsevier, 2017.

MACKENZIE, D. I.; BAILEY, L. L. Assessing the fit of site-occupancy models. **Journal of Agricultural, Biological, and Environmental Statistics**, v. 9, n. 3, p. 300–318, 2004.

MAZEROLLE, M. J. **Package "AICcmodavg": Model Selection and Multimodel Inference Based on (Q)AIC(c)**, 2019.

MCDONNELL, M. J.; HAHS, A. K. Adaptation and adaptedness of organisms to urban environments. **Annual Review of Ecology, Evolution, and Systematics**, v. 46, p. 261–80, 2015.

MCGILL, B. J. et al. Fifteen forms of biodiversity trend in the Anthropocene. **Trends in Ecology & Evolution**, v. 30, n. 2, p. 104–113, 2015.

MCNAB, B. K. Energetics, population biology, and distribution of xenarthrans, living and extinct. In: MONTGOMERY, G. G., ed., **The evolution and ecology of armadillos sloths and vermilinguas**. Washington: Smithsonian Institution Press, 1985. p. 219-232.

MEREDITH, M.; RIDOUT, M. **Package "overlap": Estimates of Coefficient of Overlapping for Animal Activity Patterns**, 2018.

MIRANDA, F. R. et al. Avaliação do Risco de Extinção de *Myrmecophaga tridactyla* Linnaeus, 1758 no Brasil. In: Instituto Chico Mendes de Conservação da Biodiversidade, ed. **Avaliação do Risco de Extinção dos Xenartros Brasileiros**. Brasília, DF: ICMBio, 2015, p. 89–105.

MIRANDA, G. H. B. **Ecologia e Conservação do tamanduá-bandeira (*Myrmecophaga tridactyla*, Linnaeus, 1758) no Parque Nacional das Emas**. 2004. 67 f. Thesis – Instituto de Ciências Biológicas, Universidade de Brasília. Brasília, Goiás, Brazil. 2004.

MIRANDA, G. H. B. et al. Giant anteater (*Myrmecophaga tridactyla*) population Survey in Emas National Park, Brazil – a proposed monitoring program. **Endangered Species Update**, v. 23, p. 96-103, 2006.

MONTGOMERY, G. G. Movements, foraging and food habits of the four extant species of neotropical vermilinguas (Mammalia; Myrmecophagidae). In: MONTGOMERY, G. G. ed. **The evolution and ecology of armadillos, sloths and vermilinguas**. Washington: Smithsonian Institution Press, 1985.

MOURÃO, G.; MEDRI, Í. M. Activity of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) in the Pantanal of Brazil. **Journal of Zoology**, v. 271, n. 2, p. 187–192, 2007.

PETRAZZINI, P. B. **Padrão de Ocupação e Atividade de Tamanduá-bandeira em uma Área de Proteção no Cerrado**. 2019. 83 f. Thesis (Master's degree) – Instituto de Ciências Biológicas, Universidade de Brasília. Brasília, Goiás, Brazil. 2019.

QUIROGA, V. A. et al. Local and continental determinants of giant anteater (*Myrmecophaga tridactyla*) abundance: Biome, human and jaguar roles in population regulation. **Mammalian Biology**, v. 81, n. 3, p. 274–280, 2016.

RIBEIRO, J. F; WALTER, B. M. T. As Principais Fitofisionomias do Bioma Cerrado. In: SANO, S. M.; ALMEIDA, S. P. de; RIBEIRO, J. F. (Ed.). **Cerrado**: ecologia e flora v. 2. Brasília: EMBRAPA-CERRADOS, 2008. 876 p.

RIDOUT, M. S.; LINKIE, M. Estimating overlap of daily activity patterns from camera trap data. **Journal of Agricultural, Biological, and Environmental Statistics**, v. 14, n. 3, p. 322–337, 2009.

RODRIGUES, F. H. G. et al. Anteater Behavior and Ecology. In: VIZCAÍNO, S. F.; LOUGHRY, W. J. eds. **The Biology of the Xenarthra**. Florida: University Press of Florida, 2008, p. 257-268.

ROSA, A. M. L. **Efeito da temperatura ambiental sobre a atividade, uso de habitat e temperatura corporal do tamanduá-bandeira (*Myrmecophaga tridactyla*) na fazenda Nhumirim, Pantanal**. 2007. 32 f. Thesis (Master's degree) – Universidade Federal do Mato Grosso do Sul. Corumbá, Mato Grosso do Sul, Brazil. 2007.

ROSALINO, L. M.; VERDADE, L. M.; LYRA-JORGE, M. C. Adaptation and evolution in changing environments. In: VERDADE L. M.; LYRA-JORGE, M. C.; PIÑA, C. I. eds. **Applied ecology and human dimensions in biological conservation**. New York: Springer, 2014. p. 53–71.

ROYLE, J. A.; NICHOLS, J. D. Estimating abundance from repeated presence-absence data or point counts. **Ecology**, v. 84, n. 3, p. 777–790, 2003.

RSTUDIO TEAM. **RStudio: Integrated Development for R. RStudio, Inc.** 2015.

SASAKI, D.; DE MELLO-SILVA, R. Levantamento florístico no cerrado de Pedregulho, SP, Brasil. **Acta Botanica Brasilica**, v. 22, n. 1, p. 187–202, 2008.

SCHMID, F.; SCHMIDT, A. Nonparametric estimation of the coefficient of overlapping - Theory and empirical application. **Computational Statistics and Data Analysis**, v. 50, n. 6, p. 1583–1596, 2006.

SRBEK-ARAUJO, A. C.; CHIARELLO, A. G. Domestic dogs in Atlantic forest preserves of south-eastern Brazil: A camera-trapping study on patterns of entrance and site occupancy rates. **Brazilian Journal of Biology**, v. 68, n. 4, p. 771–779, 2008.

VANAK, A. T.; GOMPPER, M. E. Dogs *Canis familiaris* as carnivores: their role and function in intraguild competition. **Mammal Review**, v. 39, n. 4, p. 265-283, 2009.

VASCONCELOS, H. L. Respostas das formigas à fragmentação florestal. **Série Técnica IPEF**, v. 12, n. 32, p. 95-98, 1998.

VERSIANI, N. F. **O tamanduá-bandeira (*Myrmecophaga tridactyla*) em áreas protegidas e seus entornos no Cerrado do nordeste do estado de São Paulo**. 2016. 170 f. Thesis - Faculdade de Filosofia, Ciências e Letras, Universidade de São Paulo. Ribeirão Preto, São Paulo, Brazil. 2016.

VYNNE, C. et al. Resource selection and its implications for wide-ranging mammals of the Brazilian Cerrado. **PLoS ONE**, v. 6, n. 12, 2011.

WOODROFFE, R.; GINSBERG, J. R. Edge effects and the extinction of populations inside protected areas. **Science**, v. 280, n. 5372, p. 2126-2128, 1998.

ZANIRATO, G. L. **A influência da perda e da fragmentação do habitat sobre a ocupação e o padrão de atividade do tamanduá-bandeira (*Myrmecophaga tridactyla*)**. 2017. 53 f. Thesis (Master's degree) - Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista "Julio de Mesquita Filho". São José do Rio Preto, São Paulo, 2017.

ZAPATA-RÍOS, G.; BRANCH, L. C. Altered activity patterns and reduced abundance of native mammals in sites with feral dogs in the high Andes. **Biological Conservation**, v. 193, p. 9–16, 2016.

APPENDIX A - Sources of information about covariates used in this study. These works were used to choose which were considered for each covariate. *Dogs were only evaluated for giant anteater landscape use. **Prey was only evaluated for dog landscape use. Slope was used because of the rugged topography of the park, and days were used because of the extension of sampling days.

Covariate	Source
dense500, dense250 and dense100	CAMILO-ALVES; MOURÃO, 2006; MOURÃO; MEDRI, 2007; ROSA, 2007.
open500, open250 and open100	BERTASSONI et al., 2017; BRAGA, 2010; CAMILO-ALVES; MOURÃO, 2006; MACEDO, 2008; MIRANDA, 2004; MOURÃO; MEDRI, 2007; PETRAZZINI, 2019; ROSA, 2007.
pasture500, pasture250 and pasture100	BRAGA, 2010; MIRANDA, 2004.
coffee500, coffee250 and coffee100	MIRANDA, 2004; VASCONCELOS, 1998.
builds500, builds250, builds100	LACERDA; TOMAS; MARINHO-FILHO, 2009; SRBEK-ARAUJO; CHIARELLO, 2008; QUIROGA et al., 2016.
water	BERTASSONI et al., 2017; PETRAZZINI, 2019.
UCdist	ZANIRATO, 2017.
urban	VERSIANI, 2016.
ways	BRAGA, 2010; MIRANDA, 2004; VERSIANI, 2016; VYNNE et al., 2011.
road	FREITAS; JUSTINO; SETZ, 2014; PETRAZZINI, 2019; VYNNE et al., 2011.
slope	-
dogs*	LACERDA; TOMAS; MARINHO-FILHO, 2009; SRBEK-ARAUJO; CHIARELLO, 2008.
prey**	CAMPOS et al., 2007, VANAK; GOMPPER, 2009
temp	CAMILO-ALVES; MOURÃO, 2006; MOURÃO; MEDRI, 2007; ROSA, 2007
day	-

Source: Prepared by author.

APPENDIX B – Spearman correlation between the evaluated site covariates. The shaded numbers were the value of two correlated covariates which was not combined in additive models.

	d500	o500	c500	p500	b500	d250	c250	c250	p250	b250	d100	o100	c100	p100	b100	slope	urban	water	Ucdist	ways	road	dogs
dense500	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
open500	-0.09	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
coffee500	-0.65	-0.19	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pasture500	-0.65	0.11	0.23	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
builds500	-0.45	-0.03	0.36	0.28	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
dense250	0.86	-0.18	-0.58	-0.68	-0.35	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
open250	-0.22	0.67	0.01	0.24	0.08	-0.46	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
coffee250	-0.60	-0.17	0.93	0.14	0.34	-0.53	-0.02	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pasture250	-0.64	0.18	0.22	0.89	0.22	-0.72	0.30	0.10	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-
builds250	-0.20	-0.09	0.12	0.21	0.38	-0.21	-0.05	0.08	0.24	**1**	-	-	-	-	-	-	-	-	-	-	-	-
dense100	0.73	-0.26	-0.48	-0.66	-0.23	0.92	-0.49	-0.44	-0.74	-0.24	**1**	-	-	-	-	-	-	-	-	-	-	-
open100	-0.11	0.50	0.08	0.09	0.12	-0.40	0.74	0.10	0.13	0.09	-0.49	**1**	-	-	-	-	-	-	-	-	-	-
coffee100	-0.47	-0.16	0.75	0.08	0.27	-0.36	-0.09	0.78	0.03	0.02	-0.33	0.02	**1**	-	-	-	-	-	-	-	-	-
pasture100	-0.56	0.25	0.15	0.73	0.16	-0.70	0.35	0.04	0.90	0.20	-0.76	0.24	-0.10	**1**	-	-	-	-	-	-	-	-
builds100	-0.20	-0.12	0.16	0.14	0.37	-0.17	-0.05	0.11	0.18	0.79	-0.25	0.05	0.01	0.21	**1**	-	-	-	-	-	-	-
slope	0.35	0.13	-0.25	-0.02	-0.13	0.20	0.23	-0.23	-0.03	0.10	0.14	0.12	-0.31	-0.03	0.10	**1**	-	-	-	-	-	-
urban	-0.04	-0.07	0.11	0.17	-0.09	-0.08	0.02	0.10	0.14	0.19	-0.16	-0.03	0.08	0.20	0.21	0.16	**1**	-	-	-	-	-
water	-0.21	0.02	0.28	0.19	0.12	-0.16	0.11	0.33	0.03	0.07	-0.08	-0.03	0.12	-0.04	0.07	0.08	0.05	**1**	-	-	-	-
Ucdist	-0.79	-0.26	0.62	0.41	0.28	-0.63	-0.06	0.57	0.41	0.17	-0.47	-0.17	0.48	0.35	0.09	-0.40	0.13	0.10	**1**	-	-	-
ways	0.52	-0.11	-0.59	-0.43	-0.22	0.54	-0.25	-0.53	-0.42	0.01	0.54	-0.20	-0.52	-0.33	0.05	0.07	0.00	-0.22	-0.26	**1**	-	-
road	0.53	0.23	-0.47	-0.26	-0.43	0.36	0.10	-0.36	-0.15	-0.04	0.14	0.16	-0.35	-0.02	-0.03	0.37	0.12	-0.20	-0.56	0.32	**1**	-
dogs	-0.15	0.12	0.09	-0.08	0.13	-0.05	0.12	0.08	-0.03	-0.09	-0.05	0.06	0.18	-0.05	0.02	-0.17	-0.48	-0.19	0.08	-0.14	-0.10	**1**

Source: Prepared by author.

APPENDIX C - Summary of the top single-species single-season models for giant anteaters, ranked by AICc. The ĉ-value was so high (41.78) that it was not possible to adjust the inflation by QAICc; therefore, these models cannot explain the system. Here, K is the number of parameters, AICc is the Akaike Information Criterion corrected for small samples, ΔAICc is a measure of each model relative to the model with the smallest AICc and AICcWt is the AICc weight.

	Models	**K**	**AICc**	**ΔAICc**	**AICcWt**
Detection	pTempDay_psi(.)	4	840.11	0	0.96
	pDay_psi(.)	3	846.76	6.65	0.035
	pTemp_psi(.)	3	867.50	27.39	0
	p(.)_psi(.)	2	920.32	80.21	0
Occupancy	pTempDay_lamways	5	838.81	0	2.30e-01
	pTempDay_lampasture100	5	839.27	0.46	1.80e-01
	pTempDay_lam1	4	839.36	0.55	1.70e-01
	pTempDay_lamurban	5	839.37	0.56	1.70e-01
	pTempDay_lamdense100	5	840.06	1.25	1.20e-01
	pTempDay_lamdense250	5	840.18	1.37	1.20e-01
	p(.)_psi(.)	2	920.1	81.29	5.10e-19

Source: Prepared by author.

APPENDIX D - Summary of the top ten ranked RN models for giant anteaters, ranked by AICc (ĉ=0.02, p=0.18). Here, K is the number of parameters, AICc is the Akaike Information Criterion corrected for small samples, ΔAICc is a measure of each model relative to the model with the smallest AICc and AICcWt is the AICc weight.

	Models	**K**	**AICc**	**ΔAICc**	**AICcWt**
Detection	pDay_lam(.)	3	820.43	0	0.6538
	pTempDay_lam(.)	4	821.71	1.27	0.346
	pTemp_lam(.)	3	836.67	16.23	0.0002
	p(.)lam(.)	2	853.75	33.32	0
Occupancy	pDay_lamUcdist _ dense250_dogs	6	813.3543	0	0.104
	pDay_lamUcdist _dense250_dogs _builds500	7	813.4667	0.1124	0.0983
	pDay_lamUcdist_ways_open250	6	814.1198	0.7655	0.0709
	pDay_lamUcdist_ dense250	5	814.4862	1.1318	0.0591
	pDay_lamUcdist_ways	5	814.6021	1.2477	0.0557
	pDay_lamUcdist_dense250_dogs_slope	7	814.958	1.6037	0.0467
	pDay_lamUcdist_dogs_ways	6	815.0375	1.6832	0.0448
	pDay_lamUcdist_dogs _ways _open250	7	815.2996	1.9453	0.0393
	pDay_lamUcdist_ways_open100	6	815.6092	2.2549	0.0337
	pDay_lamways_open250	5	816.0287	2.6744	0.0273
	p(.)_lam(.)	2	853.7494	40.3951	0

Source: Prepared by author.

APPENDIX E - Summary of the top-ranked RN models for dogs, ranked by QAICc (ĉ=1.8, p=0.007). Here, K is the number of parameters, QAICc is the Quasi- Akaike Information Criterion corrected for small samples, ΔQAICc is a measure of each model relative to the model with the smallest QAICc and QAICcWt is the QAICc weight.

	Models	**K**	**QAICc**	**ΔQAICc**	**QAICcWt**
Detection	p(.)_lam(.)	2	547.48	0	0.39
	pDay_lam(.)	3	548.08	0.59	0.29
	pTemp_lam(.)	3	548.72	1.24	0.21
	pTempDay_lam(.)	4	550.33	2.85	0.09
Occupancy	p(.)_lamurban	4	298.2308	0	0.5075
	p(.)_lamurban_prey	5	299.789	1.5582	0.2329
	pDay_lamurban	5	300.5449	2.3141	0.1596
	pDay_lamurban_prey	6	302.0328	3.8021	0.0758
	p(.)_lam(.)	3	308.2577	10.027	0.0034

Source: Prepared by author.

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