

Ninhos arbóreos de quatis (Carnivora: *Nasua nasua*) em uma área do Pantanal brasileiro: inferências ecológica e zoonótica

Juliane Saab de Lima

Dissertação apresentada ao Programa de Pós-Graduação em **Ecologia e Conservação** da Universidade Federal de Mato Grosso do Sul, como parte das exigências para a obtenção do título de **Mestre** em Ecologia e Conservação.

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Juliane Saab de Lima

ORIENTADOR: Guilherme de Miranda Mourão

BANCA EXAMINADORA:

Dr. Fernando Cesar Cascelli de Azevedo
Dra. Natalie Olifiers
Dra. Rita de Cássia Bianchi
Dr. Heitor Miraglia Herrera
Dr. Erich Arnold Fischer

CAMPO GRANDE, MS
Abril, 2013

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APRESENTAÇÃO

Esta dissertação está dividida em dois capítulos. Os dois estudos foram realizados no Pantanal da Nhecolândia, entre os meses de outubro de 2011 e outubro de 2012. O primeiro capítulo trata-se de um manuscrito redigido em inglês, de acordo com as normas do periódico *Journal of Mammalogy*, sobre a seletividade de área para a construção de ninhos arbóreos por quatis (Carnivora: *Nasua nasua*). O segundo capítulo é um manuscrito redigido em inglês, de acordo com as normas do periódico *Acta Tropica*, sobre infestação de ninhos arbóreos de quatis (Carnivora: *Nasua nasua*) por barbeiros, um inseto vetor da doença de Chagas, que é altamente incidente na população de quatis na área de estudo. As tabelas e figuras foram anexadas ao final de cada um dos capítulos.

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Capítulo 1

Habitat selection by coati (Carnivora: *Nasua nasua*) at Arboreal Nest Sites in the Brazilian Pantanal and the implication on the species ecology

Juliane Saab de Lima^{1,*}

¹ Programa de Pós-graduação em Ecologia e Conservação, Universidade Federal de Mato Grosso do Sul, Campo Grande – MS, Brasil – julianesaab@yahoo.com.br

* Correspondent: julianesaab@yahoo.com.br

Abstract

The construction and use of arboreal nests, similar to a bird species, is a rare behavior among mammals. The brown nosed coati (*Nasua nasua*) uses these nests both for daily resting and breeding where females give a birth annually. The objective of this study was to understand the real role these nests on the coatis' ecology, by evaluating if coatis selected specific microhabitat characteristics for to build the nests and if these differ from those available (random samples) in this area of Brazilian Pantanal. I located a total of 36 arboreal nests. A total of 36 plots with nests and 91 plots without nests (random sites) were measured for microhabitat structure. I found preference for trees (highest trees and with larger diameters at breast height – DBH) for to build the nests. Moreover, nests' placement was more common in areas with highest density of canopy and with highest density of big trees. These results show the importance of vegetation structure to build arboreal nests by coatis. The conservation of the area, with forests well established, is essential both in the daily activities and reproduction of coatis because this is the place that offers support for the construction of nests.

Key words: arboreal nests, coatis, shelter, microhabitat,

Resumo

Seletividade de habitat na construção de ninhos arbóreos por quatis (Carnivora: *Nasua nasua*) no Pantanal brasileiro e sua implicação na ecologia da espécie. A construção e uso de ninhos arbóreos, similar a muitas espécies de aves, é um comportamento raro entre mamíferos. O quati (*Nasua nasua*) usa estes ninhos para descanso diário e para reprodução, onde fêmeas parem seus filhotes anualmente. O objetivo deste estudo foi avaliar se quatis selecionam características específicas de microhabitat e se estas diferem daquelas disponíveis (áreas aleatórias) em uma área do Pantanal brasileiro para entender o real papel destes ninhos na ecologia de quatis. Nós localizamos um total de 36 ninhos arbóreos. Um total de 36 parcelas com ninhos e 91 parcelas sem ninhos (áreas aleatórias) foram caracterizadas quanto à estrutura de microhabitat. Nós verificamos uma preferência por árvores (mais altas e com maior diâmetro à altura do peito – DAP) para a construção dos ninhos. Além disso, a alocação dos ninhos foi feita em uma área com maior densidade de dossel e com maior densidade de árvores de maior porte. Estes resultados evidenciam a importância da estrutura de vegetação da área para a construção de ninhos por quatis. A conservação da área de estudo, com áreas de mata bem estabelecidas, é essencial tanto para as atividades diárias como para a reprodução de quatis já que este é o local que oferece subsídios para a construção dos ninhos.

Palavras-chaves: abrigo, microhabitat, ninhos arbóreos, quatis

The selection and modification of a site for resting, protection from predators and giving birth, among others activities is a critical choice for animals, as they spend parts of their lives sleeping or resting, especially when dependent young are kept in shelters (Hediger 1977; Kappeler 1998).

The construction and use of arboreal nests, similar to many bird species, is rare among mammals. However, several species of rodents, primates and coatis (Procyonidae: *Nasua*) build such nests that are used in two distinct contexts: reproduction and resting (Kappeler 1998; Olifiers et al. 2009; Steele and Koprowski 2001; Wagner et al. 2000). Birds, rodents and primates use arboreal nests mainly for protection from predators, to enhance offspring survival, and thermoregulatory costs (Collias and Collias 1984; Martin 1972; Wagner et al. 2000).

The brown-nosed coati is a diurnal and scansorial species widely distributed in South America (Emmons 1997; Gompper and Decker 1998). The species is organized in a complex social structure with adult females and immature individuals forming groups (Emmons 1997; Gompper and Decker 1998). During the reproductive period, males join these groups to reproduce with females. After reproduction, pregnant females leave their groups and build nests on trees, giving birth to up to 7 cubs (Emmons 1997; Gompper and Decker 1998; Hirsch 2007). After 4-6 weeks, the females and cubs return to their group (Beisiegel 2001; Cabrera and Yepes 1960).

Although some studies have observed the use of arboreal nests by coatis (Beisiegel 2001; Bonatti 2006; Kaufmann 1962) and characterized the general habitat surrounding the nests (Olifiers et al. 2009), no attempt has been made to quantify the habitat characteristics of arboreal nest sites. This knowledge serves as a basis for inferences about the real role of nests on the species ecology.

In order to increase the knowledge about the use of these nests by coatis we study the microhabitat characteristics selected by them to build nests and compared with those available

in the study area. With this information we were able to assess whether coatis exhibit some pattern of selection, based on variables measured, or if this is done randomly within availability where they occur. We hypothesized that specific characteristics of the habitat in which coatis are found induce them to select a nest site.

Materials and Methods

Study area

This study was carried out in a farmland located in the central Brazilian Pantanal wetland (Mato Grosso do Sul state), 160km east from Corumbá city (18°59'S and 56°39'W). This region is a mosaic composed by fresh water and saline lakes, forest patches, savannah and scrub savannah corridors (Rodela 2006). During the wet season (November - April), many parts of open grassland change from terrestrial habitats into aquatic ones and in the dry season (May - October) the land only scarce pools, creeks and some lakes remain. The flooding regime is classified as low height (30 to 40 cm), with an average duration of 3 to 4 months (Soriano et al. 1997).

Nest searches

In order to find the nests, I tracked coatis previously fitted with radio-transmitters (HLPM-3180, Wildlife Materials), during the nights from December 2011 to September 2012. Great care was taken to ensure that coatis in the nests were not stressed by our approach.

All procedures employed in this study were in accordance with the license obtained by IBAMA, the Brazilian Environment Institute (first license No. 28772-1/2011 and last license No. 28772-4/2012) and sanctioned by the “Comitê de Ética e Utilização de Animais” (Universidade Federal de Mato Grosso do Sul; CEUA; protocol No. 350/2011).

Microhabitat measurements

At occupied arboreal nests of coatis, we measured seven microhabitat characteristics, described below. These characteristics were related mostly to the structure of the surrounding vegetation. As shown in Figure 1, I established a plot of 10 x 10 m surrounding the nest site to measure environmental variables where the nests were constructed. Following, I did a raffle of three areas to establish more 3 plots (10 x 10 m each), 15 meters away from the nest tree, for inference of variables available in the area. This information allowed analyzing if there are differences between the environmental variables where the nests were constructed and those available in the area. The following measurements were taken for all plots: density of canopy, percentage of understory, percentage of bromeliads (*Bromelia balansae*) and diameter at breast height (DBH), as well as height (which was made with the equipment rangefinder), of all trees found in the plots. Only trees with DBH greater than 30cm were considered based on nest studies from the same study area (Olifiers et al. 2009). Considering the information to trees, I calculated the median of DBH and median of height trees for each plot which represented, thus, two other variables. The canopy percentage was calculated using a concave densiometer. I made the readings at four points standardized within each plot (Fig. 1). To measure the percentage of understory, I used a white gridded cardboard of 50 x 50 cm with 100 square of 5 x 5 cm each. The cardboard was arranged the in the center of the plots and, to five meters away, four pictures were taken (Fig. 1), with 7.0 standard zoom. Finally, I counted the number of squares (each square represent 1%) on the cardboard occupied by vegetation to obtain the percentage of understory coverage.

Data analyses

I made two types of analysis. First I analyzed the preference for trees (tree height and DBH) through a histogram of nest tree and random site of trees. After graphical assessment of these distributions I used the Kolmogorov-Smirnov test to know if the variables differ

significantly. Second, I used PCoA to ordinate both nest site plots and random site plots (without nest), in multidimensional space based on the microhabitat habitat features that were measured at those sites (described in the previous section). All analyses were performed with R, version 2.14.2 (<http://www.r-project.org>). *P* values 0.05 were considered significant.

Results

I examined a total of 129 plots. Of those, 38 had an active coati arboreal nest and 91 were random plots where I evaluate the microhabitat characteristics available in the area.

In accordance with the analysis for trees preference, the frequency of selected trees for construction, considering the data of DBH ($D = 0.4655$, $P < 0.001$) and height ($D = 0.4651$, $P < 0.001$), differed significantly of frequency trees available for the area (Fig. 2). Coatis exhibited a tendency to selecting larger trees to build their nests.

For the plots, two of the five microhabitat variables were significantly correlated ($P < 0.001$) with the ordination axes (Fig. 3). The first axis is directly correlated with canopy density and the second axis is directly correlated with DBH median of plots. These variables differed significantly between areas selected for the construction of nests and areas available without nest (Fig. 4).

Discussion

The results indicate that coatis select larger trees with well-formed canopy, sites where there are greater density of older trees (with high trees and with large diameter) and greater density of canopy. The percentage of bromelidae and understory in the plots did not differ between nest and random plots. Therefore, we have no evidence to support that coatis select these features when building their nests.

The results of this study represent an advance in knowledge and understanding of coatis ecology. Although coatis are tolerant to open areas like cerrado grassland and wetland

field (Bianchi 2009; Trovati 2004) this species selects forests formations (Chiarello 1999; Desbiez and Borges 2010; Emmons 1997; Gompper and Decker 1998; Holt 2001). Studies have shown that a greater supply of resources, greater protection from predators and reproduction are the reasons for this preference (Gompper 1996; Hass and Valenzuela 2002; Valenzuela and Ceballos 2000). The construction of arboreal nests in the way described in this study, justifies this preference as only forests can provide the conditions and materials to build a nest. Indeed, areas with greater density of canopy and larger trees do not occur in open landscapes.

Coatis are scansoriais, with the predominance of land use (Eisemberg and Redford 1999; Emmons 1997; Gompper and Decker 1998; Kaufmann 1962). The construction of nests by coatis highlights the importance of arboreal stratum for their daily activities and reproduction as coatis use these nests both for rest daily and females give a birth annually (Kaufmann 1962; Russell 1982). This reflects directly in coatis conservation and, thus, in the conservation area. In the Pantanal, the deforestation of forest have already been altered for cattle ranching by introduction of exotic grass species (Padovani et al. 2004). Futhermore, this habitat have the lowest carrying capacity for cattle (Santos et al. 2002), so are the primary targets for deforestation. The deforestation in forest areas with woody vegetation can have negative impacts in the Pantanal wildlife, damaging the species nesting like caimans and several species of birds, as well as reducing refuge areas, during flooding, to several species like pampas deer. (Alho et al. 1988; Campos 1993; Pimm et al. 1995). Although coatis are classified as least concern in accordance with the Red List of Threatened Species (IUCN 2012), my results reinforce such predictions for this species. The recent increase of land use in the study area is detrimental to coatis because they can interfere directly in the population stability.

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Literature Cited

- ALHO, C. J. R., LACHER, T. E. & CAMPOS, Z. M. S. 1988. Mamíferos da fazenda Nhumirim, sub-região de Nhecolândia, Pantanal do Mato Grosso do Sul: levantamento preliminar de espécies. *Revista Brasileira de Biologia* 48: 213–225.
- BEISIEGEL, B. 2001. Notes on the coati, *Nasua nasua* (Carnivora:Procyonidae) in an Atlantic forest area. *Brazilian Journal of Biology* 61: 689–692.
- BIANCHI, R.C. 2009. Ecologia de Mesocarnívoros em uma área no Pantanal Central, Mato Grosso do Sul. *Ph.D. thesis*. Programa de Pós-graduação em Ecologia e Conservação. Universidade Federal de Mato Grosso do Sul.
- BONATTI, J. 2006. Uso e seleção de hábitat, atividade diária e comportamento de *Nasua nasua* (Linnaeus, 1766) (Carnivora: Procyonidae) na Ilha do Campeche, Florianópolis, Santa Catarina. MSc thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre.
- CABRERA, A., AND YEPES, J.1960. Mamíferos Sud Americanos. Buenos Aires, Ediar, vol. 1, 187p.
- CAMPOS, Z. 1993 Effect of habitat on survival of eggs and sex ratio of hatchlings of *Caiman crocodilus yacare* in the Pantanal, Brazil. *Journal of Herpetology* 27: 127-132.
- CHIARELLO, A.G. 1999. Effects of fragmentation of the Atlantic forest on mammal communities in south-eastern Brazil. *Biological Conservation* 89: 71-82.

- COLLIAS, N.E., AND COLLIAS, E.C. 1984. Nest building and bird behavior. Princeton, Princeton University Press XIX+336p.
- DESBIEZ, A., AND BORGES, L. 2010. Density , habitat selection and observations of South American Coati *Nasua nasua* in the central region of the Brazilian Pantanal wetland. *Small Carnivore Conservation* 42: 14–18.
- EISEMBERG, J.F. AND REDFORD, K.H. 1999. Mammals of the Neotropics: the Central Neotropics. V.3. University of Chicago Press: Chicago. 609p.
- EMMONS, L. 1997. Neotropical rainforest mammals: a field guide. Chicago, The University of Chicago Press XVI+307p.
- GOMPPER, M. E. 1995. *Nasua narica*. *Mammalian species* 487: 1-10.
- GOMPPER, M.E. 1996. Sociality and associability in white-nosed coatis (*Nasua narica*): foraging costs and benefits. *Behavioral Ecology* 7: 254-263.
- GOMPPER, M.E., AND DECKER, D.M. 1998. *Nasua nasua*. *Mammalian Species* 580: 1-9.
- HASS, C. C. & VALENZUELA, D. 2002. Anti-Predator benefits of group living in white-nosed coatis (*Nasua narica*). *Behavioural Ecology Sociobiology* 51: 570-578.
- HEDIGER, H. 1977. Nest and home. *Folia Primatologica* 28:170-187.
- HIRSCH, B.T. 2007. Spoiled brats: is extreme juvenile agonism in ring-tailed coatis (*Nasua nasua*) dominance or tolerated aggression? *Ethology* 113: 446-456.
- HOLT, T.V. 2001. The influences of the *Sheelea phalerata* palm and landscape patterns on the terrestrial mammalian and avian communities of forest islands in the Brazilian Pantanal. MSc. thesis, University of Florida, Gainesville, FL. 129p.
- INGLES, L.G. 1957. Observations of behavior of the coatimundi. *Journal of Mammalogy* 38: 263-264.

IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 05 April 2013.

KAPPELER, P. M. 1998. Nests, tree holes, and the evolution of primate life histories. *American Journal of Primatology* 46: 7–33.

KAUFMANN, J.H. 1962. Ecology and social behavior of the coati, *Nasua narica* on Barro Colorado Island Panama. *University of California Publications in Zoology* 60: 95-222.

McCLEARN, D. 1992. Locomotion, posture, and feeding behavior of kinkajous, coatis, and raccoons. *Journal of Mammalogy* 73: 245-261.

MARTIN, R. D. 1972. Review adaptive lecture of radiation and behaviour the malagasy lemurs. *Biological Sciences* 264: 295–352.

OLIFIERS, N., BIANCHI, R. D. C., MOURÃO, G. D. M., AND GOMPPER, M. E. 2009. Construction of arboreal nests by brown-nosed coatis, *Nasua nasua* (Carnivora: Procyonidae) in the Brazilian Pantanal. *Zoologia* 26: 571–574.

PADOVANI, C. R., CRUZ, M. L. L., PADOVANI, S. L. A. G. 2004. Desmatamento do Pantanal brasileiro para o ano 2000. IV Simpósio sobre recursos naturais e sócio-economicos do Pantanal, Embrapa Pantanal. Corumbá, MS, Brazil.

PIMM, S. L.; RUSSEL, G. J.; GITTLEMAN, J. L.; BROOKS, T. M. 1995. The future of biodiversity. *Science* 269: 347-350.

RODELA, L.G. 2006. Unidades de vegetação e pastagens nativas do Pantanal da Nhecolândia, Mato Grosso do Sul. Ph.D. dissertation, São Paulo: Fac. Filosofia, Letras e C. Humanas, Universidade de São Paulo.

RUSSELL, J.K. 1982. Timing of reproduction by coatis (*Nasua narica*) in relation to fluctuation in food resources. Pp. 413-431. In: Leigh Jr, E.G.; Rand, A.S. & Windsor, D.M. (eds). *The ecology of a tropical forest: seasonal rhythms and long-term changes*. 2ed. Smithsonian Institution Press, Washington, D.C.

- SANTOS, S. A., CARDOSO, E. L., AGUILAR, R., PELLEGRIN, A. O. 2002. Princípios Básicos para a produção sustentável de bovinos de corte no pantanal. Documentos 37. Embrapa Pantanal. Corumbá, MS, Brazil.
- SORIANO, B. M. A., OLIVEIRA, H., CATTO, J. B., COMASTRI FILHO, J. A., GALDINO, S., SALIS, S. M. 1997. Plano de utilização da fazenda Nhumirim. Documentos Embrapa Pantanal, Corumbá, MS, Brazil.
- STEELE, M.A., AND KOPROWSKI, J.L. 2001. North American tree squirrels. London, Smithsonian Institution Press XII+201p.
- TROVATI, R. G. 2004. Monitoramento radiotelemetrico de pequenos e médios carnívoros na área de influência da UHE Luiz Eduardo Magalhães/Lajeado – TO. *Dissertação de mestrado*. Universidade de São Paulo, Piracicaba, São Paulo. 72p.
- VALENZUELA, D. & CEBALLOS, G. 2000. Habitat selection, home range and activity of the white-nosed coati (*Nasua narica*) in a mexican tropical dry forest. Journal of mammalogy 81: 810-819.
- WAGNER, D. M., FELDHAMER, G. A., NEWMAN, J. A. 2000. Microhabitat Selection by Golden Mice (*Ochrotomys nuttalli*) at Arboreal Nest Sites. The American Midland Naturalist 144: 220–225.

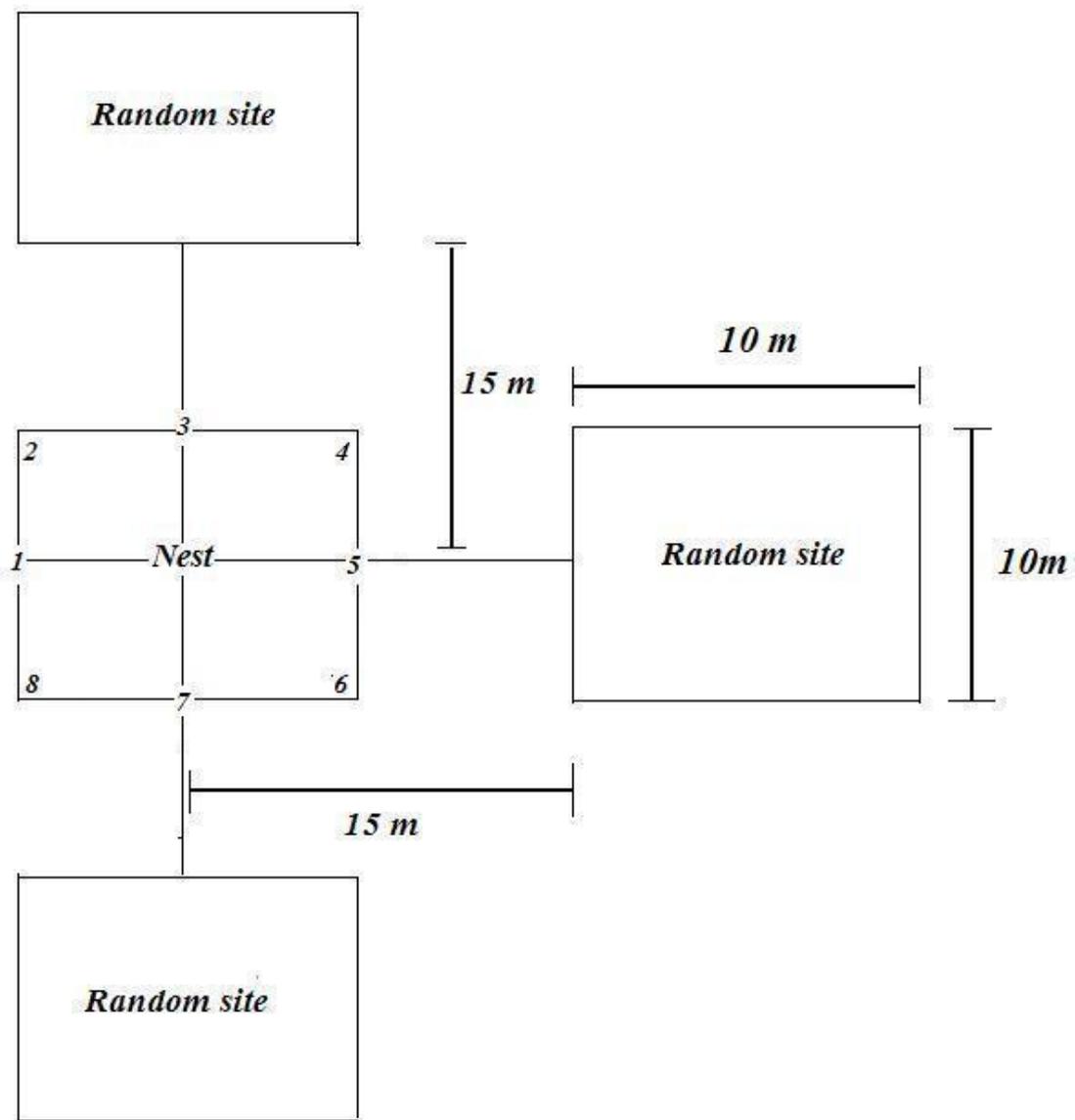


Fig. 1. — Scheme of the methodology used in this study for microhabitats measurements. The canopy density measurements were made at points 2,4,6,8 and in the center of all plots. The photos for the calculation of understory percentage were taken at points 1, 3, 5 and 7 that were all distant 5 meters from the nest. All the plots had the same size (10x10 m).

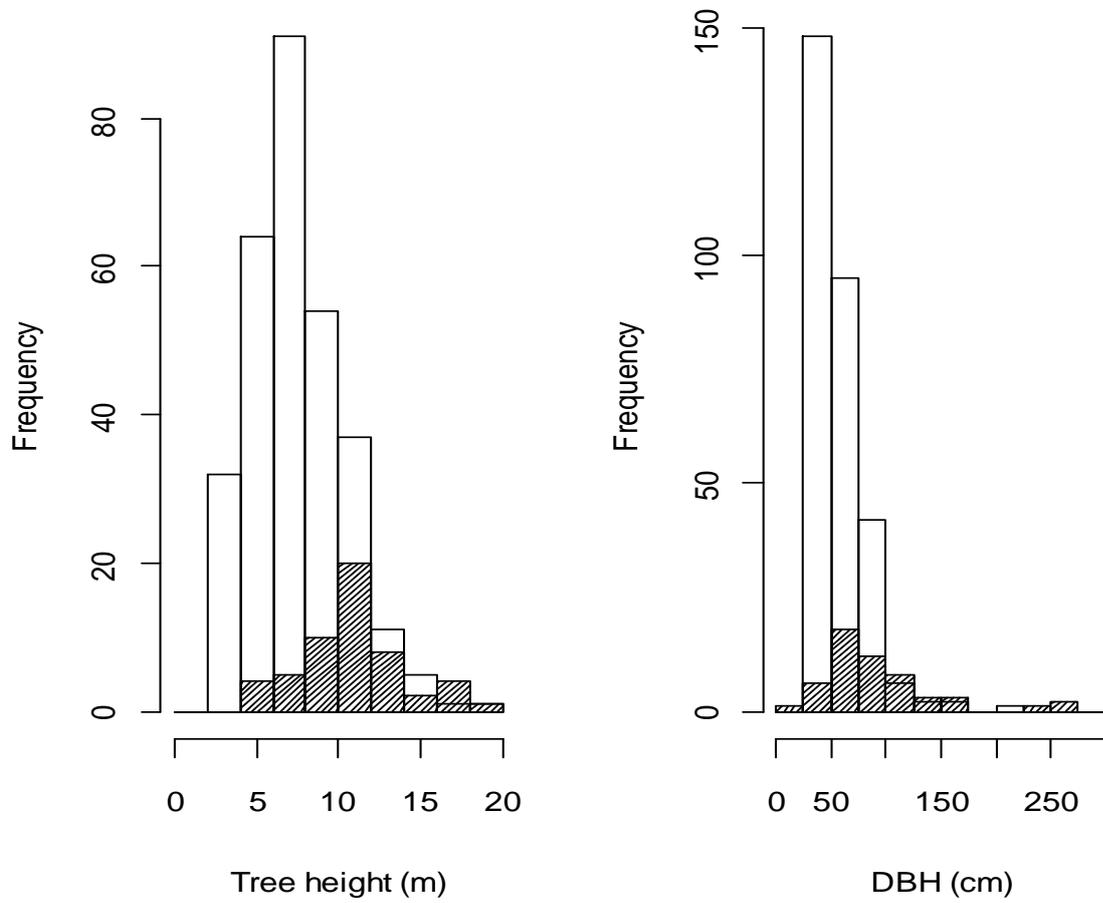


Fig. 2. — Frequency of tree height (left) and values of DBH (right) available (white area) and selected by coatis (hatched area) in an area of the Brazilian Pantanal.

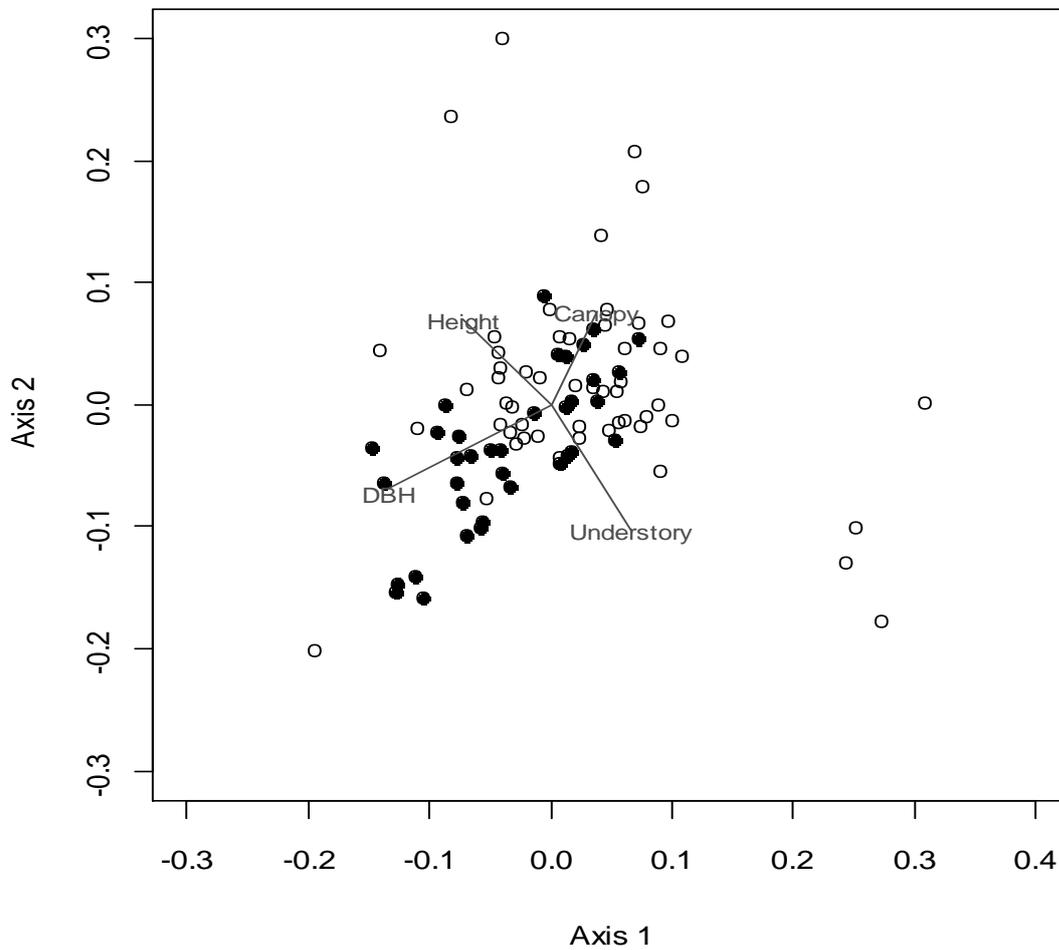


Fig. 3. — PCoA ordination of 36 nest site plots (●) of coatis (*Nasua nasua*) and 59 random site plots (○) in an area of Brazilian Pantanal. DBH and height are measures of trees defined as median values to the each plot.

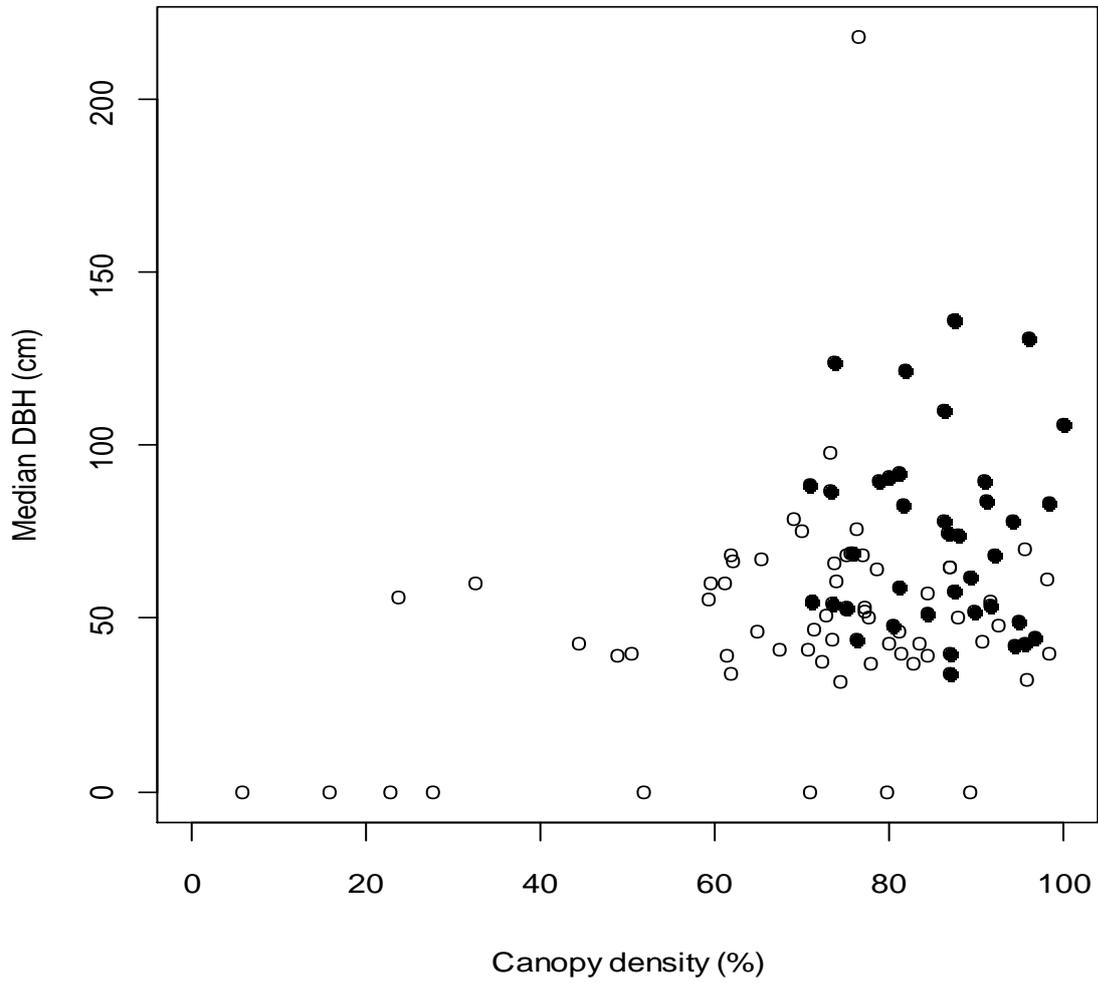


Fig. 4. —Relationship between median DBH values and canopy density for nest site plot (●) of coatis (*Nasua nasua*) and random site plot (○) in an area of the Brazilian Pantanal.

Normas para publicação

Journal of Mammalogy

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1. PREPARATION OF MANUSCRIPTS

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HALL, E. R. 1981. *The mammals of North America*. 2nd ed. John Wiley & Sons, Inc., New York

1:1–600 + 90. [OR ...2:601–1181 + 90.]

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Capítulo 2

Infestation of arboreal nest of coati (Carnivora: *Nasua nasua*) by Triatomine Bugs, a vector of *Trypanosoma cruzi*, in the Brazilian Pantanal

Juliane Saab de Lima^{1,*}

¹ Programa de Pós-graduação em Ecologia e Conservação, Universidade Federal de Mato Grosso do Sul, Campo Grande – MS, Brasil – julianesaab@yahoo.com.br

* Correspondent: julianesaab@yahoo.com.br

Abstract

The brown-nosed coati (*Nasua nasua*) is a medium-sized carnivore mammal that occurs in high density in the Pantanal wetlands (Mato Grosso do Sul, Brazil). Differently of most mammals, coatis construct arboreal nests, similar a bird species, used for resting daily and reproduction where females give a birth annually. Several studies indicated the coati as an important host of *Trypanosoma cruzi* in this region, the causative agent of Chagas disease. However, it is not known what the role of coati in the maintenance and transmission of parasite in sylvatic cycle and how this mammal is infected for *T. cruzi*. The objectives of this study were to determine (i) whether arboreal nest used by coatis in Pantanal of Brazil are infested by triatomines bugs, a vector of Chagas disease, as well as their rate infestation, (ii) what species of triatomine bugs are most frequent in the nests and (iii) what are the triatomines food resources. Of the 23 nests of coatis sampled, 7 were infected with triatomines, in a total of 36 bugs of different stages. The species found in the nests were *Rhodnius stali* and *Triatoma sordida*. In one nest, I found that the two species of triatomines co-occurred. *R. stali* and *T. sordida* fed on multiple resources, including coatis. This is the first recorded occurrence of Triatomines in coatis' nests and the first record of *R. Stali* sylvatic in this region of the Pantanal. This close association between coatis, arboreal nests and triatomines may represent, at first, an important scenario for *T. cruzi* sylvatic cycle to coatis in this region of the Pantanal.

Key words: arboreal nests; coatis; triatomine bugs; *Trypanosoma cruzi*

Resumo

Infestação de ninhos arbóreos de quatis (Carnivora: *Nasua nasua*) por barbeiros, um vetor do *Trypanosoma cruzi*, no Pantanal brasileiro. O quati (Carnivora: *Nasua nasua*) é um mamífero carnívoro de médio porte que ocorre em alta densidade no Pantanal (Mato Grosso do Sul, Brasil). Diferente de muitos mamíferos, quatis constroem ninhos arbóreos, como muitas espécies de aves, que são usados para descanso diariamente e reprodução onde fêmeas parem seus filhotes anualmente. Vários estudos revelam que, nesta região, quatis são importantes hospedeiros do *Trypanosoma cruzi*, parasita que causa a doença de Chagas. Entretanto, não é conhecido qual o real papel do quati na manutenção e transmissão deste parasita no ciclo silvestre e como este mamífero é infectado por *T. cruzi*. Os objetivos deste estudo foram determinar (i) se ninhos arbóreos usados por quatis no Pantanal brasileiro são infestados por barbeiros, inseto vetor da doença de Chagas, tanto quanto sua taxa de infestação, (ii) quais espécies de barbeiros ocorrem nestes ninhos e (iii) quais os recursos alimentares destes barbeiros. Dos 23 ninhos arbóreos de quatis amostrados, 7 foram infestados com 36 barbeiros de diferentes estágios. As espécies de barbeiros encontradas nos foram *Rhodnius stali* e *Triatoma sordida*. Em um único ninho eu encontrei as duas espécies co-ocorrendo. Barbeiros alimentaram-se de múltiplos recursos, incluindo quatis. Este é o primeiro registro de ocorrência de barbeiros em ninhos de quatis e o primeiro registro de *R. stali* silvestre nessa região do Pantanal. Essa íntima associação entre quatis, ninhos arbóreos e barbeiros pode representar, a princípio, um importante cenário para ciclo silvestre de *T. cruzi* entre quatis nessa região do Pantanal.

Palavras-chaves: barbeiro, ninho arbóreo, quati, *Trypanosoma cruzi*

1. Introduction

The *Trypanosoma cruzi* transmission cycle is a complex system that involves different components such as the protozoan parasite *T. cruzi*, triatomine vectors and many host species (Noireau et al., 2009). The sylvatic hosts of *T. cruzi* are mammals from eight orders: Carnivora, Pilosa, Primates, Chiroptera, Cingulata, Didelphimorphia, Rodentia and Artiodactyla (Alvarado-Otegui et al., 2012; Coura et al., 2002; Deane, 1964; Jansen et al., 1997). In the wild, the oral infection route may occur both through the ingestion of infected triatomines or when mammals eat other infected bugs or mammals - a phenomenon called trophic transmission (Herrera et al., 2008; World Health Organization, 2002).

Observations on the distribution, ecology and behavior of triatomine sylvatic populations are fundamental to understand the risk factors and how to prevent the disease. However, studies on the ecology of wild triatomine species are still scarce, mainly because specimens' collection and field observations are laborious and time-consuming (Noireau et al., 2005).

In the Chaco region, *Rhodnius* and *Triatoma* species are Chagas disease vectors with a large distribution and the main species responsible for disease transmission in domestic, peridomestic and in the sylvatic environments (Justi et al., 2010; Matias et al., 2003; Noireau, 2005; Rolón et al., 2011). In the Brazilian Amazon, the *Rhodnius* species, found in high rates in *Attalea* palms, is the main vector responsible for the high incidence of the disease in the wild and in the human population (Abad-Franch et al., 2007, 2010).

Virtually all species of *Rhodnius* have a close ecological association with palms species (Abad-Franch and Monteiro, 2007; Gaunt and Miles, 2000; Justi et al., 2010) while species of *Triatoma* are more related to terrestrial rocky habitats, rodent burrows or bird nests (Miles et al., 1981, Noireau et al., 2005).

In the Pantanal of Brazil, the brown-nosed coati (Procyonidae; *Nasua nasua*) is described as the main reservoir host of *T. cruzi* due to its high biomass (Desbiez et al., 2010;

Desbiez and Borges, 2010) together with high prevalence of infection and high parasitemias (Alves et al., 2011; Herrera et al., 2008, 2011). Despite omnivore diet of coatis (Alves-Costa et al., 2004; Bianchi, 2009) the *T. cruzi* oral transmission has been suggested but it is not clear how this mammal is infected by *T. cruzi*.

Coatis use arboreal nests, that are similar to bird nest, overnight to rest and annually to give birth (Emmons 1997; Kaufmann 1962). Thus, the possible presence of the triatomine bugs in coatis' arboreal nests could help to answer many questions about the *T. cruzi* transmission cycles and if this is an important infection route for coatis. Such information is currently unavailable and this substantially hampers our understanding of *T. cruzi* transmission dynamics in the Pantanal.

The purpose of this study was to investigate whether the nests built by coatis indeed represent a sylvatic ecotope for triatomine bugs populations in the Brazilian Pantanal. Specific objectives were to determine (i) the rate infestation by triatomine bugs in the coati's nests, (ii) what species of triatomines are most frequent in these nests and (iii) what are the triatomines blood meal sources in these nests.

2. Materials and Methods

2.1. Study area

This study was carried out in the Central Pantanal of Mato Grosso do Sul – Brazil, located 160 km east from Corumbá city (18°59'S and 56°39'W). This region is a mosaic composed by fresh water and saline lakes, forest patches (“cordilheiras”), savannah and scrub savannah corridors (Rodela, 2006). During the wet season (November - April), many parts of open grassland change from terrestrial habitats into aquatic ones and during the dry season (May - October) the land dries out and only scarce pools, creeks and some lakes remain. The flooding regime is classified as low height (30 to 40 cm), with an average duration of 3 to 4 months (Soriano et al., 1997).

2.2. *Coatis and Triatomine capture*

In order to identify coatis' nests, I tracked coatis equipped with radio-collared during the nights from May 2012 to September 2012. When I detected that the radio-signal was coming from the top of a tree, I approached it in silence to locate the nest without disturbing the coatis. In the following morning, when the coatis had already left the nest, the nests were collected in boxes or plastic bags and analyzed it in the laboratory, where I carefully dismantled them to search for triatomine bugs and stored them alive in falcon tubes.

All procedures employed in this study were in accordance with the license obtained by IBAMA, the Brazilian Government Institute (first license No. 28772-1/2011 and last license No. 28772-4/2012) and sanctioned by the “Comitê de Ética e Utilização de Animais” (Universidade Federal de Mato Grosso do Sul; CEUA; protocol No. 350/2011).

2.3. *Taxonomic identification of Triatomines*

The triatomines were identified in the National and International Laboratory of Reference on Taxonomy of Triatominae of “Fundação Oswaldo Cruz” (FIOCRUZ), by their external morphological conformations, following Carcavallo et al. (1997) and Lent and Wygodzinsky (1979) taxonomic references.

The blood feeding sources for triatomines were determined based on the precipitin test. The precipitin test was applied to the intestinal contents of triatomines previously fed on vertebrate blood. The stomach content was triturated in 0.85% saline and was left for 12 hours at a temperature between 4 °C and 8 °C. It was then centrifuged for 5 minutes at 1.500rpm, and the supernatant confronted with the antiserums of bird, coati, opossum, armadillo, rodent, lizard, dog, cat, goat, cow, human, horse and pig (Lorosa et al. 1998).

3. Results

I sampled 23 arboreal nests (Fig. 1) and found triatomines in seven of them. In total, 36 triatomines were found: five nymphs of the stage unidentified; two first instar nymphs;

four third instar nymphs; seven fourth instar nymphs; four fifth instar nymphs and 14 adults (Table 1).

The species found were *Triatoma sordida* (n=17; Fig. 2) and *Rhodnius stali* (n=16; Fig.2) and the genus of 3 specimens were not possible to identify because they were first stage nymphs. I found *T. sordida* in 5 nests and *R. stali* in 4 nests. In a single arboreal nest I found 20 individuals of both species *R. stali* (n=8) and *T. sordida* (n=11) showing different developmental stages.

Triatomines of the three different nests were to analyzed to the precipitin test. *R. Stali* and *T. sordida* fed of coati, bird, rodent and marsupial (Table 1).

4. Discussion

The arboreal nets of coatis represent an important sylvatic ecotope for two triatomine species, *R. stali* and *T. sordida*, in the study area. This is the first record of occurrence triatomines in the arboreal nests of coatis. Ferriolli-Filho and Barretto (1968), in São Paulo State - Brazil, found triatomines infected in the hollow tree used as shelter by coatis.

The results of this study represent an advance in the knowledge of the ecology these triatomines. In accordance with literature, the triatomines genus *Rhodnius* have a close ecological association with palms trees (Abad-Franch and Monteiro, 2007; Gaunt and Miles, 2000; Justi et al., 2010) while *Triatoma* species are associated with terrestrial rocky habitats or rodent burrows (Miles et al., 1981, Noireau et al., 2005). Yet, *Rhodnius stali* have a large distribution in Bolivia (Cortez 2007; Justi et al., 2010; Matias et al., 2003) and in the Amazon biome in (Abad-Franch et al., 2007). This is the first recorded of occurrence colonies sylvatic *R. stali* in this region of Brazilian Pantanal.

The oral route, by ingestion of triatomines infected, has been suggested as an important mechanism for *T. cruzi* transmission and perpetuation in coatis in the wild (Herrera et al., 2008, 2011). Indeed, the diet of coatis included a high percentage of insects (Alves-Costa et

al., 2004; Bianchi et al., 2013) underlining, then, the oral transmission. However, this study lead us to more a perspective: the vectorial transmission as an other possible route of transmission of *T. cruzi* from coatis in the study area, due to high infestation rate of triatomines in the nests. This perspective is further reinforced by the fact that triatomines have effectively fed the coatis, as seen by the precipitin test results (Table 1).

Pregnant females give birth in these nests (Emmons 1997; Kaufmann 1962) and the youngs remain for about one month, continuously, after birth (Saab, unpublished datas). The presence of triatomines in these nests seems to be the primary cause of occurrence of high seroprevalence in youngs coatis (Alves et al. 2011; Herrera et al. 2008, 2011).

This study represents a new epidemiological scenario with regard to the understanding of the sylvatic cycle of *T. cruzi* in a population of coatis highly infected in the Brazilian Pantanal. The association between arboreal nests, coatis and triatomines may represent an important link for transmission cycle and dispersion of *T. cruzi* to coatis and, consequently, to others species.

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References

- Abad-Franch, F. and Monteiro, F., 2007. Biogeography and evolution of Amazonian triatomines (Heteroptera: Reduviidae): implications for Chagas disease surveillance in humid forest ecoregions. *Mem. Inst. Oswaldo Cruz.* 102, 57–70.
- Abad-Franch, F., Ferraz, G., Campos, C., Palomeque, F. S., Grijalva, M. J., Aguilar, H. M., Miles, M., 2010. Modeling disease vector occurrence when detection is imperfect: infestation of Amazonian palm trees by triatomine bugs at three spatial scales. *PLoS Negl Trop Dis.* 4, e620.
- Alvarado-Otegui, J., Ceballos, L.A., Orozco, M. M., Enriquez, G. F., Cardinal, M. V, Cura, C., Schijman, Kitron, U., Gürtler R.E., 2012. The sylvatic transmission cycle of *Trypanosoma cruzi* in a rural area in the humid Chaco of Argentina. *Acta Trop.* 124, 79–86.
- Alves, F. M., Olifiers, N., Bianchi, R. D. C., Duarte, A. C., Cotias, P. M. T., D’Andrea, P. S., Gompper, M. E., Mourão, G.M., Herrera, H.M., Jansen, A.M., 2011. Modulating variables of *Trypanosoma cruzi* and *Trypanosoma evansi* transmission in free-ranging Coati (*Nasua nasua*) from the Brazilian Pantanal region. *Vector Borne and Zoonotic Dis.* 11, 835-841.
- Alves-Costa, A. C. P., Fonseca, G. A. B., Christófaró, C., 2004. Variation in the diet of the brown-nosed coati (*Nasua nasua*) in southeastern Brazil. *J. Mammal.* 85, 478–482.
- Bianchi, R.C. 2009. Ecologia de Mesocarnívoros em uma área no Pantanal Central, Mato Grosso do Sul. Ph.D. thesis. Programa de Pós-graduação em Ecologia e Conservação. Universidade Federal de Mato Grosso do Sul.
- Carcavallo, R.U., Galíndez, G. I., Jurberg, J., Galvão, C., Lent, H., 1997. Pictorial keys for tribes, genera and species of the subfamily Triatominae. In: Carcavallo RU, Galíndez Girión I, Jurberg J, Lent H. (Eds.), *Atlas Chagas Dis. Vectors Am.*, vol. 3. Fiocruz, Rio de Janeiro, Brazil, pp. 107–244.
- Cortez, M.R., 2007. Triatomines de Bolivia y la enfermedad de Chagas. Ministério de Salud y Deportes, Programa Nacional de Chagas, Bolívia.

- Coura, J.R., 2006. Transmissão da infecção chagásica por via oral na história natural da doença de Chagas. Ver. Soc. Bras. Med. Trop. 39, 113-117.
- Coura, J.R., Junqueira, A.C.V., Fernandes, O., Valente, S.A.S., Miles, M.A., 2002. Emerging Chagas disease in Amazonian Brazil. Trends. Parasitol. 18, 171-176.
- Deane, L.M. 1964. Animal reservoirs of *Trypanosoma cruzi* in Brazil. Rev. Bras. Malariol. Doenças Trop. 16, 27-48.
- Desbiez, A., and Borges, L., 2010. Density, habitat selection and observations of South American Coati *Nasua nasua* in the central region of the Brazilian Pantanal wetland. Small Carniv. Conserv. 42, 14-18.
- Desbiez, A.L.J., Bodmer, R.E., Tomas, W.M., 2010. Mammalian Densities in a Neotropical Wetland Subject to Extreme Climatic Events. Biotropica 42, 372-378.
- Emmons, L., 1997. Neotropical rainforest mammals: a field guide. Chicago, The University of Chicago Press XVI+307p.
- Ferriolli, E., and Barretto, M. P., 1968. Estudos sobre reservatórios e vetores silvestres do *Trypanosoma cruzi*. XXIX. Infecção natural da *Nasua nasua solitária* Schinz, 1821 pelo *T. cruzi*. Rev. Inst. Med. Trop. de São Paulo, 10, 354-363.
- Gaunt, M., and Miles, M., 2000. The ecotopes and evolution of triatomine bugs (triatominae) and their associated trypanosomes. Mem. Inst. Oswaldo Cruz 95, 557-65.
- Gompper, M.E. and Decker, D.M., 1998. *Nasua nasua*. Mamm. Species. 580, 1-9.
- Herrera, H. M., Lisboa, C. V, Pinho, a P., Olifiers, N., Bianchi, R. C., Rocha, F. L., Mourão, G. M., Jansen, A.M., 2008. The coati (*Nasua nasua*, Carnivora, Procyonidae) as a reservoir host for the main lineages of *Trypanosoma cruzi* in the Pantanal region, Brazil. Trans. R. Soc. Trop. Med. Hyg. 102, 1133-1139.
- Herrera, H. M., Rademaker, V., Abreu, U. G. P., D'Andrea, P. S., Jansen, A. M., 2007. Variables that modulate the spatial distribution of *Trypanosoma cruzi* and *Trypanosoma evansi* in the Brazilian Pantanal. Acta Trop. 102, 55-62.

- Herrera, H. M., Rocha, F. L., Lisboa, C. V., Rademaker, V., Mourão, G. M., Jansen, A. M., 2011. Food web connections and the transmission cycles of *Trypanosoma cruzi* and *Trypanosoma evansi* (Kinetoplastida, Trypanosomatidae) in the Pantanal Region, Brazil. *Trans. R. Soc. Trop. Med. Hyg.* 105, 380–7.
- Jansen, A. M., Madeira, F., Carreira, J. C., Medina-Acosta, E., Deane, M. P., 1997. *Trypanosoma cruzi* in the opossum *Didelphis marsupialis*: a study of the correlations and kinetics of the systemic and scent gland infections in naturally and experimentally infected animals. *Exp. Parasitol.* 86, 37–44.
- Justi, S. A., Noireau, F., Cortez, M. R., Monteiro, F. A., 2010. Infestation of peridomestic *Attalea phalerata* palms by *Rhodnius stali*, a vector of *Trypanosoma cruzi* in the Alto Beni, Bolivia. *Trop. Med. Intern. Health.* 15, 727–32.
- Lent, H., and Wygodzinsky, P., 1979. Revision of de Triatominae (Hemiptera: Reduviidae) and their significance as vector of Chagas Disease. *Bull. Am. Mus. Nat. Hist.* 163,125–520.
- Lorosa, E.S., Andrade, R.E., Santos, S.M., Pereira, C.A., 1998. Estudo da infecção natural a da fonte alimentar do *Triatoma sordida* (Stal, 1859), (Hemiptera: Reduviidae) na região norte de Minas Gerais, Brasil, através da realção de precipitina. *Entomol. Vectores.* 5, 13–22.
- Matias, A., De la Riva, J., Martinez, E., Torrez, M., Dujardin, J. P., 2003. Domiciliation process of *Rhodnius stali* (Hemiptera: Reduviidae) in Alto Beni, La Paz, Bolivia. *Trop. Med. Intern. Health.* 8, 264–8.
- Miles, M. A., De Souza, A.A., Póvoa, M., 1981. Chagas' disease in the Amazon basin III. Ecotopes of ten triatomine bug species (Hemiptera: Reduviidae) from the vicinity of Belém, Pará State, Brazil. *J. Med. Entomol.* 18, 266–78.
- Noireau, F., Carbajal-de-la-Fuente, A. L., Lopes, C. M., Diotaiuti, L., 2005. Some considerations about the ecology of Triatominae. *Anais da Academia Brasileira de Ciências* 77, 431–6.
- Noireau, F., Diosque, P., Jansen, A. M., 2009. *Trypanosoma cruzi*: adaptation to its vectors and its hosts. *Vet. Res.* 40, 26.

- Rodela, L.G., 2006. Unidades de vegetação e pastagens nativas do Pantanal da Nhecolândia, Mato Grosso do Sul. Ph.D. dissertation, São Paulo: Fac. Filosofia, Letras e C. Humanas, Universidade de São Paulo.
- Rolón, M., Vega, M. C., Román, F., Gómez, A., Rojas de Arias, A., 2011. First report of colonies of sylvatic *Triatoma infestans* (Hemiptera: Reduviidae) in the Paraguayan Chaco, using a trained dog. PLoS. Negl. Trop. Dis. 5, e1026.
- Silva, R.A.M.S., Victório, A.M., Ramirez, L., Dávila, A.M.R., Trajano, V., Jansen, A.M., 1999. Hematological and blood chemistry alterations in coatis (*Nasua nasua*) naturally infected by *Trypanosoma evansi* in the Pantanal, Brazil. Revue Élev. Méd. Vét. Pays. Trop. 52, 119-122.
- Soriano, B. M. A., Oliveira, H. de, Catto, J. B., Comastri Filho, J. A., Galdino, S. & Salis, S. M. 1997. Plano de utilização da fazenda Nhumirim. Documentos Embrapa Pantanal, Corumbá, MS, Brazil.
- World Health Organization, 2002. Control of Chagas Disease: Second Report of the WHO Expert Committee. World Health Organization, Geneva, 905.
- Yoshida, N., 2008. *Trypanosoma cruzi* infection by oral route: how the interplay between parasite and host components modulates infectivity. Parasitol. Int. 57, 105–9.



Fig.1. A coati arboreal nest, a sylvatic ecotope of triatomine bugs in the Brazilian Pantanal.
Scale is an approximation.



Fig.2. (A) *Rhodnius stali* and (B) *Triatoma sordida* specimens captured in the arboreal nest of coatis (*Nasua nasua*) in the Brazilian Pantanal.

Table 1. Information from the triatomine bugs collected in arboreal nests of coatis (*Nasua nasua*), as well as results of precipitin test that evaluated the use of blood feeding in the Pantanal Nhecolândia, between the months of May and September 2012.

Infested nests	Date	Triatomine Bugs		
		Number of specimens collected	Species	Precipitin test
1	24/5/2012	3 (2N, 1Ad)	<i>Rhodnius stali</i>	Coati, Bird and Marsupial
2	7/7/2012	3 (2N4, 1N5)	<i>Triatoma sordida</i>	NA
3	8/7/2012	3 (2Ad, 1N)	<i>Triatoma sordida</i>	NA
4	2/8/2012	4 (3N4, 1N3)	<i>Rhodnius stali</i>	NA
5	4/8/2012	1Ad	<i>Triatoma sordida</i>	NA
6	7/8/2012	20 (10Ad, 2N, 1N1, 3N5, 2N3, 2N4)	<i>Triatoma sordida</i> and <i>Rhodnius stali</i>	Coati, Rodent, Bird
7	13/9/2012	2 (1N1, 1N3)	<i>Rhodnius stali</i>	Marsupial

N: stage nymph unidentified, N1: first instar nymph, N3: third instar nymph, N4: fourth instar nymph, N5: fifth instar nymph, Ad: ad, NA: Not available

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