Density, habitat selection and observations of South American Coati *Nasua nasua* in the central region of the Brazilian Pantanal wetland

Arnaud Léonard Jean DESBIEZ [1, 2] and Paulo André Lima BORGES [3]

Abstract

The South American Coati *Nasua nasua* occurs almost throughout South America. This study took place in the central Brazilian Pantanal wetland. Using line transects and direct observations, densities and habitat selection were analysed and behaviour observed. Coati densities were highest in the forests (16.5 individuals/km²) and lowest in the floodplains (9.0 individuals/km²). Coatis were found to select the forest and forest edge and avoid open grasslands and scrub grasslands. Group size was similar throughout the three landscapes, averaging 6.6 animals per group. From line transects between sunrise and mid-day, 89% of Coati sightings were on the ground and 11% in trees; 30.5% were of Coatis travelling, 55.1% of them foraging and 14.4 % of them resting. Coatis were found to consume over 15 different species of fruit. Nesting females were observed twice, both during peak fruiting season. Results from this study predict that current intensification of cattle ranching and changes in land use practice will be detrimental to South American Coatis in the Pantanal.

Keywords: carnivore, frugivore, Neotropical, Procyonidae

Densidade Populacional, Seleção de Habitat e Observações Gerais sobre o Quati Sul-Americano na Região Central do Pantanal Brasileiro

Resumo

O quati sul-americano – *Nasua nasua* – ocorre por toda a América do Sul. O presente estudo foi realizado na região central do Pantanal Brasileiro. Densidade populacional e seleção de habitat, bem como observações gerais sobre comportamento dos quatis, foram estudadas através de transectos lineares e observações diretas. As densidades populacionais mais altas foram observadas em paisagens florestais (16,5 indivíduos/ km²) e as mais baixas em paisagens de planícies alagadas e vazantes (9,0 indivíduos/km²). Os quatis demonstraram selecionar significativamente habitats de floresta e borda florestal e evitar áreas de campo limpo e campo sujo. Tamanho de grupo foi similar para os três diferentes tipos de paisagem, resultando em uma média de 6,6 animais por grupo. Através do uso de transectos lineares entre o nascer do sol e meio-dia, 89% dos quatis foram avistados no chão, 11% em árvores, 30,5% estavam em deslocamento, 55,1% estavam se alimentando e 14,4% estavam em descanso. Os quatis consumiram mais de 15 diferentes espécies de frutos. Fêmeas com filhotes em ninhos foram observadas em duas ocasiões, ambas durante o pico da estação de frutificação. Resultados deste estudo indicam que a presente intensificação das práticas de manejo de gado bovino e mudanças nas práticas de uso da terra terão um grande impacto sobre as populações do quati sul-americano no Pantanal.

Palavras-Chave: carnívoro, frugívoro, Neotropical, Procionídeo

Introduction

Coatis *Nasua* are widespread, medium-sized, gregarious procyonids living in habitats ranging from arid environments to humid tropical rainforests, from southern USA to northern Argentina (Gompper 1995, Gompper & Decker 1998). The South American Coati *Nasua nasua* (Figs 1–3) can be found from Colombia and Venezuela to Northern Uruguay and Argentina (Gompper & Decker 1998). Published studies on South American Coatis exist mostly for the Atlantic forest of Brazil (Alves-Costa *et al.* 2004, Beisiegel & Mantovani 2006, Hirsch 2009) with none for the Pantanal biome where the species is widespread and abundant (Schaller 1983, Rodrigues *et al.* 2002).

Until recently the Brazilian Pantanal wetland was rather pristine. Private ranches with the main economic activity of cattle production occupy approximately 95% of the area (Harris *et al.* 2005). Under traditional management practices that consist of the seasonal movement of herds among patches of native savannas, cattle ranching is considered to have a low environmental impact (Santos *et al.* 2002, 2004). However, this is rapidly changing. Ranching is intensifying and modifying the landscape. The goal of this study was to evaluate South American Coati densities in different landscapes of the Pantanal and evaluate which habitat the animals selected. Results were used to hypothesise impacts the changes in cattle ranching may have on Pantanal Coati populations. Observations of the species's behaviour are also reported here.

Materials and methods

Study area

This study took place in a 200 km² area which included six traditionally managed cattle ranches in central Pantanal (18º59′S, 56º39′W). Such ranches mostly comprise of native vegetation. Cattle range freely within large grazing areas, and human densities and anthropogenic impacts are considered limited. Mortality of South American Coati in the region due to anthropogenic activity is low because native mammals are seldom hunted (Desbiez *et al*. in press b) and there are no roads (most travel is by horse) and therefore no road kill. The study area includes three different landscapes typical of the region: (1) floodplains, dominated by seasonally flooded grasslands; (2) forests, characterised by strips

Fig. 1. South American Coati Nasua nasua *eating the flower of Bromelia balansae.*

and patches of semi-deciduous forest; and (3) cerrado, covered by scrub forest and open scrub grasslands. Further details of the study area are in Desbiez (2007) and Soriano *et al*. (1997).

Density estimations

Twenty one transects 3½–5 km long and marked at 50 m intervals were randomly placed within the study area with no previous knowledge of animal distribution: seven in the forest landscape, six in the cerrado landscape and eight in the floodplain. In total, 2,174 km of transects were walked (848 km in the forest landscape, 906 in the cerrado landscape and 420 km in the floodplain landscape). Surveys took place between July 2002 and October 2004. Transects were walked alone by the same observer (first author), except in the floodplains 200 km of which were walked alone by another trained observer (second author). Transects were cleaned bi-monthly to ensure detection of animals on the line and to avoid noise while walking. Transect census began at sunrise and usually finished before noon; no nocturnal surveys were conducted. In both forest and cerrado landscapes, transects were walked at approximately 1–2 km/h, followed by a minimum one hour wait in a location 500 m from the end of the transect, and then data was collected on the walk back as well. In the floodplain, transects were walked at 2–4 km/h and, at the end of the trail, the observer stopped data collection, walked to a parallel transect 1 km away, and walked back along it collecting data. In the floodplain, transects were walked slightly faster because most of this landscape is open grasslands and animals are quickly sighted, whereas in the forest detection is more difficult. For detections to remain as independent events, Coatis were grouped into clusters and group sightings were considered as single detections (Buckland *et al*.

Figs 2 & 3. South American Coati Nasua nasua.

2001). Date, time of the day, species, perpendicular distance from the transect to the centre of the group, habitat type, group size and activity were registered for each sighting. Perpendicular distances were estimated to the nearest meter with a measuring tape or using a GPS.

Densities were estimated using DISTANCE software (Thomas *et al.* 2006). Multiple Covariates Distance Sampling (MCDS) methods (Marques & Buckland 2003) were applied to estimate densities because the Pantanal is an extremely heterogeneous environment, where landscapes are composed of a mosaic of exceptionally different habitats. This means that, on the same line-transect, the observer may walk through a forested environment with a maximum visibility of 25 m and later find him-/herself in open grasslands, where the maximum visibility is well over 250 m. In MCDS, the detection function is modelled as a function of both distance and one or more additional covariates, in this case habitat visibility. Habitat types were grouped in two categories, closed and open, according to the visibility within the habitat, and were entered as factorial covariates. Closed habitats included semi-deciduous and scrub forests where visibility was restricted by the vegetation. Open habitats included grasslands and scrub grasslands where visibility was greater. Effort in each habitat type on each trail was quantified. The study area was divided into three strata based on landscape: floodplain, forest, cerrado. A global detection function and stratum-specific encounter rates were used to obtain density estimates for each landscape. Distance data from repeat transect visits were pooled. The detection function was modelled using the half-normal, uniform and hazard rate key functions and cosine, simple and hermite polynomial series adjustments. The Akaike's Information Criterion (AIC) was used to select the combination that produced the best fit. Model fit and the fit of the estimated detection functions to the empirical histograms of distance data were assessed through the Qq-plot and the Chi-square goodness-of-fit, Kolmogorov–Smirnov and Cramer–von Mises tests reported by DISTANCE.

Habitat use and availability

Encounter rates of Coati groups for habitats from the three landscapes were calculated. Each 50 m portion of the 21 transects was categorised into five different habitats: 1) open grasslands, 2) scrub grasslands, 3) scrub forest, 4) semi-deciduous forest, and 5) forest edge. Each landscape has different proportions of each habitat. For each 50 m portion of all transects, the encounter rates for each species within 8 m from the trail was determined. This fixed width (8 m) is the effective strip width calculated by DISTANCE and it is assumed that all animals regardless of habitat are sighted at this distance. The frequency of sightings took into account the number of times each section was sampled to standardise the frequency of sightings. By grouping the encounter rate in each habitat category, habitat use was then determined. Habitat availability was estimated from the total proportion of 50 m habitat segments from the 21 transects.

Habitat selection

Manly's standardised habitat selection index for constant resources was used to compare habitat selection in the different landscapes. The index is based on the selection ratio w_i. This is the proportional use divided by the proportional availability of each resource, $w_i = o_i / \pi_i$, where: o_i = proportion of the sample of used resource units in category i (encounter rate); π_i = proportion of available resource units in category i (available habitat). A w_i value larger than 1 indicates a positive selection for the resource and a value less than 1 indicates avoidance; a value around 1 indicates that the resource was used in proportion to its availability, implying no resource selection. The preference/avoidance of each species for each resource was calculated from the selection ratio w_i and tested for each species in each habitat using a chi-square test adjusted by Bonferroni. Calculations were made with the extension *adehabitat* in the statistical package R (Ihaka & Gentleman 1996, Calenge 2006).

Results

In total 305 observations of single individuals or groups of South American Coatis were made (Tables 1 and 2). Over 1,310 individual animals were seen. Density was highest in the forest landscape and lowest in the floodplain landscape (Table 1). When considering the habitats across the three landscapes, encounter rates of groups of South American Coatis were highest in the forest (Table 2). Coatis were found significantly to select the forest and forest edge and avoid open and scrub grasslands (Table 3). Group size was fairly similar throughout the three landscapes, around 6–7 animals, but ranged from two to 27 (Table 1). Even larger groups, thought to exceed 40 animals, were sighted opportunistically during the dry season around drying ponds. Coatis were sighted either alone or in groups. In the forest landscape Coatis were seen singly 57 times and 94 times in groups, in the cerrado landscape they were seen 44 times alone and 57 times in groups, while in the floodplain landscape they were sighted 20 times alone and 22 times in groups. It was not always possible to decide the sex of animals sighted, but singletons were predominantly large males, while groups were composed predominantly of females, immature males and juveniles.

South American Coati groups travel in loose formations and there can be over 50 m between the first individual and the last.

Table 1. Density estimates (D) (individuals/km²), standard error (SE) of densities calculated using DISTANCE and mean (M), standard error (SE), maximum (max) and minimum (min) values of group sizes of South American Coati from central Pantanal between July 2002 and October 2004.

Parameter	Floodplain	Forest	Cerrado
D±SE	9.09 ± 5.00	16.66 ± 2.94	10.47 ± 1.88
M±SE	6.5 ± 1.1	6.6 ± 0.5	6.7 ± 0.7
(max; min)	(27; 2)	(27; 2)	(20; 2)

Table 2. Encounter rates (sightings/100km) of groups of South American Coatis in different habitats from the centre of the Pantanal between October 2002 and November 2004 up to 8 m from the trail (N=160).

Habitat	Sightings/100 km
Open grasslands	4.47
Scrub grasslands	2.64
Scrub forest	6.01
Forest	18.07
Forest edges	12.00

They usually travel on the ground but are agile climbers and can travel through the canopy, particularly through *Attalea phalerata* palms which occur in high-density aggregations scattered around the landscape. Coatis are often observed resting in these palms. In general they were usually observed to rest high in the canopy, rather than on the ground. From the transect, 89% (N=291) of Coati sightings were on the ground and 11% were in trees (N=36). A group with some individuals in trees and some on the ground was counted as both a ground and an arboreal observation. Furthermore 30.5% of the sightings from the trail were of Coatis travelling (N=93), 55.1% of them foraging (N=168) and 14.4 % of them resting (N=14.4).

When travelling in groups Coatis constantly communicate by chirping and whistling. In the open grasslands they raise their tails vertically, seemingly to communicate their position. Single individuals are usually silent and travel with their tails lowered. When startled or sensing a danger the group makes alarm grunting sounds and runs up trees. These alarm calls are well known by other animals, and we have observed Collared Peccaries *Pecari tajacu* and South American Brown Brockets (Grey Brockets) *Mazama gouazoubira* react to alarm calls from Coati groups.

Coatis were observed to forage in leaf litter to consume invertebrates. They dig characteristic 5–10 cm narrow holes into which they poke their snouts. They also search for invertebrates at the base of the palm leaves of *A. phalerata* and dig around the crown of the palm. They upturn or scratch at rotting logs. One Coati was observed eating termites. They are avid fruit consumers and were observed, directly or through their tracks, to consume over 15 different species of fruit (Table 4). They were observed to spit out seeds of large fruit such as *A. phalerata*, *Ximenia americana*, *Vitex cymosa*, *Hancornia speciosa* and *Dipteryx alata*. Seeds are usually dropped at or near the base of the tree. However, Coatis may be capable of swallowing and potentially dispersing smaller seeds such as *Ficus* spp. or *Alibertia* spp. Coatis consumed fruit both from the ground and directly in the trees. Often some individuals fed in the tree while others foraged beneath it, eating fruits dropped and dislodged by other Coatis. Several times Collared Peccaries were seen foraging on fruits dropped by Coatis. Coatis were never observed to eat carrion, but tracks were observed near a cow carcass.

Nesting females were observed twice, in November 2003 and in December 2002; both sightings are at the height of the fruiting season. The first female was nesting in a tree hole and had two tiny pups; another female Coati was near her. The second observation was a single female in a crown of *A. phalerata* with three pups. Females seem to isolate themselves and rejoin their group when the cubs are old enough to travel.

Discussion

The use of MCDS methods enables the analysis of line transect data collected in a mosaic landscape such as the Pantanal. Line transects were found to be an appropriate method to analyse Coati densities in the different landscapes because encounter rates were high and all habitats in the study area were used. Densities of Coatis in the Pantanal are high compared with other studies. In another study on the south-western ridge of the Pantanal, Schaller (1983) reported 2.14 individuals/km². In several Atlantic forest fragments, Cullen *et al*. (2001) found densities of 3.11–5.20 individuals/km². Finally in a secondary forest in northeastern Brazilian Amazonia, Parry (2004) found densities of 15.4 individuals/km². In part of the area where the present study was conducted Alho *et al*. (1988) recorded frequency of encounter of species sighted while horse-riding to the ranch: South American Coatis were the most sighted mammal in the ranch. There are few Coatis deaths from anthropogenic causes in the study area, so densities there may have reached carrying capacity.

South American Coatis are widely reported to consume invertebrates and fruits (Gompper & Decker 1998, Alves-Costa *et al.* 2004, Beisiegel & Mantovani 2006, Hirsch 2009). The observation of Collared Peccaries foraging alongside South American Coatis, detailed in Desbiez *et al*. (in press a) is the first report of a foraging association between coatis and another mammal. Birds have already been reported to benefit from following foraging coatis (Booth-Binczik *et al.* 2004, Beisiegel 2007).

In the Pantanal, cattle ranching is becoming increasingly competitive and many land owners are now either selling their properties or intensifying ranching practices (Seidl *et al.* 2001 Santos *et al.* 2002). Since the early 1970s, ranchers are clearing land and planting pastures of exotic grasses to increase the carrying capacity for livestock. Ranchers tend to plant pastures on the highest grounds available in their ranch since these are not subject to regular flooding: these areas are usually forested (Comastri Filho & Pott 1996, Seidl *et al.* 2001). Deforestation in the Pantanal is on the increase: more than 40% of forest and savanna habitats have already been altered for cattle ranching by introduction of exotic grass species (Padovani *et al.* 2004). Forested landscapes had the highest densities of Coatis and semi-deciduous forest and forest edge were the habitats most selected by the species. In addition, fruits, an important resource for Coatis, are mostly found in forested areas. These habitats have the lowest carrying capacity for cattle (Santos *et al*. 2002), so are the primary targets for deforestation. Results from this study predict that current intensification and changes in land use practices will be detrimental to South American Coatis.

Acknowledgements

Funding for this work was provided by the European Union INCO PECARI project, Embrapa Pantanal and the Royal Zoological Society of Scotland (RZSS). We are very grateful to the owners of Porto Alegre, Dom Valdir, Campo Dora, Ipanema and Alegria ranches for allowing research on their properties and the people living on the EMBRAPA-Pantanal Nhumirim ranch for their help and support.

References

Alho, C. J. R., Lacher, T. E. & Campos, Z. M. S. 1988. Mamiferos da fazenda Nhumirim, sub-regiao de Nhecolandia, Pantanal do Matto Grosso do Sul: levantamento preliminar de especies. *Revista Brasileira de Biologia* 48: 213–225.

Alves-Costa, C. P., da Fonseca, G. A. B. & Christofaro, C. 2004. Variation in the diet of the Brown-nosed Coati (*Nasua nasua*) in Southeastern Brazil. *Journal of Mammalogy* 83: 478–482.

Beisiegel, B. M. 2007. Foraging association between Coatis (*Nasua nasua*) and birds of the Atlantic Forest, Brazil. *Biotropica* 39: 283–285.

Beisiegel, B. M. & Mantovani, W. 2006. Habitat use, home range and foraging preferences of the Coati *Nasua nasua* in a pluvial tropical Atlantic forest area. *Journal of Zoology, London* 269: 77–87.

Booth-Binczik, S. D., Binczik, G. A. & Labisky, R. F. 2004. A possible foraging association between White Hawks and White-nosed Coatis. *Wilson Bulletin* 116: 101–103.

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L. & Thomas, L. 2001. *Introduction to Distance sampling: estimating abundance of biological populations*. Oxford University Press, Oxford, U.K.

Calenge, C. 2006. The package "adehabitat" for the R software: a tool for the analysis of space and habitat use by animals. *Ecological Modelling* 197: 516–519.

Comastri Filho, J. A. & Pott, A. 1996. *Introdução e avaliação de forrageiras em "cordilheira" desmatada na sub-região dos Paiaguás, Pantanal mato-grossense*. Boletim de Pesquisa e Desenvolvimento, 05 Embrapa Pantanal, Corumbá, MS, Brazil.

Cullen, L., Jr, Bodmer, R. E. & Valladares-Padua, C. 2001. Ecological consequences of hunting in Atlantic forest patches, Sao Paulo, Brazil. *Oryx* 35: 137–144.

Desbiez, A. L. J. 2007. *Wildlife conservation in the Pantanal: habitat alteration, invasive species and bushmeat hunting*. PhD thesis, Durrell Institute of Conservation and Ecology (DICE), University of Kent, Canterbury, U.K.

Desbiez, A. L. J., Keuroghlian, A. & Rocha, F. L. in press a. Interspecific associations between an ungulate and a carnivore or a primate. *Acta Ethologica*.

Desbiez, A. L. J, Keuroghlian, A., Piovezan, U. & Bodmer, R. E. in press b. Invasive species and bushmeat hunting contributing to wildlife conservation: the case of feral pigs in a Neotropical wetland. *Oryx*.

Gompper, M. E. 1995. *Nasua narica*. *Mammalian Species* 487: 1–10.

Gompper, M. E. & Decker, D. M. 1998. *Nasua nasua*. *Mammalian Species* 580: 1–9.

Harris, M. B., Tomás, W. M., Mourão, G., Da Silva, C. J., Guimarães, E., Sonoda, F. & Fachim, E. 2005. Safeguarding the Panatanal wetlands: threats and conservation initiatives. *Conservation Biology* 19: 714–720.

Hirsch, B. T. 2009. Seasonal variation in the diet of Ring-tailed Coatis (*Nasua nasua*) in Iguazu, Argentina. *Journal of Mammalogy* 90: 136–143.

Ihaka, R. & Gentleman, R. 1996. R: a language for data analysis and graphics. *Journal of Computational and Graphical Statistics* 5: 299–314.

Marques, F. F. C. & Buckland, S. T. 2003. Incorporating covariates into standard line transect analyses. *Biometrics* 59: 924–935.

Padovani, C. R., Cruz, M. L. L. & Padovani, S. L. A. G. 2004. *Desmatamento do Pantanal brasileiro para o ano 2000*. IV Simposio sobre recursos naturais e socio-economicos do Pantanal, Embrapa Pantanal. Corumbá, MS, Brazil.

Parry, L. 2004. *Large vertebrate communities of primary and secondary forests in the Brazilian Amazon*. Masters thesis, University of East Anglia, Norwich, U.K.

Rodrigues, F. H. G., Medri, I. M., Tomás, W. M. & Mourão, G. M. 2002. *Revisão do conhecimento sobre ocorrência e distribuição de mamíferos do Pantanal*. Documentos 38. Embrapa Pantanal, Corumbá, MS, Brazil.

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.

Santos, S. A., Crispim, S. M. A., Comastri Filho, J. A. & Cardoso, E. L. 2004. *Princípios de agroecologia no manejo das pastagens nativas do Pantanal*. Documentos 63. Embrapa Pantanal. Corumbá, MS, Brazil.

Schaller, G. B. 1983. Mammals and their biomass on a Brazilian ranch. *Arquivios de Zoologia* 31: 1–36.

Seidl, A. F., Vila de Silva, J. S. & Moraes, A. S. 2001. Cattle ranching and deforestation in the Brazilian Pantanal. *Ecological Economics* 36: 413–425.

Soriano, B. M. A., Oliveira, H. de, Catto, J. B., Comastri Filho, J. A., Galdino, S. & Salis, S. M. de 1997. *Plano de utilização da fazenda Nhumirim*. Documentos 2. Embrapa Pantanal, Corumbá, MS, Brazil.

Thomas, L., Laake, J. L., Strindberg, S., Marques, F. F. C., Buckland, S. T., Borchers, D. L., Anderson, D. R., Burnham, K. P., Hedley, S. L., Pollard, J. H., Bishop, J. R. B. & Marques, T. A. 2006. Distance 5.1 release 1. In: *Research Unit for Wildlife Population Assessment*. <University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/>.

[1]Royal Zoological Society of Scotland, Murrayfield, Edinburgh, EH12 6TS, Scotland, UK.
Email: adesbiez@hotmail.com, adesbiez@RZSS. org.uk
[2]Embrapa Pantanal, Rua 21 de Setembro 1880, Bairro Nossa Senhora de Fátima, Caixa Postal 109, Corumbá 79320–900, Mato Grosso do Sul, Brazil.
[3]Department of Environmental Management, Griffith University, Brisbane, QLD, Australia.
Email: pauloalborges@gmail.com