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Research Article

Density and survivorship of the South American coati (*Nasua nasua*) in urban areas in Central–Western Brazil

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Abstract

Biodiversity is constantly threatened by urbanization. However, species with greater behavioral plasticity can establish themselves in urbanized landscapes and, in some cases, can reach high densities, which can result in human-wildlife conflict. Therefore, a study on the population parameters of wildlife in an urban environment can provide important information to support the management of these populations. We estimated the population parameters of South American coatis (*Nasua nasua*) using capture–mark–recapture models. We used Huggins robust models to estimate detectability using sex, weight, and time as covariates and used the best-fitting model to estimate the apparent survival of coatis in an urban landscape. The abundance was obtained as a derivative parameter. The density was obtained based on abundance estimates. Total annual apparent survival was low in both study sites, and almost double in the Brazilian Air Force Private Area (AFPA) compared to the Parque Estadual do Prosa (PEP). The population size was estimated at 41 individuals in the AFPA group and 30 individuals in the PEP group. The density in AFPA was 19.5 individuals/km^2, and was 11.2 individuals/km^2 in PEP. Our estimates were the lowest when compared to those reported for urban areas in the existing literature. Our results suggest that the low apparent survival is compensated by dietary supplementation and low susceptibility to predation, which maintains a stable population density over time.

Introduction

Urbanization and consequent fragmentation and habitat loss constitute a major threat to biodiversity at the global level, negatively affecting community structures and ecosystem services (Mcdonald et al., 2008; Crooks et al., 2017). Although most species are unable to persist in urban environments, few can establish and benefit from urban parks, forest fragments and peri-urban areas (Kark et al., 2007; Evans et al., 2011). In these scenarios, there is usually a reduction in species richness and an increase in the abundance of species that can adapt to the pressures exerted by urbanization (McKinney, 2006; Shochat et al., 2006).

Bottom-up and top-down processes regulate animal populations in different landscapes, for example, through the availability of resources and predation, respectively (McQueen et al., 1986; Leroux and Loreau, 2015). In urban habitats, resource availability and disease incidence seem to be the main pressures on population dynamics (Prange et al., 2003; Contesse et al., 2004). In contrast, in natural habitats, predation and agonistic interactions, in addition to resource availability, seem to be the main forces controlling populations (Sinclair et al., 2003; Rocha, 2006; Olifiers, 2010; Goldstein et al., 2018).

In urban areas, the availability of natural and anthropic food resources, absence of natural predators, and habitat availability are among the factors that can favor the establishment of species with greater plasticity (McKinney, 2006; Bateman and Fleming, 2012). For example, raccoons (*Procyon lotor*: Procyonidae) respond positively to urban environments and reach high population densities when compared to those in rural areas (Prange et al., 2003). This phenomenon is common in other carnivorous species (e.g., *Vulpes vulpes*, *Martes foina*, and *Meles meles*) and can be related to the availability of natural and anthropic resources, resulting in better body condition and higher reproductive rates (Rosatte and Allan, 2009; Bateman and Fleming, 2012).

The South American coati (*Nasua nasua*; hereafter coati) is a medium-sized, social, scansorial, and diurnal mammal, occurring from Colombia and Venezuela to Northern Uruguay and Argentina (Gompper and Decker, 1998). It occupies forested habitats, including deciduous forests, galleries, chacos, and savannas (Redford et al., 1993; Gompper and Decker, 1998). Coatis are important seed dispersers, and their omnivore diet is composed mainly of invertebrates, small vertebrates, and fruits (Gompper and Decker, 1998; Hirsch, 2009). In addition, in urban environments, they frequently feed on organic waste from human consumption (Alves-Costa, 2004; Repolês, 2014). Felines such as jaguars (*Panthera onca*), pumas (*Puma concolor*), and ocelots (*Leopardus pardalis*) are the main predators of adult coatis in the natural environment (Gompper and Decker, 1998); however, primates can play an important role by predating juveniles on nests (Hirsch and Gompper, 2017).

The composition of social groups was suggested to be composed of adult females, their pups, and subadults of both sexes, whereas adult males are considered solitary, joining social groups exclusively during the reproductive period (Emmons and Feer, 1990; Gompper and

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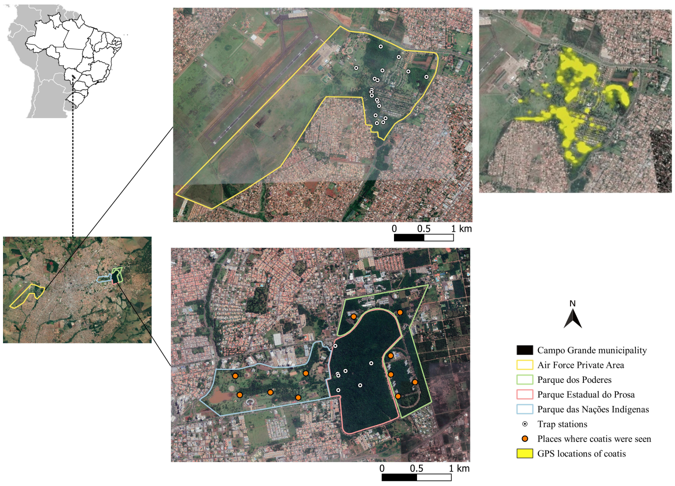

Figure 1 – Delimitation of study sites and the location of trap stations for the capture of South American coatis (*Nasua nasua*) in the urban area of Campo Grande, Brazil, from March 2018 to November 2019. Upper right in yellow are the distribution of the locations of coatis monitored in the Air Force Private Area according to data obtained by GPS telemetry.

Decker, 1998). However, anecdotal observations at different sites have challenged the expected social structure, suggesting a high degree of adult male sociability outside the mating season (Alves-Costa, 2004; de Resende et al., 2004; Costa et al., 2009; Hirsch, 2011), which should indicate, at least, an unrecognized heterogeneity in coati social structures across space.

The population density of coatis varies according to the region and habitat (e.g., Bodmer et al., 2009; Desbiez and Borges, 2010). Coati density seems to scale up with the anthropization level, since reported density estimates in urban environments (range=30.3 to 59.8 individuals per km^2) (Costa et al., 2009; Hemetrio, 2007, 2011) are consistently much higher than those observed in natural environments (e.g. Cullen et al., 2001; Bovendorp and Galetti, 2007).

Since population demography provides the most important guide for species management and conservation practices (Krebs, 1999), we aimed to estimate the population size, density, and apparent survival of two coati populations living in a large urban area. Specifically, by controlling for imperfect detection, we provided rigorous abundance estimation for two urban coati populations, and also investigated the effects of sex, age, and body weight on individual annual survival. Our results contribute to the understanding of urbanization effects on population abundance of coatis, providing further insight on the demographic mechanisms responsible for maintaining high densities in urban areas.

Materials and methods

Study sites

This study was conducted in two fragments of the Cerrado in the urban area of Campo Grande, Mato Grosso do Sul, Brazil (20°26′34″ S, 54°38′47″ W): Brazilian Air Force Private Area (AFPA) and Parque Estadual do Prosa (PEP) (Fig. 1). The climate of the region is classified by Köppen's system as tropical humid or savanna (Aw), with the rainy season from November to March and the dry season from April to October.

The AFPA comprised an area of approximately 484 ha. The vegetation cover was dense forest, cerrado, riparian forest, and veredas. The entire area consisted of a residential complex and an operational area of the Brazilian Air Force (ALA-5). At least 730 people and their domestic animals inhabited the residential complex. The houses were not fenced, and they all had a trash can at the front. Although there was an institutional boundary, there were no physical limitations that prevented the free movement of animals between the two areas, since the only barrier was a fence that was easily climbed by coatis or crossed in places that had gaps. In contrast, the entire area was surrounded by a brick wall with a concertina fence on top, which possibly limited the movement of coatis out of the area. Other wild mammals had already been sighted in the area, such as *Cerdocyon thous*, *Hydrochoerus hydrochaeris*, *Dasypus novemcinctus*, *Dasyprocta azarae*, and *Pecari tajacu*.

The PEP covered an area of 134 ha formed by cerrado sensu stricto (savanna), cerradão (tall savanna woodland), and riparian forest (Barbosa, 1996; Costa et al., 2009). The local fauna consisted of several species, including mammals (e.g., *C. thous*, *Myrmecophaga tridactyla*, *Didelphis albiventris*, *D. novemcinctus*, *D. azarae*, and *Hydrochoerus hydrochaeris*), birds (e.g., *Crax fasciolata* and *Aramides cajaneus*), and reptiles (e.g., *Boa constrictor* and *Tupinambis merianae*). In addition to wildlife, domestic cats and dogs have been seen on site. Furthermore, inside PEP there is a Wildlife Rehabilitation Center, which is a source of food for coatis since they consume food offered to the captive species. The PEP is surrounded by wire fences and is adjacent to the Parque dos Poderes (PP) and the Parque das Nações Indígenas (PNI) (Fig. 1). In both PP and PNI, there is a high daily circulation of people (approximately 2000 visitors attend the PEP during the week, and on weekends, it can exceed 6000 users).

Data collection (animal trapping)

From March 2018 to November 2019, we used 39 Tomahawk traps (20 PEP, 19 AFPA) baited with bacon to capture coatis. In the last two capture expedition, 39 traps were used only at the AFPA. Traps were installed to sample the largest area in accessible and shaded locations (Fig. 1). The traps were arbitrarily distributed in blocks ranging from two to five traps and were checked early in the morning, baited, and reassembled early in the afternoon. Once captured, the animals were anesthetized with Telazol®100 (tiletamine hydrochloride and zolazepam hydrochloride, ±6 mg/kg), and their weight and sex were recorded. To mark individuals, we applied numbered colored ear-tags (Qualyplast®) after a local injection of lidocaine in each ear. The coatis were also marked with interscapular subcutaneous transponders (AnimalTag®) since the ear-tags could be lost. Very young coatis (<1.5 kg and <5 months) were not sampled, data refer only to juvenile and adult animals. We also recorded the date and place of each capture event. We released the animals at the capture site after complete recovery from the anesthesia.

It is worth mentioning that in AFPA, we identified three groups of coatis with a variable number of individuals per group. In PEP, at least three groups were found, which is in line with the findings of Costa et al. (2009). In both study areas, the groups consisted of females and their offspring and, on many occasions, adult males associated with the group regardless of the reproductive period.

Field procedures were conducted per the license granted by the Instituto Chico Mendes de Conservação da Biodiversidade (49662-7/2018), IMASUL (71/404517/2017), and Air Force Cooperation Agreement (Nº01/GAP-CG/2018). All procedures followed the Guidelines of the American Society of Mammalogists for the use of wild mammals in research (Sikes, 2016).

Demographic parameters

Population parameters were estimated using a capture-mark-recapture (CMR) sampling scheme. This method consists of capturing individuals from the population, marking, and releasing them. From the subsequent capture events, we constructed capture histories for each coati sampled during the study with sex and weight as covariates.

Capture histories were constructed based on four and three primary sampling occasions for AFPA and PEP, respectively. Each primary occasion was composed of seven to 22 secondary sampling occasions [AFPA: (i) 19 days (Apr-Jun), (ii) 18 days (Aug-Nov), (iii) 22 days (Jan-Apr), (iv) seven days (Nov 2019); PEP: (i) nine days (Mar), (ii) nine days (May-Jun), and (iii) 17 days (Aug-Oct)]. We used a Huggins robust design model (Huggins, 1991) including age, sex, weight, time (primary sampling occasion), and interaction between sex and weight as covariates to estimate the probability of capture (p), probability of recapture (c), survival (ϕ) using `RMark` (Laake, 2013) and `MuMin` (Barton, 2020) packages in R.

Table 1 – Model selection results from Huggins robust-design models exploring covariates for detectability of South American coatis (*Nasua nasua*) from two study sites (AFPA and PEP) based on capture-mark-recapture data from Campo Grande, Brazil, collected from March 2018 until November 2019. AICc: Akaike's information criterion; ΔAIC: delta Akaike's Information Criterion; K: number of parameters; ω_i: model AICc weight; AFPA: Air Force Private Area; PEP: Parque Estadual do Prosa.

Study site	Model	K	AICc	ΔAICc	ω_i
AFPA	$p(age+sex+weight)c(.)\phi(.)$	6	1243.1	0.00	0.112
	$p(.)c(.)\phi(.)$	3	1243.4	0.33	0.095
	$p(time+weight)c(.)\phi(.)$	7	1243.4	0.38	0.092
	$p(weight)c(.)\phi(.)$	4	1243.7	0.63	0.081
	$p(sex+weight)c(.)\phi(.)$	5	1243.9	0.86	0.072
	$p(time+sex+weight)c(.)\phi(.)$	8	1244.4	1.28	0.059
	$p(age+time+sex+weight)c(.)\phi(.)$	9	1244.4	1.32	0.057
	$p(age+sex+weight+sex:weight)c(.)\phi(.)$	7	1244.5	1.44	0.054
	$p(sex)c(.)\phi(.)$	4	1244.6	1.52	0.052
	$p(age+time)c(.)\phi(.)$	7	1244.7	1.61	0.050
	$p(age)c(.)\phi(.)$	4	1244.8	1.70	0.048
	$p(age+time+weight)c(.)\phi(.)$	8	1245.3	2.27	0.036
	$p(time+sex+weight+sex:weight)c(.)\phi(.)$	9	1245.7	2.61	0.030
	$p(age+time+sex+weight+sex:weight)c(.)\phi(.)$	10	1245.8	2.72	0.029
	$p(time)c(.)\phi(.)$	6	1245.8	2.72	0.029
	$p(age+weight)c(.)\phi(.)$	5	1245.8	2.75	0.028
	$p(sex+weight+sex:weight)c(.)\phi(.)$	6	1246.0	2.98	0.025
	$p(age+sex)c(.)\phi(.)$	5	1246.4	3.31	0.021
	$p(age+time+sex)c(.)\phi(.)$	8	1246.8	3.76	0.017
	$p(time+sex)c(.)\phi(.)$	7	1247.4	4.38	0.013
PEP	$p(weight)c(.)\phi(.)$	4	774.2	0.00	0.257
	$p(age)c(.)\phi(.)$	4	775.8	1.66	0.112
	$p(age+weight)c(.)\phi(.)$	5	776.2	2.03	0.093
	$p(.)c(.)\phi(.)$	3	776.2	2.07	0.091
	$p(sex+weight+sex:weight)c(.)\phi(.)$	6	776.2	2.08	0.091
	$p(sex+weight)c(.)\phi(.)$	5	776.3	2.16	0.087
	$p(age+sex)c(.)\phi(.)$	5	777.8	3.60	0.042
	$p(age+sex+weight+sex:weight)c(.)\phi(.)$	7	777.9	3.72	0.040
	$p(sex)c(.)\phi(.)$	4	778.3	4.16	0.032
	$p(age+sex+weight)c(.)\phi(.)$	6	778.4	4.22	0.031
	$p(time+weight)c(.)\phi(.)$	6	778.5	4.33	0.029
	$p(time+sex+weight+sex:weight)c(.)\phi(.)$	8	778.9	4.77	0.024
	$p(age+time)c(.)\phi(.)$	6	780.1	5.96	0.013
	$p(time)c(.)\phi(.)$	5	780.1	5.97	0.013
	$p(age+time+sex+weight+sex:weight)c(.)\phi(.)$	9	780.5	6.34	0.011
	$p(age+time+weight)c(.)\phi(.)$	7	780.6	6.39	0.011
	$p(time+sex+weight)c(.)\phi(.)$	7	780.7	6.57	0.010
	$p(age+time+sex)c(.)\phi(.)$	7	782.0	7.87	0.005
	$p(time+sex)c(.)\phi(.)$	6	782.2	8.04	0.005
	$p(age+time+sex+weight)c(.)\phi(.)$	8	782.8	8.66	0.003

Model notation:
p = capture probability; c = recapture probability; ϕ = apparent survival; *age* = initial age class of sampled individuals; *sex* = sex of sampled individuals; *time* = secondary sampling occasion; *weight* = weight of sampled individuals.

Therefore, ϕ was estimated between successive primary occasions (open population), while N, p and c were estimated within primary occasions (closed population). We fixed the parameters γ' and γ'' to one and zero, respectively, which are related to temporary unavailability to be captured in the trapping area (Huggins, 1991). These values were fixed based on GPS telemetry evidence (17 individuals for approximately nine months; unpublished data), from which we observed that coatis were permanent residents during the entire course of monitoring in AFPA. These GPS data were also used to define the effective sampled area by the total area used by coatis during the trapping season (Fig. 1). Because of a lack of movement data in PEP and since the coatis were seen frequently in PEP, PNI, and PP, we considered these sites as potential habitats and included them as effective sampled areas of PEP. The population abundance was obtained as a derived parameter in the Huggins model (Huggins, 1991). We used abundance estimates to calculate density, obtained by dividing the number of coatis by the effective sampled area (Thompson et al., 1998). This approach was carried out for both AFPA and PEP.

We used a 2-step approach by first modeling the best model structure for p, including a combination of all covariates in a dredge model. Once we defined the best-fitting model for capturability, we kept this structure, and then estimated the apparent survival and covariate effects using the dredge function (Huggins, 1991). We used Akaike's Information Criterion corrected to a small sample size (AICc) to compare the candidate models (Burnham and Anderson, 2002). If only one model presented ΔAICc<2, we assumed it was the best; otherwise, we model-averaged the set of best models (ΔAICc<2) to draw our conclusions. In addition, we verified whether the 95% confidence interval (CI) of the estimated coefficients overlapped zero to support the influence of covariates on detectability.

Results

We accumulated a sampling effort of 1953 trap-days at AFPA and 177 captures of 67 different individuals (29 males and 38 females), with a capture success of 9.06%. At PEP, the total sampling effort was 778 trap-days, resulting in 129 captures representing 51 individuals (21

Table 2 – Model selection results from Huggins robust-design models exploring covariates for the apparent survival of South American coatis (*Nasua nasua*) from two study sites (AFPA and PEP) based on capture-mark-recapture data. Data from individuals sampled at Campo Grande, Brazil, from March 2018 until November 2019. AICc: Akaike's information criterion with small sample size; ΔAICc: delta Akaike's information criterion with small sample size; K: number of parameters; ω_i: model AICc weight; AFPA: Air Force Private Area; PEP: Parque Estadual do Prosa.

Study site	Model	K	AICc	ΔAICc	ω_i
AFPA	$p(.)c(.)\phi(age+sex+weight)$	6	1239.3	0.00	0.257
	$p(.)c(.)\phi(age+sex+time+weight)$	8	1240.1	0.74	0.177
	$p(.)c(.)\phi(age+sex+weight+sex:weight)$	7	1240.9	1.53	0.119
	$p(.)c(.)\phi(age+sex+time+weght+sex:weight)$	9	1241.5	2.12	0.089
	$p(.)c(.)\phi(sex)$	4	1241.8	2.48	0.074
	$p(.)c(.)\phi(sex+weight)$	5	1242.9	3.51	0.044
	$p(.)c(.)\phi(sex+time)$	6	1243.3	3.91	0.036
	$p(.)c(.)\phi(.)$	3	1243.4	4.05	0.034
	$p(.)c(.)\phi(age+sex)$	5	1243.7	4.39	0.029
	$p(.)c(.)\phi(time)$	5	1243.9	4.54	0.026
	$p(.)c(.)\phi(sex+time+weight)$	7	1244.1	4.77	0.024
	$p(.)c(.)\phi(sex+weight+sex:weight)$	6	1244.9	5.55	0.016
	$p(.)c(.)\phi(age+sex+time)$	7	1245.2	5.88	0.014
	$p(.)c(.)\phi(weight)$	4	1245.3	5.97	0.013
	$p(.)c(.)\phi(age)$	4	1245.4	6.00	0.013
	$p(.)c(.)\phi(time+weight)$	6	1245.8	6.43	0.010
	$p(.)c(.)\phi(age+time)$	6	1246.0	6.62	0.009
	$p(.)c(.)\phi(sex+time+weight+sex:weight)$	8	1246.2	6.90	0.008
	$p(.)c(.)\phi(age+weight)$	5	1247.4	8.08	0.005
	$p(.)c(.)\phi(age+time+weight)$	7	1247.9	8.59	0.003
PEP	$p(wei)c(.)\phi(.)$	4	774.2	0.00	0.168
	$p(wei)c(.)\phi(sex)$	5	776.0	1.79	0.069
	$p(wei)c(.)\phi(age)$	5	776.0	1.82	0.068
	$p(wei)c(.)\phi(sex+tim+wei+sex:wei)$	8	776.2	2.01	0.061
	$p(wei)c(.)\phi(tim)$	5	776.2	2.01	0.061
	$p(wei)c(.)\phi(wei)$	5	776.3	2.16	0.057
	$p(wei)c(.)\phi(sex+wei)$	6	777.3	3.15	0.035
	$p(wei)c(.)\phi(age+sex)$	6	777.4	3.26	0.033
	$p(wei)c(.)\phi(sex+tim)$	6	778.0	3.81	0.025
	$p(wei)c(.)\phi(age+wei)$	6	778.1	3.90	0.024
	$p(wei)c(.)\phi(age+tim)$	6	778.1	3.92	0.024
	$p(wei)c(.)\phi(age+sex+wei+sex:wei)$	8	778.3	4.12	0.021
	$p(wei)c(.)\phi(tim+wei)$	6	778.3	4.18	0.021
	$p(wei)c(.)\phi(sex+wei+sex:wei)$	7	778.5	4.33	0.019
	$p(wei)c(.)\phi(age+sex+wei)$	7	778.7	4.52	0.018
	$p(wei)c(.)\phi(age+sex+tim)$	7	779.6	5.43	0.011
	$p(wei)c(.)\phi(age+sex+tim+wei)$	8	779.6	5.69	0.010
	$p(wei)c(.)\phi(age+tim+wei)$	7	780.1	5.94	0.009
	$p(wei)c(.)\phi(sex+tim+wei)$	7	780.2	6.01	0.008
	$p(wei)c(.)\phi(age+sex+tim+wei+sex:wei)$	9	780.6	6.42	0.007

Model notation:
p = capture probability; *c* = recapture probability; ϕ = apparent survival; *age* = initial age class of sampled individuals; *sex* = sex of sampled individuals; *time* = secondary sampling occasion; *weight* = weight of sampled individuals.

males and 30 females), with a capture success of 16.6%. Two adult females were found dead during the study. It was not possible to determine the cause of death due to advanced decomposition.

At AFPA, 11 models were among the set of best-ranked models (Tab. 1), however, their covariates had 95% CI that overlapped zero. The capture probability at AFPA was 0.03 (95% CI=0.01–0.07) for adult females, 0.11 (95% CI=0.04–0.26) for adult males, 0.006 (95% CI=0.001–0.044) for juvenile females, and 0.03 (95% CI=0.01–0.07) for juvenile males. The probability of recapture at AFPA was 0.07 (95% CI=0.05–0.08). At PEP, the detectability was influenced by the weight of coatis (β=0.43; 95% CI=0.03–0.83); heavier coatis were more likely to be caught (Tab. 1). The probability of capturing coatis was 0.11 (95% CI=0.07–0.17), whereas the recapture probability was 0.10 (95% CI=0.08–0.13).

Apparent survival estimates at AFPA were supported by three best-ranked models. The covariates included in the set of best models were age, sex, weight, time, and sex/weight interaction (Tab. 2). However, only the age coefficient did not overlap zero. Apparent survival was ϕ=0.65 (95% CI=0.44–0.81) for adult females, ϕ=0.98 (95% CI=0.80–0.99) for adult males, ϕ=0.06 (95% CI=0.003–0.554) for juvenile female and ϕ=0.67 (95% CI=0.32–0.89) for juvenile male (Fig. 2). At PEP, we had three supported models, but the 95% CI overlapped zero for all covariates (Tab. 2). The apparent survival at PEP was estimated to be ϕ=0.66 (95% CI=0.47–0.81) (Fig. 3). The annual apparent survival was ϕ=0.41 and ϕ=0.22 for AFPA and PEP, respectively.

The population size at AFPA was estimated to be 41 (36–46) coatis. The adult female abundance for each primary occasion, respectively, was 20 (95% CI=16–34), 20 (95% CI=15–33), 18 (95% CI=14–29), and 11 (95% CI=6–30). For adult males it was 10 (95% CI=7–19), 10 (95% CI=8–20), 6 (95% CI=5–14), and 8 (95% CI=4–25). For juvenile females, the abundance was 1 (95% CI=1–6), 4 (95% CI=3–11), 5 (95% CI=4–12), and 5 (95% CI=2–20). For juvenile males it was 5 (95% CI=4–13), 12 (95% CI=9–22), 12 (95% CI=9–21), and 17 (95% CI=10–39) (Fig. 2). The effective sampled area at AFPA was estimated to be 2.1 km^2. Therefore, the density was estimated to be 19.5 individuals/km^2. At PEP, the population size was estimated to be 30

Table 3 – Density of South American coatis (*Nasua nasua*) reported in the literature and in this study.

Density ind/kmq	Method[1]	Location	Reference
6.2	SC	Acurizal farm (deciduous forest)	Schaller (1983)
13.0	SC	Acurizal farm (gallery forest)	Schaller (1983)
4.2	LT	PE Morro do Diabo	Cullen et al. (2001)
4.5	LT	EE Cateto	Cullen et al. (2001)
3.4	LT	Mosquito farm	Cullen et al. (2001)
3.1	LT	Tucano farm	Cullen et al. (2001)
5.2	LT	Rio Claro farm	Cullen et al. (2001)
0.2[2]	LT	Northeastern Brazilian Amazonia	Parry et al. (2007)
0.7	MPD	Nhumirim farm	Rocha (2006)
52.8	CMR	PM Mangabeiras[3]	Hemetrio (2007)
25.1	LT	Island of Anchieta	Bovendorp and Galetti (2007)
0.5–4	LT	Pacaya-Samiria National Reserve	Bodmer et al. (2009)
33.7	LT	PE Prosa[3]	Costa et al. (2009)
16.7	LT	Pantanal (forest)	Desbiez and Borges (2010)
9.1	LT	Pantanal (floodplain)	Desbiez and Borges (2010)
10.5	LT	Pantanal (cerrado)	Desbiez and Borges (2010)
30.3	CMR	PM Mangabeiras[3]	Hemetrio (2011)
19.5	CMR	AFPA[3]	This study
11.2	CMR	PE Prosa[3]	This study

[1] CMR: capture-mark-recapture; LT: linear transect; MPD: minimum population density; SC: strip censuses.
[2] Individuals per 10 km^2.
[3] Study sites located within urban areas.
AFPA: Air Force Private area; EE: Estação Ecológica; PE: Parque Estadual; PM: Parque Municipal.

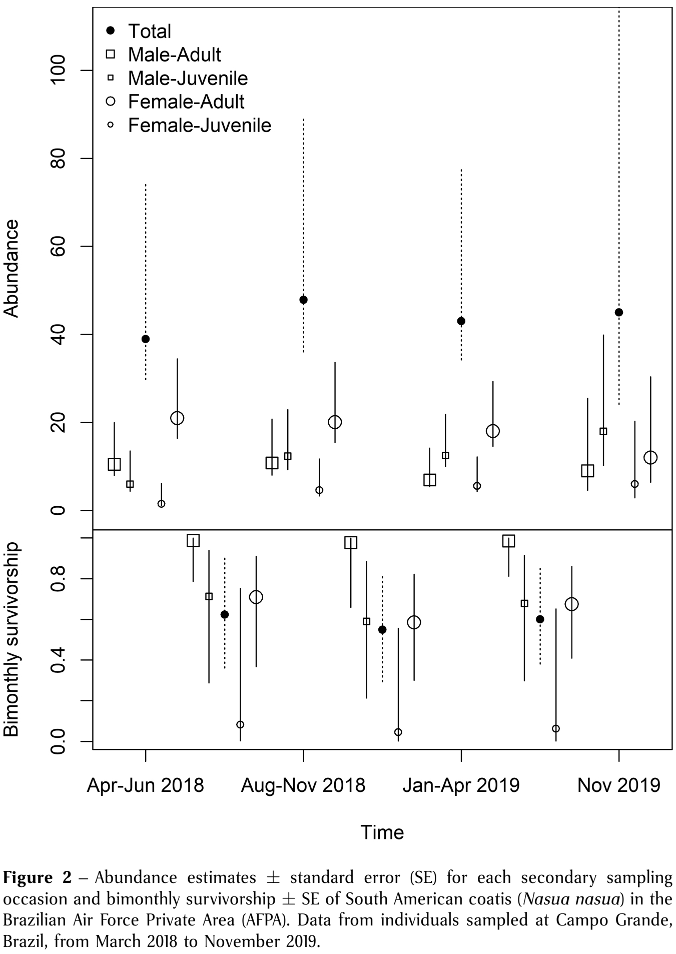

Figure 2 – Abundance estimates ± standard error (SE) for each secondary sampling occasion and bimonthly survivorship ± SE of South American coatis (*Nasua nasua*) in the Brazilian Air Force Private Area (AFPA). Data from individuals sampled at Campo Grande, Brazil, from March 2018 to November 2019.

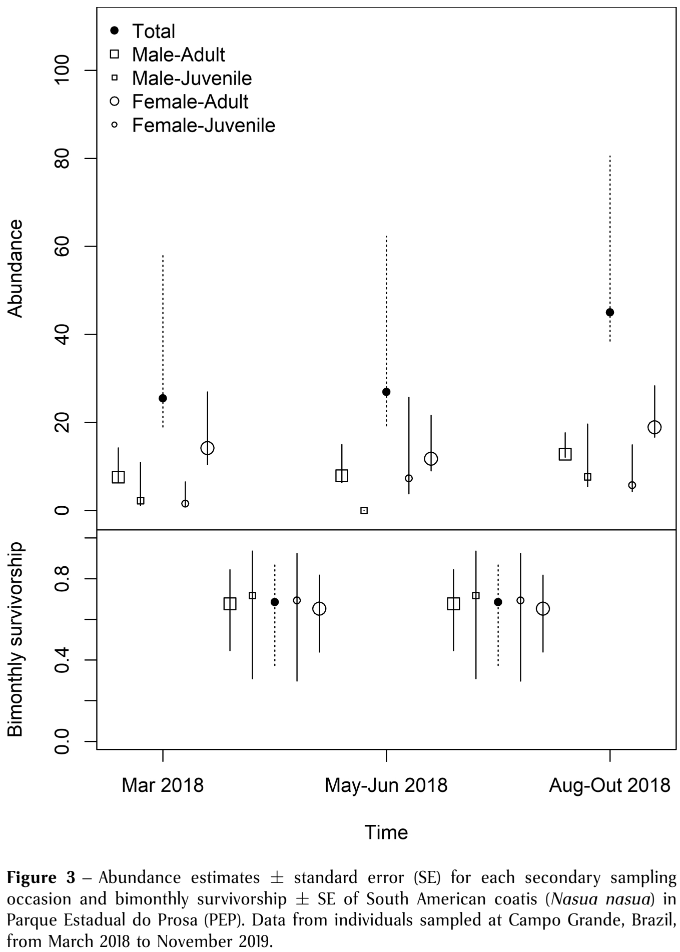

Figure 3 – Abundance estimates ± standard error (SE) for each secondary sampling occasion and bimonthly survivorship ± SE of South American coatis (*Nasua nasua*) in Parque Estadual do Prosa (PEP). Data from individuals sampled at Campo Grande, Brazil, from March 2018 to November 2019.

(24–42) coatis. The adult female abundance for each primary occasion was 14 (95% CI=10–26), 11 (95% CI=9–21), and 18 (95% CI=16–28), while adult male abundance was 7 (95% CI=6–14), 7 (95% CI=6–14), and 12 (95% CI=12–17). For juvenile female abundance was 1 (95% CI=1–6), 7 (95% CI=3–25) and 5 (95% CI=4–14). The juvenile male abundance was 2 (95% CI=1–10), 0 (95% CI=0–0) and 7 (95% CI=5–19) (Fig. 3). The effective sampled area at PEP was estimated to be 2.7 km^2, and the density was 11.2 individuals/km^2 (Tab. 3).

Discussion

Heavier individuals were easier to capture in PEP, but not in AFPA. A possible explanation is that heavier individuals are older, perform wider movements, and are more habituated to human presence, making them more prone to risk, and consequently easier to be capture in traps. In both study sites, the detectability was as low as in other studies with coatis (Hemetrio, 2011), although in PEP it was twice as high as in AFPA. We believe this low capturability is associated with the high motor and cognitive ability of coatis (Hemetrio, 2011), because we found many traps were triggered and were missing baits but no coatis were captured, or even situations where the trap had been overturned and the bait had been taken. Moreover, in our study, several species, mainly *D. albiventris*, *A. cajaneus*, and *T. merianae* were captured several times in the traps, which reduced the opportunity for the coatis to be captured.

When considering annual apparent survival, our estimates were relatively low, mainly at PEP. In urban forest fragments, some environmental characteristics (e.g., high availability of food resources and shelter, and the absence, or at least a reduced number of natural predators) led us to expect high survival rates for coatis (Prange et al., 2003). This can be related to the fact that they inhabit forested locations, have generalist eating habits, and are reportedly highly adaptable to urban environments (Gompper and Decker, 1998; Alves-Costa, 2004; Hemetrio, 2011). Studies on coati apparent survival are limited, and with very large uncertainty in the estimates: only one study has been carried out in an urban area (Hemetrio, 2011) and two in natural environments (Hirsch, 2007; Olifiers, 2010). The low annual survival observed in our study areas were similar to those obtained in the other urban area ($\phi \approx 0.28$) (Hemetrio, 2011), and lower than those observed in natural areas, such as Iguazu National Park (ϕ=0.71; Hirsch, 2007), and for adults coatis in Pantanal wetland (Olifiers, 2010), even though these estimates have very wide confidence intervals.

At AFPA, adults had higher apparent survival than juveniles, which is expected for mammals, where juveniles experience high rates of mortality by predation (Caughley, 1966). However, since the natural predators of coatis are reduced or even absent in urban areas, the mortality of younger animals is likely to be related to the occurrence of infections by pathogens and diseases. Juveniles have less pathogen exposure and, consequently, immature adaptive immunity that should yield a weak response against infectious diseases (Loukas and Prociv, 2001; Tinsley et al., 2012). It is important to note that our estimates do not refer to pups, who are likely to have even higher mortality rates.

The density estimates in AFPA are almost twice as high as those in PEP. Despite this, the number of social groups in both areas was similar and equally composed of females and males regardless of age class throughout the year. Even though both study sites have similar characteristics (e.g., natural and anthropic food resources, movement of people, presence of domestic animals, and fast and intense vehicle traffic routes around the area), there is an approximately 2.5 m high brick wall with a concertina fence on top that limits the movement of coatis out of AFPA. On the other hand, PEP is connected with other forest remnants and is surrounded by fences that are easily climbed up by the coatis, which are often seen crossing the surrounding avenues. In this environment, coatis are frequently road killed by vehicles (Costa et al., 2009), which consists of an important source of mortality (Public Ministry of Campo Grande road kill monitoring programme, *pers. comm.*). Therefore, coatis in PEP likely leave the park more frequently to access other areas, which exposes them to enhanced mortality risk. Unlike PEP, AFPA and other natural and urban areas (Hirsch, 2007; Hemetrio, 2011), roadkill is not a relevant cause of mortality for coatis.

Our density estimates were the lowest when compared to those reported for other urban areas (Hemetrio, 2007; Costa et al., 2009; Hemetrio, 2011), but still higher than those estimated for most of natural environments (Tab. 1). Despite our short-term monitoring, the population density seemed stable over time, which was reinforced by the similar coati density found in PEP almost 20 years ago (Costa et al., 2009). Therefore, the high density associated with stability in the fluctuating abundance observed in urban areas (Hemetrio, 2007; Costa et al., 2009; Hemetrio, 2011, and this study) suggests that the advantages provided by food supplementation and the absence of predators surpass the enhanced mortality rates.

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