The Rufford Small Grants Foundation

Final Report

Congratulations on the completion of your project that was supported by The Rufford Small Grants Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Darren Norris
Project title	Understanding the collapse of White-lipped Peccary populations in continuous areas of Atlantic Forest
RSG reference	8129-1
Reporting period	August 2010 to September 2011
Amount of grant	£5691
Your email address	doon75@hotmail.com
Date of this report	28 November 2011

1. **Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.**

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Quantify peccary abundances		X		I have been able to determine that white lipped peccaries are very rare (probably "ecologically" extinct). Only partially achieved because I was unable to apply the full survey effort I had planned (see answers to question 2 and full details of the field work activities available at: http://peccary-tapir.blogspot.com/).
Quantify spatial relationships between abundances and anthropogenic influences	X			Despite an intensive field work campaign only one record of white lipped peccaries was obtained. With only one record it is impossible to evaluate these spatial relationships. However, the fact that white-lipped peccaries are so rare in the largest remaining areas of Atlantic Forest is a clear indication of the impacts of more than 300 years of human disturbances.
Dissemination of results		X		I was able to disseminate results nationally through presentations, and interviews with reporters (see answers to question 6). To date international dissemination is via the blog. Only partially achieved as anticipated presentations with national groups such as CENAP-ICMBio are scheduled for 2012 and funding was not available for international presentations.

2. **Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).**

a) The research licence required to carry out the project in the protected areas was only received in March 2011. This delayed the start of the research activities, which has subsequently delayed the dissemination of results**.** To achieve the number of days of field work that I had set as a minimum survey effort additional personnel were used so that it was possible to survey different areas simultaneously.

b) Camera traps were only available during July 2011. Cameras originally promised by project partners were not available for our surveys. I borrowed cameras from an alternative source, but these cameras were only available during July 2011. Unfortunately 1 month was only enough time to survey one area (Serra do Mar) with camera traps. To increase the information from camera traps I am speaking with other research groups who are currently conducting camera-trap surveys in the same areas to see if data sharing partnerships / collaborations can be established.

c) The fact that white lipped peccaries are so rare is a very important discovery. However, I was only able to obtain one location of white-lipped peccaries. This meant that it is not possible to assess factors influencing the abundance of this species in the areas surveyed. This result (peccaries being so rare) is even more important and will be used to bring attention to the plight of this species and the Atlantic Forest in general.

3. Briefly describe the three most important outcomes of your project.

a) White-lipped peccaries appear to be ecologically extinct (i.e. so rare that they no longer perform their keystone ecological functions that maintain forest biodiversity) in both the areas surveyed. As the areas I surveyed represent the largest remnants of Atlantic Forest it appears that the future of white-lipped peccary populations is very uncertain in the Brazilian state of Sao Paulo and perhaps throughput the southern portion of their range.

b) The field work activities meant that I have established a number of collaborations with other research groups. All the information has been shared on the understanding that the support of the Rufford Small Grants for Nature Conservation is fully acknowledged by these other research groups. This has resulted in what I believe to be important contributions to the conservation of Atlantic Forest biodiversity:

- Whilst searching for peccary, I found faeces of several species (tapir and carnivores e.g. puma). I collected these samples and they are currently being used to understand the population dynamics of these species by other Brazilian research groups.
- Sharing of data e.g. contributing locations of tracks for the development of the action plan for puma (*Puma concolor*) in Brazil.
- Collaborating with other research groups to disseminate results (see answer to question 6).

c) Increased awareness and receptiveness of the protected area managers and workers. Although not a specific project objective this is an important result. The fact that white-lipped peccary appear to be so rare makes such an outcome even more vital as awareness and receptiveness will be the foundation upon which future long term conservation activities can be built. During the field work activities the park managers were maintained informed of research progress and actively encouraged the research activities at all stages e.g. through the provision of logistic support. Park workers were also involved in the research activities e.g. as field assistants. As such both managers and workers now have greater awareness of the importance of white-lipped peccaries and are likely to be receptive to future activities aimed at conserving both the species and the Atlantic Forest in general.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Not applicable

5. Are there any plans to continue this work?

The results obtained i.e. that white-lipped peccaries appear to be “ecologically extinct” means that research needs to move to action. This requires the involvement of the IUCN Pigs and Peccaries Specialist Group. And will likely require evaluation of options and provision of recommendations for the maintenance / re-introduction of white-lipped peccary populations in the areas surveyed.

Thanks to the field work activities funded by the Rufford Small Grant, managers of both the protected areas that were surveyed during the project are aware of the importance of White-lipped peccaries and are likely to be receptive to any recommendations and future research proposals. One manager (at the Serra do Mar) is using the park rangers to continue the monitoring activities that I started.

6. How do you plan to share the results of your work with others?

a) **Internet:** via the blog (http://peccary-tapir.blogspot.com/) and media coverage (http://www.fflorestal.sp.gov.br/noticias2.php?id=239)

b) **Scientific publications:** 2 articles have been submitted (see appendices) and 2 more are in preparation.

c) **Presentations:** I have presented results to park managers and workers. Further presentations to groups responsible for the management of Brazilian biodiversity are scheduled for 2012.

7. Timescale: Over what period was the RSG used? How does this compare to the anticipated or actual length of the project?

August 2010 to September 2011 – as anticipated.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Personnel	2104	2362	-258	Rate for technician was above that originally budgeted and there was also need to use 2 field assistants on occasion to complete field work activities which was not originally budgeted.
Local travel	1150	1273	-123	Increased due to additional trips and journeys within the parks.
Materials (consumables)	640	447	193	Reduced number of camera traps meant that it was not necessary to buy the amount of batteries originally budgeted
Permanent equipment	536	398	138	GPS obtained at a cheaper price than originally budgeted
Food and lodging	1261	1222	39	
Total	£5,691.00	**£5,702.00**	-£11	**Based on exchange rate of £1.00 = R$2.41**

9. Looking ahead, what do you feel are the important next steps?

a) Submission and publication of the results to the IUCN Pigs and Peccaries Specialist Group.

b) Presentation of the results to Brazilian departments responsible for the management and maintenance of biodiversity (e.g. ICMBio).

10. Did you use the RSGF logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

Logo: on the project blog **(**http://peccary-tapir.blogspot.com/**)** and in presentations of results (copies available at http://peccary-tapir.blogspot.com/).

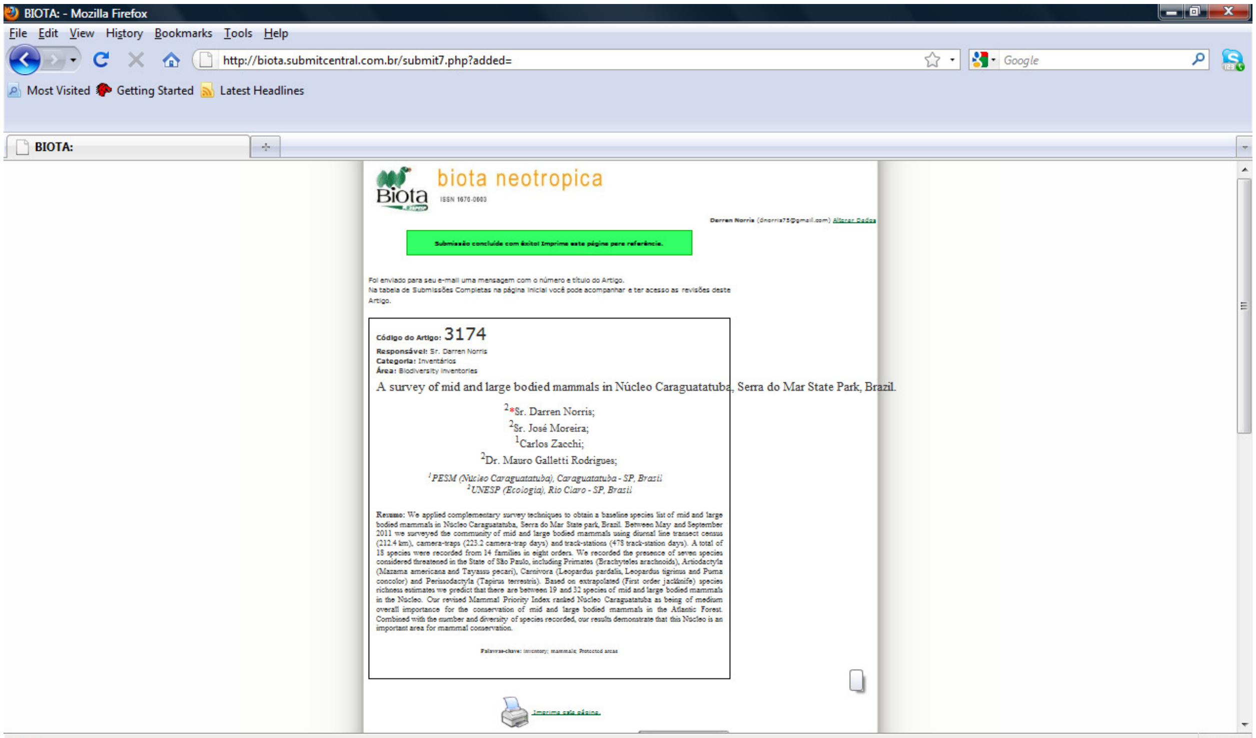
Publicity:

a) locally via presentations of results to park managers and workers
b) locally at the visitor centre at the Serra do Mar park. We produced a video presentation including photos of terrestrial mammals recorded by camera-traps in the park. The presentation is played daily at the visitor centre which receives approximately 5000 visitors annually. Copy available at (http://peccary-tapir.blogspot.com/)
c) nationally via media reports (http://www.fflorestal.sp.gov.br/noticias2.php?id=239)
d) Internationally via blog and the planned publication of scientific articles in journals which disseminate publications freely accessible online (see submitted articles in appendix).

11. Any other comments?

I would like to thank the Rufford Small Grant Foundation for supporting this project. The funding provided has enabled me collect vital information relevant to the management of the species and the Atlantic Forest.

Appendix 1 – Submission of preliminary findings to "Biota Neotropica" (http://www.biotaneotropica.org.br/v5n1/pt/about)



A survey of mid and large bodied mammals in Núcleo Caraguatatuba, Serra do Mar State Park, Brazil.

Mastofauna de médio e grande porte na Núcleo Caraguatatuba, Parque Estadual Serra do Mar, SP, Brasil

Darren Norris[1,*], José Moreira[1], Carlos Zacchi[2] and Mauro Galetti[1]

[1] Laboratório de Biologia da Conservação, Departamento de Ecologia, Universidade Estadual Paulista (UNESP), Caixa Postal 199, Rio Claro, 13506-900, SP, Brazil.

[2] PESM – Núcleo Caraguatatuba, Rua do Horto, 1200, Caraguatatuba, 11750-730 SP, Brazil.

* Corresponding author: Email: dnorris75@gmail.com

Abstract

We applied complementary survey techniques to obtain a baseline species list of mid and large bodied mammals in Núcleo Caraguatatuba, Serra do Mar State park, Brazil. Between May and September 2011 we surveyed the community of mid and large bodied mammals using diurnal line transect census (212.4 km), camera-traps (223.2 camera-trap days) and track-stations (478 track-station days). A total of 18 species were recorded from 14 families in eight orders. We recorded the presence of seven species considered threatened in the State of São Paulo, including Primates (*Brachyteles arachnoids)*, Artiodactyla (*Mazama americana* and *Tayassu pecari),* Carnivora (*Leopardus pardalis, Leopardus tigrinus* and *Puma concolor)* and Perissodactyla *(Tapirus terrestris).* Based on extrapolated (First order jackknife) species richness estimates we predict that there are between 19 and 32 species of mid and large bodied mammals in the Núcleo. Our revised Mammal Priority Index ranked Núcleo Caraguatatuba as being of medium overall importance for the conservation of mid and large bodied mammals in the Atlantic Forest. Combined with the number and diversity of species recorded, our results demonstrate that this Núcleo is an important area for mammal conservation.

Key words: inventory, mammals, protected area

Resumo

Nós aplicamos técnicas de amostragem complementares para obter uma lista de espécies de mamíferos de médio e grande porte no Núcleo Caraguatatuba, Parque Estadual da Serra do Mar, Brasil. As amostragens de campo realizaram-se nos meses de Maio e Setembro de 2011. Utilizou-se, censo ao longo de transectos (212,4 km), armadilhas fotográficas (223,2 armadilhas-dias) e armadilhas de pegadas (478 armadilhas-dias). Foram obtidos registros de 18 espécies, pertencentes a 14 famílias e oito ordens. Nós registramos a presença de sete espécies consideradas ameaçadas no Estado de São Paulo, incluindo primatas (*Brachyteles arachnoids*), Artiodactyla (*Mazama americana* e *Tayassu pecari*), Carnivora (*Leopardus pardalis*, *Leopardus tigrinus* e *Puma concolor*) e Perissodactyla (*Tapirus terrestris*). Com base em numa extrapolação da riqueza de espécies ("First order jackknife") nós prevemos que existem entre 19 e 32 espécies de mamíferos de médio e grande porte no Núcleo. Nosso "Mammal Priority Index" classificou o Núcleo Caraguatatuba como uma área de importância "média" para a conservação de mamíferos de médio e grande porte na Mata Atlântica. Combinado com o número e a diversidade de espécies registradas, nossos resultados demonstram que este Núcleo é uma área importante para a conservação de mamíferos no Estado.

Palavras-chave: inventário, mamíferos, unidade de conservação

Introduction

The Atlantic Forest is the most intensively studied biome for Brazilian mammals (Brito et al. 2009). The sampling intensity and availability of both published and un-published studies has enabled the establishment of priority areas for the conservation of mammals across the Atlantic Forest biome (Galetti et al. 2009, Albuquerque et al. 2011). Yet these studies also highlight that there remain significant gaps not only in our understanding but also in the published data describing Atlantic Forest mammals (Brito et al. 2009, Galetti et al. 2009, Albuquerque et al. 2011). With greater attention required to the development and dissemination of studies focusing on obtaining solutions to the management problems facing wild mammal species (Brito et al. 2009).

Conservation initiatives in Brazil, particularly the Atlantic Forest, are cited as examples of the successful integration of legal protection, protected area management, and science-based conservation planning (Russo 2009, Brancalion et al. 2010, Tabarelli et al. 2010). However, despite such positive examples, the situation for the fauna and flora of the Brazilian Atlantic Forest remains precarious (Marsden et al. 2005,Tabarelli et al. 2005, Fonseca et al. 2009, Galetti et al. 2009,Teixeira et al. 2009,Tabarelli et al. 2010). Protected areas are recognized as a key part of conservation initiatives (Naughton-Treves et al. 2005, Rands et al. 2010, Stockstad 2010) with > 13% of Brazilian terrestrial biomes receiving legal protection at federal or state levels (Rylands & Brandon 2005). There are >700 areas of Atlantic Forest with at least some level of legal protection (Galindo-Leal & Câmara 2003,Tabarelli et al. 2010). However, the management of protected areas for mid and large bodied mammals in the Atlantic Forest is challenging as the majority of these areas (~75%) are small i.e. <100 km^2 (Ribeiro et al. 2009) and may not retain suitable environmental conditions for endangered species (Norris et al. 2011a, Norris et al. 2011b) and threats from anthropogenic perturbations such as urbanization, illegal hunting and palm heart harvesting are ubiquitous (Galetti & Fernandez 1998, Tabarelli et al. 2005, Galetti et al. 2009, Teixeira et al. 2009, Tabarelli et al. 2010).

The Serra do Mar biogeographical sub-region is the largest area of Atlantic Forest in Brazil. More than 50% of forest cover in the sub-region is found in forest fragments > 50,000 ha and it also includes the largest remnant - a continuous forest area of 1,109,546 ha that is located along the coast of São Paulo State (Ribeiro et al. 2009). The Serra do Mar State Park is embedded within this continuous area, protecting 315,390 ha of Atlantic Forest that includes a variety of habitat types from lowland (sea-level) coastal restinga to highland (> 1200 masl) dense mountainous ombrofilous forest (Instituto Florestal 2008, p. 11-15). The size of the protected area generates unique management challenges and to meet these challenges it was necessary to divide the area into eight administrative units or “Núcleos” (Instituto Florestal 2008, p.13-15). Although this area is continuous, the Serra do Mar continues to suffer from intensive hunting and palm heart harvesting. The numerous highways that cross the park, and the presence of major gas and oil pipelines facilitates entry of hunters to “remote” park areas (Aguiar et al. 2003, Instituto Florestal 2008, p.129). Additionally, park borders are densely populated and illegal hunting, palm heart and bromeliad harvesting is common place (Instituto Florestal 2008, p.119-143).

Although challenging from a management perspective, the size and diversity of protected habitats means that we expect to find high levels of biodiversity within the Serra do Mar State park (Aguiar et al. 2003). Indeed, within such a well connected and biodiverse expanse of forest (Aguiar et al. 2003) it is not unreasonable to predict the occurrence of a significant proportion of the 45 species (de Vivo et al. 2011) of mid and large bodied terrestrial mammals recorded in São Paulo State within this park. However, even the most basic management information (i.e. which mammal species are present) is not available for the majority of the Serra do Mar Núcleos, with 6 of the 8 classified as having zero or low levels of knowledge regarding the mammalian fauna (Instituto Florestal 2008, p.180).

Recent diurnal line transect surveys recorded a maximum of 8 mid to large bodied mammal species within 4 of the Serra do Mar Núcleos (Picinguaba, Caraguatatuba, Cunha and Sta Virginia (Galetti et al. 2009). Although standardized line transect surveys provide a powerful dataset for analysis of species abundances they are unlikely to approximate a truly representative sample of the mid and large bodied mammal fauna. This group includes rare, cryptic and illusive species that to achieve management objectives including knowledge of which species are present are best surveyed with a combination of techniques (Michalski & Peres 2007, Espartosa et al. 2011, Munari et al. 2011). The objective of the present study was to use complementary survey techniques to obtain a baseline species list and estimate the species richness of mid and large bodied mammals in Núcleo Caraguatatuba as the first step to increasing our knowledge of the regional mammalian fauna and to support the management activities within this protected area.

Material and methods

Study area

Mammal surveys took place in Núcleo Caraguatatuba of the Serra do Mar State park (Figure 1). Núcleo Caraguatatuba protects a 49 953 ha (Instituto Florestal 2008) of the pre-Cambrian Serra do Mar mountain chain (Mantovani 1993).Of the eight administrative "Núcleos" of the Serra do Mar, 5 including Caraguatatuba are coastal, with Núcleo Caraguatatuba being located in the center of the "litoral" tourist region of the state, receiving approximately 5000 visitors annually. The Núcleo is bisected by the Tamoios road, a state highway that leads to the town of Caraguatatuba (45º 25' 57'' W and 23º 35' 52'' S). The western portion of the Núcleo is also traversed by one of the main pipelines of the Brazilian petroleum company "Petrobras". The poorly monitored access provided by the Tamoios highway and the pipeline are the two principal vectors of anthropogenic pressure (i.e. illegal hunting and palm-heart harvesting) in the Núcleo (Instituto Florestal 2008, p.119-143).

The regional climate is subtropical, with a mean annual temperature of 23.2 (daily means ranging from 4.6 to 36.1, data from 2010 downloaded from the Brazilian weather center http://www.cptec.inpe.br/, station ID: 83671, Lat -21.98 , Long: -47.35, masl = 598) and annual rainfall from 1400 to 4000 mm (Mantovani 1993). Soils are predominantly nutrient-impoverished yellow-red latosol, podzols and lithosols (Radambrasil 1983). Forests range from coastal (≈20 m) to elevations > 900m, generating stark floristic gradients, from shrubs to well-developed montane forests (Veloso et al. 1991).

Mammal surveys

Between May and September 2011 we used complementary techniques (line transect census, track surveys and camera-traps) to sample the mid and large bodied mammal community across Núcleo Caraguatatuba (Figure 1). Surveys were conducted by two observers with a minimum of 5 years experience in monitoring neotropical mammals. Nomenclature follows that presented in de Vivo et al. (2011) except for *Alouatta guariba* which follows Groves (2005).

During 34 days we conducted a total of 212.4 km of diurnal line transect census along 13 (total km = 71.9) preexisting (established for > 10 yrs) trails (trail length: mean, range = 4.9, 0.7 – 15.7 km). To provide a representative sample, trails were distributed throughout the Núcleo (Figure 1) and encompassed a variety of secondary and primary forest habitats. From the total of 71.9 trail km, the majority (51.9 km) were in forest dominated by early or advanced secondary successional stages, followed by primary (7.9 km) and eucalyptus and pine plantations (6.8 km).

Standard line transect protocols (Peres 1999, Buckland et al. 2010) were adapted to fit our main objective of sampling mid and large bodied mammals across the widest possible variety of habitats within the park. Census was not conducted during heavy rainfall but did occur during light showers i.e. when observers could walk comfortably without wearing protective clothing. Census was carried out during the morning (5:40 – 13:13) and or afternoon (12:47 – 17:35), with times varying due to logistical constraints and weather conditions. Although there was a slight overlap between the timing of morning and afternoon census, on any one day there was a minimum of 2 hours between the end of morning and start of afternoon census when we used the same trail and a minimum of 1 hour between morning and afternoon census when different trails were used. We do not consider this extension of the timing of our morning census to have biased our surveys. The standardization of census times has been determined from studies in tropical conditions where the heat during midday hours (between 12:00 and 14:00) limits mammal activity (Peres 1999). Diurnal temperatures within our sub-tropical study area are not comparable to those in these tropical areas. At the latitude of Núcleo Caraguatatuba mammals are often seen during these "midday" hours, appearing to avoid activity during the often cold (<14°C) early mornings. For example we did not detect any mammals before 9am. To enable us to survey the maximum range of habitats possible we did not follow the recommended line transect survey speed of ≈1.25 km per hour (Peres 1999, Buckland et al. 2010). Although we did pause regularly at 100 to 300 m intervals to listen for detection cues, our mean per trail census speed was above the recommended value (survey speed: mean, range = 2.4, 1.1 – 3.4 km per hour). Although it is possible that this increased census speed resulted in missed detections, we found no significant relationship between the number of detections recorded per km and the survey speed (Spearmans correlation, rho = -0.223, P= 0.221). We are therefore confident that our modifications of the standard census protocols did not introduce any systematic bias and that our line transect survey results are directly comparable with previous studies.

During our line transect surveys we also recorded tracks that were visible along the trails. These "ad hoc" detection events were supplemented by a total of 25 un-baited track-stations placed along two of our census trails (Figure 1). Track-stations were prepared by removing leaf litter, rocks and surface roots from a 75 x 75 cm quadrant followed by loosening, separating and smoothing the soil surface with a machete so that it would be possible to discern track impressions of mid to large bodied mammals > 2 kg (tested by the gentle application of finger tips to the prepared surface). Track-stations were checked at 3 – 6 day intervals. Days with heavy rain were excluded from our effort, resulting in an overall effort of 478 track-station days.

From June to July 2011 we installed 12 digital camera-traps (6 Reconyx, 6 Ecotone). Cameras were installed in two areas (Figure 1) separated by a 12.9 km straight line distance – one close to the park base (5 cameras – 103.7 camera-trap days) and one in an area that receives no visitors and has been relatively undisturbed for at least 30 years (7 cameras – 119.5 camera-trap days), providing a total effort of 223.2 camera-trap days. Cameras were operational continuously over the 24 hr diel cycle and placed at random locations between 5 and 15 m to the side of existing trails within each area, with a minimum straight line nearest neighbor distance of 530m. However, due to the steep topography including near vertical ravines, the minimum distance between cameras for any terrestrial mammal is effectively > 1400 m. We attached cameras to trees at a height of ≈ 40 cm above the ground. The area in front of cameras was cleared of green foliage and herbs to prevent sunlight reflections damaging image quality. Due to licensing restrictions cameras remained un-baited, but were checked at 2 – 9 day intervals to ensure continuous operation and for routine maintenance e.g. to change batteries.

Data analysis

To understand the relationship between species richness and our survey effort we used the "specaccum" function of the "vegan" package (Oksanen et al. 2011) in the R software (R Development Core Team 2011) to estimate the individual based rarefaction curve of mean species richness per sample day. For this analysis we summed all individuals recorded for each species using any technique by the survey date, generating a matrix of 18 species by 22 survey days (we excluded days with no mammal species records). To predict the total number of species present in the Núcleo that it would be possible to detect using the combination of survey techniques we used the "First order jackknife" estimator to extrapolate the species richness from the frequencies of species encountered per day (function "specpool", package "vegan"). Although a number of extrapolation estimators are available we choose this one to enable comparison with previous studies (Espartosa et al. 2011).

Results

We obtained records of 18 mid to large bodied mammal species from 14 families in 8 orders, of which seven species are considered threatened ("Vulnerable" or "Endangered") in the State of São Paulo (Table 1). Camera-traps recorded the most species (12), followed by tracks (10), other indirect detections (7) and finally direct visual detections from diurnal line transect census (6). *Tapirus terrestris* was the only species that was recorded with all four classes of detection technique whereas six species (*Didelphis aurita* – photos, *Tayassu pecari* - tracks, *Leopardus tigrinus* - photos, *Lontra longicaudis* - tracks, *Bradypus variegatus* – carcass and *Brachyteles arachnoids*- visual) were only recorded by a single class (Table 1).

The estimated curve of species richness per survey day did not reach an asymptote, with species continuing to accumulate at a rate of 0.4 species per day after 22 survey days (Figure 2). Based on the First order jackknife our extrapolated species richness was 26 species (estimate ± 95% CI = 25.63 ± 6.07).

Relative abundances from line transect census ranged from 0.040 (*Brachyteles arachnoids*, *Mazama cf. americana*, *Tapirus terrestris*, and *Guerlinguetus ingrami*) to 1.089 (*Cebus nigritus*) detections per 10 km. The relative abundances obtained from diurnal census enabled us to calculate a revised Mammalian Priority Index of 15.29, which following the thresholds established by Galetti et al.(2009) classifies the Núcleo as an area of medium overall importance for large-bodied mammals in the Atlantic Forest.

Although rarely detected during diurnal censuses *Tapirus terrestris* was the most commonly recorded species with camera-traps (0.524 independent photos per 10 camera-trap nights), followed by *Dasypus novemcinctus* and *Didelphis aurita* (0.242 independent photos per 10 camera-trap nights). The most infrequently photographed species were *Cebus nigritus*, *Cuniculus paca*, *Dasyprocta cf. azarae*, and *Guerlinguetus ingrami* (0.040 independent photos per 10 camera-trap nights).

Discussion

Although Atlantic Forest mammals are relatively well studied there is little comparative data available from studies of mid and large bodied mammals in continuous forest areas. In a recent compilation (Galetti et al. 2009) found that from a total of 31 mid and large bodied mammal species a maximum of only 13 (41.9%) species were recorded using diurnal line transect census in 34 mainland Atlantic Forest sites. Other studies that employ a range of techniques generally record a greater number of species on a per site basis. For example, using line transect census (241 km) in secondary forest areas of the Morro Grande Forest Reserve – a 10,870 ha protected area close to the city of São Paulo (Negrão & Valladares-Pádua 2006) recorded 5 species of mid to large bodied mammals but when these results were combined with sand track-stations (600 track-station days) a total of 18 species were recorded in the same area (Negrão & Valladares-Pádua 2006). Other studies from the Brazilian Atlantic Forest report similar patterns with more species recorded when different techniques were applied simultaneously: a total of 16 species were recorded in a 221 ha area of semi-deciduous Atlantic Forest using visual searches and camera-traps (Abreu Jr & Köhler 2009), 23 species in a 230 ha semi-deciduous forest area using line transect census (271 km), camera-traps (336.5 camera-trap days) and track-stations (1258 track-station nights) (Gaspar 2005), 29 species in a 17 491 ha protected area using visual searches (128 km), camera-traps (1842 camera-trap nights) and nocturnal surveys along park roads (Kasper et al. 2007). However none of these studies present species richness curves / estimates that would facilitate a between site comparison of the mid to large bodied mammal communities.

Previous studies have demonstrated the importance of protected areas for the regional conservation of mammals in São Paulo (de Araujo et al. 2008, Galetti et al. 2009, Paviolo et al. 2009, Norris et al. 2011a, Norris et al. 2011b). Although it is not possible to make direct comparisons with other Atlantic Forest studies our predicted species richness shows the importance of Núcleo Caraguatatuba for the conservation of regional masto-fauna. Of the 18 species recorded 7 (39%) are threatened in the State of São Paulo and 5 (27.8%) are threatened at the international level (Table 1, Magalhães-Bressan et al. 2009, IUCN 2011). It is worth noting that of the 18 species recorded, populations of only one (*D. novemcinctus*) are increasing (Abba & Superina 2009). From a survey of 24 secondary forest sites (some connected to the western part of the Serra do Mar forest massive) using baited camera-traps (minimum effort of 2160 camera-trap days) and baited sand track-stations (minimum effort of 1224 track-station days) Espartosa et al. (2011) recorded a total of 14 native species of mid to large bodied mammals, with species richness estimates predicting a maximum of 15 native species present in the 10 000 ha study region. We managed to record a similar number of species to Espartosa et al. (2011) using a fraction of their survey effort and time, which emphasizes the diversity of the mid and large bodied mammal community in Núcleo Caraguatatuba compared with unprotected and fragmented Atlantic Forest remnants. Another important difference is that the mammal community within the Núcleo appears to be relatively intact including large bodied species such as *T. terrestris* and *T. pecari*, whereas the species recorded by Espartosa et al. (2011) represented a relatively simplified assemblage of smaller bodied generalists.

As our species richness estimate showed that we missed between 2 and 14 species we also expect further studies to add to the list of threatened species within the Núcleo. For example populations of the threatened buffy-tufted-ear marmoset (*Callithrix aurita*) have been recorded in the neighboring Núcleo Sta. Virginia (Norris et al. 2011b) and it seems likely that there may be as yet undetected populations within Núcleo Caraguatatuba. We would also expect to find carnivores such as jaguar (*Panthera onca*) and the crab-eating fox (*Cerdocyon thous*) plus at least one additional cervid species – the small brocket deer (*Mazama bororo*). Indeed, cervids highlight a remaining problem in neotropical mammalogy – uncertainty in species identification and classification (Brito et al. 2009). We identified the cervid species (*M. americana*) based on characteristic size and coloration, however similarities with *M. bororo* mean that genetic studies are necessary to confirm the species presence. The same is true for the rodent *D. azarae*, which may be confused with *D. leporina*. Although the characteristic "red-rump" of *D. leporina* was not apparent in the photo taken, further genetic studies are required to confirm the species identity within the Núcleo. Although predicting which species are likely to be detected is inherently speculative, these issues highlight that even though the Atlantic Forest is the most intensively studied biome for mammals in Brazil (Brito et al. 2009), the knowledge necessary for effective conservation and management of Atlantic Forest mammals is far from complete.

Our revised Mammal Priority Index ranked Núcleo Caraguatatuba as being of medium overall importance for the conservation of mid and large bodied mammals in the Atlantic Forest. Combined with the number and diversity of species recorded we believe this group of mammals must be considered a management priority within this protected area. Our species list provides a baseline upon which management activities can be measured and evaluated. However, future studies focusing on species ecology, habitat preferences and population densities are required to inform management activities. For example further studies are required to enable the definition of zones within the protected area as defined by Brazilian Law (Law: 9.985/2000 (SNUC)). Zonation will enable the myriad objectives of a protected area to be met efficiently and in harmony with the regional and national socio-economic context (Wells & Brandon 1993, Halpin 1997). Although species richness and diversity is a criteria for establishing the conservation value of zones within the park (Instituto Florestal 2008, p. 257), there is as yet no data to define a spatially explicit map of species distributions for any floral or faunal group within Núcleo Caraguatatuba. We hope the list of mammals presented here encourages future studies to fill such gaps.

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References

ABBA, A. M. & SUPERINA, M. 2009. Dasypus novemcinctus. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. http//www.iucnredlist.org (last accessed on 10/09/2011).

ABREU JR, E. F. & KÖHLER, A. 2009. Mastofauna de médio e grande porte na RPPN da UNISC, RS, Brasil. Biota Neotrop. 9(4): 169-174 http://www.biotaneotropica.org.br/v9n4/en/abstract?inventory+bn02109042009 (last accessed on 05/08/2011).

AGUIAR, A.P., CHIARELLO, A.G., MENDES, S.L. & DE MATOS, E.N. 2003. The Central and Serra do Mar Corridors in the Brazilian Atlantic Forest. In The Atlantic Forest of South America: biodiversity status, threats, and outlook (C. Galindo-Leal & I. Câmara, eds.). Island Press, Washington, DC, p.118-132.

ALBUQUERQUE, F., TEIXEIRA ASSUNCAO-ALBUQUERQUE, M.J., GALVEZ-BRAVO, L., CAYUELA, L., RUEDA, M. & REY BENAYAS, J.M. 2011. Identification of Critical Areas for Mammal Conservation in the Brazilian Atlantic Forest Biosphere Reserve. Natureza & Conservacao 9: 73-78.

BRANCALION, P.H.S., RODRIGUES, R.R., GANDOLFI, S., KAGEYAMA, P.Y., NAVE, A.G., GANDARA, F.B., BARBOSA, L.M. & TABARELLI, M. 2010. Legal instruments can enhance high-diversity tropical forest restoration. Revista Arvore 34: 455-470.

BRITO, D., OLIVEIRA, L.C., OPREA, M. & MELLO, M.A.R. 2009. An overview of Brazilian mammalogy: trends, biases and future directions. Zoologia 26: 67-73.

BUCKLAND, S.T., PLUMPTRE, A.J., THOMAS, L. & REXSTAD, E.A. 2010. Design and analysis of line transect surveys for primates. Int. J. Primatol. 31: 833–847.

DE ARAUJO, R.M., DE SOUZA, M.B. & RUIZ-MIRANDA, C.R. 2008. Density and population size of game mammals in two Conservation Units of the State of Rio de Janeiro, Brazil. Iheringia Ser. Zool. 98: 391-396.

DE VIVO, M., CARMIGNOTTO, A.P., GREGORIN, R., HINGST-ZAHER, E., IACK-XIMENES, G.E., MIRETZKI, M.,. PERCEQUILLO, A.R., ROLLO, M. M., ROSSI, R.V. & TADDEI, V.A. 2011. Checklist of mammals from São Paulo State, Brazil. Biota Neotrop. 11(1a): http://www.biotaneotropica.org.br/v11n1a/en/abstract?inventory+bn0071101a2011 (last accessed on 02/08/2011).

ESPARTOSA, K., PINOTTI, B. & PARDINI, R. 2011. Performance of camera trapping and track counts for surveying large mammals in rainforest remnants. Biodivers. Conserv. in press.

FONSECA, C.R., GANADE, G., BALDISSERA, R., BECKER, C.G., BOELTER, C.R., BRESCOVIT, A.D., CAMPOS, L.M., FLECK, T., FONSECA, V.S., HARTZ, S.M., JONER, F., KAEFFER, M.I., LEAL-ZANCHET, A.M., MARCELLI, M.P. MESQUITA, A.S., MONDIN, C.A., PAZ, C.P., PETRY, M.V., PIOVENSAN, F.N., PUTZKE, J., STRANZ, A., VERGARA, M. & VIEIRA, E.M. 2009. Towards an ecologically-sustainable forestry in the Atlantic Forest. Biol. Conserv. 142: 1209-1219.

GALETTI, M. & FERNANDEZ, J.C. 1998. Palm heart harvesting in the Brazilian Atlantic Forest: changes in industry structure and the illegal trade. J. Appl. Ecol. 35: 294-301.

GALETTI, M., GIACOMINI, H.C., BUENO, R.S., BERNARDO, C.S.S., MARQUES, R.M., BOVENDORP, R.S., STEFFLER, C.E., RUBIM, P., GOBBO, S.K., DONATTI, C.I., BEGOTTI, R.A., MEIRELLES, F., NOBRE, R., CHIARELLO, A.G. & PERES, C.A. 2009. Priority areas for the conservation of Atlantic Forest large mammals. Biol. Conserv. 142: 1229-1241.

GALINDO-LEAL, C. & CÂMARA, I.G. 2003. The Atlantic Forest of South America: Biodiversity status, threats, and outlook. Island Press, Washington.

GASPAR, D.A. 2005. Comunidade de mamíferos não voadores em um fragmento de floresta Atlântica semidecídua no município de Campinas, SP. PhD Thesis. Universidade Estadual de Campinas, Campinas.

GROVES, C.P. 2005. Order Primates. In Mammal Species of the World (D.E. Wilson & D.M. Reeder eds.). The Johns Hopkins University Press, Baltimore, Maryland, USA, p.111-184.

HALPIN, P. N. 1997. Global climate change and natural-area protection: Management responses and research directions. Ecol. Appl. 7: 828-843.

INSTITUTO FLORESTAL. 2008. Parque Estadual da Serra do Mar Plano de Manejo. Instituto Florestal do Estado de São Paulo, São Paulo.

IUCN. 2011. IUCN Red List of Threatened Species. Version 2011.1. http//www.iucnredlist.org (last accessed on 10/09/2011).
KASPER, C.B., MAZIM, F.D., SOARES, J.B.G., DE OLIVEIRA, T.G. & FABIÁN, M.E. 2007. Composição e abundância relativa dos mamíferos de médio e grande porte no Parque Estadual do Turvo, Rio Grande do Sul, Brasil. Revista Brasileira De Zoologia 24: 1087-1100.
MAGALHÃES-BRESSAN, P., MARTINS-KIERULFF, M.C. & MIDORI SUGIEDA, A. 2009. Fauna Ameaçada de Extinção no Estado de São Paulo: Vertebrados Fundação Parque Zoológico de São Paulo: Secretaria do Meio Ambiente, São Paulo.
MANTOVANI, W. 1993. Estrutura e dinâmica da floresta Atlântica na Juréia, Iguape-SP. Livro Docente Thesis. Universidade de São Paulo, São Paulo.
MARSDEN, S., WHIFFIN, M., GALETTI, M. & FIELDING, A. 2005. How Well Will Brazil's System of Atlantic Forest Reserves Maintain Viable Bird Populations? Biodivers. Conserv. 14: 2835-2853.
MICHALSKI, F. & PERES, C.A. 2007. Disturbance-mediated mammal persistence and abundance-area relationships in Amazonian forest fragments. Conserv. Biol. 21: 1626-1640.
MUNARI, D.P., KELLER, C. & VENTICINQUE, E.M. 2011. An evaluation of field techniques for monitoring terrestrial mammal populations in Amazonia. Mamm. Biol. 76: 401-408.
NAUGHTON-TREVES, L., HOLLAND, M.B. & BRANDON, K. 2005. The role of protected areas in conserving biodiversity and sustaining local livelihoods. Annu. Rev. Env. Resour. 30: 219-252.
NEGRÃO, M.F.F. & VALLADARES-PÁDUA, C. 2006. Records of mammals of larger size in the Morro Grande Forest Reserve, São Paulo. Biota Neotrop. 6(2): 1-13 http://www.biotaneotropica.org.br/v6n2/pt/abstract?article+bn00506022006 (last accessed on 03/08/2011).
NORRIS, D., ROCHA-MENDES, F., FROSINI DE BARROS FERRAZ, S., VILLANI, J.P. & GALETTI, M. 2011a. How to not inflate population estimates? Spatial density distribution of white-lipped peccaries in a continuous Atlantic Forest. Anim. Conserv. in press.
NORRIS, D., ROCHA-MENDES, F., MARQUES, R., DE ALMEIDA NOBRE, R. & GALETTI, M. 2011b. Density and Spatial Distribution of Buffy-tufted-ear Marmosets (Callithrix aurita) in a Continuous Atlantic Forest. Int. J. Primatol. 32: 811-829.
OKSANEN, J., GUILLAUME BLANCHET, F., KINDT, R., LEGENDRE, P., O'HARA, R. B., SIMPSON, G. L., SOLYMOS, P., STEVENS, M. H. H. & WAGNER, H. 2011. vegan: Community Ecology Package version 1.17-10. http://CRAN.R-project.org/package=vegan (last accessed on 02/08/2011).
PAVIOLO, A., DI BLANCO, Y.E., DE ANGELO, C.D. & DI BITETTI, M.S. 2009. Protection affects the abundance and activity patterns of pumas in the Atlantic Forest. J. Mammal. 90: 926-934.
PERES, C.A. 1999. General guidelines for standardizing line-transect surveys of tropical forest primates. Neotropical Primates 7: 11–16.
R DEVELOPMENT CORE TEAM. 2011. R version 2.13.0: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/ (last accessed on 13/01/2011).
RADAMBRASIL. 1983. Projeto Radambrasil: levantamento de recursos naturais. IBGE, Rio de Janeiro.
RANDS, M.R.W., ADAMS, W.M., BENNUN, L., BUTCHART, S.H.M., CLEMENTS, A., COOMES, D., ENTWISTLE, A., HODGE, I., KAPOS, V., SCHARLEMANN, J.P.W., SUTHERLAND, W.J. & VIRA, B. 2010. Biodiversity Conservation: Challenges Beyond 2010. Science 329: 1298-1303.
RIBEIRO, M.C., METZGER, J.P., MARTENSEN, A.C., PONZONI, F. & HIROTA, M.M. 2009. Brazilian Atlantic Forest: how much is left and how is the remaining forest distributed? Implications for conservation. Biol. Conserv. 142: 1141–1153.
RUSSO, G. 2009. Biodiversity's bright spot. Nature 462: 266–269.
RYLANDS, A. B. & BRANDON, K. 2005. Brazilian Protected Areas. Conserv. Biol. 19: 612-618.
STOCKSTAD, E. 2010. Despite progress, biodiversity declines. Science 329: 1272-1273.
TABARELLI, M., AGUIAR, A.V., RIBEIRO, M.C., METZGER, J.P. & PERES, C.A. 2010. Prospects for biodiversity conservation in the Atlantic Forest: Lessons from aging human-modified landscapes. Biol. Conserv. 143: 2328-2340.
TABARELLI, M., PINTO, L.P., SILVA, J.M.C., HIROTA, M. & BEDÊ, L. 2005. Challenges and Opportunities for Biodiversity Conservation in the Brazilian Atlantic Forest. Conserv. Biol. 19: 695-700.
TEIXEIRA, A.M.G., SOARES-FILHO, B.S., FREITAS, S.R. & METZGER, J.P. 2009. Modeling landscape dynamics in an Atlantic Rainforest region: Implications for conservation. Forest Ecol. Manag. 257: 1219-1230.
VELOSO, H.P., RANGEL-FILHO, A.L.R. &. LIMA, J.C.A. 1991. Classificação da vegetação brasileira adaptada a um sistema universal. IBGE, Rio de Janeiro.

WELLS, M.P. & BRANDON, K.E. 1993. The principles and practice of buffer zones and social and local participation in biodiversity conservation. Ambio 22: 157-162.

Table 1 List of mammal species from Núcleo Caraguatatuba, Serra do Mar State Park, São Paulo, Brazil.

Order	Family	Species	Detection type [a]				Threat	Abundance [d]	
			Photo	Track	Visual	Other	S[b] / Int[c]	LT	CT
Artiodactyla									
	Cervidae	*Mazama cf. americana*		X	X		VU/DD	0.040	
	Tayassuidae	*Pecari tajacu*	X	X		X	NT/LC		0.081
		Tayassu pecari		X			EN/NT		
Carnivora									
	Felidae	*Leopardus pardalis*	X	X			VU/LC		0.161
		Leopardus tigrinus	X				VU/VU		0.081
		Puma concolor	X	X			VU/LC		0.081
	Mustelidae	*Lontra longicaudis*		X			NT/DD		
Cingulata									
	Dasypodidae	*Dasypus novemcinctus*	X	X		X	LC/LC		0.242
Didelphimorphia									
	Didelphidae	*Didelphis aurita*	X				LC/LC		0.242
Perissodactyla									
	Tapiridae	*Tapirus terrestris*	X	X	X	X	VU/VU	0.040	0.524
Pilosa									
	Bradypodidae	*Bradypus variegatus*				X	LC/LC		
Primates									
	Atelidae	*Alouatta guariba*			X	X	NT/LC	0.202	
		Brachyteles arachnoides			X		EN/EN	0.040	
	Cebidae	*Cebus nigritus*	X		X	X	NT/NT	1.089	0.040
Rodentia									
	Caviidae	*Hydrochoerus hydrochaeris*	X			X	LC/LC		0.081
	Cuniculidae	*Cuniculus paca*	X	X			NT/LC		0.040
	Dasyproctidae	*Dasyprocta cf. azarae*	X	X			LC/DD		0.040
	Sciuridae	*Guerlinguetus ingrami*	X		X		LC/NE	0.040	0.040

[a] How species were detected. Photo = camera-trap, Track = tracks observed along trails or on prepared track-stations, Visual = diurnal line transect census, and Other = carcass, feces, or vocalizations.

[b] Threat status in the State of São Paulo (Magalhães-Bressan et al. 2009, p. 599). From least to most threatened: LC = least concern, NT = near threatened, VU = vulnerable, EN = endangered

[c] International threat status following (IUCN 2011). NE= not evaluated, DD = data deficient, then from least to most threatened: LC = least concern, NT = near threatened, VU = vulnerable, EN = endangered

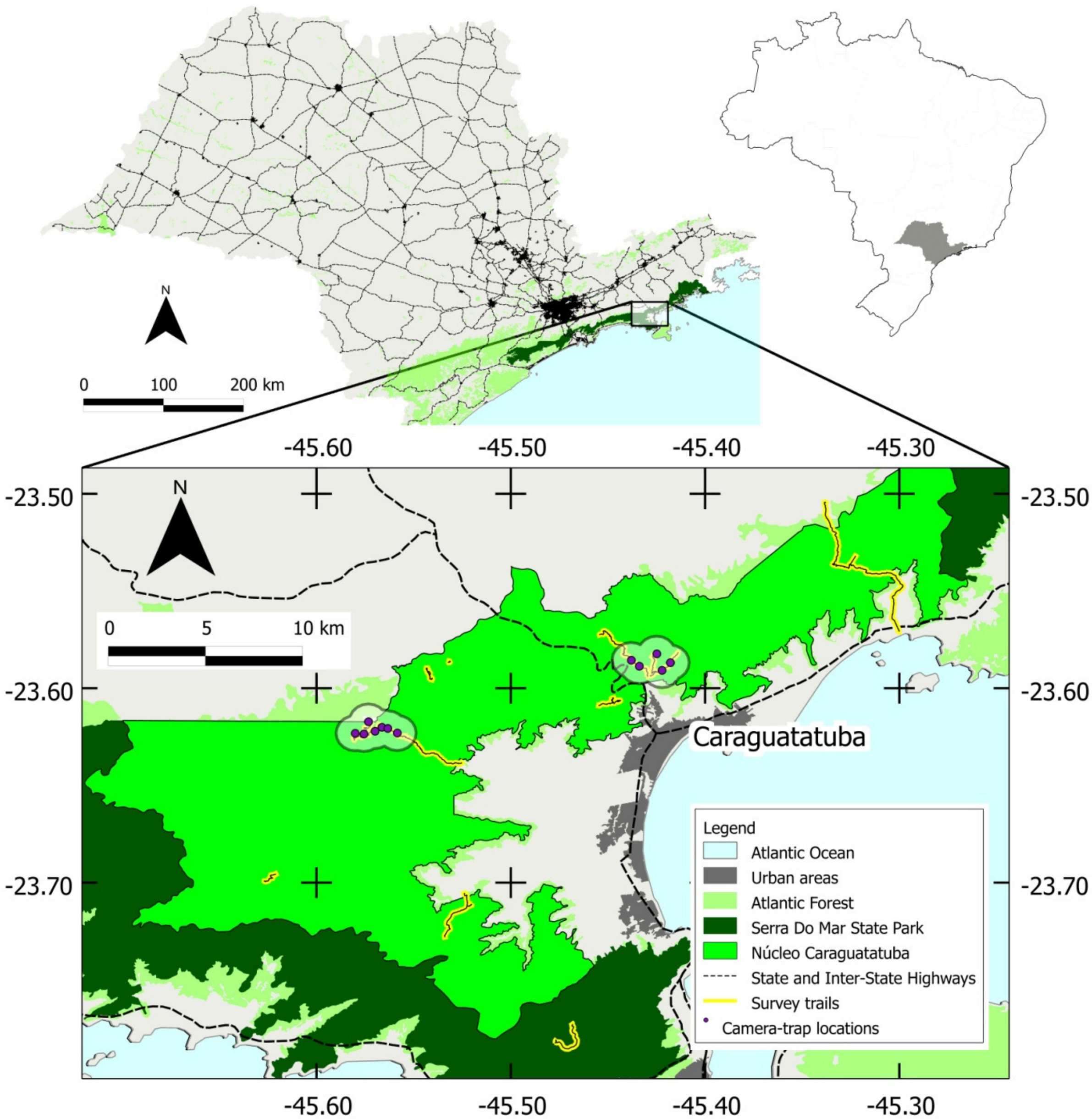
[d]Species relative abundance.LT = detections per 10 km of line transect census and CT = independent photos per 10 camera-trap nights.

Figure legends

Figure 1 Study area showing locations of survey trails and camera-traps used to survey mid and large bodied mammals in Núcleo Caraguatatuba, Serra do Mar State Park, São Paulo, Brazil

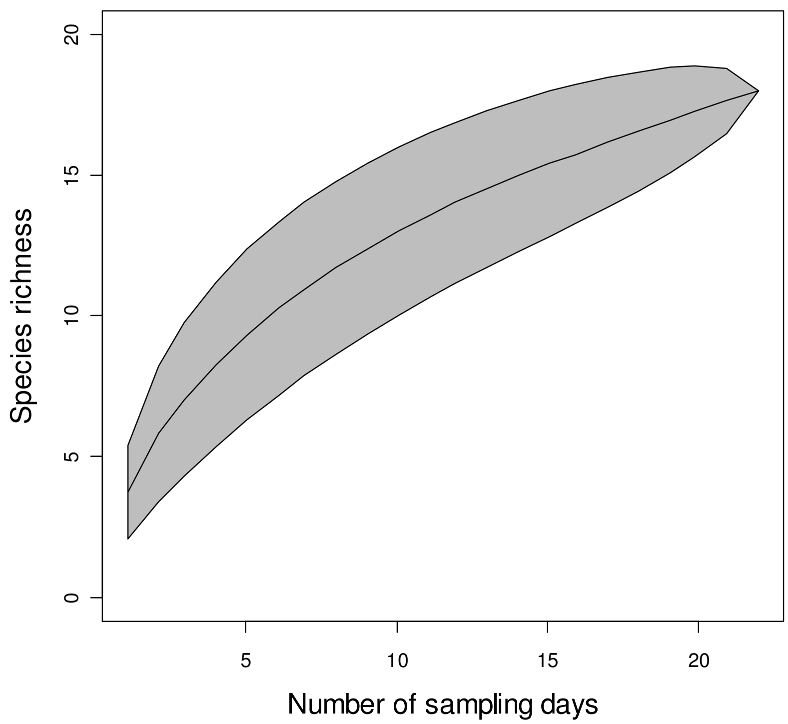
Figure 2 Mean accumulation curve and 95% confidence interval (shaded area) of the expected number of mid to large bodied mammal species in Núcleo Caraguatatuba, Serra do Mar State Park, São Paulo, Brazil.

Fig 1.



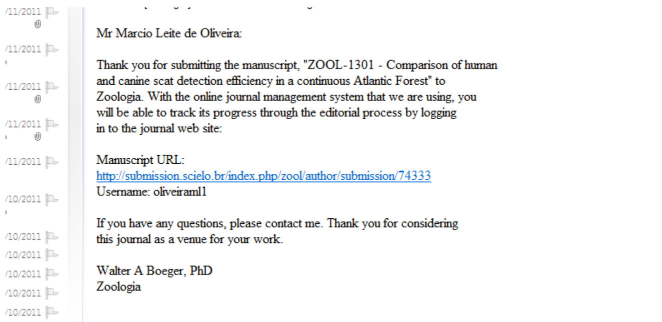
0
100
200 km
N
-45.60
-45.50
-45.40
-45.30
-23.50
-23.60
-23.70
0
5
10 km
Caraguatatuba
Legend
Atlantic Ocean
Urban areas
Atlantic Forest
Serra Do Mar State Park
Núcleo Caraguatatuba
State and Inter-State Highways
Survey trails
Camera-trap locations

Fig.2



Species richness
0
5
10
15
20
5
10
15
20
Number of sampling days

Appendix 2 – Submission to "Zoologia" (http://www.scielo.br/zool)



Mr Marcio Leite de Oliveira:

Thank you for submitting the manuscript, "ZOOL-1301 - Comparison of human and canine scat detection efficiency in a continuous Atlantic Forest" to Zoologia. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

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If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Walter A Boeger, PhD
Zoologia

SHORT COMMUNICATION

Comparison of human and canine scat detection efficiency in a continuous Atlantic Forest

Márcio L. de Oliveira[1,3]; Darren Norris[2]; José F. Moreira[2]; Pedro H. de F. Peres[1]; Mauro Galetti[2]; José M. B. Duarte[1]

[1] Núcleo de Pesquisa e Conservação de Cervídeos - NUPECCE, UNESP Campus de Jaboticabal. 14884-900 Jaboticabal, SP, Brasil. E-mail: oliveiraml1@yahoo.com.br; pedrof182@gmail.com
[2] Laboratório de Biologia da Conservação, Departamento de Ecologia, Universidade Estadual Paulista (UNESP), Caixa Postal 199, Rio Claro, 13506-900, SP, Brazil
[3] Corresponding author.

ABSTRACT. Scat detection dogs have been used to locate feces of rare and elusive species across terrestrial and tropical biomes, however their detection efficiency in relation to human observers has rarely been evaluated. In this study we evaluated the ability of a scat detection dog to locate feces in comparison with human researchers. Human researchers and a scat detection dog surveyed for deer (*Mazama* spp) feces in dense ombrofilous Atlantic forest in the Paranapiacaba continuum, SP, Brazil. A controlled experiment was used to assess the maximum effective perpendicular distance from a transect search line that the dog could detect a *Mazama* spp fecal sample. Results from a linear regression model revealed that the maximum effective perpendicular distance from a transect search line that the dog could detect a scat was 7.2 meters. The detection success from our surveys in the Atlantic forest were zero for human researchers and 0.15 samples/ha or 0.20 samples/km walked for the dog team. Our

results demonstrate how important scat detection dogs are for non-invasive sampling and provide data relevant for the design of future studies.

KEY WORDS. Atlantic Forest; deer; fecal samples, *Mazama*; sampling;

Fecal samples have a wide range of applications for temperate and tropical wildlife studies (KOHN & WAYNE 1997, BEJA-PEREA *et al.* 2007, GONZALEZ *et al.* 2009). A common challenge for all such studies is that of finding large amounts of fecal samples in the field. The challenge of obtaining sufficient quantities of fecal samples becomes even more acute when research involves prey species that have developed strategies to make scats cryptic to avoid predation. One possibility to locate such samples is the use of a scat detection dog (SMITH *et al.* 2001). The use of detection dogs to locate scats has proved to be a flexible and adaptable survey technique. They have been used to locate fecal samples from whales in the North Atlantic (ROLLAND *et al.* 2006) and to locate fecal samples from a variety of carnivore species in various North American ecosystems (SMITH *et al.* 2003, WASSER *et al.* 2004, SMITH *et al.* 2005, HARRISON 2006, LONG *et al.* 2007, REED *et al.* 2011). Scat detection dogs have also been used in the Cerrado and Amazon biomes of Brazil to locate carnivore and xenarthran fecal samples, (MICHALSKI *et al.* 2011, VYNNE *et al.* 2011). However the use of scat detection dogs to locate ungulate fecal samples in the Neotropics has yet to be demonstrated. The present study aimed to compare the sampling efficiency of a scat detection dog to that of human researchers.

The present study was conducted in the Paranapiacaba Ecological Continuum, which is part of the Southern Reserves of the Brazilian Atlantic Forest World Heritage Site. More specifically research activities took place at the Carlos Botelho State Park (24° 08' S and 47° 59' W) and the neighboring Intervales State Park (24° 16' S and 48° 52' W) (Fig. 1), which together protect an area of 78,837 ha (37 433 and 41 404 ha Carlos Bothelo, Intervales respectively). The climate in the region is humid temperate ("Cfa", according to the Köppen climate classification), with hot austral summer temperatures associated with high rainfall and the absence of a dry winter. A variety of primary and secondary Atlantic Forest types are found within the protected areas including dense ombrofilous forest. The occurrence of three deer species has been confirmed in the region: *Mazama americana, Mazama gouazoubira* and *Mazama bororo*. (BLACK-DÉCIMA *et al.* 2010, VOGLIOTTI & DUARTE 2010). Populations of the small red brocket deer (*M. bororo*) are present in both Carlos Botelho and Intervales State Parks, with an estimated maximum of 615 individuals and a density of 1.51 ind/km^2 recorded at Intervales (GONZÁLEZ & GARCÍA 2010, VOGLIOTTI & DUARTE 2010). Due to similarities in forest types, topography and anthropogenic pressure between the neighboring areas we assumed that deer population densities are similar in both parks.

The dog, a female of mixed breed, was trained by the Military Police of São Paulo State narcotics detection program. The only modification to the standard training program was that the target odor was changed to a mix of *Mazama* species feces obtained from captive individuals. To ensure that fecal samples were as similar as possible to those from wild individuals the deer were fed only with fruits and fresh leaves prior to the collection of training feces. When the dog finds a deer scat sample, it sits nearby and barks. After that, the handler provides the reward of play with a tennis ball.

From April to June 2011, 194.9 kilometers of trails were walked across the Intervales State Park by two observers visually searching for fecal samples (Fig. 1). Based on detections of > 45 fecal samples from non-target species (*Tapirus terrestris* and unidentified carnivores) the sampling strip width for human observers was estimated at 2 meters (i.e. one meter either side of the survey trail).

Between March and May 2011, 39 kilometers of trails were walked across the Carlos Botelho State Park by a dog team. The dog team consisted of a handler, his dog (working off-lead) and an orienteer that did the GPS navigation (Fig. 1). In order to determine the dogs effective sampling strip width an experiment was carried out in a rubber tree (*Hevea brasiliensis*) plantation where 122 scat samples were placed every 10 m along a transect at known perpendicular distances (0, 3, 6, 9, 12, 15, 18, 21m). Perpendicular distances were randomly selected and fecal samples were placed alternately one to the left and one to the right of the transect line. The dog handler walked along the transect line with the dog working freely off-lead. We used linear regression to estimate the maximum perpendicular distance from the transect line that a sample could be found. In the regression model we used perpendicular distance (modeled as a continuous variable) to predict the response of the percentage of samples recovered. We used the lower 95% confidence interval from the regression model to estimate the distance until which the dog would effectively detect a fecal sample, defined as the perpendicular distance value where the lower 95% confidence interval was 0.

Overall the dog detected 29% of our experimental fecal samples. We found a clear linear decline in detections with 57, 44 and 17% of the samples detected at perpendicular distances of 0, 3 and 6 meters, respectively and no samples were detected at the other distances. The effective perpendicular search distance estimated from the lower 95% confidence interval of the linear regression model (R^2_{adj}=0.9762, $F_{1,2}$ = 124.2, P = 0.008) was 7.2 meters. We rounded this value to 7 meters, providing a strip width of 14 m. Therefore by multiplying the total distance walked by the strip width, we calculated the sampling area of the field surveys as 54.6 ha for the dog team and 39.0 ha for human observers.

Human observers did not detect any deer feces; however deer tracks were recorded on 24 separate occasions. In comparison, the dog detected a total of 8 fecal samples, providing a detection success of 0.15 samples/ha or 0.21 samples/km for the dog team. This dog sampling success in the Paranapiacaba ecological continuum is lower than that reported from North America, for example in the Carrizo Plain National Monument and in the LoKern Natural Area, both in California, scat dogs detected from

0.43 to 5.37 presumptive kit fox (*Vulpes macrotis mutica*) fecal samples/km (SMITH *et al.* 2003).

It is important to point out that the dogs' detection success in Paranapiacaba could have been higher. The warm and humid weather in Carlos Botelho State Park may have negatively influenced the dogs' ability to detect scats as odor particles do not disperse at high moisture levels and high temperatures increase canid panting rates (SMITH *et al.* 2003, WASSER *et al.* 2004), which reduces sniffing rates and therefore limits scat detection. Another factor that could explain the lower success in Paranapiacaba is the fact that herbivore feces have a weaker odor compared with those of the carnivores surveyed in the other studies (SMITH *et al.* 2003, WASSER *et al.* 2004, SMITH *et al.* 2005, HARRISON 2006, LONG *et al*. 2007, REED *et al*. 2011).

For the first time we demonstrated how important a scat detection dog was to obtain fecal samples, which would otherwise be missed by human researchers in the Neotropics. Although the dog did not follow a fixed path and may therefore miss samples close to the trail, we found that the overall area that is effectively covered more than compensates for these losses. This is particularly true for deer fecal pellets which are easily missed by human observers especially when covered by leaf litter on the forest floor. Scat detection dogs clearly have the potential to obtain fecal samples that when analyzed with molecular tools can provide reliable baseline information, such as geographical ranges and population estimates, for poorly known Neotropical species (GONZALEZ *et al.* 2009, WEBER & GONZALEZ 2003). However, scat detection dogs remain an under exploited resource by Neotropical researchers.

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REFERENCES

BEJA-PEREIRA, A.; R. OLIVEIRA; P.C. ALVES; M.K. SCHWARTZ & G. LUIKART. 2009. Advancing ecological understandings through technological transformations in noninvasive genetics. **Molecular Ecology Resources** 9 (5): 1279-1301. doi: 10.1111/j.1755-0998.2009.02699.x.

BLACK-DÉCIMA, P.; R.V. ROSSI; A. VOGLIOTTI; J.L. CARTES; L. MAFFEI; J.M.B. DUARTE; S. GONZÁLEZ & J.P. JULIÁ. 2010. Brown brocket deer *Mazama gouazoubira*, p. 190-201. *In*: J.M.B. DUARTE & S. GONZÁLEZ (Ed.). Neotropical Cervidology. Jaboticabal, Funep/IUCN, XIV+394 p.

González, S.; J.E. Maldonado; J. Ortega; A.C. Talarico; L. Bidegaray-Batista; J.E. Garcia & J.M.B. Duarte. 2009. Identification of the endangered small red brocket deer (*Mazama bororo)* using noninvasive genetic techniques (Mammalia; Cervidae). **Molecular Ecology Resources** 9: 754-758. doi: 10.1111/j.1755-0998.2008.02390.x.

González, S. & J.E. García. 2010. Fecal DNA, p. 306-312. *In*: J.M.B. Duarte & S. González (Ed.). Neotropical Cervidology. Jaboticabal, Funep/IUCN, XIV+394 p.

Harrison, R.L. 2006. A comparison of survey methods for detecting bobcats. **Wildlife Society Bulletin** 34 (2): 548-542. doi: 10.2193/0091-7648(2006)34[548:ACOSMF]2.0.CO;2.

Kohn, M.H. & R.K. Wayne. 1997. Facts from feces revisited. **Trends in Ecology and Evolution** 12 (6): 223-227.

Long. R.A.; T.M. Donavan; P. Mackay; W.J. Zielinski & J.S. Buzas. 2007. Effectiveness of Scat Detection Dogs for Detecting Forest Carnivores. **The Journal of Wildlife Management** 71 (6): 2007-2017. doi: 10.2193/2006-230.

Michalski, F.,; F.P. Valdez; D. Norris; C. Zieminski; C.K. Kashivakura; C.S. Trinca; H.B. Smith; C. Vynne; S.K. Wasser; J.P. Metzger & E. Eizirik. 2011. Successful carnivore identification with faecal DNA across a fragmented Amazonian landscape. **Molecular Ecology Resources** 11: 862-871. doi: 10.1111/j.1755-0998.2011.03031.x

Reed, S.E.; A.L. Bidlack; A. Hurt & W.M. Getz. 2011. Detection Distance and Environmental factors in Conservation Detection Dog Surveys. **Journal of Wildlife Management** 75 (1): 243-251. doi: 10.1002/jwmg.8.

Rolland, M.R.; P.K. Hamilton; S.D. Kraus; B. Davenport; R.M. Gillett & S.K. Wasser. 2006. Faecal sampling using detection dogs to study reproduction and health in North Atlantic right whales (*Eubalaena glacialis*). **Journal of Cetacean Research and Management** 8 (2): 121-125.

Smith, D.A.; K. Ralls; B. Davenport; B. Adams & J.E. Maldonado. 2001. Canine Assistants for Conservationists. **Science** 291 (5503): 435.

Smith, D.A.; K. Ralls; A. Hurt; B. Adams; M. Parker; B. Davenport; M.C. Smith & J.E. Maldonado. 2003. Detection and accuracy rates of dogs trained to find scats of San Joaquin kit foxes. **Animal Conservation** 6: 339-346. doi: 10.1017/S136794300300341X.

SMITH, D. A.; RALLS, K.; CYPHER, B. L.; MALDONADO, J. E. 2005. Assessment of scat-detection dog surveys to determine kit fox distribution. **Wildlife Society Bulletin** 33 (3): 897-904.

VYNNE, C.; J.R. SKALSKI; R.B. MACHADO; M.J. GROOM; A.T.A. JÁCOMO; J. MARINHO-FILHO; M.B.R. NETO; C. POMILLA; L. SILVEIRA; H. SMITH & S.K. WASSER. 2011. Effectiveness of Scat-Detection Dogs in Determining Species Presence in a Tropical Savanna Landscape. **Conservation Biology** 25 (1): 154-162. doi: 10.1111/j.1523-1739.2010.01581.x.

WASSER, S.K.; B. DAVENPORT; E.R. RAMAGE; K.E. HUNT; M. PARKER; C. CLARKE & G. STENHOUSE. 2004. Scat detection dogs in wildlife research and management: application to grizzly an black bears in the Yellowhead Ecosystem, Alberta, Canada. **Canadian Journal of Zoology** 82: 475-492. doi: 10.1139/Z04-020.

WEBER M. & S. GONZALEZ 2003. Latin America Deer diversity and conservation: a review of status and distribution. **Écoscience** 10 (4): 443-454.

VOGLIOTTI, A. & J.M.B. DUARTE. 2010. Small red brocket deer *Mazama bororo*, p. 172-176. *In*: J.M.B. DUARTE & S. GONZÁLEZ (Ed.). Neotropical Cervidology. Jaboticabal, Funep/IUCN, XIV+394 p.

Figure legend: Study area showing locations of human and scat detection dog survey trails in the Paranapiacaba Continuum, São Paulo, Brazil

Figure 1