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Inventory

Medium to large-sized mammals of an urban protected area and its ecological corridor in Rio de Janeiro City, Brazil

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Abstract: Protected areas play a fundamental role in the preservation of species, environmental education, and ecosystem services maintenance. Most of the world population live in urban areas, which highlight the importance of preserved areas in urban centers. However, many urban protected areas in Brazil lack species surveys, which limits biodiversity conservation and implementation of management plans. In this study, we surveyed the species of medium and large mammals of Chico Mendes Municipal Natural Park (MNP) and Canal das Taxas corridor through camera traps, thus providing the first comprehensive *in situ* survey of terrestrial mammals for the area. We also verified whether there was mammalian fauna exchange between the Chico Mendes and Marapendi MNPs through the vegetation corridor formed by the Canal das Taxas. Between November 2020 and July 2021, with a sampling effort of 1,334 trap-days, we recorded five native and five exotic species in the studied areas, including one Vulnerable species in the Municipality and State of Rio de Janeiro (*Cuniculus paca*). We also confirmed that Canal das Taxas works as a wildlife corridor for native species. Finally, we highlight that species checklists based on secondary information for the region are of limited usefulness and recommend *in situ* surveys even in small, urban protected areas of Rio de Janeiro city.
Keywords: *Camera trap; conservation unit; ecological corridor; terrestrial mammals; urban areas.*

Mamíferos de médio a grande porte de uma Unidade de Conservação urbana e seu corredor ecológico na cidade do Rio de Janeiro, Brasil

Resumo: As áreas protegidas têm papel fundamental na preservação das espécies, na educação ambiental e na manutenção dos serviços ecossistêmicos. A maior parte da população mundial vive em áreas urbanas, o que evidencia a importância das áreas preservadas nos centros urbanos. No entanto, muitas áreas protegidas urbanas no Brasil carecem de levantamentos de espécies, o que limita a conservação da biodiversidade e a implementação de planos de manejo. Neste estudo, inventariamos as espécies de mamíferos de médio e grande porte do Parque Natural Municipal Chico Mendes e do corredor do Canal das Taxas por meio de armadilhas fotográficas, fornecendo assim o primeiro levantamento *in situ* abrangente de mamíferos terrestres para a área. Também verificamos se houve intercâmbio de fauna de mamíferos entre os parques Chico Mendes e Marapendi através do Canal das Taxas. Entre novembro de 2020 e julho de 2021, com um esforço amostral de 1.334 armadilhas-dia, registramos cinco espécies nativas e cinco espécies exóticas nas áreas de estudo, incluindo uma espécie Vulnerável no município e estado do Rio de Janeiro (*Cuniculus paca*). Confirmamos que o Canal das Taxas funciona como um corredor de fauna para espécies nativas. Por fim, ressaltamos que listas de espécies baseadas em informações secundárias para a região são de utilidade limitada e recomendamos levantamentos *in situ*, mesmo em pequenas Unidades de Conservação urbanas da cidade do Rio de Janeiro.
Palavras-chave: *Armadilha fotográfica; Unidade de Conservação; corredor ecológico; mamíferos terrestres; áreas urbanas.*

Introduction

Protected areas play a fundamental role in the preservation of species, since they promote the protection of endangered species, the preservation and restoration of biodiversity, environmental education, and ecosystem services maintenance (Henry-Silva 2005, Hummel et al. 2019, Kabisch et al. 2017). However, in Brazil, basic information on the biodiversity of these parks, such as from fauna species surveys, is often lacking, which limits the proper formulation and implementation of management strategies. In fact, many protected areas do not have management plans proposed or implemented in the country (Barros & Leuzinger 2019). For example, in the state of Rio de Janeiro, 83.4% of protected areas – called conservation units – still did not have published management plans in 2019 (CNUC 2023), and in the city of Rio de Janeiro, only 27% of conservation units have these plans (De Mattos Bezerra & Lira 2020). Moreover, several of these protected areas have species checklists based on secondary information, without adequate *in situ* surveys.

Currently, 55% of the world's population lives in urban areas, and this proportion is expected to increase to 70% by 2050 (United Nations 2019). Protected areas located near or within large urban centers may be more susceptible to certain anthropic impacts (Mcdonald et al. 2008, Filho et al. 2017), such as high number of visitors, hunting and fishing, pollution, and introduction of exotic species (SMAC 2016, Gibaldi 2019, Gibaldi et al. 2020, Pacheco et al. 2020). On the other side, they may offer a good opportunity to implement environmental education projects due to the large number of visitors. The city of Rio de Janeiro has 59 protected areas (CNUC 2023). Among them is the Chico Mendes Municipal Natural Park (Chico Mendes MNP), a small protected area inserted in the urbanized landscape of the Recreio dos Bandeirantes district that was created with the goal of preserving, protecting, and restoring the area's landscape heritage, the coastal sand dune (restinga) ecosystem, and the Lagoinha lagoon, as well as providing green spaces for leisure (FUNBIO et al. 2014). However, this park faces problems such as water pollution by sewage and solid waste, presence of exotic species, loss of the restinga ecosystem, impact on the trails generated by excessive visitors, among others (FUNBIO et al. 2014).

Knowledge about the mammals that inhabit the area of Chico Mendes MNP is incipient (FUNBIO et al. 2014). The management plan of Chico Mendes MNP was published nine years ago and was based on a three-day primary data survey, being mainly complemented by potential species occurrences based the scientific literature (FUNBIO et al. 2014). Therefore, *in situ* sampling is necessary to adequately characterize the biodiversity of the park, including their mammalian fauna. Furthermore, there may be fauna exchange between the Chico Mendes and Marapendi MNPs through a vegetation corridor that connects both parks, so sampling such corridor (Canal das Taxas) can help define whether it functions as an ecological corridor between the two parks. Ecological corridors are one of the main processes for forest defragmentation, thus being important to preserve biodiversity (Seoane et al. 2010). In small protected areas, the connection promoted by ecological corridors with other areas of natural habitat can be essential to the long-term viability of some populations, especially for species of medium to large size.

The survey of the mammal fauna of Chico Mendes MNP and Canal das Taxas corridor is also important to identify the presence of exotic species that may become or are invasive alien species (IAS), i.e., species that have been introduced – accidentally or intentionally – outside their natural range and that pose a risk to biodiversity conservation (Zalba & Ziller 2007); IAS can cause several types of impacts on native species and ecosystems, such as predation and herbivory of native fauna and flora; competition with and exclusion of native species; changes in the original habitats; physical environment and ecosystem processes; and hybridization with native species, among other impacts (Sampaio and Schmidt 2013).

In this context, the objective of this study was to survey the species of medium and large mammals of Chico Mendes MNP and Canal das Taxas corridor and identify the potential fauna exchange between the Chico Mendes and Marapendi MNPs through Canal das Taxas, thus contributing to the update of the management plan of the protected areas.

Material and Methods

1. Study area

Chico Mendes Municipal Natural Park (23°01'23.3"S; 43°28'15.2"W) has 40.65 hectares and was created in 1989 by Municipal Decree 8.452. It has areas of restinga vegetation, shrubs and closed tree formations and flooded forests, serving as habitat for several endemic and endangered species (FUNBIO et al. 2014). A water body (Lagoinha) occupies much of its area (Figure 1) and, in the rainy season, its volume increases via flooding additional land. Chico Mendes MNP faces problems such as pollution of the water body, presence of exotic species, human invasions, and impacts on the trails generated by visitors (FUNBIO et al. 2014).

Chico Mendes MNP is connected to Marapendi MNP (23°01'1.58" S; 43°26'34.59" W) by Canal das Taxas, which connects Lagoinha and Marapendi lagoons in Marapendi MNP (Figure 1). The Canal is approximately 1.5 kilometers long and is bordered by vegetation that extends no more than 50 meters from the edges. Canal das Taxas is included in the Green Corridor project, an initiative of the municipal, state and federal governments that involves actions to replant native species, improve basic sanitation, and provide environmental education (SMAC 2015). However, the importance of Canal das Taxas as an ecological corridor has not been properly evaluated yet in relation to the mammal fauna.

The Chico Mendes MNP, Canal das Taxas, and the Marapendi MNP, along with the Barra da Tijuca MNP, Nelson Mandela MNP and Marapendi Environmental Protection Area form a complex of 359 hectares of protected areas inserted in the urban area. Marapendi MNP (23°01'01.8 "S 43°26'58.6 "W) covers 152 hectares, with predominantly restinga forest and mangrove vegetation bordering Marapendi Lagoon (SMAC 2016). It is negatively impacted by solid waste, the presence of exotic species, and human occupation. Marapendi Lagoon is also impacted by raw sewage discharge and by unregulated fishing and water transport (Gibaldi 2019). The Marapendi MNP headquartes is nearby Canal das Taxas and this area is also fenced, like the Chico Mendes MNP. However, other areas of the park are relatively less protected and apparently are more impacted by anthropic activities (Gibaldi 2019).

2. Data collection

Between November 2020 and July 2021, nine Scoutguard ® SG560C White LED camera traps were arranged to cover most of Chico Mendes

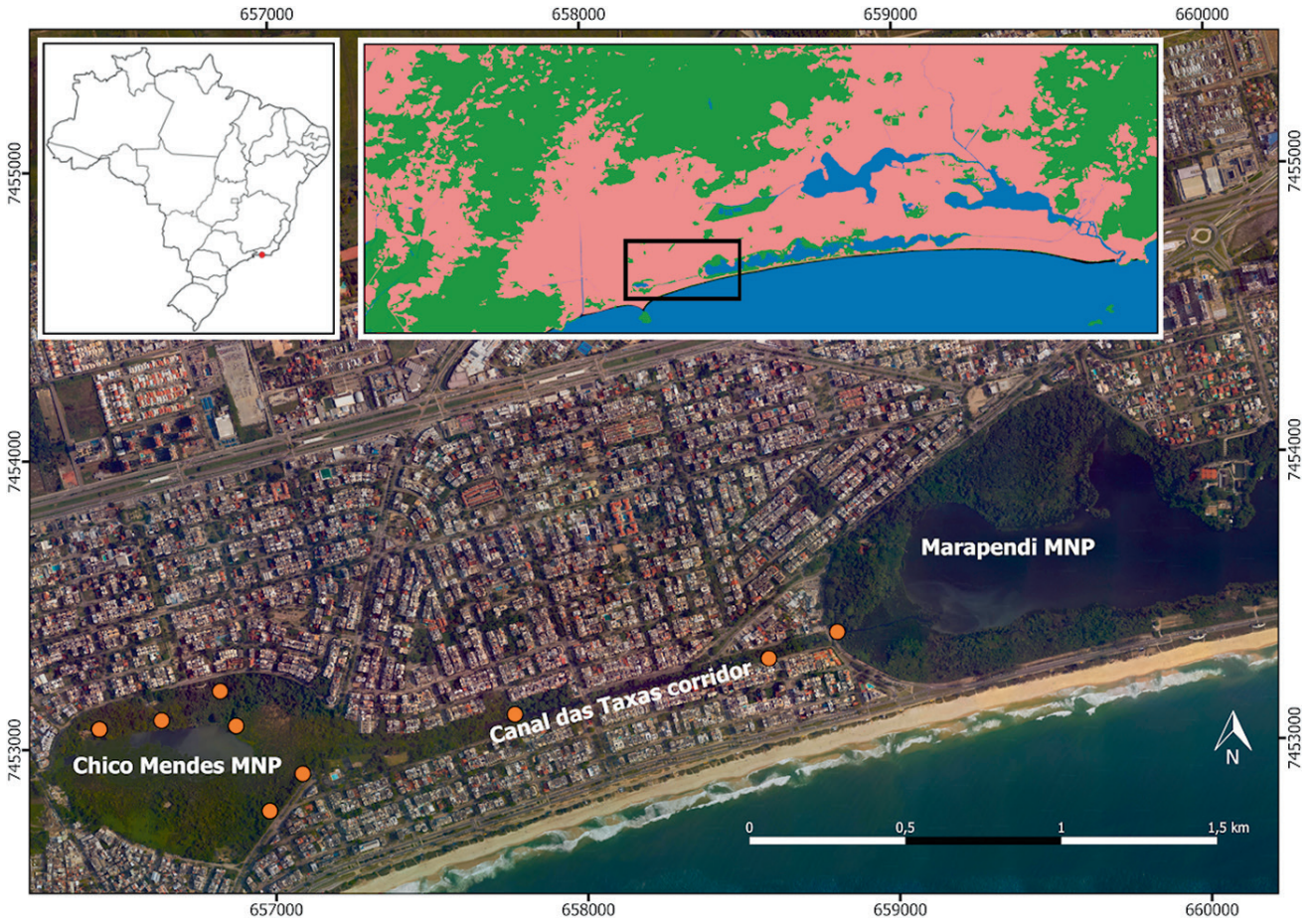

Figure 1. Map showing camera traps (yellow marks) in Chico Mendes Municipal Natural Park (Chico Mendes MNP), Canal das Taxas corridor, and Marapendi Municipal Natural Park (Marapendi MNP). The map at the upper, left side of the figure shows the location of the study area in Brazil. The map at the upper, central part of the figure shows the overall location of the study area on a regional scale; green color is vegetated areas, pink is urbanized areas and blue is water bodies.

MNP, as well as the Canal das Taxas and the border of Marapendi MNP (Figure 1). The minimum spacing between traps was approximately 150 meters. Two of the traps were set along Canal das Taxas and one trap was set at the border of Marapendi MNP and next to Canal das Taxas, to verify the potential interchange of mammals between Chico Mendes and Marapendi MNPs (Figure 1).

The cameras were inspected every month to change batteries and memory cards. The traps were baited with a small quantity of banana, bacon, and peanut meal on the first day of trapping only. Baits were renewed whenever the traps' batteries were checked (roughly once a month). The procedures were carried out according to authorization from the Municipal Environmental Secretariat, permit number 10/2020, process number 14/000.632/2020.

3. *Data analysis*

To verify the sampling sufficiency of the survey for Canal das Taxas and Chico Mendes MNP, the species accumulation curve for medium to large-sized mammals was calculated using the first-order jackknife richness estimator and its standard deviation ("Jack 1 Mean" and "Jack 1 SD") and 1000 randomizations, using the EstimateS program version 9.1 (Colwell 2016). The curve was generated based on the frequency of species' photographic records, considering each field excursion (month) as a sampling unit. Records of medium to large-sized exotic species (*Felis catus*, the domestic cat; see Table 1) and the black-eared opossum (*Didelphis aurita*) were included.

The relative frequency of species occurrence was based on independent photographic records of species: consecutive pictures of the same species within a one-hour interval were disregarded to minimize pseudo-replication in the analyses (Hurlbert 1984). Because distance between cameras was small and individuals might have been photographed in more than a camera within one hour, we considered photographic records as if they had been obtained by a single camera, thereby not discriminating between cameras in distinct places. For the relative frequency of occurrence, records of non-volant, smaller species (rodents, marsupials and primates) were also considered, although the methodology employed was not the most appropriate for small mammals or arboreal species. Finally, the camera-trap on Marapendi MNPs was not considered in these analyses, since data of this camera-trap was used only to verify potential interchange between parks through the Canal das Taxas.

Results and Discussion

With a total sampling effort of 1,334 trap-days, ten species of mammals were recorded in Chico Mendes MNP, Canal das Taxas and/or Marapendi MNP, distributed in nine families and five orders

(Table 1). The species accumulation curve for Chico Mendes MNP and Canal das Taxas stabilized on the seventh fieldwork (Figure 2), showing that sampling effort was adequate for terrestrial medium to large-sized mammals.

Five exotic species were recorded: *Callithrix jacchus*, *Rattus rattus*, *Felis catus, R. norvergicus*, and *Canis lupus familiaris*. The first three occurred in all the areas sampled, whereas *R. norvergicus* was recorded in Canal das Taxas only and *C. familiaris* in the Marapendi MNP camera trap, next to the Canal das Taxas (Table 1; Figure 1). In addition, human presence was also detected at one point in Chico Mendes MNP where access by people was temporarily prohibited. Except for *Cuniculus paca*, all species recorded were mentioned in the Chico Mendes MNP management plan as species with "probable occurrence" in the area, since that previous survey was largely based on potential records instead of *in situ* observations (FUNBIO et al. 2014). *Cuniculus paca* is classified as Vulnerable both in the state of Rio de Janeiro and city of Rio de Janeiro (Tanizaki-Fonseca et al. 2000, SMAC 2022), although all the species are of Least Concern according to the IUCN RedList (IUCN, 2022).

Three native species of medium-sized mammals that were listed in the management plan as "likely to occur" were not recorded in the present study: the spiny tree porcupine (*Coendou spinosus*), brown-throated sloth (*Bradypus variegatus*), and agouti (*Dasyprocta leporina*) (FUNBIO et al. 2014). The two first species are arboreal and commonly found in parks within the urban area of Rio de Janeiro and were seen at Chico Mendes by park employees in the last ten years (Fernanda G.M.P Lima, Pers. Comm). They may occur in the park even though we did not record them in the camera traps because the method used was not adequate to sample arboreal species. The agouti has also been seen by park employees (Fernanda G.M.P Lima, Pers. Comm) although we did not record this species in camera traps, even having applied a large sampling effort. Since rescued agoutis have been translocated and released in the Marapendi MNP (Fernanda G.M.P Lima, Pers. Comm), such visual record by employees might be of one of the translocated individuals that reached MNP Chico Mendes through the Canal das Taxas. Under this scenario, an established population of agoutis might not occur in the area. In addition, according to park employees, a crab-eating fox (*Cerdocyon thous*) has also been

Table 1. Mammals detected through camera traps in protected areas in the city of Rio de Janeiro. Site: CM = Chico Mendes Natural Municipal Park; CT = Canal das Taxas corridor; MA = Marapendi Natural Municipal Park. Data for MA came from one camera trap placed at the limits of this park with Canal das Taxas (see Figure 1).

Order	Family	Species	Common name	Site
Didelphimorphia	Didelphidae	*Didelphis aurita* Wied-Neuwied, 1826	Black-eared opossum	CM, CT, MA
Cingulata	Dasypodidae	*Dasypus novemcinctus* Linnaeus, 1758	Nine-banded armadillo	CM, CT, MA
Rodentia	Cuniculidae	*Cuniculus paca* (Linnaeus, 1766)	Paca	CM, CT, MA
	Caviidae	*Hydrochoerus hydrochaeris* (Linnaeus, 1766)	Capybara	CM, CT, MA
	Muridae	*Rattus rattus* (Linnaeus, 1758)	Black rat	CM, CT, MA
	Muridae	*Rattus norvergicus* Berkenhout, 1769	Norway rat	CT
Primates	Callitrichidae	*Callithrix jacchus* (Linnaeus, 1758)	White-tufted marmoset	CM, CT, MA
	Procyonidae	*Procyon cancrivorus* (Cuvier, 1798)	Crab-eating raccoon	MA
Carnivora	Canidae	*Canis lupus familiaris* Linnaeus, 1758	Domestic dog	MA
	Felidae	*Felis catus* Linnaeus, 1758	Domestic cat	CM, CT, MA

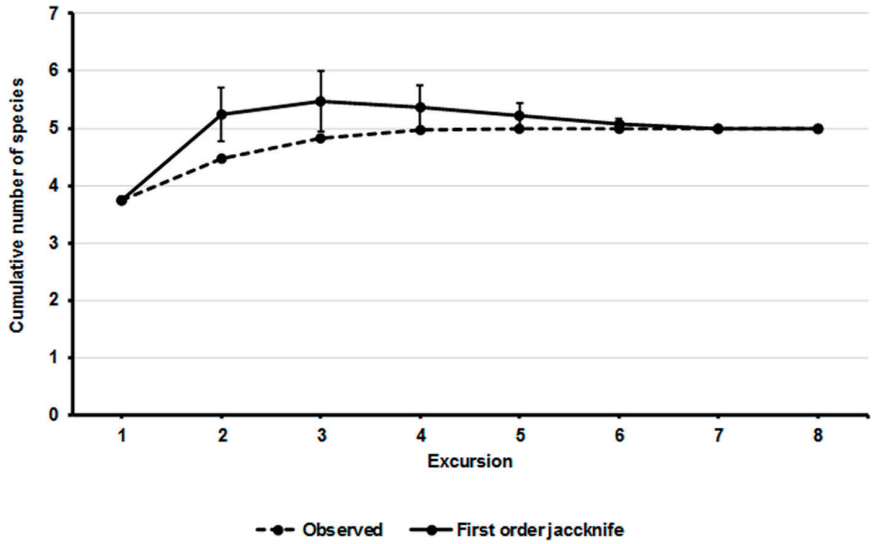

Figure 2. Species accumulation curve of terrestrial medium to large-sized mammals of Chico Mendes Municipal Natural Park and Canal das Taxas corridor, with data from camera traps set between 2020 and 2021. The richness estimator used was the first-order Jackknife. The "Observed" curve corresponds to the accumulated number of species observed in the study area. The bars correspond to the standard deviation.

seen in the park in 2021. This is certainly the single (male) individual that was released in Marapendi MNP (Fernanda G.M.P Lima, Pers. Comm) and is using Chico Mendes MNP area as well.

The species with the highest frequency of occurrence were *D. aurita* and *H. hydrochaeris*, which occurred in both Chico Mendes and Marapendi MNPs, as well as in Canal das Taxas (Figure 3). *Didelphis aurita* is a synanthropic species that can reach high population densities even in urban areas (Gentile et al. 2018), whereas capybaras adapt well to secondary or disturbed forests, reproduce throughout the year, with litters that can reach up to eight pups (De Oliveira & Bonvicino 2006), besides being closely associated with the water bodies in both parks and triggering the camera traps more easily. The capybara and black-eared opossum are considered generalist species that are tolerant to disturbances and favored by forest fragmentation (Fonseca & Robinson 1990, Olifiers et al. 2005).

The three species of rarest occurrence were exotic species: the house cat (*Felis catus*), the white-tufted marmoset (*Callithrix jacchus*) and the Norway rat (*Rattus norvergicus*). The presence of domestic cats, stray or feral, inside a protected area can cause several negative impacts on native fauna, such as competition with other species, disease transmission, and predation (Loss & Marra 2017). Animals preyed upon by cats include birds, invertebrates, small mammals, amphibians, and reptiles (Baker et al. 2005, Mella-Méndez et al. 2022). The presence of exotic marmosets poses a risk mainly to the region's avifauna, due to the predation of bird eggs and chicks by marmosets and potential competition for resources with other species (Lyra-Neves et al. 2007). *Callithrix jacchus* and *C. penicillata* adapt easily and exhibit great ability to occupy new habitats; they are generalists, possess behavioral flexibility and high reproductive rate (Reis et al. 2008), which make them potential invaders (Traad & Weckerlin 2012). *Callithrix penicillata* (black-tufted marmoset) was also recorded as probably occurring in Chico Mendes MNP, according to the management plan (FUNBIO et al. 2014), although we could not detect it in this study. This species, as well as hybrid forms, are likely to occur in the area. The presence of *Rattus* species also deserves attention, since they are reservoirs of important diseases such as leptospirosis and are potential vectors of bubonic plague (Carter & Cordes 1980).

The management plan of Chico Mendes MNP indicates two native species that transit between Chico Mendes and Marapendi MNPs through Canal das Taxas: capybaras and brown-throated sloths (*B. variegatus*) (FUNBIO et al. 2014). With the exception of the crab-eating raccoon (*P. cancrivorus*) and the domestic dog (*C. l. familiaris*), which were recorded only in Marapendi MNP border, all other species occurred in both parks and/or in Canal das Taxas, indicating potential exchange of these species between the parks. Indeed, when we analyzed the pelage pattern of pacas recorded in the camera traps, we found the presence of the same individual in Chico Mendes MNP, Canal das Taxas and Marapendi MNP, confirming the interchange of individuals of native

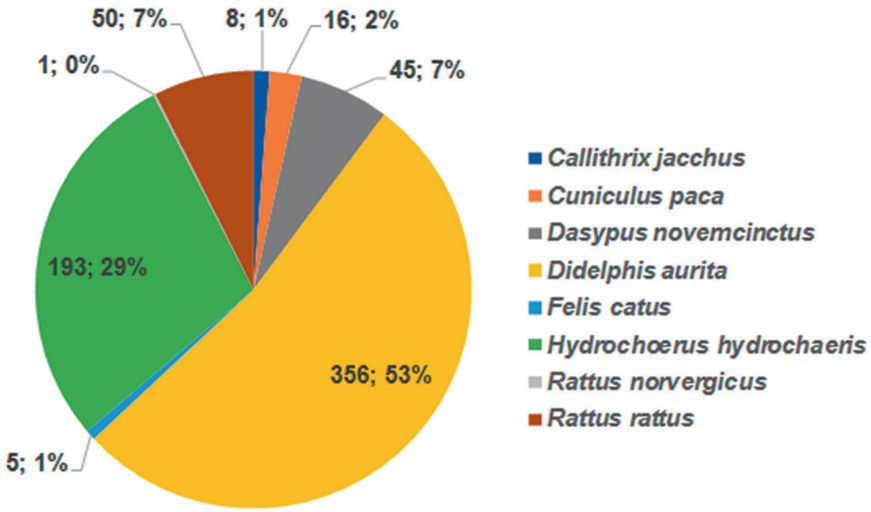

Figure 3. Number of records and relative frequency of occurrence of mammal species in Chico Mendes Natural Municipal Park and Canal das Taxas corridor using camera traps between 2020 and 2021. Records of non-volant, smaller species (rodents, marsupials and primates) were also shown. Data obtained in the single camera trap placed within the Marapendi Natural Municipal Park was not included.

Figure 4. Photographic records of the same individual of Cuniculus paca in Chico Mendes Municipal Natural Park (Chico Mendes MNP), Canal das Taxas corridor, and Marapendi Municipal Natural Park (Marapendi MNP).

mammal fauna between the parks (Figure 4). However, the presence of white-tufted marmosets, cats, and rats in Canal das Taxas is also an indication that these exotic species are using the corridor, although they also occur around the parks in unforested areas. Although the presence of the ecological corridor is important for the transit of native species between the parks, it may also facilitate the movement of exotic species. Therefore, the management of this corridor and of Chico Mendes MNP should take exotic species into account.

Although domestic dogs were not recorded in Chico Mendes MNP in this study, they were identified in the park during the survey for the management plan (FUNBIO et al. 2014). The fencing of Chico Mendes MNP is relatively intact, which may explain the absence of domestic dog records in the current study. Several researches have reported that small and medium-sized mammals are most preyed upon by domestic dogs, especially the opossum *D. aurita* (Galetti & Sazima 2006, Campos et al. 2007, Rangel & Neiva 2013, Lessa et al. 2016). Both domestic dogs and cats tend to hunt either by instinct and/or by lack of care – such as proper feeding – negatively influencing the behavior, feeding, and reproductive success of native fauna (Young et al. 2011, Silva-Rodríguez & Sieving 2011). Fencing maintenance in Chico Mendes MNP is therefore an important management action which were highlighted in the management plan (FUNBIO et al. 2014).

Finally, several municipal parks in Rio de Janeiro do not have *in situ* surveys. This study showed that a checklist based on secondary sources for the region (that is, potential occurrence of species) is misleading, at least for mammals, because it has missed important species while listed others that do not seem to occur in the park (except perhaps for occasional translocated individuals). Municipal parks that have management plans but no *in situ* mammals surveys include: Catacumba MNP (26.5 ha), which has two native species of medium to large-sized non-volant mammals that are likely to occur (SMAC 2008); Serra do Mendanha MNP (1,444.86 ha), with 21 species of probable occurrence (FUNBIO & SEA RJ 2012a); Grumari MNP (804.73 ha) and Prainha MNP (146.93 ha), which potentially have 17 species each (FUNBIO & SEA RJ 2012b); Bosque da Barra MNP (53.65 ha), with 10 species (SMAC 2014); and Paisagem Carioca MNP (159.82 ha), which has five species of probable occurrence (SMAC 2013); for all these parks, *D. aurita* was included in the species richness counting. We believe that *in situ* surveys should always be performed for the management plan of protected areas, preferable employing an array of available techniques for sampling terrestrial as well as arboreous species.

Conclusion

Chico Mendes MNP and Canal das Taxas have a mammalian fauna that is probable a subset of the species in Marapendi MNP, including with respect to exotic species. Although small, Chico Mendes MNP is mostly fenced, with public access controlled. Thus, although it does not have a very distinct mammalian fauna, Chico Mendes MNP may be helping to compose an additional and relatively more protected area – like a refuge – for native species that use the region's park complex. The finding that Canal das Taxas, in the stretch between Chico Mendes and Marapendi MNPs, might be effectively contributing to the exchange of native mammals species corroborates its importance for the long-term maintenance of these populations and underscores the need to effectively implement the Recreio Green Corridor Plan in the region. Finally, we believe that adequate, in situ surveys are a requirement for the management plan of protected areas.

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Associate Editor

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Author Contributions

Beatriz Elvas: Contribution to data collection; resources; conceptualization; data analysis; writing – original draft and manuscript preparation.

Cecília Bueno: Contribution to conceptualization; resources; critical revision.

Natalie Olifiers: Contribution to conceptualization; data analysis; resources; critical revision, adding intellectual content.

Conflicts of Interest

The author(s) declare(s) that they have no conflict of interest related to the publication of this manuscript

Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

Data Availability

Supporting data are available at <https://doi.org/10.48331/scielodata.OMHLOH>.

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