

# Small mammals (Didelphimorphia, Rodentia) in the Atlantic Forest area in northeast Brazil

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**Abstract.** Several patterns can occur in a community, one of which is that a few species show high dominance, which is also evident in small mammals. This group had a wide distribution in the Brazilian territory, presenting variations in richness and abundance, which may be related to seasonality, habitat structure, and changes in resource availability. The objective of this study was to characterize the small mammal community and analyze the influence of precipitation on the capture of species in the Atlantic Forest area in Sergipe, northeastern Brazil. The study area is in the municipality of Itabaiana, Parque dos Falcões, and campaigns were conducted monthly on three consecutive nights between August/2022 and July/2023. 120 Sherman traps baited on the ground and understory were used in this study. Capture effort success, and estimated richness were calculated. A simple linear regression was performed between the number of captures and monthly precipitation. Additionally, a circular analysis was carried out with the most captured species to verify uniformity distribution in the monthly capture frequency. 44 captures were made of three species of rodents and six of marsupials were made after an effort of 4,320 traps-night (1% trap success). Approximately 70% of captures were from *Marmosa demerarae*, *Cerradomys vivoi*, and *Didelphis albiventris*. The invasive species *Rattus rattus* was captured. Despite the greater number of captures in rainy months, there was no influence of precipitation on these captures. Uniformity in species capture was observed during the sampling months for *M. demerarae*, *C. vivoi*, and *D. albiventris*. *Marmosa demerarae* was most captured in the area, and is reported in literature as having a broad and opportunistic diet. The uniformity of the temporal distribution of the species may be related to the regularity of precipitation during the study period. The presence of invasive species reflects anthropization close to the sampled area, affecting native species and highlighting the vulnerability of surrounding environments.

**Keywords.** Abundance; Marsupials; Precipitation; Rodents; Sergipe.

## INTRODUCTION

Small non-flying mammals (Didelphimorphia and Rodentia) are a very diverse group distributed throughout the Brazilian territory (Paglia *et al.*, 2012), enabling studies on patterns of diversity, abundance, and fluctuations that occur in communities during the year (Santos-Filho *et al.*, 2008; Ferreira *et al.*, 2020; Urquizo *et al.*, 2021).

In general, few species have a high relative abundance, whereas many species are less abundant (Pardini & Umetsu, 2006; Santos & Henriques, 2010; Gatto-Almeida *et al.*, 2016; Calazans & Bocchiglieri, 2020; Falchetto *et al.*, 2020). Some small mammal species may be dominant in certain areas (for example, Santos & Henriques, 2010; Gatto-Almeida *et al.*, 2016; Urquizo *et al.*, 2021) are generally characterized as better competitors in relation to the others, with habit generalists in relation to diet and showing less sensitivity to

environmental disturbances such as habitat loss (Gatto-Almeida *et al.*, 2016).

In environments, such as ecotones, changes in species composition in relation to nearby areas are due to high environmental heterogeneity (Faria & Kaizer, 2020), which provides a greater variety of habitats that can favor different species, both with specialist and generalist habits. In areas with high heterogeneity, for example, a high richness of small mammals can be found (Cherem & Althoff, 2019; Faria & Kaizer, 2020; Vieira & Oliveira, 2020) and a species composition shared with both environments in addition to endemic species (Faria & Kaizer, 2020) because of the different phytophysiognomies shared in these areas.

One of the factors that can influence species abundance is seasonal variation (Pardini & Umetsu, 2006; Santos-Filho *et al.*, 2008; Urquizo *et al.*, 2021; Costa-Pinto *et al.*, 2023; Ferreira *et al.*, 2023), considering changes in resource availability

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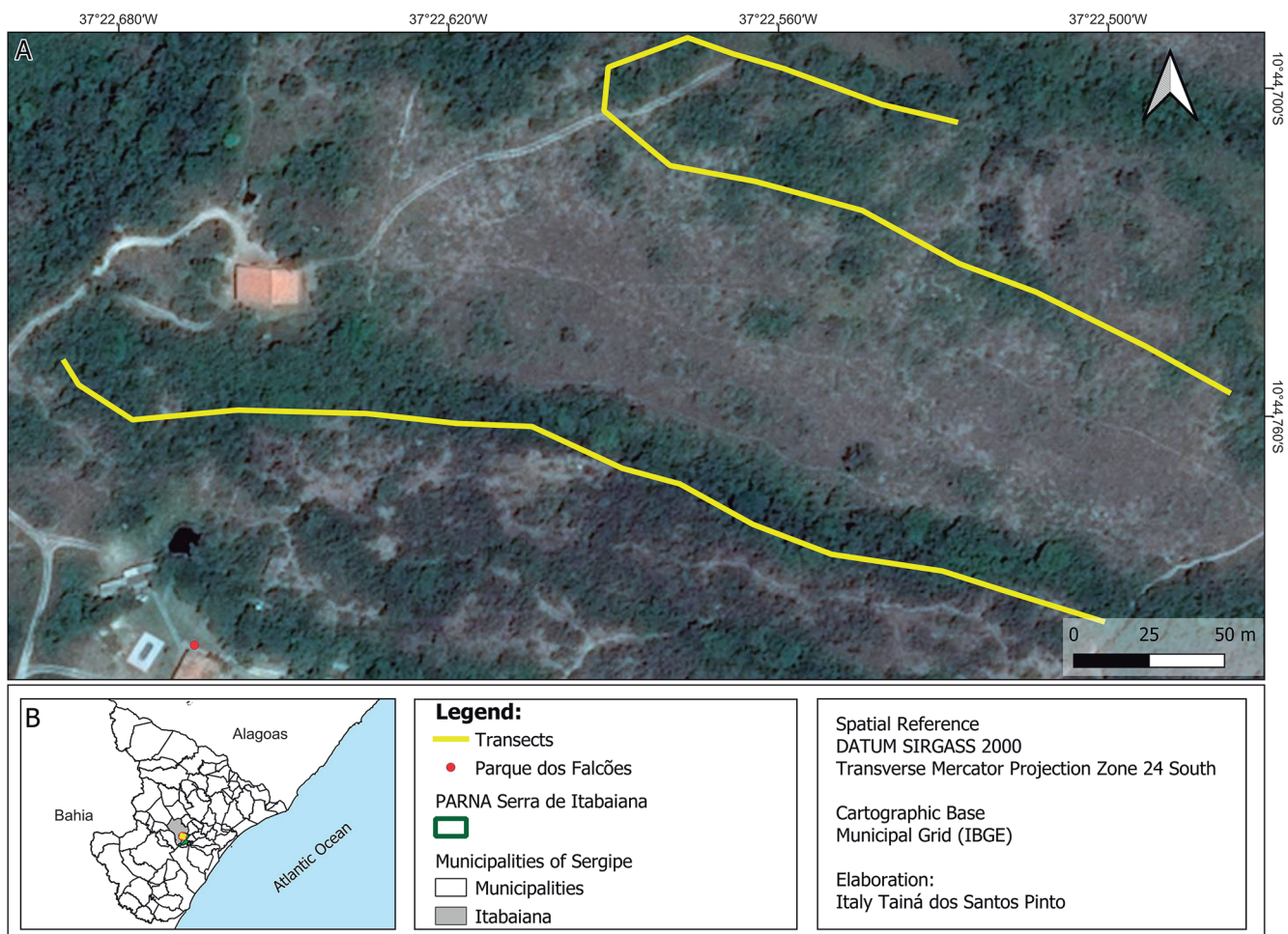
throughout the year (Santos-Filho *et al.*, 2008; Cáceres & Lessa, 2012; Urquizo *et al.*, 2021; Costa-Pinto *et al.*, 2023). Some studies reported a greater abundance of small mammals during rainy periods (for example, Ribeiro & Marinho-Filho, 2005; Pardini & Umetsu, 2006; Santos-Filho *et al.*, 2008; Ferreira *et al.*, 2023), which may be related to the greater availability of food in the environment, mainly arthropods (Santos-Filho *et al.*, 2008) and fruits (Cáceres & Lessa, 2012). The greater abundance of some species during this period is due to the fact that they synchronize their reproduction considering these resources to be more abundant in the environment (Cáceres & Lessa, 2012; Ferreira *et al.*, 2023) and some studies have reported temporal fluctuations in the abundance of small mammal species (Santos-Filho *et al.*, 2008; Falquetto *et al.*, 2020; Costa-Pinto *et al.*, 2023; Ferreira *et al.*, 2023).

In this context, this study aims to contribute information about the structure of the community and variations in the abundance of small mammal species throughout the year in an Atlantic Forest area in Sergipe, Northeast Brazil. Considering the changes in the availability of food resources during the year, it is expected that the abundance of small mammals is related to seasonality, with a greater number of captures during the rainy season. Therefore, we hypothesized that the most abundant species in this area will not present a uniform monthly capture frequency.

## MATERIAL AND METHODS

The study area, Parque dos Falcões (10°44'50"S, 37°22'40"W), is located in the municipality of Itabaiana (Fig. 1), approximately 48 km from the capital city of Aracaju, Sergipe, northeastern Brazil. With an area of approximately 3,500 km<sup>2</sup>, the location corresponds to a private area that conducts activities for the management, reintroduction, and conservation of birds, mostly birds of prey. The study site has great ecological relevance considering its proximity to the Serra de Itabaiana National Park (PARNA Serra de Itabaiana), an integrally protected Federal Conservation Unit with an area of 7,960 hectares, where several springs and more are found for 800 plant species (Silva *et al.*, 2019).

The region corresponds to a transition area between the Atlantic Forest and the Caatinga, with distinct environments and heterogeneous vegetation, with places with a predominance of plants with a shrub-arboreal size, and areas with a predominantly arboreal size. The most open areas at the site appearing very degraded and have shrubby-arboreal vegetation with sparse trees while the shrubs tend to form thickets (Dantas *et al.*, 2010). Secondary forest vegetation is characterized by a discontinuous canopy and sparse understory, with a few dominant species (Dantas & Ribeiro, 2010), and a ground covered in leaf litter. Nevertheless, the regions surrounding PARNA



**Figure 1.** Transects used for sampling small mammals (A) in Parque dos Falcões, in the state of Sergipe, Northeastern Brazil (B).

Serra de Itabaiana and Parque dos Falcões are regularly impacted by hunting activities, extraction of soil and timber, and fire incidents (Sobral *et al.*, 2007), which affect the ability of animal species to persist in the area.

The monthly precipitation data for the study region were obtained from the Sergipe Agricultural Development Company website (<https://emdagro.se.gov.br/pluviososidade>). During the sampling period, the closest station was Ribeirópolis, 33 km away from Parque dos Falcões, which recorded an accumulated rainfall of 689.10 mm, and in just one month, no rain was recorded.

### Data collection and analysis

Data were collected on three consecutive nights per month from August 2022 to July 2023 using the capture-mark-recapture method. 120 Sherman traps (30 × 8 × 9 cm) were distributed in two transects, each with 30 capture stations. Each station contained two traps (one on the ground and the other 1.5 m high) and was 15 meters away from another station. The traps were baited with a mixture of corn flour, roasted and ground peanuts, banana, corn, and sardines in oil, checked daily in the morning and reset when necessary. The captured animals were identified according to Faria *et al.* (2019) and Patton *et al.* (2015), marked with a numbered earring (Eartags) in the left ear, and released in the same capture location. The captures took place under license Nº 84157-1 from SISBIO/ICMBio, and some specimens were collected and incorporated into the Coleção de Mamíferos da Universidade Federal de Sergipe/CMUFS (Appendix).

The capture effort (number of traps × campaign days) for this study was determined. The capture success ( $[\text{number of records} \div \text{capture effort}] \times 100$ ) of small mammals in the area was obtained according to Stallings (1989). To evaluate sample sufficiency, the rarefaction curve and extrapolation of the estimated richness twice the sampling effort were obtained by standardizing the Hill number ( $q = 0$ ) based on the sample size in the iNext software (Chao *et al.*, 2016).

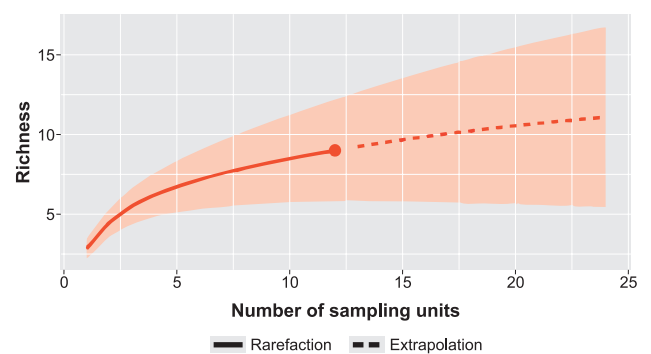
A simple linear regression was performed between the number of catches and monthly precipitation (in mm) during the study period in BioEstat 5.3 program (Ayres *et al.*, 2007). To verify the uniformity in the monthly distribution of captures, a circular analysis was carried out, with the species most captured in the area, using the Rayleigh (Z) uniformity test in the ORIANA program (Kovach, 2011). A significance level of 5% was adopted for all analyses.

## RESULTS

In full 44 captures (eight of which were recaptures) of small mammals belonging to nine species, six marsupials, and three rodents were made (Table 1). From a sampling effort of 4,320 trap-nights, the total number of records represents 1% capture success. Only 16% of the captures were made on the third day of sampling and

**Table 1.** Captures (and recaptures) in small mammals in Parque dos Falcões, Itabaiana, Sergipe, Northeastern Brazil. \* invasive and exotic species.

Species	Captures (Recaptures)
<b>Didelphimorphia</b>	
<i>Didelphis albiventris</i>	9
<i>Gracilinanus agilis</i>	2
<i>Marmosa demerarae</i>	8 (5)
<i>Marmosa murina</i>	1
<i>Marmosops incanus</i>	3 (2)
<i>Monodelphis domestica</i>	1
<b>Rodentia</b>	
<i>Cerradomys vivoi</i>	8 (1)
<i>Rattus rattus</i> *	3
<i>Trinomys albispinus</i>	1
<b>Total</b>	<b>36 (8)</b>



**Figure 2.** Small mammalian species curve in Parque dos Falcões, Itabaiana, Sergipe, Northeastern Brazil. The continuous line represents the interpolation curve, whereas the dashed line represents the extrapolation curve up to 24 months (sampling units).

no new species were recorded in this study after the second day. One of the species captured corresponds to the exotic and invasive rodent, *Rattus rattus* Linnaeus, 1758. The estimated richness of the locality was greater than that recorded in this study (Fig. 2).

The most captured species were *Marmosa demerarae* (Thomas, 1905) ( $N = 13$ ), *Cerradomys vivoi* Percequillo, Hingst-Zaher & Bonvicino, 2008 ( $N = 9$ ), and *Didelphis albiventris* Lund, 1840 ( $N = 9$ ) (Table 1), totaling approximately 70% of the total captures occurring in Parque dos Falcões. The months with the highest number of captures were August/2022, June and July/2023, with monthly precipitation varying between 70.6 and 135.6 mm, while October and January, months with the lowest precipitation rates (0 to 3.0 mm), had only one capture each. However, precipitation had no influence on the number of captures ( $R^2 = 0.021$ ;  $p = 0.072$ ).

There was no significant difference in the capture of *M. demerarae*, *C. vivoi*, and *D. albiventris* throughout the study period ( $p > 0.05$ ), with uniformity observed in the capture of these species between the months (Fig. 3).

## DISCUSSION

The species found in Parque dos Falcões has already been reported in other studies of the state (Stevens &

Husband, 1998; Oliveira *et al.*, 2005; Rocha *et al.*, 2015, 2017; Freitas *et al.*, 2017; Beltrão-Mendes *et al.*, 2020; Calazans & Bocchiglieri, 2020). The capture success was lower compared to other studies conducted in Atlantic Forest regions of Sergipe by Rocha *et al.* (2017), Beltrão-Mendes *et al.* (2020), and Calazans & Bocchiglieri (2020). Although these studies employed three monthly nights for sampling, the sampling effort varied from 1,296 to 8,188 trap-nights and the richness registered varied from 4 to 10 species.

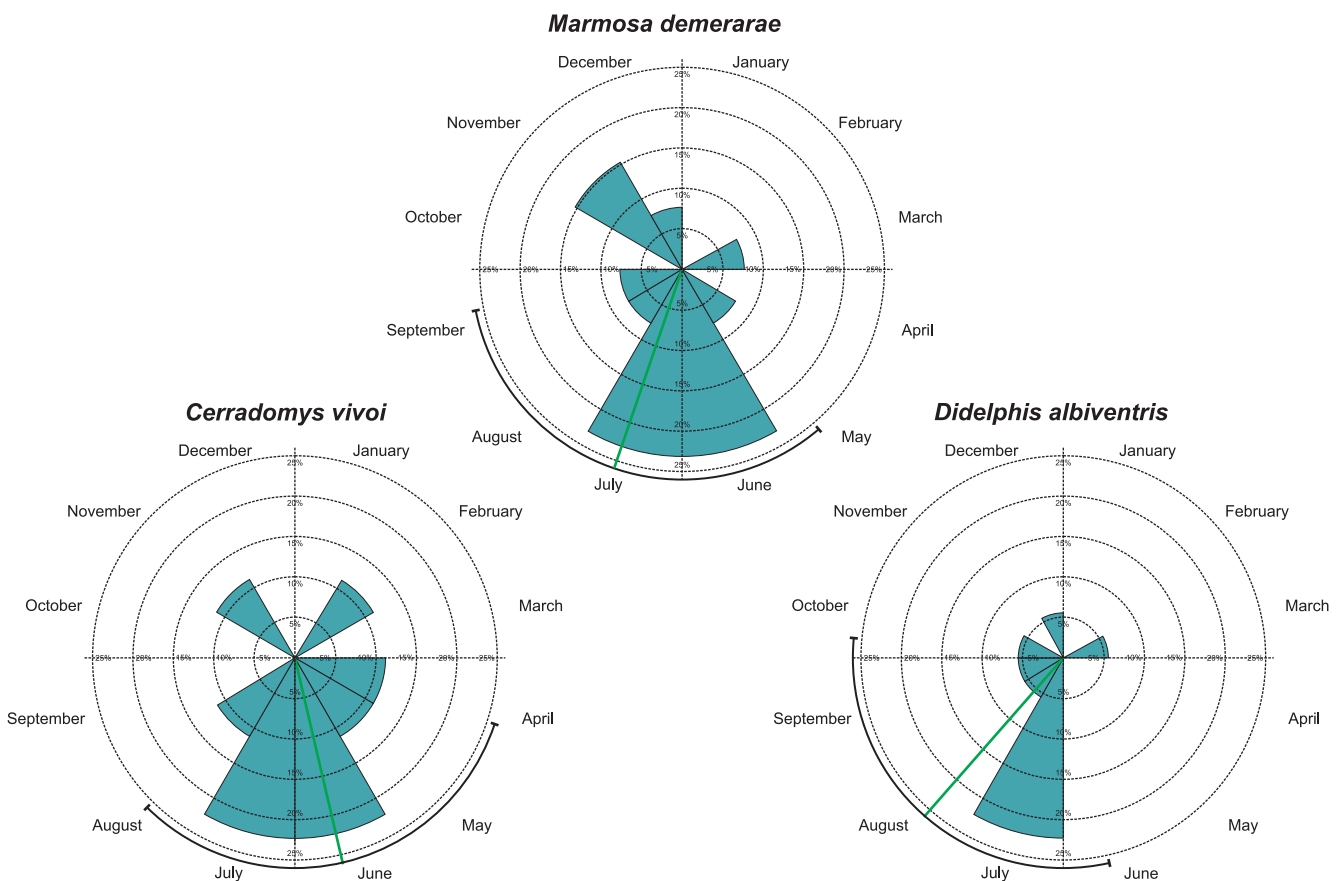
The low capture success in this study may be related to two factors: the small number of nights sampled each month and the recurring anthropogenic impacts in the region, resulting in the alteration and isolation of forest remnants. However, studies with three nights of sampling in different environments have shown capture successes ranging from 1.9% to 16.56% (*e.g.*, Cademartori *et al.*, 2008; Leiner & Silva, 2012; Rocha *et al.*, 2017; Beltrão-Mendes *et al.*, 2020; Calazans & Bocchiglieri, 2020; Hannibal & Venturini, 2021; Urquizo *et al.*, 2021), showing that anthropogenic pressures, area size, type of vegetation formation, sampling effort and altitude seem to reflect more on the parameters found in the communities. In a study of 23 Atlantic Forest fragments in Rio de Janeiro, Vieira *et al.* (2009) reported that 80% of small mammal species were captured by the third day of sampling, reflecting satisfactory sampling.

However, we believe that changes in the local landscape and the quality of the habitat have a greater in-

fluence on the catches in this study. The contact area between Parque dos Falcões and PARNA is subject to constant removal of soil and wood, burning, hunting, the presence of garbage and exotic species, agriculture and trails, resulting, for example, in a decrease in local fauna (Sobral *et al.*, 2007). Vieira *et al.* (2009) reported that isolation and land use negatively affect the richness of small mammals in Atlantic Forest areas, while Delciellos *et al.* (2015) related that habitat structure, such as vertical stratification, understory density and the presence of fallen trunks, were determinants of the richness and abundance of this group in the biome.

Furthermore, the Parque dos Falcões region is susceptible to predation pressure because of the high number of birds of prey in the area and human pressure, such as fires and the regular flow of people on existing trails in the locality (personal observations), which can negatively influence the captures of small mammals in the area. In the PARNA Serra de Itabaiana, the adjacent area, three species of marsupials and two species of rodents were captured in open and forested areas (Oliveira *et al.*, 2005), and only three of these were found in Parque dos Falcões (*C. vivoi*, *D. albiventris*, and *M. murina*).

The capture of *Rattus rattus*, an exotic and invasive rodent species, in Parque dos Falcões may be related to the proximity of the area to surrounding housing and the constant flow of people, causing the regular presence of garbage. Therefore, its registration raises concerns owing to the proximity of this area to the PARNA Serra de Ita-



**Figure 3.** Temporal distribution of the frequency of captures of the most abundant small mammals in Parque do Falcões, Itabaiana, Sergipe, northeastern Brazil. The black line indicates the confidence limit of the mean.

baiana and the inherent threats to the local fauna. The congeneric species, *R. norvegicus* (Berkenhout, 1769), is also exotic and invasive, and has already been found in a UC in the Sergipe Atlantic Forest (Rocha *et al.*, 2017), showing that the state's conservation areas are being affected by anthropization. In addition to being a potential disease vector (Cab-Romero *et al.*, 2020), the highly competitive power of these species and the fact that they are present throughout the Brazilian territory (Bonvicino *et al.*, 2008) also reflect threats to local communities. *Rattus rattus* has been reported in several locations in the country (Caldara-Junior & Leite, 2007; Quintela *et al.*, 2012; Cherem & Althoff, 2019; Cherem *et al.*, 2022), which can negatively affect the communities' native species because of their lower sensitivity to anthropogenic disturbances in relation to generalist wild species. Monitoring and management of *R. rattus* is recommended to reduce the impact of this species on UCs by ICMBio (2023).

*Didelphis albiventris* is a marsupial reported in numerous studies as one of the most abundant forest fragments in different environments (Cherem & Althoff, 2019; Vieira & Oliveira, 2020; Machado *et al.*, 2021; Bella *et al.*, 2022), urban, and altered areas (Cantor *et al.*, 2010; Oliveira *et al.*, 2010; Silva *et al.*, 2017), as well as in Parque dos Falcões. The generalist habit (Cherem & Althoff, 2019) and its opportunistic and varied diet (Santori *et al.*, 2012) favored this species to be the most abundant at the site of this study. In Sergipe, this species has been reported both in the Atlantic Forest (Oliveira *et al.*, 2005; Rocha *et al.*, 2017; Beltrão-Mendes *et al.*, 2020; Calazans & Bocchiglieri, 2020) and Caatinga (Bezerra *et al.*, 2014; Rocha *et al.*, 2015). Furthermore, its local abundance may be under-sampled in Parque dos Falcões, as the traps used only captured juveniles and sub-adults because of their larger size compared to other species; thus, the number of individuals in this community is even greater.

*Marmosa demerarae* is widely distributed in Brazil and has been reported in secondary and primary forests, occurring in regions of the Amazon (Carmignotto & Aires, 2011; Santos-Filho *et al.*, 2017; Mercês & Alves-Silva, 2022), Atlantic Forest (Stevens & Husband, 1998; Passamani, 2000; Graipel *et al.*, 2017; Beltrão-Mendes *et al.*, 2020), and transition areas (Miranda *et al.*, 2005; Faria & Kaizer, 2020). Studies have reported *M. demerarae* to be more abundant in forest areas of the Atlantic Forest in Sergipe (Stevens & Husband, 1998; Beltrão-Mendes *et al.*, 2020). Its diet is characterized as insectivorous-omnivorous (Paglia *et al.*, 2012; Santos-Filho *et al.*, 2017; Mercês & Alves-Silva, 2022), which is the result of a broad and opportunistic diet (Mercês & Alves-Silva, 2022), as evidenced by its distribution across different environments.

*Cerradomys vivoi* is a rodent distributed in the state of Sergipe in the restinga areas (Calazans & Bocchiglieri, 2020) and semi-deciduous forests (Beltrão-Mendes *et al.*, 2020). Its presence was reported in the PARNA Serra de Itabaiana (Oliveira *et al.*, 2005), adjacent to the area of this study, both in open and closed environments, demonstrating its generalist habit. Furthermore, it has been found in the Atlantic Forest (Prado *et al.*, 2015; Leite & Costa, 2018; Geise & Aguiar, 2021), and Caatinga

(Gomes *et al.*, 2020; Cherem *et al.*, 2022), showing its wide distribution and adaptation to different environments.

Although a greater number of small mammal captures was recorded during the rainiest months, there was no relationship between these captures and precipitation. This may be related to the fact that precipitation was regular throughout the year in the region during the sampling. The study period was influenced by La Niña, which resulted in increased rainfall in the northeastern and northern regions of Brazil (INMET, 2023). Thus, it is likely that food resources remained stable and available during the study and this regularity in rainfall may also explain the uniformity in capture of the most abundant species in the area. The relationship between precipitation and community structure has been reported mainly in extreme environments, in which water is a limiting factor (Urquiza *et al.*, 2021; Costa-Pinto *et al.*, 2023), considering that environmental conditions exert greater pressure on local species.

Studies on small mammals are relevant considering the knowledge gaps in different environments in the state of Sergipe. In the present study, the richness recorded in Parque dos Falcões was similar to that in other locations in the state. The presence of the invasive alien species *R. rattus* is a warning sign for the adjacent area of PARNA Serra de Itabaiana and regular rains during the study period did not influence the capture of the species.

**AUTHORS' CONTRIBUTIONS:** AB: Conceptualization; AB, ITSP: Methodology, Formal analysis; ITSP: Validation, Investigation, Writing – Original Draft; AB: Resources, Writing – review & editing, Supervision. All authors actively participated in the discussion of the results and reviewed and approved the final version of the paper.

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## APPENDIX

Vouchers deposited in the Coleção de Mamíferos da Universidade Federal de Sergipe (CMUFS): *Cerradomys vivoi*: CMUFS 0222 ♀; *Rattus rattus*: CMUFS 0224, 0251 ♂; *Trinomys albispinus*: CMUFS 0223 ♂; *Monodelphis domestica*: CMUFS 0241 ♂; *Marmosops incanus*: CMUFS 0257 ♀.