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# SMALL MAMMALS IN RESTINGA AREAS OF NORTH-EASTERN BRAZIL

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**ABSTRACT.** The restingas are an important component of the Atlantic Forest, affected by anthropic impacts along the Brazilian coast. The mastofauna that occurs in these environments is little known, especially in the north-east of the country. This study characterized the richness, abundance and composition of small mammal species in arboreal restinga areas in the state of Sergipe, north-eastern Brazil. Sampling was performed monthly, from September 2017 to August 2018. An effort composed of 8188 trap-nights with Sherman traps and 1782 trap-night with pitfall traps resulted in the capture of 120 individuals from 10 species; four marsupials (*Didelphis albiventris*, *Marmosa demerarae*, *Marmosa murina*, and *Marmosops incanus*) and six rodents (*Calomys* sp., *Cerradomys vivoi*, *Oligoryzomys* sp., *Phyllomys blainvillii*, *Rhipidomys mastacalis*, and *Trinomys* sp.). *Phyllomys blainvillii* is a new record for the state. The observed richness corresponds to 73% of that estimated by Jackknife 1 ( $13.6 \pm 1.5$  species). *Marmosops incanus* and *R. mastacalis* were the most abundant, corresponding to 84% of the individuals captured. The community composition differs from the restingas of other regions of Brazil, but the majority of the species correspond to a subset of those found in the Atlantic Forest of the region. The locality presented the greatest richness of small mammals in areas of the Atlantic Forest of Sergipe, reinforcing the importance of the preservation of these areas and contributing to understanding the mastofauna in the restingas. This study also presents an updated list for this group in the state.

**RESUMO. Pequenos mamíferos em áreas de restinga no nordeste do Brasil.** As restingas são um componente importante da Mata Atlântica, sendo afetadas por impactos antrópicos ao longo da costa brasileira. A mastofauna que ocorre nesses ambientes ainda é pouco conhecida, principalmente no nordeste do país. O presente estudo caracterizou a riqueza, abundância e composição de pequenos mamíferos em uma fitofisionomia de restinga arbórea em Sergipe, nordeste do Brasil. A amostragem foi realizada mensalmente de setembro de 2017 a agosto de 2018. O esforço de 8188 armadilhas-noite e 1782 pitfalls-noite resultou na captura de 120 indivíduos pertencentes a 10 espécies, quatro marsupiais (*Didelphis albiventris*, *Marmosa demerarae*, *Marmosa murina* e *Marmosops incanus*) e seis roedores (*Calomys* sp., *Cerradomys vivoi*, *Oligoryzomys* sp., *Phyllomys blainvillii*, *Rhipidomys mastacalis* e *Trinomys* sp.). O registro de *P. blainvillii* é inédito para o estado. A riqueza observada corresponde a 73% da estimada por Jackknife 1 ( $13.6 \pm 1.5$  espécies). *Marmosops incanus* e *R. mastacalis* foram as espécies mais abundantes, correspondendo a 84% dos indivíduos capturados. A composição da comunidade difere das restingas de outras regiões do Brasil, mas a maioria das espécies corresponde a um subconjunto das encontradas nas áreas de Mata Atlântica da região. A localidade apresentou a maior riqueza de pequenos mamíferos em áreas da Mata Atlântica de Sergipe, reforçando a importância da preservação dessas áreas e contribuindo para o entendimento sobre a mastofauna que ocorre nas restingas. Este estudo apresenta assim uma lista atualizada de pequenos mamíferos para o estado.

**Key words:** Brazilian coast, Didelphimorphia, *Phyllomys blainvillii*, Rodentia, Sergipe.

**Palavras-chaves:** costa brasileira, Didelphimorphia, *Phyllomys blainvillii*, Rodentia, Sergipe

## INTRODUCTION

The restingas are coastal ecosystems associated with the Atlantic Forest that are distributed discontinuously along the Brazilian coast (Pessôa et al. 2010). These formations occur on sandy strips of the coastal plains where soils are leached and nutrient poor, and there may be an influence from freshwater or brackish water (Cerqueira 2000; Souza et al. 2008). These factors differentiate vegetation in these ecosystems (Araújo & Lacerda 1987; Falkenberg 1999; Thomas & Barbosa 2008), contributing to the establishment of different types of vegetation physiognomy (Pereira 2003; Silva & Brites 2005).

Although threatened and situated relatively close to the largest urban centers in the country (Rocha et al. 2007; Souza et al. 2008; Silva et al. 2012; Fundação SOS Mata Atlântica & INPE 2018), the existing knowledge about the mammals comes from studies in the south-eastern and southern regions of the country (e.g., Cerqueira et al. 1990; Freitas et al. 1997; Cerqueira 2000; Fabián et al. 2010; Lopes et al. 2010; Pessôa et al. 2010; Quintela et al. 2012). Thus, our knowledge of the mastofauna that occur in restingas in north-eastern Brazil is still obscure, being limited to two inventories (Dias et al. 2017; Campos et al. 2018).

Some authors suggest that the mammals that occur in the restingas constitute a subset of those occurring in the adjacent Atlantic Forest (Cerqueira 2000; Pessôa et al. 2010; Campos et al. 2018). Taking this into consideration, few cases of endemism are known, represented by the rodents *Ctenomys* spp. (Blainville, 1826) and *Cerradomys goytaca* Tavares, Pessôa & Gonçalves, 2011 in the south and south-east of the country (Lopes et al. 2010; Tavares et al. 2011). The characteristics of these areas seem relevant for endemic species, which more frequently occupy open areas, where water availability is a limiting factor (Tavares et al. 2011). However, the great variation in humidity and temperature of this environment tends to restrict the occurrence of small mammals, the majority of the species being associated with the arboreal vegetation (Cerqueira 2000). In this context, the present study characterizes the structure of the community of small mammals in relation to the richness, abundance and composition of species in an arboreal restinga, phytophysiology on the coast of the state of Sergipe, north-eastern Brazil.

## MATERIALS AND METHODS

### Study area

The study was conducted at the Santa Isabel Biological Reserve (REBIO Santa Isabel), one of the priority areas for biodiversity conservation in Brazil (MMA 2018). REBIO Santa Isabel occupies an area of 2 766 ha and is located along a coastal stretch of approximately 40 km between the municipalities of Pirambu and Pacatuba (Brasil 1988), in the north-east of the state of Sergipe. In this region the temperature ranged from 28 to 32 °C during the study period and the accumulated annual rainfall was 1 254.5 mm (SINDA 2018). The climate is characterized as rainy tropical with dry summers (Alvares et al. 2013).

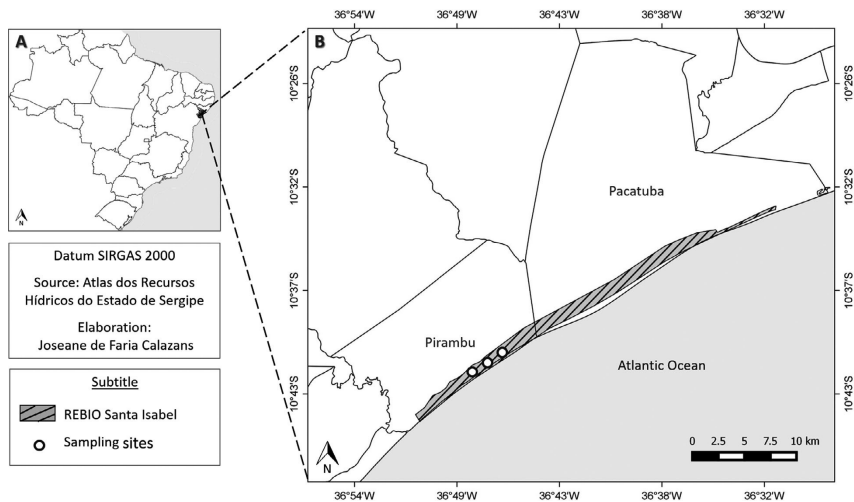
Three sites were selected for sampling the mammals (Fig. 1), separated by approximately 1.5 km (10° 42' S 36° 48' W, 10° 41' S 36° 47' W, and 10° 40' S 36° 47' W) and about 600 m distant from the high tide line. In the mosaic of different phytophysionomies (beach-grassland and woody formations) that REBIO Santa Isabel represents, these sites correspond to a closed non-flooded, "fruticeto fechado" physiognomy, which includes shrub and tree species leeward of the dunes, forming a sparse canopy of variable heights (Silva & Brites 2005; Oliveira & Landim 2014).

### Data sampling and analysis

Between September 2017 and August 2018, with the exception of February, three monthly capture nights were completed at each of the three sampling sites, avoiding periods with a full moon. Each of these sites comprised 47 capture stations, 10 m apart; 41 stations with Sherman traps (25 x 9 x 8 cm) arranged in the ground and understorey (approximately 1.5 m from the ground), and six stations with pitfall traps (22 L). The Sherman traps were baited during the day with a mixture of banana, sardines in oil, peanut butter, corn, and corneal. Each pitfall trap station was composed of three buckets arranged linearly and connected by a canvas of 0.5 m in height and 5 m in length. All traps were checked in the morning and baited when necessary.

Captured individuals were marked with numbered aluminum ear tags (Model 1005-1, National Band and Tags Co.) and released at the same capture station. The collected specimens were deposited in the Coleção de Mamíferos da Universidade Federal de Sergipe (CMUFS; Table S1). Species identification was confirmed according to Weksler (2006); Bonvicino et al. (2008); Percequillo et al. (2008); Rossi et al. (2012); Patton et al. (2015), and consultations with specialists. This study was conducted in accordance with SISBIO license number 59943-1.

Sampling effort and capture success were calculated for the two types of traps used in the study following Stallings (1989). Presence/absence data for each species were grouped for the three sampling sites and each month of sampling, and rarefaction curves were constructed from 10 000 randomizations using the non-parametric estimator Jackknife 1 in the software EstimateSWin 9.0 (Colwell 2013), aiming to estimate the richness of the area.



**Fig. 1.** Brazil with the State of Sergipe highlighted (A), location of the Reserva Biológica de Santa Isabel between the municipalities of Pirambu and Pacatuba, according to ICMBIO (2018), and the sampling sites (B). Source: Calazans & Bocchiglieri (2019).

## RESULTS

Ten species of small mammals were recorded in the REBIO Santa Isabel: four marsupials and six rodents (Fig. 2) in 157 captures, of which 37 were recaptures. After 11 campaigns, the success rate of the Sherman traps was 1.9% (154 records in an effort of 8 188 trap-nights). In pitfall traps, the capture success was 0.16% (three records and an effort of 1 782 trap-nights). This richness observed corresponds to 73% of that estimated ( $13.6 \pm 1.5$  species) for sites studied (Fig. 3).

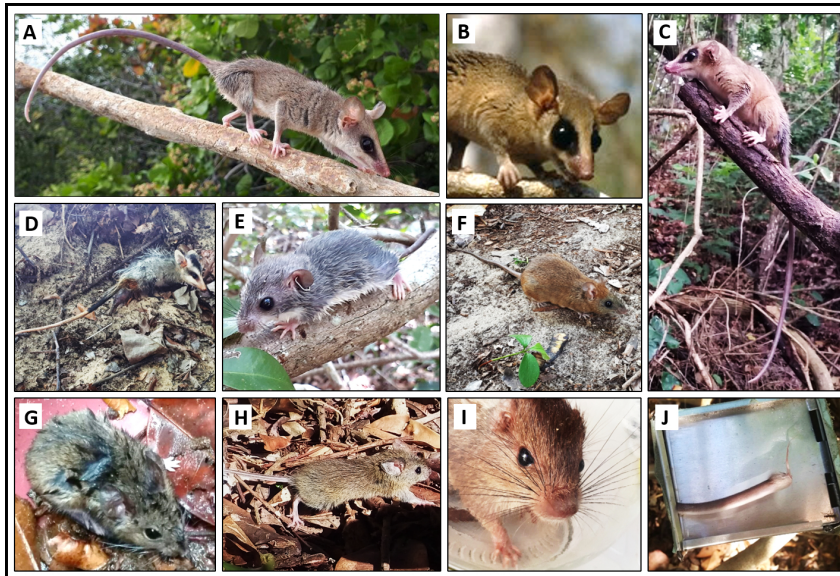
The most abundant species were the marsupial *Marmosops incanus* (Lund, 1840; N = 76) and the rodent *Rhipidomys mastacalis* (Lund, 1840; N = 25), which together represented about 84% of the individuals captured (Fig. 4). Three captures (1.9%) occurred in pitfall traps, corresponding to a specimen of *M. incanus*, one of *Didelphis albiventris* Lund, 1840, and one of a *Calomys* sp. (Waterhouse, 1837). Although not considered in the present study, tracks of larger mammals, such as carnivores *Cerdocyon thous* (Linnaeus, 1766) and *Procyon cancrivorus* (G. Cuvier, 1798), were found in the area, the armadillo *Dasylops* sp. (Linnaeus, 1758) was observed and a juvenile primate, *Callithrix jacchus* (Linnaeus, 1758), was captured in a Sherman trap.

## DISCUSSION

From the 10 species recorded here, REBIO Santa Isabel is considered the locality with the greatest

richness, to date, of small mammals in ecosystems associated with the Atlantic Forest of Sergipe. Previous studies in this biome recorded between four and nine species in the state (Stevens & Husband 1998; Oliveira et al. 2005; Dias et al. 2017; Rocha et al. 2017), and from three to 11 species were recorded in caatinga ecoregions (Freitas et al. 2011; Bezerra et al. 2014; Rocha et al. 2015; Freitas et al. 2017), resulting in 25 species of small mammals recorded in total (Table S1). The use of small pitfall traps in this area was not optimal for mastofauna sampling, as suggested by the review by (Bovendorp et al. 2017). The pitfall traps were not particularly efficient in the study area, probably due to its smaller size, contributing little to increase our knowledge of the abundance and richness of local species (only addition of *D. albiventris*). This may too be a reflection of a low abundance of cursorial species in the community and the need to use larger size pitfall traps.

Most species of small mammals found in REBIO Santa Isabel have previously been recorded in the Atlantic Forest in Sergipe (according to Stevens & Husband 1998; Oliveira et al. 2005; Dias et al. 2017; Rocha et al. 2017). However, the echimyid rodent *Phyllomys blainvillii* (Jourdan, 1837) corresponds to an unpublished record for the state, extending the occurrence of the species previously recorded by Campos & Percequillo (2007) in the coastal region south of the São Francisco River. Recent studies indicate that the specimens identified as *P. blainvillii* on the north-eastern coast (and this may also be the



**Fig. 2.** Small mammal species recorded in the Reserva Biológica de Santa Isabel in Sergipe, north-eastern Brazil. A) *Marmosops incanus*; B) *Marmosa murina*; C) *Marmosa demerarae*; D) *Didelphis albiventris*; E) *Rhipidomys mastacalis* (juvenile); F) *Cerradomys vivoi*; G) *Calomys* sp.; H) *Oligoryzomys* sp.; I) *Phyllomys blainvillii*; J) bicolor tail of rodent *Trinomys* sp. in the Sherman trap.

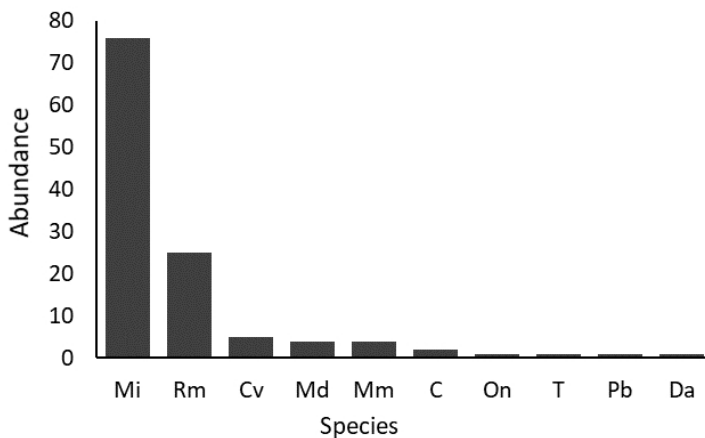
case for the REBIO Santa Isabel specimen) represent a species not yet described (Loss & Leite 2011; Patton et al. 2015; Machado et al. 2018), highlighting the importance of future studies of the mastofauna and its taxonomy in restinga environments of the region.

Observed species composition differed our study area and other areas of restinga in the Brazilian northeast; Campos et al. (2018) captures more species of marsupials in Paraíba while in the REBIO Santa Isabel more species of rodents were captured. In this context, the REBIO Santa Isabel survey corresponds to the second systematic study on small mammals in restinga environment in north-eastern Brazil. However, other differences in species composition were observed in relation to the restingas in the south-east and south. *Oligoryzomys nigripes* (Olfers, 1818), for example, is a dominant species in areas of arboreal restinga in the south (Quintela et al. 2012), but in the REBIO Santa Isabel we captured only one specimen of this genus. The generalist habit of this rodent may be reflected in its wide geographic distribution (Patton et al. 2015), but variations in the abundance of this species may be associated with different habitat characteristics, the presence of other generalist species as well as the period in which the study was carried out at REBIO.

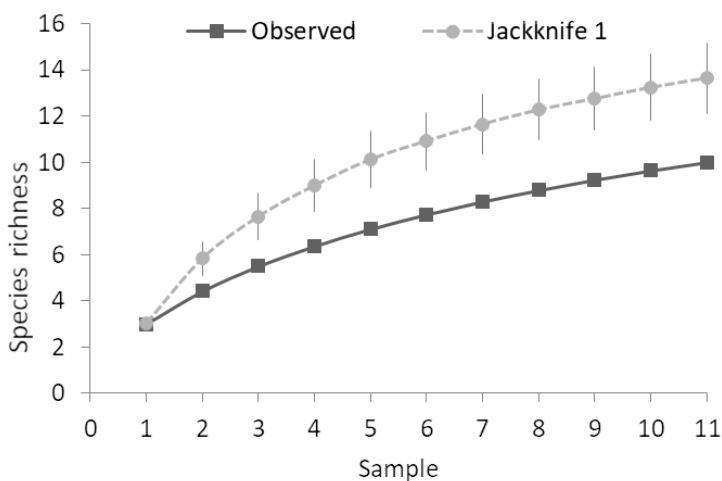
Neither *Cerradomys vivoi* (Percequillo et al. 2008), nor *P. blainvillii* is mentioned in studies on the mastofauna in south-eastern and southern restingas, suggesting a more restricted distribution to north-eastern restingas, according reports of this species at the mouth of the São Francisco River, in Sergipe, and in the coastal region of Bahia, north-eastern Brazil (Percequillo et al. 2008; Patton et al. 2015). The most abundant species in the REBIO Santa Isabel, *M. incanus* and *R. mastacalis*, however, have already been recorded in south-eastern restingas (Moreira & Mendes 2010), but there is no data on the abundance of these species in these environments.

As most of the species recorded in the present study present a distribution that includes the Sergipe Atlantic Forest (Stevens & Husband 1998; Oliveira et al. 2005; Rocha et al. 2017), these species seem to constitute a subset of those occurring in the nearby areas of Atlantic Forest (Cerqueira 2000; Pessôa et al. 2010; Campos et al. 2018) for other regions. In this context, connectivity between forests areas and the restinga of the Atlantic Forest seems to be relevant to the conservation of small mammal species (Campos et al. 2018). In addition, these ecosystems comprise an important area of the biome, since they present particular environmental conditions that can con-

**Fig. 3.** Abundance of small mammal species captured in Santa Isabel Biological Reserve, Sergipe, Brazil (total trapping effort = 9970 trap-nights). Mi) *Marmosops incanus*; Rm) *Rhipidomys mastacalis*; Cv) *Cerradomys vivoi*; Md) *Marmosa demerarae*; Mm) *Marmosa murina*; C) *Calomys* sp.; On) *Oligoryzomys nigripes*; T) *Trinomys* sp.; Pb) *Phyllomys blainvillii*; Da) *Didelphis albiventris*.



**Fig. 4.** Observation and rarefaction curves of small mammal species estimated by Jackknife 1 related to sampling effort (monthly sampling) in the Reserva Biológica de Santa Isabel, Sergipe, Brazil. The vertical bars represented the standard deviation.



tribute to the variability of the species in the region (Cerqueira 2000).

A structural dissimilarity between environments may reflect different patterns in the composition and abundance of small mammal species, as observed by Pardini (2004); Pardini et al. (2005), and Delciellos et al. (2015). In the case of the sites sampled in the present study, the vegetation structure is more similar to the altered forests, with a sparse canopy and border effect (personal obs.), than to the local vegetation of the Atlantic Forest, which is in more structured and complex. Differences regarding relative abundance of species between restinga formations and Atlantic Forest forests may be related, among other factors, to the structural differences between these environments (Araújo & Lacerda 1987; Oliveira & Landim 2014; Fundação SOS Mata Atlântica & INPE 2018). In this sense, approaches that consider long-term studies can contribute to the determination of factors related to variations in composition and species abundance.

The quality of the habitat, considered by Hall et al. (1997) as the ability of the environment to provide conditions for individual and population persistence, may be an important factor in the composition of small mammal species in the REBIO Santa Isabel. *Marmosops incanus*, the most abundant species in the REBIO Santa Isabel, is present in most areas of Sergipe's Atlantic Forest, but is not the most dominant in these other areas (Stevens & Husband 1998; Oliveira et al. 2005; Rocha et al. 2017; A. Bocchiglieri, pers. comm). Thus, the dominance of this species in the REBIO Santa Isabel area may reflect, in addition to local interspecific relations, its range of tolerance to habitat characteristics (Pardini et al. 2005; Bezerra & Geise 2015) and the specific conditions of period in that this study were realized.

The occurrence of both the marsupials *M. incanus* and *Marmosa murina* (Linnaeus, 1758), as well as the rodents *C. vivoi* and *R. mastacalis*, has been associated to varied environments, from mature Atlantic Forest to early regeneration forests, edge areas, and open areas (Stevens & Husband 1998; Pardini 2004; Pardini et al. 2005; Percequillo et al. 2008; Püttker et al. 2008; Bezerra & Geise 2015; Delciellos et al. 2015). Thus, a certain plasticity regarding requirements for habitat quality may favor the occupation of the restinga areas by these small mammal species.

## CONCLUSIONS

The composition of the community in general, including the relative abundance of the species, is a peculiar feature of the locality studied when com-

pared to other Atlantic Forest areas of the region, and also to other restinga areas along the Brazilian coast. Future studies that consider evaluate the factors related to variations in composition and species abundance will be important to understand the differences in this parameters between the areas. Habitat quality may be a relevant aspect in considering the occupation of these ecosystems. In addition, the richness recorded in REBIO Santa Isabel was higher than that of mastofauna surveys carried out in the Atlantic Forest areas in the state of Sergipe, highlighting the importance of this Conservation Unit for the group, especially the areas of arboreal physiognomy.

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## ONLINE SUPPLEMENTARY MATERIAL

### Supplement 1

**Table S1.** Small mammal species recorded in Sergipe, north-eastern Brazil. A1 - REBIO Santa Isabel, A2 - RPPN Caju, A3 - Mata do Crasto, A4- RVS Mata do Junco, A5 - Serra de Itabaiana, C1 - Serra da Guia, C2- MONA Grota do Angico, C3 - Porto da Folha, C4 - Nossa Senhora da Glória, C5 - Monte Alegre de Sergipe, C6 - Poço Redondo, C7 - Canindé de São Francisco. Letters correspond to information source. \* Identification reviewed with voucher deposited in the CMUFS.