**A SURVEY OF SMALL MAMMALS IN THE ATLANTIC FOREST OF NORTHWESTERN REGION OF THE RIO DE JANEIRO STATE**

**ABSTRACT**

Small mammals (marsupials and rodents) are one of the most diverse group in Atlantic Forest fauna, representing 40% of the total diversity of mammals in this biome. Some regions, such as the northwestern of Rio de Janeiro state, have gaps of mammal inventories; in this study, we performed small mammal inventories in four fragmented landscapes in northwest of Rio de Janeiro state using live-traps and camera traps. Capture transects were placed both in forest fragments and the altered matrix. We captured six species of marsupials, six Sigmodontinae rodents and one echimyid rodent. Small mammal fauna recorded in this study was composed predominantly of typical Atlantic Forest species, with four endemic species. Furthermore, we obtained the first record of *Calomys cerqueirai* in the Atlantic forest of Rio de Janeiro state as well as its syntopy with *C. tener*; the geographic distribution of both species was expanded.

**Keywords**: *Calomys*, Fragmented landscapes, Geographic distribution, Karyotype, Small mammal inventories..

Running title: Small mammals of Northwest Rio de Janeiro

**INTRODUCTION**

The Atlantic Forest is considered the world's fourth biodiversity hotspot (Myers *et al.* 2000). Deforestation has reduced the Atlantic Forest area to about 12.5% of its original extent, with 8.5% being represented by forest fragments of at least 100 hectares (SOS Mata Atlântica, 2014), and only 1.62% being represented by protected areas (Rocha *et al.* 2003; Bergallo *et al.* 2009). In northwestern of Rio de Janeiro, forest remnants cover only 5.65% (SOS Mata Atlântica, 2014).

Small mammals (marsupials and rodents) are one of the most diverse ecological groups of Atlantic Forest mammals (Reis *et al.* 2011; Paglia *et al.* 2012). The Order Rodentia represents 32% of mammals of this biome (98 species), while Didelphimorphia represents 7.3% (22 species) (Paglia *et al.* 2012). Several studies of small mammals were carried out in the Atlantic Forest of Rio de Janeiro, but little information is available about the northwestern region of the state (Albuquerque *et al.* 2013), a region with few protected areas.

The scarcity of information regarding small mammals occurrence in northwest of Rio de Janeiro is a problem for defining species distribution and the conservation status of remaining forest fragments (Bergallo *et al.* 2009). In this context, four municipalities were surveyed in northwestern of the state resulting in a list of small mammal species with comments on geographical distribution and habitat association.

**MATERIAL AND METHODS**

*Study area*

Surveys were performed in four municipalities in northwestern of Rio de Janeiro state: (1) Cambuci, 21°29'10.06"S, 41°51'31.40"W, (2) Miracema, 21°21'11.39"S, 42°12'57.93"W, (3) Itaperuna, 21°05'33.48"S, 42°07'3.82"W, and (4) Varre-Sai, 20°53'1.13"S, 41°49'48.01"W (Figure 1). These municipalities are located the north-northwest domain (Cambuci, Miracema and Itaperuna) and in the plateau of Itabapoana river (Varre-Sai). The climate in the north-northwest domain is dry tropical (*Aw,* Köppen (1948). The annual average temperature varies between 23° and 25°C, and average rainfall between 1000 to 1200 mm/year. This domain has 4 to 6 dry months, during which average rainfall is below 60 mm (Dantas *et al.* 2001; Lumbreras *et al.*, 2004). The climate in the plateau of Itabapoana river is subtropical and humid (*Cwa*, Köppen, 1948), and the annual average temperature varies from 19 to 22°C, with slightly higher rainfall (1400mm/year) and 3 to 5 dry months with annual water deficit below 60mm (Dantas *et al.* 2001; Lumbreras *et al.* 2003; 2004).

These areas are characterized by fragmented landscapes of secondary seasonal semi-deciduous forest formations in medium and advanced stages of regeneration, and a highly disturbed matrix composed mainly of shrub vegetation close to the forest edges and pastures as a consequence of cattle raising activities and fires (Carvalho et al. 2000; Albuquerque et al. 2013; SOS Mata Atlântica, 2014). Sampled fragments varied from XXX to YYY ha.There were also watercourses crossing pastures and forest areas in Varre-Sai and Miracema study areas. Vof the studied areas varied from to ;t (Riski et al 2015)

*Data collection*

We used 234 live-traps in each municipality, with 117 Sherman (7.62 x 9.53 x 30.48cm) and 117 Tomahawk (40.64 x 12.70 x 12.70 cm) allocated in seven transects placed at least 500 m apart from each other. Each transect was composed of 15 capture stations placed 20 meters apart from one another. Four of these transects were placed in forest fragments and three on the altered matrix (pasture). In every capture station, we placed one Sherman and one Tomahawk live-trap on the ground; in addition, in up to six of the trapping stations of each transect located in forest fragments, we placed six traps (three Sherman and three Tomahawk) in the understory (1-2 meters high). Two surveys were performed in each municipality, one in the dry season (April to August 2013) and another in the rainy season (October 2013 to March 2014). Each survey lasted five nights, resulting in a total sampling effort of 2340 traps nights per locality. The bait used was a mixture of bacon, oatmeal, banana and peanut butter.

Captured small mammals were identified by morphology (Costa *et al.* 2003; Gonçalves & Oliveira 2004; Voss & Jansa 2009; Pessôa *et al*. 2015) and five of them also by karyotype. Cells suspensions were obtained in the field with short-term bone marrow culture following Bonvicino (2011). Specimens were captured, anesthetized, and euthanized following protocols approved by the FIOCRUZ Committees of Bioethics (License number LW-81/12).

In addition to live-traps, we placed ten camera traps model Scoutguard SG560C White-led in each locality between August 2013 and October 2014. Camera-traps were used for sampling medium to large-sized mammals as part of another study, but as it also recorded the presence of some species of small mammals, the data were used in our analysis. The cameras were placed inside forest fragments (7 to 9 cameras) and in the altered matrix (1 to 3 cameras), and were at least 500m apart from each other. Cameras were baited with bacon, banana, avocado, corn, salt and bobcat urine (*Lynx rufus*) when set (day 1) and remained active for 30 days in the dry season and 30 days in the wet season. Once triggered, cameras would take a picture every 5 seconds so that we could obtain several photographs from each animal, thereby facilitating species identification.

All individuals were collected/photographed upon license of capture (ICMBIO#13373-1) and deposited in the mammal collections of Museu Nacional, Universidade Federal do Rio de Janeiro and of Laboratory of Biology and Parasitology of Wild Reservoirs Mammals (LABPMR/IOC/Fiocruz).

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**Figure 1.** Study areas in northwestern state of Rio de Janeiro. Black dots = sample sites. Gray shaded areas represent the municipalities sampled.

**RESULTS**

With a total sampling efforts of 9360 trap-nights (2340 per locality) we obtained thirteen non-volant small mammal species (Table 1), six marsupials (Didelphimorphia, Didelphidae), six Sigmodontine (Rodentia, Cricetidae), and one echimyid (Rodentia, Echimyidae). The most frequent species were the rodent *Akodon cursor* (69 specimens), followed by the marsupial *Didelphis aurita* (47 specimens). Both species as well as *Nectomys squamipes* occurred inside fragments and in the altered matrix; however, *N. squamipes* was captured only close to watercourses. Six species occurred only in forest fragments: the marsupials *Marmosops incanus*, *Marmosa* (*Micoureus*) *paraguayana*, *Philander frenatus*, *Gracilinanus microtarsus*, and the rodents *Oxymycterus dasytrichus* and *Trinomys setosus*; whereas four other species occurred only in altered matrix, the rodents *Calomys cerqueirai*, *Calomys tener*, *Oligoryzomys nigripes* (all of them only in pasture) and the marsupial *Metachirus nudicaudatus* (in shrub vegetation).

We recorded three marsupials (*M. nudicaudatus*, *Marmosops* sp.. and *P. frenatus*), three sigmodontinae rodents (*Akodon* sp., *N. squamipes* and *Oligoryzomys* sp.) and one echimyid rodent (*Trinomys* sp.) with camera traps (Figure 2). The use of camera traps did not increase the overall species richness of small terrestrial mammals, but it added *M. nudicaudatus* and *P. frenatus* in three localities. All obtained karyotypes were already described (Figure 3).

**Table 1.** Records of non-volant small mammal species in four localities of north western of Rio de Janeiro state. CT = record (presence) obtained with camera trap. All the remaining records were obtained with live-traps.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Species** | **Cambuci** | **Itaperuna** | **Miracema** | **Varre-Sai** |
| **Family Didelphidae Subfamily Didelphinae** |  |  |  |  |
| *Didelphis aurita* | 9 | 7 | 10 | 21 |
| *Gracilinanus microtarsus* | 1 |  |  |  |
| *Metachirus nudicaudatus* | CT |  | 1 |  |
| *Marmosops incanus* | 6 | 2 | 3 | 9 |
| *Marmosa paraguayana* | 1 |  | 1 |  |
| *Philander frenatus* |  | CT | CT | 2 |
| **Family Cricetidae**  **Subfamily Sigmodontinae** |  |  |  |  |
| *Akodon cursor* | 10 |  | 12 | 23 |
| *Calomys cerqueirai* | 1 | 1 |  | 3 |
| *Calomys tener* | 1 |  | 1 | 1 |
| *Nectomys squamipes* | 1 |  | 3 | 22 |
| *Oligoryzomys nigripes* |  |  | 1 | 1 |
| *Oxymycterus dasytrichus* |  |  |  | 2 |
| **Family Echimyidae: Subfamily Echimyinae** |  |  |  |  |
| *Trinomys setosus* | 5 |  |  |  |
| Abundance | 35 | 10 | 32 | 84 |
| Richness | 10 | 4 | 9 | 9 |
| Trap capture success | 1.5% | 0.4% | 1.35% | 3.6% |

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**Figure 2**. Species of non-volant small mammal recorded by camera traps: A) *Akodon* sp.; *Oligoryzomys* sp.; C) *N. squamipes*; D)  *Trinomys* sp.; E) *P. frenatus*; F) *M. nudicaudatus* and G) *Marmosops* sp.

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**Figure 3.** Karyotypes of (A) *Oligoryzomys nigripes* 2n=62 and NFa=81, male LBCE18146 from Miracema; (B) *Calomys tener* 2n=66 and NFa=66, female LBCE18147 from Miracema; (C) *Calomys cerqueirai* 2n=36 and NFa=66, male LBCE18067 from Varre-Sai; (D) *Nectomys squamipes* 2n=56 and NFa=56, male LBCE13349 from Varre-Sai; (E) *Akodon cursor* 2n=14 and NFa=18, male LBCE13318 from Varre-Sai.

**DISCUSSION**

All marsupial species captured in the northwestern region of Rio de Janeiro are considered common in the Atlantic Forest of the state (Olifiers, 2002; Vieira *et al.* 2009; Feliciano *et al.* 2002; Pires *et al.* 2002). *Philander frenatus* and *M. nudicaudatus*, mainly terrestrial species, are marsupials commonly observed in fragmented landscapes (Pinto *et al.* 2009; Vieira *et al.* 2009). Even the species with arboreal habits and supposedly relatively more susceptible to deforestation, such as *M. incanus*, *M. (M.) paraguayana* and *G. microtarsus,* have frequently been observed in small forest fragments (Olifiers, 2002; Castro & Fernandez, 2004; Pardini *et al.* 2005; Vaz *et al.* 2007). The low capture success of these marsupials as well as rodent species in this study may be a consequence of the high habitat disturbance caused mainly by forest fragmentation in the study areas (Lumbreras *et al.*, 2004; SOS Mata Atlântica, 2013).

*Akodon cursor*, the most captured species in this study, is often the most abundant rodent in fragmented landscapes of the Atlantic Forest (Stallings, 1988; Paglia *et al.* 1995; Gentile, 1996; Olifiers, 2002). This species has generalist habits and is tolerant to human disturbance and is indeed very common in open areas(Pires *et al.* 2002; Olifiers, 2002).

*Calomys cerqueirai* has few records since it was first described (Bonvicino et al., 2010). Herein, this is the first record of *C. cerquerai* in Rio de Janeiro state and the fourth to sixth record in the Atlantic forest biome. This species occurs in the state of Minas Gerais, in Capitão Andrade (type locality), Lagoa Santa, and Lavras (Bonvicino *et al.* 2010; Mesquita & Passamani, 2012). Recently, it was also found in Nova Venécia (Espirito Santo state), which is 140 km northeast away from its type locality (Colombi & Fagundes, 2014). Records of this species obtained in this study (in Varre-Sai, Cambuci and Itaperuna) are about 220 km away from the type locality of Capitão Andrade, thereby increasing the species distribution toward southeast. This rodent inhabits Atlantic Forest and seasonal forest in the transition areas between this biome and Cerrado (Bonvicino *et al.* 2010); however, in this study, it was found in very disturbed vegetation (pasture grassland near patches of secondary vegetation), as also reported in the state of Espírito Santo (Colombi & Fagundes, 2014).

*Calomys tener* occurs mainly in Brazilian Cerrado, but also in transitional areas with Atlantic Forest (Almeida *et al.* 2007) in Bahia, Mato Grosso, Minas Gerais, Rio Grande do Sul, São Paulo, and Tocantins states (Patton *et al.* 2015). In this study, we captured *C. tener*in the municipalities of Varre-sai and Cambuci. Recently *C. tener* was also recorded in two additional areas of the Rio de Janeiro state: one in the coast and another in Comendador Levy Gasparian municipality, nearby the borderland with the state of Minas Gerais (Lemos *et al.* 2015). The distribution of this species in the state is, therefore, poorly known. *Calomys tener* and *C. expulsus* are sympatric in Cerrado, whereas *C. cerqueirai* inhabits semi deciduous forest of the Atlantic Forest (Almeida *et al*. 2007). Here, the syntopy between *C. tener* and *C. cerqueirai* is recorded for the first time in the Atlantic Forest of Rio de Janeiro, and the geographic distribution of both species was expanded (Figures 4 and 5).

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**Figure 4**. Collected localities of *Calomys cerqueirai* : Minas Gerais state: 1- Capitão Andrade , type locality , 2 - Lagoa Santa (Geise et al. 1996), 3- Lavras (Passamani et al 2012) , Espírito Santo state: 4- Nova Venécia (Colombi et al 2014), Rio de Janeiro state (this study): 5- Cambuci, 6- Raposo, 7-Varre-sai.

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**Figure 5.** Geographical distribution (modified from Patton et al. 2015) and recent records of *Calomys tener*. Minas Gerais state: 1- Lagoa Santa, type locality, Winge, 1887, 2 - Comendador Levy Gasparian (Lemos et al. 2015), Rio de Janeiro state: 3- Restinga in Macaé (record of owl pellets, Lemos et al . 2015), 4 - Miracema (this study), 5- Varre-sai (this study).

*Oxymycterus* is a semi-fossorial rodent which occurs in forest borders and open areas (Reis *et al.* 2011); however, in this study, *O. dasytrichus* was captured only in forest fragments of Varre-Sai. It is the only of the six captured Sigmodontinae species that is endemic of Atlantic forest, the other five occurring in Cerrado or in transitional areas between Cerrado and Atlantic forest (Bonvicino *et al.* 2008; Paglia *et al.* 2012).

*Trinomys setosus* is a terrestrial, mainly frugivorous rodent, but that also feeds on seeds and invertebrates (Pessôa *et al.* 2015). The occurrence of *T. setosus* in northwestern state of Rio de Janeiro was already known from Cambuci (Attias *et al.* 2009; Albuquerque *et al.* 2013). The last compilation of rodents considered the existence of two *T. setosus* subspecies: *T. s. setosus* from the states of Sergipe, Bahia and Espírito Santo and characterized by a karyotype of 2n = 56 and FN = 108; and *T. s. elegans* from the states of Minas Gerais and Rio de Janeiro and characterized by a karyotype of 2n = 56 and FN = 104 (Patton *et al.* 2015; Correa *et al.*. 2005). Like anterior studies in northeast of Rio de Janeiro state, it was not possible to karyotype the collected specimens. The cytochrome b sequences of the two captured specimens were obtained, but however there are not sequences of *T. setosus* subspecies with this marker deposited in the sequence bank, and the identification at the subspecies level was therefore not possible.

Small mammal fauna recorded in this study was predominantly composed of typical Atlantic Forest species (Rocha et al. 2004; Paglia et al. 2012), with four endemic species, the marsupials *D. aurita* and *G. microtarsus*, and the rodents *O. dasytrichus* and *Trinomys setosus* (Paglia et al. 2012). Otherwise, five rodent species recorded are distributed in transitional areas of Cerrado and Atlantic Forest.Moreover, the knowledge of small mammal species obtained from this region also provided important biogeographical information, given that the distribution of two species was expanded. Finally, since the use of camera traps increased local species richness, we recommend using such kind of data in small mammal surveys whenever available, especially for recording marsupials.

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