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

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ABSTRACT

Small mammals (marsupials and rodents) are one of the most diverse groups of Atlantic Forest mammals, representing 40% of the total diversity of mammals in this biome. Some regions, such as northwestern Rio de Janeiro State, have gaps in mammal inventories. Therefore, we performed small mammal inventories in four fragmented landscapes in the northwestern 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. The 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.* These findings expand the reported geographic distribution of both species.

Keywords: *Calomys*; fragmentation; geographic distribution; karyotype; small mammal inventories.

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 (Fundação SOS Mata Atlântica & INPE 2015), and only 1.6% consisting of protected areas (Rocha *et al.* 2003, Bergallo *et al.* 2009). In northwestern Rio de Janeiro State, forest remnants cover only 5.7% of the region (Fundação SOS Mata Atlântica & INPE 2015).

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 accounts for 32% of mammals in this biome (98 species), while Didelphimorphia represents 7.3% (22 species) (Paglia *et al.* 2012). Several studies of small mammals have been carried out in the Atlantic Forest of Rio de Janeiro State, but little information is available about the state's northwestern region (Albuquerque *et al.* 2013), where there are few protected areas (Bergallo *et al.* 2009).

The scarcity of information regarding small mammal occurrence in northwestern Rio de Janeiro is a problem for efforts to define species distribution and the conservation status of remaining forest fragments (Bergallo *et al.* 2009). In this context, four municipalities were surveyed in northwestern Rio de Janeiro, 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 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-northwestern domain (Cambuci, Miracema and Itaperuna) and in the plateau of the Itabapoana River (Varre-Sai). The climate in the north-northwest domain is dry tropical (*Aw;* Koeppen 1948). The annual average temperature varies between 23 and 25°C, and average rainfall ranges from 1,000 to 1,200 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 Itabapoana River plateau is subtropical and humid (*Cwa*; Koeppen 1948), and the annual average temperature varies from 19 to 22 °C, with slightly higher rainfall (1,400 mm/year) and 3 to 5 dry months with average rainfall below 60 mm (Dantas *et al.* 2001, Lumbreras *et al.* 2003, 2004).

The studied 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 and pastures resulting from cattle raising activities and fires (Carvalho *et al.* 2000, Albuquerque *et al.* 2013, Fundação SOS Mata Atlântica & INPE 2015). The vegetation cover of the studied areas varied from 18 to 26%; the area with greatest vegetation cover was Miracema (approximately 26%), followed by Itaperuna (19%) and, Varre-sai and Cambuci, both with approximately 18% (Riski *et al.* 2015). Sampled fragments varied from 2.95 to 1,776 ha.

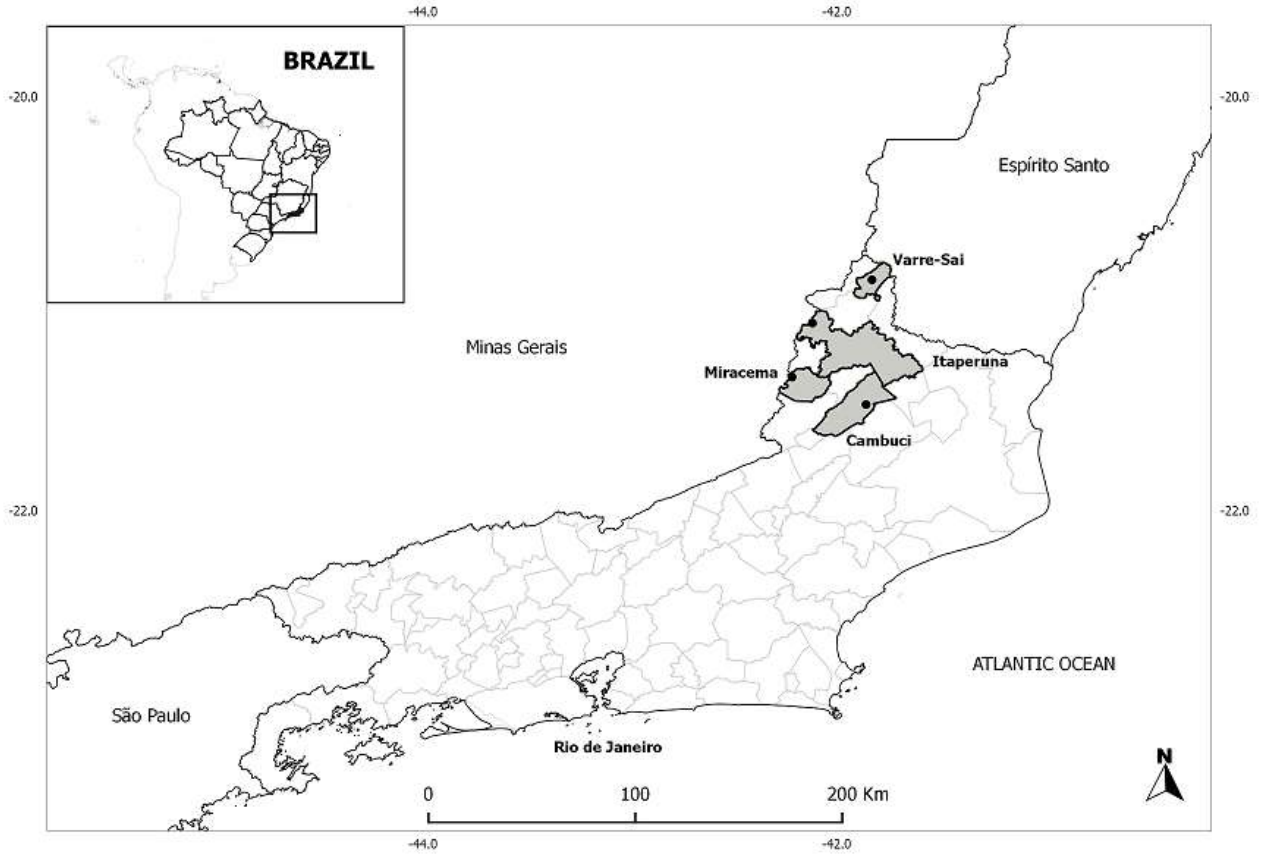

Figure 1. Study areas in northwestern Rio de Janeiro State, Brazil. Black dots=sampled sites. Gray shaded areas represent the municipalities sampled.

Data collection

We used 234 live traps in each municipality, with 117 Sherman traps (7.62 x 9.53 x 30.48 cm) and 117 Tomahawk traps (40.64 x 12.70 x 12.70 cm) allocated in seven transects placed at least 500 m apart. Each transect was composed of 15 capture stations placed 20 m apart. Four of these transects were placed in forest fragments and three in the altered matrix (pasture). At each capture station, we placed one Sherman and one Tomahawk live trap on the ground; in addition, while at 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 consecutive nights, resulting in a total sampling effort of 2,340 trap-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. Cell 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 Committee on Bioethics (License number LW-81/12).

In addition to live traps, we placed ten camera traps (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 since they 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. 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 both the dry and wet seasons. Once triggered by heat and motion, the cameras took a picture every 5 seconds, obtaining several photographs of each animal, thereby facilitating species identification.

All individuals were collected/photographed under a capture license (ICMBIO#13373-1) and deposited in the mammal collections of the National Museum, Rio de Janeiro Federal University and Laboratory for Biology and Parasitology of Small Wild Mammal Reservoirs (LABPMR/IOC/Fiocruz).

RESULTS

With a total sampling effort of 9,360 trap-nights (2,340 per locality) we obtained 13 non-volant small mammal species (Table 1), six marsupials (Didelphimorphia, Didelphidae), six Sigmodontine rodents (Rodentia, Cricetidae), and one echimyid rodent (Rodentia, Echimyidae). The most frequent species was 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 matrices: the rodents *Calomys cerqueirai*, *Calomys tener*, *Oligoryzomys nigripes* (all of them captured only in pasture) and the marsupial *Metachirus nudicaudatus* (captured in shrub vegetation). *Calomys tener* and *C. cerqueirai* occurred in syntopy and the geographic distribution of both species was expanded (Figures 2 and 3).

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 4). All obtained karyotypes have already been described (Figure 5). We found *Oligoryzomys nigripes* with 2n=62 and NFa=81 (Bonvicino *et al*. 2001), *Calomys tener* with 2n=66 and NFa=66 (Bonvicino & Almeida 2000), *Calomys cerqueirai* with 2n=36 and NFa=66 (Bonvicino *et al.* 2010), *Nectomys squamipes* with 2n=56 and NFa=56 (Bonvicino 1994) and *Akodon cursor* with 2n=14 and NFa=18 (Cerqueira *et al.* 1993).

Table 1. Records of non-volant small mammal species in four localities of northwestern Rio de Janeiro State, Brazil. 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%	1.4%	3.6%

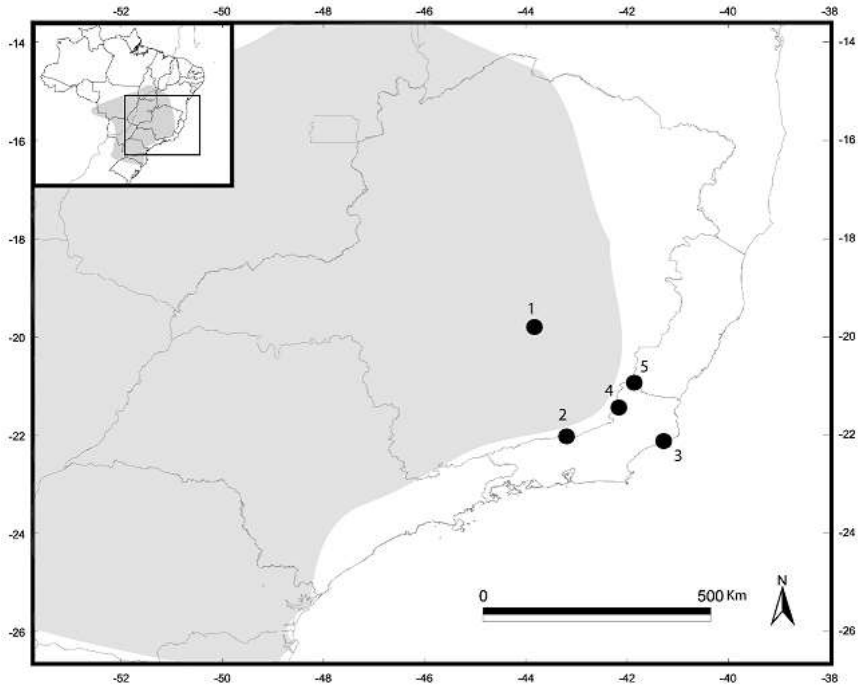

Figure 2. Geographical distribution (gray area; modified from Patton *et al.* 2015) and recent records of *Calomys tener*. Minas Gerais state: 1-Lagoa Santa, type locality 2-Comendador Levy Gasparian (Lemos *et al.* 2015); Rio de Janeiro State: 3-Restinga in Macaé (record of owl pellets, Lemos *et al*.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

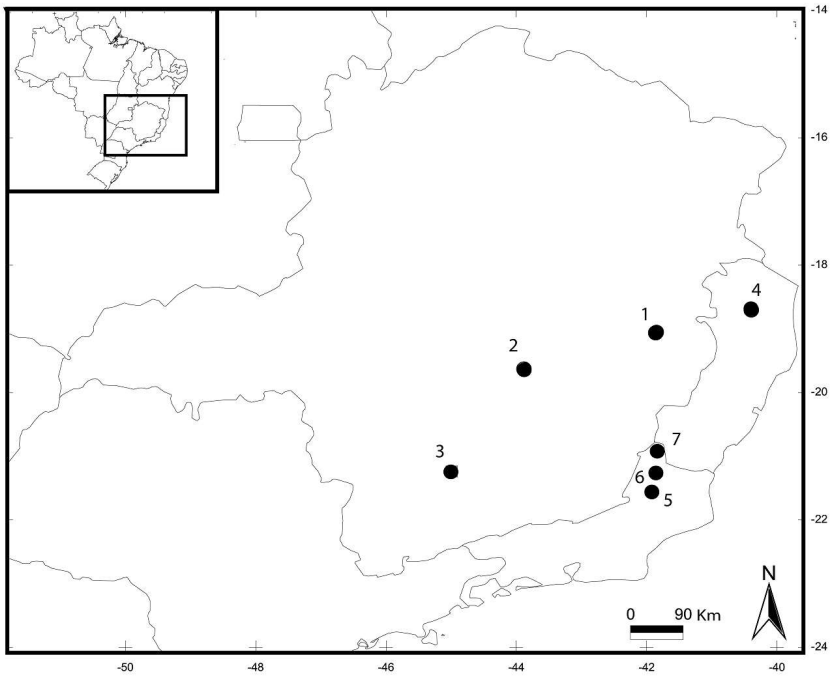

Figure 3. Sampled localities for *Calomys cerqueirai*: Minas Gerais State: 1-Capitão Andrade, type locality, 2-Lagoa Santa (Geise *et al.* 1996), 3-Lavras (Mesquita & Passamani 2012); Espírito Santo State: 4-Nova Venécia (Colombi & Fagundes 2015); Rio de Janeiro State (this study): 5-Cambuci, 6-Raposo, 7-Varre-sai.

DISCUSSION

All marsupial species captured in the northwestern region of Rio de Janeiro State are considered common in the Atlantic Forest areas in the state (Olifiers 2002, Feliciano *et al.* 2002, Pires *et al.* 2002, Vieira *et al.* 2009). *Philander frenatus* and *M. nudicaudatus* are mainly terrestrial marsupials, commonly observed in fragmented landscapes (Pinto *et al.* 2009, Vieira *et al.* 2009). Even species with arboreal habits, and thus 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, Fundação SOS Mata Atlântica & INPE 2015). *Akodon cursor*, the most common 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, being very common in open areas (Pires *et al.* 2002, Olifiers 2002, Geise 2012).

Calomys cerqueirai has few records since it was first described (Bonvicino *et al.* 2010). Our observation 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 from its type locality (Colombi & Fagundes 2015). 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 reported species distribution toward the southeast. This rodent inhabits Atlantic Forest and seasonal forest areas in the transition between this biome and the Cerrado (Bonvicino *et al.* 2010). However, in this study we found it in very disturbed vegetation (pasture grassland near patches of secondary vegetation), as also reported in Espírito Santo (Colombi & Fagundes 2015).

Figure 4. Species of non-volant small mammals recorded by camera traps in northwestern Rio de Janeiro State, Brazil: a) *Akodon* sp.; b) *Oligoryzomys* sp.; c) *Nectomys squamipes*; d) *Trinomys* sp.; e) *Philander frenatus*; f) *Metachirus Nudicaudatus*, and g) *Marmosops* sp.

Calomys tener occurs mainly in the Brazilian Cerrado, but also in transitional areas with Atlantic Forest (Almeida *et al.* 2007) in the states of Bahia, Mato Grosso, Minas Gerais, Rio Grande do Sul, São Paulo and Tocantins (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 Rio de Janeiro State: one near the coast and another in Comendador Levy Gasparian municipality, near the border with the Minas Gerais (Lemos *et al.* 2015). The distribution of this species in Rio de Janeiro is therefore poorly known. *Calomys tener* and *C. expulsus* are sympatric in Cerrado, whereas *C. cerqueirai* inhabits semideciduous forest patches 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. *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 one of the six captured Sigmodontinae species that is endemic to the 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).

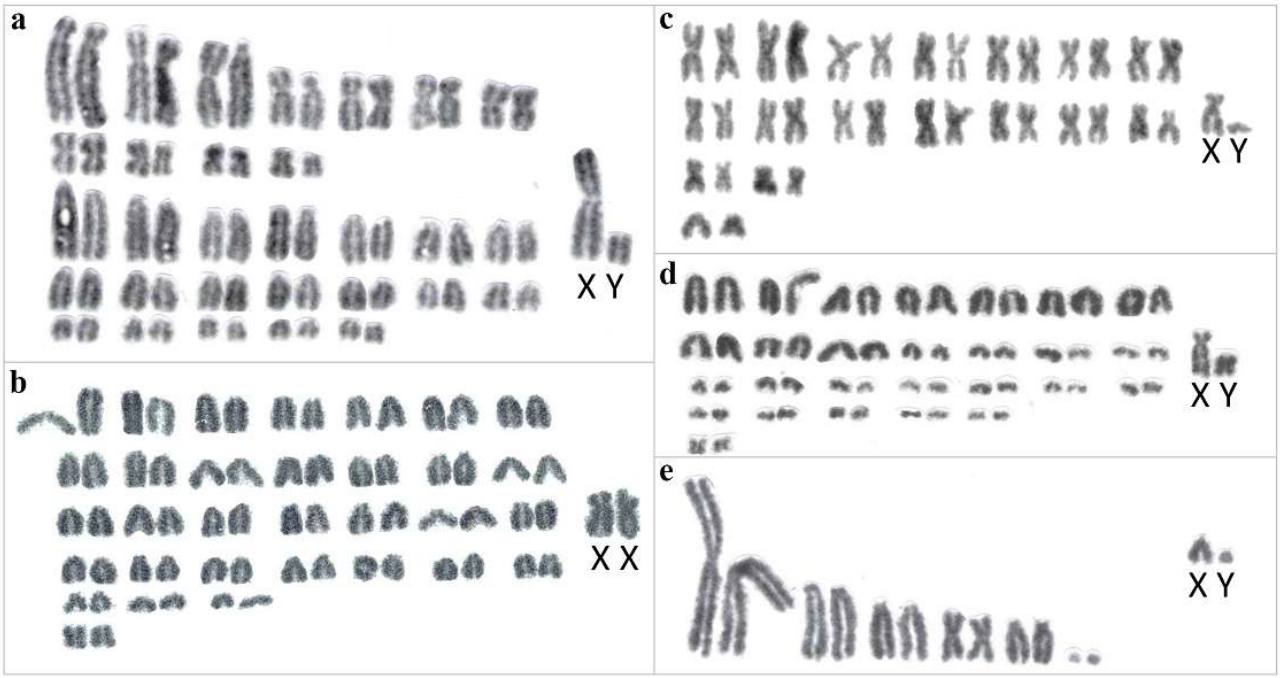

Figure 5. Karyotypes of a) *Oligoryzomys nigripes* 2n=62 and NFa=81, male LBCE18146 from Miracema; b) *Calomys tener* 2n=66 and NFa=66, female LBCE18147 from Miracema; c) *Calomys cerqueirai* 2n=36 and NFa=66, male LBCE18067 from Varre-Sai; d) *Nectomys squamipes* 2n=56 and NFa=56, male LBCE13349 from Varre-Sai; e) *Akodon cursor* 2n=14 and NFa=18, male LBCE13318 from Varre-Sai.

Trinomys setosus is a terrestrial, mainly frugivorous, rodent that also feeds on seeds and invertebrates (Pessôa *et al.* 2015). The occurrence of *T. setosus* in northwestern Rio de Janeiro has already been reported in 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, characterized by a karyotype of 2n=56 and FN=108; and *T. s. elegans* from the states of Minas Gerais and Rio de Janeiro, characterized by a karyotype of 2n=56 and FN=104 (Patton *et al.* 2015, Corrêa *et al.* 2005). Like previous studies in northeastern Rio de Janeiro, it was not possible to karyotype the collected specimens. The cytochrome b sequences of the two captured specimens were obtained, but there are no sequences of *T. setosus* subspecies with this marker deposited in the sequence bank, so the identification at the subspecies level was not possible.

The 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 *T. setosus* (Paglia *et al.* 2012). Moreover, five rodent species recorded are distributed in transitional areas of Cerrado and Atlantic Forest. The knowledge of small mammal species obtained from this region also provides important biogeographical information, given that the reported distribution of two species was expanded. 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 some localities. Since the use of camera traps increased local species richness, we recommend using this type of sampling in small mammal surveys whenever available, especially for recording marsupials.

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