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Non-Volant mammals of a remnant of the Atlantic Forest in northeastern Brazil

Mamíferos não voadores em remanescente de Mata Atlântica no Nordeste do Brasil

Patrício Adriano da Rocha[1]
parocha2@yahoo.com.br

Raone Beltrão-Mendes[1]
raonebm@yahoo.com.br

Juan Ruiz-Esparza[2]
juancolorado21@hotmail.com

Mônica Alves Cunha
monicaalves92@hotmail.com

Caroline dos Santos Silva[3]
carolinesilva.bio@gmail.com

Stephen Francis Ferrari[3]
ferraricesad@gmail.com

Abstract

Home of several endemic species, the Brazilian Atlantic Forest has been reduced to about 11-16% of its original area, and is currently considered to be one of the hotspots of global conservation. In the northeastern Brazilian state of Sergipe, the 900-hectare Mata do Junco Wildlife Refuge was established in order to protect the regional fauna and flora. Mammals were surveyed in the Refuge on three days per month between June, 2011, and May, 2012, using a combination of sample methods. A total of 16 species representing 12 families were recorded, with the order Carnivora being the most common (seven species). Whereas three didelphimorph species were trapped, only one exotic rodent – *Rattus norvegicus* – was captured. Comparisons with surveys from other Atlantic Forest sites indicate an intermediate species richness in Mata do Junco Wildlife Refuge and similar to that of other sites in the northern portion of the biome.

Keywords: mammalian diversity, species richness, protected areas.

Resumo

Habitat de inúmeras espécies endêmicas, a Mata Atlântica brasileira foi reduzida a cerca de 11-16% de sua área original, sendo considerada atualmente como uma das áreas prioritárias para a conservação no planeta. No estado de Sergipe, Nordeste do Brasil, o Refúgio de Vida Silvestre da Mata do Junco, com 900 hectares, foi estabelecido para proteger a fauna e a flora locais. Os mamíferos do Refúgio foram amostrados durante três dias por mês, entre junho de 2011 e maio de 2012, utilizando uma combinação de métodos amostrais. Foram registradas 16 espécies de mamíferos, pertencentes a 12 famílias, sendo Carnivora a ordem mais comum (sete espécies). Enquanto foram capturadas três espécies de Didelphimorphia, apenas uma espécie exótica de Rodentia – *Rattus norvegicus* – foi capturada. Em comparação com resultados de inventários em outras áreas de Mata Atlântica, a diversidade de mamíferos é considerada intermediária no Refúgio de Vida Silvestre da Mata do Junco, sendo similar à de outros estudos em áreas de Mata Atlântica no Nordeste do Brasil.

Palavras-chave: diversidade de mamíferos, riqueza de espécies, áreas protegidas.

[1] Universidade Federal da Paraíba, Programa de Pós-Graduação em Ciências Biológicas - Zoologia. Cidade Universitária, Castelo Branco III, 58051-900, João Pessoa, PB, Brazil.
[2] Universidade Federal de Sergipe, Núcleo de Educação em Ciências Agrárias e da Terra. Rodovia Engenheiro Jorge Neto, km 3, Centro, 49680-000, Nossa Senhora da Gloria, SE, Brazil.
[3] Universidade Federal do Sergipe, Programa de Pós-Graduação em Ecologia e Conservação. Av. Marechal Rondon, s/n, Rosa Elze, 49100-000, São Cristóvão, SE, Brazil.

Introduction

The Brazilian Atlantic Forest is considered a hotspot for biodiversity conservation (Myers *et al.*, 2000; Fisher and Christopher, 2007) due to its species richness, endemism and habitat loss. Recent estimates indicate between 11.4% and 16% of forest remaining, from the original forest cover, mostly in relatively small fragments (Ribeiro *et al.*, 2009). In Brazil, the Atlantic Forest is the second richest biome in terms of mammalian diversity, after the Amazon basin, and around 30% of its species are endemic (Paglia *et al.*, 2012). About 15% of the 732 mammal species found in Brazil are considered to be under some threat of extinction (Chiarello *et al.*, 2008; Paglia *et al.*, 2012; MMA, 2017), of which more than a third are found in the Atlantic Forest (MMA, 2014).

While the Atlantic Forest coincides with the most densely-populated region of Brazil, surprisingly few systematic inventories of its non volant mammalian communities have been conducted, and the vast majority of studies undertaken over the past thirty years have focused on sites in the southern half of the biome. The non volant mammalian faunas recorded at these sites have varied considerably in richness, ranging from nine species (Oliveira *et al.*, 2005; Pardini and Umetsu, 2006) to 56 (Modesto *et al.*, 2008a).

Very few inventories are available for the northern half of the biome (Stevens and Husband, 1998; Oliveira *et al.*, 2005; Percequillo *et al.*, 2007; Silva and Mendes-Pontes, 2008; Chagas *et al.*, 2010; Feijó *et al.*, 2016; Table 1), and one of the primary aims of the present study is to redress this imbalance, especially given the potential importance of regional variation in the composition of the mammalian fauna for the conservation and management of the biome (Beisiegel, 2010). The present study reports a survey of the mammal species of the Mata do Junco Wildlife Refuge, in the northeastern Brazilian state of Sergipe.

Materials and methods

Study site

The Mata do Junco Wildlife Refuge (RVS Mata do Junco; RVSMJ) covers a total area of approximately 900 hectares, in the municipality of Capela (Figure 1), state of Sergipe, northeastern Brazil (10º 32' S, 37º 03' W; 10º 34' S, 37º 00' W). One of the aims to the establishment of the

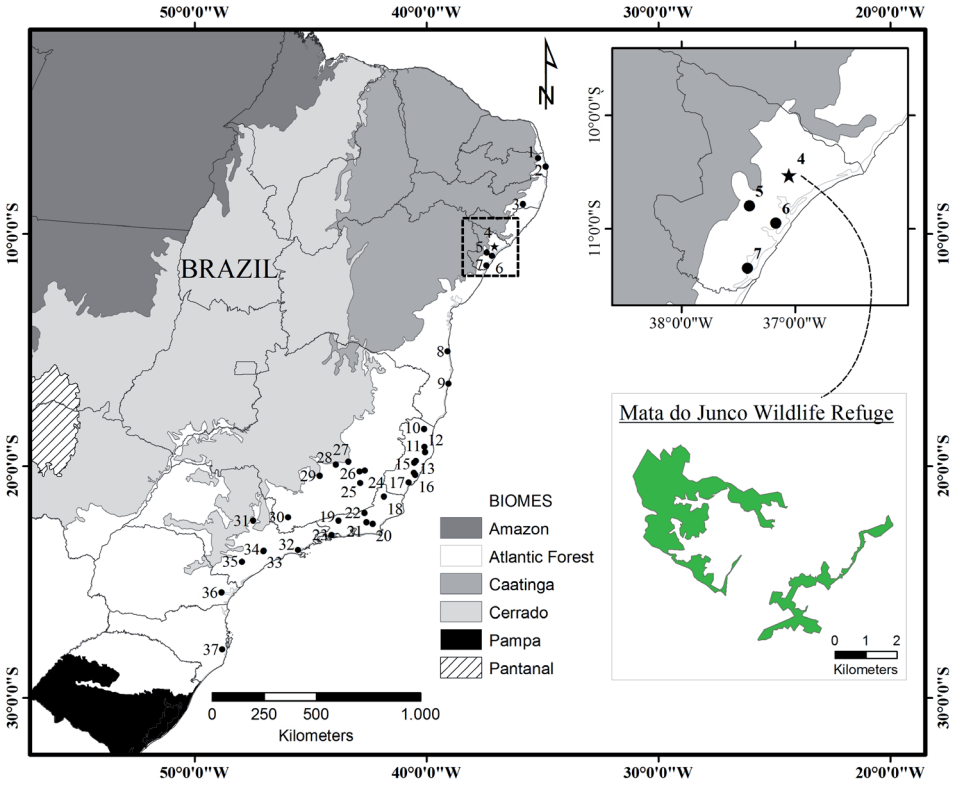

Figure 1. Location of the Mata do Junco Wildlife Refuge in Capela, in the northeastern Brazilian state of Sergipe. The numbered points represent other sites with inventories of mammals in the Atlantic Forest (see Table 1 for localities). The Mata do Junco Wildlife Refuge is the green detail (bottom right).

Table 1. Localities with inventories of mammals in the Atlantic Rainforest. The codes represent the sites in the Figure 1.

Brazilian State	Code	Coordinates	Site	References
Paraíba	1	6°43's35°11'w	Reserva Biológica Guaribas - Mamanguape	Feijó *et al.*, 2016
	2	7º6's 34º51' w	Mata do buraquinho - João Pessoa	Percequillo *et al.*, 2007
Pernambuco	3	8º43's 35º50'w	Forested Remnants of Frei Caneca	Silva and Mendes-Pontes, 2008
	4	10º32's 37º3'w	Refúgio de Vida Silvestre Mata do Junco - Capela	**Present study**
Sergipe	5	10º48's 37º24'w	Parque Nacional Serra de Itabaiana - Itabaiana	Oliveira *et al.*, 2005
	6	10º57's 37º10'w	Fazenda Trapsa - Itaporanga	Chagas *et al.*, 2010
	7	11º21's 37º25'w	Fazenda Crasto - Estância	Stevens and Husband, 1998
Bahia	8	15º4'-15º14's 39º5'-39º22'w	Cacao-Growing Region	Cassano *et al.*, 2012
	9	16º27's 39º3'w	Porto Seguro - Bahia	Moura, 2003
	10	18º25's 40º6'w	Reserva Biológica do Córrego do Veado - Pinheiros	Chiarello, 1999
	11	19º11's 40º5'w	Reserva Biológica Sooretama - Sooretama	Chiarello, 1999
	12	19º25's 40º3'w	Reserva Florestal de Linhares - Linhares	Chiarello, 1999
Espirito Santo	13	19º48's 40º27'w	Reserva Biológica de Mata Atlântica	Chiarello, 1999
	14	19º52's 40º31'w	Reserva Biologica do Corrego Grande - Conceição da Barra	Chiarello, 1999
	15	20º18's 40º32'w	Reserva Biológica de Duas Bocas – Cariacica	Tonini *et al.*, 2010
	16	20º23's 40º29'w	Viana- Vitória	Pinto *et al.*, 2009
	17	20º43's 40º46'w	Samarco Mineração S.A. - Anchieta	Passamani *et al.*, 2005
	18	21º20's 41º50'w	Parque Estadual do Desengano - Santa Maria Madalena	Modesto *et al.*, 2008a
	19	22º22's 43º47'w	Parque Estadual da Serra da Concórdia	Modesto *et al.*, 2008b
Rio de Janeiro	20	22º30's 42º19'w	Reserva Biologica Poço das Antas	Brito *et al.*, 2004
	21	22º26's 42º35'w	Parque Nacional Serra dos Órgãos	Olifiers *et al.*, 2005; Prevedello *et al.*, 2008
	22	22º2's 42º40'w	Sumidouro	D'Andrea *et al.*, 2007
	23	22º59's 44º37'w	Rio das Pedras - Mangaratiba	Pessôa *et al.*, 2009
	24	20º12's 42º39'w	Fazenda Esmeralda - Rio Casca	Fonseca, 1989
	25	20º45's 42º51'w	Centro de Estudos de Florestas Naturais - Viçosa	Paglia *et al.*, 1995; Prado *et al.*, 2008
	26	20º15's 42º53'w	Parque Estadual do Rio Doce - Timóteo	Stallings *et al.*, 1990
	27	19º49's 43º22'w	EPDA-Peti - São Gonçalo do Rio Abaixo	Paglia *et al.*, 2005
Minas Gerais	28	19º57's 43º54'w	Parque das Mangabeiras - Belo Horizonte	Oliveira *et al.*, 2007
	29	20º26's 44º36'w	Estação Ecologica Mata do Cedro - Carmópolis de Minas	Penido and Zanzini, 2012
	30	22º13's 45º58'w	Parque municipal de Pouso Alegre- Pouso Alegre	Costa *et al.*, 2010
	31	22º22's 47º28'w	Fazenda São José- Araras	Briani *et al.*, 2001
	32	23º38's 45/º32'w	Parque Nacional da Serra do Mar State - Caraguatatuba	Norris *et al.*, 2012
São Paulo	33	23º39's 47º1'w	Reserva Florestal do Morro Grande- Morro Grande	Pardini and Umetsu, 2006
	34	23º41's 47º2'w	Caucaia do Alto - Cotia	Umetsu *et al.*, 2006
	35	24º08's 47º57'w	Parque Estadual Carlos Botelho - São Miguel Arcanjo	Brocardo *et al.*, 2012
Paraná	36	25º28's 48º50'w	Mananciais da Serra - Piraquara	Cáceres, 2004
Santa Catarina	37	27º55's 48º48'w	Parque Estadual da Serra do Tabuleiro - Palhoça	Cherem *et al.*, 2011

RVSMJ was the protection of the local population of *Callicebus coimbrai* Kobayashi and Langguth, 1999 (Sergipe, 2007), an endangered (EN) primate species, according to the IUCN Red List (see Veiga *et al.*, 2008), endemic to the Atlantic Forest of Sergipe state and the north shore of Bahia state.

The vegetal cover is a semi-deciduous and open forest of slope, with many clearings, surrounded by an anthropogenic matrix, consisting mainly of sugarcane (*Saccharum* sp.) plantations and cattle pasture. However, the vegetation is well structured, with three main strata – (i) understory with bushes and herbaceous plants; (ii) lower canopy with small trees and lianas; and (iii) main canopy with some emergent trees over 15 m high. The megathermic sub-humid climate is characterized by a rainy winter (April-August) and dry summer, classified as *As* by Köppen's climate classification (Alvares *et al.*, 2013), with a mean annual temperature of 24.9°C and a mean annual precipitation of 1,372 mm (SEMARH, 2007), in a slope relief ranging from 40 to 120 m above sea level.

Data collection

We conducted the samplings on three days each month, between June 2011 and May 2012. We use complementary approaches to record the presence of cryptic mammal species, both medium-large (adults > 1 kg) or small (adults < 1 kg) species, according to Rocha and Dalponte (2006) and Paglia *et al.* (2012). The occurrence of medium and large species were verified based on a combination of approaches, as the direct observation, vocalizations, and opportunistic indirect observation of vestiges, such as feces, tracks and footprints, burrows and bones. The tracks were identified based on Becker and Dalponte (1991). Additionally, we considered the presence of some cryptic and rare mammal species, according to the report of few local informers, mainly local residents and landowners close to the Refuge for over 50 years, through non-systematic informal talks.

For small mammal species, we set 36 Sherman type traps (22.5 x 7.8 x 9.2 cm) per night, along three transects in the dense forest, each with six capture points, 50 m apart. Each point included two traps, one set on the ground (substratum), and other in the vegetation (understory), up to 2 m above the ground. We baited the traps with a mixture of peanut candy, sardines, corn and banana, checked in the following morning.

We moved trapped animals to the laboratory, at field station, to the identification and record morphometric parameters, as total body length (mm), caudal length (mm), anterior/posterior foot length (mm) and weight (g). We use coded incisions on the ear to mark the released specimens. Collected specimens were handled in accordance with the Animal Care and Use Committee (Sikes *et al.*, 2011). Species were identified through Gardner (2007), Voss and Jansa (2009), and Feijó and Langguth (2013). We deposited the voucher specimens (skin and/or skull) of different species in dry conditions, both in the Conservation Biology Laboratory (LBC), and in the mammalian collection of the Federal University of Sergipe (CMUFS), São Cristóvão, Sergipe, Brazil (Appendix 1).

Analyses

We ran the Jackknife 1 species richness estimator and species accumulation curve (observed and estimated) based on 1,000 replications (Colwell and Coddington, 1994), in the software EstimateS 8.0 (Colwell, 2005).

Results

We recorded 16 species of non-volant mammals during the present study, representing 12 families of seven orders (Table 2). An effort of 1,296 trap nights resulted in the capture of 32 individuals (2.62% of efficiency), that represents only four species of small mammals, including three marsupials, *Didelphis albiventris* Lund, 1840 (n=18; 56.2%), *Marmosops incanus* Lund, 1840 (n=6; 18.7%), and *Marmosa demerarae* Thomas, 1905 (n=7; 21.8%), as well as an exotic rat, *Rattus norvegicus* (Berkenhout, 1769) (n=1; 3.1%) (Table 2; Figure 2).

Despite the low richness accessed by traps, estimated species richness according to Jackknife 1 was S = 4.9 species, which indicates that the results of the study were relatively satisfactory, given that 81.3% of this total was recorded. This assumption is supported by the fact that the standard deviations of the two curves overlapped at many points (Figure 2).

The complimentary methods identified 12 species, six of them through direct observation, while other three were registered exclusively through tracks and/or bones (Figure 3). The three remaining additional species, *Leopardus* sp. Gary 1842, *Puma yagouaroundi* (É. Geoffory Saint-Hi-

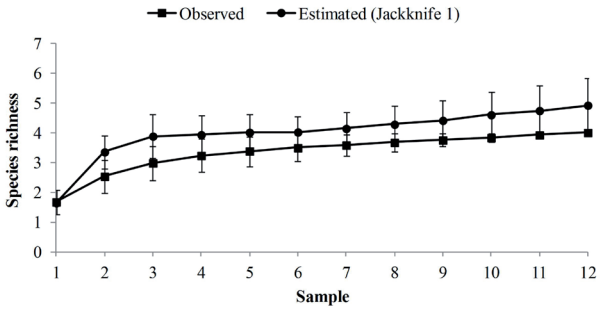

Figure 2. Observed and estimated (Jackknife 1) cumulative species curves (vertical lines = standard deviation) for the community of small mammals of the Mata do Junco Wildlife Refuge, Sergipe, northeastern Brazil, between June 2011 and May 2012.

Table 2. Non-volant mammal species recorded at the Mata do Junco Wildlife Refuge in Sergipe, Brazil, between June 2011 and May 2012. C = Captured; O = Observed; V = Vestiges*; R = Reports; S = Carcass.

Taxon	Common name	Type of record	N
Order Didelphimorphia			
Family Didelphidae			
Didelphis albiventris Lund, 1840	White-eared opossum	C	18
Marmosa demerarae (Thomas, 1905)	Woolly mouse opossum	C	7
Marmosops incanus (Lund, 1840)	Gray slender opossum	C	6
Order Pilosa			
Family Myrmecophagidae			
Tamandua tetradactyla (Linnaeus, 1758)	Southern tamandua	O	2
Order Cingulata			
Family Dasypodidae			
Dasypus novemcinctus Linnaeus, 1758	Nine-banded armadillo	O/V[b]	_
Euphractus sexcinctus (Linnaeus, 1758)	Six-banded armadillo	O	1
Order Primates			
Family Cebidae			
Callithrix jacchus (Linnaeus, 1758)	Common marmoset	O	_
Família Pitheciidae			
Callicebus coimbrai Kobayashi and Langguth, 1999	Coimbra-Filho's titi	O/S	_
Order Carnivora			
Family Canidae			
Cerdocyon thous (Linnaeus, 1766)	Crab-eating fox	V[b,d]	_
Family Felidae			
Leopardus sp. (Schreber, 1775)	Oncilla	R	_
Puma yagouaroundi (É. Geoffory Saint-Hilare, 1803)	Jaguarundi	R	_
Family Mustelidae			
Galictis cuja (Molina, 1782)	Lesser grison	R	_
Family Procyonidae			
Procyon cancrivorus (G. [Baron] Cuvier, 1798)	Crab-eating raccoon	V[b]	_
Order Lagomorpha			
Family Leporidae			
Sylvilagus brasiliensis (Linnaeus, 1758)	Brazilian rabbit	O/V[a]	1
Order Rodentia			
Family Dasyproctidae			
Dasyprocta sp. Illiger, 1811	Agouti	O/V[d]	4
Family Muridae			
Rattus norvegicus (Berkenhout, 1769)	Brown rat	C	1

* Vestiges such as feces[a], tracks[b] and footprints[b], burrows[c] and bones[d]. Taxonomy according to Paglia *et al.,* (2012) and Feijó and Langguth (2013).

lare, 1803) and *Galictis cuja* (Molina, 1782), were registered through the reports of local residents. Curiously, all the reported species were from the order Carnivora, which may indicate an actual absence of some top predators.

Discussion

The most interesting aspect of the data was the absence of native species of rodents, despite the sampling effort (1,296 trap-nights), although 31 marsupial specimens (representing three different species) have been collected during the sample period. This might indicate some factor limiting the occurrence and/or abundance of rodents at the study site. It seems unlikely, however, that rodents are absent altogether, and the lack of records in the present study may be due to a combination of factors, including the type of bait (Astúa *et al.*, 2006), the distance from the edge of the forest, and the type of trap (Cáceres *et al.*, 2011; Hice and Velazco, 2013). The recent establishment of the study site as a protected area (Sergipe, 2007) may reinforce the idea of edge effect, associated with historical hunting pressure. Therefore, the maintenance of habitat generalist species is expected (Silva and Pontes, 2008), as well as the recolonization of the area by some species considering their vagility.

Together with the species confirmed in the present study, a total of 30 non-volant mammals are known to oc-

Figure 3. Some non-volant mammal species found at the Mata do Junco Wildlife Refuge, Sergipe, northeastern Brazil, recorded between June 2011 and May 2012. (A) Woolly mouse opossum (*Marmosa demerarae*), (B) White-eared opossum (*Didelphis albiventris*), (C) Brown rat (*Rattus norvegicus*), (D) Common marmoset (*Callithrix jacchus*), (E) Coimbra-Filho's titi monkey (*Callicebus coimbrai*).

cur in the Atlantic Forest of Sergipe (Oliver and Santos, 1991; Stevens and Husband, 1998; Oliveira *et al.*, 2005; Chagas *et al.*, 2010; Rocha *et al.*, 2012). Considering only surveys based on procedures comparable to those applied in the present study, species richness varied considerably, from nine at the Serra de Itabaiana National Park (Oliveira *et al.*, 2005) and Morro Grande Forest Reserve (Pardini and Umetsu, 2006) to 36 at the EPDA-Peti reserve in Minas Gerais (Paglia *et al.*, 2005). A number of factors may have influenced this variation, including zoogeographic limitations (Mares, 1975) and human impacts, as well as the size and age of fragmentation (Brooks and Rylands, 2003) and hunting pressure (Cullen Jr. *et al.*, 2000). This variation reinforces the need for more detailed data from a larger number of sites, as well as continued monitoring in already sampled sites, for a more systematic understanding of the diversity and zoogeography of the mammals of the Atlantic Forest.

The number of recent surveys available for the Atlantic Forest (Table 1) is not only relatively limited, in comparison with the dimensions of this biome, but is also concentrated in the South and Southeastern regions of Brazil (Figure 1). Filling the vast knowledge gaps in the Northeastern region (or even further in the South) is important not only for the understanding of the diversity of mammals within this region in general, but also the local distribution of specific taxa. A number of recent studies have redefined the local ranges of species such as *Bradypus torquatus* Illiger, 1811 (Chagas *et al.*, 2010) and *Marmosops incanus* (Rocha *et al.*, 2012).

In relation to the species not found in the RVSMJ, but registered in other areas in the Sergipe state, there are at least three mammal species, which are at risk of local extinction, the rodents *Chaetomys subspinosus* (Olfers, 1818) and *Coendou insidiosus* Lichtenstein, 1818 (Oliver and Santos, 1991), and the feline *Puma concolor* (Linnaeus, 1771)

(Chagas *et al.*, 2010). These species have their records just up to the Vaza-Barris river, south portion of the Atlantic Forest in the state. This river may be a geographic barrier to their distribution, or yet those species may have suffered local extinction in other areas. Other species that have their distributions expected to the RVSMJ, as the wild hogs *Tayassu pecari* (Link, 1795) and *Pecari tajacu* (Linnaeus, 1758), probably have already been extinguished throughout the state, since there are not even anecdotic records.

Therefore, we highlight the importance of a continued monitoring of the community of mammal species in the RVSMJ. This monitoring may contribute to the understanding the role of ecological succession in the mammal community, as a consequence of the protection of the area. Ultimately, the construction of a vast database on the occurrence and distribution of mammals in the Atlantic Forest will provide an important tool for the development of effective conservation and management strategies. This database is an important management tool, in order to define the priority areas for conservation, development of action plans for endangered species, planning sustainable landscape, and the establishment of new protected areas, as proposed by Costa *et al.* (2005).

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Appendix 1: Specimens examined

Didelphis albiventris: Male (LBC 35); *Marmosa demerarae*: Male (LBC 28, 31), female (LBC 28); *Marmosops incanus*: Male (CMUFS 17, 18, 19); *Rattus novergicus*: female (LBC 30); *Cerdocyon thous*: (LBC32); *Sylvilagus brasiliensis* (LBC34); *Procyon cancrivorus* (LBC 33); *Callicebus coimbrai* (LBC 36, 38); *Dasyprocta* sp. (LBC 37).