

Bats (Mammalia: Chiroptera) from a remnant of Atlantic Forest in Pernambuco, northeastern Brazil

Fábio Angelo Melo Soares¹; Carlos Eduardo Borges Pinto Ribeiro²; Marcela Regina de Melo Daher²,
Deoclécio de Queiroz Guerra³ & Stephen Ferrari¹

¹Laboratório de Biologia da Conservação, Departamento de Ecologia, Universidade Federal de Sergipe. Cidade Universitária Prof. Aloísio de Campos, Av. Marechal Rondon, s/n Jardim Rosa Elze, CEP:49100-000 - São Cristóvão, SE, Brasil.

²Faculdade Frassinetti do Recife – FAFIRE, Av. Conde da Boa Vista. CEP 50060-002, 921 – Boa Vista, Recife, PE.

³Universidade Federal de Pernambuco - UFPE, Departamento de Zoologia, Centro de Ciências Biológicas. Campus Cidade Universitária. Rua Nelson Chaves, s/n, Cidade Universitária, CEP 50670-420, Recife, PE, Brasil.

*Corresponding author: fabiosoares9@gmail.com

Abstract. The RPPN Carnijó (08° 07' 07" S, 35° 05' 32" N) is a 25 hectare fragment of Atlantic Forest located in the municipality of Moreno, Pernambuco. Bats were sampled at this site during a total of 19 months between 2006 and 2008. Four mist-nets were set for six hours each night along trails, the forest edge, natural clearings, and over watercourses, while roosts were located during daytime searches. A total of 518 specimens were captured during 43 nights, representing 20 species in 16 genera. Total species richness was estimated to be 25.7 ± 2.0 , and diversity was $H' = 2.07$. The family Phyllostomidae predominated, with 98% (N = 509) of the specimens captured. The species recorded represent 28% of the known chiropteran fauna of the state of Pernambuco. The results indicate that the reserve may play a fundamentally important role in the maintenance of local biodiversity by acting as a "stepping stone" linking the larger fragments within the local landscape.

Keywords: Bats assemblage, Diversity, Municipality of Moreno, Pernambuco Center of Endemism, Phyllostomidae.

Resumo. Morcegos (Mammalia: Chiroptera) de um remanescente de Mata Atlântica em Pernambuco, Nordeste do Brasil. A RPPN Carnijó (08° 07' 07" S, 35° 05' 32" N) é um fragmento de Mata Atlântica de 25 hectares localizado no município de Moreno, Pernambuco. Os morcegos foram amostrados durante 19 meses, entre 2006 e 2008. Quatro redes de neblina foram armadas por seis horas em cada noite em trilhas no interior da área florestada, na borda, em clareiras naturais e próximas a córregos e alagados. Buscas por abrigos foram realizadas durante o dia. Um total de 518 espécimes foram capturados em 43 noites de amostragem, representando 20 espécies de 16 gêneros. A riqueza foi estimada em $25,7 \pm 2,0$ e a diversidade foi $H' = 2,07$. A família Phyllostomidae predominou com 98% (N = 509) das espécies capturadas. As espécies registradas no presente estudo representam 28% da quiropterofauna conhecida para o estado de Pernambuco. Os resultados indicam que a RPPN Carnijó pode desempenhar um importante papel na manutenção da biodiversidade local atuando como "trampolim ecológico" na paisagem local.

Palavras-chave: Comunidade de morcegos, Diversidade, Município de Moreno, Centro de Endemismo de Pernambuco, Phyllostomidae.

INTRODUCTION

The Brazilian Atlantic Forest and Cerrado are among the conservation hotspots identified by MYERS *et al.* (2000), regions characterized by high diversity and endemism, combined with extensive habitat loss. Originally covering an area of more than one million square kilometers, this biome has now been reduced by more than 92%, leaving less than 10% of its original coverage (SOS MATA ATLÂNTICA, 2013). Despite this devastation, the Atlantic Forest is estimated to contain between 1% and 8% of the plant's biodiversity (SILVA & CASTELETI, 2003), including a large number of endemic species (GALINDO-LEAL & CÂMARA, 2003). More than two thousand vertebrate species are known to occur in this biome (CAMPANILI & SCHAFFER, 2010), of which 298 are mammals, including 90 endemic forms (PAGLIA *et al.*, 2012).

The Pernambuco Center of Endemism (PECE) is the part of the Atlantic Forest located to the north of the São Francisco River, with an original area of 56,400.8 km² (PRANCE, 1982). Historically, this region has suffered the highest rates of deforestation, and is the least well known, in scientific terms, and the least well protected (SILVA & TABARELLI, 2000). Only 2% of the original forest cover of the PECE remains (SILVA & TABARELLI, 2000), and in many cases, the fragments have an area of less than 10 ha (RANTA *et al.*, 1998).

Bats are among the most diverse tropical mammals (PATTERSON *et al.*, 2003; PERACCHI *et al.*, 2011), corresponding to approximately 25% of all known mammalian species, with a total of 1.116 already described (SIMMONS, 2005). There are 178 species are known to occur in Brazil, representing

nine families (NOGUEIRA *et al.*, 2014), at least 113 have occurred in the Atlantic Forest (PAGLIA *et al.*, 2012). Furthermore, the Atlantic Forest bat communities are better studied, compared with those of other Brazilian biomes (BERNARD *et al.*, 2011).

At least 71 species are known to occur in the Brazilian state of Pernambuco, based on studies in the semi-arid Caatinga (WILLIG, 1983; WILLIG & MARES, 1989; SOUSA *et al.*, 2004; SILVA, 2007; GUERRA, 2007; SILVA & MARINHO-FILHO, 2010), the Atlantic Forest (SILVA, 2000; SILVA & GUERRA 2000; GUERRA, 2007; DANTAS-TORRES *et al.*, 2009; SOARES *et al.*, 2013), and urban areas (DANTAS-TORRES *et al.*, 2005). These species represent 40% of the chiropteran fauna of Brazil, including forms of these families Emballonuridae (8 species), Phyllostomidae (40 spp.), Mormoopidae (3 spp.), Natalidae (1 spp.), Noctilionidae (2 spp.), Furipteridae (1 sp.), Molossidae (9 spp.), and Vespertilionidae (7 spp.).

The present study provides information on the bat assemblage found at a private heritage reserve in the municipality of Moreno, Pernambuco, northeastern Brazil, analyzing potential species richness and diversity.

MATERIALS AND METHODS

The Santa Beatriz do Carnijó Private Natural Heritage Reserve (RPPN Carnijó, Figure 1) is located in the municipality of Moreno, in the forest zone of the northeastern Brazilian state of Pernambuco (08° 07' 07" S, 35° 05' 32" W). The reserve is located in the Pernambuco Center of Endemism (PECE), the portion of the Atlantic Forest located to the north of the São Francisco River, in northeastern Brazil, a

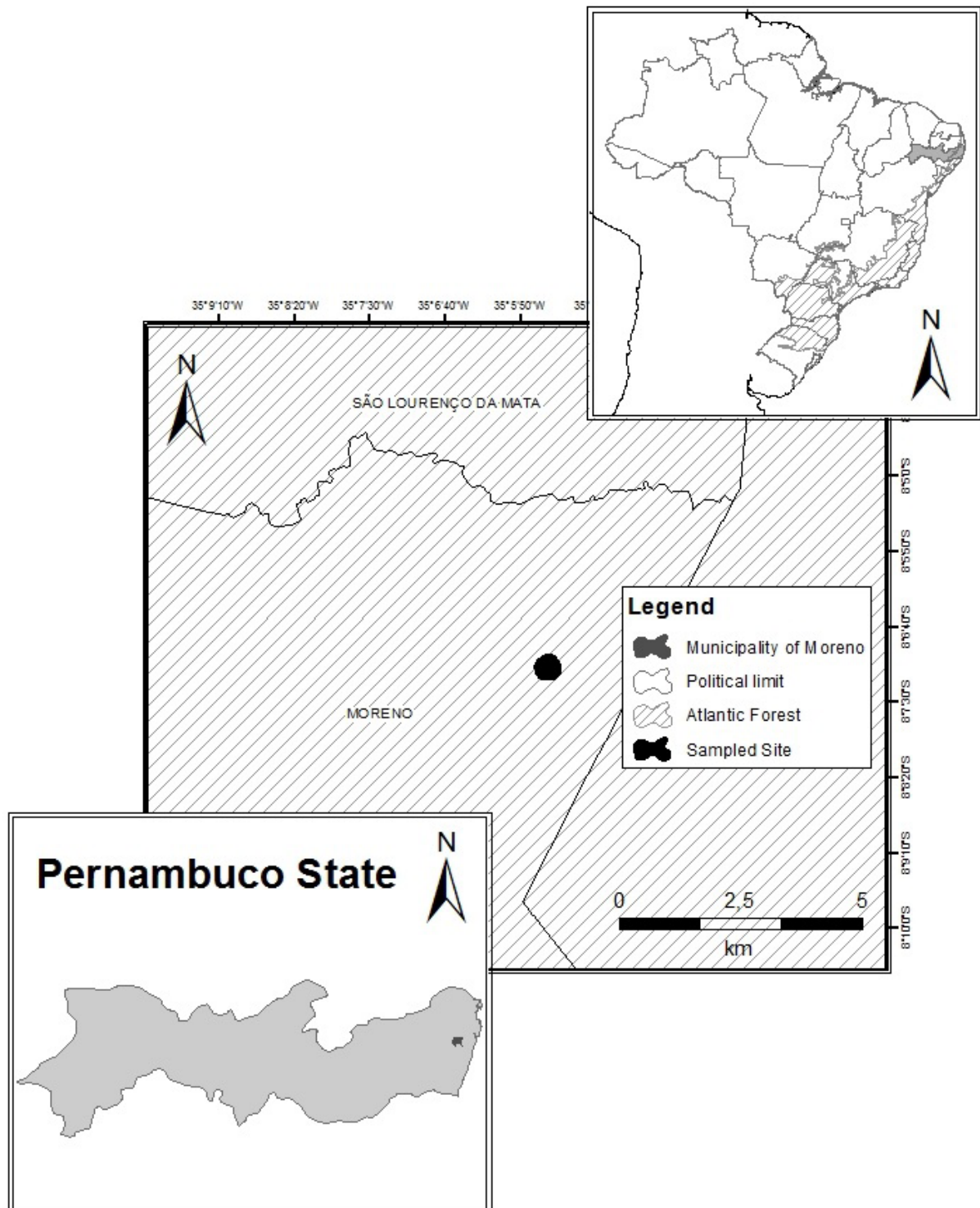


Figure 1. Location map of RPPN Carnijó, municipality of Moreno, Pernambuco, northeastern Brazil.

region that has lost 98% of its original forest cover (ASFORA & PONTES, 2009).

The RPPN Carnijó contains 25 hectares of Atlantic Forest, surrounded by sugarcane plantations and pastures. The rainy season typically lasts from April

to August, with mean annual precipitation of 1,025 mm (ANDRADE-LIMA, 1960). The characteristics of the vegetation of the reserve reflect a range of anthropogenic impacts, in particular edge effects, given the small size and irregular shape of the fragment. Despite this, the habitat is diverse, with numerous plant species, in particular those of the families Fabaceae, Euphorbiaceae, Myrtaceae, Solanaceae, and Urticaceae (personal observation, FS).

The bat individuals were captured at a number of different sites (Table 1), including the forest edge, natural clearings, next watercourses, and roosts (tree holes, bridges, palms, and termite nets). Four mist nets (12 m x 3 m, mesh 25 mm) were set between 18:00 h and 00:00 h on two to four nights during each month during the study period (May–November 2006 and March 2007–February 2008). The nets were monitored every 20 minutes during the sampling period. Bats were captured in daytime roosts using a hand-net. Excursions were conducted

during all moon phases, given that the restriction of specimen collection to a specific phase may not sample adequately the full diversity of the local phyllostomid fauna (ESBÉRARD, 2007).

Four areas were sampled: *Trilha da Mata Atlântica 1* (TMA 1)– located approximately 30 meters from the fragment’s edge, with a predominance of Piperaceae and Solanaceae.; *Trilha da Mata Atlântica 2* (TMA 2)– It is located next to the headquarters of the RPPN Carnijó, it is a track often used by tourists and employees. Around the track, you can see small banana plantations (*Musa paradisiaca*) and the presence of Urticaceae; *Represa Tamanduá* (RT): it is a small reservoir of water, with small vegetation on the banks); *Bica do Popó* (BP) – open area located near the dam Carnijó.

The captured individuals were placed in cotton bags and identified in the field before being released. The bats captured during this study were not labeled and the number of individuals likely

Table 1. Sampled areas between the years 2006 and 2007 in the PRNP Carnijó and total catches nights.

Area	Coordinates	Nights
Trilha Mata Atlântica 1	8° 8'45.43"S 35° 4'39.51"O	15
Trilha Mata Atlântica 2	8° 8'26.57"S 35° 4'45.05"O	17
Represa do Tamanduá	8° 8'39.55"S 35° 4'49.65"O	02
Bica do Popó	8° 8'36.26"S 35° 5'18.58"O	09

captured includes recaptures. Trophic guilds are in accordance with KALKO *et al.* (1996). The species were identified based on the keys of VIZOTTO & TADDEI (1973), GREGORIN & TADDEI (2002), and GARDNER (2008). The species-level nomenclature follows SIMMONS (2005), except for *Artibeus planirostris* (Spix, 1823), which is according to LIM *et al.* (2004), *Dermanura cinerea* (Gervais, 1856), based on REDONDO *et al.* (2008), and *Platyrrhinus lineatus* (É. Geoffroy, 1810), which follows VELAZCO & PATTERSON (2008). Some individuals were collected and deposited at the Museu de História Natural da Universidade Federal de Alagoas, MHN-UFAL (Appendix 1).

Mist-net sampling effort was calculated as the total net area (length x width x number of nets) multiplied by the total sampling time (sampling time x number of sessions), following STRAUBE & BIANCONI (2002). Total species richness was estimated using the Jackknife 1 procedure in Estimates, with 1,000 randomizations. Diversity was based on Shannon-Wiener's index (H').

RESULTS

A total of 27,864 m².h of mist-netting was conducted in the RPPN Carnijó over a 19-month sampling period (43 nights). Overall, 518 individuals were captured, representing 20 species belonging to 16 genera (Table 2). Estimated species richness was 25.7 ± 2.0 (Figure 2), but the cumulative species curve was not asymptotic, indicating that additional species will likely be found at the study site, after further research. Approximately 80% of the expected species were caught. Shannon-Wiener's diversity (H') was 2.07.

The great majority of the individuals were phyllostomids (N = 509; 98.3% of the total), with 16 species caught, followed by emballonurids, with two species and seven specimens, and a single representative each of the families Vespertilionidae and Molossidae. The most diverse phyllostomid subfamilies were Phyllostominae (S = 6) and Sternodermatinae (S = 6). The frugivore guild was represented by the largest number of

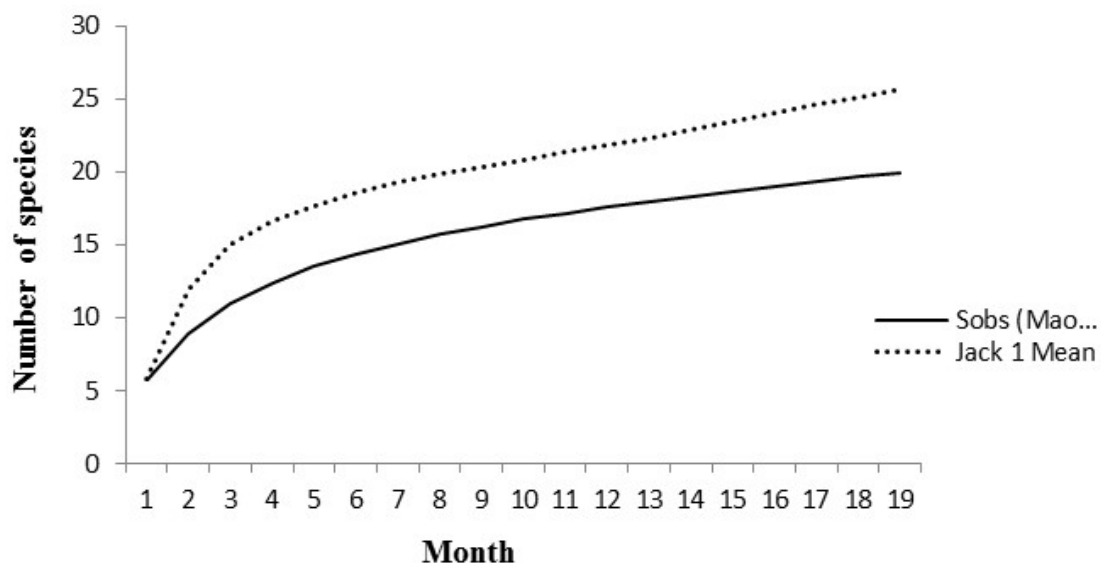


Figure 2. Cumulative species curve for the bat specimens captured in the RPPN Carnijó, Pernambuco, northeastern Brazil.

Table 2. Bat species recorded in the RPPN Carnijó, Pernambuco northeastern Brazil, showing the feeding guild and number of individuals captured. Guilds: CA = Carnivore; FR = Frugivore; OM = Omnivore; HE = hematophagous; NE = Nectarivore; IN: insectivore. * Species found in shelter.

TAXON	GUILD	N
Family Emballonuridae		
Subfamily Emballonurinae		
<i>Peropteryx macrotis</i> (Wagner, 1843)*	IN	2
<i>Rhynchonycteris naso</i> (Wied-Neuwied, 1820)*	IN	5
Family Phyllostomidae		
Subfamily Desmodontinae		
<i>Desmodus rotundus</i> (É. Geoffroy, 1810)	HE	9
Subfamily Lonchorhininae		
<i>Lonchorhina aurita</i> Tomes, 1863	IN	1
Subfamily Phyllostominae		
<i>Lophostoma brasiliense</i> Peters, 1866	IN	2
<i>Lophostoma silvicola</i> d'Orbigny, 1836	CA	1
<i>Phylloderma stenops</i> Peters, 1865	OM	1
<i>Phyllostomus discolor</i> (Wagner, 1843)	OM	54
<i>Phyllostomus hastatus</i> (Pallas, 1767)	OM	6
<i>Trachops cirrhosus</i> (Spix, 1823)	CA	6
Subfamily Glossophaginae		
<i>Glossophaga soricina</i> (Pallas, 1766)	NE	9
Subfamily Carolliinae		
<i>Carollia perspicillata</i> (Linnaeus, 1758)	FR	257
Subfamily Stenodermatinae		
<i>Artibeus planirostris</i> Spix, 1823	FR	28
<i>Artibeus lituratus</i> (Olfers, 1818)	FR	70
<i>Artibeus obscurus</i> (Schinz, 1821)	FR	10
<i>Dermanura cinerea</i> Gervais, 1856	FR	25
<i>Platyrrhinus lineatus</i> (É. Geoffroy, 1810)	FR	24
<i>Sturnira lilium</i> (É. Geoffroy, 1810)	FR	6
Family Vespertilionidae		
Subfamily Myotinae		
<i>Myotis lavalii</i> Moratelli, Peracchi Dias e Oliveira 2011	IN	1
Family Molossidae		
Subfamily Molossinae		
<i>Molossus rufus</i> É. Geoffroy 1805*	IN	1
TOTAL		518

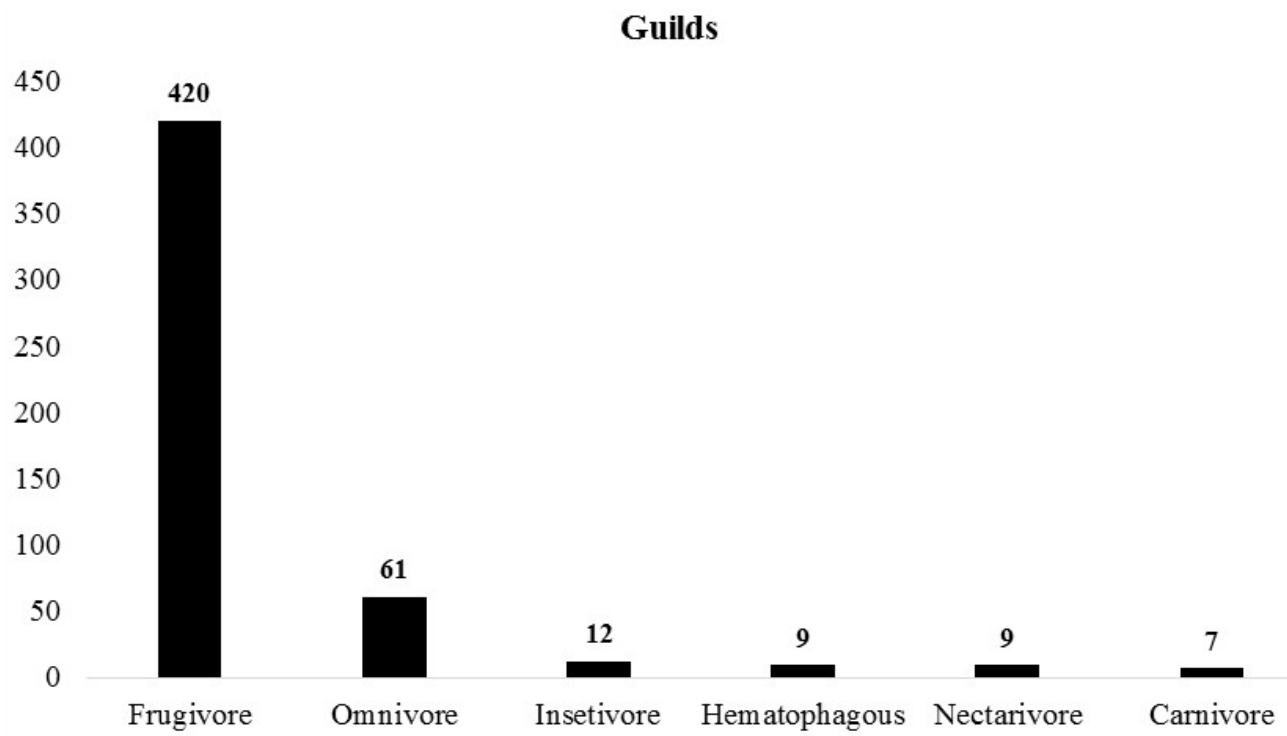


Figure 3. Abundance of bats representing each feeding guild captured in the RPPN Carnijó, Pernambuco, northeastern Brazil.

species (seven) and the great majority (81%) of the individuals captured, with the majority of the remaining individuals being made up of insectivores (S = 6) and omnivores, with three species (Figure 3).

Except for *M. rufus*, *P. macrotis* and *R. naso*, all other species were captured with mist nets. These three species were captured in shelters, with

the aid of hand nets. A colony of approximately 20 *R. naso* was found in the roof of a house adjacent to the study area, and *M. rufus* was found in an abandoned house. A small colony (6 individuals) of *P. macrotis* was observed in the forest itself, roosting in fallen trees. Only *T. cirrhosu* and *C. perspicillata* were captured in all sampled areas of PRNP Carnijó (Table 3).

Table 3. List of species recorded in the PRNP Carnijó and their capture sites. TMA 1 – Trilha da Mata Atlântica 1; TMA 2 – Trilha da Mata Atlântica 2; RT – Represa Tamanduá and BP – Bica do Popó.

Specie	TMA 1	TMA 2	RT	BP
<i>Peropteryx macrotis</i>	-	-	-	X
<i>Rhynchonycteris naso</i>	X	-	-	-
<i>Desmodus rotundus</i>	X	X	-	X
<i>Lonchorhina aurita</i>	-	-	-	X
<i>Lophostoma brasiliense</i>	-	-	-	X
<i>Lophostoma silvicolum</i>	-	X	-	-
<i>Phylloderma stenops</i>	X	-	-	-

Table 3. Continuação.

<i>Phyllostomus discolor</i>	X	X	-	X
<i>Phyllostomus hastatus</i>	X	-	-	-
<i>Trachops cirrhosus</i>	X	X	X	X
<i>Artibeus planirostris</i>	X	X	-	X
<i>Artibeus lituratus</i>	X	X	-	X
<i>Artibeus obscurus</i>	X	X	-	X
<i>Dermanura cinerea</i>	X	X	-	X
<i>Platyrrhinus lineatus</i>	X	-	X	X
<i>Sturnira lilium</i>	X	X	-	X
<i>Carollia perspicillata</i>	-	X	X	X
<i>Glossophaga soricina</i>	X	X	-	-
<i>Myotis lavalii</i>	-	X	-	-
<i>Molossus rufus</i>	-	-	-	X
Total	172	229	07	110

DISCUSSION

The species recorded in the present study represent 28.2% of the chiropterans known to occur in Pernambuco (GUERRA, 2007; LIRA *et al.*, 2009; SILVA & MARINHO-FILHO, 2010), and approximately 12% of those found in Brazil (PERACCHI *et al.*, 2011, NOGUEIRA *et al.*, 2014). In addition to the fact that Phyllostomidae is by far the most diverse group of Neotropical chiropterans (FENTON *et al.*, 1992), the predominance of members of this family in the present study is probably also due to the capture methods used here, in particular mist-netting, which favors the sampling of bats that are found primarily in the under-canopy (GREENHALL & PARADISO, 1968; TRAJANO, 1984; PEDRO & TADDEI, 1997). Mist-netting is more effective for the capture of frugivorous bats, which tend to forage in the lower strata of the forest, as well as the carnivorous and gleaning insectivore species, which capture their prey in the

dense vegetation of the understory (NOWAK, 1994).

In turn, the comparative rarity of emballonurids, vespertilionids and molossids may be related to their capacity of avoiding mist nets (KUNZ & KURTA, 1988). In particular, emballonurids and molossids generally fly above the canopy, requiring other methods to further study and sample the group, while vespertilionids are capable of detecting the nets through echolocation, while some species forage over water (NOWAK, 1994; GREGORIN & TADDEI, 2002).

The species diversity recorded in the present study ($H' = 2.07$) is similar to those in other Brazilian Atlantic Forest sites (ESBÉRARD, 2003; DIAS & PERACCHI, 2008; LUZ *et al.*, 2011; ROCHA *et al.*, 2010) and in Neotropical chiropteran communities in general (Pedro & Taddei, 1997). The cumulative species curve did not reach the asymptote, indicating that the full inventory of the species

present at this site has yet to be reached. This was confirmed by the Jackknife estimate, which indicated that only around 78% of the total species richness was identified.

The species *C. perspicillata* and *A. lituratus* were the most abundant in the study area, representing approximately 63% of the total number of individuals captured. The predominance of these species has been observed in other Atlantic Forest sites in different regions of Brazil (BIANCONI, *et al.*, 2004; ESBÉRARD *et al.*, 2006; ORTÊNCIO-FILHO & REIS, 2009; LOURENÇO *et al.*, 2010; ROCHA *et al.*, 2010; BRITO & BOCCHIGLIERI, 2012; NOVAES *et al.*, 2015), as well as in the Amazon basin (BERNARD, 2001; MARTINS *et al.*, 2006), and even in urban environments. The abundance within the study area of typical pioneer plants (Piperaceae, Urticaceae, and Solanaceae) that produce small, edible fruits, may also have contributed to the predominance of these two bats (personal observation). These two species are also known to thrive in disturbed habitats, such as that found in the study area (CASTRO-LUNA *et al.*, 2007).

On the other hand, we had a few species with low number of catches, such as insectivorous bats and representatives of Phyllostominae subfamily. The insectivorous bat *L. aurita* its well-developed sonar system allows ready detection and avoidance of mist nets, making this species particularly difficult to sample (LASSIEUR & WILSON 1989). Phyllostomines bats are more sensitive to habitat disruption, current status of RPPN Carnijó, it is associated with habitats with greater availability of food (FENTON *et al.*, 1992). In addition, the habitat fragmentation effect and changes caused by man may be the main cause of the low number of capture of these species in RPPN Carnijó.

Despite being a relatively small fragment of Atlantic Forest, the RPPN Carnijó may play a fundamentally important role in the maintenance of local faunal diversity. Bats, in particular, may use fragments of this type as “stepping stones” during long-distance foraging, thus reducing the isolation of forests within the landscape (ESTRADA & COATES-ESTRADA 2002). In this context, Carnijó has a strategic location, approximately 10 km from the Manassú Ecological Reserve and the Gurjaú State Reserve in the municipality of Jaboatão dos Guararapes, and 18 km from the Dois Irmãos State Park, in Recife. This record indicates the need for further sampling efforts in this region, in order to obtain a better understanding of the diversity, distribution patterns, and natural history of the bats, as well as their functional roles in the local ecosystems.

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APPENDIX 1

Voucher specimens deposited in the zoological collection of the Museu de História Natural da Universidade Federal de Alagoas, Alagoas, Brazil (code: MUFAL).

Trachops cirrhosis ♂ MUFAL0161; *Lophostoma brasiliense* ♂ MUFAL0162; *Carollia perspicillata* ♂ MUFAL0163; *Dermanura cinerea* ♂ MUFAL0164; *Myotis livali* ♂ MUFAL0165; *Artibeus obscurus* ♂ MUFAL0166; *Artibeus planirostris* ♂ MUFAL0167; *Artibeus lituratus* ♂ MUFAL0168; *Phyllostomus discolor* ♀ MUFAL0169; *Glossophaga soricina* ♀ MUFAL0170; *Desmodus rotundus* ♂ MUFAL0171; *Sturnira lilium* ♂ MUFAL01672; *Rinchonycteris naso* ♂ MUFAL0173.