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Bats of Alagoa Grande, a semi-arid area of Northeastern Brazil

Morcegos de Alagoa Grande, uma área de semiárido no Nordeste do Brasil

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Abstract

Bat fauna is surveyed mainly by mist-nets set in the ground level, and usually employing six hours per night of capture comprising the first peak of activity to most bat groups. Bat inventories with whole-night sampling effort (12 hours) have not been conducted so far in the northeastern of Brazil. This paper aims to report a whole-night survey of the bat assemblage from Alagoa Grande, a Caatinga site in the state of Paraíba, northeastern Brazil. Additionally, we compared the species richness and abundance between the two halves of the night, from dusk (5h p.m.) to 11h p.m., and 11h p.m. to dawn (5h a.m.). We conducted 15 nights of sampling from September/2010 to January/2011, sampling three nights per month. A total of 56 individuals belonging to 12 species were captured, with *Rhynchonycteris naso* and *Artibeus planirostris* being the most abundant species. The Chao1 richness estimator predicted an average estimated richness of 18 species. There was no significant difference in the species richness between the first and the second halves of the night. However, the second half presented a higher overall abundance and three species were exclusive to each half. Our data highlighted the importance of whole-night samplings, mainly in short surveys.

Keywords: whole-night sampling, Caatinga, Chiroptera, diversity, *Rhynchonycteris naso*.

Resumo

A fauna de morcegos é principalmente amostrada usando-se redes de neblina ao nível de solo, normalmente abertas por seis horas a cada noite, registrando o primeiro pico de atividade da maioria dos grupos de morcegos. Inventários com esforços de coleta ao longo de toda a noite (12 horas) são inéditos no nordeste brasileiro. O presente artigo relata o inventário da taxocenose de morcegos de Alagoa Grande, uma área de Caatinga no estado da Paraíba, Brasil. Além disso, comparamos a riqueza e abundância de morcegos entre as duas metades da noite, do pôr-do-sol (17h) às 23h, e das 23h ao amanhecer (5h). Foram realizadas 15 noites de amostragem entre setembro/2010 e janeiro/2011, amostrando-se três noites por mês. Um total de 56 indivíduos de 12 espécies foi capturado, *Rhynchonycteris naso* e *Artibeus planirostris* foram as espécies mais abundantes. O estimador de riqueza Chao 1 previu riqueza de 18 espécies. Não houve diferença significativa de riqueza entre as metades da noite. Entretanto, a segunda metade teve maior abundância, e três espécies foram exclusivas da segunda metade. Os dados apresentados reforçam a importância de coletas ao longo de toda a noite, especialmente em inventários de curta duração.

Palavras-chave: amostragem noturna completa, Caatinga, Chiroptera, diversidade, *Rhynchonycteris naso*.

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Introduction

Chiroptera is the second most diverse order of mammals, including nearly 22% of the known living mammalian species, with remarkable ecological and trophic diversity (Wilson and Reeder, 2005; Reis *et al.*, 2007). So far, 59 species from eight families are known to occur in the state of Paraíba (Feijó and Langguth, 2011; Ferreira *et al.,* 2013; Nunes *et al.,* 2013; Vilar *et al.,* 2015; Beltrão *et al.,* 2015; Feijó *et al.,* 2015a), but most studies are concentrated in the Atlantic Forest biome. The Caatinga remains poorly sampled (Feijó and Langguth, 2011; Feijó *et al.,* 2016).

The Caatinga is a semi-arid biome characterized by strong seasonality, irregular rainfall, high mean temperatures and long periods of drought (Menezes *et al.,* 2012). It has a long story of scientific negligence (Santos *et al.,* 2011) that has only started to be well-addressed recently. In the last 14 years, the bat richness known from the Caatinga has increased in 20%, currently with 81 species (Oliveira *et al.*, 2003; Paglia *et al.,* 2012; Moratelli and Dias, 2015; Rocha *et al.*, 2015; Feijó *et al.*, 2015a; Feijó *et al.*, 2015b). Recent studies have shown that Caatinga areas can maintain bat assemblages with similar levels of diversity to the moist tropical areas, which highlights the importance to expand the network of protected areas in this threatened biome (Beltrão *et al.,* 2015).

Bat fauna is surveyed mainly by mist-nets set in the ground level (Flaquer *et al.,* 2007), and usually employing six hours of capture per night, right after dusk, corresponding to the first peak of activity to most bat groups (Pedro and Taddei, 2002; Aguiar and Marinho-Filho, 2004). Bat inventories with whole-night sampling effort (12 hours) have not been conducted so far in the Caatinga or even in the northeastern of Brazil (Esbérard and Bergallo, 2005). Herein we report the results of a whole-night bat survey conducted in Alagoa Grande, an area of Caatinga in the state of Paraíba, northeastern Brazil.

Material and Methods

Study area

The survey was held in Fazenda Riachão do Progresso (FRP), located in the municipality of Alagoa Grande, state of Paraíba (07º06'01" S; 35º35'57" W), northeastern Brazil. The area is located in the mesoregion of Agreste, within the Caatinga ecosystem, presenting As' climate on Köppen's classification, with the rainy season from March to July (Sudema, 2011). The vegetation is 'Caatinga alta' (*sensu* Mares *et al.,* 1981), with canopy reaching 12m. The sampling site was a dry forest fragment of scrub-arboreal Caatinga surrounding an artificial lake, which is used by locals for fishing and recreational purposes, as well as water supply. The area is surrounded by pastures destined to cattle raising.

Sampling

We conducted 15 nights of sampling from September/2010 to January/2011, sampling three consecutive nights per month. Nine ground-level mist-nets (7 x 3 m) were opened at 5h p.m. (dusk) and closed at 5h a.m. (dawn), totalizing 12 hours of sampling effort per night. The mist-nets were installed in juxtaposition at the same spots in all sampling nights, following the margin of the lake. Two additional samplings were held by active search in roosts during daytime, to search for species that could be missed by the mist-nets.

Each specimen captured was manually removed from the mist-nets, had the time of capture annotated, the sex determined, anatomic measurements taken using a digital calliper (0.01 mm precision) and their weight using a portable scale (Pesola™). Their age class (juvenile, sub-adult or adult) was determined by the calcification of the metacarpal phalanx (Kunz and Anthony, 1982). All captured individuals were euthanized and deposited as voucher specimens at Coleção de Mamíferos of Universidade Federal da Paraíba. All samplings under license #20321-2 granted by Ministério do Meio Ambiente (MMA).

Data Analysis

The sampling effort was calculated according to Straube and Bianconi (2002), multiplying the area of mist-nets installed by the amount of sampling hours. We performed a Chao 1 estimator (Chao, 1984) and a species' accumulation curve with 95% confidence intervals that were compared to infer the sampling sufficiency on EstimateS (Colwellm, 2000). To evaluate the differences on abundance and species richness between the first (5h p.m. to 11h p.m.) and second half of the night (11h p.m. – 5h a.m.) (pre-mid and post-mid), the data was screened by a Shapiro-Wilk Test to check normality, and compared by a Wilcoxon rank sum test with continuity correction, analysis performed on R (R Core Team, 2014).

Results

The sampling effort totalized 34.020 h.m^2. We captured 56 individuals distributed in 5 families, 11 genera and 12 species (Table 1). The family Phyllostomidae comprised the majority of the species registered (N = 6) and the second most abundant species, *Artibeus planirostris* (Spix, 1823), corresponding to 23% of the captures. The family Emballonuridae was represented by two species. *Rhynchonycteris naso* (Wied-Neuwied, 1820) was the most abundant species, being represented in 30.7% of the total captures. Only individuals of *Glossophaga soricina* (Pallas, 1766) were captured in roost samplings. None of the species captured were considered endangered at country

Table 1. Species sampled at Fazenda Riachão do Progresso, Paraíba, northeastern Brazil, from September 2010 to January 2011, discriminated by abundance and relative abundance between the first and second halves of the night. Feeding guilds are assigned according to Kalko *et al.* (1996), and Collection Number as voucher specimens at Coleção de Mamíferos-UFPB.

Species	Abundance (Relative Abundance)		Voucher Number (UFPB)
	Pre-mid	Post-mid	
EMBALLONURIDAE			
Peropteryx macrotis (Wagner 1843)	1 (0.05%)	0	8629
Rhynchonycteris naso (Wied-Neuwied 1820)	4 (0.2%)	16 (0.44%)	8592-8604, 8636-8, 8643-5, 8648
PHYLLOSTOMIDAE			
Glossophaga soricina (Pallas 1766)	2 (0.1%)	3 (0.08%)	8650-2, 8655, 8659
Lophostoma brasiliense Peters 1866	1 (0.05%)	1 (0.03%)	8627, 8628
Trachops cirrhosis (Spix 1823)	2 (0.1%)	1 (0.03%)	8633, 8634, 8639
Carollia perspicillata (Linnaeus 1758)	1 (0.05%)	1 (0.03%)	8631, 8632
Artibeus planirostris (Spix 1823)	4 (0.2%)	11 (0.3%)	8635, 8661-74
Artibeus lituratus (Olfers 1818)	0	1 (0.03%)	8660
NOCTILIONIDAE			
Noctilio leporinus (Linnaeus 1758)	0	1 (0.03%)	8640
MOLOSSIDAE			
Cynomops planirostris (Peters 1866)	0	1 (0.03%)	8630
Molossus molossus (Pallas 1766)	1 (0.05%)	0	8642
VESPERTILIONIDAE			
Myotis lavali Moratelli, Peracchi, Dias and Oliveira, 2011	4 (0.2%)	0	8606-9
Total of individuals	20	36	
Total of species	9	9	

and global levels (Chiarello *et al.,* 2004; IUCN, 2014). The estimator Chao 1 showed an average richness of 18 species (Figure 1).

Regarding the comparison to the bat richness and abundance between the two halves of the night (Figure 2), we found that both had the same richness (9 species), and that two species, *Carollia perspicillata* (Linnaeus, 1758), and *Lophostoma brasiliense* Peters, 1866, had the same abundances, and *T. cirrhosis* and *G. soricina* differed only in one individual between both halves. *Rhynchonycteris naso* and *A. planirostris*, presented higher capture rates at the second half of the night. *Myotis lavali* Moratelli, Peracchi, Dias and Oliveira, 2011*, Molossus molossus (*Pallas, 1766) and *Peropteryx. macrotis* (Wagner, 1843) were recorded solely in the first half of the night, whereas *Artibeus lituratus* (Olfers, 1818)*, Cynomops planirostris* (Peters, 1865) and *Noctilio leporinus* (Linnaeus, 1758) were registered only in the second half. Six of the nine species registered in the second half of the night were recorded in a single capture, including *A. lituratus, C. planirostris* and *N. leporinus*. With the exception of *Myotis lavali*, all species that were exclusive to one of the halves had only a single individual captured. The Wilcoxon test pointed no significant difference between both halves on richness ($W = 152$, $p = 0.08256$) but detected differences on abundance ($W = 164$, $p = 0.02959$), the second half of the night having 1.8 times the individuals captured (36, compared to 20 for the first half of the night). Analyzing the total captured individuals per night (first, second and third successive nights) in each month of sampling, we found no trend of diminishing in abundance throughout the consecutive nights (Figure 3).

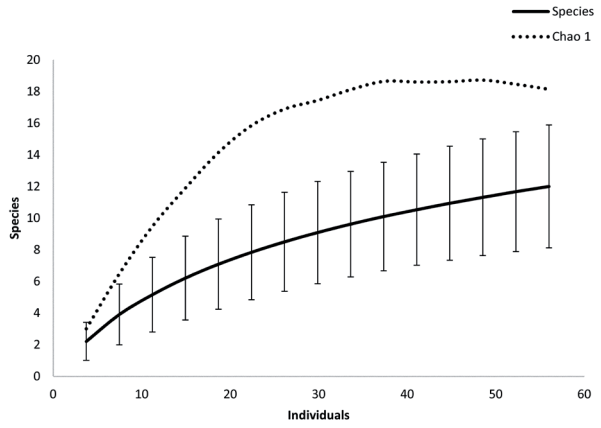

Figure 1. Bat species' accumulation curve, with 95% confidence intervals and Chao 1 richness estimator in an area of Caatinga in the state of Paraíba, northeastern Brazil.

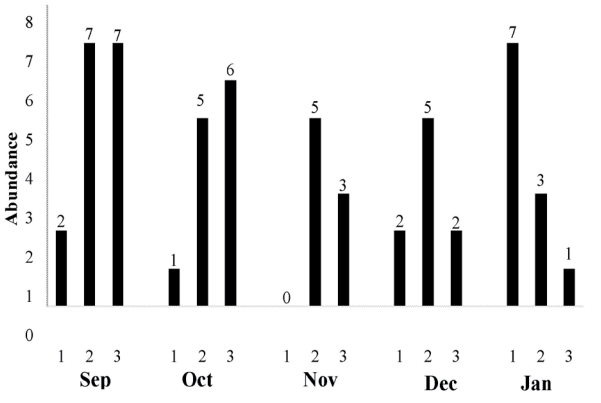

Figure 3. Bat abundance distribution by day and month of sampling in an area of Caatinga in Paraíba, northeastern Brazil.

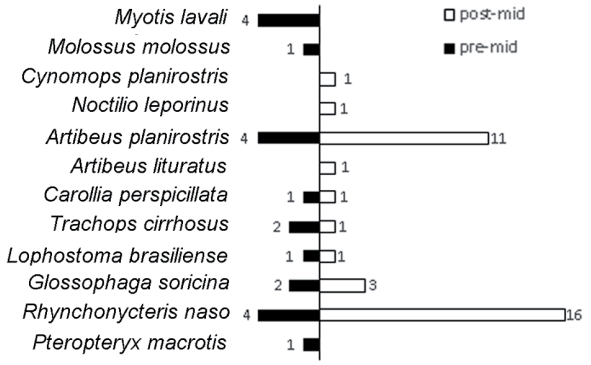

Figure 2. Species abundance of bats before (pre-mid) and after (post-mid) 11h p.m. in an area of Caatinga in Paraíba, northeastern Brazil.

Discussion

Our work recorded a low species richness compared to other surveys in the Caatinga. Novaes and Laurindo (2014) recorded 24 species to Chapada do Araripe in the states of Ceará and Pernambuco employing a comparable amount of mist-net hours. Sá-Neto and Marinho-Filho (2013) recorded 31 species to middle São Francisco River in the Bahia state with 7.6 times the sampling effort used herein. Beltrão *et al.* (2015) recorded 19 species to RPPN Fazenda Almas in the Paraíba state with 3.663.6 h.m^2 sampling effort. In addition, Silva *et al.* (2004) recorded 16 species to Serra das Almas in the Ceará and Gregorin *et al.* (2008) recorded 22 species to Serra das Confusões in the state of Piauí. On the other hand, Rios *et al.* (2008), with similar effort to our study, sampled only seven species for a Caatinga site in Bahia state. The low species richness in the area may be associated to the high level of anthropic landscape alterations, as intense livestock and wood exploitation, and few sparse patches of original vegetation. On the other hand, the difference between the estimated and the observed richness indicates the sampling effort performed was not sufficient, as we surveyed only 67% of the richness predicted by Chao 1. For instance, despite the presence of cattle, frequently attractive to hematophagous bats (Anderson *et al.*, 2012), no Desmodontinae bat was captured in our study.

Five of the nine species recorded in the present work were singletons. Among these species, *Peropteryx macrotis, Cynomops planirostris* and *Noctilio leporinus* had between 1 and 4 individuals captured by ground level mist-nets in other studies (Gregorin *et al.,* 2008; Novaes and Laurindo, 2014; Rios *et al.,* 2008; Sá-Neto and Marinho-Filho, 2013; Silva *et al.,* 2004). This result could be related to the inefficiency of the chosen sampling method to capture insectivorous species. Another study in the Caatinga captured 21 individuals of *Peropteryx macrotis* by sampling daily roosts (Beltrão *et al.,* 2015).

In surveys with continuous sampling effort, Esbérard (2006, 2009) detected a declining trend on capture rates during consecutive sampling nights, and a negative trend on capture rates for common species with continuous effort, suggesting that bats might learn the position of the mist-nets and avoid them. Our results suggest that bats did not learn the position of the mist-nets, as the capture rates only slightly change over the three nights sampled each month. Among the sampled species, we must highlight the unusual high abundance of *Rhinchonycteris naso*

possibly due to the proximity of mist-nets to a colony of the species, what has also affected the results of the comparison between the two halves of the night: when excluding *Rhinchonycteris naso* from the statistics, the Wilcoxon test detects no difference between the two halves of the night both for abundance (W = 49, p = 0.4408), and richness (W = 42.5, p = 04023). The final abundance was only detected due to the whole night sampling, as most of the individuals were captured during the second half of the night (Figure 2). Furthermore, *Lophostoma brasiliense* represents the first record for the Caatinga of the Paraíba state. Records of five insectivorous (*Rhinchonycteris naso, Peropteryx macrotis, Molossus molossus, Cynomops planirostris, Myotis lavali*) and a piscivorous species (*Noctilio leporinus*) may be explained by the location of mist-nets, which were set up at the the margin of a perennial body of water. This water body works as a refuge area during the dry season to those species in highly seasonal sites like Caatinga.

The majority of the Neotropical bats have their activity peak immediately before, during or right after sunset when they leave their daytime roosts (Avery, 1986; Erkert, 1978; Catto *et al.,* 1995), which justify the common practice of sampling bats for the first half of the night. However, our data highlighted the importance of a whole-night surveys, mainly in short samplings. Three species (25% of the richness), *A. lituratus*, *N. leporinus* and *C. planirostris*, were sampled only during the second half of the night, as well as the majority (about 64%) of the captures in this study. In contrast, *M. lavali, M. molossus* and *P. macrotis* were sampled only during the first half of the night.

Increasing the sampling effort commonly result in higher richness and abundance (Bergallo *et al.,* 2003; Esberard and Bergallo, 2005), what could be achieved by adding more collection days or more hours per night. The first choice allows to detect seasonal variations (food availability, weather oscillations), as well as minimizing the effects of punctual effects (*e.g.*, moonlight intensity, storms, mist). The second choice allows sampling bats both leaving and returning to their daytime roosts, maximizing the chances of capture in different activity periods. However, logistically, 12-hour sampling nights might hinder the practice of diurnal active search in roosts, a practice that allows recording species that normally are not trapped in mist-nets (Voss and Emmons, 1996). Hence, in long term studies, we advocate that it is more recommendable to increase the number of sampling nights, making possible the search for daily roost, whereas, in short-span surveys as ours, the use of whole-night sampling might yield a more realistic scenario of the local bat fauna.

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