



Bat assemblage of Guaribas Biological Reserve, an Atlantic forest conservation unit in North-eastern Brazil: Results of a two-stage long-term survey

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ABSTRACT. Inventories are the basis of every work with biodiversity, with increased importance due to the current environmental crisis. Bats are one of the most diverse groups of mammals, with high ecologic versatility and are good bioindicators to monitor environmental impacts. We performed a two-stage survey at an Atlantic Forest reserve in the State of Paraíba, the first stage registering 187 individuals of 24 species and the second stage, 1073 individuals of 11 species; the second stage's richness being a subset of the first as pointed by the Mann-Whitney test. The second stage was more efficient in accumulating individuals, while the first accumulated species more efficiently. The diversity estimation (Chao 1) pointed that the survey was efficient in registering 93.75% of the species richness predicted for the area, and that diversity estimators are more reliable to evaluate sampling efficiency than methods based in number of captures. The inventory survey registered over 42% of the species richness registered for the State of Paraíba, as well as included a new register, *Natalus stramineus*, pointing that the bat richness for the state is yet to be sufficiently studied.

Keywords: Chiroptera, inventory, diversity estimation, species richness, *Natalus stramineus*.

Assembleia de morcegos da Reserva Biológica de Guaribas, uma unidade de conservação da Mata Atlântica no Nordeste do Brasil: resultados de um estudo de longa duração em duas etapas

RESUMO. Inventários são a base de qualquer trabalho com biodiversidade, com sua importância exacerbada dada a crise ambiental atual. Morcegos são um dos grupos de mamíferos mais diversos, com alta versatilidade ecológica, e se apresentam como bons bioindicadores para monitorar impactos ambientais. O presente trabalho é um inventário de morcegos em longo prazo, dividido em duas etapas, numa reserva biológica de Floresta Atlântica no Estado da Paraíba, Brasil. A primeira etapa capturou 187 indivíduos de 24 espécies, o segundo registrou 1073 indivíduos de 11 espécies, sendo a diversidade deste um subgrupo da diversidade do primeiro, como apontado pelo teste de Mann-Whitney. O segundo estágio foi mais eficaz em acumular indivíduos, enquanto o primeiro acumulou espécies mais eficientemente. O estimador de diversidade Chao 1 apontou que o inventário foi eficiente em registrar 93,75% da riqueza de espécies prevista para a área, e que estimadores de diversidade são mais confiáveis para avaliar suficiência amostral que métodos baseados em número mínimo de capturas. O inventário registrou cerca de 42% da riqueza de espécies conhecida para o Estado da Paraíba, assim como incluiu um novo registro, *Natalus stramineus*, ressaltando que a riqueza de espécies de morcegos no estado está por ser suficientemente estudada.

Palavras-chave: Chiroptera, inventário, estimativa de diversidade, riqueza de espécies, *Natalus stramineus*.

Introduction

Inventories are the basis of every work on biodiversity; Without them, any bioscience study lacks

appropriate backing, hindering more sophisticated and robust analysis (Cotterill & Foissner, 2010). In an era of unprecedented biodiversity loss, inventories become even more important as a primary source of scientific

knowledge on biodiversity and contribute to the decision-making for conservation issues (Telfer et al., 2015; Wheeler, 1995).

The order Chiroptera is the second most speciose order of mammals, with over 1300 species known worldwide, and 178 known for Brazil (Fenton & Simmons, 2014; Nogueira et al., 2014). Bats are also known for their ecologic versatility, exploring every non-parasitic trophic strategy, as well as hematophagy (Rego, Zeppelini, Lopez, & Alves, 2015), contributing with ecological services such as seed dispersal, pollination and insect population control (Aguar & Antonini, 2008; Stevens, Willig, & Fox, 2004).

Despite being the best sampled biome for bats in Brazil (Bernard, Aguiar, & Machado, 2011), the Atlantic Forest is a diversity hotspot highly endangered by human activity (Colombo & Joly, 2010). Bats are considered good bioindicators to monitor environmental changes (Meyer et al., 2010) and could be valuable to assess and monitor the impacts, helping in decision-making to protect endangered biomes.

Here we report the results of a long-term, whole-night bat survey performed in Guaribas Biological Reserve, an Atlantic Forest reserve located in the state of Paraíba, Brazil. The Atlantic Forest in the North-eastern coast of Brazil has a long history of deforestation and degradation since the early colonization period, with only small fragments remaining.

Material and methods

Fieldwork was conducted at Guaribas Biological

Reserve (06° 44' 33.472" S, 35° 08' 33.011" W), a protected area located in the municipalities of Rio Tinto and Mamanguape, north coast of Paraíba (Figure 1). This reserve is composed of three forest fragments totaling approximately 4028.55 hectares. The climate is hot and humid with an average temperature between 24 and 26°C. Average rainfall of 1700 mm / year and the rainy season ranges from February to July (Ministério do Meio Ambiente [MMA], 2006; Endres, Creão-Duarte, & Hernández, 2007). On the reserve, prevail two physiognomies, the "Tabuleiro Nordestino" and forest areas. "Tabuleiro Nordestino" is an open formation dominated by grasses, with small-sized trees distributed sparsely, while the forests areas present higher tree density and taller trees forming closed canopy (Endres et al., 2007).

Captures were performed between 2011 and 2012, divided in two stages. The first campaigns, carried out between April 2011 and October 2011 were traditional survey campaigns, with production of voucher specimens. The campaigns of the second stage, carried out between February and October 2012 employed a mark-and-release protocol, without the production of voucher material. Thirty-four days of capture for the first stage, and twenty-eight days for the second, were carried. The "Tabuleiro Nordestino" area surveyed was located near the Reserve's buildings, the Atlantic Forest area surveyed was a locality called "Cabeça de Boi" (Ox's head), about 2 km west from the Reserve's buildings.

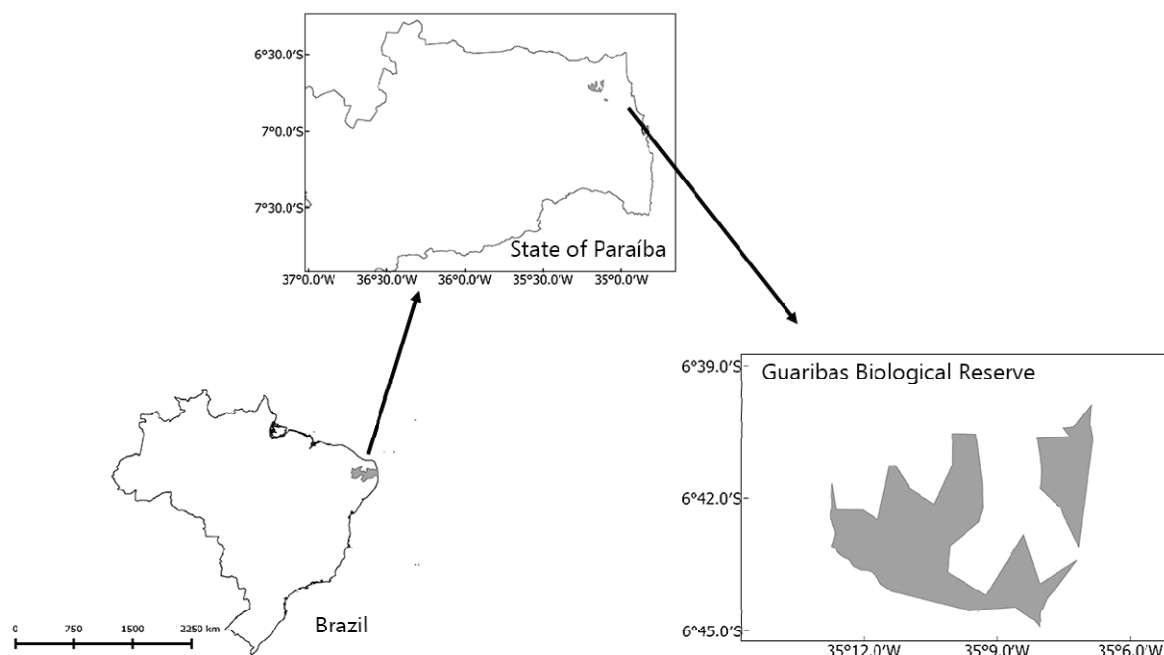


Figure 1. Map of Guaribas Biological Reserve. In the detail, its relative position in the State of Paraíba.

Captures were performed using nine ground level mist nets (7 x 3 m) opened at sunset (17 hours) and closed at sunrise (05 hours), checked every half hour for removal of specimens. The mist nets were placed at the same spots on each campaign, in order to avoid differences in capture between campaigns. During the first stage campaigns, captured individuals were sacrificed, had body measurements, weight sex and reproductive status registered, were taxonomically identified and deposited as voucher specimens in the *Coleção de Mamíferos* of *Universidade Federal da Paraíba*. During the second stage campaigns, individuals were removed from the nets, taxonomically identified, weight and forearm measured, received color-coded collars for identification and then released.

The sampling effort was calculated following Straube & Bianconi (2002) (effort = total area of nets x hours of open nets per night x number of nights). Capture efficiency was expressed as the ratio between sampling effort and 1) the number of individuals, 2) the number of species. To assess the sampling efficiency the diversity estimator Chao 1 (Chao, 1984) was calculated using EstimateS (Colwell, 2006) using the data from the first stage samplings. We compared the difference in abundance of the two sampling stages through a Mann-Whitney test (with prior normality test), as well as the abundance of the most common species. The efficiency of the two sampling on accumulating individuals and species was also compared. Tests and graphs performed using Sigmaplot. (Yoshioka, 2008).

Results and discussion

For the first stage campaigns, the total sampling effort was 77,052 h m⁻², registering 187 individuals from 24 species, 17 genera and 4 families (Table 1). The second stage campaigns had sampling effort of 63,504 h m⁻², registering 1073 individuals of 11 species, 9 genera and 3 families (Table 1). The capture success of the first stage is 0.002 individuals per unit of sampling effort, while for the second stage the capture success was 0.017. Based on the first stage campaigns, Chao 1 estimator predicted 25 species occurring in the sampled area. No species were considered endangered according to the current list of endangered fauna (Machado, Drummond, & Paglia, 2008). The sampling also

captured the first registry of *Natalus stramineus* for the State of Paraíba.

Table 1. Species registered in the inventory and mark-and-release studies. The most common species, posteriorly analysed, are highlighted in bold text.

Family/Genus	Species	Inventory	Mark-and-Release
Phyllostomidae			
<i>Artibeus</i>	<i>A. fimbriatus</i>	2	
	<i>A. lituratus</i>	6	77
	<i>A. obscurus</i>	2	2
	<i>A. planirostris</i>	22	599
<i>Dermaptera</i>	<i>D. cinerea</i>	31	124
<i>Platyrrhinus</i>	<i>P. lineatus</i>	10	7
	<i>P. recifinus</i>	2	
<i>Chiroderma</i>	<i>C. doriae</i>	1	
	<i>C. villosum</i>	1	
<i>Sturnira</i>	<i>S. lilium</i>	6	11
<i>Carollia</i>	<i>C. perspicillata</i>	29	178
	<i>C. auritus</i>	1	
<i>Rhinophylla</i>	<i>R. pumilio</i>	1	
<i>Desmodus</i>	<i>D. rotundus</i>	11	14
<i>Glossophaga</i>	<i>G. soricina</i>	31	57
<i>Lonchorhina</i>	<i>L. aurita</i>	2	
<i>Lophostoma</i>	<i>L. silvicolu</i>	2	
<i>Micronycteris</i>	<i>M. minuta</i>	1	
	<i>M. schmidtorum</i>	1	
<i>Phyllostomus</i>	<i>P. discolor</i>	5	
<i>Tonatia</i>	<i>T. saurophila</i>	2	
Vespertilionidae			
<i>Myotis</i>	<i>M. nigricans</i>	14	7
Natalidae			
<i>Natalus</i>	<i>N. stramineus</i>	2	
Emballonuridae			
<i>Saccolaryx</i>	<i>S. leptura</i>	2	1

The difference in abundance between sampling stages was considered significant by Mann-Whitney test ($U = 59$, $P = 0.009$). However, when compared only the species registered on both stages, the result is non-significant ($U = 45$, $P = 0.323$), the second stage pool being a subset of the inventory. Comparing the capture of the most common species (Figure 2), all species were more abundant in second stage campaigns, except *Myotis nigricans*, but the test found no significant difference between catches ($U = 10.500$, $P = 0.073$). The first stage campaigns accumulated species on a rate of 1 specie for every 3210 h.m², while for the second stage campaigns the rate was 1 for every 5773.1 h m⁻².

With 24 recorded species, we registered about 42% of the bat species richness known to the State of Paraíba (Feijó & Langguth, 2011; Ferreira, Melo, & Ribeiro, 2013; Nunes, Feijó, Beltrão, Lopez, & Fracasso, 2013; Vilar, Nunes, Nascimento, & Estrela, 2015), and greater richness compared to other works for the Atlantic Forest (Bianconi, Mikich, & Pedro, 2004; Brito & Bocchiglieri, 2012; Moratelli & Peracchi, 2007; Nascimento, Stumpp, & Lessa, 2013; Novaes, Laurindo, Souza, & Gregorin, 2013; Ortêncio-Filho & Reis, 2009; Teixeira & Peracchi,

1996). Esbérard et al. (2013), Dias, Peracchi, & Silva. (2002), Dias and Peracchi (2008) and Luz, Costa, Lourenço, & Esbérard. (2011) reported similar richness.

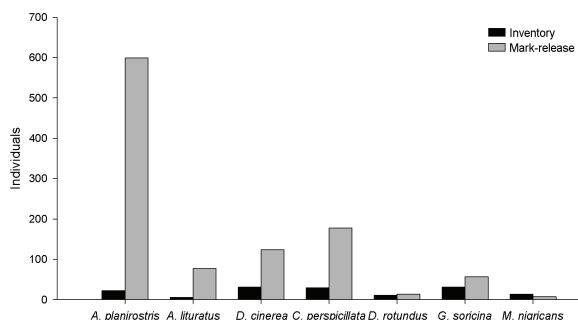


Figure 2. Comparison of captures for the most abundant species in both stages of the survey, values expressed in absolute numbers.

Comparing the species richness registered with the result of Chao 1, the survey could be considered efficient in representing the local assemblage, as it comprises 93.75% of the estimated richness. According to the protocol suggested by Bergallo et al. (2003), we achieved the minimal sampling effort needed to efficiently sample a bat assemblage in the Atlantic Forest (at least 1000 captures). However, the present results indicate that a protocol based on a minimal capture number is not reliable, as the gross majority of our captures happened during the second-stage samplings, that registered only 11 species (or 45.8% of the estimated richness). With about six times less captures, the first stage of our survey was more efficient in representing the bat assemblage surveyed, pointing that diversity estimators are more reliable to predict sampling sufficiency.

This work presents the first record of *Natalus stramineus* for the State of Paraíba, which now has 58 known species of bats in its territory (Feijó & Langguth, 2011; Ferreira et al., 2013; Nunes et al., 2013; Vilar et al., 2015). Registering of new species in the state indicates that there is still an inventorial gap to be filled and that further efforts are needed to successfully know the bats diversity in the state.

Conclusion

We conclude that the bat fauna in the state of Paraíba is still subject for further investigation, as it is yet to be adequately registered. Our long-term survey, despite the extended time range, gave us signs that the diversity of bats might be even higher than currently known. Adding *N. stramineus* to the list at the last inventory campaigns is a sign that: 1) The inventory produced in this work is

underestimated despite the proximity to the statistical estimation (see Vilar et al. (2015), which brought a new record for the same study area). 2) It is important to maintain long-term inventory projects.

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