Bat community species richness and composition in a restinga protected area in Southeastern Brazil

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Abstract

In Brazil, restingas are under severe human-induced impacts resulting in habitat degradation and loss and remain one of the less frequently studied ecosystems. The main objectives of the present study are to describe the bat community in a restinga in Paulo Cesar Vinha State Park, Guarapari municipality, state of Espírito Santo, southeastern Brazil. Fieldwork was conducted twice a month from August 2004 to September 2005. A total sampling effort of 40,300 m^2/h, represents the largest sampling effort for sampling bats in restingas to date. Bats were sampled in five different vegetational types in the area. Captured bats were processed recording information on species, sex, age, forearm length and weight. Shannon Diversity and Jaccard indexes were used to analyse diversity and similarity among habitats in the Park. A total of 554 captures belonging to 14 species and two families were obtained. *Noctilio leporinus* was recorded through direct observation and an ultra-sound detector also registered the presence of individuals from the family Molossidae, without being possible to distinguish it at specific level. Frugivores were the most representative guild. Richness was higher in *Clusia* shrubs (11 species) and Caraís lagoon (10 species). Shannon diversity index was estimated at H' = 1.43 for the overall sample, with Caraís lagoon representing the most diverse habitat (H' = 1.60). The greater similarity (J = 0.714) was observed for the two areas under high human influence.

Keywords: Chiroptera, community ecology, diversity, restinga.

Estrutura de comunidade de morcegos numa área protegida de restinga no Sudeste do Brasil

Resumo

No Brasil, as restingas sofrem severos impactos humanos que resultam em perda e degradação de habitat. Além disso, constituem um dos ecossistemas menos estudados. Os principais objetivos deste estudo foram descrever uma parcela da quirópterofauna do Parque Estadual Paulo Cesar Vinha, município de Guarapari, Estado do Espírito Santo, e descrever a estrutura de comunidade de morcegos nessa área de restinga, no Sudeste do Brasil. O trabalho de campo foi realizado duas vezes por mês, de agosto de 2004 a setembro de 2005. O esforço de amostragem total foi de 40.300 m^2/h, que representa o maior esforço de captura para morcegos em restingas até o momento. Os morcegos foram capturados em diferentes tipos de vegetação e tiveram as informações de espécie, sexo, idade, comprimento do antebraço e peso anotadas. Os índices de diversidade de Shannon e Jaccard foram utilizados para analisar a diversidade e a similaridade entre os habitats. Foram obtidas 554 capturas representando 14 espécies e duas famílias.

Noctilio leporinus foi registrado através de observação direta. Com o uso de um detector de ultrassons, registrou-se a presença de indivíduos da família Molossidae, não sendo possível a identificação da espécie. A riqueza foi maior no ambiente de *Clusia* (11 espécies) e na lagoa de Caraís (10 espécies). O índice de diversidade de Shannon foi estimado em H' = 1,43 na área total amostrada, com a lagoa de Caraís, representando o habitat mais diverso (H' = 1,60). A maior similaridade (J = 0,714) foi observada entre as duas áreas sob maior influência antrópica. Um aumento no número de pesquisas em áreas de restinga é importante para garantir melhores medidas de conservação para esse ecossistema.

Palavras-chave: Chiroptera, diversidade, ecologia de comunidades, restinga.

1. Introduction

The Atlantic Forest is one of the world's most threatened and biodiverse biomes, being listed among the 34 biodiversity hotspots (Myers et al., 2000; Mittermeier et al., 2005). Historically, the coastal region of Brazil has been occupied by most of the country's population and it has been the most exploited region (Galindo-Leal and Câmara, 2003; Rocha et al., 2003; 2005; Dean, 2004). As a consequence, coastal ecosystems like restinga habitats (coastal sand dune habitats), are particularly threatened by human-induced habitat loss and fragmentation (Rocha and Bergallo, 1997; Rocha et al., 2003; 2005). Even though there is still no detailed quantification of restinga remnants, a significant amount of this ecosystem is lost yearly due to urbanisation (SOS Mata Atlântica and INPE, 2001; Rocha et al., 2007).

The restingas remain one of the less known and studied ecosystems within the Atlantic Forest (Rocha et al., 2003; 2004a; 2005). For the great majority of the restingas, there is an astounding lack of even the most basic information, like the species composition of terrestrial vertebrates (Rocha et al., 2003; 2005). Surprisingly, restingas remain one of the least-known environments, not only in biodiversity, but also regarding the present conservation status of their remnants, even though they are located in the highest human density zone in Brazil (Rocha, 2000; Rocha et al., 2005). Most of the studies in restingas regarding terrestrial vertebrates deal with reptiles (e.g. Rocha, 2000; Rocha et al., 2004b), amphibians (e.g. Carvalho e Silva et al., 2000; Izeckshon and Carvalho e Silva, 2001; Van Sluys et al., 2004), birds (e.g. Gonzaga et al., 2000; Alves et al., 2004) and small mammals (rodents and marsupials) (Cerqueira et al., 1990; 2000; Bergallo et al., 2004). Given the current high degree of destruction under which restingas are subject to (Rocha et al., 2007), one can imagine a scenario in which a great portion of these habitats are being eradicated without us having at least the knowledge even on the simple species composition and of the eventual presence of endemic and threatened species in such areas. This is particularly true and worrisome for bats.

There are a total of 512,434.83 ha of protected areas in the central corridors of the Atlantic Forest that encompass the restinga ecosystem (Rocha et al., 2003). The state of Espírito Santo has five protected areas that have restingas within their borders. These protected areas total more than 25,000 ha of restinga habitat protected in Espírito Santo, 22% of which are under strict protection (Rocha et al., 2003). Nonetheless, the total amount of scientific information in these areas is still relatively restricted when compared to other ecosystems (Rocha et al. 2003). Setiba is one of the best studied restingas in Brazil (Rocha et al., 2003; 2005). A study evaluating 10 restingas in southeastern Brazil concluded that Setiba has an intermediate level of disturbance and a high level of vertebrate species richness (Rocha et al., 2003). The same study observed a negative relationship between human disturbance and vertebrate richness, stressing the importance of preserving this ecosystem in the face of anthropogenic threats (Rocha et al., 2003).

The main objectives of the present study are: 1) to inventory the bat species occuring in the Paulo Cesar Vinha State Park, 2) to compare species richness, abundance and diversity in five different restinga habitats within the Paulo Cesar Vinha State Park.

2. Material and Methods

2.1. Study area

Paulo Cesar Vinha State Park (20° 32' 02''-20° 37' 50'' S and 40° 22' 43''-40° 25' 59'' W), Guarapari municipality, state of Espírito Santo, southeastern Brazil, covers an area of 1,500 ha in southeastern Brazil (IPEMA, 2005). Its high plant diversity (Peixoto and Silva, 1997; Thomaz and Monteiro, 1997; Assis et al., 2004) contributes to the occurrence of a rich fauna (Pereira, 1990; Rocha et al., 2003). The climate of the region is tropical, with mean annual temperature of 23.3 °C and mean annual rainfall of 1,307 mm (Fabris and César, 1996). Paulo Cesar Vinha State Park borders one of the main roads in southeastern Brazil (BR060, also known as Rodovia do Sol). The restinga of Setiba is listed as a priority area with high biological importance for the preservation of the Atlantic Forest biodiversity (CI Brasil, 2000). Paulo Cesar Vinha State Park's restinga ecosystem is comprised by different habitats: coastal lagoons, *Clusia* formations, restinga forest, and beaches (Cogliatti-Carvalho et al., 2000; Rocha et al., 2003). It also has two areas under human influence: the park's visitor centre (with buildings and exotic plants) and the trail used by visitors to access the beach. The park has three coastal lagoons (Feia, Vermelha and Caraís lagoons) and Caraís lagoon is the only one that is permanently connected to the sea and it has mangroves on one of its shores (IPEMA, 2005).

2.2. Data sampling and analysis

Sampling sessions were conducted twice a month from August 2004 to October 2005. In each sampling session, we used from 8 to 10 mist-nets, that remained open for six hours consecutively since sunset and were checked every 20 minutes. We captured bats in five different habitats within Paulo Cesar Vinha State Park: 1) visitors centre; 2) main trail; 3) *Clusia* shrubs; 4) restinga forest, and 5) Caraís lagoon. Sampling effort was calculated following Straube and Bianconi (2002). Captured animals were measured (forearm length), weighed, sexed, and had their reproductive condition recorded. The species and location of capture were also recorded, and the bats kept in individual cotton bags until the end of the sampling session, when they were released at the same point where they were captured. Species richness and relative abundance were estimated for each habitat and for the entire sample (the whole park). Diversity was estimated using Shannon's index (Ludwig and Reynolds, 1988). Jaccard's index was used to calculate similarity between the park's habitats (Ludwig and Reynolds, 1988). The captured species were also classified into feeding guilds (adapted from Kalko et al., 1996): 1) insectivore, 2) carnivore, 3) piscivore, 4) sanguivore, 5) frugivore, 6) nectarivore and 7) omnivore. An ultrasound detector was used opportunistically during fieldwork, and visual observations were also made during the fieldwork sessions.

3. Results

We attained a total sampling effort of 40,300 m²/h, and obtained a total of 554 captures, with a success of capture of 0.013 captures/m²/h. We captured 14 species from two families (Phyllostomidae and Vespertilionidae) (Table 1). *Noctilio leporinus* (Noctilionidae) was registered through direct observation at Caraís lagoon and by one dead individual encountered after colliding with a car at BR060. Molossidae bats were recorded using an ultra-sound device (Petersson 240), but they could not be identified to species level. At least two species are common in southeastern Brazil: *Molossus molossus* and *Molossus rufus*. The collector's curve suggested that more bat species should be recorded, if additional sampling effort were conducted at Paulo Cesar Vinha State Park (Figure 1).

The habitats having higher bat richness were Caraís lagoon and *Clusia* shrubs (Table 1). *Carollia perspicillata*, *Artibeus lituratus*, *Artibeus cinereus* and *Glossophaga soricina* were captured in all five habitats sampled (Table 1). *Uroderma magnirostrum*, *Chiroderma doriae* and *Desmodus rotundus* were captured only in the *Clusia* shrubs, and *Phyllostomus hastatus* and *Anoura geoffroyi* only at Caraís lagoon (Table 1). Shannon's diversity index for Paulo Cesar Vinha State Park was H' = 1.43. The diversity values for each habitat were: visitors centre H' = 1.13, main trail H' = 1.26, restinga forest H' = 0.886, Caraís lagoon H' = 1.60, and *Clusia* shrubs H' = 1.56. The visitors centre and the main trail were the most similar habitats (J = 0.714), whereas the main trail and the *Clusia* shrubs were the least similar ones (J = 0.400) (Table 2).

The analysis of feeding guilds showed that frugivores (*Artibeus lituratus*, *A. cinereus*, *Carollia perspicillata*, *Chiroderma villosum*, *C. doriae*, *Platyrrhinus lineatus*, *Pygoderma bilabiatum* and *Uroderma magnirostrum*)

Table 1. Species richness and relative abundance of bats captured in the five habitats within Paulo Cesar Vinha State Park (PEPCV), Guarapari municipality, state of Espírito Santo, and the totals for the overall area of the park.

Species	Guild	Habitats					PEPCV (Total)
		Visitors center	Main trail	*Clusia* shrubs	Restinga forest	Caraís lagoon	
Desmodus rotundus	Sanguivore	-	-	2	-	-	2
Anoura geoffroyi	Nectarivore	-	-	-	-	1	1
Glossophaga soricina	Nectarivore	5	5	17	1	35	63
Carollia perspicillata	Frugivore	62	49	28	31	21	191
Artibeus cinereus	Frugivore	5	8	6	6	2	27
Artibeus lituratus	Frugivore	30	20	63	88	26	227
Chiroderma doriae	Frugivore	-	-	1	-	-	1
Chiroderma villosum	Frugivore	-	-	2	2	-	4
Platyrrhinus lineatus	Frugivore	3	-	5	-	3	11
Pygoderma bilabiatum	Frugivore	-	-	2	-	1	3
Uroderma magnirostrum	Frugivore	-	-	2	-	-	2
Phyllostomus discolor	Omnivore	1	-	2	1	6	10
Phyllostomus hastatus	Omnivore	-	-	-	-	1	1
Myotis nigricans	Insectivore	1	9	-	-	1	11
Total number of captures		107	91	130	129	97	554
Total number of species		7	5	11	6	10	14

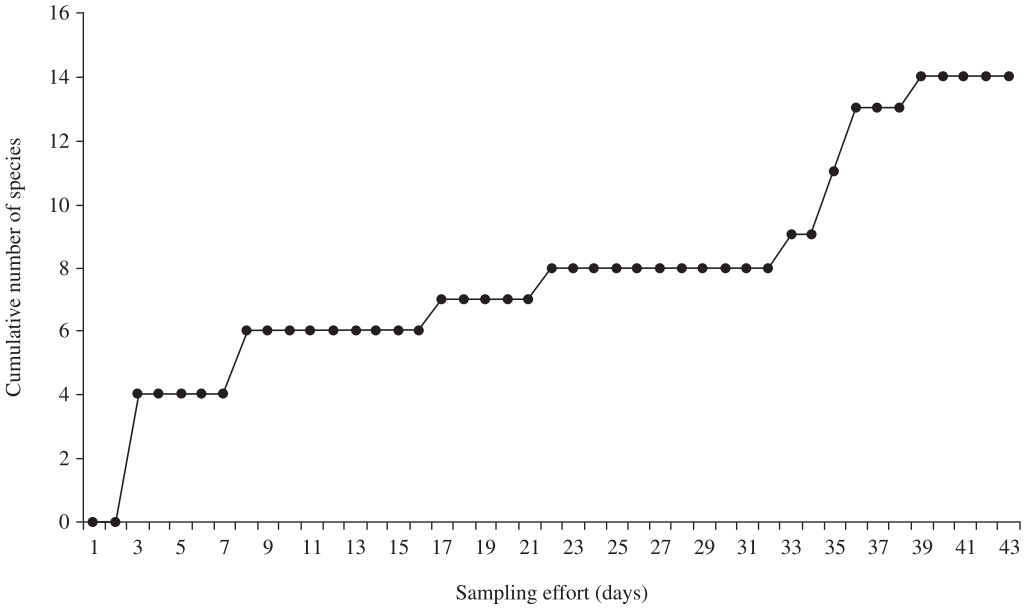

Figure 1. Cumulative numbers of bat species captured (collector's curve) at Paulo Cesar Vinha State Park, Guarapari municipality, State of Espírito Santo.

Table 2. Jaccard's similarity index (J) comparing each pair of habitats among the five sampled habitats at Paulo Cesar Vinha State Park, Guarapari municipality, State of Espírito Santo.

Habitats	Visitors centre	Main trail	Clusia shrubs	Restinga forest	Caraís lagoon
Visitors centre	-	-	-	-	-
Main trail	0.714	-	-	-	-
Clusia shrubs	0.454	0.400	-	-	-
Restinga forest	0.625	0.571	0.545	-	-
Caraís lagoon	0.700	0.500	0.538	0.454	-

represent the majority of species (57%) and the majority of captures (84%) (Table 1). Nectarivores were represented by *Glossophaga soricina* and *Anoura geoffroyi* (Table 1). Two species of omnivores were recorded: *Phyllostomus discolor* and *P. hastatus* (Table 1). The insectivores were represented by the species *Myotis nigricans* and *Molossus* sp. (Table 1). Sanguivores and piscivores were represented by only one species each, *Desmodus rotundus* and *Noctilio leporinus* (Table 1).

4. Discussion

To date, only 12 restinga sites have studies focusing on bats: Restinga da Ilha de Cabo Frio (Fernandez et al., 1988); Restinga de Ilha Grande (Fernandez et al., 1988); Restinga da Barra de Maricá (Cerqueira et al., 1990); Restinga de Saquarema (Esbérard, 2004); Chico Mendes State Park (Esbérard, 2004); Restinga da Praia dos Ossos (Esbérard, 2004); Arruda Câmara Municipal Park (Marques, 2000); Restinga de Macaé (Esbérard, 2004); Restinga de Jurubatiba National Park (Mangolin, 2005); Restinga de Guriri (Moreno et al., 2000); Ilha do Cardoso State Park (Fazzolari-Correa, 1995); Rio da Onça State Park (Fogaça, 2003; Dala Rosa, 2004) (Figure 2).

The present study represents the largest sampling effort for bats in the restinga ecosystem. The diversity index of Paulo Cesar Vinha State Park (H' = 1.43) is relatively high when compared to other restingas studied: Ilha do Cardoso (H' = 1.41; Fazzolari-Corrêa, 1995), Praia dos Ossos (H' = 1.21; Dala Rosa, 2004), Arruda Câmara Park (H' = 0.68; Marques, 2000).

The bat species richness of Paulo Cesar Vinha State Park (15 species) is also among the highest among restinga sites. Restinga de Jurubatiba National Park is the restinga with highest bat richness recorded (17 species; Mangolin, 2005) and the restingas with lower bat richness are Maricá, Saquarema and Cabo Frio (2 species in each one; Fernandez et al., 1988; Cerqueira et al., 1990; Esbérard, unpublished data), although it is important to consider differences among studies in sampling effort and period of the year sampled. However, these restingas with lower richness were also those with smaller sampling effort and they probably house more species than

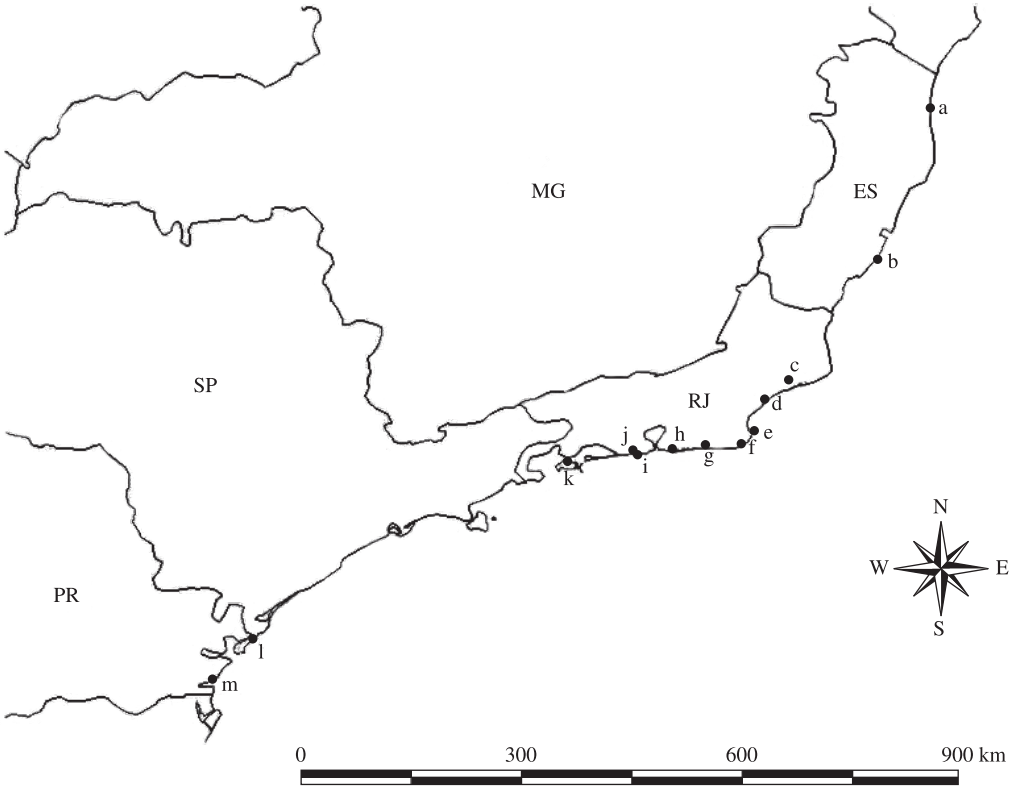

Figure 2. Restinga areas that have already been surveyed for bats: a) Restinga de Guriri (Moreno et al., 2000); b) Paulo Cesar Vinha State Park (this study); c) Restinga de Jurubatiba National Park (Mangolin, 2005); d) Restinga de Macaé (Esbérard, 2004); e) Restinga da Praia dos Ossos (Esbérard, 2004); f) Restinga da Ilha de Cabo Frio (Fernandez et al., 1988); g) Restinga de Saquarema (Esbérard, 2004); h) Restinga da Barra de Maricá (Cerqueira et al., 1990); i) Chico Mendes State Park (Esbérard, 2004); j) Arruda Câmara Municipal Park (Marques, 2000); k) Restinga de Ilha Grande (Fernandez et al., 1988); l) Ilha do Cardoso State Park (Fazzolari-Correa, 1995); and m) Rio da Onça State Park (Fogaça, 2003; Dala Rosa, 2004).

currently recorded. Bergallo et al. (2003) suggest that 1,000 captures is the sample size needed to properly inventory Atlantic Forest sites. Taking this estimative into account it is clear that all restingas sampled so far are considerably under-sampled. Even though the present study represents the largest mist-netting effort in restingas, the low success of capture for bats in this ecosystem suggests that bats are quite under-sampled and consequently an important gap in the knowledge of restinga biodiversity persists.

There were differences in species composition in the sampled habitats. Habitats under higher human influence (visitors centre and main trail) had lower diversity values. *Carollia perspicillata* was captured in all habitats, and it represented more than half of the captures at the visitor's centre and at the main trail. *P. lineatus*, *A. lituratus* and *G. soricina* are cited as generalist species able to adapt themselves to human disturbance (Bredt and Uieda, 1996). Regarding guild structure, our results seem to corroborate the restricted information available (e.g. Dala Rosa 2004), with frugivores being the most representative guild. The higher representation of frugivores may be a true result, but it may also reflect a bias in the sampling method used (mist-nets) (Arita, 1993; Pedro and Taddei, 1997). *Artibeus lituratus* was the most common species at Paulo Cesar Vinha State Park, and this is in accordance with observations from other restinga sites (e.g. Fazzolari-Correa 1995; Fogaça 2003; Dala Rosa 2004).

The restingas are recognised as important areas for biodiversity conservation in Brazil (CI Brasil et al., 2000; Rocha et al., 2003; 2005). However, there are still relatively few protected areas comprising restingas (e.g. Jurubatiba National Park), covering a small representative area of this ecosystem, even though this environment is under severe threat. There is urgent need for a better representativeness in the network of protected areas in the Atlantic Forest, including restingas (Rocha et al., 2007). In order to achieve this goal, a better knowledge of the species that occur in the restinga, and their ecology, is needed, as exemplified by indications that bats are still severely understudied in this ecosystem.

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