

Species richness and abundance of bats in fragments of the seasonal semideciduous forest, Upper Paraná River, southern Brazil

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(With 2 figures)

Abstract

The Upper Paraná River floodplain is inserted in a region of the Mata Atlântica biome, which is a critical area to preserve. Due to the scarcity of researches about the chiropterofauna in this region, the present study investigated species richness and abundance of bats in remnants from the seasonal semideciduous forest of the Upper Paraná River, southern Brazil. Samplings were taken every month, from January to December 2006, using 32 mist nets with 8.0 × 2.5 m, resulting in 640 m²/h and totaling a capture effort of 87,040 m²/h. In order to estimate the species richness, the following estimators were employed Chao1 and Jack2. During the study, a total of 563 individuals belonging to 17 species (*Artibeus planirostris*, *Artibeus lituratus*, *Carollia perspicillata*, *Platyrrhinus lineatus*, *Sturnira lilium*, *Artibeus fimbriatus*, *Myotis nigricans*, *Desmodus rotundus*, *Artibeus obscurus*, *Noctilio albiventris*, *Phyllostomus discolor*, *Phyllostomus hastatus*, *Chrotopterus auritus*, *Lasiurus ega*, *Chiroderma villosum*, *Pygoderma bilabiatum* and *Lasiurus blossevillii*) were captured. The estimated richness curves tended to stabilize, indicating that most of the species were sampled. Captured species represented 10% of the taxa recorded in Brazil and 28% in Paraná State, revealing the importance of this area for the diversity of bats. These findings indicate the need to determine actions aiming to restrict human activities in these forest fragments, in order to minimize anthropogenic impacts on the chiropterofauna.

Keywords: chiropterofauna, diversity, forest remnants, fragmentation.

Riqueza e abundância de espécies de morcegos em fragmentos de floresta estacional semidecidual do Alto Rio Paraná, sul do Brasil

Resumo

A planície de inundação do Alto Rio Paraná está inserida em uma região de bioma Mata Atlântica, área crítica para preservação. Pela carência de pesquisas acerca da quiropterofauna da região, o presente estudo investigou a riqueza e abundância de morcegos em remanescentes de floresta estacional semidecidual do alto rio Paraná, sul do Brasil. As amostragens foram realizadas mensalmente, de janeiro e dezembro de 2006, com a utilização de 32 redes de neblina com 8,0 × 2,5 m, resultando em 640 m²/h e totalizando um esforço de captura de 87.040 m²/h. Para a estimativa da riqueza foram utilizados os estimadores Chao1 e Jack2. Durante o estudo um total de 563 indivíduos pertencentes a 17 espécies (*Artibeus planirostris*, *Artibeus lituratus*, *Carollia perspicillata*, *Platyrrhinus lineatus*, *Sturnira lilium*, *Artibeus fimbriatus*, *Myotis nigricans*, *Desmodus rotundus*, *Artibeus obscurus*, *Noctilio albiventris*, *Phyllostomus discolor*, *Phyllostomus hastatus*, *Chrotopterus auritus*, *Lasiurus ega*, *Chiroderma villosum*, *Pygoderma bilabiatum* e *Lasiurus blossevillii*) foram capturados. As curvas de riqueza estimada tenderam à estabilidade, indicando que a maioria das espécies foi amostrada. As espécies capturadas representaram 10% dos táxons registrados para o Brasil e 28% para o estado do Paraná, revelando a importância dessa área para a diversidade de morcegos. Estes resultados indicam a necessidade de serem estabelecidas medidas para a restrição de atividades humanas nos fragmentos buscando-se minimizar os impactos antropogênicos sobre a quiropterofauna.

Palavras-chave: quiropterofauna, diversidade, remanescentes florestais, fragmentação.

1. Introduction

The Upper Paraná River floodplain is located in the latest stretch free of dams in the Paraná River within the Brazilian territory. Due to its location and importance as an ecological system, and the fact that is characterized as a region belonging to the Mata Atlântica biome, its preservation is critical. The anthropogenic activities in the area are related to deforestation of "várzea" environments for cropping, which usually involve the use of pesticides that may be carried to the waterbodies and to the marginal lakes, natural nurseries and feeding areas of several species (Vazzoler et al., 1997). This situation may generate an imbalance for the various components of the ecosystem, such as the chiroptero fauna that has been threatened over the time, mainly by insecticides and deforestation (Reis et al., 2007). Fenton et al. (1992) stated that bats diversity is generally greater in conserved areas, where species can fulfill their different niches, when compared to altered areas by the habitat conditions.

Environmental alteration has caused severe decline in the number of species, with the loss of important elements in different trophic levels and changes in the structure and functioning of the ecosystem, resulting in the simplification of the structure of taxocenoses from different species, including bats (Aguiar, 1994). The ability to fly tends to mitigate such situations, since these animals may move between fragments and explore the environments in a complex way (Almansa et al., 1982), performing important roles within ecosystems, acting in the maintenance of several ecological processes (Eisenberg, 1989), as pollinators agents, seed dispersers (Van Der Pijl, 1957) and controlling natural insects populations (Goodwin and Greenhall, 1961).

Some studies conducted in the Paraná State reported species richness and abundance of chiropterans in areas of stationnal semidecidual forests. Reis et al. (1993) studied the Londrina region, followed by Reis and Muller (1995), and reported the importance of forests for the diversity and conservation of chiropterans in the same locality. For instance, Miretzki and Margarido (1999) carried out a survey of bats in the Estação Ecológica do Caiuá, Diamante do Norte city; Bianconi et al. (2004) studied forest remnants in the Fênix municipality; and Ortêncio Filho et al. (2005) surveyed bats in the Parque Municipal do Cinturão Verde in Cianorte municipality. The stationnal semidecidual forest, in the area of this study, is the forest formation in the Paraná State with the highest species diversity of bats and, among the species in this state ten are exclusive to this biome (Miretzki, 2003).

Information on the species richness of bats will contribute as a database and will provide subsidies for future conservation programs of local chiroptero fauna. Therefore, the present study aimed to investigate the species richness and relative abundance of bats from the remnants from the stationnal semidecidual forest of the Upper Paraná River, southern Brazil.

2. Material and Methods

The study area includes the upper stretch of the Paraná River. The climate is classified as humid subtropical mesothermic (Cfa), with mean temperatures, in winter, inferior to 18 °C, with uncommon frosts; and during the summer, above 22 °C and tendency of rainfall concentrations (Agostinho and Zalewski, 1996). The annual precipitation ranges from 1,400 to 1,500 mm (IAPAR, 1994).

The study was accomplished during one night per month, from January to December 2006, throughout the nocturnal period, beginning when the light intensity was lesser than 5 Lux, and ending when the same reached value higher than the previously cited, determined using the digital Minipa® luximeter (MLM-1010). Thus, between April and August, the number of sampling hours was 12 hours and in the other months it was 11 hours, except in January, when it lasted ten hours.

In the beginning and in the end of the samples, air temperature was measured using psicrometer, and precipitation data were provided by the Instituto Tecnológico SIMEPAR. Air temperature ranged from 10.0 °C (August) to 31.3 °C (December), with annual mean of 21.5 °C. The months between April and June were the drier ones, with the least precipitation in May (16.2 mm). Greater precipitation was registered from January to March, peaking in December (259.0 mm). In general, higher precipitation coincided with warmer months.

The area is formed by stationnal semidecidual forest (Campos and Souza, 1997), composed mainly by the families Leguminosae (12.6%), Poaceae (7.1%), Euphorbiaceae (5.4%), Rubiaceae (4.9%), Cyperaceae (4.1%), Myrtaceae (5.4%) and Asteraceae (3.1%) (Souza and Kita, 2002).

Samplings were performed in four fragments: 1) Field station (22° 45' S and 53° 15' W): degraded forest remnant of about 1.7 ha (Souza et al., 2005); 2) Mutum Island (22° 48' 18" S and 53° 13' 26" W): total area of 1,012 ha, with partial deforestation of its forest (Correa, 1998), sampling sites encompassed approximately 1.5 ha; 3) Araldo Forest (22° 47' 37" S and 53° 19' 03" W): remnant with about 20.0 ha, formed by a marginal strip subjected to flooding during seasonal floods (Souza and Monteiro, 2005); and 4) Unida Farm (22° 41' 01" S and 53° 17' 34" W): altered forest remnant, isolated by a matrix for cultivation of exotic fruit species, pasture and natural regeneration, with 1.22 ha (Souza, 2004) (Figure 1).

To capture the bats, 32 mist nets were used, eight in each sampling site, with 8.0 × 2.5 m, resulting in 640 m²/h per hour and totaling a capture effort of 87.040 m²/h (Straube and Bianconi, 2002); the nets were set between 0.5 and 3.0 m from the ground to facilitate the capture of frugivorous phyllostomids that due to the higher food availability in the region, they are frequent in the stratum corresponding to the sub-forest (Pedro,

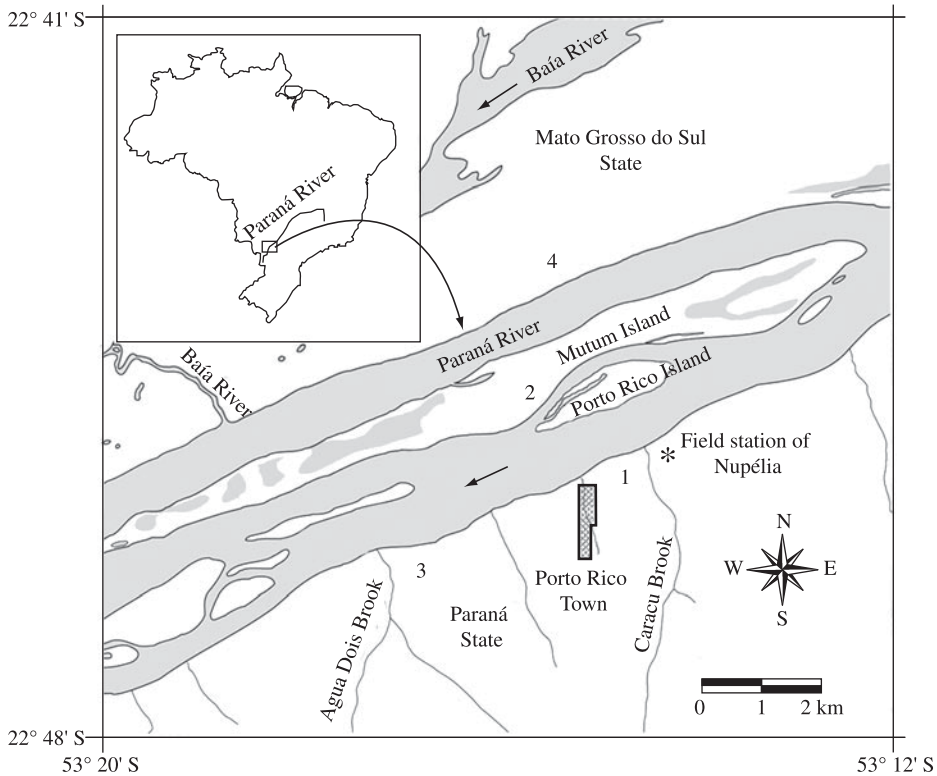


Figure 1. Area of captures with the respective selected sites in the Upper Paraná River floodplain: 1) Field Station, 2) Mutum Island, 3) Araldo Forest and 4) Unida Farm.

1998). The capture method were based on Greenhall and Paradiso (1968), with nets set in places with high preference of bats in their movements, as forest clearings, little busy roads, trails and waterways, and inspected every 15 minutes, following criteria of Reis (1984).

After the capture, the length of the forearm and the weight were taken and then the species identified. Two individuals from each species were deceased with an intraperitoneal dose of sodium tiopental (Ortêncio Filho et al., 2005), and fixed in formaldehyde 10% during 48 hours and, then preserved in alcohol 70%. The individuals were identified using stereoscopic microscope, according to Vizoto and Taddei (1973), Jones and Carter (1976) and Gregorin and Taddei (2002), confirmed by Professor Adriano Lucio Peracchi (Universidade Federal Rural do Rio de Janeiro) and deposited in the Laboratório de Zoologia of Universidade Paranaense, Campus Cianorte. All captured bats were labeled with aluminum rings (Etiquetal-models 3.5 and 4.0), in their left forearm, allowing to identify possible recaptures.

In order to extrapolate the species richness of bats in the region of Porto Rico municipality, the EstimateS software (version 5.0.1) was used (Colwell, 1997), and the following non-parametric methods were employed Chao1 and Jack2 (Jackknife2).

3. Results

During the studied period, we capture 563 bats, belonging to 17 species. A total of 0.007 bats/m².h was sampled. Phyllostomidae presented the highest number of species (13), with the predominance of frugivorous (10), followed by two carnivorous species and one hematophagous (Gardner, 1977). Vespertilionidae was represented by the insectivores *Lasiurus blossevillii*, *L. ega* and *Myotis nigricans*, whereas Noctilionidae by *Noctilio albiventris* which consumes insects and fishes (Gardner, 1977) (Table 1).

The most frequent species in the samplings was *Artibeus planirostris* which totaled 24.2% of the captures, followed by *A. lituratus* and *Carollia perspicillata* (21.3% each), *Platyrrhinus lineatus* (10.8%) and *Sturnira lilium* (7.5%). Together, these species accounted for 85.1% of all captured bats, whereas the remaining 12 species represented only 14.9% of the total. The study was marked by the low occurrence of some species, since 41.2% of the species presented number of captures equal or inferior to four individuals.

The curves of estimated species richness in relation to the curve of observed species indicated a trend to stability for the bat species captured in accordance

Table 1. Bats captured in forest fragments from the Upper Paraná River, Brazil, between January and December, 2006.

| Taxa | Number of captures | Relative abundance (%) | Feeding habit* |
|--|--------------------|------------------------|----------------|
| PHYLLOSTOMIDAE | | | |
| Desmodontinae | | | |
| <i>Desmodus rotundus</i> (E. Geoffroy, 1810) | 7 | 1.2 | Hematophagous |
| Phyllostominae | | | |
| <i>Chrotopterus auritus</i> Peters, 1865 | 2 | 0.4 | Carnivorous |
| <i>Phyllostomus discolor</i> Wagner, 1843 | 4 | 0.7 | Frugivorous |
| <i>Phyllostomus hastatus</i> (Pallas, 1767) | 2 | 0.4 | Omnivorous |
| Carollinae | | | |
| <i>Carollia perspicillata</i> (Linnaeus, 1758) | 120 | 21.3 | Frugivorous |
| Stenodermatinae | | | |
| <i>Artibeus fimbriatus</i> Gray, 1838 | 32 | 5.7 | Frugivorous |
| <i>Artibeus lituratus</i> (Olfers, 1818) | 120 | 21.3 | Frugivorous |
| <i>Artibeus obscurus</i> (Schinz, 1821) | 5 | 0.9 | Frugivorous |
| <i>Artibeus planirostris</i> (Spix, 1823) | 137 | 24.2 | Frugivorous |
| <i>Chiroderma villosum</i> Peters, 1860 | 1 | 0.2 | Frugivorous |
| <i>Platyrrhinus lineatus</i> (E. Geoffroy, 1810) | 61 | 10.8 | Frugivorous |
| <i>Pygoderma bilabiatum</i> (Wagner, 1843) | 1 | 0.2 | Frugivorous |
| <i>Sturnira lilium</i> (E. Geoffroy, 1810) | 42 | 7.5 | Frugivorous |
| VESPERTILIONIDAE | | | |
| <i>Lasiurus blossevillii</i> (Lesson and Garnot, 1826) | 1 | 0.7 | Insectivorous |
| <i>Lasiurus ega</i> (Gervais, 1856) | 2 | | |
| <i>Myotis nigricans</i> (Schinz, 1821) | 22 | 0.2 | Insectivorous |
| NOCTILIONIDAE | | | |
| <i>Noctilio albiventris</i> Desmarest, 1818 | 4 | 3.9 | Insectivorous |
| Total | 563 | 100 | |

*Gardner (1977)

with the employed method (Figure 2). The bats survey in the region of Porto Rico city reached between 70.2 (24.23 ± 0.00) for Jack2 and 95.8% (17.75 ± 1.42) for Chao1 of expected species, considering the limitations of the applied sampling method, that is, the set of the nets near the ground.

4. Discussion

The 17 captured species accounted for 10% of the species recorded in Brazil and 28% in Paraná State (Reis et al., 2007). The present study registered lower values of species richness when compared to others carried out in this state, possibly due to the fact that these surveys used other capture methods in the other studies. For example, in the region of Londrina municipality, in 680 ha of forest remnants, 42 species were registered (Reis et al., 2008); in the 52,000 ha in the Telêmaco Borba municipality, 22 species were observed (Reis et al., 1999); and, in the 170,000 ha of Parque Nacional do Iguaçu, in the Foz do Iguaçu municipality, 26 species were sampled (Sekizawa et al., 2001).

In the present study, we did not conducted samplings in shelters; thus, individuals of Molossidae, commonly found in these places or captured using other sampling gears, were not registered. Therefore, the number of sampled species in the forest fragments of the region of Porto Rico, which totaled about 26.8 ha from a floodplain region with 526,752 ha (Agostinho and Zalewski, 1996), revealed the importance of this area for the diversity of bats.

In contrast, values of species richness lower than we registered were verified in other studies performed in Northwestern Paraná State, such in the 1.427 ha from the Estação Ecológica do Caiuá, with 14 species (Miretzki and Margarido, 1999), 16 species in 703 ha of forest fragments in the Fênix municipality (Bianconi et al., 2004) and, in the Parque Municipal do Cinturão Verde de Cianorte, area of 312 ha, with 12 registered species (Ortêncio Filho et al., 2005). Sampling time (Santos, 2003) and effort (Straube and Bianconi, 2002) may also have influenced these results.

The predominance of Phyllostomidae (76%) in the samples occurred due to the capture method which

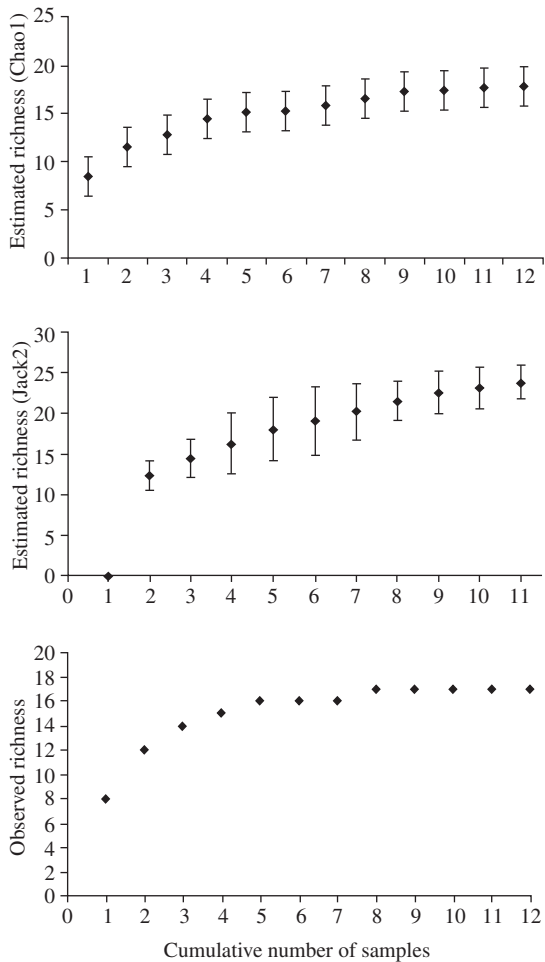


Figure 2. Estimated species richness for bat species in forest fragments from the Upper Paraná River, according to Chao1 and Jackknife2 estimators between January and December, 2006.

is characterized by the installation of the nets near the ground (Pedro and Taddei, 1997), more efficient in capturing frugivorous species from the sub-forest stratum, and carnivorous, which capture invertebrates or even small vertebrates, present in the foliage of the shrub layer (Fleming, 1982; Nowak, 1994). On the other hand, this family is the richest in the Neotropical region (Fenton et al., 1992), and their representatives do not have sharp ability to detect nets (Nowak, 1994).

The low diversity of Vespertilionidae (18%) was also due to the capture method, since these animals easily perceive the nets (Greenhall and Paradiso, 1968). Similar situation explains Noctilionidae (6%) which uses echolocation to capture insects and fishes (Nowak, 1994). As mentioned, the absence of individuals of Molossidae may be ascribed to the fact that these insectivorous fly high, above the canopy of trees (Greenhall and Paradiso, 1968), as well as because samplings in shelters were not conducted (Gregorin and Taddei, 2002).

The existence of few remnants, caused by habitat fragmentation (Mikich and Silva, 2001), may generate loss of species in the region due to anthropogenic changes in the habitats (Reis and Muller, 1995). This favors the increase in the density of bats as *A. planirostris*, *A. lituratus*, *C. perspicillata*, *P. lineatus* and *S. lilium*, which consume fruits (Gardner, 1977), common in the region. These species represented 85.1% of the total sampled at the expense of those demanding species, whose abundance was very low or even null. The predominance of some species in the study area is related to the fact that they are abundant in the Neotropical realm due to their diets which are composed by regionally common fruits (Medellín et al., 2000), represented by Solanaceae, Cecropiaceae, Moraceae and Piperaceae Families (Souza and Monteiro, 2005).

It must be highlighted that, for 53% of species, five or fewer individuals were sampled, which may suggest the fragility of *C. auritus*, *P. discolor*, *P. hastatus*, *A. obscurus*, *C. villosum*, *P. bilabiatum*, *N. albiventris*, *L. blossevillii* and *L. ega* to the region. Pires et al. (2006) argued that, due to low population densities, less abundant species are more susceptible to local extinctions or to restricted distribution, as in the case of the above mentioned species. In addition, it is important to emphasize the occurrence of bats associated to food availability, such as *C. villosum*, specialist in the consumption of *Ficus* (Zortéa, 2007).

Some species, such as *A. lituratus*, present a high integration with the environment, considering aspects linked to the occupation of time, space and food, which evidences high adaptive potential (Reis et al., 2000). These same authors argue that environmental changes may lead to great occupation by trophic generalist species, inducing the displacement of more sensitive species to other areas and, hence, decreasing the species richness in a fragment.

The low captures of *C. auritus* and *P. hastatus* (Phyllostominae) may be due to the fact that these large bodied animals present tendency to be poorly represented in perturbed areas (Medellín et al., 2000). *Chrotopterus auritus*, a large bodied carnivore (Nogueira et al., 2007), that acts as top predator, may disappear more quickly (Pires et al., 2006).

Desmodus rotundus, the only hematophagous species recorded, is characterized as the most common and abundant species with such feeding habit, and it is distributed throughout Brazil (Aguiar, 2007). The occurrence of this species in the studied region may be associated to the availability of food resource from wild origin, as well as cattle from farms close to our sampling sites.

In relation to bats from the Paraná State, some species were captured for the first time in the Northwestern region of this state. *Phyllostomus discolor*, was previously recorded only in the Northern region, *A. obscurus* (Eastern, Southwestern and Northern regions; Reis et al., 2008) and *L. ega* in the Northern region (Miretzki,

2003). These findings point out the importance of these fragments, even modified.

Indeed, the studied area may be considered well surveyed, basing on the net captures. The results of the estimators suggest that our survey in the region of Porto Rico municipality reached between 70.2% (Jack2) and 95.8% (Chao1) of the total number of expected species, even considering the restrictions of the sampling method. Therefore, the use of other sampling techniques certainly would beget records of other species, especially those belonging to Vespertilionidae and Molossididae.

In the present study, the species richness estimators tended to the stability, however, the curve from the Chao1 estimator presented such result faster than the other one. In the Jack2 estimator, the curves stabilization followed the accumulation curve of observed species. Between the estimative of species richness obtained in the analysis, Jack2 presented a number of species greater than 24. The Chao1, although had estimated only 17 species for the local, presented the greatest standard deviation, in spite of decreasing the result reliability, emphasized the chance of existing until 19 species for the area.

The estimators of species richness used here are based on the rarity quantification to determine diversity (Santos, 2003). Therefore, the species analysis with this characteristic is of fundamental importance to assure the reliability of the obtained results and, certainly, the capture method used interfered in the efficiency of sampling those species.

During the sampling period, some low abundant species, that could be considered as rare, were sampled: three *Singletons* (*C. villosum*, *P. bilabiatum* and *L. blossevillii*), three *Doubletons* (*C. auritus*, *P. hastatus* and *L. ega*), five *Uniques* (*P. bastatus*, *P. discolor*, *C. villosum*, *P. bilabiatum* and *L. blossevillii*) and two *Duplicates* (*L. ega* and *C. auritus*). Nevertheless, the quantification of these species may be more associated to the capture method and to the characteristics of the species than to the low abundance of these organisms in the region. Some species may be abundant for the local, but, by the used method, it was not possible to sample them.

In the present study, considerable values of species richness and abundance of bats were verified, when compared to the other regions in the Paraná State, emphasizing the importance to conserve this area for the maintenance of this group diversity. Thus, it is important to restrain human activities in the fragments to retain the degradation of these environments, due to the occurrence of low abundant species. These results contribute for the knowledge about bats biology in the Northwestern region of Paraná State. The information produced suggests the need to accomplish conservation strategies focusing on the relevance to minimize the impacts in the area, since such condition may cause the loss of bat species diversity in the region.

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