

Bats of Parque Natural Municipal de Pouso Alegre

**BATS (MAMMALIA, CHIROPTERA) FROM THE PARQUE NATURAL
MUNICIPAL PROFESSOR DOUTOR FERNANDO AFONSO BONILLO
FERNANDES, MINAS GERAIS STATE, BRAZIL**

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Abstract. In Brazil, 186 species of bats have been recorded, of which 98 occur in the Atlantic Forest. This threatened biome is considered a biodiversity hotspot and contains more than half of the bat species recorded in South America. However, knowledge about this group is insufficient due to sampling gaps. The Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes is in the municipality of Pouso Alegre, state of Minas Gerais, and contains a fragment of seasonal semideciduous forest. The objective of this study was to survey the bat species of the park. Three sampling areas were determined, and campaigns were conducted monthly between November 2021 and December 2022. A total mist net sampling effort of 59,400 m².h resulted in

174 capture events of eight bat species from the Phyllostomidae and Vespertilionidae families. The assemblage was predominantly composed of generalist and frugivorous species, a pattern commonly reported for disturbed Atlantic Forest remnants sampled with ground-level mist nets. Despite the relatively low species richness observed, the accumulation curve indicated high sample adequacy within the adopted methodological framework. This study helps to fill the sampling gap regarding bats in southern Minas Gerais and contributes to the knowledge of the bat fauna of the Atlantic Forest.

Keywords: Atlantic Forest; bat assemblage; urban forest fragment; Wallacean shortfall.

INTRODUCTION

Fauna inventories are essential baseline studies for assessing biodiversity, especially in areas with knowledge gaps for certain groups. The data from these studies enable the recognition of patterns and interactions, promoting research in various areas such as taxonomy, ecology, and evolution (Sawaya 2008). Therefore, the lack of such studies creates barriers not only to a better understanding of species but also to the establishment of appropriate strategies for their conservation (Hortal *et al.* 2015, Whittaker *et al.* 2005).

In this context, bats can be considered a priority group, as they are diverse in terms of their morphology and ecology, participate in important ecological processes (Kunz & Fenton 2003), and some species are considered indicators of environmental quality (Jones *et al.* 2009) due to their sensitivity to changes in food availability and shelter (Schulze *et al.* 2000, Aguirre *et al.* 2003). Despite their importance, there are still many knowledge gaps about these animals (Eisenberg & Redford 1999).

Currently, 302 species of bats are registered in South America (Díaz *et al.* 2021), with 127 recorded in the Atlantic Forest (Abreu *et al.* 2025). Although most studies with bats in Brazil are concentrated in this biome, knowledge of the group is still fragmented, and many biologically relevant areas have not yet been surveyed (Peracchi & Nogueira 2008).

In addition to species inventories, studies addressing trophic structure, seasonal variation, and community organization provide important ecological information for understanding how bat assemblages respond to local environmental conditions and habitat characteristics, particularly in fragmented Atlantic Forest landscapes (Schulze *et al.* 2000, Jones *et al.* 2009, Gomes *et al.* 2015). These approaches help identify dominant trophic guilds, seasonal fluctuations in bat activity, and patterns of species distribution within assemblages, contributing to a broader understanding of bat ecology in human-modified environments (Meyer *et al.* 2016).

In southern Minas Gerais, available studies involving mammals in Atlantic Forest remnants remain relatively scarce and are mostly focused on non-volant mammals or isolated records (e.g., Costa *et al.* 2010, Santos *et al.* 2022). Information regarding bat assemblages in the region is still limited, particularly concerning ecological aspects such as trophic structure, seasonal variation, and community organization in fragmented landscapes.

Thus, to contribute to filling the Wallacean deficit concerning bat species in Brazil (Tavares *et al.* 2008, Hortal *et al.* 2015), this study aimed to inventory the bat fauna of a protected area located in the Atlantic Forest in southeastern Brazil, the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes (hereafter PNMFABF), as well as to describe patterns of trophic structure, capture frequency, and seasonal variation within the local bat assemblage.

MATERIAL AND METHODS

Study Area

The PNMFABF (22°12'57" S, 45°57'44" W) is a strictly protected area located in the municipality of Pouso Alegre, in the Vale do Sapucaí region, southern Minas Gerais state, southeastern Brazil (Figure 1). It covers an area of 178 ha, divided into a recreation area for the public and a restricted-access reserve composed of a fragment of seasonal semideciduous forest in various stages of regeneration. The park is surrounded by pastures, urban expansion, and monocultures; therefore, the fragment is an important refuge for biodiversity in the Pouso Alegre

microregion (Santos *et al.* 2022, Costa *et al.* 2010). The region presents a Cwb climate, classified as subtropical highland, with a mean annual temperature of 19.9 °C and annual precipitation ranging from 1,300 to 1,700 mm (Costa *et al.* 2010). The rainy season extends from October to March, with mean temperatures of approximately 23 °C and average monthly precipitation close to 240 mm, while the dry season occurs between April and September, with mean temperatures of approximately 18 °C and average monthly precipitation close to 50 mm. July is considered the driest month, with precipitation close to 20 mm (Costa *et al.* 2010). The region reaches a maximum altitude of approximately 1350 m (Neto 2017).

Species Inventory

Three sampling areas were established at the park's boundaries based on accessibility (a, b and c; Figure 1). Bat sampling was conducted over 12 campaigns, each lasting three consecutive nights, between November 2021 and December 2022 (excluding December 2021 and November 2022), totaling 36 sampling nights. All campaigns were carried out during the new moon phase (authorization no. 76896-1 SISBIO; CEUA approval no. 296/2021).

The same sampling areas were maintained throughout the study period to ensure temporal comparability, and mist nets were installed in predefined microhabitats during each of the three sampling nights per campaign. However, given bats' high mobility, captures obtained across nights and campaigns may not represent fully independent sampling events. Because individuals were not marked, recaptures on different nights could not be completely excluded. Therefore, the abundance metrics presented here should be interpreted as capture frequency rather than true measures of population abundance.

To capture the bats, 10 mist nets were used at each sampling area: six nets measuring 9 m x 2.5 m with 14 mm mesh and four nets measuring 14 m x 3.0 m with 25 mm mesh. Mist nets were installed at ground level near food sources, water bodies, flight paths, and potential shelters and were left open for six consecutive hours from sunset, being inspected at 20-minute intervals. The captured bats were placed in cotton bags, and biological information such as species, weight

(g), sex, reproductive status, and biometrics were collected for each individual. After being photographed, bats were released at the capture site at the end of the sampling night, minimizing the likelihood of recaptures within the same night. The specimens collected as voucher material were deposited in the *Coleção de Mamíferos do Centro de Coleções Taxonômicas da Universidade Federal de Minas Gerais* (CCT-UFMG) (Supplementary Material).

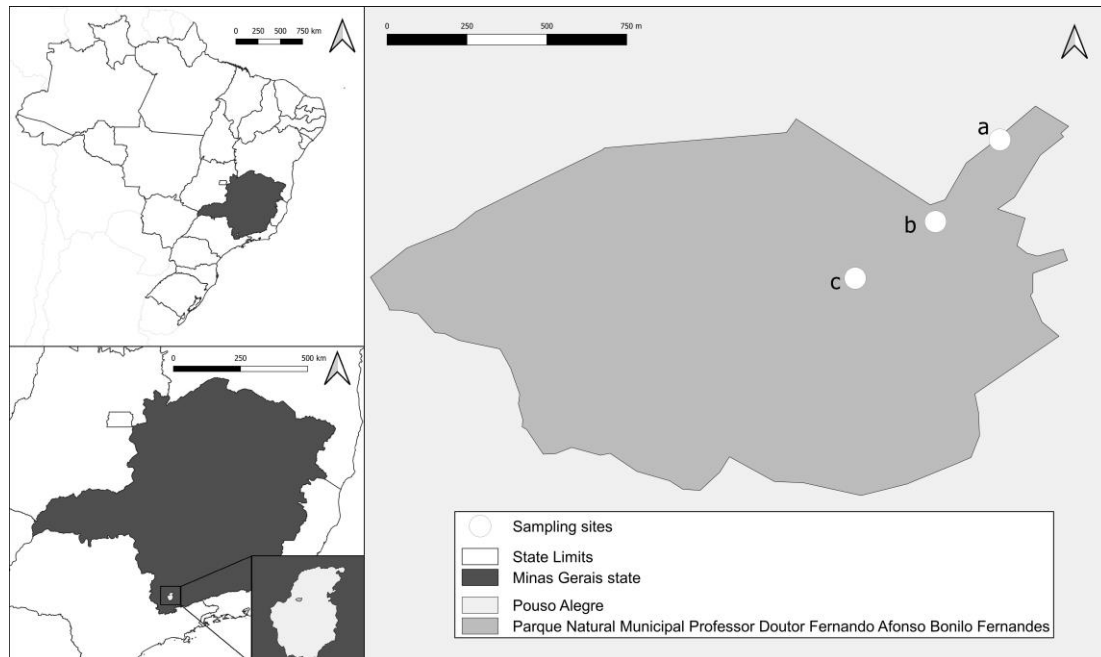


Figure 1. Map of the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes in Minas Gerais state, Brazil, showing the location of the sampling areas: a ($22^{\circ}12'52.27''$ S, $45^{\circ}57'40.86''$ W), b ($22^{\circ}13'1.17''$ S, $45^{\circ}57'47.89''$ W), and c ($22^{\circ}13'0.68''$ S, $45^{\circ}57'49.99''$ W).

Data Analysis

The sampling effort was calculated based on the method proposed by Straube & Bianconi (2002). To evaluate sampling sufficiency in relation to species richness, we constructed a sample-based species accumulation curve using sampling nights as the sampling unit. For this analysis, we used incidence data (presence/absence of each species per night), considering only standardized mist-net capture events. The accumulation curve was generated with 100 randomizations of sample order to obtain the mean accumulated richness and its variation across permutations. Sampling completeness was assessed using the first-order Jackknife estimator. Analyses were implemented in EstimateS v. 9.1.0 (Colwell & Coddington 1994).

In addition, ecological diversity indices such as the Shannon-Wiener diversity index (H') and Pielou's evenness index (J) were also generated for comparison with similar areas. These analyses were implemented using the software PAST 4.03 (Hammer *et al.* 2001), considering the standardized capture events obtained from the mist nets.

The relative frequency of species was calculated by dividing the number of capture events of each species by the total number of capture events recorded during the study. Given that individuals were not marked, these values represent capture frequency rather than true abundance.

Seasonal variation in species richness (number of species per sampling night) and capture frequency (number of individuals captured per night) were evaluated by comparing rainy and dry seasons. Prior to analysis, data distribution was tested for normality using the Shapiro–Wilk test. As assumptions of normality were not met, seasonal differences were assessed using the non-parametric Mann–Whitney U test (Zar 2010). To evaluate potential differences in species composition between seasons, we performed a one-way Analysis of Similarities (ANOSIM) based on a Jaccard distance matrix constructed from presence–absence data per sampling night. Statistical significance was assessed using 9,999 permutations. Data on precipitation and average temperature for the sampling period were extracted from the Instituto Nacional de Meteorologia (INMET) database from the “CALDAS (A530)” station located in the municipality of Caldas, MG (i.e., the station closest to the study area, approximately 75 km away). All analyses regarding seasonal differences in species richness and composition were conducted in PAST 4.03 (Hammer *et al.* 2001).

The species were consulted regarding their conservation status at global (IUCN 2026), national (MMA 2022), and state (COPAM 2010) levels. Additionally, data for species categorized as DD (Data Deficient) and NT (Near Threatened) at the national level were consulted through the available data on the Extinction Risk Assessment System – SALVE (ICMBio 2026) and at the state level through Fundação Biodiversitas (2007). The species were classified according to their preferred diet, following the information available in Reis *et al.* (2007). The taxonomic nomenclature follows Garbino *et al.* (2024). For species identification, we used the following

guides: *História Natural dos Morcegos Brasileiros: Chave de Identificação de Espécies* (Reis et al. 2017) and *Clave de Identificación de los Murciélagos de Sudamérica/Chave de Identificação dos Morcegos da América do Sul* (Díaz et al. 2016).

RESULTS

A total of 174 capture events, representing eight species, eight genera, and two families, were obtained in the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes through a standardized mist-net sampling effort totaling 59.40 m²·h. (Table 1; Figure 2). Phyllostomidae was the most diverse family (7 species) and the most representative in terms of capture events, accounting for 87.50% of the records, followed by Vespertilionidae (one species and 12.50% of the records). The species with the highest relative frequency was *Desmodus rotundus* (N=60, FR=34.48%), whereas *Platyrrhinus recifinus* showed the lowest relative frequency (N=2, FR=1.15%) (Table 1, Figure 3). The bat community was characterized by a small number of species accounting for a large proportion of capture events (*D. rotundus*, *C. perspicillata*, and *M. nigricans*), with most species (S=5) each representing less than 10% of the total records (Figure 3). The values of Pielou's evenness ($J' = 0.83$) indicate a relatively balanced distribution of capture frequencies among species, without strong numerical dominance by a single taxon, whereas the Shannon-Wiener index ($H' = 1.72$) reflects the overall diversity of the sampled bat assemblage.

Table 1. Bat species recorded for the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes, municipality of Pouso Alegre, state of Minas Gerais, Brazil. NEC = nectarivorous; FRU = frugivorous; HEM = hematophagous; INS = insectivorous. F = female, M = male; 1 = MMA (2022), ICMBio, 2026; 2 = Fundação Biodiveristas (2007), COPAM (2010); 3 = IUCN (2026IC); LC = Least Concern; NT = Near Threatened.

Species	Common name	Diet	Sampling point	Relative frequency %	Number of specimens	Conservation Status		
						Brazil ₁	Minas Gerais ₂	IUCN ₃
PHYLLOSTOMIDAE								
<i>Anoura caudifer</i>	Lesser Tailless Bat	NEC	A, C	5.75	6F, 5M	LC	LC	LC
<i>Artibeus fimbriatus</i>	Fringed Fruit-eating	FRU	A, B, C	4.60	5F, 3M	LC	LC	LC

Bat								
<i>Carollia perspicillata</i>	Seba's Short-tailed Bat Common Short-tailed Bat	FR U	A, B, C	25.86	20F, 25M	LC	LC	LC
<i>Desmodus rotundus</i>	Common Vampire Bat	HE M	A, B, C	34.48	15F, 45M	LC	LC	LC
<i>Glossophaga soricina</i>	Pallas's Long-tongued Bat	NE C	A, C	6.32	6F, 5M	LC	LC	LC
<i>Platyrrhinus recifinus</i>	Recife Broad-nosed Bat	FR U	A	1.15	1F, 1M	LC	NT	LC
<i>Sturnira lilium</i>	Little Yellow-shouldered Bat	FR U	A, B, C	6.90	3F, 9M	LC	LC	LC
VESPERTILIONIDAE								
<i>Myotis nigricans</i>	Common Black Myotis	INS	A, B, C	14.94	1F, 24M	LC	LC	LC

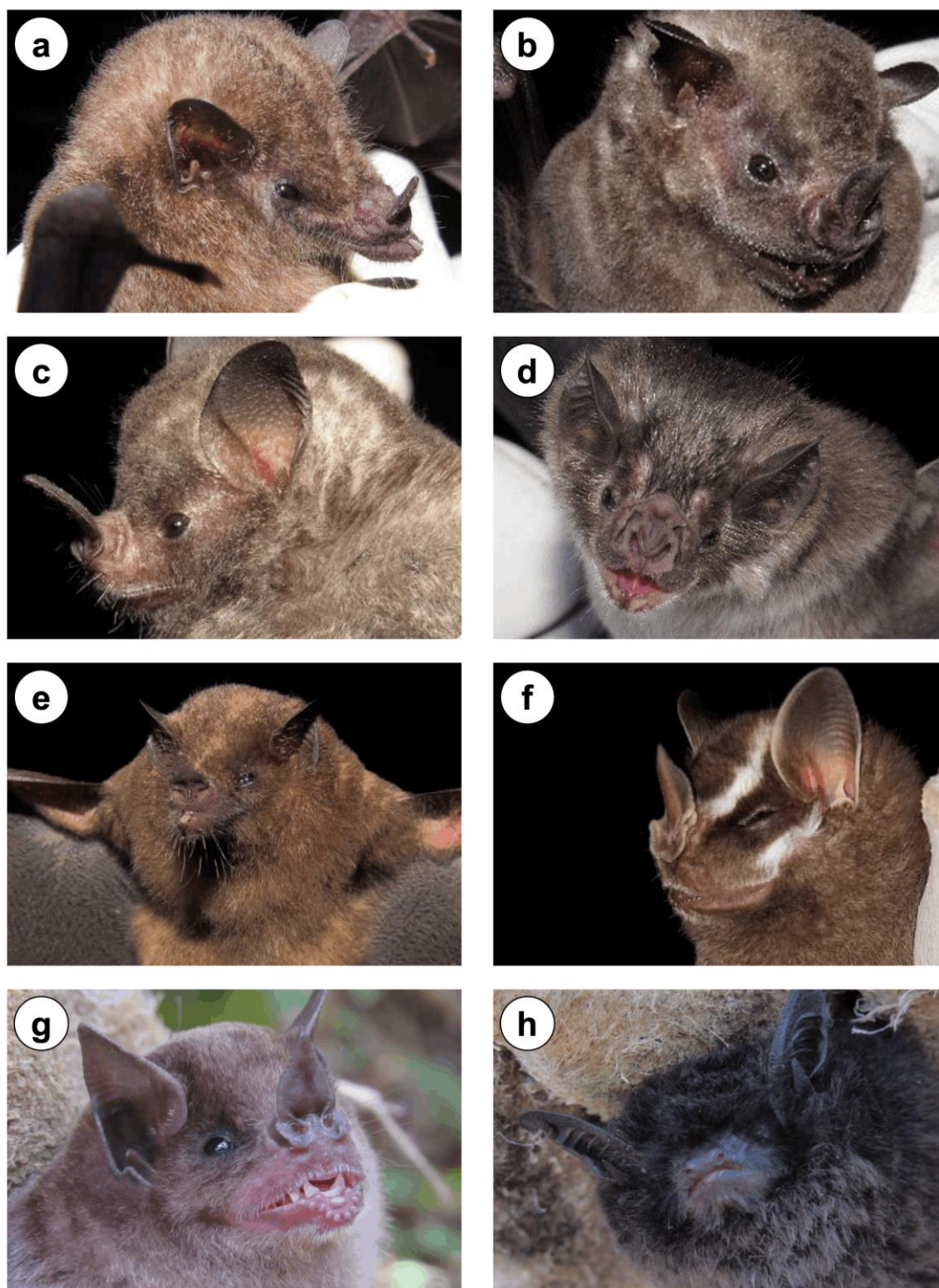


Figure 2. Bat species recorded for the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes, municipality of Pouso Alegre, state of Minas Gerais, Brazil: a) *Anoura caudifer*; b) *Artibeus fimbriatus*; c) *Carollia perspicillata*; d) *Desmodus rotundus*; e) *Glossophaga soricina*; f) *Platyrrhinus recifinus*; g) *Sturnira lilium*; h) *Myotis nigricans*.

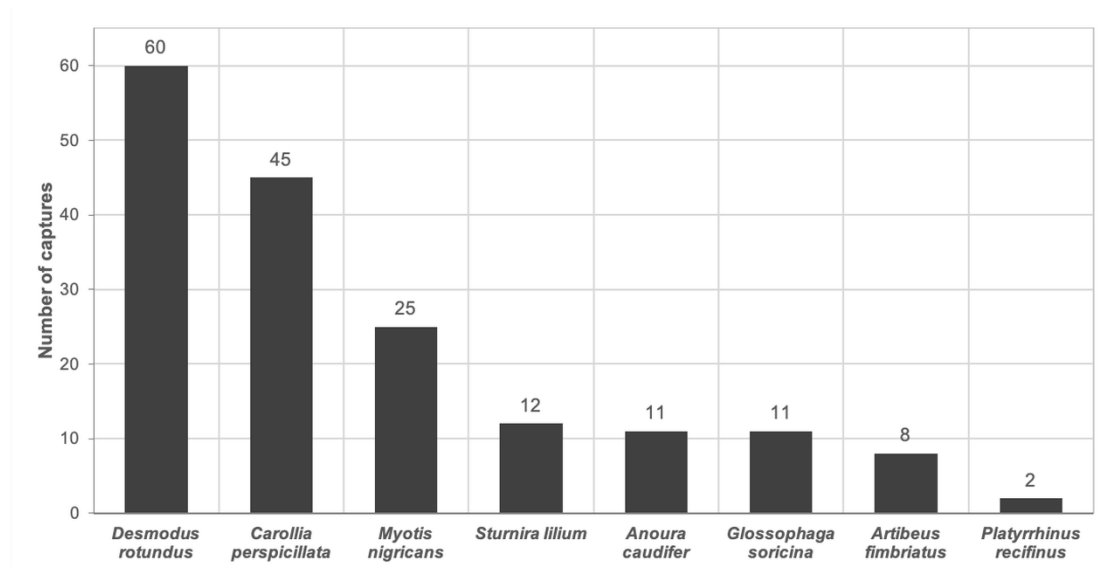


Figure 3. Number of capture events for each bat species through mist net sampling at the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes, Pouso Alegre, Minas Gerais state, Brazil.

The trophic structure of the assemblage showed that the frugivore guild was the most diverse ($S=4$) and the most representative in terms of capture events ($N=67$). The hematophagous guild, represented only by *D. rotundus*, was the second most representative guild. The

nectarivorous guild, although comprising two species, showed the lowest number of capture events (Figure 4).

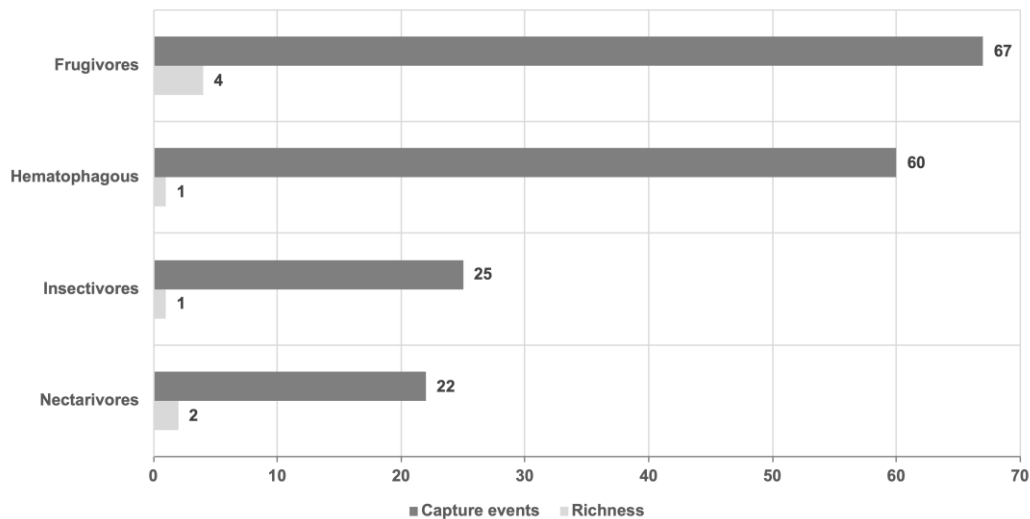


Figure 4: Distribution of the capture events and species richness by trophic guilds recorded through mist net sampling in the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes, municipality of Pouso Alegre, state of Minas Gerais, Brazil.

Regarding seasonality, monthly variation in species richness, capture frequency, temperature, and precipitation throughout the sampling period is presented in Figure 5. Species richness per sampling night differed significantly between seasons (Mann–Whitney $U = 459$, $z = 2.26$, $p = 0.02$), with higher species richness recorded during the dry season. The capture frequency per night was also significantly greater during the dry season (Mann–Whitney $U = 288$, $z = 4.17$, $p < 0.001$). Despite these differences, species composition did not vary between seasons (ANOSIM, $R = -0.019$, $p = 0.71$). All eight species were recorded in both dry (April to September 2022) and rainy seasons (November 2021 and October to March 2022).

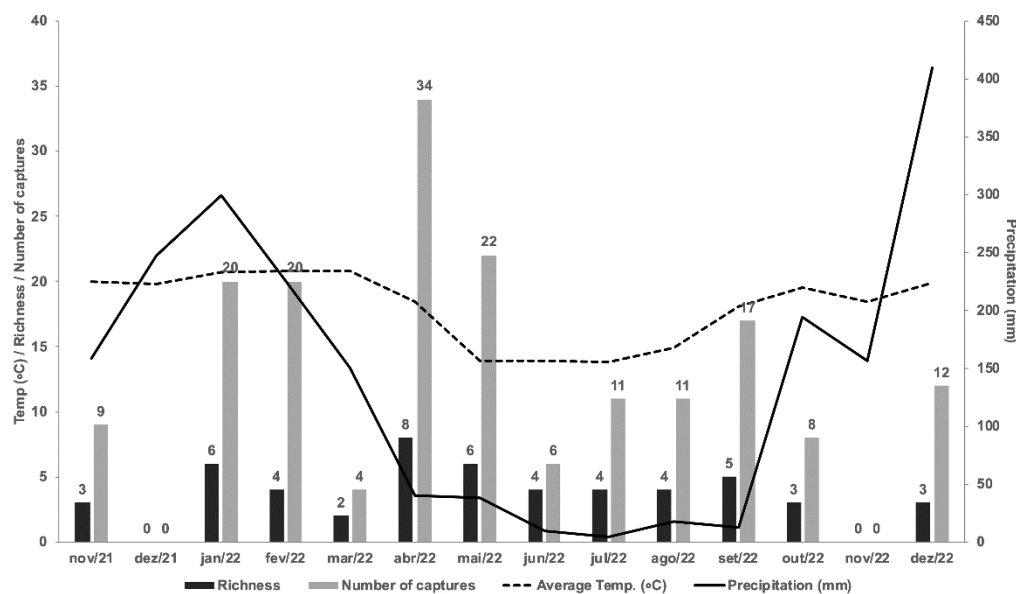


Figure 5. Monthly precipitation and mean temperature in relation to species richness and capture events of bats recorded during the sampling period at the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes, municipality of Pouso Alegre, state of Minas Gerais, Brazil. No sampling was conducted in December 2021 and November 2022.

The sample-based species accumulation curve showed a marked reduction in the rate of species addition as sampling nights progressed (Figure 6). The observed species richness reached a total of eight species by the end of the sampling period. The estimated richness, obtained using the first-order Jackknife estimator, showed slightly higher values during part of the accumulation process due to the occurrence of rare species records, but converged toward the observed richness at the end of the sampling period. This convergence ($S = 8$; $SD = 0$) reflects the absence of species recorded in only one sampling unit and indicates low influence of rare species on richness estimation. In addition, the narrow confidence intervals and the concordance between observed and estimated richness support a high level of sample adequacy within the methodological and temporal framework adopted in this study. The conservation status of most of the recorded bat species were classified as “Least Concern” in the consulted threat lists, except for *Platyrrhinus recifinus*, categorized as “Near Threatened” (NT) at the state level in Minas Gerais (Table 1).

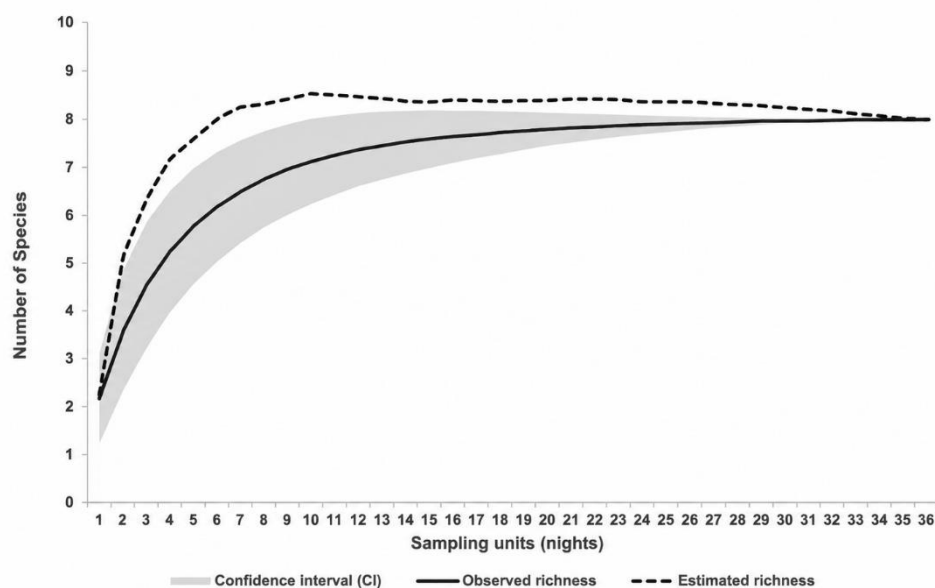


Figure 6: Sample-based species accumulation curve for the bat community of the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes, municipality of Pouso Alegre, state of Minas Gerais, Brazil, using sampling nights as the sampling unit. The observed richness curve was generated using 100 randomizations, and estimated richness was calculated using the first-order Jackknife estimator.

DISCUSSION

The bat species recorded for the Parque Natural Municipal Professor Doutor Fernando Afonso Bonillo Fernandes in Pouso Alegre correspond to 9% of the bat fauna of the state of Minas Gerais (Ferreira *et al.* 2024), 7% of the species of the Atlantic Forest (Abreu *et al.* 2025), and 5% of the Brazilian bat fauna (Abreu *et al.* 2025). As expected, the family Phyllostomidae was the most diverse and most representative in terms of capture events, as found in studies conducted in similar areas (e.g., Bianconi *et al.* 2004, Esbérard *et al.* 2006, Nascimento *et al.* 2013, Batista *et al.* 2018). This pattern is common in bat inventories in the Neotropical region due to the high richness of this family, which includes the greatest diversity of Neotropical bats (230 species) (Mammal Diversity Database 2026). In addition, the use of mist nets set at ground level is an efficient method for capturing species that forage in the understory, which are generally included in Phyllostomidae (Fleming 1982). However, mist nets tend to under-sample other bat families composed of aerial insectivores that forage at higher altitudes (Voss & Emmons 1996; Simmons

& Voss 1998) and possess more efficient echolocation systems, allowing them to detect and avoid mist nets (Batista *et al.* 2018).

Among the three species with the highest relative frequency, only *C. perspicillata* is frequently captured in studies conducted in the Atlantic Forest (Muylaert *et al.* 2017). This species shows a certain degree of tolerance to anthropogenic disturbances, occurring even in altered environments (Reis *et al.* 2007). Its occurrence is strongly related to the presence of *Piper* plants, which were widely found in the sampling areas in this study. The high relative frequency of common vampire bats (*D. rotundus*) may be explained by the herds raised in the pastures surrounding the park, which serve as a food resource for this species (Costa & Esberárd 2011). Finally, the captures of *Myotis nigricans* may reflect the sampling strategy adopted to reduce capture limitations of mist nets, such as positioning nets near potential roosts (quarries in the park) and water bodies and opening them before sunset to capture bats leaving their roosts (Pacheco *et al.* 2010). Other species, although common in Atlantic Forest bat inventories (Muylaert *et al.* 2017), were less frequent in the present study, possibly reflecting local environmental characteristics or regional variation in relative frequency (Muylaert *et al.* 2017, Batista *et al.* 2018).

Because captured individuals were not individually marked, recaptures across different sampling nights could not be unequivocally identified. Consequently, the capture frequencies reported here should be interpreted as measures of capture frequency rather than true population abundance (Otis *et al.* 1978). Nevertheless, as the same sampling protocol was consistently applied throughout the study, these data provide a reliable basis for describing the relative representation of species within the sampled assemblage and for comparing seasonal patterns of capture.

The values for Pielou's equitability ($J' = 0.8282$) and Shannon diversity index ($H' = 1.722$) are consistent with the observed structure of the assemblage. The relatively high evenness indicates that capture frequencies were not strongly dominated by a single species, despite the higher representation of *Desmodus rotundus*, *Carollia perspicillata*, and *Myotis nigricans*

compared with the remaining species. This pattern indicates that the Pielou index reflects the absence of extreme numerical dominance by a single taxon rather than an equal distribution of capture frequencies among all species (Gotelli *et al.* 2009). The Shannon diversity value falls within the range reported for Atlantic Forest bat inventories (0.418–2.605), which varies according to sampling design, effort, and local environmental conditions (e.g., Barros *et al.* 2006; Lourenço *et al.* 2010; Hoppe *et al.* 2020). Thus, the diversity observed in the park is consistent with patterns documented for comparable Atlantic Forest remnants.

The high representation of frugivorous species, although an expected result, is particularly noteworthy because these bats are considered key elements in forest conservation and restoration due to their numerical representativeness (i.e., in terms of species richness and capture frequency), as well as their high mobility and efficiency in seed dispersal (Mikich *et al.* 2015).

Capture frequency and nightly species richness were significantly higher during the dry season, whereas species composition did not differ between seasons. This pattern suggests that seasonal variation influences bat activity and detectability without evidence of seasonal changes in species composition. Although food resources are generally more abundant during the rainy season and many species synchronize reproductive events with this period, precipitation may reduce flight activity and capture success. Studies conducted in the Atlantic Forest have reported decreased capture efficiency during rainy nights, likely due to reduced foraging activity and increased detectability of mist nets by bats under wet conditions (Esbérard *et al.* 2005, Carvalho *et al.* 2011). In southeastern Brazil, seasonal variation in bat activity has also been associated with temperature and resource availability (Laurindo & Gregorin 2018), and differences between dry and rainy seasons have been documented in other Atlantic Forest inventories (Gomes *et al.* 2015, Ortêncio-Filho *et al.* 2014). Therefore, the higher capture frequency and nightly richness observed during the dry season indicate a seasonal effect on capture frequency and species richness, whereas species composition remained unchanged between seasons.

Although the observed richness was modest ($S = 8$), the species accumulation curve showed progressively smaller increments in species richness toward the final sampling nights, and the

first-order Jackknife estimator converged to the same value ($S = 8$; $SD = 0$), indicating high sample adequacy within the adopted methodological framework. The absence of species recorded in only one sampling unit indicates a low influence of rare species on species richness estimation, reinforcing the stability of the accumulation curve (Colwell & Coddington 1994).

In comparison with other studies conducted in Atlantic Forest remnants, the differences observed in species richness likely reflect variation in fragment size, landscape context, and habitat heterogeneity rather than differences in sampling sufficiency alone. Inventories performed under comparable sampling effort have reported both similar and higher species richness values, frequently accompanied by more gradual accumulation patterns (Gomes *et al.* 2015; Batista *et al.* 2018). Studies conducted in urban forest fragments have shown that species richness may vary substantially even under standardized mist-netting protocols, suggesting that local environmental structure plays a key role in shaping assemblage composition (Batista *et al.* 2018). Areas characterized by higher structural complexity and environmental heterogeneity tend to exhibit higher species richness and extended accumulation trajectories (Gomes *et al.* 2015). Therefore, the richness recorded in the present study is consistent with expectations for small to medium-sized urban forest remnants and appears to be primarily shaped by local ecological constraints rather than insufficient sampling effort. Nevertheless, because ground-level mist nets tend to under-sample aerial insectivores and canopy-foraging species, complementary approaches such as canopy netting or acoustic monitoring may further refine the understanding of local bat diversity.

Platyrrhinus recifinus was the only species classified as "Near Threatened" at the state level in Minas Gerais (Fundação Biodiversitas 2007). Although this category does not indicate immediate extinction risk, it highlights taxa that may become threatened if current pressures persist (IUCN 2026). Furthermore, this species has recently been considered endemic to the Atlantic Forest (Garbino *et al.* 2021), reinforcing the conservation relevance of its record in the study area.

The bat assemblage of the PNM FABF is predominantly composed of generalist species known to tolerate moderate levels of disturbance. Nevertheless, even these widespread taxa play key ecological roles, including pollination, seed dispersal, and regulation of insect populations (Kunz *et al.* 2011). As the first inventory focused on bat diversity in the forest remnants of the Pouso Alegre microregion, this study provides baseline information that may support future research and contribute to local conservation planning.

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