

Occurrence of ectoparasitic flies (Diptera: Streblidae) of bats (Chiroptera: Mammalia) in a semideciduous forest remnant in Northern Paraná, Brazil

Ocorrência de moscas ectoparasitas (Diptera: Streblidae) de morcegos (Chiroptera: Mammalia) em um remanescente de floresta semidecídua no Norte do Paraná, Brasil

Jader Almeida de Barros Silva¹, Tiago de Azevedo Pires², Diego Resende Rodrigues³, Laila Herta Mihsfeldt⁴, Marco Antonio Zanoni⁵

Abstract

This study constitutes the first record of parasitism and associations between bat flies ectoparasite of the Streblidae family and bats (Chiroptera: Phyllostomidae) in the São Francisco Forest State Park (SFFSP). The bats were captured using mist nets set up at various points along the park's visitor trail. Following collection, the bats were inspected for ectoparasites, which when found were collected with metal tweezers and stored in vials with 70% alcohol to be identified later. The captured bats were subjected to morphometrics so that the information obtained could help identify which bat species was the host of the ectoparasite collected and then they were released. A total of 36 dipterans from the Streblidae family belonging to six species from four genera: *Aspidoptera falcata* Wenzel, 1976; *Aspidoptera phyllostomatis* (Perty, 1833); *Megistopoda aranea* (Coquillett, 1899); *Megistopoda proxima* (Séguy, 1926); *Paratrachobius longicrus* (Miranda Ribeiro, 1907) and *Trichobius joblingi* Wenzel, 1966, infesting phyllostomids of four species: *Artibeus lituratus* (Olfers, 1818); *Artibeus planirostris* (Spix, 1823); *Carollia perspicillata* (Linnaeus, 1758) and *Sturnira lilium* (E. Geoffroy, 1810). The most abundant species were *Trichobius joblingi* (38.89%) and *Aspidoptera phyllostomatis* (27.78%).

Keywords: Parasitological index; Infra-Community; Parasitism; Phyllostomidae.

¹ Graduação em Ciências Biológicas pela Universidade Estadual do Norte do Paraná (UENP), Bandeirantes, Paraná, Brasil. E-mail: jader.barros321@gmail.com

² Graduação em Ciências Biológicas pela Universidade Estadual do Norte do Paraná (UENP), Bandeirantes, Paraná, Brasil.

³ Doutorado em Ciências Biológicas (Biodiversidade e Conservação de Habitats Fragmentados) pela Universidade Estadual de Londrina (UEL), Londrina, Paraná, Brasil. Professor na Universidade Estadual do Norte do Paraná (UENP), Bandeirantes, Paraná, Brasil.

⁴ Doutorado em Ciências (Entomologia: Biologia de Insetos) pela Escola Superior de Agricultura Luiz de Queiroz (ESALQ) da Universidade de São Paulo (USP), Piracicaba, São Paulo, Brasil. Professora na Universidade Estadual do Norte do Paraná (UENP), Bandeirantes, Paraná, Brasil.

⁵ Doutorado em Zootecnia pela Universidade Estadual de Maringá (UEM), Maringá, Paraná, Brasil. Professor na Universidade Estadual do Norte do Paraná (UENP), Bandeirantes, Paraná, Brasil.

Resumo

Este estudo constitui o primeiro registro de parasitismo e associações entre moscas ectoparasitas de morcegos da família Streblidae e morcegos (Chiroptera: Phyllostomidae) no Parque Estadual Floresta São Francisco (PEFSF). Os morcegos foram capturados usando redes de neblina instaladas em vários pontos ao longo da trilha de visitantes do parque. Após a coleta, os morcegos foram inspecionados em busca de ectoparasitas, que, quando encontrados, eram coletados com pinças metálicas e armazenados em frascos com álcool 70% para serem identificados posteriormente. Os morcegos capturados foram submetidos à morfometria para que as informações obtidas pudessem ajudar a identificar qual espécie de morcego era a hospedeira do ectoparásita coletado e, em seguida, foram liberados. Um total de 36 dípteros de Streblidae foram coletados, pertencentes a seis espécies de quatro gêneros: *Aspidoptera falcata* Wenzel, 1976; *Aspidoptera phyllostomatis* (Perty, 1833); *Megistopoda aranea* (Coquillett, 1899); *Megistopoda proxima* (Séguy, 1926); *Paratrichobius longicrus* (Miranda Ribeiro, 1907) e *Trichobius joblingi* Wenzel, 1966, infestando filostomídeos de quatro espécies: *Artibeus lituratus* (Olfers, 1818); *Artibeus planirostris* (Spix, 1823); *Carollia perspicillata* (Linnaeus, 1758) e *Sturnira lilium* (E. Geoffroy, 1810). As espécies mais abundantes foram *Trichobius joblingi* (38,89%) e *Aspidoptera phyllostomatis* (27,78%).

Palavras-chave: Índice parasitológico; Infra-comunidade; Parasitismo; Phyllostomidae.

Introduction

Chiroptera, commonly known as bats, are an important group of living beings. In terms of species diversity, the Chiroptera are second only to the order Rodentia (rodents),⁽¹⁻²⁾ in terms of the number of species described. It is estimated that 25% of the mammal species currently described are bats.⁽³⁾ Brazil has around 180 species of bats distributed in 68 genera and nine families.⁽⁴⁻⁵⁾

Another important aspect of Chiroptera is their close relationship with parasites,⁽⁶⁾ especially related to the order Diptera,⁽⁷⁾ such as the bat flies of the Nycteribiidae family, common on the old continent and in Oceania, most of which are apterous individuals and commonly mistaken for small spiders due to their morphology, while the Streblidae are more common on the new continent and have a greater morphological variety, with brachypterous and winged forms existing.⁽⁷⁻⁹⁾

As obligate hematophagous ectoparasites of bats, these flies have the potential to be disease vectors between individuals in the same population or between different populations of bats, since several of these species tend to exhibit gregarious behavior and share shelters.⁽⁹⁻¹²⁾

Although it is a topic of relevance to the fields of Public Health and Ecology, many authors report that there is a certain scarcity of studies aimed at understanding the ecological aspects involved in the host-parasite relationship between chiropterans and their ectoparasites, and apparently most of the studies focusing on these two groups of animals are descriptive in nature.⁽¹³⁾

Based on that assumption, this study aims to fill a knowledge gap that exists between studies involving Chiroptera in the São Francisco Forest State Park (SFFSP) and make the first reports on the species of bat ectoparasites that are present in the fragment.

Materials and Methods

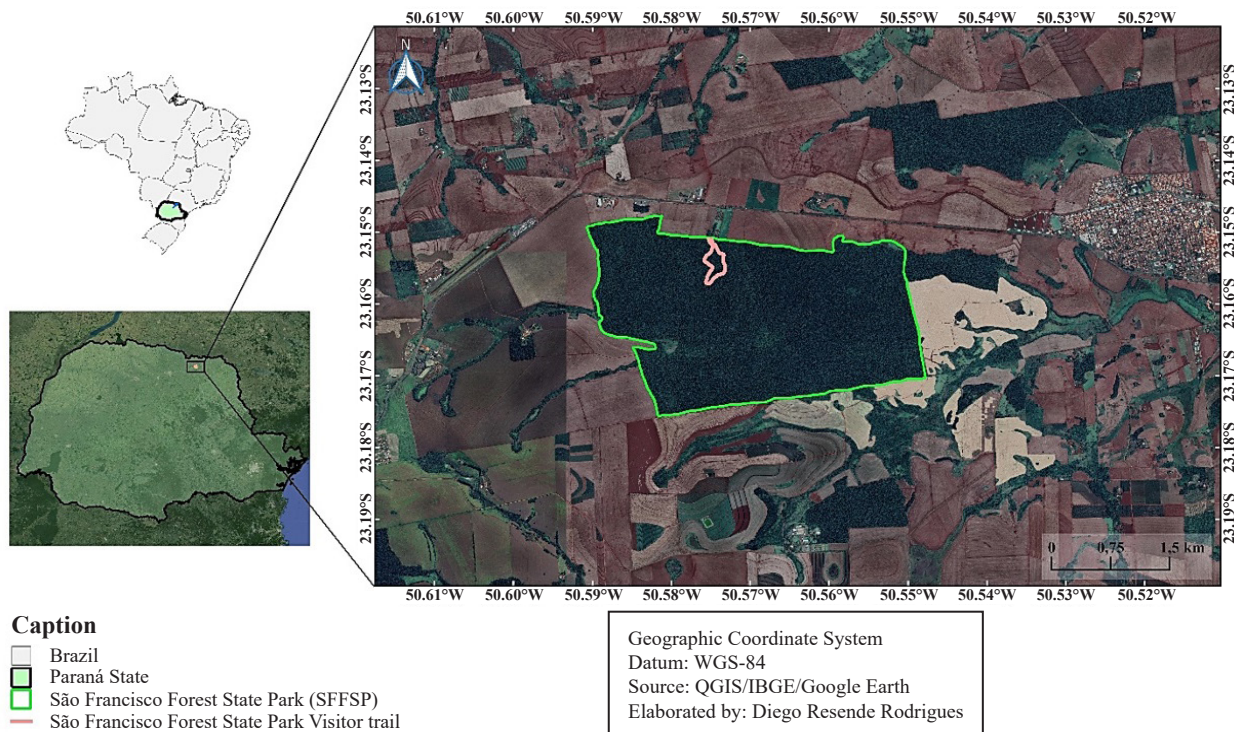
The study was carried out in the São Francisco Forest State Park (SFFSP), created by Decree-Law No. 4333 of December 5, 1994, located in the north of the state of Paraná, between the municipalities of Santa Mariana and Cornélio Procopio, latitude 23° 09' 55"S and longitude 50° 33' 93"W, with an area of 832.58 hectares, the forest is classified as Semideciduous Seasonal Forest⁽¹⁴⁾ (Figure 1).

Collections were made on the SFFSP visitor trail using six mist nets (three 9m × 2.5m and three 5m × 4m long). The nets were set up at ground level, starting at 18:00 and ending at 00:00. They were inspected every 30 minutes to check for catches.

The captured bats were removed using tweezers and gloves and placed in cotton bags for mor-

phometric sorting and weighing to help identify the species captured. After the morphometric measurements, they were placed in a cotton bag for five minutes and then released. Collections took place between February 2022 and November 2022, totaling a sampling effort of 2595 m²/hour of armed net.

Figure 1 - Map of the study area showing the São Francisco Forest State Park (SFFSP).



Source: author's own work.

The ectoparasites were collected using fine-tipped metal tweezers and a brush soaked in alcohol, and stored in an Eppendorf® with 70% alcohol. The collected streblid specimens were identified using a stereomicroscope and the pictorial key⁽¹⁵⁾ for species found in Paraná. After identifying the specimens, they were deposited in the collection of the zoology museum of the State University of Londrina (UEL), from MZUEL-ENT-0005 to MZUEL-ENT-0040.

The following ratios were used to analyze parasite-host associations: prevalence (number of bats infested / number of bats examined), average intensity of infestation (number of ectoparasites /

number of bats infested) and average abundance of infestation (number of ectoparasites / number of bats examined) according to Bush *et al.*⁽¹⁶⁾

Results

Richness and relative abundance of flies species

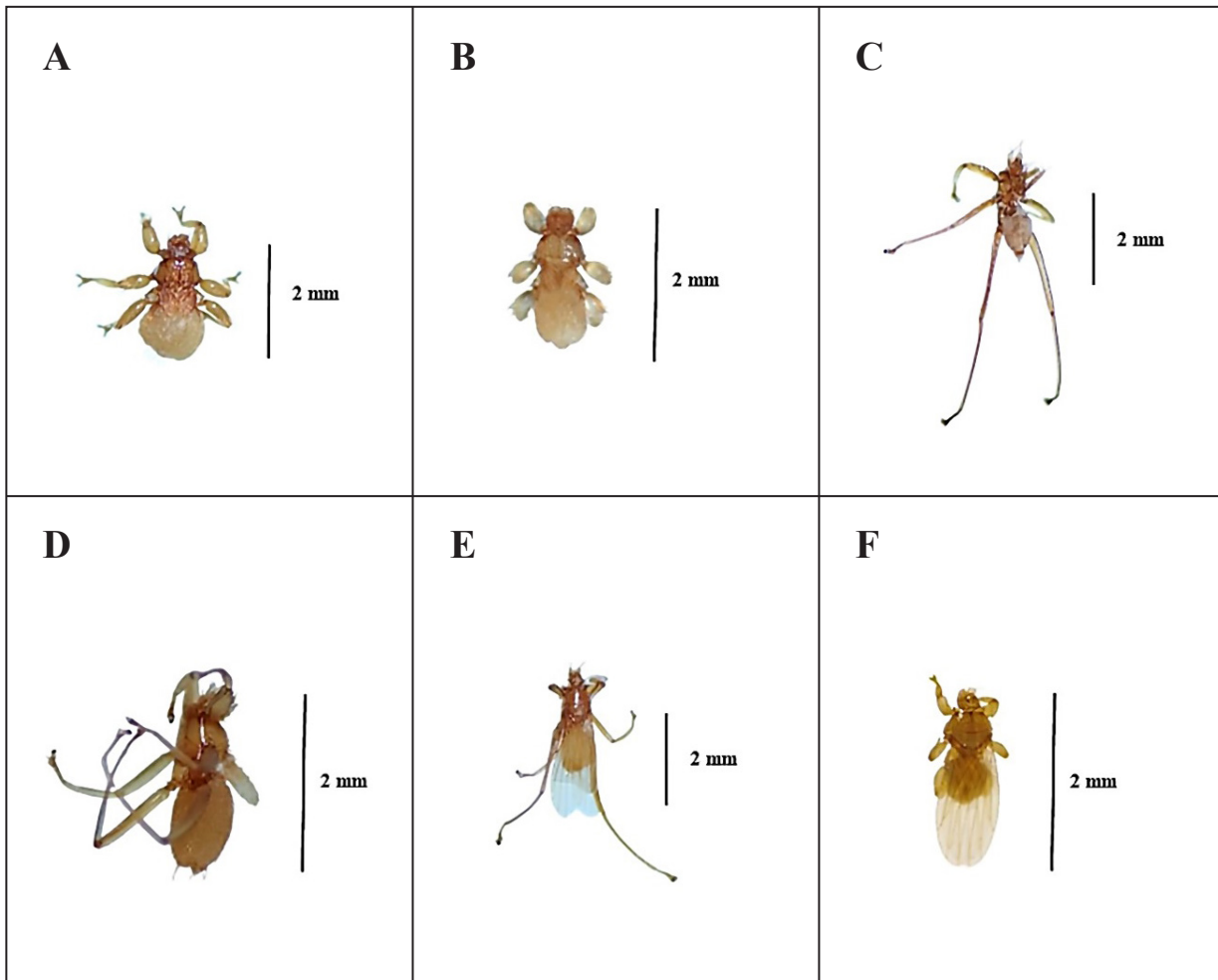
The study found six species of bat flies belonging to four genera: *Aspidoptera falcata* Wenzel, 1976; *Aspidoptera phyllostomatis* (Perty, 1833), *Megistopoda aranea* (Coquillett, 1899), *Megistopoda proxima* (Séguy, 1926), *Trichobius*

joblingi Wenzel, 1966 and *Paratrichobius longicrus* (Miranda Ribeiro, 1907) (Figure 2).

Among the 36 specimens collected, the most abundant species were *T. joblingi* (38.89%)

and *A. phyllostomatis* (27.78%). In contrast, *M. aranea*, *M. proxima*, *P. longicrus* and *A. falcata* each exhibited a relative abundance of less than 14%.

Figure 2 - Streblids found during the study: A, *Aspidoptera phyllostomatis*; B, *Aspidoptera falcata*; C, *Megistopoda aranea*; D, *Megistopoda proxima*; E, *Paratrichobius longicrus* and F, *Trichobius joblingi*.



Source: author's own work.

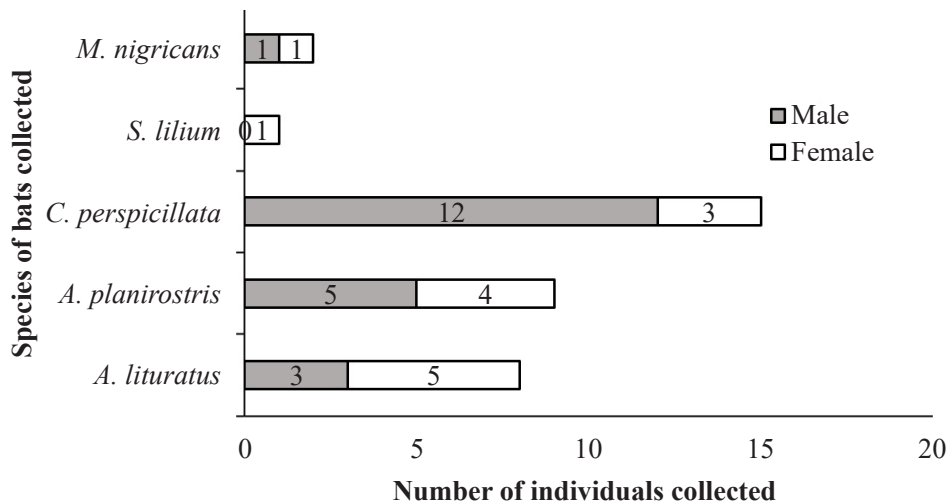
Wealth and relative abundance of bat species

Five species of bats belonging to four genera were found, one of which belongs to the Vespertilionidae *Myotis nigricans* (Schinz, 1821), and the rest to the Phyllostomidae: *Artibeus lituratus* (Olfers, 1818); *Artibeus planirostris* (Spix, 1823); *Carollia perspicillata* (Linnaeus, 1758) and *Sturnira lilium* (E. Geoffroy, 1810). A total of 35

bats were captured, distributed between 21 males (60%) and 14 females (40%) (Figure 3, on the next page).

The most abundant species were *C. perspicillata* (42.86%), *A. planirostris* (25.71%) and *A. lituratus* (22.89%). The species *M. nigricans* and *S. lilium* represent respectively (5.71%) and (2.89%), being the ones with the lowest relative abundance compared to the others that were collected.

Figure 3 - Number of males and females individuals of the bat species collected.



Source: author's own work.

Association between flies and bats

The 36 flies collected were infesting 14 bats of four species, all from the Phyllostomidae family. The bat species were parasitized by one to three fly species (Table 1), and the average infestation rate of the captured bats was 40%. No ectoparasites were found on specimens of the Vespertilionidae family (*M. nigricans*).

Artibeus lituratus was the species with the highest ectoparasite richness, being the only one to be infested by three species of flies and showing an infestation rate of 37.50%. *S. lilium* and *A. planirostris* had 100% and 66.67% infestation rates respectively, with each species being parasitized by two fly species. The fly species *T. joblingi* and *M. proxima* had the highest average intensity (IM) of ectoparasites per host, 3.5 (*T. joblingi*) and 4.0 (*M. proxima*) (Table 1).

Table 1 - Bat species and ectoparasites found during this study.

Bat species	Nm	Ni	Pm %	Ectoparasite species	Ne	Im	Pe %	Am
<i>A. lituratus</i>	8	3	37.5	<i>P. longicrus</i>	2	2,000	12,5	0,25
				<i>A. phyllostomatis</i>	4	2,000	25,00	0,50
				<i>M. aranea</i>	3	3,000	12,5	0,37
<i>A. planirostris</i>	9	6	66.67	<i>A. phyllostomatis</i>	6	1,200	55,55	0,66
				<i>M. aranea</i>	2	2,000	11,11	0,22
<i>C. perspicillata</i>	15	4	26.67	<i>T. joblingi</i>	14	3,500	26,66	0,93
<i>S. lilium</i>	1	1	100	<i>A. falcata</i>	1	1,000	100,00	1,000
				<i>M. proxima</i>	4	4,000	100,00	4,000
<i>M. nigricans</i>	2	0	0	N/A	0	N/A	N/A	N/A
Total/average	35	14	40	-	36	2,337	42,91	-

Caption: Nm = number of bats captured; Ni = number of bats infested; Pm = prevalence of ectoparasites of the bat species; Ne = number of ectoparasites collected; Im = average intensity of ectoparasites; Am = average abundance. **Source:** author's own work.

Discussion

When comparing the sampling effort of this study to other studies conducted in Paraná, as evidenced by the relatively low number of bats ($n=35$) and flies ($n=36$) collected, the observed species richness was similar to that found in other collection areas within the state.⁽¹⁷⁻²⁰⁾ This result suggests that, despite the lower sampling effort, the species diversity observed may be representative of the studied region. However, a study with a greater sampling effort could provide a more comprehensive understanding of species diversity.

It is important to note that a low species richness of this type of ectoparasite may be the result of inherent characteristics of the biogeographical area where the study is being carried out.⁽²¹⁾ The Seasonal Forest (FES) has the lowest species richness of streblid flies (43% $n=17$) compared to other phytophysionomies in Paraná such as the Mixed Ombrophilous Forest (FOM), 64% $n=25$ and the Dense Ombrophilous Forest (FOD), 46% $n=18$).⁽²²⁾ On the other hand, a study conducted in the Atlantic Forest in the state of São Paulo⁽²³⁾ showed that as the sampling effort increased, the species richness of streblid flies also increased.

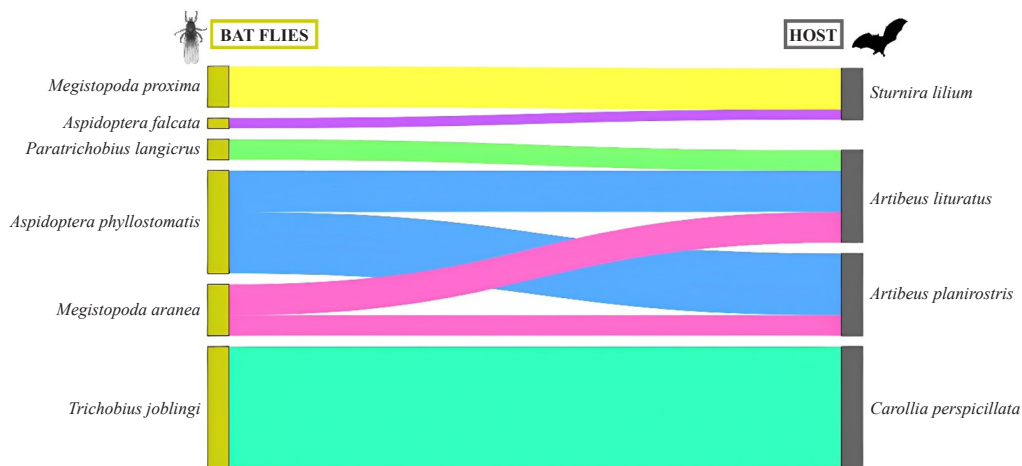
Of the five species exclusive to the FES, this study only reported the presence of *M. proxima*,

the other species found in the study are part of the 17 recorded in the FES, but are not exclusive to this forest formation. The species *A. phyllostomatis* and *T. joblingi* that were reported in the study also occur in the FOD.⁽²²⁾

Carollia perspicillata, which was the bat species with the highest number of individuals captured in this study and which in other studies^(17, 24-25) was being parasitized by more than one species of fly, was only being parasitized by *T. joblingi* in this study. A plausible explanation for this is the isolation of the study area (SFFSP) and the behavior of *C. perspicillata*⁽²⁶⁾ report that the species in question has an average daily movement capacity of 2 km, which would make it impossible for individuals of this species to be exchanged between nearby areas, which are more than 2 km apart.

Another important point to be discussed about the parasite-host relationship is the sharing of parasite species between different host species (Figure 4), it was observed that *A. lituratus* and *A. planirostris* shared two ectoparasite species (*A. phyllostomatis* and *M. aranea*). It is likely that phenotypic and phylogenetic similarities between these related bats may have acted as a filter for parasite species with similar ecological characteristics.⁽²⁷⁾

Figure 4 - Interaction network between bats and ectoparasites observed in the SFFSP. The lines and their different colors represent the interactions between species, and the width of the line indicates the strength of the interactions.



Source: author's own work.

During the bat collections, it was also possible to observe that the parasites showed a preference for certain regions of the host's body. In general, the species of streblid flies whose morphology of the three pairs of legs was similar, differing very little in terms of shape and size, such as *A. falcata*; *A. phyllostomatis* and *T. joblingi* (Figure 2), were always found in the region of the inner margin of the plagiopatagium (the portion of the patagium that extends from the last toe to the hind limbs).

As for the parasite species in which there was a difference between the three pairs of legs, especially in relation to the length of the third posterior pair, which was always longer than the anterior and middle pairs, *M. aranea*; *M. proxima* and *P. longicrus* (Figure 2), these species were always found in the midst of the host's fur in the ventral and dorsal regions of the body. It was evident during the handling of the bats to remove them from the nets that the most elongated pair of legs of these fly species is used to push the body of the parasite in order to hide them in the midst of the host's fur when threatened.

This type of ecomorphological characteristic was reported and discussed by,⁽⁹⁾ where they studied the influence that the size of the legs of bat flies streblid flies has on their preference for specific locations on the body of their hosts. The hypothesis put forward to explain the emergence of this type of characteristic is that increasing specificity in parasitizing certain regions of the host's body could reduce interspecific competition from the infra-community of ectoparasites that inhabit the host's body.

The streblid fauna and parasite-host associations found in this study seem to be consistent with what has been observed in other areas of the state of Paraná, thus contributing to the expansion of knowledge regarding the distribution of fly species and their associations with bats.

Conclusion

The fauna of bat flies and the host-parasite associations found in this study seem to correspond

to what has been observed in other areas of the state of Paraná, thus contributing to the expanding knowledge of the distribution of bat flies species and their associations with bats. Although the sampling effort was small and the data obtained do not provide a comprehensive overview of the entire study area, the observations made in the SFFSP regarding streblid flies and their hosts are unprecedented.

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