ECTOPARASITIC FLIES (DIPTERA, STREBLIDAE) ON BATS (MAMMALIA, CHIROPTERA) IN THE STATE FOREST OF ASSIS WITH A SPECIES CHECKLIST FROM SÃO PAULO, BRAZIL

MOSCAS ECTOPARASITAS (DIPTERA, STREBLIDAE) EM MORCEGOS (MAMMALIA, CHIROPTERA) NA FLORESTA ESTADUAL DE ASSIS COM UM CHECKLIST DE ESPÉCIES DE SÃO PAULO, BRASIL

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Abstract

Inventories of bat flies from the state of São Paulo are scarce, especially in the Cerrado ecoregion. Thus, we described the bat flies community in the State Forest of Assis, located in the municipality of Assis, São Paulo (Brazil). 34 specimens of six bat flies species were recorded in the study area. The *Trichobius propinquus* flies, as well as its first association with the bat species *Anoura caudifer,* are recorded for the first time in São Paulo. In addition, we present a checklist of the bat flies species (Streblidae), with a total of 38 species recognized in the São Paulo State.

Key words: Ectoparasites; Phyllostomidae; Inventories; Cerrado.

Resumo

Inventários de moscas ectoparasitas de morcegos do estado de São Paulo são escassos, especialmente na ecorregião do Cerrado. Assim, descrevemos a comunidade de moscas-morcego na Floresta Estadual de Assis, localizada no município de Assis, São Paulo (Brasil). 34 espécimes de seis espécies de moscas de morcego foram registrados na área de estudo. As moscas *Trichobius propinquus*, bem como sua primeira associação com a espécie de morcego *Anoura caudifer*, são registradas pela primeira vez em São Paulo. Além disso, apresentamos uma lista atualizada das espécies de moscas ectoparasitas de morcegos (Streblidae), com um total de 38 espécies reconhecidas no Estado de São Paulo.

Palavras-chave: Ectoparasitas; Phyllostomidae; Inventários; Cerrado.

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INTRODUCTION

Flies of the Streblidae (bat flies) family are obligate hematophagous ectoparasites of bats with larval development involving adenotrophic viviparity. Condition that the larvae developed into female body to posteriorly been deposited in the wall of host roost (Dick and Gettinger 2005). Streblidae has a broad distribution in the New World, mainly in the tropical and subtropical areas, marked by their parasitic associations with Phyllostomidae bats (Dick and Miller 2010). The Brazilian Streblidae fauna is composed of 83 species in 23 genera (Graciolli 2018), are 182 species into 69 genera of bats to Brazil (Nogueira et al. 2018).

Although the bat fauna from São Paulo state has been widely studied in the past few years, the bat flies community and their parasite-host associations have been poorly sampled in this region. The most recent inventories about the bat flies fauna from São Paulo were developed in the past 15 years only Atlantic Forest ecoregion: Altitudinal Atlantic Forest at the State Park of Cantareira (Bertola et al. 2005); Semi-deciduous Atlantic Forest at the Ecological Station of Caetetus (Graciolli et al. 2006); and Insular environment at the State Park of Cardoso Island (Dornelles and Graciolli 2017). This study aimed to present the parasitic host relationship and the bat flies community in the State Forest of Assis, a Brazilian Savanna (Cerrado) ecoregion, as well as a checklist of these bat flies species (Streblidae) for São Paulo State.

METHODS

The study was conducted at the Floresta Estadual de Assis (FEA) (22°35′31′′ S, 50°23′50′′ W), characterized by Brazilian Savanna (Cerrado) and located in the municipality of Assis, western São Paulo State (Brazil) with an area of about 2,816 ha. The native vegetation is Cerrado, but is currently predominated by exotic species as *Pinus* and *Eucalyptus* (Max et al. 2007). The FEA is located in a climatic transition zone between Cwa and Cfa Koppen classifications, marked by extensive hot and rainy summers, and short and dry winters. The mean annual temperature is 21.8°C.

Samples were conducted monthly (of two to three days of capture) between January till December 2012, for a total of 16 nights. To catch the bats, six mist nets (8.0m/2.5m) were placed 0.5m from the ground open for 6 hours. The nets were placed along possible bat flight routes as trails, inside the woods, in open areas near food resources (flowering or fruiting plants), and in front of diurnal shelters. The sampling effort followed Straube and Bianconi (2002) (sampling effort = mist nets total area x exposure time x number of repetitions x total number of mist nets) Collections were authorized by the Sistema de Autorização e Informação em Biodiversidade (number: 3319931) and by the Instituto Florestal (number: 260108-006.734/2011).

The sampled bats were identified in the field according to the identification keys of Vizotto and Taddei (1973), Gregorin and Taddei (2002), and Vicente et al.

(2005). Part of the dorsum hairs were cut off of the bats for recognition in case of recaptures. The bat flies were caught using tweezers and a brush with alcohol, and were placed in plastic tubes with alcohol 70%. Posteriorly, the flies were transported to the Laboratório de Sistemática, Ecologia e Evolução da Universidade Federal de Mato Grosso do Sul (LSEE/UFMS), to identify the species using identification keys presented by Guerrero (1994, 1995).

For bat flies checklist from São Paulo state, we following databases of Streblidae in Brazil by Lourenço et al. (2016) and the most recent study by Dornelles and Graciolli (2017) in São Paulo. Additionally, we looking for other studies in platforms as Scielo, Scopus, Web of Science and Google Scholar. We consider only articles to checklist. The key words utilized in the search were: bat flies in Brazil; bat flies in São Paulo; flies ectoparasites in São Paulo; ectoparasite flies and bats in São Paulo.

RESULTS

We captured and examined 112 bats from 14 species belong 11 genera and three family: Molossidae: *Molossops temminckii* (Burmeister, 1854) (*n* = 1), (*Nyctinomops laticaudatus* (É. Geoffroy, 1805) (*n* = 1); Phyllostomidae: *Anoura caudifer* (**É.** Geoffroy, 1818) (*n* = 7), *Artibeus lituratus* (Olfers, 1818) (*n* = 15), *Carollia perspicillata* (Linnaeus, 1758) (*n* = 18), *Desmodus rotundus* (É. Geoffroy, 1810) (*n* = 5), *Glossophaga soricina* (Pallas, 1766) (*n* = 38), *Platyrrhinus lineatus* (É. Geoffroy, 1810) (*n* = 4), *Sturnira lilium* (É. Geoffroy, 1810) (*n* = 9); Vespertilionidae: *Eptesicus diminutus* Osgood, 1915 (*n* = 1), *E. furinalis* (d'Orbigny, 1847) (*n* = 2), *Myotis albescens* **É.** Geoffroy, 1806 (*n* = 6), *M. nigricans* (Schinz, 1821) (*n* = 3), *M. riparius* Handley, 1960 (*n* = 2). Of all the captured bats, only 18 had been parasitized by bat flies, of which 34 specimens of Streblidae were removed (Table 1), all from the Streblinae subfamily as follows: *Megistopoda proxima* (Coquillett, 1899) (*n* = 13), *Paratrichobius longicrus* (Ribeiro, 1907) (*n* = 3), *Trichobius dugesii* Townsend, 1891 (*n* = 5), *T. joblingi* Wenzel, 1966 (*n* = 2), *T. propinquus* Wenzel, 1976 (*n* = 2), *T. tiptoni* Wenzel, 1976 (*n* = 9). The sampling effort was 11,520 h.m². About checklist, we found 17 studies and 38 species of Streblidae in São Paulo State (Table 1). Below is a short discussion about the relationship between bats and bat flies.

Table 1. Species of Streblidae checklist from São Paulo state in annual growing order. (1) Pessoa and Galvão (1936); (2) Guimarães (1937); (3) Pessoa and Guimarães (1937); (4) Guimarães (1941); (5) Guimarães (1944); (6) Garcia and Casal (1965); (7) Wenzel et al. (1966); (8) Wenzel (1970); (9) Graciolli and Carvalho (2001); (10) Graciolli (2003a); (11) Graciolli (2003b); (12) Graciolli and Dick (2004); (13) Bertola et al. (2005); (14) Graciolli et al. (2006); (15) Graciolli and Carvalho (2012); (16) Graciolli and Dick (2012) and (17) Dornelles and Graciolli (2017).

Taxa	Reference
STREBLIDAE	
Streblinae	
Anastrebla caudiferae Wenzel, 1976	13
Anastrebla modestini Wenzel, 1966	13,17
Paraeuctenodes longipes Pessôa & Guimarães, 1936	3,5
Paraeuctenodes similis Wenzel, 1976	13
Strebla carvalhoi Graciolli, 2003	10
Strebla chrotopteri Wenzel, 1976	14
Strebla diaemi Wenzel, 1966	9
Strebla diphyllae Wenzel, 1966	17
Strebla guajiro (Garcia & Casal, 1965)	7,13,14,17
Strebla hertigi Wenzel, 1966	17
Strebla miriabilis (Waterhouse, 1879)	5,17
Strebla wiedemanni Kolenati, 1856	6,8,17
Trichobiinae	
Anatrichobius passosi Graciolli, 2003	11,13
Aspidoptera falcata Wenzel, 1976	13,14,17
Aspidoptera phyllostomatis Wenzel, 1976	14,17
Exastinion clovisi (Pessôa & Guimaraes, 1937)	3,13,17
Joblingia minuta (Graciolli & Dick, 2012)	16
Megistopoda aranea (Coquillett, 1899)	8,13,17
Megistopoda proxima (Séguy, 1926)	13,14,17, This Study
Metelasmos pseudopterus Coquillett, 1907	1,13,17
Metelasmus wenzeli Graciolli & Dick, 2004	12

Taxa	Reference
Neotrichobius delicatus (Machado-Allison, 1966)	15,17
Paradyschiria fusca Speiser, 1900	4
Paradyschiria parvula Falcoz, 1931	9
Paratrichobius longicrus (Ribeiro, 1907)	3,13,14,17, This Study
Paratrichobius salvini Wenzel, 1966	17
Speiseria ambigua Kessel, 1925	3
Trichobius anducei Guerreiro, 1998	17
Trichobius diphyllae Wenzel, 1966	17
Trichobius dugesii Townsend, 1891	2,5,17, This Study
Trichobius dugesioides dugesioides Wenzel, 1966	8,13,14,17
Trichobius furmani Wenzel, 1966	13,17
Trichobius joblingi Wenzel, 1966	2,13,14,17, This Study
Trichobius longipes (Rudow, 1871)	2,5
Trichobius pallidus (Curran, 1934)	15
Trichobius phillostomae Kessel, 1925	13,15,1
Trichobius propinquus Wenzel, 1976	This Study
Trichobius tiptoni Wenzel, 1976	13,17, This Study

Megistopoda proxima (Séguy, 1926)

Host examined: *Sturnira lilium* (É. Geoffroy, 1810).

Material examined: Brasil, SP, Assis, Floresta Estadual de Assis (22º34' S, 50º24' W), 7 males e 6 females.

Comments: Previously recorded in São Paulo state, *M. proxima* is considered a complex of species (Wenzel 1976). Their primary hosts are bats from the genera *Sturnira* (Graciolli & Carvalho 2001). This species are widely distributed in the Cerrado and in others ecoregions in Brazil (see Barbier e Graciolli 2016; Loureço et al. 2016).

Distribution in São Paulo State region. Atlantic Forest at the State Park of Cantareira (Bertola et al. 2005), Ecological Station of Caetetus (Graciolli et al. 2006), State Park of Cardoso Island (Dornelles and Graciolli 2017).

Paratrichobius longicrus (Ribeiro, 1907)

Host examined: *Artibeus lituratus* (Olfers, 1818); *Platyrrhinus lineatus* (E. Geoffroy, 1810).

Material examined: Brasil, SP, Assis, Floresta Estadual de Assis (22º34' S, 50º24' W), 1 male e 2 females.

Comments: Previously recorded in São Paulo State, *P. longicrus* is a species complex (Wenzel et al. 1966). Their primary host is *A. lituratus* (Rui & Graciolli 2005), but the parasitic species can be found in other species of *Artibeus* (Graciolli & Rui 2001, Almeida et al. 2011, Patrício et al. 2016). *Paratrichobius longicrus* presents an intimate relationship with *P. lineatus* in southern Brazil (Prevedello et al. 2005). Examination of comparative morphology between specimens of *P. longicrus* associated with different host species, supports the existence of a complex of distinct species (Graciolli & Carvalho 2001). These associations were widely recorded in other environments in the Cerrado and in others ecoregions in Brazil (see Lourenço et al. 2016).

Distribution in São Paulo State region. São Paulo (Pessoa and Guimarães 1937), Atlantic Forest at the State Park of Cantareira (Bertola et al. 2005), Ecological Station of Caetetus (Graciolli et al. 2006), State Park of Cardoso Island (Dornelles and Graciolli 2017).

Trichobius dugesii Townsend, 1891

Host examined: *Glossophaga soricina* (Pallas, 1766).

Material examined: Brasil, SP, Assis, Floresta Estadual de Assis (22º34' S, 50º24' W), 2 males e 3 females.

Comments: Previously recorded in São Paulo state, *T. dugesii* primary host is the bat *G. soricina* (Wenzel et al. 1966). This species are widely distributed in the Cerrado and in others ecoregions in Brazil (see Lourenço et al. 2016). Of the bat flies parasites of *G. soricina*, *T. dugesii* is the only species which shares its distributional pattern with its host in the Cerrado and Atlantic Forest (Eriksson et al. 2011). As presented in this study, the species was registered in transitional areas between Cerrado and Atlantic Forest (Dornelles et al. 2017).

Distribution in São Paulo State region. São Paulo (Guimarães 1937), Monte Alegre do Sul (Guimarães 1944), State Park of Cardoso Island (Dornelles and Graciolli 2017).

Trichobius joblingi Wenzel, 1966

Host examined: *Carollia perspicillata* (Linnaeus, 1758).

Material examined: Brasil, SP, Assis, Floresta Estadual de Assis (22º34' S, 50º24' W), 1 male e 1 female.

Comments: Previously recorded in São Paulo state and commonly recorded parasitizing the bat species *C. perspicillata* as their primary host (Wenzel 1976). This species are widely distributed in the Cerrado and in others ecoregions in Brazil (see Lourenço et al. 2016).

Distribution in São Paulo State region. São Paulo (Guimarães 1937), Atlantic Forest at the State Park of Cantareira (Bertola et al. 2005), Ecological Station of Caetetus (Graciolli et al. 2006), State Park of Cardoso Island (Dornelles and Graciolli 2017).

Trichobius propinquus Wenzel, 1976

Host examined: *Anoura caudifer* (É. Geoffroy, 1818).

Material examined: Brasil, SP, Assis, Floresta Estadual de Assis (22º34' S, 50º24' W), 1 male e 1 female.

Comments: This is the first record of the species in São Paulo State. The species belongs to the *T. dugesii* species complex (Wenzel et al. 1966). Their hosts are bats from the genus *Anoura* (Guerrero 1994a). The first record in Brazil was presented inside caves in Brasília, DF (Graciolli & Coelho 2001).

Distribution in São Paulo State region. State Forest Assis. This is the first record for São Paulo state.

Trichobius tiptoni Wenzel, 1976

Host examined: *Anoura caudifer* (É. Geoffroy, 1818).

Material examined: Brasil, SP, Assis, Floresta Estadual de Assis (22º34' S, 50º24' W), 5 male e 4 female.

Comments: Previously recorded in São Paulo state, *T. tiptoni* primary host is the bat species *A. caudifer* (Graciolli & Carvalho 2001). This species is more common in areas of Atlantic Forest (Whitaker & Mumford 1977, Graciolli & Carvalho 2001, Bertola et al. 2005, Lourenço et al. 2014), and has a large distribution pattern throughout Brazil (Lourenço et al. 2016).

Distribution in São Paulo State region Brazil: Atlantic Forest at the State Park of Cantareira (Bertola et al. 2005), State Park of Cardoso Island (Dornelles and Graciolli 2017).

DISCUSSION

Although most bat flies recorded in this study have been previously recorded in São Paulo state, this is the first faunal inventory of these insects from the Cerrado ecoregion in São Paulo State. In 2016 the state had largest number of studies about Streblidae in Brazil with 16 studies (Lourenço et al. 2016), we updating to 17. The large number of studies is explained by the concentration of researchers in this state and partnerships with others researchers, especially in Atlantic Forest areas (Lourenço et al. 2016). In addition, the checklist suggests increase in the records of species Streblidae to state from 2004 (Figure 1). Herein the first record of *T. propinquus* in São Paulo, as well as the first association of this bat flies with the bat species *A. caudifer,* are presented. The most frequent bat flies in checklist for São Paulo state

were *T. joblingi* and *P. longicrus*, both with 5 records (Table 1). This can be explained by the abundance of their primary hosts in the state (see Wenzel et al. 1966, Wenzel 1976), *C. perspicillata* and *A. lituratus* respectively.

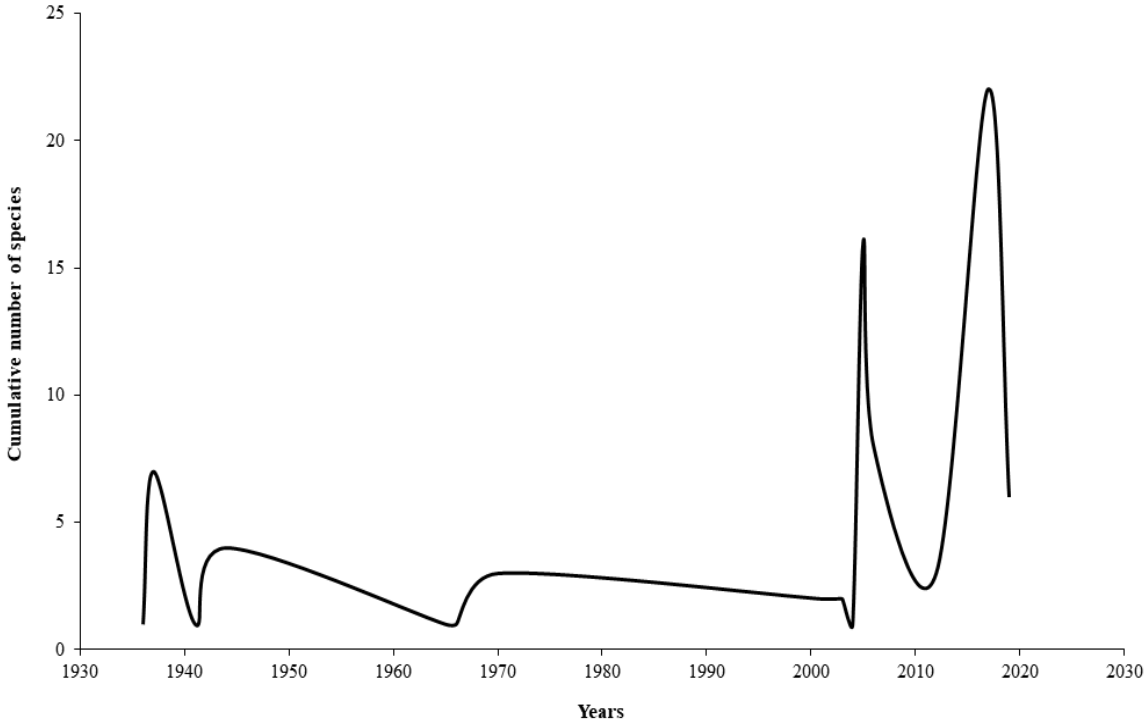

Figure 1. Cumulative records of Streblidae species for São Paulo State since 1936 (data of Table 1). Despite the oscillation, note the increase of records of species since 2004.

Concerning the richness bat flies species, this study reported lower records when compared to similar studies from other Cerrado ecoregions in Brazil (Eriksson et al. 2011, Santos et al. 2013, Vasconcelos et al. 2016, Aguiar and Antonini 2016, Barbier and Graciolli 2016, Dornelles et al. 2017). However, like Graciolli and Aguiar (2002), a higher richness of bat species with lower sampling effort was recorded. Overall, this study described parasite-host associations between bat flies and host bats from the FEA, with the goal of corroborating the knowledge of these associations in a Cerrado environment in São Paulo state. Even though a parasitology index was not used in this study, the results suggest that qualitative faunal inventories are important for recognizing these communities in poorly studied areas, as well as understanding their dynamics and the distributional patterns of these species in different ecoregions as the Atlantic Forest, Cerrado, and transitional zones.

ACKNOWLEDGEMENTS

We thank the Guilherme Dornelles and Elizabete Captivo Lourenço for providing some of the information that improved the bibliographic review of this

manuscript. And to Paraíba State Research Foundation (FAPESQ) by a doctoral scholarship from grant nº 518/18.

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