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ECTOPARASITIC BAT FLIES (DIPTERA, STREBLIDAE) OF BATS (CHIROPTERA, MAMMALIA) FROM MATA DO JUNCO WILDLIFE REFUGE, SERGIPE, NORTHEASTERN BRAZIL

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ABSTRACT
Bats are hosts of many groups of parasites, including bat flies (Diptera, Streblidae). Although parasitism is common in bats, especially in members of the family Phyllostomidae, few studies have discussed host–parasite associations. In this paper, we present data on the community of bat flies parasitizing bats in a remnant of Atlantic Forest in Sergipe, northeastern Brazil. The bats were captured with mist nets over an eight-month period (between July 2009 and February 2010) in the Mata do Junco Wildlife Refuge in Sergipe, Brazil. For all ectoparasites captured, we calculated parasitism rates – prevalence, mean abundance and mean intensity of infestation by the parasite. We collected 269 bat flies, representing 18 species, parasitizing 113 specimens of bats belonging to the families Emballonuridae (2 spp.) and Phyllostomidae (16 spp.). The bat fly species *Trichobius joblingi* (45.9%), *Speiseria ambigua* (10%), and *Trichobius costalimai* (8.8%) were the most common, accounting for 65% of the total specimens. The mean intensity of parasitism ranged 1-7 in all bat species, with the highest prevalence being recorded for *T. costalimai* on *Phyllostomus discolor* (P = 66.6%). About 72% of the associations were considered to be primary. Our results in relation to abundance, mean intensity and prevalence of bat flies are in agreement with the reported in the scientific literature for the Atlantic Forest and Cerrado. On the other hand, we reported a large number of infracommunities (N = 18) in eight species of bats. Seven species of bat flies are recorded for the first time to Sergipe, where 23 species of bat flies are known.
Keywords: Atlantic Forest; bat infracommunity; flies; Phyllostomidae.

INTRODUCTION

Bats (Chiroptera) are among the most diverse and widely-distributed mammals (Simmons 2005), constituting an important group for a range of ecological studies, including host-parasite interactions (Komeno & Linhares 1999*,* Bertola *et al*. 2005). The diversity and ample adaptive radiations of bats has contributed to the diversity and dispersal of their specific ectoparasites (Hill & Smith 1988*,* Rui & Graciolli 2005).

Two families of Diptera, the Nycteribiidae and Streblidae, are exclusive bat parasites (Marshall 1982*,* Azevedo & Linardi 2002*,* Graciolli & Aguiar 2002*,* Bertola *et al*. 2005). The flies of these families are highly specialized and only found on association with these mammals, feeding on their blood and living on their bodies and wing membranes (Wenzel & Tripton 1966*,* Marshal 1982).

The streblids present ample morphological variability, including winged, apterous and brachypterous species (Guerrero 1993). The eyes may also be small or absent (Whitaker Jr. 1988). The Streblidae has a cosmopolitan distribution, with 237 species in 33 genera, distributed in five subfamilies: Nycteriboscinae, Ascopterinae, Trichobiinae, Streblinae and Nycterophiliinae. The latter three are exclusive to the New World (Guerrero 1993, 1997). In Brazil, about 80 species have been recorded, representing 23 genera (Graciolli 2016).

Understanding the relationship between the parasite fauna and their bat hosts provides important insights into the biology, systematics, and phylogeny of these organisms, in addition to the epidemiological aspects of disease transmission in bats (Fritz 1983, Bush *et al*. 1997, Aguiar & Antonini 2011). While studies of bat ectoparasites have focused mainly on southern Brazil (Graciolli *et al*. 2006), recent research has spread into the Brazilian Midwest (Graciolli *et al*. 2006, 2010, Eriksson *et al*. 2011) and Northeast (Rios *et al*. 2008, Dias *et al*. 2009, Santos *et al*. 2009, Soares *et al*. 2013, Barbier & Graciolli 2016, Bezerra *et al*. 2016).

Forty-three bat species representing seven families have been recorded in the Brazilian State of Sergipe (Mikalauskas 2005, Feijó & Nunes 2010, Rocha *et al*. 2010, 2011a, b, Mikalauskas *et al*. 2011, 2014, Brito & Bocchiglieri 2012, Leal *et al*. 2013), while 16 bat fly species have been identified (Bezerra *et al*. 2016). These authors collected data on bat ectoparasites at two sites – the Serra de Itabaiana National Park and the Mata do Junco Wildlife Refuge. The present study is a continuation of this research, providing new records of ectoparasitic bat flies in Sergipe through the analysis of the streblid community of the Mata do Junco Wildlife Refuge, a protected area in the Atlantic Forest of northeastern Brazil, and the identification of parasite–host relationships and infracommunities. Moreover, parasitological indices were calculated for each ectoparasitic bat flies.

MATERIAL AND METHODS

Study area

The Mata do Junco Wildlife Refuge (RVS-Mata do Junco) (10°32' S, 37°03' W) is a 894 ha state reserve located in the municipality of Capela, State of Sergipe, northeastern Brazil (Figure 1). It is an area of rainforest with numerous clearings surrounded by an anthropogenic matrix dominated by sugarcane (*Saccharum* spp.) plantations (Mikalauskas *et al*. 2011, 2014). The region's climate is semi-humid tropical (As), characterized by a rainy season in the austral winter and a dry season in the summer (Köppen 1936). Mean monthly temperatures are above 18°C, with maximum between 21°C and 38°C and minimum between 18 and 22.2°C (Seplantec/Srh 2009).

Sampling

The bats were captured between July 2009 and February 2010 with mist nets (12 m x 2.5 m, 10 nets) set at ground level, two nights each month (total 16 nights), which remained open for 12 consecutive hours, combined with the active search for refugia (Esbérard & Bergallo 2008). The sampling effort was 26,400 h.m² of mist nets. Captured animals were identified according to the criteria used by Gardner (2007), marked with the color-coded plastic cable ties and released immediately after the collection of ectoparasites. Only a small percentage (10%) of captured bats were collected and deposited as voucher specimens in the Adriano Lúcio Peracchi Collection, at the Biology Institute of the Federal Rural University of Rio de Janeiro, Brazil (License SISBIO 11283).

Ectoparasites found on the body of the hosts were removed with the help of tweezers and stored in labeled Eppendorf tubes with 70% ethanol. The specimens were examined with the aid of a stereomicroscope, identified according Guerrero (1993, 1994a, 1994b, 1995a, 1995b, 1996) and deposited in the Zoological Reference Collection of the Federal University of Mato Grosso do Sul, Campo Grande, Brazil.

Data analysis

An infracommunity consist of specimens of organism from different orders occurring in the same host (Bush *et al*. 1997). The following criteria for the classification of host-parasite associations were used, according to Dick (2007): primary associations, when there was 5% or more streblid bat flies individuals of a species and non-primary or accidental associations, when the parasite was associated with the host in less than 5% of total of individuals of a species.

The mean abundance (number of ectoparasites/ number of bats examined), the prevalence (number of infested bats / number of bats examined x 100) and the mean intensity of infestation by parasites (number of parasites/number of infested hosts) were calculated following the approach of Bush *et al*. (1997). These analyses were run in the Quantitative Parasitology 3.0 software (Rózsa *et al*. 2000), with the confidence interval being calculated from 2000 randomizations.

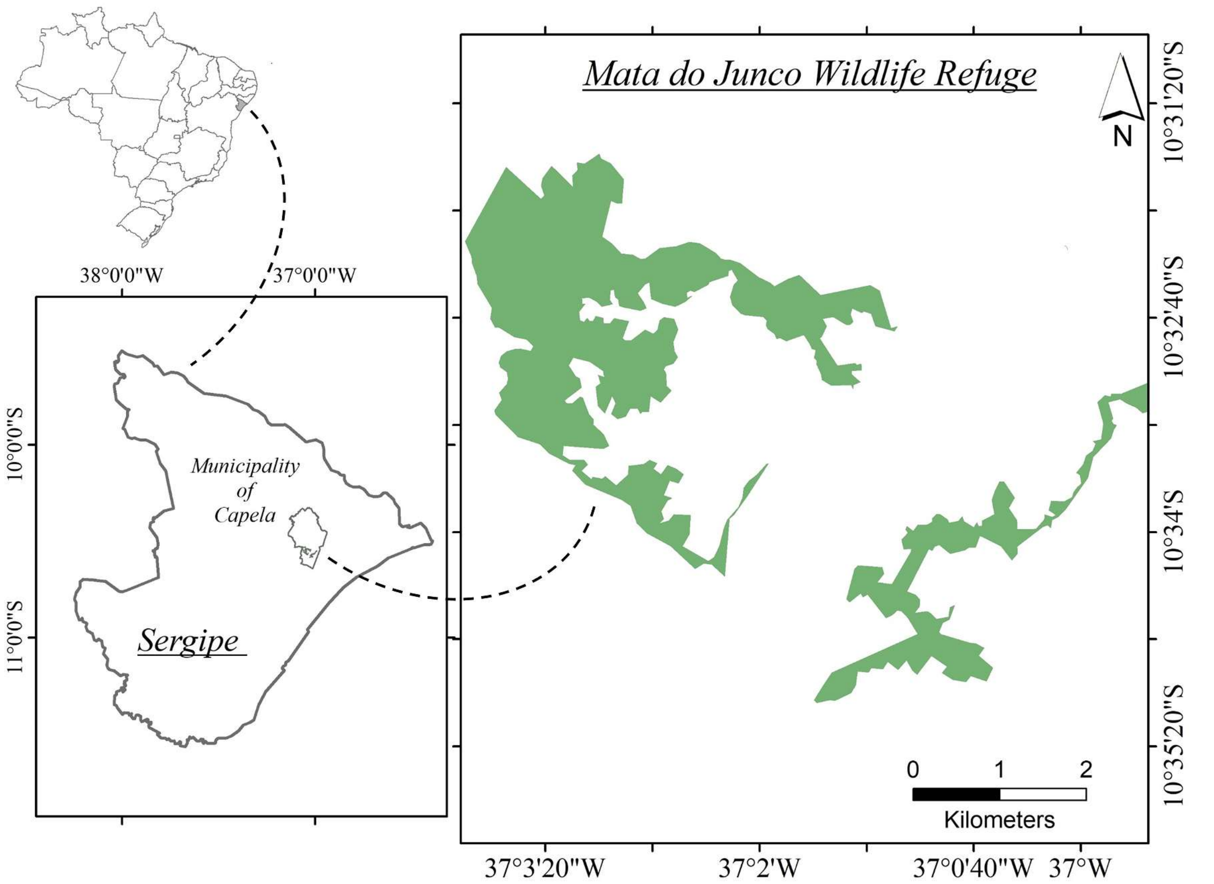

Figure 1. Location of the Mata do Junco Wildlife Refuge, state of Sergipe, northeastern Brazil.

RESULTS

We captured 269 bats belonging to 21 species and three families (Emballonuridae, Phyllostomidae and Vespertilionidae) (Table 1). The most common bat species were *Carollia perspicillata* (30.7%), *Dermanura cinerea* (27.7%) and *Artibeus planirostris* (7.4%).

Overall, 269 streblid flies of 18 species were captured on 113 bats of two families (Emballonuridae and Phyllostomidae). Bat flies were found on twelve species of bats and the most common parasite species were *Trichobius joblingi* (45.9%), *Speiseria ambigua* (10.0%), and *Trichobius costalimai* (8.8%). Together, these three species represented approximately 65% of the ectoparasites collected. Nine bat species had no ectoparasites. These bats were relatively rare in the present study, representing about 7% of the total.

A range of bat–streblid associations were observed, with some bat fly species being associated with more than one species of bat. *Trichobius joblingi*, for instance, was the most widespread, being collected on seven bats (*A. planirostris*, *C. perspicillata*, *Chiroderma doriae*, *D. cinerea*, *Desmodus rotundus*, *Glossophaga soricina*, and *Sturnira lilium*), while *Speiseria ambigua* was associated with six bat species (*A. planirostris*, *C. perspicillata*, *D. cinerea*, *D. rotundus*, *Platyrrhinus recifinus*, and *S. lilium*). *Trichobius costalimai* was collected on three bats (*D. cinerea*, *Phyllostomus discolor*, and *Platyrrhinus lineatus*).

Eight bat species hosted at least three species of ectoparasite. *Dermanura cinerea* hosted the highest number of streblid species (10), while seven species were recorded on *C. perspicillata*, and six on *S. lilium*. By contrast, four bats (*G. soricina, Lonchophylla mordax, P. recifinus* and *Saccopteryx bilineata*) hosted a single species of bat fly. Three specific interactions were observed: *Trichobius anducei* with *C. perspicillata*, *Trichobius longipes* with *P. lineatus* and *Trichobius tiptoni* with *S. bilineata* (Table 2).

Table 1. List of species of bats captured in Mata do Junco Wildlife Refuge, state of Sergipe, Northeastern Brazil.

Species	Abundance	Bats infested	Number of bat flies species
Emballonuridae			
Saccopteryx bilineata (Temminck, 1838)	2	1	1
Peropteryx leucoptera Peters, 1867	3	-	-
Phyllostomidae			
Subfamily Desmodontinae			
Desmodus rotundus (E. Geoffroy, 1810)	11	6	5
Subfamily Glossophaginae			
Glossophaga soricina (Pallas, 1766)	8	1	1
Lonchophylla mordax (Thomas, 1903)	4	1	1
Dryadonycteris capixaba (Nogueira, Lima, Peracchi & Simmons, 2012)	1	-	-
Subfamily Phyllostominae			
Lonchorhina aurita Tomes, 1863	2	-	-
Lophostoma brasiliense (Peters, 1866)	1	-	-
Tonatia saurophila Koopman & Williams, 1951	1	-	-
Trachops cirrhosus (Spix, 1823)	1	-	-
Phyllostomus discolor Wagner, 1843	6	6	4
Phyllostomus hastatus (Pallas, 1767)	1	-	-
Subfamily Carollinae			
Carollia perspicillata (Linnaeus, 1758)	82	41	7
Subfamily Stenodermatinae			
Dermanura cinerea (Gervais, 1855)	74	25	10
Artibeus lituratus (Olfers, 1818)	9	-	-
Artibeus planirostris (Spix, 1823)	20	9	5
Chiroderma doriae Thomas, 1891	4	4	4
Platyrrhinus lineatus (E. Geoffroy, 1810)	16	5	4
Platyrrhinus recifinus (Thomas, 1901)	3	1	1
Sturnira lilium (E. Geoffroy,1810)	19	13	6
Vespertilionidae			
Rhogeessa hussoni Genoways & Baker, 1996	1	-	-
All individuals	269	113	-

The mean infection intensity of parasitism varied between 1 and 7 on bat species (N e" 10 individuals). The highest mean intensity was observed for *T. anducei* (IM = 7) on *C. perspicillata. Dermanura cinerea* was the second species with highest infestation (IM = 5), as the host of *T. costalimai*. The highest prevalence was recorded for *T. costalimai* (P= 66.6%) on *P. discolor* (Table 2). Approximately 72.0% of the associations were considered primary.

A number of infracommunities were observed (Table 3), the most common being the association between *T. joblingi* and *S. ambigua* (N = 12). These two species parasitized five bats species. The combination of three streblid species (*T. perspicillatus*, *T. costalimai* and *S. hertigi*) occurring on the same host was observed on *P. discolor*, *D. cinerea* and *P. lineatus*. The *A. falcata* and *M. proxima* association occurred only on *S. lilium* and *D. rotundus*.

Carollia perspicillata presented the highest number of infracommunities (Table 3), with five associations between different fly species. *Trichobius joblingi* was present in most these associations, sharing the same host with three other fly species.

Table 2. Bat flies and their respective hosts in Mata do Junco Wildlife Refuge, state of Sergipe, Northeastern Brazil. Average intensity, prevalence and mean abundance of parasitism. IM: average infestation intensity, (IC 95 %): confidence interval at 95%, P (%) prevalence.

Host	Ectoparasites	Total	IM (95% CI)	P (%)	Abundance
Artibeus planirostris	*Megistopoda aranea*	2	2.0	5	0.12 (0-0.37)
	Aspidoptera phyllostomatis	1	1.0	5	0.06 (0-0.18)
	Trichobius joblingi	9	3.0 (2-3.67)	15	0.56 (0.12-1.39)
	Speiseria ambigua	4	1.33 (0.04-0.45)	15	0.25 (0-0.56)
	Trichobius sp.1	1	1.0	5	0.06 (0-0.18)
Carollia perspicillata	*Trichobioides perspicillatus*	1	1.0	1.2	0.01 (0-0.03)
	Trichobius joblingi	65	2.41 (1.85-2.96)	32.9	0.80 (0.53-1.15)
	Speiseria ambigua	15	1.88 (1.12-2.88)	9.7	0.18 (0.07-0.40)
	Megistopoda aranea	1	1.0	1.2	0.01 (0-0.03)
	Strebla guajiro	2	1.0	2.4	0.02 (0-0.06)
	Trichobius anducei	7	7.0	1.2	0.08 (0-0.25)
	Aspidoptera phyllostomatis	1	1.0	1.2	0.01 (0-0.03)
Chiroderma doriae	*Strebla guajiro*	1	1.0	25	0.33 (0-0.66)
	Trichobius joblingi	5	5.0	25	1.67 (0-3.33)
	Aspidoptera falcata	1	1.0	25	0.33 (0-0.66)
	Megistopoda proxima	1	1.0	25	0.33 (0-0.66)
Dermanura cinerea	*Megistopoda proxima*	5	1.67 (1-2.33)	4.1	0.06 (0.01-0.21)
	Trichobioides perspicillatus	2	2.0	1.4	0.02 (0-0.08)
	Trichobius costalimai	5	5.0	1.4	0.06 (0-0.20)
	Strebla hertigi	3	3.0	1.4	0.04 (0-0.12)
	Aspidoptera falcata	2	1.0	2.7	0.02 (0-0.06)
	Trichobius joblingi	29	3.62 (2.38-5.38)	11.0	0.39 (0.15-0.77)
	Speiseria ambigua	4	1.0	4.1	0.04 (0-0.09)
	Trichobius sp.	3	3.0	1.4	0.04 (0-0.12)
	Trichobius cf. *angulatus*	1	1.0	1.4	0.01 (0-0.04)
	Megistopoda aranea	3	1.0	4.1	0.04 (0-0.09)
Desmodus rotundus	*Trichobius joblingi*	6	2.0	18.2	0.2 (0-0.6)
	Speiseria ambigua	2	2.0	9	0.2 (0-0.6)
	Megistopoda proxima	1	1.0	9	0.1 (0-0.3)
	Aspidoptera falcata	2	2.0	9	0.2 (0 -0.6)
	Trichobius parasiticus	2	2.0	9	0.2 (0-0.6)

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Host	Ectoparasites	Total	IM (95% CI)	P (%)	Abundance
Glossophaga soricina	*Trichobius joblingi*	1	1.0	12.5	0.14 (0-0.28)
Lonchophylla mordax	*Trichobius* sp. (complex *dugesii*)	1	1.0	25	0.33 (0-0.66)
Phyllostomus discolor	*Trichobius costalimai*	15	4.33 (3-5.67)	66.6	2.6 (0.6-4.8)
	Trichobioides perspicillatus	11	3.67 (2-5)	50	2.2 (0.4-4.2)
	Strebla hertigi	1	1.0	16.6	0.2 (0-0.4)
	Megistopoda aranea	1	1.0	16.6	0.2 (0-0.4)
Platyrrhinus lineatus	*Trichobius longipes*	1	1.0	6.2	0.06 (0-0.2)
	Trichobius costalimai	4	4.5 (4-4.5)	12.5	0.6 (0-1.53)
	Trichobioides perspicillatus	2	2.0	6.2	0.13 (0-0.4)
	Strebla hertigi	7	2.0	6.2	0.13 (0-0.4)
Platyrrhinus recifinus	*Speiseria ambigua*	1	1.0	33.3	0.5 (0-0.5)
Saccopteryx bilineata	*Trichobius tiptoni*	8	8.0	50	8.0
Sturnira lilium	*Aspidoptera falcata*	9	2.25 (1-3.25)	21	0.5 (0.11-1.28)
	Megistopoda proxima	5	2.0 (1-3)	15.7	0.33 (0.05-1.16)
	Trichobius joblingi	8	2.67 (1-4.33)	15.7	0.44 (0.05-1.5)
	Trichobius cf. *angulatus*	2	2.0	5.2	0.11 (0-0.33)
	Trichobius sp. (complex *dugesii*)	4	4.0	5.2	0.22 (0-0.66)
	Speiseria ambigua	1	1.0	5.2	0.05 (0-0.16)
	Total	269			

DISCUSSION

The abundance of *T. joblingi*, *S. ambigua* and *T. costalimai* is consistent with the findings of Soares *et al*. (2013) in the Atlantic Forest of Pernambuco and Vasconcelos *et al*. (2016) in the Cerrado savannas of Minas Gerais, and other studies in Brazil (Graciolli & Rui & 2001, Graciolli *et al*. 2006, Graciolli *et al*. 2010, Barbier & Graciolli 2016). These three species also were the most abundant taxa recorded by Bezerra *et al*. (2016) at the RVS-Mata do Junco. *Dermanura cinerea*, *C. perspicillata* and *S. lilium* were the bats with the highest number of associations, however, other bat species presented two to three bat flies species on a single host. The presence of infracommunities on bat species has been reported in Brazil (Komeno & Linhares 1999, Graciolli & Rui 2001, Bertola *et al*. 2005, Teixeira & Ferreira 2010, Moras *et al*. 2013, Barbier & Graciolli 2016, Bezerra *et al*. 2016), however, infracommunities with a low number of associations. In Puerto Rico, Gannon & Willig (1995) recorded complex associations between bats and ectoparasites, involving seven or more species. In the present study, associations typically involved only two or three coexisting species, corroborating previous studies (Gannon & Willig 1995, Bertola *et al*. 2005, Moras *et al*. 2013, Barbier & Graciolli 2016). Little is known about these complex interactions. However, our date may be the largest numbers of streblid flies recorded on a bat species.

While studies of these infracommunities typically focus on a single group, they may often include species of different orders, such as the Siphonaptera and Diptera (Moras *et al*. 2013). Most of the infracommunities recorded here are unique in Brazil, but in São Paulo. Bertola *et al*. (2005) observed an infracommunity of *A. falcata* and *M. proxima* on bats of the genus *Sturnira*, as observed in the present study,

Table 3. Infracommunities of bat flies at Mata do Junco Wildlife Refuge, State of Sergipe, Northeastern Brazil.

Infracommunities	Bat hosts	Occurrence
Trichobioides perspicillatus + *Trichobius costalimai* + *Strebla hertigi*	*Phyllostomus discolor*	1
Trichobioides perspicillatus + *Trichobius costalimai*	*Phyllostomus discolor*	1
Aspidoptera falcata + *Megistopoda proxima*	*Sturnira lilium*	1
Trichobius joblingi + *Speiseria ambigua*	*Sturnira lilium*	1
Trichobius joblingi + *Speiseria ambigua*	*Carollia perspicillata*	5
Trichobioides perspicillatus + *Trichobius joblingi* + *Speiseria ambigua*	*Carollia perspicillata*	1
Trichobius joblingi + *Strebla guajiro*	*Carollia perspicillata*	1
Trichobius anducei + *Strebla guajiro*	*Carollia perspicillata*	1
Trichobius joblingi + *Strebla guajiro*	*Chiroderma doriae*	1
Trichobius joblingi + *Speiseria ambigua*	*Desmodus rotundus*	1
Aspidoptera falcata + *Megistopoda proxima*	*Desmodus rotundus*	1
Trichobioides perspicillatus + *Trichobius costalimai* + *Strebla hertigi*	*Dermanura cinerea*	1
Trichobius joblingi + *Speiseria ambigua*	*Dermanura cinerea*	2
Trichobioides perspicillatus + *Trichobius costalimai* + *Strebla hertigi*	*Platyrrhinus lineatus*	1
Trichobius joblingi + *Speiseria ambigua*	*Artibeus planirostris*	3

in this case, on *D. rotundus*. However, Komeno & Linhares (1999) found a negative relationship between the occurrence of *A. falcata* and *M. proxima* on the same host. Farther, Prevedello *et al*. (2005) reported the occurrence of *A. falcata* at locations in Paraná where *M. proxima* was absent. The co-occurrence of *T. joblingi* and *S. guajiro* on *C. perspicillata* was also recorded by Teixeira & Ferreira (2010), but in Minas Gerais. The infracommunity formed by three streblids (*T. perspicillatus, T. costalimai* and *S. hertigi*) was observed on two host species (*P. discolor* and *D. cinerea*) in the present study, being the first record for Brazil.

The association between *S. ambigua* and *T. joblingi* and the host *C. perspicillata* appears to be relatively common. In the Brazilian Cerrado, similar associations between these two bat fly species were observed by Barbier & Graciolli (2016). Bezerra *et al*. (2016) recorded *S. ambigua* and *T. joblingi* on *C. perspicillata* specimen at RVS-Mata do Junco, as well as *T. perspicillatus* and *T. costalimai* on *P. discolor*. In the present study, we have added eight streblid species (*Aspidoptera falcata, Trichobius* sp. [*dugesii* complex], *Trichobius* sp., *Trichobius* sp.1, *Trichobius tiptoni, Trichobius* cf. *angulatus, Trichobius longipes*, and *Trichobius parasiticus*) not recorded by these authors at the Mata do Junco. A total of 25 species of parasitic bat flies are now known to occur in State of Sergipe.

Almost half of the ectoparasites collected were *Trichobius joblingi*, which was more common on *C. perspicillata*. Wenzel (1976) identified *C. perspicillata* as the primary host of *T. joblingi* and considered that associations with other bat species were accidental. However, in the present study, six other bats species also hosted *T. joblingi* with more than 5%, suggesting that *T. joblingi* may be a generalist species. Also, it is important to note that the abundance of *T. joblingi* recorded in the present study may be related to the higher abundance of its principal host, as observed by Komeno & Linhares (1999) in the State of Minas Gerais and Dias *et al*. (2009) in the State of Maranhão. *Carollia perspicillata* is widely distributed in Brazil, occurring in all biomes, as well as urban areas (Peracchi *et al*. 2011). The plasticity of this bat fly, and its ability to parasitize a variety of hosts, also contributes to its abundance (Komeno & Linhares 1999, Moras *et al*. 2013, Soares *et al*. 2013, França *et al*. 2013, Bezerra *et al*. 2016, Vasconcelos *et al*. 2016). In addition, the geographical distributions of bat fly species closely mirror those of their host species (Wenzel 1976).

The association between *Megistopoda proxima* and *Sturnira lilium* has been reported in Brazil (Wenzel & Tripton 1966, Komeno & Linhares 1999, Rui & Graciolli 2005, Bertola *et al*. 2005, França *et al*. 2013, Bezerra *et al*. 2016), and this fly is considered a primary parasite of the genus *Sturnira* (Dick 2007). Most Neotropical streblids are associated with a single primary host (Dick *et al*. 2007).

The bat fly species with the highest mean intensity were relatively rare. Mean intensity ranged between 1 and 7 in RVS-Mata do Junco, similar to the values recorded by Rui & Graciolli (2005), Santos *et al.* (2009), Barbier & Graciolli (2016), and Vasconcelos *et al.* (2016). Few data on prevalence and mean intensity of *Trichobius anducei* are available in the literature. The mean intensity of *T. anducei* on *Carollia perspicillata* (7) in RVS-Mata Junco is much higher than previous values found in Altlantic Forest areas, like 1.63 (Lourenço *et al.* 2014) and 1 (Dornelles & Graciolli 2017). But only one specimen of *C. perspicillta* was parasitized by *T. anducei* (Table 2). *Trichobius costalimai* is normally associated with *Phyllostomus discolor* (Wenzel 1966) and in RVS-Mato do Junco was found on *P. discolor* and two others species of bats (Table 2). On these three species *T. costalimai* shows high mean intensity (higher than 4). Other studies have corroborated this pattern, with a mean intensity of 3.5 found in the State of Maranhão (Santos *et al.* 2013), 7.41 in the State of Minas Gerais (Vasconcelos *et al.* 2016), and 7.0 in the State of Mato Grosso do Sul (Barbier & Graciolli 2016).

All of the specimens of some bat species, such as *Chiroderma doriae* (4 specimens) and *Phyllostomus discolor* (6 specimens) were parasitized. Some factors may influence parasitism rates, such as the type of shelter used by the host (*e.g.,* caves are considered favorable sites for infestation due to their microclimate), as well as the presence of other species in the shelter and the behavior of hosts and parasites (Vasconcelos *et al.* 2016). The main factors that influence the prevalence and intensity of infestation by bats ectoparasites, in particular bat flies, include climatic variables (temperature and rainfall), roosting and feeding behavior, and the type and size of shelters (Marshall 1982, Gannon & Willig 1995, Komeno & Linhares 1999, Hofstede *et al.* 2004, Rui & Graciolli 2005).

Approximately 72% of the associations recorded in the RVS-Mata of Junco were considered to be primary. Similar results were observed by Vasconcelos *et al.* (2016) and Bezerra *et al.* (2016), both in the Atlantic Forest, where 74% and 73.2% of associations were primary, respectively. The vast majority of ectoparasite flies are associated with a single primary host species (Dick *et al.* 2007). In the Cerrado, Eriksson *et al.* (2011) recorded low number of primary associations (46%), and only three specific interactions were observed: *Trichobius anducei* with *C. perspicillata*, *Trichobius longipes* with *P. lineatus* and *Trichobius tiptoni* with *S. bilineata*. However, *T. longipes* has been recorded on other bats, such as *Phylloderma. stenops*, *P. discolor*, *P. hastatus* and *Lophostoma brasiliense* (Soares *et al.* 2013, Esbérard *et al.* 2014, Vasconcelos *et al.* 2016). *Trichobius tiptoni* has also been recorded parasitizing *Chrotopterus auritus, Carollia castanea, C. perspicillata, S. lilium, Anoura caudifer,* and *A. geoffroyi* (Guerrero 1995a, Bertola *et al.* 2005, Graciolli *et al.* 2010, Moras *et al.* 2013, França *et al.* 2013, Vasconcelos *et al.* 2016). By contrast, *T. aduncei* has been collected more rarely, even though its host *C. perspicillata* is quite common and abundant (Guerrero 1998). This is only the second record of *T. anducei* for Brazil. The lack of records of *T. anducei* in Brazil may be related primarily to the paucity of studies in this country.

Despite the present study focused on the same area surveyed by Bezerra *et al.* (2016), it presents new and complementary records of the local diversity of bat flies, and bat–ectoparasite associations. The higher species richness and abundance of ectoparasites recorded in the present study were probably related primarily to the greater sampling effort. The diversity of sites, such as streams, bamboo stands, and forest margins, sampled in the study may have contributed to the probability of capturing a larger number of bat species (see Esbérard & Bergallo 2008, Novaes *et al.* 2015), and thus of ectoparasites. Bezerra *et al.* (2016) nevertheless recorded high rates of parasitism on *A. lituratus*, a bat that was captured rarely in the present study.

This study provides an update of the list of bat flies known to occur in the Brazilian State of Sergipe, where 23 species have now been recorded. However, host-parasite associations are still poorly understood in this region, and further research is required, including sampling of cave shelters and the Caatinga biome. It is also interesting to note that no nycteribiid parasites were recorded, possibly due to the rare captures of vespertilionid and absence of molossid bats, which are the principal hosts of the bat flies of this family. The number of bat fly species found in the region is thus likely to increase as further surveys are conducted.

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