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VERSITA

Bat flies (Diptera: Streblidae, Nycteribiidae) and mites (Acari) associated with bats (Mammalia: Chiroptera) in a high-altitude region in southern Minas Gerais, Brazil

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Abstract

A total of 71 bat flies belonging to families Nycteribiidae and Streblidae, and 37 mites were collected on 12 species of bats (Phyllostomidae and Vespertilionidae) from the Chapada do Abanador (Minas Gerais, Brazil), between July 2009 and April 2010. Two new occurrences of ectoparasites were recorded on *Histiotus velatus* (bat fly *Basilia producta*) and on *Carollia perspicillata* (mite *Parichoronyssus bakeri*). Five new occurrences were recorded for the state of Minas Gerais, increasing the range for bat flies *Anatrichobius passosi*, *Paraeuctenodes similis*, *Basilia juquiensis*, *Basilia producta* and for mite *Periglischrus vargasi*. Moreover, two new species of mites were recorded for Brazil (*P. bakeri* and *Macronyssus* aff. *leislerianus*). With regard to infracommunities, the most frequent association was between *Anastrebla modestini* and *Exastinion clovisi* on bat *Anoura geoffroyi*. This study contributed to characterize the fauna of bat ectoparasites in representative but poorly-sampled environments of the Atlantic Forest, the *campos de altitude* (high altitude grasslands) and cloud forests of southern Minas Gerais.

Keywords

Acari, Nycteribiidae, Streblidae, bats, high altitude

Introduction

Bats host a fauna of ectoparasites consisting of arthropods, most of which are species exclusive to them. Among these organisms are Diptera from families Streblidae and Nycteribiidae, in addition to mites belonging to several species from orders Mesostigmata, Sarcoptiformes and Trombidiformes (Webb and Loomis 1977, Marshall 1982). As with species richness, the manner in which relationships are established between host, parasite and the degree of dependency between them can vary as well (Kim 1985). Certain mites, such as Spinturnicidae, are obligate and permanent parasites (Rudnick 1960, Dusbábek 1971) and can show high specificity, being found at specific locations in a single bat host species (Rudnick 1960). However, some Macronyssidae mites and Streblidae bat flies can feature variable degrees of association. These parasites feed on the blood and lymph of their hosts, but can deposit their young in the environment, without depending completely on physical contact with the host to complete all stages of its life cycle (Dittmar *et al.* 2009, Radovsky 2010).

Over the last 10 years, there has been an increase in the number of works reporting the associations between parasites and bats in Brazil. However, most of them describe the pattern of association of streblid and nycteribiid bat flies with their hosts (Bertolla *et al.* 2005, Graciolli and Bianconi 2007, Dias *et al.* 2009, Camilotti *et al.* 2010, Teixeira and Ferreira 2010, Eriksson *et al.* 2011), while some deal exclusively with mites (Gettinger and Gribel 1989, Azevedo *et al*. 2002, Dantas-Torres *et al.* 2009, Silva *et al.* 2009). The only work featuring both groups of ectoparasites was published by Almeida *et al.* (2011).

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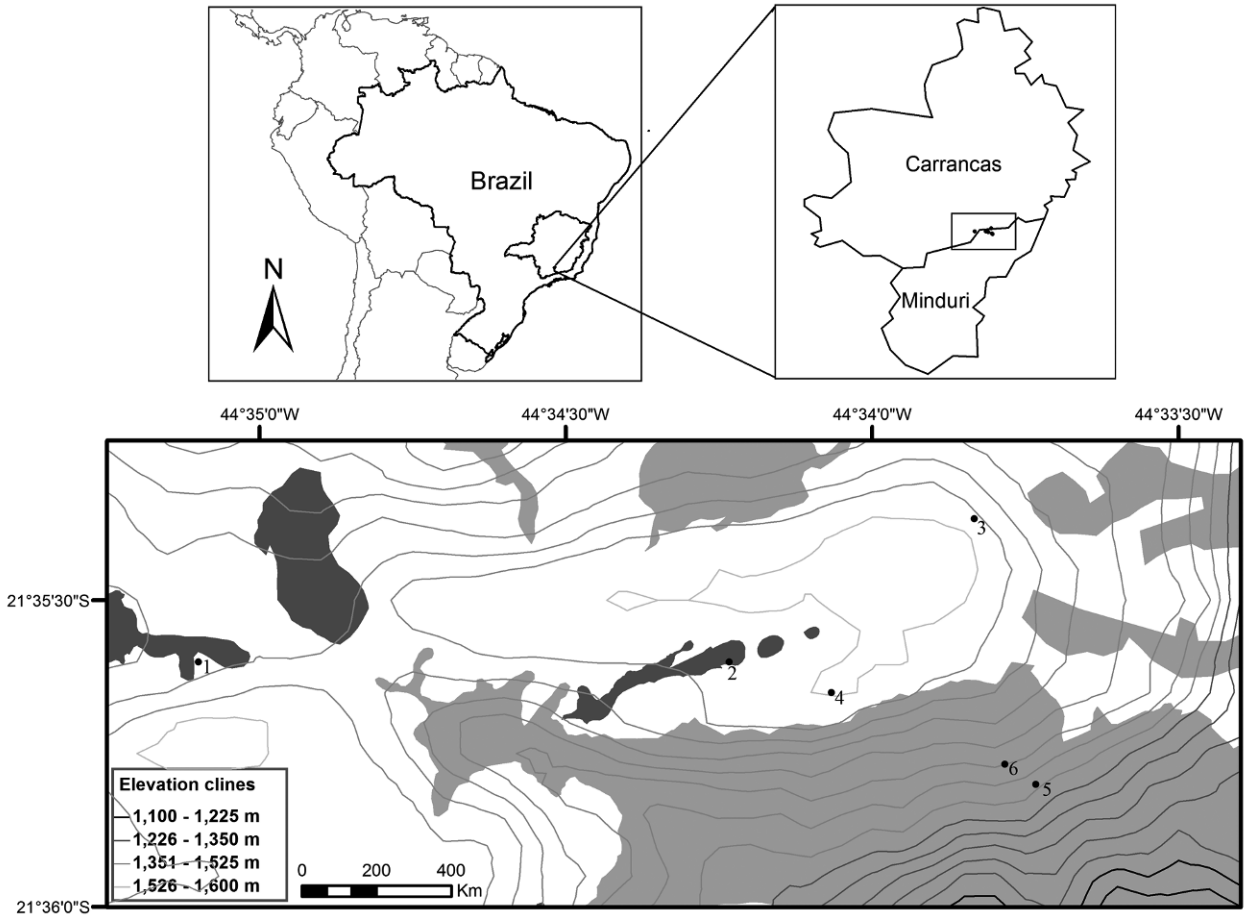

Fig. 1. Map of Chapada do Abanador, a high-altitude area of Atlantic Forest in the state of Minas Gerais, Brazil. Patches in pale gray represent the montane forest, in dark gray the cloud forest and in white the campo de altitude. Contour lines represent elevation clines. Circles mark the sites sampled, numbered as in Table I

Currently in Brazil, 92 bat flies and 32 bat-parasitizing mite species are known (another 10 are identified down to genus level), with most studies taking place in the South and Southeast regions of that country (Graciolli *et al.* 2008). Furthermore, practically all knowledge on the distribution of the ectoparasite fauna is based on collections carried out at low altitudes. Until now, only a single work on bat flies at higher altitudes has been performed at the Serra da Cantareira, São Paulo State (800–1700m above sea level) (Bertolla *et al.* 2005).

Considering the scarcity of data on bat parasites in those regions, the goal of this work was to describe the infracommunities of bat flies and mite ectoparasites of bats in a high-altitude region in southern Minas Gerais State, Brazil.

Table I. Relationship of the sampled sites for an inventory of bat fauna in three different habitats at Chapada do Abanador, state of Minas Gerais, Brazil, between July 2009 and April 2010, with their sampled area, elevation and coordinates

Habitat	Site	Area (ha)	Elevation (m)	Coordinates
CF	1	37	1,501	21°35′36″S/44°35′06″W
	2	34	1,530	21°35′36″S/44°34′14″W
C	3	387	1,540	21°35′22″S/44°33′50″W
	4	387	1,549	21°35′39″S/44°34′04″W
MF	5	300	1,345	21°35′48″S/44°33′44″W
	6	300	1,425	21°35′46″S/44°33′47″W

Abbreviations: MF, montane forest; CF, cloud forest; C, campo de altitude.

Table II. Ectoparasites collected on bats in Chapada do Abanador, Minas Gerais, Brazil

Bat species	*n*	Ectoparasites		*n*
		Batflies	***Mites***	
Phyllostomidae				
Anoura caudifer (E. Geoffroy, 1818)	3	*Anastrebla caudiferae* Wenzel, 1976		1
		Trichobius tiptoni Wenzel, 1976		6
Anoura geoffroyi Gray, 1838	8	*Exastinion clovisi* (Pessôa *and* Guimarães 1937)		13
		Anastrebla modestini Wenzel, 1966		9
			Periglischrus vargasi Hoffman, 1944 [b]	3
Artibeus fimbriatus Gray, 1838	1		*Tyrophagus* sp.1	1
			Macronyssus aff. *leislerianus* [a]	1
Artibeus lituratus (Olfers, 1818)	3	*P. longicrus* Miranda-Ribeiro, 1907		5
Carollia perspicillata (Linnaeus, 1758)	11	*Paraeuctenodes similis* Wenzel, 1966[b]		1
		Trichobius joblingi Wenzel, 1966		10
		T. tiptoni		7
		Strebla guajiro (García *and* Casal, 1965)		1
		Strebla mirabilis (Waterhouse, 1876)		3
			Periglischrus ojastii Machado-Allison, 1964	6
			Parichoronyssus bakeri Morales-Malacara and Guerrero, 2007[a/c]	1
Chrotopterus auritus (Peters, 1856)	2	*Trichobius dugesioides* Wenzel, 1966		3
Desmodus rotundus (E. Geoffroy, 1810)	1	*S. mirabilis*		1
Pygoderma bilabiatum (Wagner, 1843)	1		*Periglischrus* sp.	1
Sturnira lilium (E. Geoffroy, 1810)	5	*Megistopoda próxima* (Séguy, 1926)		6
		P. similis		1
		T. joblingi		3
			P. ojastii	7
			P. bakeri	1
Vampyressa pusilla (Wagner, 1843)	1		*Tyrophagus* sp. 2	1
Vespertilionidae				
Histiotus velatus (I. Geoffroy, 1824)	6	*Basilia producta* Maa, 1968[b/c]		1
			Chiroptonyssus sp.	5
			Macronyssus aff. *leislerianus*	6
			Radfordiella desmodi Radovsky, 1967	4
Myotis nigricans (Schinz, 1821)	2	*Basilia juquiensis* Guimarães, 1943[b]		3
		Anatrichobius passosi Graciolli, 2003[b]		1
12 species			23 species	112

New record for Brazil[a]; New record for the state of Minas Gerais[b]; New record for the host[c].

Materials and Methods

Study area

The study was carried out at an area known as Chapada do Abanador (21°35′S, 46°33′W), located between the municipalities of Minduri and Carrancas, southern Minas Gerais (Fig. 1). The Cwa climate (warmer) predominates in the region, whereas the Cwb climate (cooler) is restricted to mountaintops, as in the study area. Rainfall and average temperatures range between 1,536– 1,605 mm and 14.8–18.6°C, respectively (Pereira *et al.* 2007).

The vegetation in Chapada do Abanador consists mainly of, of *campos de altitude* and *campos rupestres* with large extensions of grasslands and eventually some shrub-sized species, intersected by rock outcrops. Semidecidual montane forests is present on the hillsides and on spring areas in *campo de altitude*, creating cloud forests. The montane forest covers

a very steepy landscape, from 1,000 to 1,500 m a.s.l., and cloud forests are above that height, having the *campos de altitude* as surrounding matrix (Fig. 1).

Data Collection

Bats were sampled in cloud forest, montane forest and *campo de altitude* (Table I). At each environment, two sites were sampled, both between 1,345 and 1,549 m a.s.l. A total of 45 nocturnal trapping sessions were carried out between July 2009 and April 2010, using 10 mist nets (12 × 2.5 m) opened from dawn to dusk, totaling a sampling effort of 153,000 m²h.

Captured bats were placed in cloth bags and properly identified while still in the field. Animal identification was done primarily based on Gardner (2007), but complementary literature and specimens for comparison were used as well. The nomenclature followed Simmons (2005).

Each captured bat was visually inspected, and ectoparasites were removed with the aid of tweezers and brushes, individualized and fixed in 70% alcohol. All samples were labeled, and host information, collection site and date were recorded.

Collected Diptera were taken to the laboratory and identified down to the specific level with the aid of the following literature: Dick and Miller (2010), Graciolli and Carvalho (2001), Graciolli (2003 and 2004), Guerrero (1996).

Diptera material is deposited at the Zoological Reference Collection – Center for Biological and Health Sciences/UFMS and at the Mammal Collection of the Universidade Federal de Lavras (CMUFLA).

Collected mites were taken to the laboratory, cleared in Nesbitt's solution and mounted between slides using Hoyer's medium (Walter and Krantz 2009). To identify the specimens down to family taxonomic level, the taxonomic key proposed by Walter and Krantz (2009) was used. Individuals were identified based on Rudnick (1960), Saunders (1975), Herrin and Tipton (1975), Radovsky (1967 and 2010), Micherdzinski (1980) and Morales-Malacara and Guerrero (2007), and by analyzing specimens from the acarology collection at Ohio State University (OSAL-Museum of Biological Diversity).

All mite materials collected during the present study are deposited at the CMUFLA.

Results

A total of 44 bats were inspected, belonging to 12 species from families Phyllostomidae and Vespertilionidae (Table II). In those hosts were collected 71 individuals from 12 Streblidae species, and four individuals from two Nycteribiidae species, totaling 14 species of bat flies (Table II). Among collected bat flies, four species represent new records for Minas Gerais, and represents a new record for host *H. velatus*.

The bat in which the largest number of bat flies was found was *C. perspicillata*, with a total of five species, followed by *S. lilium* with three species, and *A. caudifer*, *A. geoffroyi* and *M. nigricans* parasitized by two species each.

Some species of bat flies were found sharing the same host (Table III). *Anastrebla modestini* and *E. clovisi* feature the most frequent coexistence, found in the same host on five occasions.

Most bat flies were associated with only one host species, except for *T. tiptoni*, *T. joblingi*, *P. similis* and *S. mirabilis*, which were recorded in two species of bats (Table II).

In addition to bat flies, 37 individuals were collected, belonging to nine species of mites in seven species of bats. Special mention should be given to the recording of two new samples of mites for Brazil, in addition to a possible new species of *Chiroptonyssus* (Table II; Fig. 2).

Table III. Associations between ectoparasites and their frequencies on sampled bat species at Chapada do Abanador, Minas Gerais, Brazil

Infracommunities	Bat species	Frequency of occurrence
S. mirabilis + *T. joblingi*	*C. perspicillata*	1
S. mirabilis + *T. tiptoni*	*C. perspicillata*	2
S. guajiro + *T. tiptoni*	*C. perspicillata*	1
P. ojastii + *P. bakeri*	*C. perspicillata*	1
A. caudiferae + *T. tiptoni*	*A.caudifer*	1
A. modestini + *Exastinion clovisi*	*A. geoffroyi*	5
A. modestini + *P. vargasi*	*A. geoffroyi*	1
A. modestini + *E. clovisi* + *P. vargasi*	*A. geoffroyi*	1
R. desmodi + *Chiroptonyssus* sp.+ *B. producta*	*H. velatus*	1
R. desmodi + *Chiroptonyssus* sp.	*H. velatus*	1
Chiroptonyssus sp. + *R. desmodi*	*H. velatus*	1
Macronyssus sp. + *Chiroptonyssus* sp.	*H. velatus*	1
M. proxima + *P. ojastii*	*S. lilium*	2
P. similis + *T. joblingi* + *P. bakeri*	*S. lilium*	1

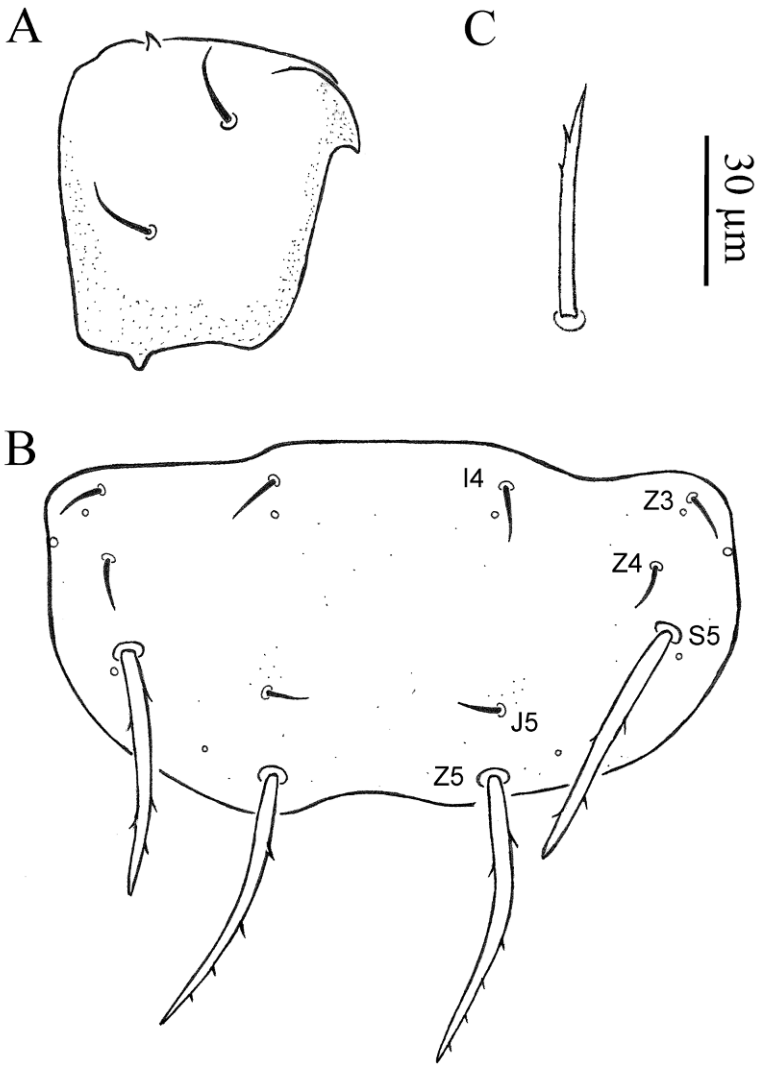

Fig. 2. *Chiroptonyssus* sp. nov., protonymph. **A.** ventral view of the coxa I; **B.** pygidial shield; **C.** detail of dorsal seta Z1

The most abundant and frequent mite species was *P. ojastii*, with 13 individuals present in five hosts, followed by *Macronyssus* aff. *leislerianus* (seven individuals on four hosts) and *Chiroptonyssus* sp. (five individuals on four hosts) (Table II).

The presence of bat flies and mites sharing the same host was observed in *A geoffroyi* (three individuals), *S. lilium* (three individuals) and *H. velatus* (one individual) (Table III). *Anoura geoffroyi* was the bat with the highest number of established infracommunities, with five associations featuring two species of flies, and two others showing associations between mites and bat flies, with *A. modestini* always present (Table III).

Discussion

The survey conducted at Chapada do Abanador presents a rich fauna of bat ectoparasites (14 bat fly species and nine mites) when compared to other works carried out in low Atlantic Forest areas in southern and southeastern Brazil (Azevedo and Linardi 2002, Rui and Graciolli, 2005, Camilotti *et al.* 2010, Almeida *et al.* 2011, Silva and Ortêncio Filho 2011). These studies recorded at least four bat fly species, with emphasis to the work by Almeida *et al.* (2011) who sampled 10 bat fly species and 11 mites. Another study, at high sections of the Serra da Cantareira, recorded an expressive diversity of ectoparasites, totaling 19 bat fly species, of which seven are new occurrences on a host and one is a new recording for South America (Bertolla *et al.* 2005).

The distribution of two Streblidae species and two Nycteribiidae species was expanded to include Minas Gerais: *A. passosi* (recorded in São Paulo, Paraná and Santa Catarina states), *P. similis* (São Paulo and Paraná), *B. juquiensis* (Distrito Federal, São Paulo, Paraná and Santa Catarina) and *B. producta* (Paraná and Santa Catarina) (Graciolli *et al.* 2008). In addition to bat flies, the mite *Periglischrus vargasi* represented the first record of the species for the state of Minas Gerais. Its record in Brazil had already been reported by Silva

et al. (2009), with exemplars collected in the state of Rio Grande do Sul, also from bat *A. geoffroyi*.

The occurrence of *B. producta* in *H. velatus* represents a new parasite-host association. This bat fly had previously been found only on *Myotis albescens* and *M. nigricans* (Graciolli *et al.* 2007), both of which also belong to family Vespertilionidae.

Among the new records of mites is species *P. bakeri*, described from specimens collected on *Phyllostomus hastatus* and *P. elongatus* in Peru (Morales-Malacara and Guerrero 2007). The individuals collected in Brazil, in addition to representing the first record of the species in the country, were also first sampled to *C. perspicillata* and *S. lilium* bats.

The collections of a macronyssid species similar to *M. leislerianus* represent an unusual record. The known distribution for *M. leislerianus* is restricted to Europe, in addition to the fact that its original host is the bat *Nyctalus leisleri* (Fain *et al.* 2003). The exemplars collected in Brazil showed the same setae patterns and similar measurements described for *M. leislerianus* (protonymph measures: podonotal shield, height 185–190 μm, width 140–147.5 μm; pygidial shield height 72–80 μm, width 87.5–97.5 μm; sternal shield, height 112–120 μm, width 77.5–80 μm; leg I 227.5–237.5 μm; leg II 187.5–192.5 μm; leg III 182.5–190 μm; leg IV 215–230 μm). Nevertheless, this record is made with caution, as the specimens were found on different hosts and the male is not known, which would be a decisive factor to precisely determine the species. Therefore, the possibility cannot be discarded that the exemplars represent a new species for the genus.

Chiroptonyssus individuals feature some similar characteristics to those described for *C. venezolanus*, such as the spine present in coxa I (Fig. 2a). However, the individuals recorded in the present work have the pair of *I4* setae located inside the pygidial shield (Fig. 2b), and the size of the dorsal setae (Fig. 2c) is larger than those presented in the description by Vitzthum (1931) and Radovsky (1967) for *C. venezolanus*. Thus, the individuals captured by us constitute the record of a new species for the genus, but in order to describe these exemplars new collections must be made so that adult individuals of both sexes are captured.

The two species from genus *Tyrophagus* found on *A. fimbriatus* and *V. pusilla* are known as dust mites and are not considered parasites. This association had already been reported on *P. pipistrellus*, a bat from family Vespertilionidae, in the British Isles by Baker and Craven (2003), but this is the first record of this association described for Brazil.

Although the occurrence of ectoparasites is treated in isolated form, these organisms are part of a small community, known as infracommunity, often consisting of specimens of organisms from different orders, but which have in common the occurrence in the same host (Bush *et al.* 1997). In Brazil, studies focusing on the entire infrafauna are exceptions, most of which are exclusive to bat flies (Graciolli and Rui 2001, Bertola *et al.* 2005, Teixeira and Ferreira 2010). These relationships can be important, as the co-occurrence of some parasites can be positively or negatively correlated, indicating or not competition between the species (Choe and Kim 1988, Simková *et al.* 2002, Tello *et al.* 2008).

As in the Serra da Cantareira (Bertola *et al.* 2005), associations were recorded at Chapada do Abanador between *A. modestini* and *E. clovisi* on bat *A. geoffroyi*, and between *A. caudiferae* and *T. tiptoni* on *A. caudifer*; also, the coexistence between species *S. mirabilis* and *T. tiptoni*, and between *S. guajiro* and *T. tiptoni* on host *C. perspicillata* had already been reported by Teixeira and Ferreira (2010).

The new records, in addition to the specimens that probably constitute new species, are a reflection of the scarce knowledge on bat mites in Brazil (Azevedo *et al.* 2002, Dantas-Torres *et al.* 2009, Silva *et al.* 2009, Almeida *et al.* 2011). Furthermore, ectoparasite sampling in the country is not homogenous and several areas remain little sampled, as is the case of high-altitude areas. These regions represent barriers for some arthropod groups, with a reduction in the number of species as the altitude increases (Janzen *et al.* 1976). On the other hand, in Panamá, Wenzel and Tipton (1966) observed that some bat ectoparasite species of arthropods in tropical areas were restricted to higher strata, and consequently environments with lower temperatures. Species of streblid in *Trichobius* group *phyllostomae* and in genera *Anatrichobius* and *Joblingia* show the same distribution pattern in the American continent (Wenzel *et al.* 1966, Graciolli 2003, Graciolli and Carvalho 2012, Graciolli and Dick 2012), occurring in the South and Southeast regions of Brazil, as well as northern South American and Central America, always 800 meters above sea level. Thus, the importance of sampling must be highlighted in various environments in order to better understand the distribution of bat ectoparasites in Brazil.

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