



## Infracommunities of bat flies (Diptera: Streblidae and Nycteribiidae) of bats (Mammalia: Chiroptera) in three conservation units in the State of Amapá, Brazil

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**Abstract:** Diptera belonging to the families Nycteribiidae and Streblidae are hematophagous ectoparasites, exclusively of bats. The Amapá State is located in the North Region of Brazil. The Amapá represents one of with the lowest rates of deforestation in the country, with approximately 80% of the territory preserved. Within the State, there are conservation units, Floresta Nacional do Amapá (FNA), Parque Nacional Montanhas do Tumucumaque (PNMT) and Reserva de desenvolvimento Sustentável do Rio Iratapuru (RDSI). These areas represent priority areas for the Conservation of Amazonian Biodiversity. Recently in Amapá studied on the diversity and distribution of bats, however, there are no records of associated arthropod ectoparasites. Therefore, the objective was to describe the pattern of association of Nycteribiidae and Streblidae species on bats in three protected areas of Amapá. Bats were collected through mist nets, where each host had its body visually revised and the Diptera collected were identified through a specific bibliography. One thousand and eighty- six individuals of bats flies were identified, distributed in 52 species (Streblidae = 49 and Nycteribiidae = three). Among the three infracommunities, the PNMT infracommunities was the largest found with abundance and richness of bats flies. All species found, represent new occurrences for the Amapá, being these, 18 new records for the North Region and seven new records for Brazil.

**Keywords:** *Hippoboscoidea*, *Host-parasite relationship*, *Amazonia*, *Geographic distribution*.

## Infracomunidades de moscas ectoparasitas (Diptera: Streblidae e Nycteribiidae) de morcegos (Mammalia: Chiroptera) em três unidades de conservação no Estado do Amapá, Brasil

**Resumo:** Dípteros pertencentes as famílias Nycteribiidae e Streblidae são ectoparasitos hematófagos, sendo exclusivamente de morcegos. O estado do Amapá localiza-se na região Norte do Brasil e representa um dos estados com as menores taxas de desmatamento do país, com aproximadamente 80% do território preservado. Dentro do Estado, existem as unidades de conservação, a Floresta Nacional do Amapá (FNA), o Parque Nacional Montanhas do Tumucumaque (PNMT) e a Reserva de Desenvolvimento Sustentável do Rio Iratapuru (RDS) que representam áreas prioritárias para a Conservação da Biodiversidade da Amazônia. Estudos sobre a diversidade e a distribuição de morcegos têm sido estudada recentemente no Amapá, no entanto, não existem registros de artrópodes ectoparasitos associados. Sendo assim, o objetivo foi descrever padrão de associação das espécies de Nycteribiidae e Streblidae sobre morcegos em três unidades de conservação do Amapá. Os morcegos foram coletados por meio de redes de neblina, onde cada hospedeiro teve seu corpo revisado visualmente e os dípteros coletados foram identificados através de bibliografia específica. Foram identificados 1086 indivíduos de moscas ectoparasitas, distribuídos em 52 espécies (Streblidae = 49 e Nycteribiidae = três). Entre as três infracomunidades, a infracomunidade de PNMT foi a maior encontrada tanto com relação a abundancia como em riqueza de dípteros ectoparasitas. Todas as espécies encontradas, representam novas ocorrências para o Estado do Amapá, sendo essas, 18 novos registros para a Região Norte e sete novos registros para o Brasil.

**Palavras-chave:** *Hippoboscoidea*; *Interações parasito-hospedeiro*; *Amazônia*; *Distribuição geográfica*.

## Introduction

Dipterans of the families Nycteribiidae and Streblidae are hematophagous ectoparasites, exclusively of bats (Wenzel et al. 1966, Marshall 1982). Nycteribiidae presents your distribution mainly in the Old World. In the American Continent, there are only two genera, *Basilia* Miranda-Ribeiro, 1903 with 53 species and *Herschkovitzia* Guimarães & D'Andretta, 1956 with four species (Graciolli et al. 2007, Graciolli & Dick 2009, Graciolli 2010). In Brazil were recorded 24 species of *Basilia* and two of *Herschkovitzia* (Graciolli 2019a). The Streblidae family occurs mainly in the New World. There are about 299 species described, with three subfamilies, Nycterophiliinae, Trichobiinae and Streblinae exclusive to the New World (Dick & Miller 2010, Dick et al. 2016).

Chiroptera represents the second largest mammal order, after Rodentia. They harbor exclusive ectoparasitic arthropod communities (Marshall 1982, Guerrero 1993). In Brazil, there are known 182 species in 69 genera of bats (Nogueira et al. 2018). In the North Region were recorded 144 bats in 63 genera (Reis et al. 2017), with 73 species recorded for Amapá State (Martins et al. 2011).

The Amapá State is located in the North Region of Brazil, on the delta of the Amazon River and making the transition to the highlands of the Guiana Shield. The State represents one of the lowest rates of deforestation in the North Region (INPE 2015). Furthermore, a large proportion of the State's territory (60%) is protected in 19 conservation units, divided into federal, state, municipal, full protection and sustainable use units (Drummond et al. 2008).

The diversity and distribution of bats have been studied recently in Amapá (Martins et al. 2006, 2011). However, there are no records of bat flies. Due to that, the objective of this work was to conduct a survey and describe the pattern of association of Nycteribiidae and Streblidae species on bats in three conservation units in the State of Amapá.

## Materials and Methods

The bat flies examined came from a rapid biological inventory of bats performed by Martins et al. (2006, 2011). The inventory followed the Rapid Assessment Program (RAP) developed by Conservation International.

### 1. Study area

Within existing protected areas in the Amapá State, Floresta Nacional do Amapá (FNA), Parque Nacional Montanhas do Tumucumaque (PNMT) and Reserva de Desenvolvimento Sustentável do Rio Iratapuru (RDSI) were chosen to be inventoried. They represent areas considered priorities for the conservation of the biodiversity of the Amazon (Capobianco et al. 2001). To select the collection sites locals, in each conservation area, were used pictures of a satellite to identify the principal vegetation formations. Prioritized regions with more than one environment, or a transition between them (Martins et al. 2006).

The FNA is located right in the center of the State and boasts an area of 4,120,000,000 m<sup>2</sup> approximately. The unit is accessed only inland waterway and feature predominantly vegetation of the upland forest, with some stains of flooded forests, "tabocais" (forest of bamboo) and rocky outcrop. The altitude varies from 80 to 450 m above sea level. This area was inventoried between four and 15th of August 2004, totalizing 21600 m<sup>2</sup>h (coordinates of collecting points: 01°18'07"N, 51°35'17"W; 01°06'37"N, 51°53'37"W).

The PNMT is located in the northwest region of the State, with an area of 38,700,000,000 m<sup>2</sup> approximately. It represents the largest continuous rainforest park in the world and therefore it is accessible only by air or waterways. The vegetation has a predominance of dense forests of mainland, igapó forest (dense ombrophylous alluvial forests), slops forests and dried formations associated with rocky outcrop. The relief varies from 100 to 400 m above sea level. In this area, two expeditions were carried out. The first occurred between 16 and 25th of September 2004, and the second expedition occurred between 10 and 20th of January 2005. Totalizing in both expedition 37800 m<sup>2</sup>h (coordinates of collecting points: 01°35'45"N, 52°29'32"W; 02°11'36"N, 54°35'15"W; 03°12'59"N, 52°01'10"W; 01°23'13"N, 51°55'39"W; 01°50'41"N, 52°44'28"W).

The RDSI is located in the southwest of the State, with about of 8,060,000,000 m<sup>2</sup>. In addition, only accessible by waterways and features a predominance of an upland forest with a high concentration of Castanheiras-do-Brazil (*Bertholletia excelsa* Humb. & Bonpl., 1808) and therefore there are traditional populations who commercially exploit the resource. The relief varies from 100 to 500 m above sea level. This area was inventoried between 12 and 20th of November, totaling 16200 m<sup>2</sup>h (coordinates of collecting points: 00°16'35"N, 53°06'24"W; 00°18'36"S, 52°26'24"W; 0°34'45"N, 52°19'08.3"W).

### 2. Capture of host and bat flies

The details of the capture of bat were described in Martins et al. (2006, 2011). Each night, 10 mist-net (12 x 2.5) were opened from 18:00 to 24:00h. In each host had the body visually reviewed and the bat flies were removed with the help of tweezers and stored in Eppendorf type tubes containing ethanol 70%, and a label with the data collection. The identification of bat flies was made using the keys presented by Guimarães & D'Andretta (1956), Guimarães (1966, 1977) and Guerrero (1993, 1994a, b, 1995a, b, 1996). The bat flies identified were deposited in the Coleção Zoológica de Referência, Universidade Federal do Mato Grosso do Sul, Campo Grande.

### 3. Data analysis

The description of the infracommunities (community of parasite infrapopulations in a single host) (Bush et al. 1997) found in common in each conservation. It was analyzed only the hosts species with at least two infested bats. In each infracommunities, it was calculated the absolute number of occurrence and relative frequency (quotient between the absolute frequency of parasites and the total number of the population in each host). Information about all infracommunities are described in the supplementary material (Table S1).

## Results

At the total, it was found 207 infested bats for the three conservation units. Among the bats species, only 10 were in common for the tree localities. In FNA from 52 bats of 18 species were infested by 29 species of bat flies. In RDSI, we found 47 bats for 17 species infested by 28 species of bat flies. Finally, PNMT, 108 individuals of 25 species were infested by 41 species of bat flies.

In relation to the bat flies, were identified 1086 individuals, distributed in 50 species and two subspecies (Strebliidae = 49 and Nycteribiidae = 3). Nycteribiidae family was represented by three

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species of *Basilia*. For Streblidae, *Trichobius dugesioides dugesioides* Wenzel, 1966 (n = 134) was the most abundant bat fly, follow of *Trichobius dugesioides phyllostomus* Guerrero, 1998 (n = 110), *Trichobius costalimai* Guimarães, 1938 (n = 98) and *Mastoptera minuta* (Costa Lima, 1921) (n = 90) (Tables 1, 2 and 3).

Four species of bats, *Pteronotus parnelli* (Gray, 1843), *Artibeus planirostris* (Spix, 1823), *Phyllostomus elongatus* (Geoffroy, 1810) and *Sturnira tildae* De la Torre, 1959, were found in all Conservation Units. We recorded a total of 39 composition of infracommunities bat flies

(FLONA = 11, PNMT = 16, RDSI = 12). *P. parnelli* presented the highest quantity of different parasites composition, with 11 infracommunities in all conservation's units. Despite this, the composition of the bat flies species infracommunities were different in each conservation unit. *Strebla consocia* Wenzel, 1976, *Trichobius dugesioides phyllostomus*, *Trichobius longipes* (Rudow, 1871) were in common for the three units. *Trichobius costalimai* and *Trichobius jobligi* Wenzel, 1966 were exclusive for PNMT and *Mastoptera minuta* and *Strebla galindoi* Wenzel, 1966 for RDSI (Table 4).

**Table 1.** Bats species, with a number of infested individuals. Their respective bat flies species and abundance in Floresta Nacional do Amapá Conservation Unit. Ni = number of individuals infested. N = number of individuals.

Family/Specie of host	Ni	Bat fly	N
<b>Mormoopidae</b>			
<i>Pteronotus parnelli</i> (Gray, 1843)	8	<i>Trichobius johnsonae</i> Wenzel, 1966	19
		<i>Trichobius caecus</i> Edwards, 1918	12
		<i>Nycterophilia parnelli</i> Wenzel, 1966	4
<b>Phyllostomidae</b>			
<i>Anoura geoffroyi</i> Gray, 1838	1	<i>Anastrebla modestini</i> Wenzel, 1966	1
<i>Artibeus planirostris</i> (Spix, 1823)	4	<i>Aspidoptera phyllostomatis</i> (Perty, 1833)	7
		<i>Megistopoda aranea</i> (Coquillett, 1899)	3
<i>Carollia brevicauda</i> (Schinz, 1821)	1	<i>Speiseria peytonae</i> Wenzel, 1976	1
		<i>Trichobius jobligi</i> Wenzel, 1966	1
<i>Carollia perspicillata</i> (Linnaeus, 1758)	3	<i>Strebla guajiro</i> (García & Casal, 1965)	4
		<i>Trichobius jobligi</i> Wenzel, 1966	3
<i>Chrotopterus auritus</i> (Peters, 1856)	1	<i>Strebla chrotopteri</i> Wenzel, 1976	1
<i>Desmodus rotundus</i> (Geoffroy, 1810)	1	<i>Strebla wiedemanni</i> (Kolenati, 1856)	2
<i>Glossophaga soricina</i> (Pallas, 1766)	1	<i>Trichobius uniformis</i> Curran, 1935	1
<i>Hsunycteris thomasi</i> (Allen, 1904)	4	<i>Trichobius lonchophyllae</i> Wenzel, 1966	26
		<i>Anastrebla</i> sp.	2
		<i>Trichobius</i> sp. (group <i>dugesii</i> )	1
<i>Lionycteris spurrelli</i> (Thomas, 1913)	1	<i>Trichobius lionycteridis</i> Wenzel, 1966	1
<i>Mimon bennettii</i> (Gray, 1838)	1	<i>Trichobius dugesioides dugesioides</i> Wenzel, 1966	3
<i>Mimon crenulatum</i> (Geoffroy, 1803)	3	<i>Basilia mimoni</i> Theodor & Peterson, 1964	2
		<i>Mastoptera minuta</i> (Costa Lima, 1921)	3
		<i>Strebla consocia</i> Wenzel, 1976	9
<i>Phyllostomus elongatus</i> (Geoffroy, 1810)	4	<i>Trichobius dugesioides phyllostomus</i> Guerrero, 1998	3
		<i>Trichobius longipes</i> (Rudow, 1871)	1
		<i>Neotrichobius delicatus</i> (Machado-Allisson, 1966)	1
<i>Rhinophylla pumilio</i> Peters, 1865	1	<i>Megistopoda proxima</i> (Séguy, 1926)	4
<i>Sturnira tildae</i> De La Torre, 1959	2	<i>Aspidoptera falcata</i> Wenzel, 1976	8
		<i>Strebla galindoi</i> Wenzel, 1966	5
<i>Tonatia saurophila</i> Koopman & Williams, 1951	1	<i>Trichobius dugesioides dugesioides</i> Wenzel, 1966	46
<i>Trachops cirrhosus</i> (Spix, 1823)	10	<i>Strebla mirabilis</i> (Waterhouse, 1879)	2
		<i>Speiseria magniocolus</i> Wenzel, 1976	3
		<i>Megistopoda aranea</i> (Coquillett, 1899)	1
		<i>Strebla alvarezi</i> Wenzel, 1966	1
<i>Trinycteris nicefori</i> (Sanborn, 1949)	5	<i>Strebla obtusa</i> Wenzel, 1976	18
		<i>Parastrebla handleyi</i> Wenzel, 1966	3

**Table 2.** Bats species, with a number of infested individuals. Their respective bat flies species and abundance in Parque Nacional Montanhas do Tumucumaque Conservation Unit. Ni = number of individuals infested. N = number of individuals.

Family/Specie of host	Ni	Bat fly	N
<b>Emballonuridae</b>			
<i>Rhynchonycteris naso</i> (Wied-Neuwied, 1820)	1	<i>Strebla asternalis</i> Wenzel, 1976	1
<i>Saccopteryx bilineata</i> (Temminck, 1838)	1	<i>Strebla asternalis</i> Wenzel, 1976	1
<b>Mormoopidae</b>			
<i>Pteronotus parnellii</i> (Gray, 1843)	7	<i>Trichobius johnsonae</i> Wenzel, 1966	18
		<i>Trichobius caecus</i> Edwards, 1918	12
		<i>Nycterophilina parnelli</i> Wenzel, 1966	2
<b>Noctilionidae</b>			
<i>Noctilio leporinus</i> (Linnaeus, 1758)	1	<i>Noctiliostrebla aitkeni</i> Wenzel, 1966	18
		<i>Paradyschiria lineata</i> Kessel, 1925	8
<b>Phyllostomidae</b>			
<i>Anoura geoffroyi</i> Gray, 1838	1	<i>Strebla curvata</i> Wenzel, 1976	1
		<i>Speiseria ambigua</i> Kessel, 1925	1
		<i>Trichobius tiptoni</i> Wenzel, 1976	1
<i>Artibeus obscurus</i> (Schinz, 1821)	1	<i>Neotrichobius bisetosus</i> Wenzel, 1976	1
<i>Artibeus planirostris</i> (Spix, 1823)	14	<i>Aspidoptera phyllostomatis</i> (Perty, 1833)	15
		<i>Megistopoda aranea</i> (Coquillett, 1899)	22
		<i>Metelasmus pseudoapterus</i> Coquillett, 1907	2
<i>Carollia perspicillata</i> (Linnaeus, 1758)	1	<i>Strebla guajiro</i> (García & Casal, 1965)	1
		<i>Trichobius joblingi</i> Wenzel, 1966	2
<i>Chrotopterus auritus</i> (Peters, 1856)	5	<i>Strebla chrotopteri</i> Wenzel, 1976	14
		<i>Trichobius johnsonae</i> Wenzel, 1966	1
		<i>Trichobius dugesioides dugesioides</i> Wenzel, 1966	12
<i>Desmodus rotundus</i> (Geoffroy, 1810)	4	<i>Strebla wiedemanni</i> (Kolenati, 1856)	16
		<i>Trichobius parasiticus</i> Gervais, 1844	8
<i>Glossophaga soricina</i> (Pallas, 1766)	2	<i>Trichobius uniformis</i> Curran, 1935	2
		<i>Trichobius dugesii</i> Townsend, 1891	3
		<i>Strebla harderi</i> Wenzel, 1976	1
<i>Lophostoma brasiliense</i> Peters, 1866	1	<i>Mastoptera minuta</i> (Costa Lima, 1921)	7
		<i>Trichobius silvicolae</i> Wenzel, 1976	1
<i>Lophostoma silvicola</i> d'Orbigny, 1836	7	<i>Mastoptera minuta</i> (Costa Lima, 1921)	23
		<i>Trichobius silvicolae</i> Wenzel, 1976	13
		<i>Pseudostrebla riberoi</i> Costa Lima, 1921	1
<i>Mimon crenulatum</i> (Geoffroy, 1803)	4	<i>Basilina mimoni</i> Theodor & Peterson, 1964	13
<i>Phylloderma sternops</i> (Peters, 1865)	1	<i>Strebla christinae</i> Wenzel, 1966	2
<i>Phyllostomus discolor</i> (Wagner, 1843)	14	<i>Strebla hertigi</i> Wenzel, 1966	31
		<i>Trichobius costalimai</i> Guimarães, 1938	63
		<i>Trichobioides perspicillatus</i> (Pessôa & Galvão, 1936)	7
		<i>Trichobius dugesioides dugesioides</i> Wenzel, 1966	2
		<i>Strebla consocia</i> Wenzel, 1976	34
<i>Phyllostomus elongatus</i> (Geoffroy, 1810)	17	<i>Trichobius dugesioides phyllostomus</i> Guerrero, 1998	76
		<i>Trichobius longipes</i> (Rudow, 1871)	9
		<i>Trichobius costalimai</i> Guimarães, 1938	4
		<i>Trichobius joblingi</i> Wenzel, 1966	2
		<i>Trichobius</i> sp. <i>parasiticus</i> complex	10

Continuation Table 2.

Family/Specie of host	Ni	Bat fly	N
<i>Phyllostomus hastatus</i> (Pallas, 1767)	4	<i>Strebla consocia</i> Wenzel, 1976	4
		<i>Trichobius longipes</i> (Rudow, 1871)	8
<i>Rhinophylla pumilio</i> Peters, 1865	2	<i>Neotrichobius delicatus</i> (Machado-Allisson, 1966)	2
<i>Sturnira tildae</i> De La Torre, 1959	2	<i>Megistopoda proxima</i> (Séguy, 1926)	1
		<i>Megistopoda aranea</i> (Coquillett, 1899)	1
<i>Tonatia saurophila</i> Koopman & Williams, 1951	1	<i>Strebla galindoi</i> Wenzel, 1966	3
<i>Trachops cirrhosus</i> (Spix, 1823)	9	<i>Trichobius dugesioides dugesioides</i> Wenzel, 1966	50
		<i>Strebla mirabilis</i> (Waterhouse, 1879)	1
		<i>Speiseria magniocus</i> Wenzel, 1976	9
<i>TrinycTERIS nicefori</i> (Sanborn, 1949)	1	<i>Strebla obtusa</i> Wenzel, 1976	2
<b>Vespertilionidae</b>			
<i>Myotis albescens</i> (Geoffroy, 1806)	5	<i>Basilina dunni</i> Curran, 1935	14
<i>Myotis riparius</i> Handley, 1960	2	<i>Basilina anceps</i> Guimarães & Andretta, 1956	3

All species recorded in this work represent the first occurrence to the State of Amapá. Among these, 17 species and two genera of Streblidae are recorded for the first time in the North Region. This increased to 58 and 15 the number of species and genera respectively for the region. In relation to the Nycteribiidae, *Basilina anceps* Guimarães & D'Andretta, 1956 is registered for the first time for the North Region, increased to eight the number of species for the region. *Strebla asternalis* Wenzel, 1976, *Strebla matsoni* Wenzel, 1976, *Paradyschiria lineata* Kessel, 1925, *Speiseria peytonae*, Wenzel 1976, *Speiseria magniocus* Wenzel, 1976, *Trichobius lionycteridis* Wenzel, 1966 and *Trichobius macrophylli* Wenzel 1966 are recorded for the first time in the Brazil, increasing to 92 the number of Streblidae species for the country (Table 5).

## Discussion

The richness of species found in this work confirms the information that the Brazilian Amazon presents a very large diversity of species of bat flies (Graciolli & Bernard 2002, Graciolli & Linardi 2002, Graciolli 2019a, 2019b). With the new occurrences of this work, the North Region remains with 58 species of Streblidae, with the same number in species to the Central-West Region. The Southeast Region has 53 species recorded, follow with Northeast with 48 and finally the South Region with 33 species (Barbier & Bernard 2017, Graciolli 2019b, Barbier et al. 2019). Despite this, the regions Central-West and Southeast have a greater amount in a number of genera of Streblidae, each with 18 genera (Graciolli 2019b). In the Northeast are found 14 genera, in the South 13 and finally, the North with the current work remains with 15 genera of Streblidae (Barbier & Bernard 2017, Graciolli 2019b, Barbier et al. 2019).

With the family Nycteribiidae this relationship is reversed. The Southeast represents the Region richer, with 18 species, following with the South Region with 13 species, Central-West with 11, the Northeast with four species and with the current work, the North Region remains with eight species of Nycteribiidae (Barbier & Bernard 2017, Graciolli 2019a, Barbier et al. 2019). Although the North and Northeast Regions not be as expressive in quantity of species, it represents the only regions that in addition the genus *Basilina*, also occurs the genus *Herskovitzia*

(*H. cabala* Peterson & Lacey, 1985, *H. inaequalis* Theodor, 1967 and *Herskovitzia* sp.) (Peterson & Lacey 1985, Graciolli 2001, Graciolli & Bernard 2002, Santos et al. 2013, Barbier & Bernard 2017, Graciolli 2019a).

Previously, Pará was the State with the highest number of species of Streblidae for the North Region of Brazil, with 28 species. Then stay Rondônia and Roraima with 14 species each and Amazonas with nine species (Graciolli 2019b). The high amount of species of bat flies found to Amapá (N = 52), demonstrates that much of the diversity species of bat flies for the region remains unknown (Graciolli & Linardi 2002, Graciolli & Bernard 2002, Graciolli 2019b).

The new registers for Brazil were already known for another country of the South and Central America. The species *S. asternalis* and *S. matsoni* where known only for Venezuela (Wenzel 1976, Guerrero 1994b, Frank et al. 2014). *S. magniocus* still be known for Venezuela, has also been found in Peru (Wenzel 1976, Guerrero 1994b, Frank et al. 2014). On the contrary, some species have a large distribution in South and Central America, but there was no occurrence for Brazil. Such as, *S. peytonae* which that is known for Bolivia, Colombia, Peru, Venezuela, Belize and Honduras (Wenzel 1976, Guerrero 1994b, Dick 2013, Frank et al. 2014, Dick et al. 2016) (Table 5).

In the present work, *Trichobioides perspicillatus* (Pessôa & Galvão, 1936) represents the first occurrence of genus and species for the North Region of Brazil. Previously the species still had occurrence for the Regions Northeast (Bahia, Maranhão, Pernambuco and Sergipe), Central-West (Distrito Federal and Mato Grosso do Sul) and Southeast (Minas Gerais) (Graciolli 2019b). Despite not have previously registered for the North Region, previous work has already pointed out that the species is found in the Amazonian ecoregion (Barbier & Bernard 2017). *Anastrebla modestini* Wenzel, 1966 also represents the first occurrence of genus/species for the North Region. Previously this species was described only for the regions South (Paraná, Santa Catarina and Rio Grande do Sul), Southeast (São Paulo, Rio de Janeiro and Minas Gerais) and Central-West (Distrito Federal and Goiás) (Graciolli 2019b). Its restricted distribution was probably the distribution of the host (*Anoura geoffroyi* Gray, 1838), which for North Region is known only for States of Amapá and Pará (Zortéa & Velazco 2017) (Table 5).

**Table 3.** Bats species, with a number of infested individuals. Their respective bat flies species and abundance in Reserva de Desenvolvimento Sustentável Rio Iratapuru Conservation Unit. Ni = number of individuals infested. N = number of individuals.

Family/Specie of host	Ni	Bat fly	N
<b>Mormoopidae</b>			
<i>Pteronotus parnellii</i> (Gray, 1843)	9	<i>Trichobius johnsonae</i> Wenzel, 1966	7
		<i>Trichobius caecus</i> Edwards, 1918	54
		<i>Nycterophilia parnelli</i> Wenzel, 1966	2
		<i>Mastoptera minuta</i> (Costa Lima, 1921)	1
		<i>Neotrichobius delicatus</i> (Machado-Allisson, 1966)	1
<i>Pteronotus</i> sp.	1	<i>Nycterophilia parnelli</i> Wenzel, 1966	4
<b>Phyllostomidae</b>			
<i>Artibeus lituratus</i> (Olfers, 1818)	2	<i>Megistopoda aranea</i> (Coquillett, 1899)	1
		<i>Paratrichobius longicrus</i> (Miranda-Ribeiro, 1907)	2
<i>Artibeus planirostris</i> (Spix, 1823)	5	<i>Aspidoptera phyllostomatis</i> (Perty, 1833)	7
		<i>Megistopoda aranea</i> (Coquillett, 1899)	2
<i>Carollia perspicillata</i> (Linnaeus, 1758)	1	<i>Trichobius joblingi</i> Wenzel, 1966	1
		<i>Speiseria ambigua</i> Kessel, 1925	1
<i>Chrotopterus auritus</i> (Peters, 1856)	2	<i>Strebla chrotopteri</i> Wenzel, 1976	3
		<i>Trichobius dugesioides dugesioides</i> Wenzel, 1966	2
<i>Lamproncycteris brachyotis</i> (Dobson, 1879)	1	<i>Strebla obtusa</i> Wenzel, 1976	5
<i>Lionycteris spurrelli</i> (Thomas, 1913)	1	<i>Trichobius lionycteridis</i> Wenzel, 1966	2
<i>Lophostoma silvicola</i> d'Orbigny, 1836	3	<i>Mastoptera minuta</i> (Costa Lima, 1921)	1
		<i>Trichobius silvicolae</i> Wenzel, 1976	3
		<i>Strebla galindoi</i> Wenzel, 1966	1
<i>Macrophyllum macrophyllum</i> (Schinz, 1821)	2	<i>Strebla matsoni</i> Wenzel, 1976	1
		<i>Trichobius macrophylli</i> Wenzel, 1966	8
<i>Micronycteris</i> sp.	1	<i>Strebla hoogstraali</i> Wenzel, 1966	6
<i>Phyllostomus discolor</i> (Wagner, 1843)	4	<i>Strebla hertigi</i> Wenzel, 1966	3
		<i>Trichobius costalimai</i> Guimarães, 1938	31
		<i>Trichobioides perspicillatus</i> (Pessôa & Galvão, 1936)	4
<i>Phyllostomus elongatus</i> (Geoffroy, 1810)	6	<i>Strebla consocia</i> Wenzel, 1976	14
		<i>Trichobius dugesioides phyllostomus</i> Guerrero, 1998	31
		<i>Trichobius longipes</i> (Rudow, 1871)	22
		<i>Strebla galindoi</i> Wenzel, 1966	5
		<i>Mastoptera minuta</i> (Costa Lima, 1921)	34
<i>Phyllostomus hastatus</i> (Pallas, 1767)	1	<i>Strebla consocia</i> Wenzel, 1976	1
		<i>Trichobius longipes</i> (Rudow, 1871)	9
		<i>Mastoptera minuta</i> (Costa Lima, 1921)	21
<i>Rhinophylla pumilio</i> Peters, 1865	2	<i>Neotrichobius delicatus</i> (Machado-Allisson, 1966)	3
<i>Sturnira tildae</i> De La Torre, 1959	2	<i>Megistopoda proxima</i> (Séguy, 1926)	4
		<i>Aspidoptera falcata</i> Wenzel, 1976	1
<i>Tonatia saurophila</i> Koopman & Williams, 1951	2	<i>Strebla galindoi</i> Wenzel, 1966	5
		<i>Trichobius silvicolae</i> Wenzel, 1976	1
<i>Trachops cirrhosus</i> (Spix, 1823)	1	<i>Trichobius dugesioides dugesioides</i> Wenzel, 1966	19
<b>Vespertilionidae</b>			
<i>Myotis albescens</i> (Geoffroy, 1806)	1	<i>Basilia dumni</i> Curran, 1935	2

Infracommunities of bat flies in Brazil

**Table 4.** Bat species with their respective infracommunity. N = Absolute number of occurrence. AR% = Values of relative abundance.

Infracommunity FNA	N	AR%	Infracommunity PNMT	N	AR%	Infracommunity RDS	N	AR%
<b><i>Pteronotus parnellii</i> (N 8)</b>			<b><i>Pteronotus parnellii</i> (N 7)</b>			<b><i>Pteronotus parnellii</i> (N 9)</b>		
<i>T. johnsonae</i>	3	37%	<i>T. johnsonae</i>	5	71%	<i>T. caecus</i>	6	66%
<i>T. johnsonae</i> + <i>N. parnellii</i>	3	37%	<i>T. johnsonae</i> + <i>N. parnellii</i>	1	14%	<i>T. johnsonae</i>	1	11%
<i>T. caecus</i>	2	25%	<i>T. caecus</i>	1	14%	<i>T. caecus</i> + <i>M. minuta</i>	1	11%
						<i>N. delicatus</i> + <i>N. parnellii</i> + <i>T. johnsonae</i>	1	11%
<b><i>Artibeus planirostris</i> (N 4)</b>			<b><i>Artibeus planirostris</i> (N 14)</b>			<b><i>Artibeus planirostris</i> (N 5)</b>		
<i>A. phyllostomatus</i>	2	50%	<i>A. phyllostomatus</i>	7	50%	<i>A. phyllostomatus</i>	3	60%
<i>M. aranea</i>	1	25%	<i>M. aranea</i>	4	28%	<i>A. phyllostomatus</i> + <i>M. aranea</i>	2	40%
<i>A. phyllostomatus</i> + <i>M. aranea</i>	1	25%	<i>A. phyllostomatus</i> + <i>M. aranea</i> + <i>M. pseudoopterus</i>	2	14%			
			<i>A. phyllostomatus</i> + <i>M. aranea</i>	1	7%			
<b><i>Phyllostomus elongatus</i> (N 4)</b>			<b><i>Phyllostomus elongatus</i> (N 17)</b>			<b><i>Phyllostomus elongatus</i> (N 6)</b>		
<i>S. consocia</i> + <i>T. dugesioides phyllostomus</i>	2	50%	<i>S. consocia</i> + <i>T. dugesioides phyllostomus</i>	7	41%	<i>T. dugesioides phyllostomus</i> + <i>S. consocia</i> + <i>T. longipes</i> + <i>M. minuta</i>	3	50%
<i>S. consocia</i>	1	25%	<i>T. dugesioides phyllostomus</i>	3	17%	<i>S. consocia</i> + <i>T. dugesioides phyllostomus</i>	1	16%
<i>T. longipes</i>	1	25%	<i>T. dugesioides phyllostomus</i> + <i>S. consocia</i> + <i>T. longipes</i>	3	17%	<i>T. dugesioides phyllostomus</i> + <i>S. galindoi</i> + <i>T. longipes</i>	1	16%
			<i>T. costalimai</i>	1	5%	<i>T. dugesioides phyllostomus</i>	1	16%
			<i>T. dugesioides phyllostomus</i> + <i>T. longipes</i>	1	5%			
			<i>S. consocia</i> + <i>T. longipes</i> + <i>Trichobius</i> sp. <i>parasiticus</i> complex	1	5%			
			<i>T. dugesioides phyllostomus</i> + <i>S. consocia</i> + <i>T. joblingi</i>	1	5%			
<b><i>Sturnira tildae</i> (N 2)</b>			<b><i>Sturnira tildae</i> (N 2)</b>			<b><i>Sturnira tildae</i> (N 2)</b>		
<i>M. proxima</i>	1	50%	<i>M. proxima</i>	1	50%	<i>M. proxima</i>	1	50%
<i>M. proxima</i> + <i>A. falcata</i>	1	50%	<i>M. aranea</i>	1	50%	<i>A. falcata</i>	1	50%

Some species have significantly increased its distribution in Brazil. Previously *T. lonchophyllae* Wenzel, 1966 and *Strebla harderi* Wenzel, 1976 were known only for the regions Central-West (Distrito Federal) and Southeast (Minas Gerais and Rio de Janeiro - *T. lonchophyllae*). *T. johnsonae* Wenzel, 1966, *B. anceps* and *Nycterophilia parnellii* Wenzel, 1966 were recorded only in the regions Central-West (Distrito Federal, Goiás – *B. anceps*, Mato Grosso – *N. parnellii* and Mato Grosso do Sul – *T. johnsonae*). *Strebla hoogstraali* Wenzel, 1966 was known only for the State of Maranhão. The other new records for the North Region (*Strebla chrotopteri* Wenzel, 1976, *Trichobius tiptoni* Wenzel, 1976 and *Trichobius dugesii* Townsend, 1891) already had a wider distribution

along the other regions of Brazil (Graciolli 2019b). Although, the specie *S. curvata* Wenzel, 1976 already has an occurrence for the North Region, the identification is in dubious (Santos et al. 2012) (G. Graciolli personal communication) (Table 5).

In PNMT was found in greater richness and abundance of bat flies (41 species, N = 559), bat (25 species, N = 108) and consequently of infracommunities (N = 16) (Tables 2 and 4). This is probably the area have received two expeditions, while the others had only an expedition (Martins et al. 2006, 2011). The frequency of species richness in the infracommunities is similar than the frequency found by others works (Santos et al. 2013, Barbier & Graciolli 2016, Dornelles & Graciolli 2017).

**Table 5.** Registered of new occurrences for the Region North and for Brazil. (<sup>1</sup>Wenzel 1966, <sup>2</sup>Wenzel 1976, <sup>3</sup>Guerrero 1994b, <sup>4</sup>Dick 2013, <sup>5</sup>Frank et al. 2014, <sup>6</sup>Dick et al. 2016, <sup>7</sup>Gracioli 2019b).

Bat fly	New occurrence	Previous occurrence
<i>S. peytonae</i> Wenzel, 1976	New occurrence for Brazil	Bolivia <sup>3,4,5</sup> , Colombia <sup>5</sup> , Peru <sup>3,5,6</sup> , Venezuela <sup>2,3,5,6</sup> , Belize <sup>5</sup> , and Honduras <sup>4,5,6</sup>
<i>S. magniocularis</i> Wenzel, 1976	New occurrence for Brazil	Peru <sup>3</sup> and Venezuela <sup>2,3,5</sup>
<i>S. asternalis</i> Wenzel, 1976	New occurrence for Brazil	Venezuela <sup>2,3,5</sup>
<i>P. lineata</i> Kessel, 1925	New occurrence for Brazil	Venezuela <sup>2,3,5</sup> , Panamá <sup>5,6</sup> , French Guiana <sup>6</sup> and Peru <sup>6</sup>
<i>T. lionycteridis</i> Wenzel, 1966	New occurrence for Brazil	Belize <sup>5</sup> , Venezuela <sup>2,3,5</sup> , Panamá <sup>1,4,5</sup> and Peru <sup>6</sup>
<i>S. matsoni</i> Wenzel, 1976	New occurrence for Brazil	Venezuela <sup>2,3,5</sup>
<i>T. macrophylli</i> Wenzel, 1966	New occurrence for Brazil	Panamá <sup>1,3,5</sup> , Costa Rica <sup>5</sup> , Venezuela <sup>2</sup> and Bolivia <sup>3</sup>
<i>A. modestini</i> Wenzel, 1966	New occurrence of Genus for the Region North	South (Paraná, Santa Catarina and Rio Grande do Sul), Southeast (São Paulo, Rio de Janeiro and Minas Gerais) and Midwest (Distrito Federal and Goiás) <sup>7</sup>
<i>T. perspicillatus</i> (Pessôa & Galvão, 1936)	New occurrence of Genus for the Region North	Northeast (Bahia, Maranhão, Pernambuco and Sergipe), Midwest (Distrito Federal and Mato Grosso do Sul) and Southeast (Minas Gerais) <sup>7</sup>
<i>T. lonchophyllae</i> Wenzel, 1966	New occurrence for the Region North	Midwest (Distrito Federal) and Southeast (Minas Gerais and Rio de Janeiro) <sup>7</sup>
<i>T. tiptoni</i> Wenzel, 1979	New occurrence for the Region North	South (Paraná and Rio Grande do Sul), Southeast (Minas Gerais, Rio de Janeiro and São Paulo) and Midwest (Distrito Federal, Goiás and Mato Grosso do Sul) <sup>7</sup>
<i>S. chropteri</i> Wenzel, 1976	New occurrence for the Region North	Midwest (Distrito Federal and Mato Grosso do Sul), Southeast (Minas Gerais and São Paulo) and South (Paraná) <sup>7</sup>
<i>T. dugesii</i> Townsend, 1891	New occurrence for the Region North	South (Rio Grande do Sul), Southeast (Minas Gerais, Rio de Janeiro and São Paulo), Midwest (Distrito Federal, Goiás and Mato Grosso do Sul) and Northeast (Maranhão and Paraíba) <sup>7</sup>
<i>S. harderi</i> Wenzel, 1976	New occurrence for the Region North	Midwest (Distrito Federal) and Southeast (Minas Gerais) <sup>7</sup>
<i>B. anceps</i> Guimarães & D'Andretta, 1956	New occurrence for the Region North	Midwest (Distrito Federal and Goiás) <sup>7</sup>
<i>T. johnsonae</i> Wenzel, 1966	New occurrence for the Region North	Midwest (Distrito Federal and Mato Grosso do Sul) <sup>7</sup>
<i>N. parnelli</i> (Gray, 1843)	New occurrence for the Region North	Midwest (Mato Grosso and Distrito Federal) <sup>7</sup>
<i>S. hoogstraali</i> Wenzel, 1966	New occurrence for the Region North	Northeast (Maranhão) <sup>7</sup>

## Conclusion

This work represents the first record of bat flies (Streblidae and Nycteribiidae) for Amapá State. The number of species of bat flies up to 50 species and two subspecies for the State of Amapá, being these 18 new records for the North Region of the country and seven new records for Brazil. In addition, the infracommunities found in the three conservations units of Amapá are described.

## Supplementary material

The following online material is available for this article:

**Table S1** - All the infracommunities found in the three Conservation Units.

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## Author Contributions

Ana Carolina Moreira Martins: Contribution to data collection.

Gabriela Hrycyna: Contribution to manuscript preparation.

Gustavo Gracioli: Contribution to critical revision, adding intellectual content; Contribution to manuscript preparation.

## Conflicts of interest

The authors declares that they have no conflict of interest related to the publication of this manuscript.



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