



Revista mexicana de biodiversidad

ISSN: 1870-3453

ISSN: 2007-8706

Instituto de Biología

Barbier, Eder; Nunes, Hannah; Rocha, Patrício Adriano
da; Rocha, Fabiana Lopes; Cordeiro-Estrela, Pedro
Updated species list of the bat ectoparasitic flies (Diptera: Nycteribiidae
and Streblidae) in the state of Paraíba, Northeastern Brazil
Revista mexicana de biodiversidad, vol. 90, 2019
Instituto de Biología

DOI: 10.22201/ib.20078706e.2019.90.2485

Available in: <http://www.redalyc.org/articulo.oa?id=42562784038>

- How to cite
- Complete issue
- More information about this article
- Journal's homepage in redalyc.org

UAEM redalyc.org

Scientific Information System Redalyc

Network of Scientific Journals from Latin America and the Caribbean, Spain and Portugal

Project academic non-profit, developed under the open access initiative

Taxonomy and systematics

Updated species list of the bat ectoparasitic flies (Diptera: Nycteribiidae and Streblidae) in the state of Paraíba, Northeastern Brazil

Lista actualizada de especies de moscas ectoparásitas (Diptera: Nycteribiidae y Streblidae) de murciélagos en el estado de Paraíba, noreste de Brasil

Eder Barbier ^{a, b, *}, Hannah Nunes ^{c, d}, Patrício Adriano da Rocha ^{c, d}, Fabiana Lopes Rocha ^{c, e},
Pedro Cordeiro-Estrela ^c

^a Departamento de Zoologia, Centro de Biociências, Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, 1235, Cidade Universitária - Recife PE 50670-901, Brazil

^b Programa de Pós-graduação em Biologia Animal, Centro de Biociências, Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, 1235, Cidade Universitária - Recife PE 50670-901, Brazil

^c Laboratório de Mamíferos, Departamento de Sistemática e Ecologia, Centro de Ciências Exatas e da Natureza, Universidade Federal da Paraíba - João Pessoa PB 58051-900, Brazil

^d Programa de Pós-graduação em Ciências Biológicas, Centro de Ciências Exatas e da Natureza, Universidade Federal da Paraíba, Cidade Jardim Universitário, s/n, Castelo Branco - João Pessoa PB 58051-900, Brazil

^e Programa de Pós-Graduação em Ecologia e Monitoramento Ambiental, Centro de Ciências Aplicadas e Educação, Universidade Federal da Paraíba, Campus IV - Rio Tinto PB 58297-000, Brazil

*Corresponding author: barbier.eder@gmail.com (E. Barbier)

Received: 2 October 2017; accepted: 15 October 2018

Abstract

Bat ectoparasitic flies are highly specialized hematophagous insects exclusive to Chiroptera. Between November 2014 and August 2016, we surveyed these ectoparasites in urban and protected areas in the state of Paraíba, northeastern Brazil. We recorded 15 fly species in 10 genera in the families Streblidae (13) and Nycteribiidae (2). Twelve species and 5 genera represent first records for the state. *Basilia anceps* and *Noctiliostrebla* sp., are new records for the northeastern region of Brazil. Fly specimens were collected on 8 species of bats, mainly phyllostomids, and ~87% were monoxenous. Our survey increased the number of known bat ectoparasitic flies in the state from 10 to 22 species, from 5 to 10 genera, and from 31 to 34 known species in the northeastern portion of the Atlantic Forest.

Keywords: Atlantic Forest; Chiroptera; Ectoparasites; Host-parasite relationship; New records; Species richness

Resumen

Las moscas ectoparásitas de murciélagos son hematófagos altamente especializados de quirópteros. Desde noviembre de 2014 hasta agosto de 2016 realizamos un estudio de estos ectoparásitos en áreas urbanas y protegidas en el estado de Paraíba, noreste de Brasil. Se registraron 15 especies de moscas de 10 géneros de las familias Streblidae (13) y Nycteribiidae (2). Doce especies y 5 géneros de moscas representan el primer registro para el estado. *Basilia anceps* y *Noctiliostrebla* sp. son nuevos registros para el noreste de Brasil. Las moscas fueron recolectadas en 8 especies de murciélagos, principalmente en filostomídeos, y ~87% eran monoxenas. A través de nuestro estudio, el número de moscas ectoparásitas de murciélagos conocidas en el estado aumentó de 10 a 22 especies, de 5 a 10 géneros y de 31 a 34 especies conocidas en la porción noreste del Bosque Atlántico.

Palabras clave: Bosque Atlántico; Chiroptera; Ectoparásitos; Relación hospedero-parásito; Nuevos registros; Riqueza de especies

Introduction

Streblidae and Nycteribiidae (Diptera: Hippoboscoidea) are 2 worldwide distributed families of blood feeding and obligate ectoparasitic flies (Dick & Patterson, 2006). Bat flies are found exclusively infesting the body or wing membranes of these flying mammals (Marshall, 1982). Even though they should be able to colonize multiple host species, researchers have suggested species-specific host-parasite relationships (Dick & Dick, 2006; ter Hofstede & Fenton, 2005).

Ecological and behavioral features of bats, such as social structure, roost environment, and species fidelity to roosting sites play an important role in the host-parasite dynamics (Patterson et al., 2007). Therefore, studies on the diversity and interactions between these parasites and bats can offer valuable information concerning different biological, phylogenetic, and systematic aspects of these mammalian hosts. They can also shed light on the role of blood-feeding arthropods in the epidemiology of bat-borne pathogens (e.g., virus and bacteria; Fritz, 1983; Joffrin et al., 2018) which is at the present moment speculative. However, basic knowledge regarding ectoparasites' diversity, distribution, and host-parasite relationships are still incipient.

In Brazil, the knowledge about these hematophagous bat flies is geographically biased where, for example, the smallest federative unit (Federal District) has the highest species richness ($n = 56$; Figueiredo et al., 2015), representing approximately half of the species occurring in the country. At a national level, the most surveyed region is the southeastern (Lourenço et al., 2016); the north and northeastern regions remain with the largest sampling gaps.

Currently, throughout northeastern Brazil, 47 streblid and only 3 nycteribiid species have been recorded infesting 8 bat families, mainly Phyllostomidae (Barbier & Bernard, 2017). Despite the advance in recent years (Bezerra et al., 2016; Santos et al., 2013; Soares et al., 2013, 2016),

species richness in the northeastern is underestimated and the majority of states is undersampled or lack information about bat ectoparasitic flies' diversity (Barbier & Bernard, 2017). The state of Paraíba, for instance, has had only 1 survey on bat ectoparasitic flies—conducted in the Caatinga (seasonally dry tropical forest)—with 10 species recorded (Barbier et al., 2016).

In the present study, we provide updated information on streblid and nycteribiid flies in the state of Paraíba, extending the known geographical range of 5 genera and 12 species. In this sense, we surveyed bats in residential areas and urban forest remnants of Atlantic Forest and produced an annotated species list of bat ectoparasitic flies with comments on associations with their hosts.

Materials and methods

Field studies were conducted in 5 protected areas of Atlantic Forest and residential neighborhoods within the metropolitan region of João Pessoa, state of Paraíba (07°07' S, 34°51' W), northeastern Brazil. The sampled areas were: 1) Mata do Buraquinho Wildlife Refuge (517.8 ha), 2) Restinga de Cabedelo National Forest (136.36 ha), 3) Cuiá Natural Park (42 ha), 4) Arruda Câmara Zoobotanical Park (26.8 ha), 5) Cidade Verde Municipal Forest (22 ha) and the neighborhoods, 6) Altiplano, 7) Alto do Mateus, 8) Bairro dos Novaes, 9) Funcionários IV, 10) Jardim Veneza, 11) Paratibe, and 12) Penha (Fig. 1).

A wide variety of phytophysiognomies of the Atlantic Forest biome can be identified among sampling sites, including areas of typical seasonal semi-deciduous forests, savanna formations on sandy soils, "restingas" (coastal vegetation), and mangroves (Amazonas & Barbosa, 2011; Gadelha-Neto & Barbosa, 2012; Vicente et al., 2014). The local climate is the type As' of Köppen's classification, hot and humid, with the wet season from March to August and a dry season from September to February. The annual rainfall varies between 1,500 mm to 1,700 mm, and the annual average temperatures and humidity are usually

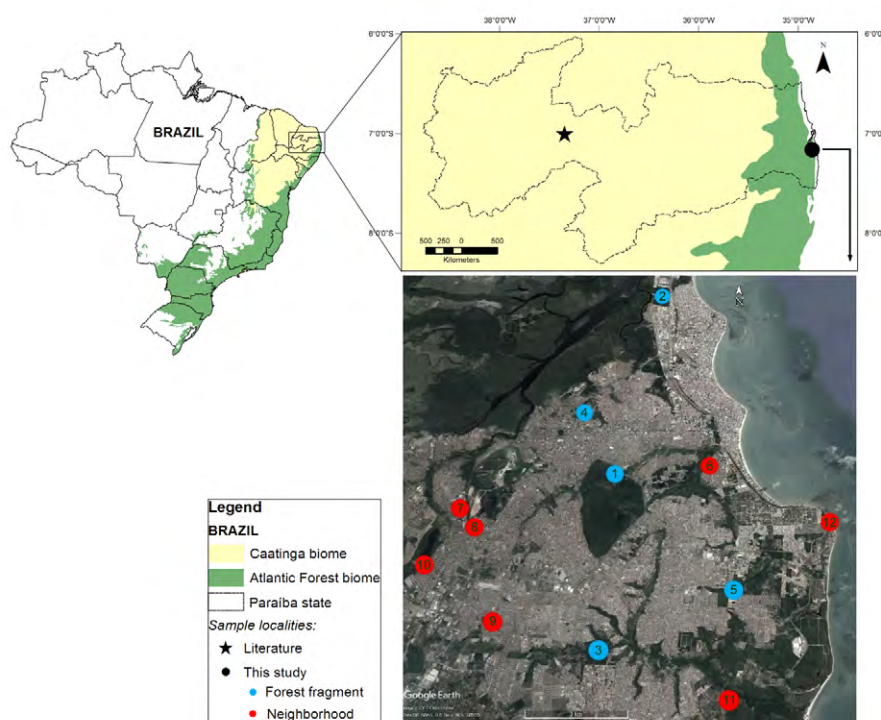


Figure 1. Sampling sites for bat ectoparasitic flies (Diptera: Nycteribiidae and Streblidae) in the state of Paraíba, northeastern Brazil.

around 22–26 °C and 80%, respectively (Feliciano & Melo, 2003).

Between November 2014 and August 2016, bats were captured in forest fragments using mist nets set both at canopy (4 mist nets of 3.0 m × 2.5 m) and understory levels (8 of 9.0 m × 2.5 m), opened from dusk until 10:00 pm. Captures in residential sites were performed with various sets of mist nets with different sizes according to the available area in each house (e.g., presence of roosts, backyards, gardens). During 60 sampling nights, the total effort was 55,580 h.m² following Straube & Bianconi (2002); calculated by multiplying mist net area (m²), the number of mist nets, and hours of exposure (h).

Nets were checked every 15–30 minutes, and captured bats were individually placed in cotton bags and later weighed, measured, sexed, and identified according to taxonomic keys (Díaz et al., 2016; Gardner, 2008). We followed Nogueira et al. (2014) for bat nomenclature. Bat capture was carried out under authorization of the Chico Mendes Institute for Biodiversity Conservation (ICMBio) (SISBIO permit number 45168-3) and residences were sampled with owner's consent. All animal procedures were approved by the Ethics Committee on Animal Use of the Federal University of Paraíba (CEUA/UFPB number 027/2016).

Bat ectoparasitic flies were collected with forceps and placed in individually labeled vials with 70% ethanol. In

the laboratory, flies were identified according to Guerrero (1995), Guimarães & D'Andretta (1956), Wenzel (1976), and Wenzel et al. (1966). For flies' nomenclature, we followed Dick & Gracioli (2008) for Streblidae and Gracioli & Dick (2008) for Nycteribiidae. Voucher specimens were deposited in the Entomological Collection of the Federal University of Pernambuco (CE-UFPE).

Results

We collected 197 bat ectoparasitic flies belonging to 15 species and 10 genera from the families Streblidae (13 species) and Nycteribiidae (2 species) (Table 1). Five genera and 12 fly species represent first records for the state of Paraíba, including *Basilia anceps* and *Noctiliostrebla* sp., as new records for northeastern Brazil. Most fly species (n = 13; ~87%) were species-specific, found on a single host species (Table 1, Fig. 2). Only *Trichobioides perspicillatus* and *Trichobius costalimai* were found on more than 1 host species (both on *Artibeus planirostris* and *Phyllostomus discolor*). The flies were collected on 102 bat specimens of 9 species and 7 genera in the families Phyllostomidae (6 species), Vespertilionidae (2 species), and Noctilionidae (1 species) (Table 1). *Phyllostomus discolor* was the bat most parasitized by flies (*Strebla hertigi*, *Trichobioides perspicillatus*, *T. costalimai*, and *T. longipes*; Fig. 2).

Below, we present, for each recorded ectoparasitic fly species, its host, comments on their geographic distribution, host-parasite interactions, information about the material examined, collection data, and voucher numbers.

Nycteribiidae Samouelle, 1819

Nycteribiinae Westwood, 1835

Basilia Miranda-Ribeiro, 1903

Basilia anceps Guimarães & D'Andretta, 1956

Host: *Myotis riparius* Handley, 1960 (Vespertilionidae).

Material examined (n = 1): 1 ♀ (CE-UFPE 100829), on *M. riparius*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 19/X/2015, Nunes, H. coll.

Remarks

Basilia anceps is widely distributed in the Neotropical region (Graciolli et al., 2007), although its records are still isolated. Our record is the first of this species in northeastern Brazil, increasing to 4 the number of *Basilia* species known in this region (Barbier et al., 2017; Dias et al., 2009; Guimarães, 1938). In Brazil, *B. anceps* was previously recorded in the Federal District on *Myotis nigricans* (Schinz, 1821) and *M. riparius* (Graciolli & Aguiar, 2002), and in the municipality of Serranópolis, state of Goiás, on *Myotis* sp. (Graciolli et al., 2010) both in the midwestern region of Brazil. Here, we increase the known geographic distribution of this species in approximately

Table 1

Ectoparasitic flies (Diptera: Nycteribiidae and Streblidae) and their hosts (Chiroptera) in the state of Paraíba, northeastern Brazil.

| Family/fly species | Host species | Site*** | Source |
|---|---|-----------------|--------|
| Nycteribiidae | | | |
| <i>Basilia anceps</i> Guimarães & D'Andretta, 1956 | <i>Myotis riparius</i> Handley, 1960 | 1 | PS |
| <i>Basilia travassosi</i> Guimarães, 1938 | <i>Myotis lavalii</i> Moratelli et al., 2011 | 1, 2, 4 | **, PS |
| Streblidae | | | |
| <i>Aspidoptera falcata</i> Wenzel, 1976 | <i>Sturnira lilium</i> (É. Geoffroy, 1810) | 8, 10 | PS |
| <i>Aspidoptera phyllostomatis</i> (Perty, 1833) | <i>Artibeus planirostris</i> (Spix, 1823) | 1, 3-8, 10, 11 | PS |
| <i>Megistopoda aranea</i> (Coquillett, 1899) | <i>Artibeus planirostris</i> | 1-8, 10-12 | **, PS |
| <i>Megistopoda proxima</i> (Séguy, 1926) | <i>Sturnira lilium</i> | 1, 9, 10 | PS |
| <i>Noctiliostrebla</i> sp. | <i>Noctilio leporinus</i> (Linnaeus, 1758) | 1 | PS |
| <i>Paradyschiria fusca</i> Speiser, 1900 | <i>Noctilio leporinus</i> | 1, 4 | PS |
| <i>Paratrachobius longicrus</i> (Miranda Ribeiro, 1907) | <i>Artibeus planirostris</i> | 1 | PS |
| <i>Speiseria ambigua</i> Kessel, 1925 | <i>Glossophaga soricina</i> (Pallas, 1766)*, <i>Carollia perspicillata</i> (Linnaeus, 1758) | 5 | **, PS |
| <i>Strebla hertigi</i> Wenzel, 1966 | <i>Phyllostomus discolor</i> (Wagner, 1843) | 2 | PS |
| <i>Strebla wiedemanni</i> Wenzel, 1966 | <i>Desmodus rotundus</i> (É. Geoffroy, 1810) | NA | ** |
| <i>Trichobioides perspicillatus</i> (Pessôa & Galvão, 1937) | <i>Artibeus planirostris</i> *, <i>Phyllostomus discolor</i> | 1-4 | PS |
| <i>Trichobius costalimai</i> Guimarães, 1938 | <i>Artibeus planirostris</i> *, <i>Phyllostomus discolor</i> | 1-5, 8 | PS |
| <i>Trichobius diphyllae</i> Wenzel, 1966 | <i>Diphylla ecaudata</i> Spix, 1823 | NA | ** |
| <i>Trichobius dugesii</i> Townsend, 1891 | <i>Glossophaga soricina</i> | NA | ** |
| <i>Trichobius dugesioides dugesioides</i> Wenzel, 1966 | <i>Trachops cirrhosus</i> (Spix, 1823) | NA | ** |
| <i>Trichobius galei</i> Wenzel, 1966 | <i>Natalus macrourus</i> (Gervais, 1856) | NA | ** |
| <i>Trichobius joblingi</i> Wenzel, 1966 | <i>Carollia perspicillata</i> | 1, 4, 5, 10, 11 | PS |
| <i>Trichobius longipes</i> (Rudow, 1871) | <i>Phyllostomus discolor</i> | 5 | PS |
| <i>Trichobius pallidus</i> (Curran, 1934) | <i>Furipterus horrens</i> (Cuvier, 1828) | NA | ** |
| <i>Trichobius parasiticus</i> Gervais, 1844 | <i>Desmodus rotundus</i> | NA | ** |
| Richness: 10 genera/22 species | 12 genera/13 species | | |

*= Non-primary association; **= Barbier et al. (2016); ***= referring to the sites sampled in the present study, which can be visualized in Fig. 1; NA= not applicable; PS= present study.

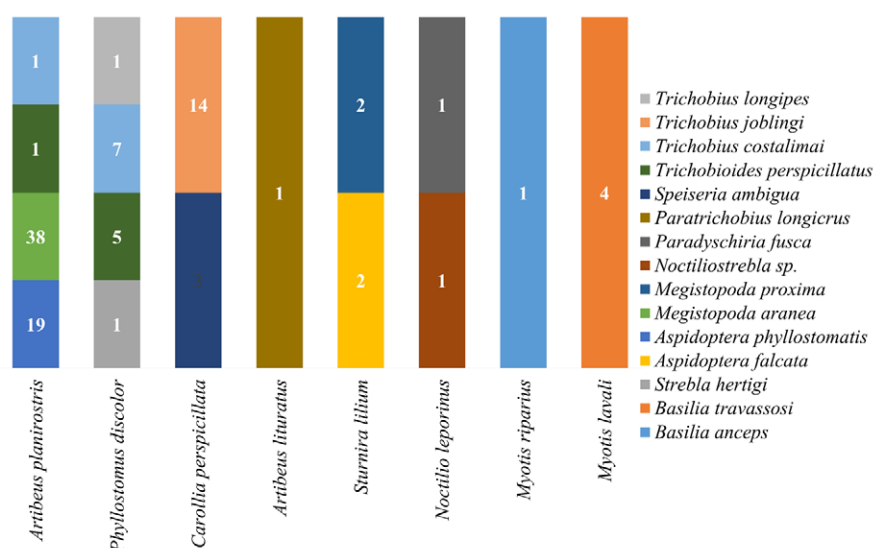


Figure 2. Host-parasite association between bats (Chiroptera) and ectoparasitic flies (Diptera: Nycteribiidae and Streblidae) in the state of Paraíba, northeastern Brazil. The numbers in the columns represent the total of bat specimens parasitized by each fly species.

1,700 km from the Federal District to Paraíba. Throughout its geographic distribution, *B. anceps* has been collected parasitizing at least 7 bat species (Gracioli, 2001; Gracioli et al., 2007).

Basilia travassosi Guimarães, 1938

Host: *Myotis lavalis* Moratelli, Peracchi, Dias & Oliveira, 2011 (Vespertilionidae).

Material examined (n = 11): 1 ♂ and 1 ♀ (CE-UFPE 100830), on *M. lavalis*, Cabedelo, PB (7°03'51.0" S, 34°51'16.6" W), 02/VII/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100831), on *M. lavalis*, same locality data, 07/VII/2015, Nunes, H. coll.; 5 ♀ (CE-UFPE 100832), on *M. lavalis*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 26/X/2015, Nunes, H. coll.; 2 ♂ and 1 ♀ (CE-UFPE 100833), on *M. lavalis*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 11/XI/2015, Nunes, H. coll.

Remarks

According to Guimarães and D'Andretta (1956), *B. travassosi* is endemic to northeastern Brazil. This species was recorded in 6 of the 9 states of the region and in different ecoregions (Barbier & Bernard, 2017). In the state of Paraíba, *B. travassosi* was recently recorded in the semi-arid Caatinga, also on *M. lavalis* (Barbier et al., 2016).

Streblidae Kolenati, 1863

Streblinae Speiser, 1900

Strebla Wiedemann, 1824

Strebla hertigi Wenzel, 1966

Host: *Phyllostomus discolor* (Wagner, 1843) (Phyllostomidae).

Material examined (n = 1): 1 ♂ (CE-UFPE 100834), on *P. discolor*, Cabedelo, PB (7°03'51.0" S, 34°51'16.6" W), 06/VII/2015, Nunes, H. coll.

Remarks

Although it has relatively few records in Brazil, *S. hertigi* is widely distributed throughout the Neotropics (Guerrero, 1996), primarily associated with *P. discolor* (Wenzel, 1976). This is the first record of the species in the state of Paraíba.

Trichobiinae Jobling, 1936

Aspidoptera Coquillett, 1899

Aspidoptera falcata Wenzel, 1976

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

Material examined (n = 2): 1 ♂ (CE-UFPE 100835), on *S. lilium*, João Pessoa, PB (7°10'06.3" S, 34°54'39.3" W), 19/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100836), on *S. lilium*, João Pessoa, PB (7°09'15.2" S, 34°54'02.0" W), 21/XI/2014, Nunes, H. coll.

Remarks

Sturnira lilium is the primary host for *A. falcata*, although Wenzel (1976) has recorded on another 2 species of *Sturnira* in Venezuela, with some frequency. This fly is relatively well sampled in Brazil and may co-occur with *Megistopoda proxima* (Linhares & Komeno, 2000). In this

study, we recorded *A. falcata* for the first time in the state of Paraíba.

Aspidoptera phyllostomatis (Perty, 1833)

Host: *Artibeus planirostris* (Spix, 1823) (Phyllostomidae).

Material examined (n = 25): 1 ♂ (CE-UFPE 100837), on *A. planirostris*, João Pessoa, PB (7°12'23.8" S, 34°49'13.0" W), 24/XI/2014, Nunes, H. coll.; 1 ♂ and 2 ♀ (CE-UFPE 100838), on *A. planirostris*, João Pessoa, PB (7°11'30.3" S, 34°51'33.1" W), 29/V/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100839), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.; 1 ♀ (CE-UFPE 100840), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 20/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100841), on *A. planirostris*, João Pessoa, PB (7°07'59.4" S, 34°49'51.3" W), 15/VII/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100842), on *A. planirostris*, same locality data, 15/VII/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100843), on *A. planirostris*, João Pessoa, PB (7°08'53.8" S, 34°54'19.6" W), 17/XI/2014, Nunes, H. coll.; 1 ♀ (CE-UFPE 100844), on *A. planirostris*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 19/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100845), on *A. planirostris*, same locality data, 20/X/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100846), on *A. planirostris*, same locality data, 21/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100847), on *A. planirostris*, same locality data, 22/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100848), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 20/IV/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100849), on *A. planirostris*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 11/XI/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100850), on *A. planirostris*, same locality data, 13/XI/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100851), on *A. planirostris*, João Pessoa, PB (7°10'06.3" S, 34°54'39.3" W), 19/XI/2014, Nunes, H. coll.; 4 ♂ and 1 ♀ (CE-UFPE 100852), on *A. planirostris*, same locality data, 19/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100853), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.; 1 ♀ (CE-UFPE 100854), on *A. planirostris*, João Pessoa, PB (7°09'15.2" S, 34°54'02.0" W), 21/XI/2014, Nunes, H. coll.; 1 ♀ (CE-UFPE 100855), on *A. planirostris*, same locality data, 21/XI/2014, Nunes, H. coll.

Remarks

Like *A. falcata*, we recorded *A. phyllostomatis* for the first time in the state of Paraíba. *Artibeus jamaicensis* Leach, 1821 is the host type for this fly (Wenzel, 1976), however, in Brazil, it is associated mainly with *A.*

planirostris and *A. fimbriatus* (Barbier & Gracioli, 2016; Dornelles & Gracioli, 2017; Eriksson et al., 2011).

Megistopoda Macquart, 1852

Megistopoda aranea (Coquillett, 1899)

Host: *Artibeus planirostris* (Phyllostomidae).

Material examined (n = 53): 1 ♂ (CE-UFPE 100856), on *A. planirostris*, João Pessoa, PB (7°12'23.8" S, 34°49'13.0" W), 24/XI/2014, Nunes, H. coll.; 1 ♀ (CE-UFPE 100857), on *A. planirostris*, João Pessoa, PB (7°11'30.3" S, 34°51'33.1" W), 29/V/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100858), on *A. planirostris*, João Pessoa, PB (7°12'23.8" S, 34°49'13.0" W), 24/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100859), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 26/XI/2014, Nunes, H. coll.; 2 ♂ (CE-UFPE 100860), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.; 1 ♀ (CE-UFPE 100861), on *A. planirostris*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 10/VI/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100862), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 20/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100863), on *A. planirostris*, João Pessoa, PB (7°09'36.1" S, 34°47'42.8" W), 13/VII/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100864), on *A. planirostris*, João Pessoa, PB (7°07'59.4" S, 34°49'51.3" W), 15/VII/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100865), on *A. planirostris*, same locality data, 15/VII/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100866), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 20/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100867), on *A. planirostris*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 19/X/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100868), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 20/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100869), on *A. planirostris*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 21/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100870), on *A. planirostris*, same locality data, 21/X/2015, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100871), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 20/IV/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100872), on *A. planirostris*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 21/X/2015, Nunes, H. coll.; 1 ♂ and 2 ♀ (CE-UFPE 100873), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 20/IV/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100874), on *A. planirostris*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 26/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100875), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 21/III/2016, Nunes, H. coll.; 1 ♂ (CE-UFPE 100876), on *A. planirostris*, same locality data, 22/IV/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE

100877), on *A. planirostris*, Cabedelo, PB (7°03'51.0" S, 34°51'16.6" W), 25/IV/2016, Nunes, H. coll.; 2 ♂ (CE-UFPE 100878), on *A. planirostris*, João Pessoa, PB (7°11'30.3" S, 34°51'33.1" W), 31/V/2016, Nunes, H. coll.; 1 ♂ (CE-UFPE 100879), on *A. planirostris*, same locality data, 16/VIII/2016, Nunes, H. coll.; 1 ♀ (CE-UFPE 100880), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 23/IV/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100881), on *A. planirostris*, João Pessoa, PB (7°10'06.3" S, 34°54'39.3" W), 19/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100882), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 23/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100883), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100884), on *A. planirostris*, João Pessoa, PB (7°10'06.3" S, 34°54'39.3" W), 19/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100885), on *A. planirostris*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 24/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100886), on *A. planirostris*, same locality data, 24/IV/2015, Nunes, H. coll.; 2 ♂ (CE-UFPE 100887), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100888), on *A. planirostris*, João Pessoa, PB (7°10'06.3" S, 34°54'39.3" W), 19/XI/2014, Nunes, H. coll.; 2 ♂ and 1 ♀ (CE-UFPE 100889), on *A. planirostris*, same locality data, 19/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100890), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.; 2 ♂ (CE-UFPE 100891), on *A. planirostris*, João Pessoa, PB (7°09'15.2" S, 34°54'02.0" W), 21/XI/2014, Nunes, H. coll.; 2 ♂ (CE-UFPE 100892), on *A. planirostris*, same locality data, 21/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100893), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100894), on *A. planirostris*, João Pessoa, PB (7°09'15.2" S, 34°54'02.0" W), 21/XI/2014, Nunes, H. coll.; 1 ♀ (CE-UFPE 100895), on *A. planirostris*, same locality data, 21/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100896), on *A. planirostris*, same locality data, 21/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100897), on *A. planirostris*, João Pessoa, PB (7°08'54.7" S, 34°54'19.1" W), 17/XI/2014, Nunes, H. coll.

Remarks

M. aranea occurs in all regions and different ecoregions of Brazil (Barbier & Graciolli, 2016; Graciolli & Bernard, 2002; Rui & Graciolli, 2005; Santos et al., 2009). In the state of Paraíba, *M. aranea* was recently recorded in a Caatinga biome also on *A. planirostris* (Barbier et al., 2016).

Megistopoda proxima (Séguy, 1926)

Host: *Sturnira lilium* (Phyllostomidae).

Material examined (n = 4): 1 ♂ (CE-UFPE 100898), on *S. lilium*, João Pessoa, PB (7°10'52.4" S, 34°53'18.7" W), 20/VII/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100899), on *S. lilium*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 21/X/2015, Nunes, H. coll.; 2 ♂ (CE-UFPE 100900), on *S. lilium*, João Pessoa, PB (7°10'06.3" S, 34°54'39.3" W), 19/XI/2014, Nunes, H. coll.

Remarks

The characteristic host for *M. proxima* is *S. lilium* (Dick & Gettinger, 2005). This species is widely distributed, occurring in all Brazilian regions (Barbier & Graciolli, 2016; Bertola et al., 2005; Santos et al., 2013; Soares et al., 2013), as well as in other American countries (Dick & Gettinger, 2005; Dick et al., 2007; Durán et al., 2017). Here, we recorded *M. proxima* for the first time in the state of Paraíba.

Noctiliostrebla Wenzel, 1966

Noctiliostrebla sp.

Host: *Noctilio leporinus* (Linnaeus, 1758) (Noctilionidae).

Material examined (n = 2): 2 ♀ (CE-UFPE 100901), on *N. leporinus*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 20/X/2015, Nunes, H. coll.

Remarks

Noctiliostrebla is a genus exclusively associated with the family Noctilionidae, formed by a species complex, including undescribed species (Wenzel et al., 1966). Currently, 4 species are recognized, but with the only 2 specimens we had, we were unable to identify to the species level. Even so, this is the first record of this genus in northeastern Brazil.

Paradyschiria Speiser, 1900

Paradyschiria fusca Speiser, 1900

Host: *Noctilio leporinus* (Noctilionidae).

Material examined (n = 6): 3 ♂ and 2 ♀ (CE-UFPE 100902), on *N. leporinus*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 20/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100903), *N. leporinus*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 12/XI/2015, Nunes, H. coll.

Remarks

Like *Noctiliostrebla*, *Paradyschiria* is a specific parasite of Noctilionidae (Wenzel et al., 1966). In northeastern Brazil, *P. fusca* was recorded only in the state of Bahia (cited as *P. dubia*; Guimarães, 1941). This

is the first record of the species for Paraíba and the second record to northeastern Brazil after a 77-year hiatus.

Paratrachobius Costa Lima, 1921

Paratrachobius longicrus (Miranda Ribeiro, 1907)

Host: *Artibeus lituratus* (Olfers, 1818) (Phyllostomidae).

Material examined (n = 1): 1 ♂ (CE-UFPE 100904), on *A. lituratus*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 19/X/2015, Nunes, H. coll.

Remarks

Paratrachobius constitutes a species complex (Graciolli & Carvalho, 2001; Wenzel et al., 1966), frequently found on Stenodermatinae (Dick & Miller, 2010). *Artibeus lituratus* is considered primary host for *P. longicrus*. Probably, the *P. longicrus* infesting another Stenodermatinae (such as *Platyrrhinus* spp.) are undescribed species (Graciolli & Carvalho, 2001; Wenzel et al., 1966). Our record is the first for this species in the state of Paraíba.

Speiseria Kessel, 1925

Speiseria ambigua Kessel, 1925

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

Material examined (n = 3): 1 ♂ (CE-UFPE 100905), on *C. perspicillata*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 26/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100906), on *C. perspicillata*, same locality data, 22/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100907), on *C. perspicillata*, same locality data, 22/IV/2015, Nunes, H. coll.

Remarks

Recently, Barbier et al. (2016) recorded *S. ambigua* on *Glossophaga soricina* (Pallas, 1766) in the Caatinga of the state of Paraíba. This species is a primary parasite of *C. perspicillata* (Guerrero, 1994). Its record on other host species is classified as a transitory association or sampling contamination.

Trichobioides Wenzel, 1966

Trichobioides perspicillatus (Pessôa & Galvão, 1937)

Hosts: *Artibeus planirostris*, *Phyllostomus discolor* (Phyllostomidae).

Material examined (n = 22): 6 ♂ and 3 ♀ (CE-UFPE 100908), on *A. planirostris*, João Pessoa, PB (7°11'30.3" S, 34°51'33.1" W), 28/V/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100909), on *P. discolor*, Cabedelo, PB (7°03'51.0" S, 34°51'16.6" W), 06/VII/2015, Nunes, H. coll.; 1 ♂ and 2 ♀ (CE-UFPE 100910), on *P. discolor*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 21/X/2015, Nunes, H. coll.; 2 ♂ and 1 ♀ (CE-UFPE 100911), on *P. discolor*,

same locality data, 22/X/2015, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100912), on *P. discolor*, same locality data, 22/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100913), on *P. discolor*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 09/XI/2015, Nunes, H. coll.; 2 ♂ and 1 ♀ (CE-UFPE 100914), on *P. discolor*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 18/V/2015, Nunes, H. coll.

Remarks

The primary host of *Trichobioides perspicillatus* is *P. discolor* (Wenzel et al., 1966). We also found this species infesting *A. planirostris* but certainly represent a transitory association or contamination, as reported by Durán et al. (2017). This is the first record of *Trichobioides perspicillatus* in the state of Paraíba.

Trichobius Gervais, 1844

Trichobius costalimai Guimarães, 1938

Hosts: *Artibeus planirostris*, *Phyllostomus discolor* (Phyllostomidae).

Material examined (n = 41): 2 ♂ and 1 ♀ (CE-UFPE 100915), on *P. discolor*, João Pessoa, PB (7°09'15.2" S, 34°54'02.0" W), 21/XI/2014, Nunes, H. coll.; 8 ♂ (CE-UFPE 100916), on *A. planirostris*, João Pessoa, PB (7°11'30.3" S, 34°51'33.1" W), 28/V/2015, Nunes, H. coll.; 5 ♂ and 2 ♀ (CE-UFPE 100917), on *P. discolor*, Cabedelo, PB (7°03'51.0" S, 34°51'16.6" W), 06/VII/2015, Nunes, H. coll.; 1 ♂ and 2 ♀ (CE-UFPE 100918), on *P. discolor*, same locality data, 06/VII/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100919), on *P. discolor*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 22/X/2015, Nunes, H. coll.; 2 ♂ (CE-UFPE 100920), on *P. discolor*, same locality data, 22/X/2015, Nunes, H. coll.; 2 ♀ (CE-UFPE 100921), on *P. discolor*, same locality data, 22/X/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100922), on *P. discolor*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 09/XI/2015, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100923), on *P. discolor*, same locality data, 12/XI/2015, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100924), on *P. discolor*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 24/IV/2015, Nunes, H. coll.; 2 ♂ and 2 ♀ (CE-UFPE 100925), on *P. discolor*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 14/V/2015, Nunes, H. coll.; 2 ♂ and 4 ♀ (CE-UFPE 100926), on *P. discolor*, same locality data, 18/V/2015, Nunes, H. coll.

Remarks

T. costalimai is widely distributed and occurs on *P. discolor*, its primary host, throughout its range (Wenzel, 1976). Infestation on other hosts is considered as a non-primary association. Conversely, Durán et al. (2017) found frequently association between *T. costalimai* and *A.*

planirostris in a dry tropical forest in Colombia. Here, we record this species for the first time in the state of Paraíba.

Trichobius joblingi Wenzel, 1966

Host: *Carollia perspicillata* (Phyllostomidae).

Material examined (n = 24): 2 ♂ and 2 ♀ (CE-UFPE 100927), on *C. perspicillata*, João Pessoa, PB (7°12'23.8" S, 34°49'13.0" W), 24/XI/2014, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100928), on *C. perspicillata*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 26/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100929), on *C. perspicillata*, same locality data, 26/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100930), on *C. perspicillata*, same locality data, 26/XI/2014, Nunes, H. coll.; 1 ♂ (CE-UFPE 100931), on *C. perspicillata*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 12/VI/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100932), on *C. perspicillata*, João Pessoa, PB (7°08'43.6" S, 34°51'41.3" W), 19/X/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100933), on *C. perspicillata*, same locality data, 22/X/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100934), on *C. perspicillata*, same locality data, 26/X/2015, Nunes, H. coll.; 2 ♀ (CE-UFPE 100935), on *C. perspicillata*, João Pessoa, PB (7°06'45.3" S, 34°52'27.2" W), 10/XI/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100936), on *C. perspicillata*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 22/IV/2015, Nunes, H. coll.; 2 ♂ (CE-UFPE 100937), on *C. perspicillata*, same locality data, 22/IV/2015, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100938), on *C. perspicillata*, same locality data, 22/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100939), on *C. perspicillata*, same locality data, 22/IV/2015, Nunes, H. coll.; 1 ♀ (CE-UFPE 100940), on *C. perspicillata*, same locality data, 23/IV/2015, Nunes, H. coll.; 1 ♂ and 1 ♀ (CE-UFPE 100941), on *C. perspicillata*, same locality data, 24/IV/2015, Nunes, H. coll.; 1 ♂ (CE-UFPE 100942), on *C. perspicillata*, João Pessoa, PB (7°10'06.3" S, 34°54'39.3" W), 19/XI/2014, Nunes, H. coll.

Remarks

This species occurs throughout Central and South America in association with *C. perspicillata* (Wenzel, 1976) in at least 20 countries (Barbier & Gracioli, 2016), and is probably the most abundant bat ectoparasitic fly in the New World (Guerrero, 1995). Despite the wide distribution and abundance, this is the first record of *T. joblingi* in Paraíba.

Trichobius longipes (Rudow, 1871)

Host: *Phyllostomus discolor* (Phyllostomidae).

Material examined (n = 1): 1 ♂ (CE-UFPE 100943), on *P. discolor*, João Pessoa, PB (7°10'06.5" S, 34°51'50.1" W), 21/IV/2015, Nunes, H. coll.

Remarks

P. hastatus is the host type for *T. longipes*, although this fly may occur in other *Phyllostomus* species as *P. discolor* (Gracioli & Carvalho, 2001; Guerrero, 1994; Santos et al., 2013). In the northeastern, this fly was little recorded (Barbier & Bernard, 2017) and this represents the first record for Paraíba.

Discussion

Although the present study is the second survey on bat ectoparasitic flies conducted in Paraíba, the state is now the fourth in species richness in northeastern Brazil, behind the states of Pernambuco, Maranhão, and Sergipe with 34, 28, and 23 species, respectively (Barbier & Bernard, 2017; Soares et al., 2017). We have increased the number of known Nycteribiidae and Streblidae in the state from 10 to 22 species, and from 5 to 10 genera; as well as from 50 to 52 species known in the region, with the records of *B. anceps* and *Noctilio strebla* sp. (Barbier & Bernard, 2017). We also increase from 31 to 34 the known species in the northeastern portion of the Atlantic Forest, above the São Francisco River (Barbier & Bernard, 2017). Despite that, the state currently accounts for about 20% (22/111) of bat ectoparasitic fly species richness in Brazil (Barbier et al., 2018; Bezerra et al., 2016; Gracioli et al., 2007; Lourenço et al., 2016).

Except for *Trichobioides perspicillatus* and *Trichobius costalimai*, both found on *A. planirostris* and here considered as non-primary infestations, all other fly species were collected on only 1 bat species, indicating high host specificity. These results corroborate other studies on bat ectoparasitic flies (Barbier & Gracioli, 2016; Komeno & Linhares, 1999; Santos et al., 2013; Soares et al., 2013; ter Hofstede et al., 2004) and reinforce the knowledge about host-parasite relationships, especially in a poorly sampled Brazilian region.

It is quite likely that the richness of bat ectoparasitic flies in Paraíba is still underestimated, not only because this is the second research conducted in the state, but also because other northeastern nearby states present a greater species richness, including the neighbor Pernambuco (with 34 species; Barbier & Bernard, 2017). Additionally, of about 61 bat species occurring in the Paraíba state (Feijó & Langguth, 2011; Feijó et al., 2015; Leal et al., 2014; Nunes et al., 2013; Rocha et al., 2017; Vilar et al., 2015) only 14 species (~23%) were surveyed for ectoparasites (Barbier et al., 2016; present study). As more studies are conducted, including hosts not yet sampled in previous studies, the number of known fly species will most likely increase.

Our records expand the knowledge on bat ectoparasites in northeastern Brazil, where this group is still poorly

studied, despite advances in recent years (Barbier et al., 2016, 2017; Santos et al., 2013; Soares et al., 2013, 2016, 2017). It is likely that the diversity of environments/roosts sampled in this study (e.g., man-made constructions, coastal vegetation, mangroves) have favored the fly species richness recorded here. Studies have shown that bat ectoparasitic fly species richness is correlated with host species richness, and that the host-fly interaction may differ between environments (Barbier & Bernard, 2017; Dick & Gettinger, 2005; Zarazúa-Carbajal et al., 2016).

The possibility of capturing more host species and, consequently, more fly species, will be enhanced when more environments are sampled. However, even with increasing studies on bats in recent years, their ectoparasites have been neglected in most cases. Therefore, we strongly suggest that bat researchers consider collecting ectoparasites whenever possible. In addition, we recommend that future studies also focus on environments with transitional areas (e.g., Atlantic Forest-Caatinga ecotone), Caatinga moist forest enclaves (regionally called “Brejos de Altitude”), and caves. Together, these efforts can help increase our knowledge and fill gaps in the geographic distribution, species richness, and host association of these bat ectoparasites. Furthermore, the great ecological diversity of bats and the conspicuous relationship with ectoparasitic flies make both groups an important model for studies on coevolution, biology, and parasitic ecology, for example. For this, basic questions, such as where species occur, are essential and must be answered. In this sense, this study also represents an important step and can serve as a basis for further studies.

Acknowledgements

To the Environmental Military Police of Paraíba and the Center for Environmental Surveillance and Zoonoses of João Pessoa, for logistic support during fieldwork. We also wish to thank our colleagues from the Laboratory of Mammals of the Federal University of Paraíba for their help during fieldwork and the owners of the residences who allowed us to sample in their houses. To Luciana Iannuzzi (UFPE) for speeding up the deposit of the fly specimens in the collection under her curatorship and Aída Otálora-Ardila for reviewing the abstract in Spanish. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001, through grants awarded to E. B. and H. N., and a PNPd/CAPES fellowship to F. L. R. and P. A. R. This study was also funded by the Programa Pesquisa para o SUS, Edital 01/2013 - PPSUS/ FAPESQ/MS/ CNPq (grant number EFP_00008705).

References

- Amazonas, N. T., & Barbosa, M. R. V. (2011). Levantamento florístico das angiospermas em um remanescente de Floresta Atlântica estacional na microbacia hidrográfica do Rio Timbó, João Pessoa, Paraíba. *Revista Nordestina de Biologia*, 20, 67–78.
- Barbier, E., & Bernard, E. (2017). From the Atlantic Forest to the borders of Amazonia: species richness, distribution, and host association of ectoparasitic flies (Diptera: Nycteribiidae and Streblidae) in Northeastern Brazil. *Parasitology Research*, 116, 3043–3055.
- Barbier, E., & Gracioli, G. (2016). Community of bat flies (Streblidae and Nycteribiidae) on bats in the Cerrado of Central-West Brazil: hosts, aggregation, prevalence, infestation intensity, and infracommunities. *Studies on Neotropical Fauna and Environment*, 51, 176–187.
- Barbier, E., Hintze, F., Jardelino, A. C., & Bernard, E. (2018). First record of the bat ectoparasitic fly *Strebba proxima* Wenzel, 1976 (Diptera: Streblidae) from Brazil. *Entomological News*, 127, 369–374.
- Barbier, E., Prado-Neto, J. G., & Bernard, E. (2016). Records of bat flies (Diptera: Nycteribiidae and Streblidae) in the semi-arid Caatinga in the state of Paraíba, Northeastern Brazil. *Neotropical Entomology*, 45, 740–745.
- Barbier, E., Souza, A. Q. S., Bezerra, J. P., Santos, J. O. F., & Telino Júnior, W. R. (2017). New record, new host, and geographic distribution of *Basilia hughscotti* Guimarães, 1946 (Diptera: Nycteribiidae). *Entomological News*, 126, 394–399.
- Bertola, P. B., Aires, C. C., Favorito, S. E., Gracioli, G., Amaku, M., & Pinto-da-Rocha, R. (2005). Bat flies (Diptera: Streblidae, Nycteribiidae) parasitic on bats (Mammalia: Chiroptera) at Parque Estadual da Cantareira, São Paulo, Brazil: parasitism rates and host-parasite associations. *Memórias do Instituto Oswaldo Cruz*, 100, 25–32.
- Bezerra, R. H. S., Vasconcelos, P. F., & Bocchiglieri, A. (2016). Ectoparasites of bats (Mammalia: Chiroptera) in Atlantic Forest fragments in northeastern Brazil. *Parasitology Research*, 10, 3759–3765.
- Dias, P. A., Santos, C. L. C., Rodrigues, F. S., Rosa, L. C., Lobato, K. S., & Rebêlo, J. M. M. (2009). Espécies de moscas ectoparasitas (Diptera, Hippoboscoidea) de morcegos (Mammalia, Chiroptera) no estado do Maranhão. *Revista Brasileira de Entomologia*, 53, 128–133.
- Díaz, M. M., Solari, S., Aguirre, L. F., Aguiar, L. M. S., & Barquez, R. M. (2016). *Clave de identificación de los murciélagos de Sudamérica*. Tucumán: Magna Publicaciones.
- Dick, C. W., & Dick, S. C. (2006). Effects of prior infestation on host choice of bat flies (Diptera: Streblidae). *Journal of Medical Entomology*, 43, 433–436.
- Dick, C. W., & Gettinger, D. (2005). A faunal survey of streblid bat flies (Diptera: Streblidae) associated with bats in Paraguay. *Journal of Parasitology*, 91, 1015–1024.

- Dick, C. W., Gettinger, D., & Gardner, S. L. (2007). Bolivian ectoparasites: a survey of bats (Mammalia: Chiroptera). *Comparative Parasitology*, 74, 372–377.
- Dick, C. W., & Graciolli, G. (2008). Checklist of world Streblidae (Diptera: Hippoboscoidea). Retrieved on November 29th, 2009 from: http://fm1.fieldmuseum.org/aa/Files/cdick/Streblidae_Checklist_1jul08.pdf
- Dick, C. W., & Miller, J. A. (2010). Streblidae (Bat flies). In B. V. Brown, A. Borkent, J. M. Cumming, D. M. Wood, N. E. Woodley, & M. Zumbado (Eds.), *Manual of Central American Diptera* (pp. 1249–1260). Ottawa: NRC Research Press.
- Dick, C. W., & Patterson, B. D. (2006). Bat flies: obligate ectoparasites of bats. In S. Morand, B. Krasnov, & R. Poulin (Eds), *Micromammals and macroparasites: from evolutionary ecology to management* (pp. 179–194). Tokyo: Springer.
- Dornelles, G. D. P., & Graciolli, G. (2017). Streblid bat flies on phyllostomid bats from an island off the coast of São Paulo, Brazil. *Papéis Avulsos de Zoologia*, 57, 31–36.
- Durán, A. A., García, D. M. A., & Graciolli, G. (2017). Ectoparasitic flies (Diptera, Streblidae) on bats (Mammalia, Chiroptera) in a dry tropical forest in the northern Colombia. *Papéis Avulsos de Zoologia*, 57, 105–111.
- Eriksson, A., Graciolli, G., & Fischer, E. (2011). Bat flies on phyllostomid hosts in the Cerrado region: component community, prevalence and intensity of parasitism. *Memórias do Instituto Oswaldo Cruz*, 106, 274–278.
- Feijó, A., & Langguth, A. (2011). Lista de quirópteros da Paraíba, Brasil com 25 novos registros. *Chiroptera Neotropical*, 17, 1055–1062.
- Feijó, A., Rocha, P. A., & Althoff, S. L. (2015). New species of *Histiotus* (Chiroptera: Vespertilionidae) from northeastern Brazil. *Zootaxa*, 4048, 412–427.
- Feliciano, M. L. M., & Melo, R. B. (2003). *Atlas do estado da Paraíba: informação para gestão do patrimônio natural (mapas)*. João Pessoa: SEPLAN/IDEME.
- Figueiredo, D., Graciolli, G., & Aguiar, L. M. S. (2015). New records of bat flies (Diptera, Streblidae and Nycteribiidae) in Cerrado of Central Brazil. *Check List*, 11, 1761.
- Fritz, G. N. (1983). Biology and ecology of bat flies (Diptera: Streblidae) on bats in the genus *Carollia*. *Journal of Medical Entomology*, 20, 1–10.
- Gadelha-Neto, P. C., & Barbosa, M. R. V. (2012). Angiospermas trepadeiras, epífitas e parasitas da Mata do Buraquinho, João Pessoa, Paraíba. *Revista Nordestina de Biologia*, 21, 81–92.
- Gardner, A. L. (2008). *Mammals of South America, volume 1: marsupials, xenarthrans, shrews, and bats*. Chicago: University of Chicago Press. [Dated 2007; published March 31st, 2008].
- Graciolli, G. (2001). Distribuição geográfica e hospedeiros quirópteros (Mammalia, Chiroptera) de moscas nictéribidas americanas (Diptera, Nycteribiidae). *Revista Brasileira de Zoologia*, 18, 307–322.
- Graciolli, G., & Aguiar, L. S. (2002). Ocorrência de moscas ectoparasitas (Diptera, Streblidae e Nycteribiidae) de morcegos (Mammalia, Chiroptera) no cerrado de Brasília, Distrito Federal, Brasil. *Revista Brasileira de Zoologia*, 19, 177–181.
- Graciolli, G., Autino, A. G., & Claps, G. L. (2007). Catalogue of American Nycteribiidae (Diptera, Hippoboscoidea). *Revista Brasileira de Entomologia*, 51, 142–159.
- Graciolli, G., & Bernard, E. (2002). Novos registros de moscas ectoparasitas (Diptera, Streblidae e Nycteribiidae) em morcegos (Mammalia, Chiroptera) do Amazonas e Pará, Brasil. *Revista Brasileira de Zoologia*, 19, 77–86.
- Graciolli, G., & Carvalho, C. J. B. (2001). Moscas ectoparasitas (Diptera, Hippoboscoidea) de morcegos (Mammalia, Chiroptera) do estado do Paraná. II. Streblidae: chave pictórica para gêneros e espécies. *Revista Brasileira de Zoologia*, 18, 907–960.
- Graciolli, G., & Dick, C. W. (2008). Checklist of world Nycteribiidae (Diptera: Hippoboscoidea). Retrieved on November 29th, 2009 from: https://web.archive.org/web/20120213212308/http://fm1.fieldmuseum.org/aa/Files/cdick/Nycteribiidae_Checklist_22oct08.pdf
- Graciolli, G., Zortéa, M., & Carvalho, L. F. A. C. (2010). Bat flies (Diptera, Streblidae and Nycteribiidae) in a Cerrado area of Goiás State, Brazil. *Revista Brasileira de Entomologia*, 54, 511–514.
- Guerrero, R. (1994). Catálogo de los Streblidae (Diptera: Pupipara) parásitos de murciélagos (Mammalia: Chiroptera) del Nuevo Mundo. IV. Trichobiinae con alas desarrolladas. *Boletín de Entomología Venezolana*, 9, 161–192.
- Guerrero, R. (1995). Catálogo de los Streblidae (Diptera: Pupipara) parásitos de murciélagos (Mammalia: Chiroptera) del Nuevo Mundo. III. Los grupos: *dugesii*, *dunni* y *phyllostomae* del género *Trichobius* Gervais, 1844. *Acta Biologica Venezuelica*, 15, 1–27.
- Guerrero, R. (1996). Catálogo de los Streblidae (Diptera: Pupipara) parásitos de murciélagos (Mammalia, Chiroptera) del Nuevo Mundo. VI. Streblinae. *Acta Biologica Venezuelica*, 16, 1–26.
- Guimarães, L. R. (1938). Sobre uma nova espécie de Nycteribiidae (Diptera, Pupipara). In H. Lent, & J. F. Teixeira de Freitas (Eds.), *Livro Jubilar Professor Lauro Travassos* (pp. 183–184). Rio de Janeiro: Ex-Libris.
- Guimarães, L. R. (1941). Notas sobre Streblidae. I - Sobre a verdadeira identidade de *Trichobius dugesii* Towns, 1891. *Papéis Avulsos do Departamento de Zoologia*, 1, 213–222.
- Guimarães, L. R., & D'Andretta, M. A. V. (1956). Sinopse dos Nycteribiidae (Diptera) do Novo Mundo. *Arquivos de Zoologia*, 10, 1–184.
- Joffrin, L., Dietrich, M., Mavingui, P., & Lebarbenchon, C. (2018). Bat pathogens hit the road: but which one? *Plos Pathogens*, 14, e1007134.
- Komeno, C. A., & Linhares, A. X. (1999). Batflies parasitic on some phyllostomid bats in Southeastern Brazil: parasitism rates and host-parasite relationships. *Memórias do Instituto Oswaldo Cruz*, 94, 151–156.
- Leal, E. S. B., Gomes-Silva, F. F., Lira, T. C., Neto, J. G. P., & Filho, P. B. P. (2014). Occurrence of *Furipterus horrens*

- (F. Cuvier, 1828) (Chiroptera: Furipteridae) in the state of Paraíba and update of the distribution of the species in Brazil. *Chiroptera Neotropical*, 20, 1280–1287.
- Linhares, A. X., & Komeno, C. A. (2000). *Trichobius joblingi*, *Aspidoptera falcata*, and *Megistopoda proxima* (Diptera: Streblidae) parasitic on *Carollia perspicillata* and *Sturnira lilium* (Chiroptera: Phyllostomidae) in Southeastern Brazil: sex ratios, seasonality, host site preference, and effect of parasitism on the host. *Journal of Parasitology*, 86, 167–170.
- Lourenço, E. C., Almeida, J. C., Famadas, K. M. (2016). Richness of ectoparasitic flies (Diptera: Streblidae) of bats (Chiroptera) - a systematic review and meta-analysis of studies in Brazil. *Parasitology Research*, 115, 4379–4388.
- Marshall, A. G. (1982). Ecology of insects parasitic on bats. In T. H. Kunz (Ed.), *Ecology of bats* (pp. 69–401). New York: Plenum Press.
- Nogueira, M. R., Lima, I. P., Moratelli, R., Tavares, V. C., Gregorin, R., & Peracchi, A. L. (2014). Checklist of Brazilian bats, with comments on original records. *Check List*, 10, 808–821.
- Nunes, H. L. F. L., Feijó, A. F., Beltrão, M., Lopez, L. C. S., & Fracasso, M. P. A. (2013). First and easternmost record of *Molossops temminckii* (Burmeister, 1854) for the state of Paraíba, Brazil. *Check List*, 9, 436–439.
- Patterson, B. D., Dick, C. W., & Dittmar, K. (2007). Roosting habits of bats affect their parasitism by bat flies (Diptera: Streblidae). *Journal of Tropical Ecology*, 23, 177–89.
- Rocha, P. A., Soares, F. A. M., Dias, D., Mikalaukas, J. S., Vilar, E. M., Feijó, J. A. et al. (2017). New records of *Micronycteris schmidtorum* Sanborn, 1935 (Phyllostomidae, Chiroptera) for northeastern Brazil. *Mastozoología Neotropical*, 24, 20–24.
- Rui, A. M., & Gracioli, G. (2005). Moscas ectoparasitas (Diptera, Streblidae) de morcegos (Mammalia, Chiroptera) no Sul do Brasil: associações hospedeiros-parasitas e taxas de infestação. *Revista Brasileira de Zoologia*, 22, 438–445.
- Santos, C. L. C., Dias, P. A., Rodrigues, F. S., Lobato, K. S., Rosa, L. C., Oliveira, T. G. et al. (2009). Moscas ectoparasitas (Diptera: Streblidae) de morcegos (Mammalia: Chiroptera) do município de São Luís, MA: taxas de infestação e associações parasito-hospedeiro. *Neotropical Entomology*, 38, 595–601.
- Santos, C. L. C., Pereira, A. C. N., Bastos, V. J. C., Gracioli, G., & Rebêlo, J. M. M. (2013). Parasitism of ectoparasitic flies on bats in the northern Brazilian cerrado. *Acta Parasitologica*, 58, 207–214.
- Soares, F. A. M., Gracioli, G., Alcântara, D. M. C., Ribeiro, A. E. B. P., Valença, G. C., & Ferrari, S. F. (2013). Bat flies (Diptera: Streblidae) ectoparasites of bats at an Atlantic Rainforest site in northeastern Brazil. *Biota Neotropica*, 13, 242–246.
- Soares, F. A. M., Gracioli, G., Ribeiro, C. E. B. P., Bandeira, R. S., Moreno, J. A. T., & Ferrari, S. F. (2016). Bat (Mammalia: Chiroptera) diversity in an area of mangrove forest in southern Pernambuco, Brazil, with a new species record and notes on ectoparasites (Diptera: Streblidae). *Papéis Avulsos de Zoologia*, 56, 63–68.
- Soares, F. A. M., Rocha, P. A., Mikalaukas, J. S., Gracioli, G., & Ferrari, S. F. (2017). Ectoparasitic bat flies (Diptera, Streblidae) of bats (Chiroptera, Mammalia) from Mata do Junco Wildlife Refuge, Sergipe, Northeastern Brazil. *Oecologia Australis*, 21, 385–395.
- Straube, F. C., & Bianconi, G. V. (2002). Sobre a grandeza e a unidade utilizada para estimar esforço de captura com utilização de captura com utilização de redes de neblina. *Chiroptera Neotropical*, 8, 150–152.
- ter Hofstede, H. M., & Fenton, M. B. (2005). Relationships between roost preferences, ectoparasite density, and grooming behaviour of Neotropical bats. *Journal of Zoology*, 266, 333–40.
- ter Hofstede, H. M., Fenton, M. B., & Whitaker Jr, J. O. (2004). Host and host-site specificity of bat flies (Diptera: Streblidae and Nycteribiidae) on Neotropical bats (Chiroptera). *Canadian Journal of Zoology*, 82, 616–626.
- Vicente, A., Almeida Jr, E. B., Santos-Filho, F. S., & Zickel, C. S. (2014). Composição estrutural da vegetação lenhosa da restinga de Cabedelo, Paraíba. *Revista de Geografia*, 31, 183–196.
- Vilar, E. M., Nunes, H., Nascimento, J. L., & Cordeiro-Estrela, P. (2015). Distribution extension of *Ametrida centurio* Gray, 1847 (Chiroptera, Phyllostomidae): first record in the Brazilian Atlantic Forest. *Check List*, 11, 1–5.
- Wenzel, R. L. (1976). The streblid bat flies of Venezuela (Diptera: Streblidae). *Brigham Young University Science Bulletin*, 20, 1–177.
- Wenzel, R. L., Tipton, V. J., & Kiewlicz, A. (1966). The streblid batflies of Panama (Diptera Calyptræ: Streblidae). In R. L. Wenzel, & V. J. Tipton (Eds.), *Ectoparasites of Panama* (pp. 405–675). Chicago: Field Museum of Natural History.
- Zarazúa-Carbajal, M., Saldaña-Vázquez, R. A., Sandoval-Ruiz, C. A., Stoner, K. E., & Benitez-Malvido, J. (2016). The specificity of host-bat fly interaction networks across vegetation and seasonal variation. *Parasitology Research*, 115, 4037–4044.