

New records of mites (Acari: Spinturnicidae) associated with bats (Mammalia, Chiroptera) in two Brazilian biomes: Pantanal and Caatinga

Novos registros de ácaros (Acari: Spinturnicidae) associados com morcegos (Mammalia, Chiroptera) em dois biomas brasileiros: Pantanal e Caatinga

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Abstract

A first survey of mite species that ectoparasitize bats in the states of Ceará and Mato Grosso was conducted. The specimens of bats and their mites were collected in areas of the Caatinga and Pantanal biomes. A total of 450 spinturnicids representing two genera and ten species was collected from 15 bat species in the Private Reserve of the Natural Patrimony Serra das Almas, Ceará State, Northeast Brazil and 138 spinturnicids represented by two genera and four species were found in seven bats species collected in Private Reserve of the Natural Patrimony Sesc Pantanal, Mato Grosso State, Central-Western Brazil. The occurrence of *Cameronieta* genus and the species *Mesoperiglischrus natali* as well as four new associations (*Periglischrus iheringi* - *Chiroderma vizottoi*; *P. micronycteridis* - *Micronycteris sanborni*; *P. paracutisternus* - *Trachops cirrhosus*; *Spinturnix americanus* - *Myotis riparius*) are registered for the first time in Brazil.

Keywords: *Periglischrus*, *Mesoperiglischrus*, *Cameronieta*, Caatinga, Pantanal, Brazil.

Resumo

Ácaros ectoparasitos de morcegos são reportados pela primeira vez para os Estados do Ceará e Mato Grosso. Os espécimes de morcegos com seus ectoparasitos foram coletados em áreas dos biomas Caatinga e Pantanal. Foi coletado o total de 450 espinturnicídeos representados por dois gêneros e dez espécies sobre 15 espécies de morcegos na Reserva Particular do Patrimônio Natural Serra das Almas, Ceará, Nordeste Brasileiro e em sete espécies de morcegos coletadas na Reserva Particular do Patrimônio Natural Sesc Pantanal, Mato Grosso, Centro-Oeste Brasileiro foram encontrados 138 espinturnicídeos representados por dois gêneros e quatro espécies. A ocorrência do gênero *Cameronieta* e da espécie *Mesoperiglischrus natali*, além de quatro novas associações (*P. iheringi* - *Chiroderma vizottoi*; *Periglischrus micronycteridis* - *Micronycteris sanborni*; *P. paracutisternus* - *Trachops cirrhosus*; *Spinturnix americanus* - *Myotis riparius*) são registradas pela primeira vez no Brasil.

Palavras-chave: *Periglischrus*, *Mesoperiglischrus*, *Cameronieta*, Caatinga, Pantanal, Brasil.

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Introduction

The family Spinturnicidae comprises hematophagous mites found exclusively on bats. These mites go through five life cycle stages, including the egg, larva, protonymph, deutonymph, and adult. The egg and larval stages occur inside a pregnant female (RUDNICK, 1960), and, according to Almeida et al. (2015), nymph and adult mites mostly infest the plagiopatagium of bats. The most recent taxonomy for the Spinturnicidae lists four genera in the New World (HERRIN & TIPTON, 1975): *Cameronieta* Machado-Allison, 1965, which are exclusive to mormoopidae bats; *Periglischrus* Kolenati, 1857, the largest genus, found in phyllostomidae bats; *Spinturnix* Von Hayden, 1826, a cosmopolitan genus, with a majority of known species occurring in association with Old World bats of the subfamily Vespertilionoidea, and seven species recorded in the New World (HERRIN & TIPTON, 1975); *Paraspinturnix* Rudnick, 1960, a monotypic genus that parasitizes the anal orifice of *Myotis* bats; and a fifth genus *Mesoperiglischrus* (DUSBÁBEK, 1968) presented by Morales-Malacara in the 10th International Congress of Acarology (2001) as a valid genus with two species found in Natalidae bats (MORALES-MALACARA, 2001).

Studies on the occurrence of Spinturnicids in Brazil have been conducted with bats collected in the capital city of Brasília, in regions of the Cerrado (GETTINGER & GRIBEL, 1989), in Atlantic forest areas in the states of Minas Gerais (AZEVEDO et al., 2002; MORAS et al., 2013), Pernambuco (DANTAS-TORRES et al., 2009), Rio Grande do Sul (SILVA et al., 2009), Rio de Janeiro (ALMEIDA et al., 2011), and in the Pantanal region, state of Mato Grosso do Sul (SILVA & GRACIOLLI, 2013), besides of Confalonieri dissertation (1976) that present a biometric study of *P. iheringi* and *P. ojasitii*. In the present paper, it is reported the diversity and distribution of ectoparasitic Spinturnicidae species found in surveys conducted in the Pantanal region in the state of Mato Grosso and in the Caatinga region in the state of Ceará.

Materials and Methods

Species inventories were conducted in different areas of two Brazilian biomes, the Private Reserve of the Natural Patrimony (RPPN, from the original Portuguese) Serra das Almas and RPPN Sesc Pantanal. The RPPN Serra das Almas (05° 15' S/41° 00' W) comprises 6,146 hectares and is considered an Outpost of the Caatinga Biosphere Reserve situated in the municipality of Cratêus, state of Ceará (ARAÚJO et al., 2011). The RPPN Sesc Pantanal (16° 41' S/56° 24' W) represents the largest RPPN in Brazil, with approximately 106,000 hectares between the rivers Cuiabá and São Lourenço in the municipality of Barão de Melgaço, state of Mato Grosso. It is an important area for the protection of Brazilian biodiversity and the preservation of genetic resources (SILVA & ABDON, 1998).

In the RPPN Serra das Almas, bats were collected during nine nights in the dry season (August 2012) and 10 nights in the rainy season (February 2013). In the RPPN Sesc Pantanal bats were collected during 15 nights in dry season (May 2008).

In both areas, bats were collected with mist nets measuring from 6 to 18 meters in length and 2.5 meters in height placed in existing trails or above streams. The sampling period extended for six hours after sunset. Bat specimens that were returned to the wild were released at the capture site following their identification in the field and voucher specimens were fixed in 10% formaldehyde and preserved in 70% alcohol, as previously described by Vizotto & Taddei (1973) and Handley (1988), and catalogued in the National Museum (MN, from the original Portuguese) Mammal Collection and the Adriano Lucio Peracchi (ALP) collection, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil.

Silva et al. (2015) and Tavares (2009) describe the bat species collected in both study areas. The taxonomic nomenclature applied to bat species follows the one proposed by Nogueira et al. (2014).

Mites were collected from live bats with fine-pointed tweezers and conditioned in flasks containing 70% alcohol. In the National Reference Laboratory for Rickettsioses Vectors, Fundação Oswaldo Cruz, Rio de Janeiro, mites were mounted as per Flechtmann (1990) and identified according to the taxonomic keys proposed by Tibbetts (1957), Machado-Allison (1964, 1965a, b), Dusbábek (1967, 1968), Herrin & Tipton (1975), Morales-Malacara (2001) and Morales-Malacara & Juste (2002).

Results and Discussion

A total of 450 Spinturnicidae mite specimens, representing two genera and 10 species, were collected from 15 bat species captured in RPPN Serra das Almas. In the RPPN Sesc Pantanal, seven bat species were collected carrying 138 mites distributed in two genera and four species of the same family (Tables 1 and 2).

Mite family, genera and species are presented in alphabetical order and by collection area. The host species is listed along with parasite load information. Released bats are listed following the same norms, but with month, in roman numerals, and year of capture (number of host), followed by parasite load.

The following results constitute the first survey of Spinturnicidae mites for the Caatinga in the state of Ceará and for the Pantanal biome in Mato Grosso.

Spinturnicidae (Acari, Mesostigmata)

Cameronieta Machado-Allison 1965

Cameronieta sp.

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas.

Host: *Preronotus gymnonotus* - II/2013 (2): one ♂, one protonymph.

Host: *P. parnellii* - II/2013 (24): 57♂, 34♀, three deutonymphs ♀, two deutonymphs ♂, 26 protonymphs; ALP 10183: five ♂, two deutonymphs ♂, one protonymph; ALP 10188: three ♂, three ♀, one deutonymph ♂.

Comments: *Cameronieta* genus is exclusive to mormoopidae bats (HERRIN & TIPTON, 1975) and is comprised of six species: *C. strandtmanni* (TIBBETTS, 1957); *C. thomasi* (MACHADO-ALLISON, 1965b) and *C. elongatus* (FURMAN, 1966) reported from Venezuela and *C. machadoi* Dusbábek, 1967; *C. tibbettsi* Dusbábek, 1967 and *C. torrei* Dusbábek, 1967 reported from Cuba. Although *P. parnellii* have been already associated with *C. elongatus* and *C. tibbettsi* in Venezuela and Cuba, respectively (DUSBÁBEK, 1967; HERRIN & TIPTON, 1975), the specimens

Table 1. Spinturnicid mite associations found in Private Reserve of the Natural Patrimony (RPPN, from the original Portuguese) Serra das Almas, Ceará state, Brazil.

Host	Spinturnicidae sp.	♂	♀	Deut ♂	Deut ♀	Prot
<i>Anoura geoffroyi</i> Gray, 1838	<i>Periglischrus vargasi</i>	–	2	–	1	–
<i>Artibeus lituratus</i> (Olfers, 1818)	<i>P. iheringi</i>	1	4	–	–	2
<i>Artibeus planirostris</i> (Spix, 1823)	<i>P. iheringi</i>	9	28	4	2	4
	<i>P. torrealbai</i>	7	10	–	1	5
<i>Carollia perspicillata</i> (Linnaeus, 1758)	<i>P. iheringi</i>	–	1	–	–	–
<i>Chiroderma vizottoi</i> Taddei & Lim, 2010	<i>P. iheringi</i>	13	2	–	–	–
<i>Glossophaga soricina</i> (Pallas, 1766)	<i>P. caligus</i>	2	1	–	–	–
<i>Micronycteris sanborni</i> Simmons, 1996	<i>P. micronycteridis</i>	1	11	–	–	2
<i>Natalus macrourus</i> (Gervais, 1856)	<i>Mesoperiglischrus natali</i>	2	–	–	–	1
<i>Phyllostomus discolor</i> (Wagner, 1843)	<i>P. torrealbai</i>	6	3	–	1	3
<i>Platyrrhinus lineatus</i> (É. Geoffroyi, 1810)	<i>P. iheringi</i>	12	6	1	4	2
<i>Pteronotus gymnotus</i> (Wagner, 1843)	<i>Cameronieta</i> sp.	1	–	–	–	1
<i>Pteronotus parnellii</i> (Gray, 1843)	<i>Cameronieta</i> sp.	65	37	5	3	27
<i>Sturnira lilium</i> (É. Geoffroyi, 1810)	<i>P. ojustii</i>	8	7	3	2	5
<i>Tonatia bidens</i> (Spix, 1823)	<i>P. torrealbai</i>	27	15	2	1	13
<i>Trachops cirrhosus</i> (Spix, 1823)	<i>P. paracutisternus</i>	35	24	1	3	11
Total		189	151	16	18	76

♂: male; ♀: female; Deut: deutonymphs; Prot: protonymphs.

Table 2. Spinturnicid mite associations found in Private Reserve of the Natural Patrimony (RPPN, from the original Portuguese) Sesc Pantanal, Mato Grosso state, Brazil.

Host	Spinturnicidae sp.	♂	♀	Deut ♂	Deut ♀	Prot
<i>Artibeus lituratus</i> (Olfers, 1818)	<i>Periglischrus iheringi</i>	4	3	–	–	–
<i>Artibeus planirostris</i> (Spix, 1823)	<i>P. iheringi</i>	23	41	4	4	10
<i>Glossophaga soricina</i> (Pallas, 1766)	<i>P. caligus</i>	4	15	–	1	1
<i>Myotis riparius</i> Handley, 1960	<i>Spinturnix americanus</i>	3	3	–	–	1
<i>Platyrrhinus incarum</i> (Thomas, 1912)	<i>P. iheringi</i>	4	1	–	1	–
<i>Platyrrhinus lineatus</i> (É. Geoffroyi, 1810)	<i>P. iheringi</i>	3	3	–	–	1
<i>Trachops cirrhosus</i> (Spix, 1823)	<i>P. paracutisternus</i>	6	–	–	–	2
Total		47	66	4	6	15

♂: male; ♀: female; Deut: deutonymphs; Prot: protonymphs.

collected could not be allocated to any known species because the position of sternal setae and the length of podosomal and metasternal setae (ALMEIDA et al., unpublished). Furthermore, this is the first time the genus is reported in Brazil.

Mesoperiglischrus natali (FURMAN, 1966)

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Natalus macrourus* - ALP 10173: two ♂, one protonymph.

Comments: Furman (1966) described the species *Periglischrus natali* as a member of the genus *Periglischrus*. However, Dusbábek (1968) described a new genus and species, *Mesoperiglischrus nyctiellinus* and considered *P. natali* to be a congener, recombining the name to *M. natali*. Years after Morales-Malacara (2001) analyzed morphologically the genus *Periglischrus* and the results supported this conclusion. Considered an exclusive parasite of the bat genus *Natalus* (FURMAN, 1966; MORALES-MALACARA, 2001), *M. natali* had not been reported in Brazil until this moment, but in Venezuela it has been reported in association with *N. tumidirostris* Miller, 1900 (HERRIN & TIPTON, 1975).

Periglischrus Kolenati, 1857

Periglischrus sp.

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Tonatia bidens* - VII/2012(1): five ♂, two deutonymphs ♂, one protonymph; II/2013(2): 17 ♂, eight ♀, one deutonymph ♀, eight protonymphs; ALP 10157: four ♂, three ♀, one protonymph; ALP 10384: one ♂, one ♀, two protonymphs; ALP 10460: three ♀, one protonymph.

Comments: Herrin & Tipton (1975) described *Periglischrus tonatii* as a primary parasite of the genus *Tonatia*, and reported the occurrence of the mite in association with *T. silvicola*, *T. brasiliensis* and *T. carrikeri*, all of which currently belong to the genus *Lophostoma* (Lee et al., 2002). In southeast Mexico and Panama, Morales-Malacara & Juste (2002) described *P. steresotrichus*, a species morphologically close to *P. tonatii*, and *P. eurysternus*, which is close to *P. paratorrealbai*, both in association with *T. evotis* (currently *Lophostoma evotis*) and *T. saurophila*, respectively. The specimens obtained from *T. bidens* in the RPPN Serra das Almas are phenetically close to *P. torrealbai*, but they belong to a new species in description process.

Periglischrus caligus Kolenati, 1857

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Glossophaga soricina* - ALP 10158: one ♂; ALP 10172: one ♂; ALP 10477: one ♀. Brazil, Mato Grosso State, RPPN Sesc Pantanal. Host: *G. soricina* - V/2008: three ♀; MN 71484: one ♂; MN 71499: six ♀; MN 71516: one ♂; MN 71521: four ♀, one deutonymph ♀; MN 71592: two ♂, two ♀, one protonymph.

Comments: Considered a primary parasite of the genus *Glossophaga* this species had been reported in Brazil in association with *G. soricina* in Rio de Janeiro, São Paulo, Brasília and Pernambuco (CONFALONIERI, 1976; GETTINGER & GRIBEL, 1989; DANTAS-TORRES et al., 2009).

Periglischrus iheringi Oudemans, 1902

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Artibeus lituratus* - VII/2012(2): one ♂, one ♀; ALP 10166: one protonymph. II/2013(3): three ♀, one protonymph. Host: *A. planirostris* - VII/2012(1): one ♂, 12 ♀, two deutonymphs ♀; I/2013(10): five ♂, eight ♀, four deutonymphs ♂, two protonymphs; ALP 10405: two ♂, five ♀, one protonymph; ALP 10412: one ♀; ALP 10441: one ♂, two ♀, one protonymph. Host: *Carollia perspicillata* - ALP 10434: one ♀. Host: *Chiroderma vizottoi* - VII/2012(1): three ♂; ALP 10196: three ♂; II/2013(7): nine ♂, two ♀; ALP 10423: one ♂. Host: *Platyrrhinus lineatus* - I/2013(2): four ♂, three ♀, two deutonymphs ♀; ALP 10397: one ♂, two ♀; ALP 10403: one ♂, one deutonymph ♀; ALP 10425: six ♂, one ♀, one deutonymph ♀, one deutonymph ♂, two protonymph. Brazil, Mato Grosso State, RPPN Sesc Pantanal. Host: *Artibeus planirostris* - V/2008 (12): 17♂, 33♀, four deutonymphs ♂, two deutonymphs ♀, seven protonymphs; MN 71505: one deutonymph ♀; MN 71502: two ♂, two ♀, one deutonymph ♀, two protonymphs; MN 71503: one ♂; MN 71504: two ♀; MN 71524: one ♂, two ♀, one protonymph; MN 71587: two ♂, two ♀. Host: *A. lituratus*, MN 71496: one ♂, three ♀; MN 71506: two ♂; MN 71514: one ♂. Host: *P. lineatus* - MN 71507: three ♂, three ♀, one protonymph. Host: *P. incarum* - MN 71523: three ♂, one ♀, one deutonymph ♀; MN 71581: one ♂.

Comments: This species is the most often cited in studies of bat parasites, and it is found in association with emballonuridae, noctilionidae, mormoopidae and with a majority of Phyllostomidae subfamilies (HERRIN & TIPTON, 1975). Given this wide range of hosts, it is possible that *P. iheringi* in fact comprises a number of species (HERRIN & TIPTON, 1975). In Brazil, this mite has been reported in *Artibeus lituratus* (GETTINGER & GRIBEL, 1989; DANTAS-TORRES et al., 2009; SILVA et al., 2009; ALMEIDA et al., 2011; CONFALONIERI, 1976), *A. planirostris* (GETTINGER & GRIBEL, 1989; DANTAS-TORRES et al., 2009), *D. cinerea* (GETTINGER & GRIBEL, 1989), *A. fimbriatus* (SILVA et al., 2009), *A. obscurus* (ALMEIDA et al., 2011), *Anoura caudifer* (GETTINGER & GRIBEL, 1989; SILVA et al., 2009), *Anoura* sp. (SILVA et al., 2009), *Carollia perspicillata* (ALMEIDA et al., 2011; CONFALONIERI, 1976), *Glossophaga soricina* (SILVA et al., 2009), *Platyrrhinus lineatus* (DANTAS-TORRES et al., 2009; SILVA & GRACIOLLI, 2013), *Desmodus rotundus* (CONFALONIERI, 1976), *Chrotopterus auritus* (CONFALONIERI, 1976), *Peropteryx macrotis* (CONFALONIERI, 1976), *Eptesicus brasiliensis* (CONFALONIERI, 1976) and

Sturnira lilium (AZEVEDO et al., 2002; ALMEIDA et al., 2011; DANTAS-TORRES et al., 2009; CONFALONIERI, 1976).

Here, we report for the first time an association between *P. iheringi* and *C. vizottoi*. Because of the vast number of cases we found, this association is likely correct.

Periglischrus micronycteridis Furman, 1966

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Micronycteris sanborni* - ALP 10155: one ♂, one ♀, one protonymph; ALP 10160: one ♀; ALP 10385: three ♀; ALP 10442: one ♀; ALP 10459: five ♀, one protonymph.

Comments: This species represents a primary parasite of the genus *Micronycteris* (FURMAN, 1966). In the state of Rio de Janeiro, it has been found in association with *M. megalotis* Gray, 1842 by Almeida et al. (2011). The association with *M. sanborni* is reported here for the first time in Brazil.

Periglischrus ojustii Machado-Allison, 1964

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Sturnira lilium* - ALP 10133: one ♂, two ♀; ALP 10150: five ♂, four ♀, two deutonymphs ♂, two protonymphs; ALP 10189: one ♀, one deutonymph ♂, one protonymph; ALP 10445: two ♂, two deutonymphs ♀, two protonymphs.

Comments: Species commonly found in association with the genus *Sturnira*. In Brazil, it has been reported in association with *C. perspicillata* in the state of Pernambuco (DANTAS-TORRES et al., 2009), *S. tildae* in Espírito Santo (CONFALONIERI, 1976) and with *S. lilium* in Brasília (GETTINGER & GRIBEL, 1989), Minas Gerais (CONFALONIERI, 1976; AZEVEDO et al., 2002) and Rio de Janeiro (CONFALONIERI, 1976; ALMEIDA et al., 2011).

Periglischrus paracutisternus Machado-Allison & Antequera, 1971

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Trachops cirrhosus* - VII/2012(2): seven ♂, three ♀, one deutonymph ♂; II/2013(3): five ♂, three ♀; ALP 10137: one ♂, one ♀, one protonymph; ALP 10139: nine ♂, 14♀, one deutonymph ♀, eight protonymphs; ALP 10156: one ♂, one ♀; ALP 10419: 12♂, two ♀, two deutonymphs ♀, two protonymphs. Brazil, Mato Grosso State, RPPN Sesc Pantanal. Host: *T. cirrhosus* - MN 71578: six ♂, two protonymphs.

Comments: In Venezuela, Herrin & Tipton (1975) found this species in association with *T. cirrhosus*, its primary host. This is the first time that this association is reported to Brazil.

Periglischrus torrealbai Machado-Allison, 1965

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Artibeus planirostris* - ALP 10391: seven ♂, ten ♀, one deutonymph ♀, five protonymphs; Host: *P. discolor* - ALP 10190: five ♂, one deutonymph ♀, one protonymph; ALP 10195: one ♂, two ♀, two protonymphs; ALP 10454: one ♀.

Comments: A primary parasite of the bat genus *Phyllostomus* (MACHADO-ALLISON, 1965a), this species has been reported in Brazil in association with *P. discolor* in Brasília (GETTINGER & GRIBEL, 1989) and with *P. hastatus* in Rio de Janeiro (ALMEIDA et al., 2011) and Minas Gerais (CONFALONIERI, 1976). This is the first time that the association with *A. planirostris* is reported in Brazil; however, because we found it in only one host, this association requires further evaluation before being considered valid. The parasite has been reported in association with *A. planirostris* in Venezuela (HERRIN & TIPTON, 1975).

Periglischrus vargasi Hoffmann, 1944

Specimens examined: Brazil, Ceará State, RPPN Serra das Almas. Host: *Anoura geoffroyi* - ALP 10177: two ♀, one deutonymph ♀.

Comments: This primary parasite of the genus *Anoura* (HERRIN & TIPTON, 1975) has been reported in Brazil in association with *A. geoffroyi* and *Anoura* sp. in the state of Rio Grande do Sul (SILVA et al., 2009) and with *A. caudifer* and *G. soricina* in Rio de Janeiro (CONFALONIERI, 1976).

Spinturnix Von Heyden, 1826

Spinturnix americanus (Banks, 1902)

Specimens examined: Brazil, Mato Grosso State, RPPN Sesc Pantanal. Host: *Myotis riparius* - MN 71589: three ♂, three ♀, one protonymph.

Comments: This mite is known to parasitize the genus *Myotis* in neotropical regions (HERRIN & TIPTON, 1975). It has been found in Brazil with *M. nigricans* (CONFALONIERI, 1976; SILVA & GRACIOLLI, 2013) and *Nyctinomops macrotis* (CONFALONIERI, 1976). The association with *M. riparius* is the first reported to Brazil.

Conclusions

The occurrence of these Spinturnicidae species is reported here for the first time for the state of Ceará and for the Pantanal region of Mato Grosso. The 15 bat species collected in the Caatinga and seven in Pantanal carried 3 genera and 11 species of Spinturnicidae mite, totaling 588 specimens. Furthermore, the occurrence of a *Cameronieta* sp. and *M. natali* and the associations *P. iheringi* – *C. vizottoi*, *P. micronycteridis* – *M. sanborni*, *P. paracutisternus* – *T. cirrhosus*, and *S. americanus* – *M. riparius* were registered for the first time in Brazil.

The available data for the Spinturnicidae family in neotropical bats leaves wide gaps in the understanding of host associations and parasite distribution. This fact reflects the lack of research focus on bat ectoparasitic fauna. Despite the fact that collection methods are almost identical, researchers often neglect ectoparasites after capturing bats. Thus, we reaffirm the need for proper and standardized ectoparasite data collection that minimizes contamination, proper cataloguing in museums, and greater collaboration between mammalogists and ectoparasitologists in identifying species.

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