Graellsia, 77(1): e135
enero-junio 2021
ISSN-L: 0367-5041
https://doi.org/10.3989/graellsia.2021.v77.293

ECTOPARASITIC FAUNA ON THE COMMON VAMPIRE BAT *DESMODUS ROTUNDUS* (GEOFFROY, 1810) (CHIROPTERA: PHYLLOSTOMIDAE) FROM HUAROCHIRI, LIMA, AND A CHECKLIST OF ECTOPARASITES IN BATS OF PERU

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ABSTRACT

The blood-sucking bat *Desmodus rotundus* (Geoffroy, 1810) is a widely distributed zoonotic vector. The purposes of this study were to assess its ectoparasitic fauna and to compile a checklist of the parasitic arthropods in bats from Peru. The bats were captured in the San Bartolomé district, Huarochirí Province, Lima, Peru. A checklist was compiled based on online databases. Twenty-seven bats were studied, of which 70.37% (n = 19) were infected with at least one species of ectoparasite, including the Diptera *Strebla wiedemanni* Kolenati, 1856, and *Trichobius parasiticus* Gervais, 1844, and the ixodid *Ornithodoros peruvianus* Kohls, Clifford & Jones, 1969. The ectoparasite with the highest abundance and prevalence was *O. peruvianus*. We report three species of lice on *D. rotundus*, which we consider as accidental parasites. According to our checklist, 104 species of ectoparasites have been reported from 75 species of bats in 19 regions of Peru, including Diptera, Hemiptera, Siphonaptera, Phthiraptera, Mesostigmata and Ixodida. *Aspidoptera falcata* Wenzel, 1976 and *Megistopoda aranea* (Coquillett, 1899) (Streblidae) are the ectoparasites with the highest number of registered hosts. *Lophostoma silvicolum* d'Orbigny, 1836; *Phyllostomus elongatus* (Geoffroy, 1810) and *Phyllostomus hastatus* (Pallas, 1767) are the hosts with the most records of ectoparasites in bats from Peru (s = 10). According to the level of specificity of the ectoparasites for their hosts, the monoxenous species (s = 47) predominate, followed by oligoxenous species (s = 21). The geographical regions with most host-parasite reports were Loreto and Madre de Dios. Further research is needed since there are no ectoparasite records for 60.3% of bat species in Peru.

Keywords: Chiroptera; Diptera; parasitology; Phthiraptera; vampire.

RESUMEN

Fauna de ectoparásitos en el vampiro común *Desmodus rotundus* (Geoffroy, 1810) (Chiroptera: Phyllostomidae) de Huarochiri, Lima, y una lista de los ectoparásitos en murciélagos del Perú

El murciélago hematófago *Desmodus rotundus* (Geoffroy, 1810) es una especie de importancia zoonótica y amplia distribución. El propósito de este estudio fue evaluar su fauna ectoparasitaria y elaborar una lista de los artrópodos parásitos presentes en los murciélagos del Perú. Los murciélagos fueron capturados en el distrito de San Bartolomé, provincia de Huarochirí, Lima, Perú. La preparación de la lista se llevó a cabo mediante la búsqueda en las principales bases de datos en línea. Se estudiaron 27 murciélagos, de los cuales el 70,37 % (n = 19) estaban infectados con al menos una especie de ectoparásito. Se registraron las especies de Diptera *Strebla wiedemanni* Kolenati, 1856, y *Trichobius parasiticus* Gervais, 1844, y el ixódido *Ornithodoros peruvianus* Kohls, Clifford & Jones, 1969. La especie de mayor abundancia y prevalencia fue *O. peruvianus*. Se reportan tres especies de piojos en *D. rotundus*, que consideramos como parásitos accidentales. En cuanto a la lista, hasta la fecha se han reportado 104 especies de ectoparásitos distribuidos entre los grupos principales: Diptera, Hemiptera, Siphonaptera, Phthiraptera, Mesostigmata e Ixodida a partir de ejemplares de 75 especies de murciélagos en 19 departamentos del Perú. *Aspidoptera falcata* Wenzel, 1976, y *Megistopoda aranea* (Coquillett, 1899) (Streblidae) son los ectoparásitos con el mayor número de huéspedes registrados. *Lophostoma silvicolum* d'Orbigny, 1836; *Phyllostomus elongatus* (Geoffroy, 1810) y *Phyllostomus hastatus* (Pallas, 1767) son los huéspedes con el mayor registro de ectoparásitos en murciélagos del Perú (s = 10). Según el nivel de especificidad de los ectoparásitos para sus huéspedes, las especies monoxenas (s = 47) fueron las dominantes, seguidas por las oligoxenas (s = 21). Las regiones geográficas con mayor información acerca de ectoparásitos huéspedes fueron Loreto y Madre de Dios. Es

necesario ampliar los estudios ya que el 60.3% de las especies de murciélagos del Perú no tienen registros de ectoparásitos.

Palabras clave: Chiroptera; Diptera; parasitología; Phthiraptera; vampiro.

Recibido/*Received:* 20/07/2020; **Aceptado/*Accepted:*** 23/12/2020; **Publicado en línea/*Published online:*** 26/05/2021

Cómo citar este artículo/*Citation*: Minaya, D., Mendoza, J. & Iannacone, J. 2021. Ectoparasitic fauna on the common vampire bat *Desmodus rotundus* (Geoffroy, 1810) (Chiroptera: Phyllostomidae) from Huarochiri, Lima, and a checklist of ectoparasites in bats of Peru**.** *Graellsia*, 77(1): e135. https://doi.org/10.3989/graellsia.2021.v77.293

Introduction

Studies about the biology and ecology of chiropterans have increased in recent decades. Among them, many have focused on the metazoan endoparasites and ectoparasites associated with bats and their high specificity with these hosts (Dick, 2007; Dick & Patterson, 2007; Walldorf & Mehlhorn, 2014; Tlapaya-Romero *et al*., 2019; Minaya *et al*., 2020).

Bats are hosts to a large number of endoparasites and ectoparasites. The most common ectoparasites that live on bats belong to the groups of mites, ticks and insects, especially bugs (Hemiptera), fleas (Siphonaptera) and bat flies (Diptera) (Frank *et al*., 2014). This last group of ectoparasites is the most specific and diverse on bats (Reeves & Lloyd, 2019).

Desmodus rotundus (Geoffroy, 1810) is distributed from northern Mexico throughout Central America and part of South America to southern Chile (Barquez *et al*., 2015). It is a hematophagous bat, known as a typical vampire, and feeds on the blood of birds and mammals (Quintana & Pacheco, 2007). Reports of ectoparasites on vampire bats have been studied extensively, and more than 33 species of ectoparasites including bat flies, mites and soft ticks have been recorded on this bat species (Frank *et al*., 2014). In Peru, ectoparasites of *D. rotundus* have been reported by Guerrero (1996a), Mendoza-Uribe & Chavez-Chorocco (2003), Autino *et al*. (2011) and Venzal *et al.* (2012).

The objective of this study is to report the ectoparasitic fauna of the vampire bat *D. rotundus* and additionally to compile a checklist that summarizes and includes all the records of bat ectoparasites in Peru.

Material and methods

Individuals of *D. rotundus* were captured in an abandoned railway cave in San Bartolomé (11°54'11.5"S, 76°30'12.5" W; 1710 m.a.s.l.) in September 2016, near La Esperanza bridge, located 3 km east of the San Bartolomé district , Huarochirí Province, Lima, Peru. This town belongs to the Yungas natural region or Warm valley.

The ectoparasites were extracted with entomological forceps and brushes soaked in alcohol (Tlapaya-Romero *et al*., 2015). All arthropods were preserved in 70% ethanol. Chewing lice were rinsed in 20% KOH for 24 h, cleared in clove oil, and mounted in Canada balsam (Price *et al*., 2003). Diptera were placed in a solution of 70% ethanol, 5% glycerin, and 25% distilled water (Autino *et al*., 2011). Additionally, some tick specimens were analyzed with scanning electron microscopy (SEM).

For the identification of lice species, the taxonomic key of Price *et al.* (2003) was used. For Diptera, the keys of Wenzel (1976), Guerrero (1993, 1995a, 1996a), and the pictorial keys of Graciolli & Carvalho (2001) were used. Ticks were identified using the taxonomic keys of Barros-Battesti *et al.* (2013) with the support of the descriptions of Venzal *et al.* (2012). The values of prevalence (P%) and mean intensity (IM) were calculated according to Bush *et al.* (1997). The ectoparasitic specimens were deposited in the collection of Helminths Parasites and Related Invertebrates – HPIA – of the zoological collection of the Museum of Natural History of the Universidad Nacional Federico Villarreal – MUFV –, Lima, Peru. Accession numbers are listed in Table 1.

The checklist was compiled from data obtained from searches of the physical and virtual literature in the country's university libraries, scientific collections, museums, and databases published until March 2020.

This review includes a list of ectoparasites, indicating their hosts, location, host specificity (HS), and the respective reference. Host Specificity was classified as Monoxenous (Mon), Stenoxenous (Est), Oligoxenous (Oli) and Polyxenous (Pol), according to Marshall (1981), and Gettinger (2018).

Results

Ectoparasites in the common vampire bat

Twenty-seven specimens of the common vampire *D. rotundus* were captured from the district of San Bartolomé, Huarochirí Province, Lima, Peru.

Table 1.— Ectoparasitic arthropods in 27 individuals of *Desmodus rotundus* from Lima, Peru, found in this study. Voucher numbers are also indicated (MUFV: Museum of Natural History of the Universidad Nacional Federico Villarreal).

Tabla 1.— Artrópodos ectoparásitos de 27 individuos de *Desmodus rotundus* de Lima, Perú, base de este estudio. Se indican también los códigos de los ejemplares (MUFV: Museum of Natural History of the Universidad Nacional Federico Villarreal).

Species	Stage	N	A	P%	MI	Voucher MUFV
DIPTERA						
Strebla wiedemanni	Adult	6	7	22.22	1.17	HPIA: 183
Trichobius parasiticus	Adult	3	4	11.11	1.33	HPIA: 184
PHTHIRAPTERA						
Campanulotes compar	Adult	2	4	7.41	2.00	HPIA: 185
Columbicola columbae	Adult	2	3	7.41	1.50	HPIA: 186
Colpocephalum sp.	Adult	1	1	3.70	1.00	HPIA: 187
IXODIDA						
Ornithodoros peruvianus	nymph, Larvae	14	183	51.85	13.07	HPIA: 188

A= abundance, MI= mean intensity, N= number of infected host individuals, P= prevalence.

Of this population, 19 individuals (70.4%) were parasitized by at least one ectoparasitic species. The taxa and ectoparasitic species registered on the *D. rotundus* sample are shown in Table 1.

The community of parasites on *D. rotundus* consisted of adult specimens of two species of bat flies in the family Streblidae, nymphs and larvae of a tick species belonging to the family Argasidae and three species of lice (considered accidental) of the families Menoponidae and Philopteridae (Figure 1). Among the collected species, *Ornithodoros peruvianus* Kohls, Clifford & Jones 1969 was the ectoparasite with the highest prevalence (P% = 51.85), Mean intensity (IM = 13.7) and abundance (s = 183).

Checklist of the ectoparasites of bats in Peru

In our review, we found 104 species of ectoparasites in bats from Peru in two major groups: Hexapoda (Diptera, Hemiptera, Siphonaptera) and Arachnida (Mesostigmata and Ixodida). Of these 104 species, 99 were identified at the species level, and the rest at genus level only. The groups with the highest number of species were the families Streblidae (Diptera) (s = 59) and Spinturnicidae (Mesostigmata) (s = 20) (Table 2). Among the species with the higher number of hosts, *Aspidoptera falcata* Wenzel, 1976 and *Megistopoda aranea* (Coquillett, 1899) were recorded on eight host species each (Table 2).

We found at least one record of some species of ectoparasite in seventy-five species of bats in Peru. These bat species are distributed in seven families, with Phyllostomidae being the one with the most reports of parasitized bats (s = 58). The bat species with the highest number of reported ectoparasitic species were *Lophostoma silvicolum* d'Orbigny, 1836, *Phyllostomus elongatus* (Geoffroy, 1810) and *Phyllostomus hastatus* (Pallas, 1767) with ten species each, followed by *Carollia perspicillata* (Linnaeus, 1758) and *Lophostoma silvicolum* d'Orbigny, 1836. Accidental ectoparasites were not considered in this count.

According to the level of specificity of the ectoparasites for their hosts, species with monoxenic associations (s = 47) were the most common, followed by oligoxenic ones (s = 21). Species of Diptera were observed to present the four types of association (Table 3).

In regards to the geographical distribution of ectoparasites and their hosts in Peru, 19 of the 24 departments in the Peruvian territory present at least some reports of an association of ectoparasites and bats. The departments of Madre de Dios and Loreto have the highest number of records, 40 and 37 species of ectoparasites, respectively, and 40 species of hosts in Loreto, followed by Madre de Dios with 30 species of hosts. Cajamarca, Huancavelica, La Libertad, Moquegua, and Tacna are the only five departments with no reports of ectoparasites on bats (Figure 2).

Discussion

Ectoparasites in the common vampire bat

It has been reported that the typical vampire bat *D. rotundus* hosts seven species of ectoparasites in Peru: *Aspidoptera falcata* (Claps *et al*., 2005), *Megistopoda aranea* (Claps *et al*., 2005), *Ornithodorus peruvianus* (Kohls *et al*., 1969), *Periglischrus herrerai* Machado-Allison, 1965 (Mendoza-Uribe & Chavez-Chorocco, 2003; Gettinger, 2018), *Strebla wiedemanni* Kolenati, 1856 (Wenzel, 1970; Claps *et al*., 2005; Autino *et al*., 2011), *Trichobius furmani* Wenzel, 1966 (Wenzel *et al*., 1966; Guerrero, 1995a), and *Trichobius parasiticus* Gervais, 1844 (Wenzel, 1970; Elliot *et al*., 1985; Guerrero, 1995a). Of these species, *O. peruvianus*, *S. wiedemanni,* and *T. parasiticus* were also found in our study.

The most studied families of ectoparasites on bats are the Streblidae and Nycteribiidae due to their specificity to their hosts (Aguiar & Antonini, 2016; Reeves & Lloyd, 2019). The family Streblidae has been reported typically

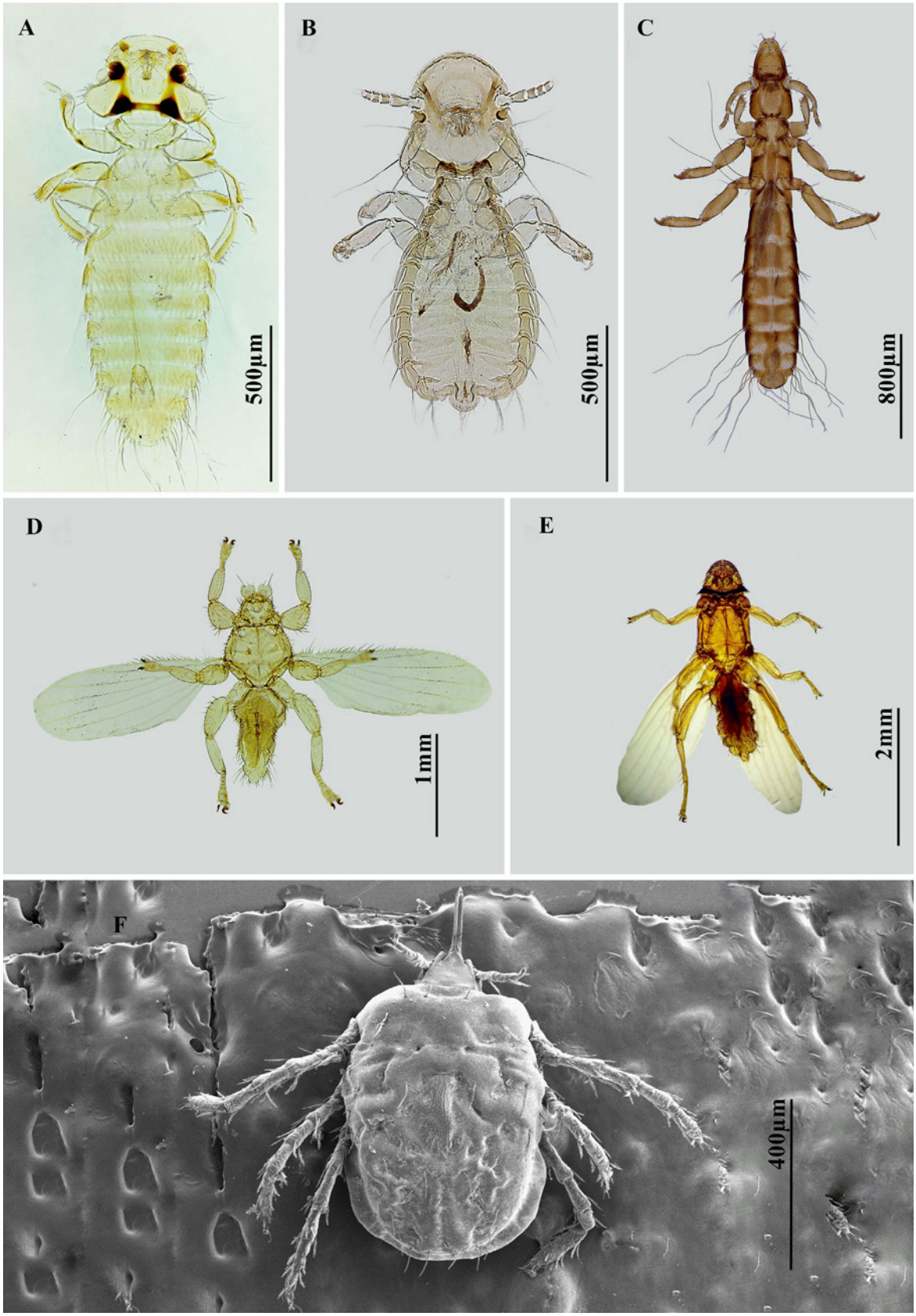

Fig. 1.— Ectoparasites of the common vampire *Desmodus rotundus* from San Bartolomé district, Huarochirí Province, Lima, Peru. A. *Colpocephalum* sp. B. *Campanulotes compar*. C. *Columbicola columbae*. D. *Trichobius parasiticus*. E. *Strebla wiedemanni*. F. *Ornithodoros peruvianus*.

Fig. 1.— Ectoparásitos del vampiro común *Desmodus rotundus* del distrito de San Bartolomé, provincia de Huarochirí, Lima, Perú. A. *Colpocephalum* sp. B. *Campanulotes compar*. C. *Columbicola columbae*. D. *Trichobius parasiticus*. E. *Strebla wiedemanni*. F. *Ornithodoros peruvianus*.

Table 2.— Checklist of reported ectoparasitic arthropods in bats from Peru.

Table 2.— Lista de los registros de artrópodos ectoparásitos en murciélagos del Perú.

Ectoparasite	Host	Locality	HS	Reference
Class: Arachnida				
Order: Mesostigmata				
Family: Macronyssidae				
Parichoronyssus alexanderfaini Morales-Malacara & Guerrero (2020)	*Rhinophylla pumilio*	Madre de Dios	Mon	Morales-Malacara & Guerrero (2020)
Parichoronyssus bakeri Morales-Malacara & Guerrero (2007)	*Phyllostomus elongatus, P. hastatus*	Cusco, Madre de Dios	Ste	Morales-Malacara & Guerrero (2007)
Parichoronyssus euthysternum Radovsky, 1967	*Lophostoma silvicola, Sturnira erythromos, S. lilium, S. magna, S. oporaphilum*	Cusco, Madre de Dios	Oli	Morales-Malacara & Guerrero (2020)
Parichoronyssus lopezi Morales-Malacara, 1996	*Artibeus glaucus, Chiroderma salvini, Platyrrhinus brachycephalus*	Cusco, Madre de Dios	Oli	Morales-Malacara & Guerrero (2020)
Parichoronyssus radovskyi Morales-Malacara, 1992	*Lophostoma silvicola*	Cusco	Mon	Morales-Malacara & Guerrero (2020)
Parichoronyssus sclerus Radovsky, 1966	*Anoura geoffroyi*	Cusco	Mon	Morales-Malacara & Guerrero (2020)
Family: Spelaeorhynchidae				
Spelaeorhynchus praecursor Neumann, 1902	*Agoura cultrate, A. geoffroyi*	Cusco, Madre de Dios	Ste	Gettinger *et al*. (2020)
Spelaeorhynchus soaresi Peracchi, 1990	*Carollia brevicauda, C. perspicillata*	Cusco, Madre de Dios	Ste	Gettinger *et al*. (2020)
Family: Spinturnicidae				
Periglischrus acutisternus Machado-Allison, 1964	*Phyllostomus elongatus, P. hastatus*	Cusco, Madre de Dios	Ste	Gettinger (2018)
Periglischrus caligus Kolenati, 1857	*Glossophaga soricina*	Ica	Mon	Mendoza-Uribe & Chavez-Chorocco (2003)
Periglischrus gameroi Machado-Allison & Antequera, 1971	*Lonchorhina* spp.	Cusco, Madre de Dios	Ste	Gettinger (2018)
Periglischrus grandisoma Herrin & Tipton, 1975	unknown	Cusco, Madre de Dios	--	Gettinger (2018)
Periglischrus herrerai Machado-Allison, 1965	*Desmodus rotundus*	Cusco, Ica, Madre de Dios	Mon	Mendoza-Uribe & Chavez-Chorocco (2003); Gettinger (2018)
Periglischrus hopkinsi Machado-Allison, 1965	*Lionycteris spurrelli*	Cusco, Madre de Dios	Mon	Gettinger (2018)
Periglischrus iheringi Oudemans, 1902	*Artibeus fraterculus*	Ica	Mon	Mendoza-Uribe & Chavez-Chorocco (2003)
Periglischrus micronycteridis Furman, 1966	*Micronycteris megalotis, M. minuta*	Cusco, Madre de Dios	Ste	Gettinger (2018)
Periglischus ojasti Machado-Allison, 1964	*Sturnira erythromos, S. lilium, S. magna, S. oporaphilum, S. tildae*	Cusco, Madre de Dios	Ste	Gettinger (2018)
Periglischrus paracutisternus Machado-Allison & Antequera, 1971	*Trachops cirrhosus*	Cusco, Madre de Dios	Mon	Gettinger (2018)
Periglischrus paravargasi Herrin & Tipton 1975	*Anoura caudifer*	Cusco, Madre de Dios	Mon	Gettinger (2018)
Periglischrus ramirezi Machado-Allison and Antequera, 1971	*Rhinophylla pumilio*	Cusco, Madre de Dios	Mon	Gettinger (2018)
Periglischrus tonatii Herrin & Tipton, 1975	*Lophostoma carrikeri, L. silvicolum*	Cusco, Madre de Dios	Ste	Gettinger (2018)
Periglischrus torrealbai Machado-Allison, 1965	*Phyllostomus elongatus, P. hastatus*	Cusco, Madre de Dios	Ste	Gettinger (2018)

Ectoparasite	Host	Locality	HS	Reference
Periglischrus vargasi Hoffmann, 1944	*Anoura geoffroyi*	Cusco, Madre de Dios	Mon	Gettinger (2018)
Order: Ixodida				
Superfamilia: Ixodoidea				
Family: Argasidae				
Antricola sp.	*Pteronotus parnellii rubiginosus*	Huánuco	Mon	Need *et al.* (1991)
Ornithodoros hasei (Schulze, 1935)	*Artibeus* sp., *Myotis albescens, Noctilio albiventris, Rhinophylla pumilio*	Lima, Loreto	Pol	Need *et al.* (1991); Díaz *et al.* (2007)
Ornithodoros peruvianus Kohls, Clifford & Jones, 1969	*Desmodus rotundus, Glossophaga* sp., *Molossus currentium*	Lima, Loreto, Piura, Ucayali	Pol	Kohls *et al.* (1969); Present study
Ornithodoros sp.	unknown	Amazonas	Mon	Need *et al.* (1991)
Class: Hexapoda				
Order: Siphonaptera				
Family: Ischnopsyllidae				
Myodopsylla wolffsohni wolffsohni (Rothschild, 1903)	*Myotis albescens*	Loreto	Mon	Autino *et al.* (2011)
Sternopsylla distincta (Rothschild, 1903)	*Tadarida brasiliensis*	Cusco	Mon	Autino *et al.* (1999)
Family: Pulicidae				
Craneopsylla minerva wolffhuegeli (Rothschild, 1909)	*Myotis nigricans***	unknown	Mon	Autino & Claps (2000)
Rhynchopsyllus pulex (Haller, 1880)	*Molossus currentium, Histiotus* sp.	Huánuco, unknown	Pol	Autino *et al.* (1999), Tipton & Machado-Allison (1972)
Order: Phthiraptera				
Family: Menoponidae				
Colpocephalum sp.	*Desmodus rotundus***	Lima	Mon	Present study
Family: Philopteridae				
Columbicola columbae (Linnaeus, 1758)	*Desmodus rotundus***	Lima	Mon	Present study
Campanulotes compar (Burmeister, 1838)	*Desmodus rotundus***	Lima	Mon	Present study
Order: Hemiptera				
Family: Polyctenidae				
Hesperoctenes angustatus Ferris & Usinger, 1939	*Molossus molossus*	Unknown, Piura	Mon	Autino *et al.* (1999); Bonifaz *et al.* (2020)
Hesperoctenes fumarius (Westwood, 1874)	*Molossus rufus, Phyllostomus hastatus*	Cusco	Pol	Maa (1961)
Order: Diptera				
Family: Nycteribiidae				
Basilia anceps Guimarães & D'Andretta, 1956	*Myotis nigricans*	Huánuco	Mon	Guimarães & D'Andretta (1956); Guimarães (1972)
Basilia constricta Guimarães & D'Andretta, 1956	*Myotis nigricans, Uroderma bilobatum*	Huánuco	Pol	Guimarães (1972)
Basilia dubia Guimarães & D'Andretta, 1956	*Myotis albescens*	Cusco	Mon	Guimarães & D'Andretta (1956); Guimarães (1972)
Basilia ferrisi Schuurmans-Stekhoven, Jr., 1931	unknown	Loreto, Ucayali	--	Guimarães & D'Andretta (1956); Guimarães (1972)
Basilia manu Guerrero, 1996	*Myotis albescens, M. nigricans, M. riparius, M. simus*	Madre de Dios	Ste	Guerrero (1996c)

Ectoparasite	Host	Locality	HS	Reference
Basilia mimoni Theodor & Peterson, 1964	*Gardnerycteris crenulatum*	Loreto	Mon	Theodor & Peterson (1964)
Basilia peruvia Guimarães & D´Andretta, 1956	*Myotis nigricans, Tadarida brasiliensis*	Cusco, Huánuco, Ucayali	Pol	Guimarães & D'Andretta (1956); Graciolli *et al.* (2007)
Basilia rugosa Schuurmans-Stekhoven, Jr., 1942	unknown	Ayacucho	--	Graciolli *et al.* (2007)
Hershkovitzia inaequalis Theodor, 1967	*Thyroptera discifera*	Loreto	Mon	Theodor (1967); Graciolli *et al.* (2007)
Family: Streblidae				
Anastrebla modestini Wenzel, 1966	*Anoura geoffroyi, A. peruana*	Lima	Ste	Claps *et al.* (2005); Bonifaz *et al.* (2020)
Anatrichobius scorzai Wenzel, 1966	*Myotis oxyotus*	Cusco	Mon	Wenzel *et al.* (1966)
Aspidoptera falcata Wenzel, 1976	*Carollia perspicillata, Desmodus rotundus, Rhinophylla pumilio, Sturnira lilium, S. magna, S. tildae, Sturnira* sp. unknown	Cusco, Lima, Loreto, Madre de Dios, Pasco	Oli	Guerrero (1995b); Claps *et al.* (2005); Autino *et al.* (2011)
Aspidoptera phyllostomatis (Perty, 1833)	*Artibeus fraterculus, A. jamaicensis, A. lituratus, A. obscurus, A. planirostris*	Loreto, Madre de Dios, Pasco, Piura	Ste	Guerrero (1995b); Autino *et al.* (2011), Bonifaz *et al.* (2020)
Exastinion clovisi (Pessóa & Guimarães, 1936)	*Anoura geoffroyi*	Lima	Mon	Claps *et al.* (2005)
Mastoptera minuta (Costa-Lima, 1921)	*Carollia brevicauda, Lophostoma silvicolum, Phyllostomus elongatus, P. hastatus*	Loreto, Madre de Dios	Oli	Guerrero (1995b); Autino *et al.* (2011)
Megistopoda aranea (Coquillett, 1899)	*Artibeus fraterculus, A. jamaicensis, A. lituratus, A. planirostris, Desmodus rotundus, Platyrrhinus brachycephalus, Uroderma bilobatum,* unknown	Lambayeque, Lima, Loreto, Madre de Dios, Pasco, Piura	Oli	Wenzel (1970); Guerrero (1994b); Claps *et al.* (2005); Autino *et al.* (2011); Bonifaz *et al.* (2020)
Megistopoda proxima (Séguy, 1926)	*Sturnira lilium, S. tildae, Sturnira* sp.	Loreto, Madre de Dios, Pasco	Ste	Guerrero (1994b); Autino *et al.* (2011)
Metelasmus pseudopterus Coquillett, 1907	*Artibeus fraterculus, A. jamaicensis, A. lituratus, A. planirostris, Artibeus* sp., *Dermanura anderseni*	Loreto, Madre de Dios, Pasco, Piura.	Oli	Guerrero (1996a); Autino *et al.* (2011), Bonifaz *et al.* (2020)
Neotrichobius bisetosus Wenzel, 1976	*Artibeus jamaicensis, A. obscurus*	Madre de Dios	Ste	Guerrero (1994b)
Neotrichobius delicatus (Machado-Allison, 1966)	*Dermanura anderseni, D. gnoma, Noctilio albiventris, Molossus rufus, Rhinophylla fischerae, R. pumilio*	Loreto, Pasco	Pol	Guerrero (1994b); Autino *et al.* (2011)
Neotrichobius ectophyllae Wenzel, 1976	*Mesophylla macconnelli*	Loreto	Mon	Autino *et al.* (2011)
Noctiliostrebla aitkeni Wenzel, 1966	*Noctilio leporinus*	Loreto	Mon	Autino *et al.* (2011)
Noctiliostrebla dubia (Rudow, 1871)	*Artibeus lituratus*	Pasco	Mon	Guerrero (1995b)
Noctiliostrebla traubi Wenzel, 1966	*Noctilio leporinus*	Tumbes	Mon	Wenzel *et al.* (1966)
Paradyschiria fusca Speiser, 1900	*Noctilio albiventris, Noctilio leporinus,* unknown	Loreto, Pasco	Ste	Guerrero (1995b); Autino *et al.* (2011)
Paradyschiria lineata Kessel, 1925	*Noctilio albiventris, Rhinophylla pumilio*	Pasco	Pol	Guerrero (1995b)
Paradyschiria parvula Falcoz, 1931	*Myotis simus, Noctilio albiventris, Noctilio* sp.	Loreto, Madre de Dios	Pol	Guerrero (1995b), Autino *et al.* (2011)
Parastrebla handleyi Wenzel, 1966	*Micronycteris megalotis*	Madre de Dios	Mon	Guerrero (1994b)
Paratrichobius dunni (Curran, 1935)	*Platyrrhinus brachycephalus, Uroderma bilobatum, Vampyriscus bidens*	Loreto, Madre de Dios	Oli	Guerrero (1994b); Autino *et al.* (2011)
Paratrichobius longicrus (Miranda-Ribeiro, 1907)	*Artibeus lituratus, Carollia perspicillata*	Loreto, Madre de Dios	Oli	Guerrero (1994b); Autino *et al.* (2011)

Ectoparasite	Host	Locality	HS	Reference
Phalconomus sp.	*Platalina genovensium*	Arequipa	Mon	Velazco *et al.* (2014)
Pseudostrebla ribeiroi Costa-Lima, 1921	*Lophostoma silvicolum*	Loreto, Madre de Dios	Mon	Guerrero (1994b); Autino *et al.* (2011)
Speiseria ambigua Kessel, 1925	*Carollia brevicauda, C. perspicillata, Myotis* sp., *Platalina genovensium, Trachops cirrhosus*	Lima, Loreto, Madre de Dios, Pasco, Piura	Pol	Guerrero (1994b, 1996b); Claps *et al.* (2005); Velazco *et al.* (2014)
Speiseria magnioculus Wenzel, 1976	*Diphylla ecaudata*	Madre de Dios	Mon	Guerrero (1994b)
Speiseria peytonae Wenzel, 1976	*Carollia brevicauda*	Madre de Dios	Mon	Guerrero (1994b)
Strebla alvarezi Wenzel, 1966	*Lonchophylla thomasi*	Madre de Dios	Mon	Guerrero (1996a)
Strebla consocia Wenzel, 1966	*Lophostoma brasiliense, L. silvicolum, Phyllostomus elongatus, P. hastatus, Phyllostomus* sp., *Platyrrhinus brachycephalus*	Loreto, Madre de Dios	Oli	Wenzel *et al.* (1966); Guerrero (1996a); Autino *et al.* (2011)
Strebla curvata Wenzel, 1976	*Carollia brevicauda, Glossophaga commissarisi*	Loreto, Madre de Dios	Oli	Guerrero (1996a); Autino *et al.* (2011)
Strebla diaemi Wenzel, 1966	*Diaemus youngi*	Loreto	Mon	Wenzel *et al.* (1966)
Strebla diphyllae Wenzel, 1966	*Diphylla ecaudata*	Madre de Dios	Mon	Guerrero (1996a)
Strebla galindoi Wenzel, 1966	*Tonatia saurophila*	Loreto	Mon	Autino *et al.* (2011)
Strebla guajiro (Garcia & Casal, 1965)	*Carollia brevicauda, C. perspicillata, Carollia* sp., *Glossophaga soricina*	Loreto, Pasco, unknown	Oli	Guerrero (1996a); Autino *et al.* (2011)
Strebla hertigi Wenzel, 1966	*Carollia brevicauda, Phyllostomus discolor, P. elongatus*	Loreto, Piura	Oli	Wenzel *et al.* (1966); Autino *et al.* (2011)
Strebla kohlsi Wenzel, 1966	*Glossophaga soricina, Lophostoma silvicolum, Phylloderma stenops*	Loreto, Madre de Dios	Oli	Guerrero (1996a); Autino *et al.* (2011)
Strebla kohlsi-Complex mirabilis	*Phyllostomus hastatus, Trachops cirrhosus*	Loreto	Oli	Autino *et al.* (2011)
Strebla mirabilis (Waterhouse ,1879)	*Phyllostomus elongatus, P. hastatus, Phyllostomus* sp., *Trachops cirrhosus,* unknown	Junín, Loreto, Madre de Dios	Oli	Wenzel *et al.* (1966); Guerrero (1996a)
Strebla machadoi Wenzel, 1966	*Gardnerycteris crenulatum, Micronycteris minuta*	Loreto, Madre de Dios	Oli	Guerrero (1996a); Autino *et al.* (2011)
Strebla obtusa Wenzel, 1976	*Trinycteris nicefori*	Loreto	Mon	Autino *et al.* (2011)
Strebla paramirabilis Wenzel, 1976	*Lophostoma silvicolum*	Loreto	Mon	Autino *et al.* (2011)
Strebla tonatie (Kessel, 1924)	*Micronycteris megalotis, Lophostoma silvicolum*	Cusco, Loreto	Oli	Wenzel *et al.* (1966); Autino *et al.* (2011)
Strebla wiedemanni Kolenati, 1856	*Desmodus rotundus, Sturnira tildae*	Apurímac, Cusco, Junín, Lima, Loreto, Piura, Puno, San Martín	Oli	Wenzel (1970); Guerrero (1996a); Claps *et al.* (2005); Autino *et al.* (2011); Present study
Trichobius caecus Edwards, 1918	*Carollia perspicillata, Phyllostomus elongatus*	Amazonas, Madre de Dios	Oli	Cáceres *et al.* (1992); Ibáñez & Jara (2008)
Trichobius costalimai Guimarães, 1938	*Phyllostomus discolor*	unknown	Mon	Wenzel *et al.* (1966)
Trichobius diaemi Wenzel, 1976	*Diaemus youngi*	Huánuco	Mon	Guerrero (1995a)
Trichobius diphyllae Wenzel, 1966	*Diphylla ecaudata*	Madre de Dios	Mon	Guerrero (1995a)
Trichobius dugesii Townsend, 1891	*Glossophaga soricina*	Junín, Madre de Dios	Mon	Wenzel *et al.* (1966); Guerrero (1995a)

Ectoparasite	Host	Locality	HS	Reference
Trichobius dugesioides Wenzel, 1966	*Carollia perspicillata, Trachops cirrhosus*	Huánuco, Madre de Dios	Oli	Guerrero (1995a); Guerrero (1996b)
Trichobius dybasi Wenzel, 1966	*Lophostoma silvicolum*	Piura	Mon	Wenzel (1970)
Trichobius furmani Wenzel, 1966	*Carollia perspicillata, Desmodus rotundus, Glossophaga soricina, Lophostoma silvicolum, Molossus molossus, Phyllostomus hastatus*	Junín, Huánuco, Puno	Pol	Wenzel *et al.* (1966); Guerrero (1995a)
Trichobius handleyi Wenzel, 1976	*Micronycteris megalotis*	Madre de Dios	Mon	Guerrero (1995a)
Trichobius joblingi Wenzel, 1966	*Carollia brevicauda, C. castanea, C. perspicillata, Glossophaga soricina, Molossus molossus, Phyllostomus elongatus, Saccopteryx bilineata*	Amazonas, Huánuco, Junín, Lima, Loreto, Madre de Dios, Pasco, Piura, Puno	Pol	Wenzel (1970), Cáceres *et al.* (1992); Guerrero (1995a); Ibáñez & Jara (2008), Bonifaz *et al.* (2020)
Trichobius lionycteridis Wenzel, 1966	*Lionycteris spurrelli*	Cusco	Mon	Wenzel *et al.* (1966)
Trichobius lonchophyllae Wenzel, 1966	*Lonchophylla thomasi*	Madre de Dios	Mon	Guerrero (1994a); Guerrero (1996b)
Trichobius longipes (Rudow, 1871)	*Phyllostomus elongatus, P. hastatus*	Amazonas, Madre de Dios, Pasco	Ste	Cáceres *et al.* (1992); Guerrero (1994a, 1996b); Ibáñez & Jara (2008)
Trichobius parasiticus Gervais, 1844	*Carollia castanea, Desmodus rotundus, Rhinophylla pumilio, Sturnira lilium, S. tildae*	Cusco, Huánuco, Huaraz, Ica, Lima, Loreto, Madre de Dios, Pasco, Piura	Oli	Wenzel (1970); Elliot *et al.* (1985); Cáceres *et al.* (1992); Guerrero (1995a), Present study
Trichobius uniformis Curran, 1935	*Glossophaga commissarisi, G. soricina*	Madre de Dios, unknown	Ste	Wenzel *et al.* (1966); Guerrero (1996b)
Trichobius sp.	*Platyrrhinus albericoi, P. infuscus, P. masu, P. nigellus*	Cusco	Ste	Graciolli & Carvalho (2012)
Xenotrichobius sp.	*Noctilio albiventris*	Madre de Dios	Mon	Guerrero (1996b)

HS= Host Specificity: Mon= Monoxenous, St= Stenoxenous, Oli= Oligoxenous, Pol= Polyxenous
HS= Especificidad de hospedador: Mon= Monoxeno, St= Estenoxeno, Oli= Oligoxeno, Pol= Polixeno
** Accidental host

Table 3.— Types of association according to host-ectoparasite specificity.

Tabla 3.—Tipos de asociación de acuerdo a su especificidad hospedador-ectoparásito.

Host specificity	Order Ectoparasites					
	Dip	Hem	Sip	Mes	Ixo	Total
Monoxenous	30	1	3	11	2	47
Stenoxenous	9	0	0	9	0	18
Oligoxenous	19	0	0	2	0	21
Polyxenous	8	1	1	0	2	12

Ixo=Ixodida, Dip= Diptera, Hem= Hemiptera, Mes=Mesostigmata, Sip= Siphonaptera.

associated with bats of the family Phyllostomidae (Aguiar & Antonini, 2016); *S. wiedemanni* and *T. parasiticus* have been reported in the present study with relatively low P% and MI (P% = 22.2, MI = 1.17 and P% = 11, MI = 1.33, respectively) on *D. rotundus*. Different studies have reported a broad range of values of these variables for these two ectoparasites on *D. rotundus*. Aguiar & Antonini (2011), in studies on the same host in Brazil, found intermediate values in *S. wiedemanni* (P% = 43.6, IM = 3.57), and in *T. parasiticus* (P% = 29.5, IM = 2.09); Rojas *et al.* (2008), in Costa Rica, observed low values in *S. wiedemanni* (P% = 11.9, IM = 2.12) and high values in *T. parasiticus* (P% = 91.4, IM = 5.65); González-Ávalos *et al*. (2014), in Mexico, found low values for *S. wiedemanni* (P% = 3.2) and high for *T. parasiticus* (P% = 94.3); Aguiar & Antonini (2016), in Brazil, found intermediate values for *S. wiedemanni* (P% = 44, IM = 3.6) and *T. parasiticus* (P% = 30, IM = 2.1); Guerrero (2019), in Venezuela, found intermediate values for *S. wiedemanni* (P% = 53.04, IM = 4.27) and low values for *T. parasiticus* (P% = 16.4, IM = 30.2). These differences may indicate that the two species present a fluctuating behavior, acting as the nucleus, secondary or satellite species of the parasitic community of *D. rotundus*, which may be influenced by different factors: environmental (specific to each ecosystem), or degree of disturbance (Lafferty & Kuris, 2005).

Early reports noted that one of the groups that are not usually found in bats is chewing lice (Phthiraptera). However, there are few reports of this significant association being considered incidental. In one of the first reports of mallophagans on bats, Gerberg & Goble (1941) noted two cases: a species of the genus *Physconelloides* Ewing, 1927, probably *Physconelloides galapagensis* (Kellogg & Kuwana, 1902), on *Carollia perspicillata* (reported as *Hemiderma perspicilliatum*) and another species, *Geomydoecus* (*Geomydoecus*) *geomydis* (Osborn, 1891), collected from *Leptonycteris nivalis* (Saussure, 1860) in Nuevo León, México. In this study, only presence was reported, but no plausible explanation for accidental parasitism was provided; still, Gerberg & Goble (1941) speculated that mallophagans can occur naturally in bats.

Another finding was by Cerny & Scholz (1983), who reported *Brueelia straminea* (Denny, 1842) (Philopteridae) in a single specimen of *Pipistrellus kuhlii* (Kuhl, 1817) in the town of Beyugdash, near Gobustan, Republic of Azerbaijan. Cerny & Scholz (1983) hypothesized that the transmission of *B. straminea* to *P. kuhlii* must have occurred in a place where the accidental host and the specific host, *Dendrocopos major* (Linnaeus, 1758), shared the same refuge for a particular time.

In our study, three species of lice, *Columbicola columbae* (Linnaeus, 1758), *Campanulotes compar* (Burmeister, 1838), and *Colpocephalum* sp. were collected from the coat of *D. rotundus*. These ectoparasite species are considered typical of columbiform birds, specifically the common pigeon *Columba livia* Gmelin, 1789 (González & Roldán, 2010; Castro *et al.,* 2017; Abdullah *et al*., 2018). It is also known that these species often parasitize domestic birds such as the common chicken *Gallus gallus domesticus* (Linnaeus, 1758) (de Chirinos *et al.,* 2001; Ferreira *et al*., 2013; Jassim & Hadi, 2019). Thus, we can consider two possibilities to explain the infestation of these lice in the vampire bat; the first is that *D. rotundus* has become parasitized when coming into contact with the common pigeon, perhaps when feeding on it; and the second possibility, when feeding on the domestic chicken. Of the two, we consider the latter most likely, based on reports of the selectivity and preference of *D. rotundus* for the blood of the domestic hen over other domestic and wild animals, probably because they are more predictable and easily available for *D. rotundus* (Bobrowiec *et al.,* 2015).

Based on the above and the results presented in this study, we consider that lice parasitosis in bats is an accidental interaction, and that it is rare, with very few reports. We do not share the idea that it is a natural interaction, as implied by Gerberg & Goble (1941).

Ornithodoros peruvianus was described by Kohls *et al.* (1969) from three hosts, with *D. rotundus* as a typical host collected from the department of Lima. Venzal *et al*. (2012) studied the same ectoparasite on the same host raised in Chile and provided new morphological data and a tentative diagnosis of *O. peruvianus*; however, the material considered by the latter authors showed severe damage to the hypostome, an organ of taxonomic importance. Finally, Muñoz-Leal *et al.* (2020) contributed with a complete redescription of the larva, nymph, and adult stages of female and male *O. peruvianus* collected from the same host in northern Chile, which helped identify the specimens in this study.

Checklist for ectoparasites on bats in Peru

In Peru, the diversity of mammals has been estimated at 559 species (Pacheco *et al*., 2018), of which 189 are

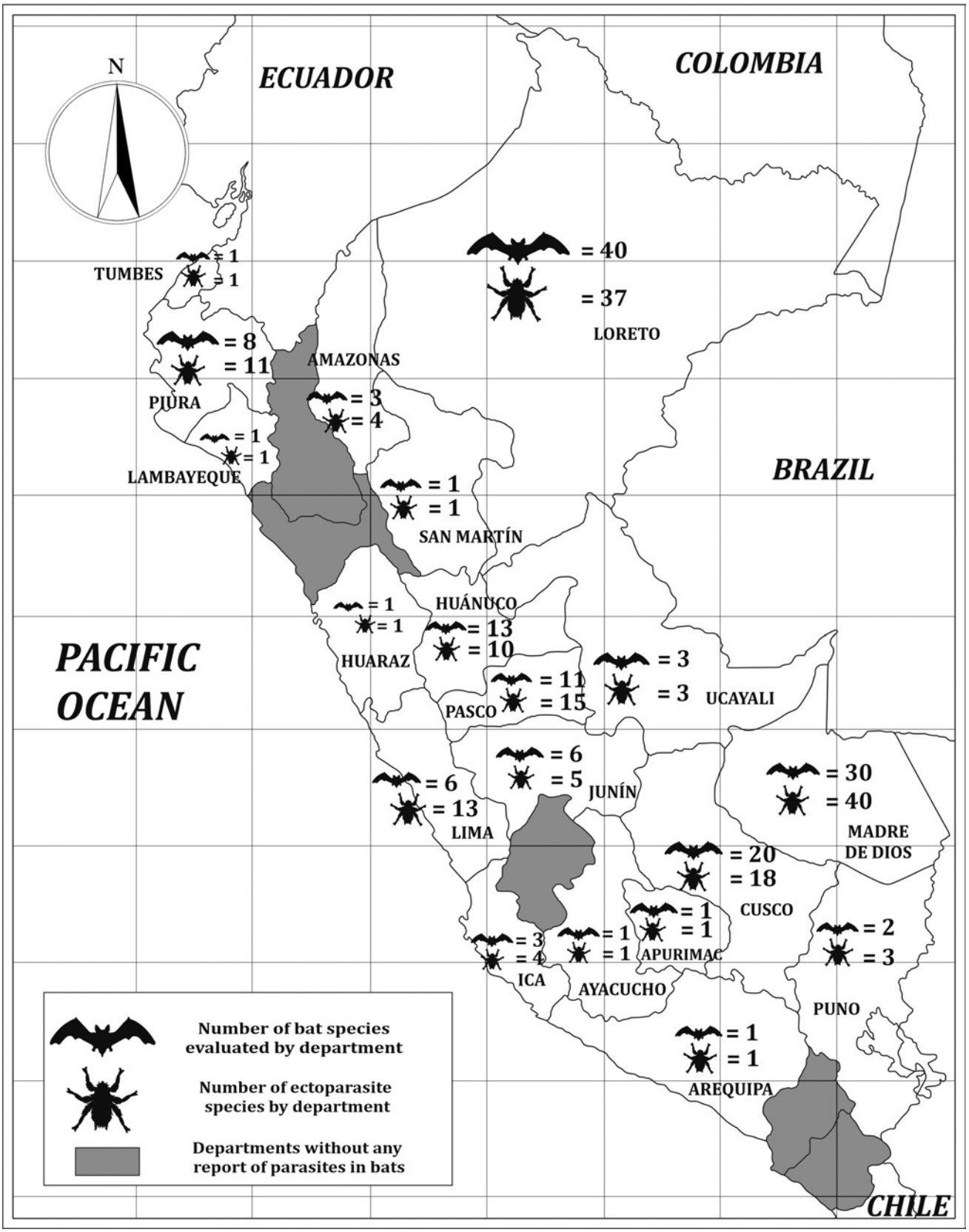

Fig. 2.— Distribution of reports of ectoparasites and their hosts in the regions of Peru.

Fig. 2.— Distribución de los registros de ectoparásitos y sus hospedadores en los departamentos del Perú.

species that belong to the order Chiroptera (Velazco, 2020). In this study, we present a summary of the reports of ectoparasites of bats in Peru, in which we found information for 75 species of bats, that is, there is no such information for 60.31% (s = 114) of bat species in Peru, which calls for further studies.

Previous checklists have summarized the fauna of endoparasites (Santos & Gibson, 2015; Minaya *et al*., 2020) and ectoparasites (Guerrero, 1997; Frank *et al*., 2014) on bats from South America including Peru. Frank *et al.* (2014) listed 38 species of ectoparasites, including 36 bat fly species (Streblidae 30, Nycteribiidae 6) and two Siphonaptera species. However, compared to our checklist, 59 species are registered in the Streblidae family (96.67% more) and four in Siphonaptera (100% more).

According to the specificity of the ectoparasites for their bat host, a greater variety of types of association was seen in the flies, presenting the four types of established associations. Even so, the monoxenous species were the most numerous. This high host specificity was also observed in other studies (Dick, 2007; Dick & Patterson, 2007). According to these authors, the behavior of the hosts, which live in large groups in close physical contact with other species of bats is not sufficient to increase the occurrence of oligoxenous or polyxenous species. The higher prevalence of monoxenous species could be explained by: (1) a mutual adaptation between host and its parasite that results in an immunological reaction that reduces the physical defense of the host (Dick & Patterson, 2007; Frank *et al*., 2014); and (2) the co-evolution of both groups playing a vital role in the specificity of the host, which is supported by the correlation between the phylogenies of the Streblidae and Nycteribiidae with their respective hosts (Patterson *et al*., 1998; Dick & Patterson, 2007). However, the latter is questioned by Graciolli & Carvalho (2012), who used phylogenic comparisons to show that some species, like *Trichobius phyllostomae* group (Streblidae), do not seem to have co-speciated with their bat hosts (Subfamily Stenodermatinae), with colonization of a new host providing a more likely explanation for this association.

The other group with higher specificity for their hosts is Acarina Mesostigmata, where only monoxenous, stenoxenous and oligoxenous species have been found. Within this group, the Spinturnicidae presented the highest number of species. According to Gettinger (2018), the family Spinturnicidae is one of the most specific in bats of the family Phyllostomidae compared to other host families, and polygenic species are not known.

Regarding the reported geographic distribution of ectoparasites and their hosts, some regions like Loreto and Madre de Dios have the highest number records because they have been comparatively more studied, probably because of the high diversity of bats that can be found in these regions, where the ecoregions of high-altitude rain forests (high jungle) and Amazonian tropical forest (low jungle) predominate. Most reports of bat ectoparasites in Peru result from the efforts of Autino *et al.* (2011) in Loreto, and Guerrero (1994b; 1995b) in Madre de Dios, which added significantly to this checklist.

It is worth mentioning that the species *Artibeus jamaicensis* Leach, 1821, *Pteronotus parnellii rubiginosus* Gray, 1843, and *Molossus currentium* Thomas, 1901 are not distributed in Peru according to Miller *et al*. (2016), Solari (2016) and Barquez & Diaz (2016), respectively. However, they have been considered in this checklist because they were cited in the works of Guerrero (1994b, 1995b, 1996a), Need *et al.* (1991), Kohls *et al.* (1969), and Autino *et al.* (1999). A review of the material deposited in the respective collections mentioned in these works is necessary to confirm species assignments.

Acknowledgments

The authors thank Gustavo Graciolli (Universidade Federal de Mato Grosso do Sul, Campo Grande, Brazil) for the kindness in answering our questions, for his comments, and for providing bibliographic material for the development of this work, and Omar Amin (Institute of Parasitic Diseases and Parasitology Center -Parasitology, Arizona, USA) and Brenton Ladd (Universidad Científica del Sur, Lima, Peru) for the suggestions and comments.

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