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Bat Fleas of the Philippines, with New Distribution Records from Bohol and Balabac Islands (Siphonaptera: Ceratophylloidea: Ischnopsyllidae)

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Abstract. Ischnopsyllidae is a highly specialized family consisting of species exclusively ectoparasitic on bats. The Philippine bat flea fauna currently comprises two subfamilies, three genera and four species. Our study presents the new distribution records from Bohol Island and Balabac Island, as well as the first overview of the natural history and distribution of known ischnopsyllid fleas in the Philippines.

Keywords: Ectoparasite, Pteropodidae, new record, *Thaumapsylla*, Philippines

Introduction

Fleas are a holometabolous group characterized primarily by the lack of wings laterally compressed bodies in adults. All members of this order exclusively rely on blood for nutrition and parasitize mammals and birds (Krenn & Aspöck, 2012). Due to their hematophagous nature, fleas are known to be vectors of diseases including bubonic plague, cat scratch fever, and murine typhus (Civen & Ngo, 2008; Dean et al., 2018; Girma et al., 2019) as well as intermediate hosts for parasites such as *Dipylidium caninum* (Linnaeus, 1758) (Wani et al., 2013) and *Hymenolepis diminuta* (Rudolphi, 1819) (Sethi et al., 2018). Currently, there are about 2575 species belonging to 18 families and taxa are known to occur across all zoogeographic regions (Hastriter & Whiting, 2009). Among the extant flea families, only Ischnopsyllidae is exclusively associated with a single host group (Marshall, 1982; Krasnov, 2008). Other families that exhibit a very narrow host range include Malacopsyllidae, which is primarily ectoparasitic on armadillos (Smit, 1987; Ezquiaga & Lareschi, 2012) and Chimaeropsyllidae, which is associated mainly with elephant shrews (Segerman, 2000; Whiting et al., 2008).

Ischnopsyllidae is a small family comprising 20 genera and 135 species (Durden & Hinkle, 2009) exclusively ectoparasitic in bats (Whiting et al., 2008). This group is divided into two subfamilies: Ischnopsyllinae and Thaumapsyllinae. The former occurs primarily on insectivorous bats, whereas the latter is associated with fruit bats (Pteropodidae) (Hopkins & Rothschild, 1956). In the Philippines, there are very few published records of ischnopsyllid fleas. These include the works of Jordan (1937), Traub (1951), Beaucournu & Kock (1994a, b), Zabat & Eduardo (2011), Hastriter & Bush (2013, 2014), Alvarez et al. (2016, 2018), and Amarga et al. (2017). Here, we report the first record of ischnopsyllid fleas in Bohol Island and Balabac Island and provide a checklist of ischnopsyllid fleas in the Philippines.

Materials and methods

Bats were collected using mist nets placed in caves (in Bohol Island) and forest edges (in Palawan Island). Collected bat specimens were identified using published taxonomic keys (Ingle & Heaney, 1999). Fleas were collected according to the Hastriter & Bush (2013) protocol and preserved in 95% ethanol prior to identification. Additional specimens were examined from the collection deposited in the Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah, USA. The collected specimens are currently in the private parasite collection of the first author.

Acronyms used in this study:

AKA - first author's private parasite collection.

BYUC - Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah, USA.

Results

Siphonaptera Latreille, 1825 (fleas)
Ischnopsyllidae Wahlgren, 1907 (bat fleas)
Thaumapsyllinae Jordan, 1947

Thaumapsylla breviceps Rothschild, 1907

(Fig. 1)

Thaumapsylla breviceps Rothschild, 1907: 329; Jordan, 1937: 290; Thompson, 1938: 146; Jordan, 1939: 374; Traub, 1951: 18–19; Smit, 1977: 39; Marshall, 1980: 83; Durden et al., 1990: 51, 53; Beaucournu, 2004: 209; Lewis, 2006: 54; Hastriter, 2009: 52; Hastriter & Bush, 2010: 225; Hastriter & Bush, 2013: 21.

Thaumapsylla breviceps orientalis Smit, 1954: 152; Klein, 1971: 225, 234; Beaucournu & Kock, 1994a: 72–73; Beaucournu et al., 1998: 1009; Ribeiro et al., 1998: 112; Suntssov & Suntssova, 1999: 575; Gong et al., 2007: appendix, p. 4.

Thaumapsylla breviceps breviceps Marcus, 1961: 175.

Material examined. PHILIPPINES: Luzon Island, Ilocos Norte Province, Adam's Village, 18.438°N 120.878°E, 750 m, *Rousettus amplexicaudatus* (P-4196/NCA049), 23. VI. 2011, leg. S. Villa (2 ♀♀, BYUC); Adam's Village, 18.449°N 120.894°E, 475 m, 1. VII. 2011, leg. S. Villa (1 ♀, BYUC); Aurora Province, Municipality of San Luis, 15.680°N 121.529°E, *Eonycteris spelaea* (P-2770/JAE-3023), 16. VI. 2009, leg. K. Dittmar (1 ♀, BYUC); Aurora Province, Municipality of San Luis, 15.680°N 121.529°E, *E. spelaea* (P-2779/JAE-3040), 16. VI. 2009, leg. K. Dittmar (1 ♂, BYUC); Aurora Province, Municipality of San Luis, 15.680°N 121.529°E, *R. amplexicaudatus* (JAE-3026), 16. VI. 2009, leg. J. Esselstyn (1 ♀, BYUC); Palawan Province, El Nido municipality, Brgy. Pasadeña, 11.253°N 119.445°E, *R. amplexicaudatus* (released), 29. VII. 2019, leg. J. Cantil (11 ♀♀, AKA); Bataraza municipality, Brgy. Rio Tuba, 8.539°N 117.423°E, *E. spelaea* (released), 21–27. VI. 2019, leg. R. Giganto (6 ♂♂ 5 ♀♀, AKA); Balabac Island, Brgy. Indalawan, 7.912°N 117.035°E, *R. amplexicaudatus* (released), 25–29. X. 2019, leg. J. Cantil (5 ♀♀, AKA), **new record**; Bohol Island, Candijay municipality, 9.817°N 124.300°E, 14. I. 2012, leg. K. Phelps (2 ♀♀, AKA), **new record**.



Figure 1. Adult *Thaumapsylla breviceps* (female) from Balabac Island, Philippines

***Thaumapsylla longiforceps* Traub, 1951**

Thaumapsylla longiforceps Traub, 1951: 15–18; Holland, 1969: 11; Sakaguti, 1972: 204; Marshall, 1980: 83; Peterson et al., 1990: 42, 45; Beaucournu & Kock, 1994a: 73–74; Lewis, 2006: 54; Hastriter, 2009: 52; Hastriter & Bush, 2013: 22.

Material examined. PHILIPPINES: Mindanao Island, Mt. Hilong, San Antonio Village, 09.064°N 125.642°E, 110 m, *R. amplexicaudatus* (P-5383/NCA264), 20. VI. 2012, leg. H. Owens (1 ♀, BYUC); Bohol Island, Bilar, Duangon Spring, *R. amplexicaudatus* ♂ (P-4816), 12. V. 2012, leg. S. Bush (4 ♂♂ 2 ♀♀, BYUC); Bohol Island, Bilar, Duangon Spring, *R. amplexicaudatus* ♀, 12. V. 2012, leg. S. Bush (1 ♀, BYUC); Luzon Island, Ilocos Norte Province, Adam's Village, 475 m, *R. amplexicaudatus* (P-4318/NCA125), 1. VII. 2011, leg. S. Villa (1 ♀, BYUC).

Ischnopsyllinae Wahlgren, 1907

***Ischnopsyllus indicus* Jordan, 1931**

Ischnopsyllus indicus Jordan, 1931: 147; Jordan, 1941: 365–366; Smit, 1952: 844; Smit, 1953: 149; Wang, 1956: 8; Sakaguti, 1957: 173; Ono, 1959: 670–671; Hopkins, 1961: 107; Sakaguti & Jameson Jr., 1962: 149–150; Smit, 1964: 486; Sakaguti, 1967: 102; Lien & Fan, 1971: 255; Liu et al., 1981: 24; Ye et al., 1982: 214, 216; Beaucournu et al., 2000: 120; Gong et al., 2005: 285; Liu et al., 2005: 375; Lewis, 2006: 47; Gong et al., 2007: appendix, p. 4.

Ischnopsyllus tatishii Sugimoto, 1933: 101.

Ischnopsyllus tateshii Liu, 1935: 1–4.

Ischnopsyllus taetishii Liu, 1936: 586.

Ischnopsyllus tateishii Liu, 1939: 89; Chow & Huang, 1950: 117; Hopkins, 1952: 364; Sakaguti, 1957: 171.

Material examined. PHILIPPINES: Negros Island, Mt. Bungal, Northern Negros Natural Park, 10.674°N 123.189°E, 1200 m, *Pipistrellus javanicus* (JAE-3252), 23. VII. 2009, leg. J. Esselstyn (1 ♂, BYUC).

***Lagaropsylla mera mera* Jordan & Rothschild 1921**

Lagaropsylla mera Jordan & Rothschild, 1921: 156–157; Thompson, 1938: 146; Dunnet & Mardon, 1974: 124; Mardon & Allison, 1978: 170; Smit, 1979: 326; Marshall, 1980: 83; Mardon & Allison, 1982: 187; Beaucournu & Kock, 1994a: 68.

Lagaropsylla mera mera Beaucournu & Kock, 1994b: 195; Lewis, 2006: 48.

Key to Species of Ischnopsyllidae in the Philippines

1. Cephalic region elongated; pronotum long; parasitic on insectivorous bats (*Ischnopsyllinae*).....2
- Cephalic region short; pronotum short; parasitic on Pteropodidae (*Thaumapsyllinae*).....3
2. Preoral tubercle long and narrow.....*Ischnopsyllus indicus* Jordan, 1931
- Preoral tubercle short and broad.....*Lagaropsylla mera mera* Jordan & Rothschild, 1921
3. Process on clasper thrice as long as 5th metatarsus; crochet apically subglobular.....*Thaumapsylla longiforceps* Traub, 1951
- Process on clasper twice as long as 5th metatarsus; crochet apically subacuminate.....*Thaumapsylla breviceps* Rothschild, 1907

Discussion

Ischnopsyllid fauna in the Philippines

The family Ischnopsyllidae was proposed by Wahlgren (1907), designating *Ischnopsyllus* Westwood as the type genus. The current taxonomic status of Ischnopsyllidae is divided into two subfamilies: Ischnopsyllinae and Thaumapsyllinae (Medvedev, 1985; Lewis, 1993). The subfamily Ischnopsyllinae was further divided into five tribes based on morphological attributes of the head, thorax, and aedeagus: Chiropteropsyllini Medvedev, Ischnopsyllini Wahlgren, Nycteridopsyllini Medvedev, Porribiini Medvedev, Sternopsyllini Medvedev (Wahlgren, 1907; Medvedev, 1985). Jordan (1947) established the subfamily Thaumapsyllinae based on the head and thorax structures of the genus *Thaumapsylla* which differs entirely from the structure of Ischnopsyllidae. Furthermore,

the family Ischnopsyllidae was monophyletic within the flea phylogenetic tree and was proposed to be a sister taxon to *Dolichopsyllus* Baker and Ceratophyllidae Dampf (Whiting et al., 2008).

Ischnopsyllidae can be distinguished from other flea families by having a combination of the following characters: presence of sclerotized genal plates situated in lateral regions of the head capsule, vestigial eyes (reduced or absent), absence of trabecula centralis, presence of pronotal ctenidia, presence of apical spinelets of metanotum and anterior region of abdominal tergites, and presence of antesensillial bristles (sometimes absent in some species) (Ewing & Fox, 1943; Stark, 1958). In the Philippines, this family is currently represented by four species belonging to the genera *Ischnopsyllus*, *Lagaropsylla*, and *Thaumapsylla*.

The genus *Ischnopsyllus* is widely distributed in the Palearctic region and extends to the Oriental and Afrotropical regions (Beaucournu, 2004). *Ischnopsyllus* (*Hexactenopsylla*) *indicus* was the first representative of the genus *Ischnopsyllus* documented in the Philippines. It was first collected from Mt. Bungal, Negros Island, parasitizing *Pipistrellus javanicus* (Hastriter & Bush, 2013). Despite its lone record in the Philippines to date, this species is widely distributed across Palearctic and Oriental zoogeographic regions and has been documented from Pakistan, Sri Lanka, China, Japan, Guam, Taiwan, Vietnam (Thompson, 1937; Hopkins, 1961; Sakaguti & Jameson Jr., 1962; Worth & Shah, 1969; Ye et al., 1982; Shi et al., 1989; Hastriter & Bush 2013; Sato & Takahashi, 2014). Host species for *I. (H.) indicus* include *Myotis ikonnikovi* (Ikonnikov's bat), *Pipistrellus babu* (Himalayan pipistrelle), *Pipistrellus ceylonicus* (Kelaart's pipistrelle), *Pipistrellus abramus* (Japanese pipistrelle), *Pipistrellus javanicus* (Javan pipistrelle) (Hopkins, 1961; Sakaguti & Jameson Jr., 1962; Mitchell & Punzo, 1976; Mitchell, 1977; Hastriter & Bush, 2013; Sato & Takahashi, 2014).

The genus *Lagaropsylla* is a widespread taxon that spans the Oriental, Australian, and Afrotropical zoogeographic regions (Beaucournu, 2004). Currently, there are 20 known species primarily parasitic on insectivorous bats. Interestingly, some Indo-Malayan species belonging to this genus have a phoretic relationship with bat earwigs (Arixeniidae). *Lagaropsylla turba* and *L. signata* tend to hitch-hike on arixeniid earwigs to gain access to their molossid bat host (*Cheiromeles torquatus*) (Hastriter et al., 2017). *Lagaropsylla mera* is the sole representative of the genus reported to date in the Philippines. This species was first documented in the Philippines from *Chaerephon plicatus* (wrinkled-lipped free-tailed bat) and *Miniopterus eschscholtzii* (common bent-winged bat) obtained from Luzon Island (Laguna and Rizal provinces) (Beaucournu & Kock, 1994a, b). The former host is mainly found in the Oriental zoogeographic region (particularly the Indo-Malayan area), whereas the latter has a wide distribution across the Indian subcontinent, Middle East, and northern Africa. Throughout its distribution range (Oriental and Australian regions), *L. mera* usually prefers molossid bats (Smit, 1979; Marshall, 1980).

The subfamily Thaumapsyllinae is only represented by a single genus, *Thaumapsylla*. The genus *Thaumapsylla* includes four species worldwide (Rothschild, 1907; Jordan, 1937, 1947; Traub, 1951; Hastriter, 2009), in which two of them occur in the Philippines: *T. breviceps* and *T. longiforceps*. *Thaumapsylla breviceps* was first described by Rothschild (1907) from specimens infesting *Rousettus collaris* (now *R. aegypticus*) and *R. stramineus* collected from South Africa. Smit (1954) established the subspecies *T. breviceps orientalis* from the Oriental region, distinguishing from the nominal subspecies from the Afrotropical region. *Thaumapsylla longiforceps* was established as a species from materials collected from *Rousettus* and *Eonycteris robusta* (Philippine dawn bat) from Mindanao Island, Philippines. This species can co-exist with *T. breviceps* on the same host (Traub, 1951). Among the *Thaumapsylla* species, *T. breviceps* has the widest geographic distribution, occurring in the Australian, Oriental, and Afrotropical zoogeographic regions (Hastriter & Bush, 2013) and extending to China (Hastriter & Bush, 2010). Host species across its geographic range include *R. amplexicaudatus* (Geoffroy's rousette), *R. leschenaultii* (Leschenault's rousette), *Eonycteris spelaea* (Cave nectar bat), and *E. robusta* (Philippine dawn bat). This genus was first documented in the Philippines by Jordan (1937) from samples retrieved from Mindoro and Bukidnon (Mindanao). *T. breviceps* is the most common ischnopsyllid species in the Philippines and is known to occur in major ecoregions. It has been documented in Greater Luzon (mainland Luzon; Marinduque Island), Greater Mindanao (mainland Mindanao; Bohol Island, **new record**), Mindoro Island, and Greater Palawan (mainland Palawan; Balabac Island, **new record**). On the other hand, *T. longiforceps* is reported in Greater Luzon (mainland Luzon; Marinduque Island), Greater Mindanao (mainland Mindanao), and Mindoro Island (Fig. 2).

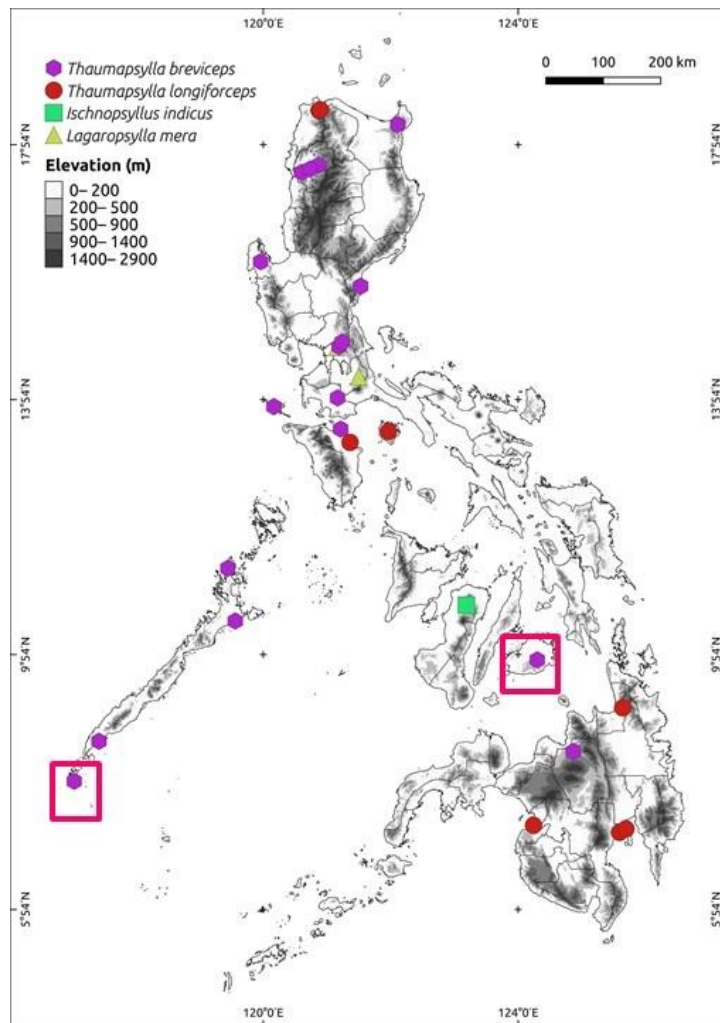


Figure 2. Geographic records of ischnopsyllid fleas in the Philippines (Pink boxes represent the new island records).

Host associations

Ischnopsyllid fleas are exclusively ectoparasitic on bats. Despite their widespread distribution, the two subfamilies show a strict association with their hosts. Ischnopsyllinae is parasitic on insectivorous bat families, whereas Thaumapsyllinae have evolved as ectoparasites of Old-World Pteropodidae (fruit bats). The genus *Ischnopsyllus* is known to parasitize a wide range of bat families both in the eastern and western hemispheres, particularly Vespertilionidae (Jordan, 1941; Edwards et al., 1978; Brinck-Lindroth & Smit, 2007; Orlova & Orlov, 2015). *Lagaropsylla* usually prefer species from the family Molossidae (free-tailed bats) particularly the genera *Tadarida* and *Cheiromeles* (Marshall, 1977; Beaucournu & Kock, 1994b; Beaucournu et al., 2015). Furthermore, some species of *Lagaropsylla* have a phoretic association with bat earwigs (Arixeniidae). *Lagaropsylla turba* and *L. signata* from Malaysia are phoretic on *Arixenia esau*, both of which are associated with *Cheiromeles torquatus*. The bat earwig *A. esau* feeds on body secretions and skin debris of *C. torquatus*, while adult *L. turba* feeds on blood (Marshall, 1977; Hastriter et al., 2017). *Thaumapsylla* is mainly associated (as true hosts) with the genera *Rousettus*, *Eonycteris*, and *Dobsonia*. In the Philippines, *T. breviceps* and *T. longiforceps* are primarily associated with cave-dwelling fruit bats, particularly *R. amplexicaudatus*, *E. spelaea*, and *E. robusta* (Table 1). Although, there are records from *Megaderma spasma* (False vampire bat) and *Rhinolophus subrufus* (small rufous horseshoe bat) (Beaucournu & Kock, 1994a). This could be due to cross-contamination of samples or accidental transfer event of the fleas to the insectivorous bats.

Table 1. Records of ischnopsyllid fleas reported in the Philippines and its world distribution and associated hosts.

| Fleas | Host species | Distribution (reference) |
|---|---|--|
| <i>Ischnopsyllus indicus</i> | <i>Barbastella darjelingensis</i> (now <i>Barbastella leucomelas</i>) | India (Jordan, 1941); Sri Lanka (Jordan, 1941) |
| | <i>Eptesicus serotinus</i> | China (Smit, 1964) |
| | <i>Nyctalus</i> sp. | China (Smit, 1964) |
| | <i>Nyctalus leisleri</i> | India (Edwards et al., 1978) |
| | <i>Pipistrellus abramus</i> | Guam (Jordan, 1941); Japan (Sakaguti, 1967) |
| | <i>Pipistrellus babu</i> | India (Edwards et al., 1978); Nepal (Mitchell & Punzo, 1976) |
| | <i>Pipistrellus javanicus</i> | Guam (Jordan, 1941; Hopkins, 1961; Reeves et al., 2012); Japan (Hopkins & Rothschild, 1956; Sakaguti & Jameson Jr., 1962); Philippines (Hastriter & Bush, 2013; Zhu et al., 2014) |
| | <i>Pipistrellus mordax</i> | Sri Lanka (Thompson, 1937) |
| | <i>Rhinolophus</i> sp. | China (Jordan, 1941) |
| | <i>Lagaropsylla mera mera</i> | <i>Chaerephon plicatus</i> |
| <i>Pipistrellus tenuis</i> | | Indonesia (Beaucournu & Kock, 1994a) |
| <i>Miniopterus eschscholtzii</i> ^(a) | | Philippines (Beaucournu & Kock, 1994a) |
| <i>Thaumapsylla breviceps</i> | <i>Cynopterus</i> sp. | Thailand (Beaucournu & Kock, 1994a) |
| | <i>Eonycteris robusta</i> | Philippines (Hastriter & Bush, 2013) |
| | <i>E. spelaea</i> | Indonesia (Beaucournu & Kock, 1994a; Fajri et al., 2018); Malaysia (Beaucournu & Kock, 1994a); Myanmar (Beaucournu & Kock, 1994a); Philippines (Hastriter & Bush, 2013); Thailand (Beaucournu & Kock, 1994a) |
| | <i>Rousettus amplexicaudatus</i> | Indonesia (Durden et al., 1990); Myanmar (Beaucournu & Kock, 1994a); Philippines (Beaucournu & Kock, 1994a; Zabat & Eduardo, 2011; Hastriter & Bush, 2013, 2014; Amarga et al., 2017; Alvarez et al., 2018); Thailand (Beaucournu & Kock, 1994a); West Timor (Rookmaaker & Bergmans, 1981) |
| | <i>R. lanosus</i> | South Africa, Congo, Kenya, Senegal (Beaucournu, 2004) |
| | <i>R. aegypticus</i> | Congo (Kwiecinski & Griffiths, 1999); Kenya; Senegal (Beaucournu, 2004); South Africa (Rothschild, 1907; Beaucournu, 2004) |
| | <i>R. leschenaulti</i> | China (Hastriter & Bush, 2010); India (Advani & Vazirani, 1981; Beaucournu & Kock, 1994a); Indonesia (Beaucournu & Kock, 1994a); Thailand (Beaucournu & Kock, 1994a) |
| | <i>Megaderma spasma</i> | Philippines (Beaucournu & Kock, 1994a) |
| | <i>Rhinolophus subrufus</i> | Philippines (Beaucournu & Kock, 1994a) |
| | <i>Chaerephon plicatus</i> | Philippines (Beaucournu & Kock, 1994a) |
| <i>Eidolon helvum</i> | South Africa, Congo, Kenya, Senegal (Beaucournu, 2004) | |

Table 1. (continued)

| | | |
|----------------------------------|---|---|
| | <i>Cynopterus brachyotis angulatus</i> (now <i>C. sphinx</i>) | Cambodia (Klein, 1971) |
| | <i>Macroglossus minimus</i> | Cambodia (Klein, 1971) |
| <i>Thaumapsylla longiforceps</i> | <i>Rousettus amplexicaudatus</i> | Indonesia (Peterson et al., 1990); West Timor (Rookmaaker & Bergmans, 1981); Philippines (Peterson et al., 1990; Hastriter & Bush, 2013, 2014; Alvarez et al., 2016; Amarga et al., 2017) |
| | <i>Eonycteris robusta</i> | Philippines (Hastriter & Bush, 2013) |
| | <i>Eonycteris spelaea</i> | Halmahera Is. (Peterson et al., 1990) |
| | <i>Eonycteris major</i> ^(b) | Philippines (Peterson et al., 1990) |
| | <i>Cynopterus brachyotis</i> | Indonesia (Peterson et al., 1990) |

^(a) Listed as *M. schreibersii* by Beaucournu & Kock (1994a). Philippine populations previously listed as *M. schreibersii* are now recognized as *M. eschscholtzii* (Juste & Ibañez, 2019).

^(b) Peterson et al. (1990) examined a single *T. longiforceps* specimen collected on the host labelled as “*Eonycteris major*” from Philippines. However, it is a dubious record because the list of the Philippine bats, including Ingle & Heaney (1999) and Heaney et al. (2010), did not include *E. major*.

Bats and bat fleas as hosts and reservoirs of pathogens

The Hematophagous (= blood-feeding) habit of ischnopsyllid fleas makes them potential vectors of bat pathogens (Goedbloed et al., 1964). Reeves et al. (2007) detected a *Bartonella* genotype similar to *B. schoenbuchensis* from *Sternopsylla texanus*. *Bartonella schoenbuchensis* causes bacteremia in deer (Dehio et al., 2001) and deer ked dermatitis in humans (De Bruin et al., 2015). Also, *Candidatus Bartonella mayotimonensis* detected in a bat flea sample from Finland (Lin et al., 2010), and this species is reported to cause endocarditis in humans (Chaloner et al., 2012; Edouard et al., 2015). Furthermore, McKee et al. (2017) suspected that bat fleas are one of the vectors of *Bartonella* strains detected on *Chaerephon plicatus*, *Hipposideros armiger*, *H. larvatus*, and *Taphozous melanopogon* from Thailand. Aside from being potential vectors for *Bartonella* spp. (McKee et al., 2019), bat fleas are potential vectors of pathogenic microbes such as *Rickettsia* (Dietrich et al., 2016) and *Coxiella* (Ferreira et al., 2018). Both pathogenic microbe genera are intracellular parasites usually vectored by blood-feeding arthropods (Azad & Beard, 1998; Ferreira et al., 2018). Recently, the pathogen *Coxiella burnettii*, which causes Q fever in humans, was documented in flying foxes (Eldin et al., 2017; Tozer et al., 2014; Dietrich et al., 2017).

Knowledge gaps on Philippine ischnopsyllids

Studies on several aspects of Philippine Ischnopsyllidae are very scarce. Most published studies on bat fleas deal with various geographic locality reports accompanied by a few notes on host association. Although all ischnopsyllid fleas known in the Philippines have a wide geographic extent and are known to occur in many countries, there are no studies concerning their morphological variation between island populations, as well as the population genetics and genetic diversity of these species. As potential vectors of pathogenic microbes, it is crucial to have in-depth studies on the extent of host associations as well as the microbial communities that these fleas harbor. Furthermore, it is also important to conduct detailed studies on the vector ecology of bat fleas, investigate the extrinsic and intrinsic factors responsible for their population dynamics, and thoroughly examine their role in pathogen transmission. With the recent pandemic of bat-associated coronavirus, serious investigations are imperative to include the detection of viral pathogens in bat fleas, especially horseshoe bats of the family Rhinolophidae.

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菲律賓的蝠蚤，附記薄荷島及巴拉巴克島的新分布紀錄（蚤目：角葉蚤總科：蝠蚤科）

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摘要：蝠蚤科是一高度特化的科，目前已發表的物種皆為蝙蝠的外寄生性昆蟲。菲律賓的蝠蚤相目前由 2 亞科 3 屬 4 種組成。本文記述在薄荷島及巴拉巴克島的新分布紀錄，及首次概述菲律賓已知的蝠蚤的自然史和分布。

關鍵詞：蝠蚤科、狐蝠科、新分布紀錄、怪蝠蚤屬、怪蝠蚤亞科