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Chiroptera-associated dipteran ectoparasites (Nycteribiidae, Streblidae) in Minalungao National Park, Nueva Ecija Philippines

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Abstract

Philippine Chiroptera-associated ectoparasites are not well-documented and their distribution and host-association are seldom studied. Identification and characterization of parasites infesting bats could give important aspects on their hosts and provide baseline for their dispersal capacity for transmission of infections. Ectoparasites were collected from bats and were identified using morphological characters. Five ectoparasites representing 2 Dipteran families (Strebliidae and Nycteribiidae) and 5 genera were identified. *Nycteribia sp (Nycteribiidae)* parasitizes bat species *Ptenochirus jagori, Miniopterus australis, Hipposideros pygmaeus. Cyclopodia sp.,* and *Eucampsipoda sp* were collected from *Ptenochirus jagori Brachytarsina* was collected from *Taphozous melanopogon* as well as *Hipposideros pygmaeus. Penicillidia* sp was found in *Rhinolopus arcuatus.* This paper offers the first report of ectoparasites collected from species of Chiroptera inhabiting Minalungao National Park, including morphological characterization and host association.

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Introduction

The Philippine archipelago, given its relatively small land area, is remarkable for the large number of indigenous endemic mammal species and has the greatest concentration of endemic mammals in the world (Heaney, 1993; Mittermeier *et al*., 1997; Heaney *et al*., 1997; Heaney *et al*., 1998; Heaney and Regalado, 1998; Turner *et al*., 2003;Esselstyn *et al*., 2004). Chiroptera is the most diverse order of mammals in the Philippines (Heaney and Regalado, 1998; O'Malley *et al*., 2006) and constitute a large proportion of the mammalian diversity globally (O'Malley *et al*., 2006). Despite this, it is also presumably the least known (Ingle and Heaney, 1992; Turner *et al*., 2003)and not well-represented albeit its high number of endemic species.

Given this circumstance, Philippine Chiroptera-associated ectoparasites is not well-documented as reflected by the scarcity of literatures. Their distribution and host-association are seldom studied and only recently had interest on bats as hosts to numerous parasites had increased (Frank *et al*., 2014). Relative to their ecological importance as major role players in complex ecosystems and food webs (Mickleburgh *et al*., 2002; Turner *et al*., 2003), it is also crucial to identify and characterize parasites infesting bats. Almost all species of mammals, including Chiropterans, have ectoparasites (Ritzi and Whitaker, 2003). The knowledge about Chiropteran ectoparasites could give important information regarding the biological, systematic, and phylogenetic aspects of their hosts (Almeida *et al*., 2011; Fritz, 1983). More importantly, bats are also known to host different ectoparasites such as mites, ticks, fleas and flies (Aroon, *et al*., 2015; Wilkinson *et al*., 2016) that are increasingly recognized as important natural reservoir hosts of emerging zoonotic viruses and bacteria, which can cross species barriers to infect domestic and wild mammals and even humans (Stamper, 2012; Brook *et al,* 2014), which also have the potential capacity to carry human pathogens among bats. Approximately more than 80 virus species of parasites have been recognized and recovered in bats (Mejaun *et al*., 2013) as well as several bacterial and protozoan species (Wilkinson *et al*., 2016). The high population density, high mobility, roosting behaviors coupled with long-distance migratory habits of bats constitute a considerable dispersal capacity for transmission of infections (Mejaun *et al*., 2013).

The initial listings of bats in Minalungao National Park through morphological (Judan Cruz and Pader, 2018) and molecular (Pader *et al*., 2017) identification had been reported. This paper offers the first report of ectoparasites collected from Chiroptera inhabiting the protected Minalungao National Park in the province of Nueva Ecija located in Central Luzon, Philippines. An ecologically and biologically notable area, Minalungao National Park offers an unexplored region where populations of globally threatened or geographically restricted and endemic species are expected to be discovered. It is a significant area for research particularly in studies for systematics, biodiversity conservation and ecology, especially in the identification of plants and animal species that dwell in the area. It is also a key location in determining species relationships and their ecological interactions, such as Chiropterans and their respective ectoparasites.

This paper offers an initial inventory and first report of ectoparasites collected from species of Chiroptera inhabiting Minalungao National Park, Nueva Ecija, Central Luzon, Philippines that provides species listing, morphology and host association.

Materials and methods

Bat Capture and Sample Collection

Three (3) caves within the Minalungao National Park which are roosting sites served as collection areas: Maipit Cave, Minalungao Cave and Makatulang Cave. Collection was done from the months of January to March. Bat host specimens were collected using hand nets and were immediately placed in separate labeled white cloth sacks. Ectoparasites from each Chiropteran species were then removed from its body

using brush and forceps and separately preserved in 95% ethanol. Exact location was determined using the Global Positioning System (GPS). Consequently, abiotic factors such as air temperature and humidity were determined using thermo-anemometer and sling psychrometer respectively.

Ectoparasite identification

The following morphological characters were used in identifying the collected ectoparasites based from Theodor (1963) and Maa (1971): (a) Wing-veins (b) Tarsomeres (c) Head capsule (d) Eyes (e) Thorax (f) Abdomen (g) Tibia (h) Ctenidia (i) Sutures (j) Setae

Results and discussion

The collected Chiroptera from the national park hosted five ectoparasites representing 2 families (Strebliidae and Nycteribiidae) and 5 genera: *Cyclopodia* sp., *Brachytarsina* sp., *Eucampsipoda* sp., *Nycteribia* sp., *Penicillidia* sp. (Table 1).

Table 1. Collected ectoparasites from Chiroptera hosts inhabiting Minalungao National Park, Nueva Ecija, Philippines.

BAT HOST	ECTOPARASITE	FAMILY
Ptenochirus jagori	Cyclopodia sp.	Nycteribiidae
	Eucampsipoda sp	Nycteribiidae
	Nycteribia sp	Nycteribiidae
Taphozous melanopogon	Brachytarsina sp.	Streblidae
Hipposideros pygmaeus	Brachytarsina sp.	Streblidae
	Nycteribia sp	Nycteribiidae
Miniopterus australis	Nycteribia sp	Nycteribiidae
Rhinolopus arcuatus	Penicillidia sp.	Nycteribiidae
Rousettus amplexicaudatus	No ectoparasite collected	——-

Family nycteribiidae

Penicillidia sp.

Hosts: *Miniopterus australis, Hipposideros pygmaeus, Taphozous melanopogon, Rhinolophus arcuatus*

Eyes are present consisting of a single un-pigmented ocellus. Its tibia is scalpel-shaped with 3-4 rows of long setae in the distal half of the ventral edge. Its notopleural sutures are converging posteriorly. Its haltere groove is covered. Spines of thoracic ctenidia are thin and pointed. Abdominal ctenidia are widely spaced ordinary spines that are reduced in number (Theodor, 1963).

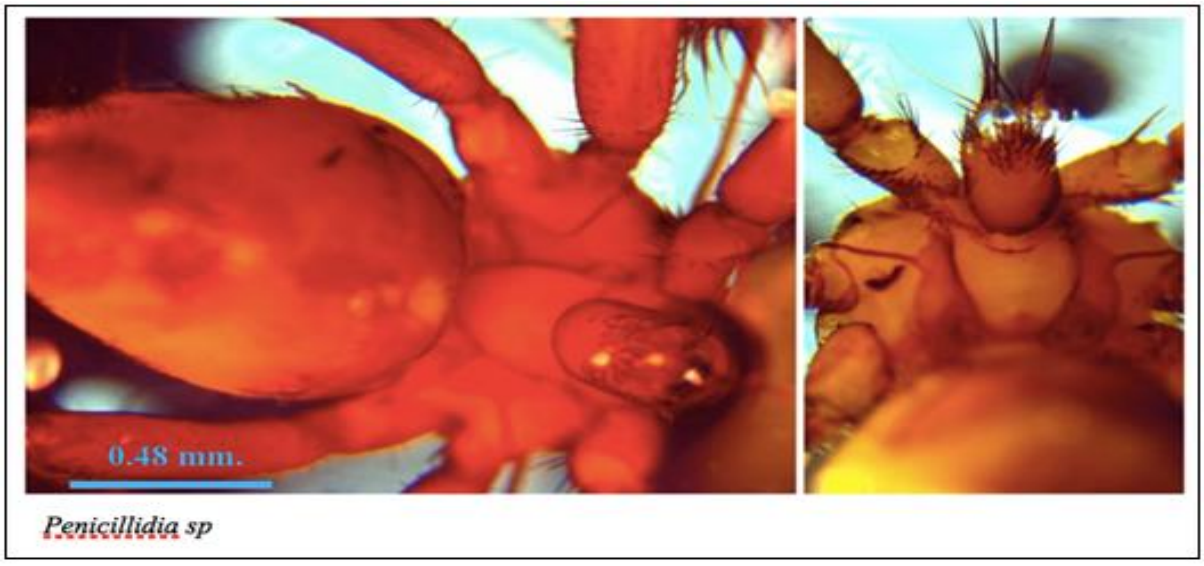

Fig. 1. sp. (Nycteriiidae).

Nycteribia sp.

Hosts: *Miniopterus australis, Hipposideros pygmaeus, Ptenochirus jagori*

Eyes are absent. Thoracic sternal plate is not as above. Lateral margin is not or hardly incurved at vicinities of thoracic ctenidium. Oblique sutures form an acute angle to median suture and never jointly form a continuous transverse suture. Basitarsi is more or less longer than tarsomeres together and is hardly shorter than corresponding tibiae; thoracic and abdominal ctenidia either both present or both absent.

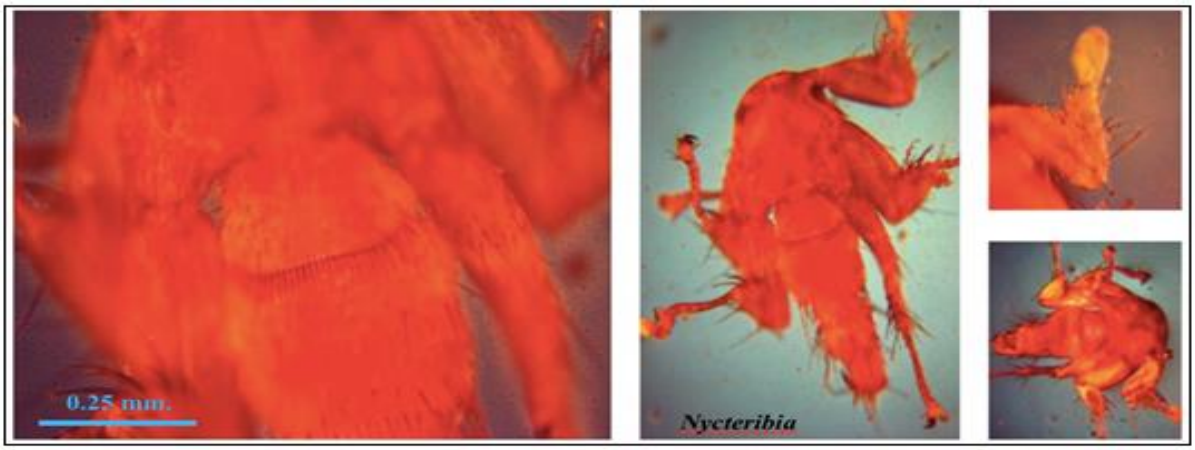

Fig. 2. *Nycteribia* sp (Nycteribiidae).

Head capsule is not as above. Eye either absent or improminent, one may be faceted and without black ring at base. Posterior margin of male synsternite is either without spines, or with loosely arranged uniseriate or closely arranged multiseriate pointed spines. Female abdominal dorsum has at least 1 median plate between tergite 2 and anal segment. Membranous area is not as described above. Head capsule is bilaterally compressed. In lateral view, it is more or less longer than high, dorsum usually with only 4-6 setae. Occasionally it has 12 short sparse fine setae. Eye is absent.

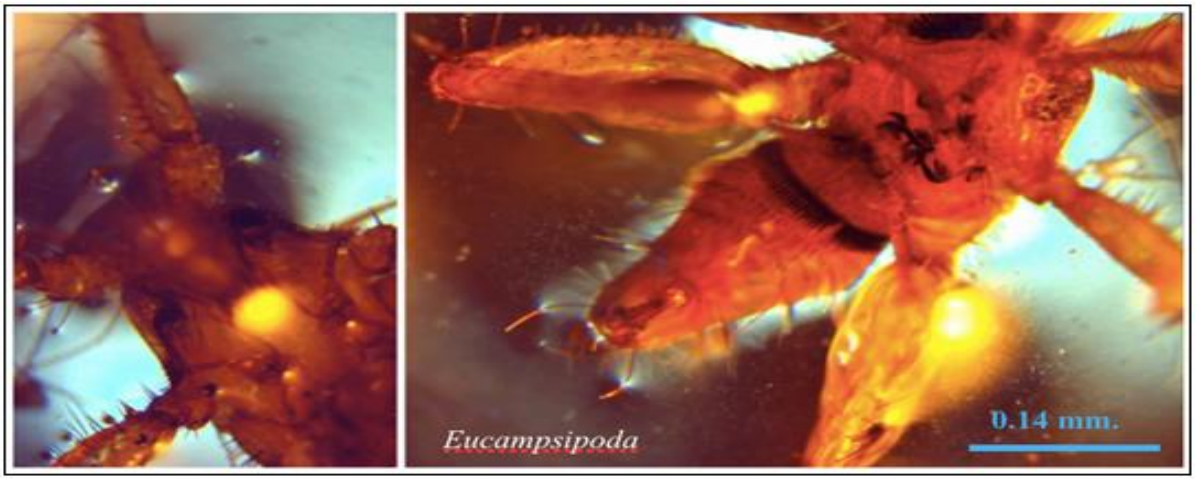

Fig. 3. *Eucampsipoda* sp. (Nycteribiidae).

Thoracic ctenidium is always well developed, about as wide as coxa 2. Abdominal ctenidium is also always well developed and with robust closely arranged teeth. Haltere groove is open. Tibiae is exceedingly short and strongly compressed, in profile somewhat semicircular, 2-3.5 times as long as wide, widest at or very near midlength (Theodor, 1963).

Eucampsipoda sp.

Host: *Ptenochirus jagori*

Eyes are present consisting of a single unpigmented ocellus. Tibiae are cylindrical, with 2 rings in the middle and short setae at their basalmargin. Notopleural sutures are diverging posteriorly. Haltere groove has no cover. Spines of ctenidia are thick and blunt, placed close together (Theodor, 1963).

Cyclopodia sp.

Host: *Ptenochirus jagori*

Head is compressed dorso-ventrally. Eyes have 2 more or less deeply separated pigmented ocelli. Thorax is similar to that of Eucampsipoda, with notopleural sutures diverging posteriorly and 1-3 notopleural setae. Tibiae are cylindrical with 3 rings in the middle and short setae at their basal margin (Theodor, 1963).

Fig. 4. *Cyclopodia* sp. (Nycteribiidae).

Family streblidae

Brachytarsina sp.

Hosts: Hipposideros pygmaeus, Taphozous melanopogon

Wing-veins are all well sclerotized and pigmented, marginal areas of wings with a number of setulae. Tarsomeres 1-4 are together about as long as 5 which are markedly enlarged and triangular in outline. Body is always normal, free-moving, ectoparasitic and with non-caducous wings in both sexes, male thorax, female labial theca and labella are all normal. Sexual dimorphism is inconspicuous except in abdomen (Maa, 1971).

This paper presents an initial faunal survey of bat ectoparasites in Minalungao National Park, in the province of Nueva Ecija, Central Luzon, Philippines representing two dipteran families, Nycteribiidae and Streblidae. These two families are exclusive parasites of bats that are obligate blood feeders (Kim *et al.*, 2012; Wilkinson *et al.*, 2016). Adaptation to ectoparasitism comprise specialized claws and ctenidia adapted for clinging the host's pelage (Dick and Patterson, 2006). Nycteribiids are wingless and depend on their hosts for transport, distribution, and nutrition, while streblids have wings for at least a portion of their adult life (Dick and Patterson, 2006). These bat flies often spend almost their entire life on the host bat with life cycles strongly connected to the host's biology (Fritz, 1983) and show strong coevolutionary ties to their hosts as most bat ectoparasites (Czenze and Broders, 2011).

These batflies are known to host species of bacteria, viruses and protozoans such as Bartonella (Brook *et al.*, 2015; Reeves *et al.*, 2016; Wilkinson *et al.*, 2016), *Rickettsia, Wolbachia* (Wilkinson *et al.*, 2016), *Plasmodium Hepatocystis* (Obame-Nkoghe *et al*,

2017) and to ensure transmission, these pathogens are often endosymbionts that inhabit insect cells and rely on maternal transmission (Wilkinson *et al*., 2016).

No evidence of host specificity was observed since the ectoparasites were found to infest different hosts. Majority of Chiropteran parasites show a high degree of host specificity (Stamper, 2012), while some appear to parasitize multiple hosts (Micherdzinski, 1980; Schmidt, 1987; Stanyukovich, 1997; Kulzer, 1998; Rupp *et al*., 2004) as was observed in this study. Batfly species, for instance, was not found to have more than four species as primary hosts. Batflies, mostly from Family Strebliidae, are host-specific (Camilotti *et al*.,2010; Dick, 2013) and exhibit remarkably high specificity to bat host species (Dick and Gettinger, 2005) that are sometimes associated exclusively with a single primary host species (Dick, 2007). Nycteribiidae show varying levels of specificity. Species of *Penicillidia* and *Nycteribia* had been found between bat species *Miniopterus* (Wilkinson *et al*., 2016; Obame-Nkoghe *et al*, 2017), *Myotis*(Wilkinson *et al*., 2016) and *Rhinolophus* (Obame-Nkoghe *et al*, 2017) while the genus *Eucampsipoda* had been reportedly specific to the bat genus *Rousettus* (Wilkinson *et al*., 2016). *Brachytarsina* infests *Hipposideros* in Africa (Obame-Nkoghe *et al*, 2017).

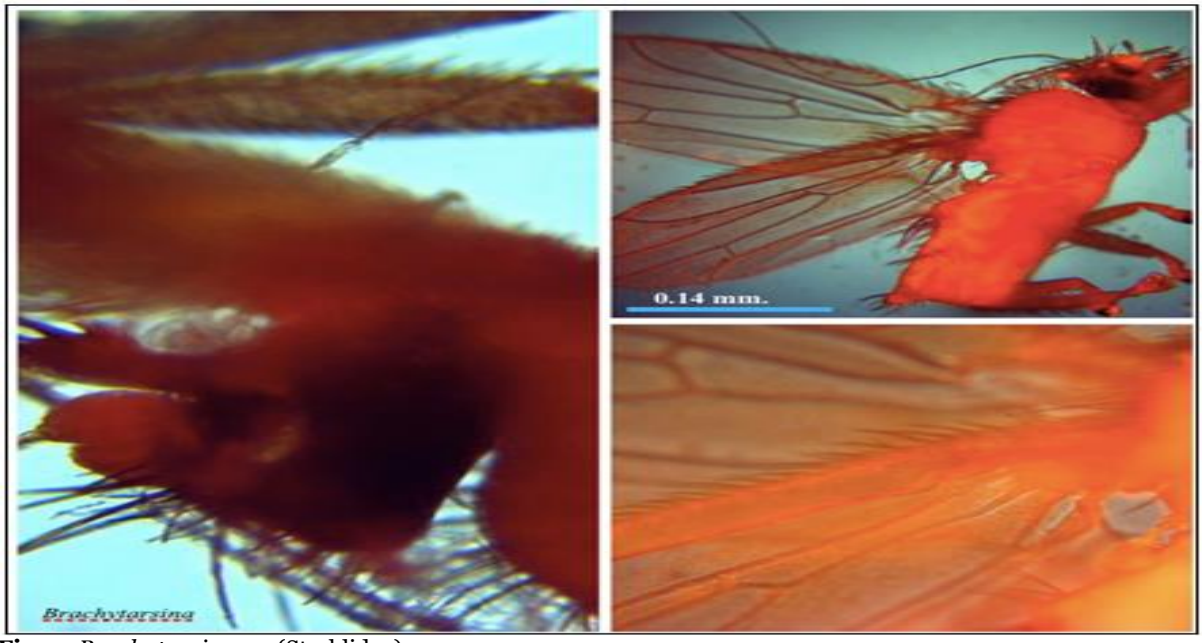

Fig. 5. *Brachytarsina* sp. (Streblidae).

It is assumed, then, that the level of identification in this study is not enough to address the level of host specificity. Nevertheless, if the identity of the ectoparasites were determined up to the species level, there may be a possibility of proving that most ectoparasites of bats are highly specific to certain species of Chiroptera.

The imminent disturbance of the roosting sites brought about by tourism or economic grounds increases human exposure and transmission of pathogens that naturally infect the bats (Obame-Nkoghe *et al,* 2017). The collected ectoparasites are known hosts to a variety of pathogenic bacterial endosymbionts. The capacity of these ectoparasites to transmit reported pathogens constitutes a potential health concern. Although the hosted viruses and bacteria of the ectoparasites collected are unknown, this listing serves as an initial data to further these studies, and to understand their potential part in the transmission of zoonotic pathogens. This also serves as an information baseline for the protection and

conservation of bats. It is then recommended that detection of viruses and bacteria hosted by these collected parasites in Minalungao National Park be studied as this poses threats and risks to bat population as well as a potential health concern.

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