



## First Report of Bat Flies (Diptera: Nycteribiidae) Associated with the Endemic Palawan Flying Fox *Acerodon leucotis* (Chiroptera: Pteropodidae), with an Overview of Bat Flies Ectoparasitic to Philippine Flying Foxes

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### ABSTRACT

The bat flies *Cyclopodia horsfieldi* de Meijere, 1899 and *Leptocyclopodia palawanensis* (Theodor, 1959) are first recorded on the Philippine flying fox *Acerodon leucotis* (Sanborn, 1950), which is endemic to the forests of Balabac, Busuanga and mainland Palawan and currently listed as vulnerable by the IUCN. An overview of bat flies parasitic on flying foxes in the Philippines is provided and the possible role of bat flies as possible vectors of bat-associated parasites and disease agents is discussed.

**Key words:** Cyclopodinae, distribution, ectoparasites, new host records

### Introduction

The Greater Palawan Faunal Region is home to three species of flying foxes (Chiroptera: Pteropodidae): *Acerodon leucotis* (Sanborn, 1950), *Pteropus hypomelanus* Temminck, 1853,

and *Pteropus vampyrus* (Linnaeus, 1758) (Esselstyn *et al.*, 2004; Heaney *et al.*, 1998, 2010). Among these, only *A. leucotis* is endemic to the region and has been reported to occur in mainland Palawan, Balabac, and Busuanga (Heaney *et al.*, 1998; Esselstyn *et al.*, 2004).

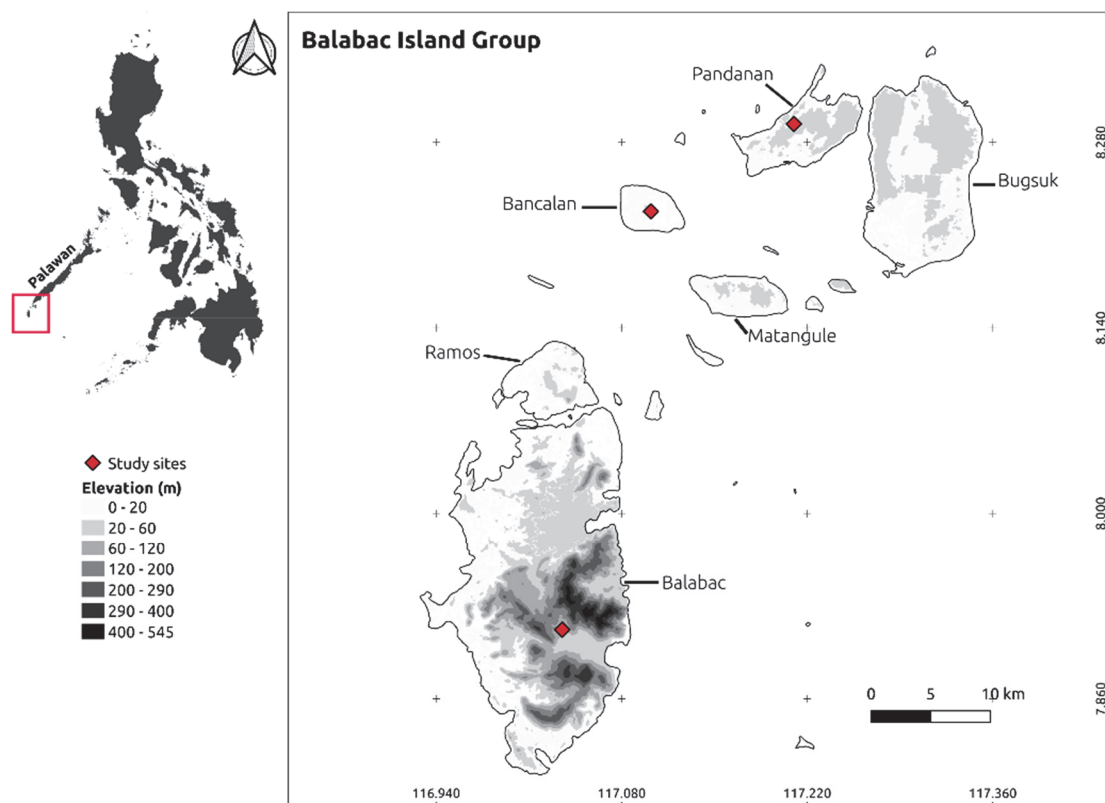


Fig. 1. Map of the Balabac Island Group, Philippines (courtesy of CE Supsup).

Currently, *A. leucotis* is categorized as a vulnerable and threatened species suffering from hunting (bush meat consumption) and habitat loss (Mickleburgh *et al.*, 2009; Mildenstein *et al.*, 2020).

Bat flies (Diptera: Nycteribiidae) are ectoparasitic blood feeders exclusively associated with bats (Chiroptera) and exhibiting varying degrees of host specificity (Marshall, 1981; ter Hofstede *et al.*, 2004). Nycteribiid bat flies on flying foxes are usually associated with *Acerodon* and *Pteropus* and belong to the subfamily Cyclopediinae (Klein, 1970, 1972; Olival *et al.*, 2013). In the Philippines, *P. hypomelanus* (Island flying fox), *P. speciosus* Andersen, 1908 (Philippine gray flying fox), *P. vampyrus* (Large flying fox), and *A. jubatus* (Eschscholtz, 1831) (Giant golden-crown flying fox) reportedly have associations with bat flies of the subfamily Cyclopediinae (Theodor, 1963; Cuy, 1980). Herein, we present the first documentation of bat flies parasitic on *A. leucotis*, in addition to an overview of the bat flies associated with flying foxes in the Philippines.

## Materials and Methods

Mist nets were used to capture bats on Balabac Island (Fig. 1), and bats were released after morphometric data was obtained and ectoparasite samples were collected. Specimens of ectoparasites were preserved in vials containing 95% ethanol prior to identification. Bat flies were identified to species using available taxonomic works (i.e., Ferris, 1925; Theodor, 1963). Bat fly specimens were examined and photographed under a stereomicroscope (Leica S9D), with subsequent focus stacking of images performed using the licensed version of Helicon Focus 7. Valid scientific names follow Giannini *et al.* (2019) for bats and Gracioli and Dick (2018) for bat flies. Diptera classification follows Pape *et al.* (2011). Voucher specimens will be deposited at the National Museum of Natural Science (Taichung, Taiwan).

## Results and Discussion

Order Diptera Linnaeus (true flies)  
Suborder Brachycera Macquart (circular-



Fig. 2. Female (A) and male (B) *Cyclopodia horsfieldi* (ventral). Scale bar = 1.00 mm.



Fig. 3. Female (A) and male (B) *Cyclopodia horsfieldi* (dorsal).

seamed flies)  
Parvorder Calypttratae Robineau-Desvoidy  
(calypttrate flies)  
Superfamily Hippoboscoidea Samouelle  
(hippoboscoid flies)  
Family Nycteribiidae Samouelle (bat flies)  
**Genus *Cyclopodia* Kolenati, 1863**  
*Oxycephalus* Bigot, 1860: 226. Unavailable name,  
published in synonymy.  
*Cyclopodia* Kolenati, 1863: 82. Type species:  
*Nycteribia sykesii* Westwood, 1835. des. Scott,  
1917: 607.

***Cyclopodia horsfieldi* de Meijere, 1899  
(Figures 2-4)**

*Cyclopodia horsfieldi* de Meijere, 1899: 153.

*Cyclopodia magna* Kishida, 1932: 242.

**Material examined: PHILIPPINES: PALAWAN:**  
on *Acerodon leucotis*: 1♀ (NMNS 8722-23), 4♂  
(NMNS 8722-24, NMNS 8722-25, NMNS 8722-  
26, NMNS 8722-27), Balabac Island, X.2019, leg.  
J Cantil.

**Philippine hosts:** *Acerodon jubatus*, *Pteropus*  
*hypomelanus*, *P. pumilus*, *P. speciosus*, *P.*  
*vampyrus*, *Rousettus amplexicaudatus* (Ferris,



Fig. 4. Lateral habitus of *C. horsfieldi* (A); and male terminalia showing the claspers (B).

1925; Theodor, 1963; Cuy, 1980; Amarga and Manalo, 2023). *Acerodon leucotis* (**new host record**).

**Philippine records:** Balabac, Busuanga, Camiguin, Cebu, Culion, Guimaras, Leyte, mainland Luzon (Camarines Sur, Ilocos Norte, Laguna, Quezon), mainland Mindanao, mainland Palawan, Mindoro, Negros, Panay, Samar, Sulu (Jolo), Ursula Is., Tawi-Tawi (Scott, 1917; Ferris, 1925; Theodor, 1963; Cuy, 1980; Amarga and Hastriter, 2023a, b; Amarga and Manalo, 2023).

**Remarks:** *Cyclopodia horsfieldi* was described from materials collected from *Pteropus edulis* Geoffroy, 1810 (now a junior synonym of *Pteropus melanotus* Blyth, 1863) in Java (de Meijere, 1899). It is a widespread species spanning across Southeast Asia (Theodor, 1959, 1967; Olival *et al.*, 2013). It has been reported in the Ryukyu Archipelago (Japan) by Kishida (1932) as *Cyclopodia magna* (now a junior synonym of *C. horsfieldi*); this report, however, is doubtful since no specimens of *C. horsfieldi* have been collected from the *Pteropus* species found in the said archipelago subsequently (Maa, 1967). Furthermore, since the true hosts of *C. horsfieldi* are flying foxes, particularly members of the genera *Acerodon* and *Pteropus* (Theodor, 1959), presence of this bat fly on other bat groups might likely represent at most a facultative occurrence (e.g., account of Farafonova and Kruskop (2001)

on *Megaerops niphanae* from Vietnam).

#### Genus *Leptocyclopodia* Theodor, 1959

*Leptocyclopodia* Theodor, 1959: 284 (as a subgenus of *Cyclopodia*). Type species: *Nycteribia ferrarii* Rondani, 1878, by original designation.

#### *Leptocyclopodia palawanensis* (Theodor, 1959)

*Cyclopodia (Leptocyclopodia) ferrarii palawanensis* Theodor, 1959: 288.

*Leptocyclopodia palawanensis*: Maa, (1965: 378).

*Leptocyclopodia ferrarii palawanensis*: Maa, (1977: 422).

**Material examined: PHILIPPINES: PALAWAN:** on *Acerodon leucotis*: 2♀ (NMNS 8722-28, NMNS 8722-29), 1♂ (NMNS 8722-30), Balabac Island, X.2019, leg. J Cantil.

**Philippine hosts:** *Cynopterus brachyotis* (Müller, 1838) (Theodor, 1959; Maa, 1966). *Acerodon leucotis* (**new host record**).

**Philippine records:** Greater Palawan faunal region (Balabac, Busuanga, Culion, mainland Palawan) (Theodor, 1959, Theodor, 1963; Cuy, 1980).

**Remarks:** This species is endemic to Palawan and adjacent archipelagos (Maa, 1966). Maa (1966) also noted that *L. palawanensis* is only associated with the Lesser short-nosed fruit bat (*Cynopterus brachyotis*). Thus, the presence of this species on other hosts can be considered as



Fig. 5. Female (A) and male (B) *Leptocyclopodia palawanensis* (ventral). Scale bar = 1.00 mm.



Fig. 6. Female (A) and male (B) *Leptocyclopodia palawanensis* (dorsal).

facultative occurrence.

## Discussion

### *Nycteribiid bat flies and the Philippine flying foxes and allies*

Nycteribiid bat flies primarily associated on Philippine flying foxes and their allies belong to the subfamily Cyclopodiinae (Theodor, 1963), a

subfamily strictly associated with Pteropodidae of the Old World (Maa, 1965). Cyclopodiinae is composed of 63 extant species belonging to 4 genera (*Cyclopodia*, *Dipseliopoda* Theodor, 1955, *Eucampsipoda* Kolenati, 1857, and *Leptocyclopodia*) (Graciolli and Dick, 2018). Recent phylogenetic and phylogeographic analyses revealed the monophyly of Cyclopodiinae and inferred that the subfamily

originated in the Oriental Region (Dittmar *et al.*, 2006). This subfamily is represented by three genera in the Philippines: *Cyclopodia*, *Leptocyclopodia*, and *Eucampsipoda* (Theodor, 1963; Cuy, 1980). Of them, members of the two genera are primarily associated with fruit bats (Pteropodidae), especially those belonging to the genera *Cynopterus* Cuvier, 1824, *Ptenochirus* Peters, 1861, and *Pteropus* Brisson, 1762 (Theodor, 1963; Cuy, 1980; Amarga and Fornesa, 2020), whereas species of *Eucampsipoda* are usually parasitic on the cave-associated genera such as *Rousettus* Geoffroy, 1810 and *Eonycteris* Dobson, 1873 (Theodor, 1963; Amarga *et al.*, 2017; Amarga and Phelps, 2021).

The first published account of nycteribiid bat flies in the Philippines was the record of *Cyclopodia horsfieldi* by Scott (1917) from a bat labeled as “*Pteropus philippinensis*” and collected in La Carlota, Negros Island; as “*Pteropus philippinensis*” it lacks a nomenclaturally available description and it is apparently an error of host listing (L. Heaney *pers. comm.*, 14 June 2023), the identity of this host remains unknown. Subsequently, Ferris (1925) documented *C. horsfieldi* from specimens retrieved on *Pteropus* flying foxes collected in Luzon, Palawan, and Mindanao. Among the bat flies associated with flying foxes in the Philippines, *C. horsfieldi* has the widest geographic distribution as well as reported host associations. This species is known from the Oriental Region and has been previously reported from Cambodia, Indonesia, Malaysia, Singapore, the Philippines, Thailand, Timor Leste, and Vietnam (de Meijere, 1899; Speiser, 1903; Maa, 1962; Bergmans and Rozendaal, 1988; Morse *et al.*, 2012; Olival *et al.*, 2013; Hou *et al.*, 2018). Outside the Philippine archipelago, *C. horsfieldi* has been reported to occur on *Pteropus alecto* (Black flying fox), *P. lylei* (Lyle’s flying fox), *P. hypomelanus* (Small flying fox), *P. melanotus* (Black-eared flying fox), and *P. vampyrus* (Large flying fox) (de Meijere, 1899; Speiser, 1903; Theodor, 1959; Maa, 1962; Jones and Kunz, 2000; Olival *et al.*, 2013). Aside from *C. horsfieldi*, the other *Cyclopodia* species occurring in the Philippines is *C. garrula* Maa, a member of *C. pembertonii* species group and ectoparasitic on Harpy fruit bat (*Harpyionycteris whiteheadi* Thomas, 1896) (Maa, 1968).

The genus *Leptocyclopodia* is represented by six species in the Philippines, all of which are endemic (Cuy, 1980). Among these, *L. pilosiptectus* Maa, 1966 and *L. palawanensis* have been reported on flying foxes. The former is primarily parasitic to *H. whiteheadi* (Maa, 1966, 1968) and has been reported on *Pteropus pumilus* Miller, 1911 (Little golden-mantled flying fox) (Maa, 1966) whereas, in this study, *L. palawanensis* have been recorded on adult *A. leucotis* from Balabac Island. *Leptocyclopodia palawanensis* is primarily associated with *C. brachyotis* (Theodor, 1959; Maa, 1966) and known to be confined to Greater Palawan faunal region (Maa, 1966).

#### ***Nycteribiid bat flies as possible vectors of bat-associated microbes***

Flying foxes have been reported to harbor a wide variety of microparasites (Mackenzie *et al.*, 2003; Olival *et al.*, 2007; Barbosa *et al.*, 2016) including various protozoan groups (Sangster *et al.*, 2012; Mackie *et al.*, 2017; Ranivoson *et al.*, 2019), bacteria (Cox *et al.*, 2005; Brook *et al.*, 2015; Hou *et al.*, 2018), and viruses (Field *et al.*, 2001; Wacharapluesadee *et al.*, 2018). Some of these microparasites are zoonotic and potentially pathogenic to humans (Jia *et al.*, 2003; Basri *et al.*, 2017; Henry *et al.*, 2018; Peel *et al.*, 2019).

Due to their haematophagous nature, bat flies have the potential to be vectors of microbes (Szentiványi *et al.*, 2019). Among the groups that have been detected in bats in the Old and New World are members of the genus *Bartonella* (Hyphomicrobiales: Bartonellaceae) (Kosoy *et al.*, 2010; Stuckey *et al.*, 2017; Becker *et al.*, 2018; McKee *et al.*, 2021). These microbes are predominantly arthropod-borne facultative intracellular proteobacteria (Chang *et al.*, 2001; Regier *et al.*, 2016) primarily infecting mammals (Ellis *et al.*, 1999; Houpikian and Raoult, 2001) and were also documented in birds (Mascarelli *et al.*, 2014; Williams and Dittmar, 2020) and reptiles (Tijssse-Klasen *et al.*, 2010; Regier *et al.*, 2016). The presence of *Bartonella* species in bat flies was first reported by Reeves *et al.* (2005) based on a bat fly retrieved from the Southeastern myotis (*Myotis austroriparius* (Rhoads, 1897)) in Florida Caverns State Park. Subsequently, *Bartonella* species were reported on the nycteribiid bat fly *Cyclopodia greefi greefi*

Karsch, 1844 parasitizing the Straw-coloured fruit bat (*Eidolon helvum* Kerr, 1792) from Ghana (Billeter *et al.*, 2012). Also, *Bartonella* was detected from *C. greefi greefi* collected from bats in Nigeria (Kamani *et al.*, 2014) and *Cyclopodia dubia* (Westwood, 1835) collected from Madagascan fruit bat (*Eidolon dupreanum* Schlegel and Pollen, 1866) in Madagascar (Brook *et al.*, 2015). *Bartonella* genotypes were reported on *C. horsfieldi* collected from *Pteropus hypomelanus* in Malaysia (Morse *et al.*, 2012; Hou *et al.*, 2018).

Despite the increasing number of discoveries of novel *Bartonella* strains associated with bats and their bat flies in recent years, very little has been known about the eco-evolutionary aspects. Some *Bartonella* genotypes tend to exhibit a phylogenetic congruency to its affiliated bat hosts, thus, suggesting a coevolutionary system (see Morse *et al.*, 2012). It is interesting to test the extent of specificity of the bat fly-*Bartonella* coevolutionary system and its role on the diversification of *Bartonella* genotypes. Vertical transmission of *Bartonella* has been reported on several in several ectoparasites (e.g., Morick *et al.*, 2013; de Bruin *et al.*, 2015; Kress *et al.*, 2022; Chaisiri *et al.*, 2023), thus it is also interesting to investigate this phenomenon on bat flies and check the possibility of transovarial transmission of *Bartonella*. Also, the degree of pathogenicity of bat-associated *Bartonella* strains is poorly understood as well as how it influences certain physiological activities of its bat hosts. Additional investigations are needed to elucidate the mechanism behind the complexity of bat–bat fly–microbe interactions.

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# 首次報導菲律賓帕拉灣果蝠 *Acerodon leucotis* (翼手目：翼足科) 體外寄生的蝠蠅 (雙翅目：蛛蠅科) 概述

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## 摘 要

帕拉灣果蝠 (*Acerodon leucotis* Sanborn, 1950) (翼手目：翼足科) 為菲律賓特有種，由於地理分布侷限於帕拉灣 (Palawan) 及鄰近的巴拉拉克島 (Balabac) 和巴隆島 (Busuanga) 的森林，國際自然保護聯盟瀕危物種紅色名錄目前將其國際保育地位列為易危 (Vulnerable, VU) 類別。本研究除報導在帕拉灣果蝠的兩個蝠蠅的新紀錄種外-*Cyclopodia horsfieldi* de Meijere, 1899 和 *Leptocyclopodia palawanensis* (Theodor, 1959) (雙翅目：蛛蠅科) 外，亦重新整理菲律賓地區狐蝠科的外寄生蟲紀錄，並探討寄生型蠅類作為蝙蝠相關疾病媒介的可能性。

**關鍵詞：**Cyclopodiinae、分佈、體外寄生蟲、新寄主記錄