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Short note

A report of ectoparasites on cave nectar bat (*Eonycteris spelaea*) among cave-dwelling in Lombok Island, West Nusa Tenggara, Indonesia

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ABSTRACT. Studies were conducted from March to August 2021 in 4 caves located in Lombok Island (Gunung Tunak cave, Gale-Gale cave, Buwun cave, and Tanjung Ringgit cave). *Eonycteris spelaea* was infested with 7 species of ectoparasites consisting of 4 species from the class Insecta (Diptera: *Eucampsipoda sundaica* and *Cyclopodia horsfieldii*, and Siphonaptera: *Ischnopsyllus hexactenus* and *Thaumapsylla breviceps*), and 3 species from the class Arachnida (*Amblyomma* sp., *Ancystropus* sp, and *Meristaspis* sp.).

Keywords: *Eonycteris spelaea*, ectoparasites, cave, Lombok Island, Indonesia

Introduction

Family Pteropodidae (Chiroptera) consists of 42 genera and 182 species worldwide [1]. In Indonesia, this family has 21 genera and 72 species [2]. Members of this family are known as seed dispersers, flower pollinators, and guano producers.

Eonycteris spelaea is one of the bats that plays a role in pollinating flowers commonly found in caves. This is why the species is often called cave fruit bat or cave nectar bat. The distribution of *Eonycteris spelaea* is very wide ranging from Malay-Indonesia, the southern Chinese islands, and the Indian continent [1]. In addition, it is widely distributed from southwest and north of India, Southern China, Andaman, Myanmar, Malaya, Philippines, Sumatra, Java, Kalimantan, Sulawesi, Bali, Lombok, Sumba, Timor and Halmahera [3–6].

The habitat of this species can be found in agricultural area, primary forest, secondary forest, and coastal mangrove [7,8]. This species forages at a distance of more than 38 km from their nesting sites at night [9], while on a trip, *Eonycteris spelaea* has been reported to cover a distance of up to 17.9 km to 38 km between the roost and foraging areas in Thailand and Malaysia [9] and Khteas Cave in southern Cambodia [10].

In general, bats play an important role in ecosystems, including seed dispersal, pollination, and insect predation. Meanwhile, *Eonycteris spelaea* bat plays a special role as plant pollinator. Various types of plants have been reported to have pollination assisted by the bat species. These plants include durian (*Durio zibethinus*), a leguminous canopy tree *Parkia* spp., and petai (*P. speciosa*) and the Indian trumpet flower (*Oroxylum indicum*) in managed agricultural habitats in southern Thailand [11,12]. Thavry et al. [10] mentioned that, *Eonycteris spelaea* is an economically important pollinator for plants in Cambodia. The colony of *Eonycteris spelaea* was found perched in the Kampot cave and is endangered. *Eonycteris spelaea* is able to provide protection to mangrove plants and is also able to provide benefits to durian farmers and banana farmers.

The threats to bats population of *Eonycteris spelaea* are habitat loss, hunting [13], hunting for humans consumption [14] wildlife trade and death

Table 1. Morphological measurements (mean and range) of adult and subadult *Eonycteris spelaea* captured in Lombok Island caves in this study (n=42) compared to other studies [23,24]

Characteristics	Tanjung Ringgit cave	Gale-Gale cave	Buwun cave	Gunung Tunak cave	[23]	[24]
N	12	9	11	10	–	–
WT	67	78	65	66.9	–	66.6
HB	105	91.7	97.8	109.9	–	110.5
T	19.9	18.4	25.1	20.4	–	16
E	20.5	20.5	20.6	19.8	16–22	17.9
TB	32.4	16.1	16.7	32.7	25–37	34
FA	65.9	78.8	74.9	67.5	60–81	72.4
HF	19.8	35.9	33.9	20.3	17–21	–

Explanations: N=number of examined, WT=weight (g), HB=head body (mm), T=tail (mm), E=ear (mm), TB=tibia (mm), FA=forearm (mm), HF=hind foot (mm)

due to the presence of ectoparasites and bacteria in their bodies. Fruit bats are more likely to have ectoparasites than insectivorous bats [14]. The presence of ectoparasites can affect bats physical condition and will have an impact on long-term survival. Several studies have shown that ectoparasites tend to decrease the fecundity of bats. Ticks, mites, chiggers, bugs, fleas, and flies are some of the types of ectoparasites found in bats [15,16]. Some ectoparasites are associated with pathogens that can cause disease in humans or animals, both wild and domestic. According to [17,18] there were 14 types of ectoparasites found in 9 species of bats that perched in caves on Lombok Island, Indonesia. The ectoparasites consist of Diptera, Siphonaptera, Ixodida, and Mesostigmata groups. The bat fly, *Cyclopodia horsfieldii*, one of the ectoparasites, dominated the ectoparasites found from 9 species of bats examined. In Batuputih Nature Tourism Park, Sulawesi-Indonesia, A total of 479 ectoparasites representing three families, namely Nycteribiidae, Streblidae (bat flies), and Spinturnicidae (mites) were collected. Majority of these ectoparasites (n=475) belonged to the family Nycteribiidae genus *Leptocyclopodia* [14]. Sauqi et al. [19] mentioned that fruit bats (*Cynopterus brachyotis*) were infested with *Leptocyclopodia ferrarii* (8%). In Goa Jepang Bukit Plawangan, Sleman Yogyakarta Indonesia, bats from the suborder Microchiroptera, were infested with ectoparasites belonged to the subclass Acarina and the Insecta class.

The species of subclass Acarina found were *Periglischrus* sp., *Spinturnix plecotinus*, *Blattisocius* sp., and *Glycyphagus* sp. Species of the Insecta class found include *Megastrebla* sp., *Stylidia caudata*, *Basilia* sp., and *Brachytarsina* sp. [20].

Thus, this study aims to analyze the morphology of bat species of *Eonycteris spelaea* in 4 caves in Lombok Island and to identify the ectoparasites present in *E. spelaea*. *Eonycteris spelaea* it is important to study ectoparasites in bats to determine their potential role as vectors of zoonotic pathogens [21]. New report from Singapore, [22] mentioned that there are 261 species of *Eucampsipoda sundaica* found in *Eonycteris spelaea*. This research is also very important because the distribution of *Eonycteris spelaea* in the caves of Lombok Island is quite high.

Materials and Methods

Study area

The study was conducted in Lombok Island in the four location, which included Central Lombok Regency: Bangkang Gale-Gale cave (08°53.188'S and 116°15.254'E, elevation 111 m), Buwun cave (08°53.375'S and 116°15.160'E, elevation 92 m), Gunung Tunak cave (08°56.60'S and 116°23.45'E, elevation 116 m), and East Lombok Regency: Raksasa cave (08°42.76'S and 116°39.56'E, elevation 92 m).

Table 2. Ectoparasites of *Eonycteris spelaea* captured in Lombok Island caves

Ectoparasites	Number of parasites (individual)			
	Tanjung Ringgit cave	Gale-Gale cave	Buwun cave	Gunung Tunak cave
Insecta				
Diptera, Nyteribiidae				
Eucampsipoda sundaica	1	1	–	2
Cyclopodia horsfieldii	2	3	2	3
Siphonaptera,				
Ischnopsyllidae				
Thaumapsylla breviceps	–	2	–	1
Ischnopsyllus hexactenus	3	2	2	4
Arachnida				
Ixodida, Ixodidae				
Amblyomma sp.	12	9	17	19
Mesostigmata,				
Spinturnicidae				
Ancystropus sp.	5	5	3	9
Meristaspis sp.	5	4	3	7

Bats sampling

Bat specimens (n=42) were collected using the trapping trap method with a mist net installed at the mouth of the four cave. The sampling was carried out when the bats came out of the cave at 18.30–19.00 WITA (Central Indonesian Time). Captured bats were removed from the net with a gloved hand and transferred into a cotton cloth bag for transport to the nearby processing station for morphometric measurements and identification using morphological criteria by [23,24].

Ectoparasites collecting techniques

Eonycteris spelaea specimens successfully collected were then examined, and samples of ectoparasites were collected manually from the bat's body was carried out sequentially starting from the head, ears, neck, wing bases, base of the feet, and toes using tweezers. In addition, the bats were carefully combed to collect additional samples of ectoparasites remaining in their fur. The ectoparasites collected were then placed in collecting tubes containing 95% alcohol. Before release, bats were marked on the head with a permanent marker to avoid resampling. All collected ectoparasites were subsequently sorted, identified, counted, mounted on microscope slide, and deposited for further study in the Laboratory Biology Center, National Research and Innovation Agency. Specimens were taxonomically identified using the taxonomic keys by [25,26].

Results and Discussion

Eonycteris spelaea

Eonycteris spelaea species were found in all caves chosen as research sites. Based on the result of morphological measurements (Tab. 1), it is known that each individual bat found in each habitat has a unique characteristic regarding its size. The result of morphology analysis of 42 specimens captured shows that there are 2 groups that have similar measurement results. The first group consists of bats found in Gale-Gale cave and Buwun cave, whereas the second group consists of bats found in Tanjung Ringgit cave and Gunung Tunak cave.

The bats found in Gale-Gale cave and Buwun cave have similar sizes of forearm which are 78.8 mm and 74.9 mm, respectively. Moreover, the sizes

of their tibias are also similar, with the value of 16.1 mm and 16.7 mm. Meanwhile, the bats in Tanjung Ringgit cave and Gunung Tunak cave also show similar morphological sizes of the forearm (FA) which are 65.9 mm and 67.5 mm, and similar calf sizes (TB) with a length of 32.4 and 32.7 mm, respectively. Long and strong arms are very beneficial to support flying ability of this species. Long hind legs really help them to grip when nesting [27].

In general, ectoparasites will live on the surface of the skin of bats to meet their needs. ectoparasites will use the fur on the surface of the bat's body for shelter. The presence of ectoparasites in the bat's body is closely related to the condition of the bat's body. Some references mentioning that bats with a better body condition or nutritional status will be able to increase the abundance of ectoparasites in bat bodies [28,29]. Tai et al. [30] mentioned that the abundance of the bat lies *N. allotopa* and *A. speiserianum* on the bat *M. fuliginous* tended slightly towards bats of moderate or higher body condition, particularly reproductive females and adult males in the wet season.

Biological differences between age and sex in host species also appear to contribute to the prevalence of ectoparasites in bat bodies [22], and adults with higher BBCI may have relatively more surface area to support increased numbers of ectoparasites [31].

In this study, ectoparasites were mostly found on the bats body (60%), while 40% were found on wings. Also, species with dense fur had larger number of ectoparasites compared to others with thin fur. The abundance, intensity, and prevalence of ectoparasites in bats are influenced by a range of variables including, morphology, habitat [32], gender, nesting, grooming [33], social behavior [34,35], diet [36] and body size [37].

Ectoparasites of Eonycteris spelaea

According to the result of the identification of ectoparasites collected from 42 specimens of *Eonycteris spelaea* in 4 caves in Lombok Island (Tab. 2), it is found that there are 7 types of ectoparasites consisting of 4 species from the class Insecta (2 species from the order Diptera, namely *Eucampsipoda sundaica* and *Cyclopodia horsfieldii* and 2 species from the order Siphonaptera namely *Ischnopsyllus hexactenus* and *Thaumapsylla breviceps*), and 3 species from the class Arachnida (*Amblyomma* sp., *Ancystropus* sp., and *Meristaspis* sp.).

Eucampsipoda sundaica. Body size is 5 mm, has a brown dorsal body, a flat body shape dorsoventrally, no wings, abdomen and legs covered with setae hair, claws on the tips of the feet, a head that can be folded towards the thorax, and femur and tibia nearly equal in length. The eye has a single elliptical lens. Small head, pentagon-shaped chest. Clasper short and tapered and hair on the lateral. The femur has a white ring and the tibia has two white rings [26]. *Eucampsipoda sundaica* was found in bat species *E. spelaea* and *R. amplexicaudatus* [38,39]. In addition, *E. sundaica* has also been found infecting *Rousettus leschenaultia* and *Cherephon aplicata* [40,41]. *Eucampsipoda sundaica* has been reported infecting *Eonycteris spelaea* bats found in two places on the Lombok Island, namely in Tanjung Ringgit cave and Gale-Gale cave. *Eucampsipoda sundaica* has also been found in *E. spelaea* bats in Gunung Reng, Jeli, Kelantan, Tioman Island Wildlife Reserve, Pahang, Wang Kelian State Park, Perlis [41], Yunnan Province of China at the Sino-Burmese border [40].

Cyclopodia horsfieldii. Body size is 6 mm. *C. horsfieldii* has a non-angled sterna plate with a curved tip. On the ventral side, white sutures diagonally across the abdomen are clearly visible. Thorn-like structures called ctenidia are clearly visible on thorax and abdomen. The head folds ventrally and can rotate 180°. White segmentation on the abdomen is clearly visible, and abdomen is also covered with setae [42]. *Cyclopodia horsfieldii* is commonly found in bat from genus *Cynopterus*. However, its presence has also been reported in *Pteropus*, *Acerodon* and *Rousettus* Gray bats, new host records including *Cynopterus brachyotis* and *Ptenochirus jagori* [43]. In addition, research conducted by Fajri et al. [44] stated that *Cyclopodia horsfieldii* was found in bat species *Eonycteris spelaea*, *Rosettus amplexicaudatus* and *Miniopterus pusillus*. *Cyclopodia horsfieldii* has been found in four locations on the Lombok Island, namely the Gale-Gale cave, Tanjung Ringgit cave, Buwun cave and Gunung Tunak cave. Also, in Philippines including Luzon, Mindoro, Busuanga, Culion, Palawan, Balabac, Leyte, Iloilo, Panay, Guima-ras, Camiguin, Mindanao, Negros and Jolo [39,45,46]. In addition, this species has also been found around the mountains in Indonesia, Cambodia, Malaysia, Thailand and Timor Leste [39].

Thaumapsylla breviceps. Body size is 6 mm. *T. breviceps* is a flea from the order Siphonaptera belonging to Ischnopsyllidae family. Ischno-

psyllidae family is a family with the highest number of species infecting bats [47]. *T. breviceps* is classified into subfamily Thaumapsyllinae, the newest subfamily known as fleas that infect bats. *T. breviceps* has shorter head compared to all identified fleas and has a very short pronotum (separated from the ctenidium) [48]. According to several studies of ectoparasites, it is known that *T. breviceps* has a narrow ectoparasite-host relationship. *T. breviceps* is only found in fruit-eater bats such as *Rousettus amplexicaudatus* [46] and *Eonycteris spelaea* [44]. Three *Thaumapsylla breviceps* were found in this study. This ectoparasite is found on the body of *E. spelaea* in the Gale-Gale cave and Gunung Tunak cave. Populations of *Thaumapsylla breviceps* have been found in southern Africa [49], southern China [50]. In addition, its distribution is also widely found in Indonesia [44], Ethiopian region and Philippines-Mindoro [46,49].

Ischnopsyllus hexactenus. Although bat lice belong to different families, they are generally similar to fleas that infect cats, dogs and other mammals. They are often seen as small oval shapes, move quickly through bat fur and are difficult to catch without a quick reaction. Like all fleas, only adults that become the hosts: egg and larval stages are found in the detritus on which bats roost. This study, *Ischnopsyllus hexactenus* have body size 5 mm. *Ischnopsyllus hexactenus* is one of the lice specifically found in bats, and is not found in other mammal species. Bats that have served as hosts for *I. hexactenus* are *Myotis frater*, *Murina hilgendorfi*, *Pipistrellus pipistrellus* and *R. microphyllum* [44]. *I. hexactenus* is an ectoparasite that can be a vector of several zoonotic pathogens such as trypanosomes. The abundance of *I. hexactenus* in bats is quite high, and *I. hexactenus* is even being able to make bats as the sole host. *Ischnopsyllus hexactenus* has been found in four locations on the Lombok Island: the Gale-gale cave, Tanjung Ringgit cave, Buwun cave and Gunung Tunak cave. The distribution of *I. hexactenus* infesting bats has been reported in Indonesia, Malaysia, Latvia, and Mongolia [52,53].

***Amblyomma* sp.** *Amblyomma* sp. belongs to the Ixodidae family. The Ixodidae family is also known as the hard tick because it has a clear capitulum characteristic. There is also scutum (chitinous dorsal board). According to the result of *Amblyomma* sp. observation, this ectoparasite has a black body and is still in the larval stage as proven by its only 3 pairs of legs. *Amblyomma* sp. has some special characteristics including mouth apparatus (palpus and chelicera) much longer than the base of the capituli, the palps longer than the chelicerae and the length of the palps twice the width [54]. *Amblyomma* sp. is a vector of *Francisella tularensis*, the agent of tularemia and *Ehrlichia chaffeensis* causing monocytic ehrlichiosis in humans. This tick also transmits *Rickettsia amblyommii*, *Borrelia lonestari*, and Heartland viruses that cause disease in humans [55]. The order Mesostigmata has the largest number of parasitic species whose members are mostly blood suckers at the adult stage [54]. This study, *Amblyomma* sp have body size 2 mm. *Amblyomma* sp. is found in several bat species including *Rousettus aegyptiacus* [46], *Eonycteris spelaea*, *Chaerephon plicata*, and *Taphozous melanopagon* [44]. Fifty-seven *Amblyomma* sp. has been found in four locations on the Lombok island: the Gale-gale cave, Tanjung Ringgit cave, Buwun cave and Gunung Tunak cave. Distribution of this species broad enough, among others in Caribbean and Africa [55], Brazil [56], Southwest Georgia and Northwest Florida, USA [57].

***Ancystropus* sp.** *Ancystropus* sp. is a mite from the family Spinturnicidae which has very enlarged legs I and claws I. It usually has 2–3 pairs of setae surrounding the anterior border of the dorsal shield, slender distal setae on tarsus I, three pairs of setae surrounding the anterior border of the dorsal shield, epigynial shield located at the level of coxa IV, no lateral hooks on tarsus I and coxa I [25]. *Ancystropus* sp. have body size 1.5 mm. The existence of *Ancystropus* sp. has been reported infesting several bats including *Rousettus leschenaulti* (Pteropodidae), *Rhinolophus rouxi* and *Hipposideros sporis* (Rhinolophidae). In addition, it has also been found in the species of *Eonycteris spelaea*. Most of *Ancystropus* sp. is found on the wing membranes of bats. In this study, twenty-two *Ancystropus* sp. were found in the four observation sites on Lombok Island. The distribution of *Ancystropus* sp. infesting several bats has been found in some caves in Sri Lanka, Indonesia, Philippines, and Thailand.

***Meristaspis* sp.** *Meristaspis* sp. has body size 2 mm and is characterized by 4 pairs of setae surrounding the anterior border of the dorsal shield. Tarsus I has a pair of large distal setae, flat distal setae, no enlarged claws I; large tritosternum usually dilated, epiginal shield at coxa III-IV, anal shield which has no postanal seta, enlarged leg I, but no enlarged claw [25]. Hosts are bats belonging to

Megachiroptera including *Eonycteris spelaea*, *Macroglossus minimum*, *Rosettus amplxicaudatus* [44], and *Rousettus aegyptiacus* [58]. Nineteen *Meristaspis* sp. has been found in four locations on the Lombok island: the Gale-gale cave, Tanjung Ringgit cave, Buwun cave and Gunung Tunak cave.

In conclusion, the result of this study shows that the *Eonycteris spelaea* species are distributed in all caves in Lombok Island. Based on the result of morphological measurements, there are differences in morphology of *E. spelaea* species found in each location. *E. spelaea* are infested wiith seven ectoparasite species consisting of 4 species from the class Insecta which are 2 species from the order Diptera (*Eucampsipoda sundaica* and *Cyclopodia horsfieldii*) and 2 species from the order Siphonaptera (*Ischnopsyllus hexactenus* and Thaumapsylla); and 3 species from the class Arachnida (*Amblyomma* sp., *Ancystropus* sp., and *Meristaspis* sp.). It is also addressed that there are several ectoparasites that are quite dangerous for humans and other animals found infecting *E. spelaea* These ectoparasites can cause several types of diseases. Thus, it is necessary to carry out special care and to give attention to this species of bat.

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