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Identification of Blood-sucking Flies of Bats in Lombok Island, Indonesia

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ABSTRACT

Bats and blood-sucking bat flies have an important role in transmitting several hemoparasites. Bat flies have been identified as vectors transmitting hemoparasites from wild bats. The purpose of the present study was to identify bats and their blood-sucking flies as vectors of hemoparasites in bat caves located at Lombok Island, Indonesia. In the course of the study, a survey was conducted on three bat caves from September to December 2018. The bats were captured by a net trap and the species of bats and bat flies were identified. A total of 66 captured bats were identified as *Hipposideros* species (n = 28), *Eonycteris spelaea* (n = 23), and *Taphozouss* species (n = 15). The blood-sucking flies were identified as *Eucampsipoda sundaica* on *Eonycteris spelaea*, and *Stylidia* cf. *euxesta*, *Brachytarsina* species, *Raymondia* species, and *Megastrebla nigriceps* on *Hipposideros* species. The results showed that five species of blood-sucking flies were present in captured bats. The bat and blood-sucking flies can influence the transmission of *Polychromophilus* species, *Babesia* species, *Plasmodium* species, and *Trypanosoma* species to humans and other hosts.

Keywords: Bats, Blood-sucking flies, Hemoparasites, Lombok, Vector

INTRODUCTION

Bats (Chiroptera) are unique mammals residing in large groups in caves. Bats and bat flies have an important role in transmitting several hemoparasites, including those which infect bats, such as *Babesia* species, *Plasmodium* species, and *Trypanosoma* species. Bat flies had been reported as vectors of hemoparasites, specially *Polychromophilus* species parasite (Obame-Nkoghe et al., 2016). Bats are the only mammals with the ability to fly and they are categorized into more than 1,100 different species (Calisher et al., 2006). Bats also have a high percentage of Lymphocytes and Monocytes as effectors of adaptive and innate immunity (Sa'diyah and Situmorang, 2020). Lombok Island has many caves where massive colonies of bats which are known hosts of blood-sucking ectoparasites live, however, little is known about bats and their blood-sucking flies can be potential vector transmission of hemoparasites in the island.

Species of bats, such as *Hipposederos bicolor*, *Eonycteris speleae*, and *Taphozous achates* have been recently identified from bat caves in Lombok Island (Agustin et al., 2019). Han et al. (2018) reported that 13.3% of 107 insectivorous bats were infected by *Babesia vesperuginis.* Several years before that, Schaer et al. (2013) documented that *Plasmodium* species. has infected insectivorous bats and fruit bats in Africa. The presence of *Rickettsia* species. and their ectoparasites (Diptera and Siphonaptera) on the bats have also been documented across South Africa and Swaziland (Dietrich et al., 2016). Also, 0.7% of *Trypanosoma* species. was recovered from 400 blood bat samples in Madagascar (Raharimanga et al., 2013). About 15 species of bat flies, *Nycteribia triangularis*, *Stylidia* cf. *euxesta*, *Stylidia* cf. *caudata*, *Basilia hispida*, *Archinycteribia octophalma*, *Eucampsipoda penthetoris*, *Eucampsipoda sundaica*, *Leptocyclopodia ferrari*, *Leptocylopodia brachytrinax*, *Leptocylopodia obliqua*, *Megastrebla gigantea*, *Megastrebla limbooliati*, *Megastrebla limbooliati*, and *Raymondia* species. have been documented from 24 species of bats in Malaysia (Azhar et al., 2015).

Cave-dwelling bats can transmit blood-sucking flies and hemoparasites among themselves and the human population due to their feeding habit, ability to travel long-distance, and aggregation behavior. The purpose of the present study was to identify bats and their blood-sucking flies as vectors of hemoparasites in bat caves in Lombok Island, Indonesia.

MATERIALS AND METHODS

Ethical consideration

The samples of bats and bat flies were collected by a qualified veterinarian from the Faculty of Veterinary Medicine, Universitas Pendidikan Mandalika, Mataram, Indonesia based on the sampling protocol of Azhar et al. (2015) and FAO (2011). The captured bats were immediately released after the flies were taken and examined for external morphology.

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Study design

The survey was conducted from September to December 2018. Bats and their bat flies were collected from three bat caves- Tanjung Ringgit Bat Cave (8.61471°S, 116.594420°E), Lembah Sempage Bat Cave (8.539900°S, 116.2776673°E), and Pujut Bat Cave (8.88693°S, 116.253830°E) in Lombok Island, Indonesia (Figure 1). Mist nets were used to collect bats in the sampling caves from 4 to 7 PM. The mist net was stretched between two fish sticks. The mist nets were monitored, and captured bats were collected by hands and placed in wire cages covered with a dark cloth. Captured bats were inspected for bat flies' presence. When found, bat flies from each bat were collected and placed in a labeled tube containing 70% ethanol.

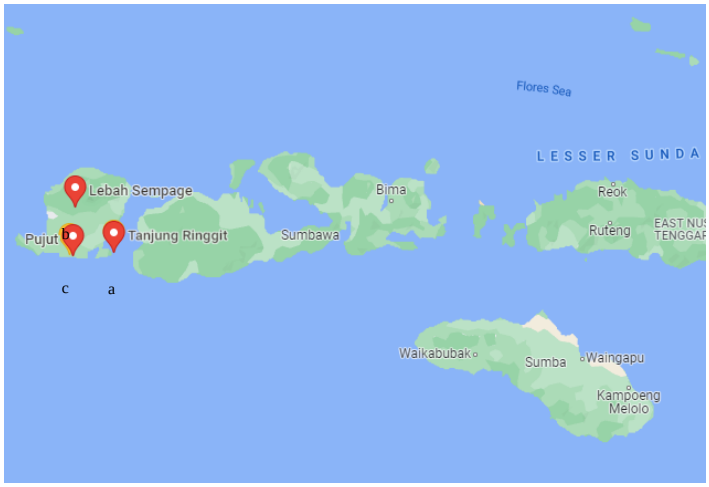

Figure 1. Bat cave locations in the study area (Google Map). a: Tanjung Ringgit Bat Cave, b: Lembah Sempage Bat Cave, c: Pujut Bat Cave

The captured bats were identified based on external morphology by measuring the length of the forearm (FA), third metacarpal (3MT), head body (HB), tibia (TIB), tail (TL), and hindfoot (HF), following the method used by Srinivasulu et al. (2010). The morphology of collected bat flies, including the head, thorax, abdomen, and wing, was identified under a microscope (Olympus, Japan, 40×) as reported by Azhar et al. (2015) and Alvarez et al. (2015).

RESULTS AND DISCUSSION

A total of 66 captured bats from three bat caves were identified as *Hipposideros* species, *Taphozous* species (insectivorous bats), and *Eonycteris spelaea* (Frugivorous bat) based on the external morphology. The details of external morphology measured are summarized in Table 1.

The FA length of *Hipposideros* species (41-50 mm) in the present study was similar to that of *Hipposideros galeritus* (FA: 45.0-51.3 mm) measured by Srinivasulu et al. (2010). The length of FA of *Eonycteris spelaea* (51-75 mm) was within the range of *Eonycteris spelaea* (FA = 66-78 mm) reported by the Srinivasulu et al. (2010). However, the length of *Taphozous* species (59-61 mm) in the present study was shorter than the key identification of *Taphozous perforatus* (FA = 59.2-63.8 mm) measured by Srinivasulu et al. (2010). The morphology of the cave-dwelling bats is shown in Figure 2.

The collected blood-sucking flies were morphologically identified as *Eucampsipoda sundaica*, *Stylidia* cf. *euxesta*, *Brachytarsina* species, *Raymondia* species, and *Megastrebla nigriceps* (Figure 3). The head morphology of *Eucampsipoda sundaica* observed in the present study was compressed and the thorax was pentagonal. The bat host of this fly was *Eonycteris spelaea*, which was previously described by Azhar et al. (2015). The morphology of *Stylidia* cf. *euxesta* was straight dark-pigmented claspers with long dorsal setae, while *Megastrebla nigriceps* had a long wing, the R1 vein had a weak bend near the base with the R2+3 vein apically curved as stated by Azhar et al. (2015). The *Brachytarsina* species recovered in the present study had a triangular and rounded head with non-prominent eyes, which was the same as the one described by Maa (1971). The head of *Raymondia* species was narrower than the distance between the two major humeral setae as previously described by Azhar et al. (2015). These species were collected from the fur area of the family Hipposideridae bat. The summary of the identification of 66 captured bats and their blood-sucking flies from bat caves in Lombok Island can be seen in Table 2.

The ecology and distribution of *Stylidia* cf. *euxesta*, *Brachytarsina* species, *Raymondia* species, and *Megastrebla nigriceps* in Indonesia are still unknown although some studies have been performed in Malaysia (Azhar et al., 2015) and Philippines (Alvarez et al., 2015). The present study could provide information on the identification and correlation between the number of bat and bat flies species found in Lombok Island.

Szentiványi et al. (2019) reported that 101 microparasites belonging to the bat fly families Nycteribiidae and Streblidae of 188 microparasites have been observed in bats. Bat flies such as *Brachytarsina* species, *Raymondia* species, and *Eucampsipoda* species in this study have been reported to be associated with blood parasites. *Polychromophilus melanipherus* Dionisi was mainly detected in *Nycteribia schmidlii scotti* Falcoz and less presence in *Eucampsipoda africana*, *Raymondia huberi* group and *Raymondia allaudi* bat flies.

The bats, including *Hipposideros* species, *Taphozous* species, and *Eonycteris spelaea*, as well as the blood-sucking flies including *Eucampsipoda sundaica*, *Megastrebla nigriceps*, *Brachytarsina* species, *Stylidia* cf. *euxesta*, and *Raymondia* species can be a potential vector of *Polychromophilus* species, *Babesia* species, *Plasmodium* species, and *Trypanosoma* species to other hosts. Nkoghe et al. (2016) reported the presence of *Polychromophilus* parasites in the bat fly fauna of Gabon. Lima et al. (2012) found *Trypanosoma erneyi* in African bats. Han et al. (2018) reported that insectivorous bats were infected by *Babesia vesperuginis*, also Schaer et al. (2013) indicated that *Plasmodium* species has infected insectivorous bats and fruit bats in Africa.

Table 1. Measurement of the external morphology of captured bats from three caves in Lombok Island, Indonesia

Species	FA (mm)	3MT (mm)	HB (mm)	TL (mm)	TIB (mm)	HF (mm)

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Hipposideros species	41-50	38-52	47-60	13- 23	22-23	14-15
Eonycteris spelaean	51-75	48-54	67-100	17-18	24-34	18-23
Taphozous species	59-61	50-54	70-74	25-25	23-24	13-14

FA: Forearm length, 3MT: Third metacarpal length, HB: Head body length, TL: Tail length, TIB: Tibia length, HF: Hind foot length

Table 2. Bats and their blood-sucking flies from bat caves in Lombok Island, Indonesia

Location	Number of bats	Species of bat	Feeding habits	Species of blood-sucking flies
Tanjung Ringgit Bat Cave (8.961°S,116.294°E)	23	*Eonycteris spelaea*	Fruits	*Eucampsipoda sundaica*
LembahSempage Bat Cave (8.5399°S,116.277°E)	28	*Hipposederos* spp	Insects	*Megastrebla nigriceps* *Brachytarsina* spp *Stylidia* cf. *euxesta*
Pujut Bat Cave (8.887°S,116.254°E)	15	*Taphozous* spp	Insects	*Raymondia* spp *Brachytarsina* spp
Total	66			

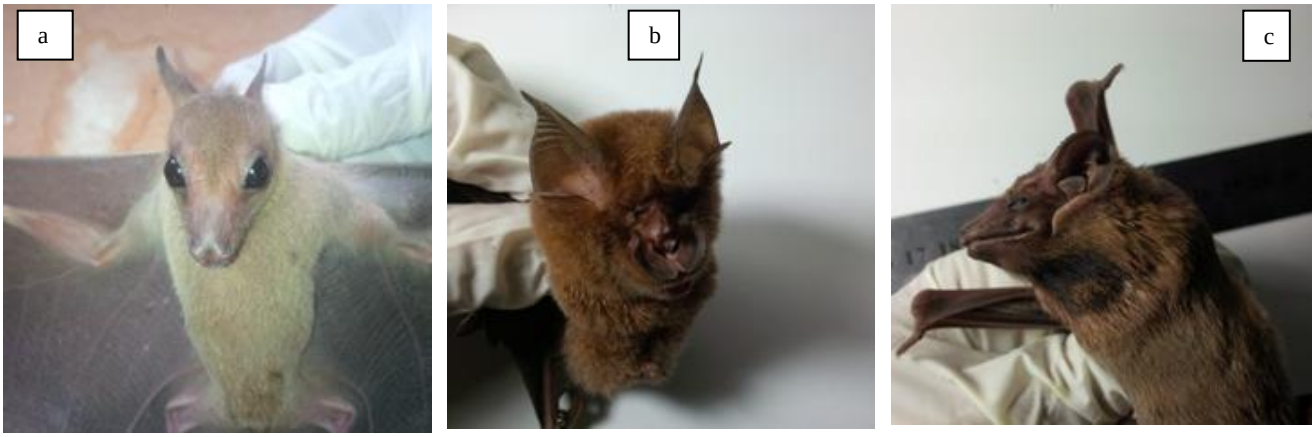

Figure 2. The morphology of the cave-dwelling bats. *Eonycteris spelaea* (a), *Hipposideros* species (b), *Taphozous* species (c)

Figure 3. Morpologhy of blood-sucking flies (40x magnification)**.** *Eucampsipoda sundaica* (a), *Stylidia* cf. *euxesta* (b), *Megastrebla nigriceps* (c), *Brachytarsina* species (d), *Raymondia* species (e), wing vein of *Megastrebla nigriceps* (f)

CONCLUSION

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The results of this study identified three species of bats, namely *Hipposideros* species, *Taphozous* species, and *Eonycteris spelaea*, in three caves on Lombok Island. The present study also documented five species of blood-sucking flies including *Eucampsipoda sundaica, Megastrebla nigriceps Brachytarsina* species, *Stylidia* cf. *euxesta*, and *Raymondia* species. Bat and bat flies can influence the transmission of *Polychromophilus species, Babesia* species, *Plasmodium* species, and *Trypanosoma* species to the other hosts in the study area and also spread the disease agent to different places.

DECLARATIONS

Authors' contribution

Kholik Kholik contributed to the design of research, data analysis, and the writing of the manuscript. Candra Dwi Atma, and Novarina SulsiaIsta'in Ningtyas collected the samples from the field and performed the laboratory analyses. All authors check the data of the present study and confirmed the final draft of the manuscript.

Competing interests

The authors declare that there are no competing interests.

Ethical consideration

The authors declare that this manuscript is original, has been checked by all the authors, and is not currently being considered for publication elsewhere.

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