DIVERSITY OF ECTOPARASITES ON BATS IN DRAMAGA, BOGOR, INDONESIA

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ABSTRACT

Ectoparasites infestation is one of the major health problems affecting animals, including bats, which are known as reservoir hosts for various pathogens. Several reports have shown that a comprehensive understanding of ectoparasites on these animals is crucial from a public health perspective. Therefore, this study aims to identify the diversity of ectoparasites on bats in Dramaga, Bogor, Indonesia. The samples were captured at night with a mist net and then identified using the species identification key. Ectoparasites were collected from the body of the samples and identified using a microscope. A total of 56 bats from 9 species, namely *Cynopterus brachyotis*, *Cynopterus sphinx*, *Cynopterus titthaecheilus*, *Macroglossus sobrinus*, *Rousettus leschenaultii*, *Myotis muricola*, *Nycteris javanica*, *Pipistrellus javanicus*, and *Scotophilus kuhlii* were obtained in this study. The results of ectoparasites identification showed the presence of *Basilia* spp., *Eucampsipoda* sp., *Leptocyclopodia ferrarii* (Nycteribiidae), *Raymondia* sp. (Streblidae), *Meristaspis* spp., *Spinturnix* spp. (Spinturnicidae), and ticks (Ixodidae). The total prevalence of infested bats was 51.7%, with females tending to have a higher intensity compared to males. Bats species with the highest prevalence of infestation were *Rousettus leschenaultii* and *Myotis muricola*. Meanwhile, this study found no ectoparasites on *Macroglossus sobrinus* and *Scotophilus kuhlii*.

Keywords: bats, bats flies, Bogor, ectoparasite, Indonesia

INTRODUCTION

Bats are known to play an essential role in maintaining the ecological balance of ecosystems, serving as seed transmitters, pollinators, and natural insect control (Suyanto 2001). Despite their significant ecological functions, these animals also serve as the natural reservoir of various pathogens. Previous studies showed that bats had unique immune systems, thereby enabling them to carry various zoonotic viruses per host species compared to rodents (Irving *et al.* 2021; Luis *et al.* 2013). Several emerging infectious diseases have also been linked to these animals bats as a source of zoonotic pathogens, including Ebola virus, SARS coronavirus, Nipah virus, and Hendra virus (Brook & Dobson 2015; Calisher *et al.* 2006). Furthermore, studies conducted in Indonesia showed their association with potential zoonotic diseases (Diptyanusa *et al.* 2021; Tsang *et al.* 2021). This indicates that the study of bats and their potential to transmit diseases to humans or other animals demands thorough investigation.

One of the health issues affecting bats is ectoparasites infestation, which warrants further investigation to comprehend the ecology and health of these creatures. The commonly associated ectoparasites belong to the class Insecta (bats flies and bats flea) and Arachnida (ticks and mites). The species within the class Insecta are known to belong to the family Nycteribiidae, Streblidae, Hippoboscidae, and Ischnopsyllidae. Meanwhile, those from class Arachnida are often members of the family Argasidae, Ixodidae, and Spinturnicidae (Fajri *et al.* 2018; Azhar *et al.* 2015). Previous studies showed that these ectoparasites in bats are vectors of pathogens, such as *Bartonella* spp., *Rickettsia* spp., and certain viruses with the ability

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to cause diseases in humans or animals (Szentiványi *et al.* 2019; Reeves *et al.* 2016).

Several studies have been carried out on bat ectoparasites in several Southeast Asia countries, including Malaysia (Azhar *et al.* 2015), Singapore (Lim *et al.* 2020), and the Philippines (Alvarez *et al.* 2015). Based on previous findings, studies related to these ectoparasites in Indonesia remains significantly limited, despite the presence of over 230 distinct bat species in this region (Maryanto *et al.* 2020). Existing reports in Indonesia primarily focused on recording ectoparasite infestation in different locations and species, especially megabats (Nangoy *et al.* 2021; Sauqi *et al.* 2021; Fajri *et al.* 2018). Based on these findings, there is a need to conduct further studies to understand the characteristics of ectoparasites, including their specific host and potential role in transmitting diseases.

Dramaga is a subdistrict located in Bogor, Indonesia, which has been extensively explored due to bats species diversity in Dramaga. Several studies have also been carried out in and around the IPB Dramaga Campus area and its surrounding villages. According to Mustari *et al.* (2014) and Mustari (2020), at least 10 species of bats were found in IPB Dramaga Campus. Another report showed the presence of 11 species in villages around the area (Sumirto 2013). Due to the role of these animals in maintaining ecosystem balance, there is a need to carry out further investigations on their ecology and health problems, such as ectoparasites infestation. Therefore, this study aims to identify the diversity of ectoparasites on bats in Dramaga, Bogor, Indonesia.

MATERIALS AND METHODS

Study Sites and Sampling Techniques

Bats used in this study were obtained from the seven locations in Dramaga, Bogor, Indonesia from November 2021 to February 2022. The habitats selected as sampling locations included arboretums, agricultural land areas, and rural areas. Furthermore, reconnaissance surveys were conducted in the area before the study began to identify the location where bats were likely to congregate. The survey targeted the regions where bats were expected to fly, such as fruiting trees or congregation sites of insects, to determine the appropriate sampling locations. The procedures for sample capturing in this study referred to the Guidelines for Bats Reservoir Data Collection published by the National Institute of Health Research and Development, Ministry of Health, Indonesia. The samples were captured at night using mist-net techniques. The mist nets were installed in determined locations and placed approximately 5 meters above the ground. The installation was carried out for four hours from 18.00 to 22.00 and monitored every hour. Bats were collected as detected trapped in the mist net, placed into a cotton bag, and transported to a nearby station for further identification (Balitbangkes 2015).

Bats Identification and Ectoparasites Collection

Captured bats were identified based on morphological features and morphometries using the species identification key from the Field Guide of Bats in Indonesia (Suyanto 2001). The identified samples were then observed to determine the presence of ectoparasites infestation. The collection procedure for ectoparasites was carried out using small tweezers. Subsequently, the parasites obtained were placed in a labeled vial containing 70% alcohol (Balitbangkes 2015), and bats were released back to the initial location.

Ectoparasites Identification

The initial grouping of ectoparasites was carried out based on their morphological characteristics. Bats flies were distinguished by their large size resembling a fly with or without wings, while mites and ticks were distinguished by their relatively small size compared to bat flies. Subsequently, the collected ectoparasites were identified using a microscope. Bats flies were identified using the publications of Maa (1971, 1968, 1962) and Theodor (1967, 1959), while mites were identified using the publication of Baker & Delfinado (1964) and Delfinado & Baker (1963). Ticks ectoparasites were identified using the publication of Hoogstraal (1955).

Data Analysis

Data on captured bats were analyzed descriptively by making a table that included the species, the number of captured bats, the number

of bats infested with ectoparasites, the prevalence of ectoparasites infestation, and the intensity of ectoparasites. Data on the collected ectoparasites were analyzed descriptively by making a table containing the types of ectoparasites, hosts, sex, and the number of collected samples per host.

RESULTS AND DISCUSSION

Bats Diversity

A total of 56 bats were obtained in this study, belonging to the suborders Megachiroptera and Microchiroptera. The samples represented nine species, namely *Cynopterus brachyotis*, *Cynopterus sphinx*, *Cynopterus titthaecheilus*, *Macroglossus sobrinus*, *Rousettus leschenaultii*, *Myotis muricola*, *Nycteris javanica*, *Pipistrellus javanicus*, and *Scotophilus kuhlii*. The results showed that the most captured species was *Cynopterus brachyotis*, with a total of 20 samples (35.7%). The least caught species was *Scotophilus kuhlii*, with only one sample (1.8%), as shown in Table 1. All bats species found in this study had a conservation status of least concern, except *Nycteris javanica*, which was considered vulnerable. *Nycteris javanica* was an endemic bats and was only found in Java and Timor (Waldien & Wiantoro 2021).

This study found a total of 29 samples that were infested with ectoparasites, accounting for 51.7% of the total population. The species with the highest prevalence (80%) of infestation were *Rousettus leschenaultia* and *Myotis muricola*. Meanwhile, there was no infestation on *Macroglossus sobrinus* and *Scotophilus kuhlii*, as shown in Table 1.

The prevalence and intensity of ectoparasites in each bat sex are presented in Table 2. The results showed that the number and intensity of ectoparasites varied widely among the samples' sex and species. Female *Rousettus lechenaultii* species had the highest intensity of infestation. Female bats tended to have a higher intensity of ectoparasites compared to males, but their population was smaller.

Table 1 Bats species and prevalence of ectoparasites infestation in bats

Bats Species	Number of Captured Bats	Number of Infested Bats	Prevalence (%)
Megachiroptera (Megabat)			
Cynopterus brachyotis	20	11	55
Cynopterus sphinx	5	2	40
Cynopterus titthaecheilus	11	6	54.5
Macroglossus sobrinus	4	0	0
Rousettus leschenaultii	5	4	80
Subtotal	45	23	51.1
Microchiroptera (Microbat)			
Myotis muricola	5	4	80
Nycteris javanica	2	1	50
Pipistrellus javanicus	3	1	33.3
Scotophilus kuhlii	1	0	0
Subtotal	11	6	54.5
Total	**56**	**29**	**51.7**

Table 2. Intensity of ectoparasites based on bats species and sex

Bats Species	Infested Bats/Captured Bats		Total Ectoparasites		Intensity of Ectoparasites	
	Male	Female	Male	Female	Male	Female
Cynopterus brachyotis	10/19	1/1	20	2	2.0	2.0
Cynopterus sphinx	1/3	1/2	3	1	3.0	1.0
Cynopterus titthaecheilus	4/6	2/5	5	2	1.25	1.0
Rousettus leschenaultii	2/3	2/2	8	24	4.0	12.0
Myotis muricola	4/5	0/0	27	0	6.75	0
Nycteris javanica	1/2	0/0	1	0	1.0	0
Pipistrellus javanicus	1/3	0/0	2	0	2.0	0
Macroglossus sobrinus	0/4	0/0	0	0	0	0
Scotophilus kuhlii	0/1	0/0	0	0	0	0
Total	**23/46**	**6/10**	**66**	**29**	**2.87**	**4.83**

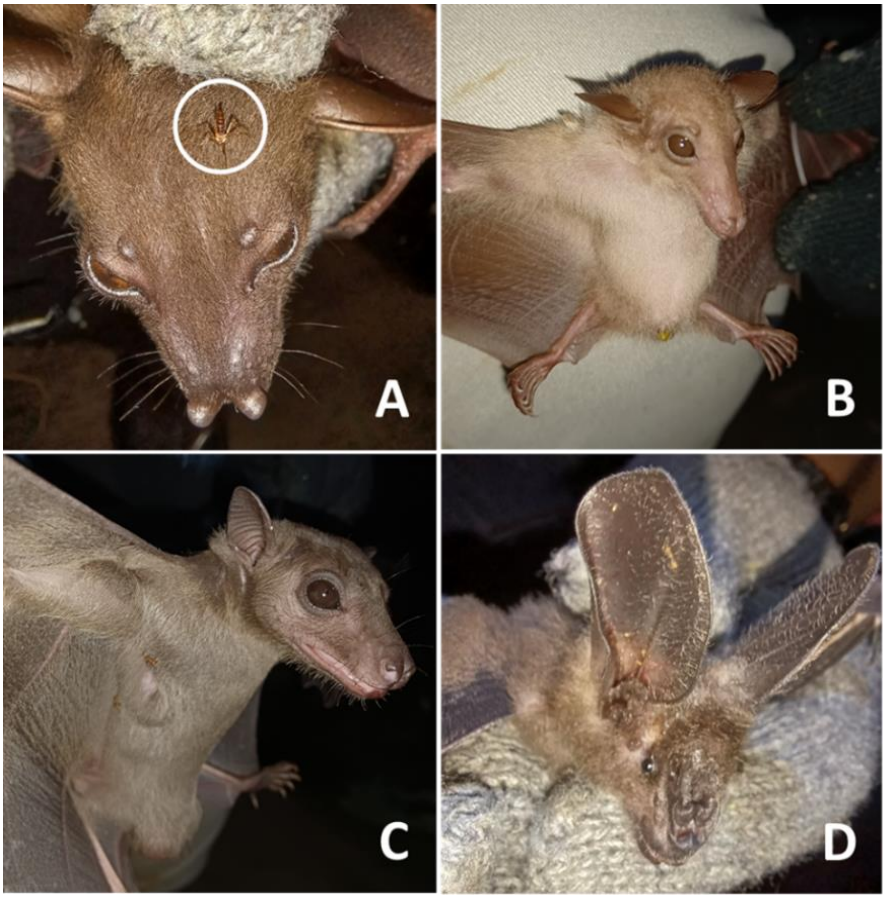

Figure 1 Bats species captured in Dramaga, Bogor: (A) *Cynopterus titthaecheilus* with ectoparasites (white circle), (B) *Macroglossus sobrinus*, (C) *Rousettus leschenaultii*, (D) *Nycteris javanica*

This was the first study to record the diversity of ectoparasites on bats in Dramaga, Bogor. The results could be used to monitor the status of bats species in Dramaga, Bogor, in line with conservation efforts. This study also presented the first record of ectoparasites infestation on vulnerable endemic bats species, namely *Nycteris javanica*. The species was endemic to Java and Timor Islands and not commonly found in nature due to its declining population and conservation status being vulnerable (Waldien & Wiantoro 2021).

Due to the absence of ectoparasites on some species, further studies must be carried out to determine the possibility of infestation on bats. This study found no infestation in *Macroglossus sobrinus* and *Scotophilus kuhlii*, possibly due to the lack of representative samples. Therefore, future reports must explore ectoparasites that could affect these species. Further studies were also needed due to the inability of this current study to cover all bat species reported by Mustari (2020), such as *Kerivoula hardwickii*, *Rhinolophus affinis,* and *Hipposideros diadema*.

Ectoparasites Diversity

Ectoparasites found in this study were from Insecta and Acarina classes, as shown in Table 3. A total of 95 samples were collected representing three groups, namely bats flies (family Nycteribiidae and Streblidae), mites (family Spinturnicidae), and ticks (family Ixodidae). Nycteribiidae bats flies were found on five microbats and megabats, namely *Myotis muricola*, *Cynopterus brachyotis*, *Cynopterus sphinx*, *Cynopterus titthaecheilus*, and *Rousettus leschenaultii*. Streblidae species was only discovered on *Nycteris javanica*. Mites were discovered on *Rousettus leschenaultii*, *Myotis muricola*, and *Pipistrellus javanicus,* while ticks were only found on *Myotis*. Furthermore, *Rousettus leschenaultia* had the highest ectoparasites infestation compared to others in Dramaga. The differences in the number of infestation were due to the variations in number of captured individual bats in each species.

Table 3 Collected ectoparasites found on bats in Dramaga, Bogor

No	Ectoparasites Species	Number of Ectoparasites								Total
		C.b	C.s	C.t	M.sb	R.l	M.m	N.j	P.j	S.k	
	Bats flies										
1	*Basilia* spp.	0	0	0	0	0	10	0	0	0	**10**
2	*Eucampsipoda* sp.	0	0	0	0	21	0	0	0	0	**21**
3	*Leptocyclopodia ferrarii*	22	4	7	0	0	0	0	0	0	**33**
4	*Raymondia* sp.	0	0	0	0	0	0	1	0	0	**1**
	Mites										
1	*Meristaspis* spp.	0	0	0	0	11	0	0	0	0	**11**
2	*Spinturnix* spp.	0	0	0	0	0	16	0	2	0	**18**
	Ticks										
1	Ixodidae	0	0	0	0	0	1	0	0	0	**1**
	Total	**22**	**4**	**7**	**0**	**32**	**27**	**1**	**2**	**0**	**95**

Notes: C.b: *Cynopterus brachyotis*, C.s: *Cynopterus sphinx*, C.t: *Cynopterus titthaecheilus*, M.sb: *Macroglossus sobrinus*, R.l: *Rousettus leschenaultii*, M.m: *Myotis muricola*, N.j: *Nycteris javanica*, P.j: *Pipistrellus javanicus*, S.k: *Scotophilus kuhlii*.

Ectoparasites from the family Nycteribiidae were the most collected ectoparasites in this study. Furthermore, Nycteribiid bats flies were ectoparasites commonly found in megabats from the genus *Cynopterus* and *Rousettus* (Nangoy *et al.* 2021). Species from the genus *Cynopterus* were reported to be the primary hosts of *Leptocyclopodia* flies (Maa 1975). Several studies collected *Leptocyclopodia ferrarii* from *Cynopterus brachyotis* in Indonesia (Nangoy *et al.* 2021; Sauqi *et al.* 2021). *Eucampsipoda* bats flies were common on megabats, and they had infested *Eonycteris spelaea* and *Rousettus leschenaultii* in Southeast Asia countries (Lim *et al.* 2020; Fajri *et al.* 2018; Azhar *et al.* 2015). *Basilia* ectoparasites were commonly obtained in megabats and microbats, and Poerwanto *et al.* (2020) reported their presence on *Miniopterus schreibersii* in Yogyakarta, Indonesia.

Ectoparasites from the genus *Raymondia* included Streblidae bats flies found in microbats (Azhar *et al.* 2015; Maa 1962). These species could be distinguished from Nycteribiidae samples by the presence of the wings (Azhar *et al.* 2015). This study only found *Raymondia* sp. on *Nycteris javanica*. This result was the first record of ectoparasites infestation by the genus *Raymondia* on *Nycteris javanica*.

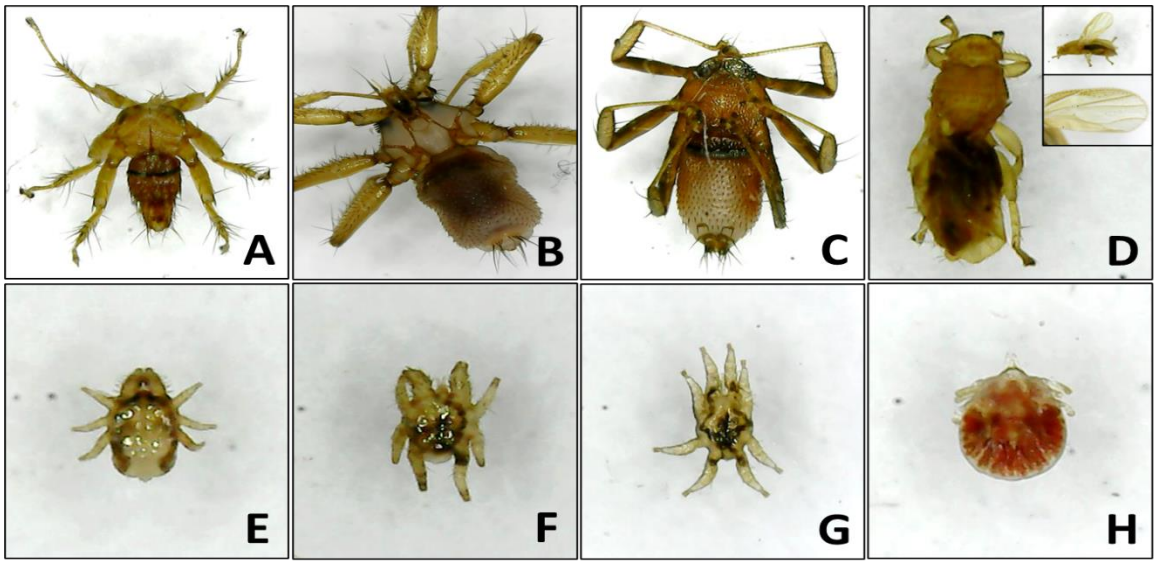

Figure 2 Ectoparasites collected from bats in Dramaga, Bogor: (A) *Basilia* sp. collected from *Myotis muricola*, (B) *Eucampsipoda* sp. collected from *Rousettus leschenaultii*, (C) *Leptocyclopodia ferrarii* collected from *Cynopterus* spp., (D) *Raymondia* sp. collected from *Nycteris javanica*, (E) Mite *Meristaspis* sp. ♀ and (F) *Meristaspis* sp. ♂ collected from *Rousettus leschenaultii*, (G) *Spinturnix* sp. collected from *Myotis muricola* and *Pipistrellus javanicus*, and (H) Ixodid tick (Ixodidae) collected from *Myotis muricola*

Mites and ticks were found in the genus *Rousettus*, *Myotis*, and *Pipistrellus*. Mite ectoparasites infesting bats in Indonesia were from the Spinturnicidae family, while the ticks were from the Ixodidae and Argasidae families (Fajri *et al.* 2018). Several studies reported ticks and mites ectoparasites infestation on bats in Indonesia (Poerwanto *et al.* 2020; Fajri *et al.* 2018). The results of *Meristaspis* sp. and *Spinturnix* sp. mites from the family Spinturnicidae and ticks larvae from the family Ixodidae were consistent with previous studies on arachnid infestation on bats.

Bat-Ectoparasites Interaction

Ectoparasites in bats spent almost their entire life cycle on the host through blood consumption (Hiller *et al.* 2019; Bordes *et al.* 2008). The intensity and prevalence of ectoparasites were affected by several factors, including host-specificity, habitat, nesting, gender, diet, and social behavior (Nangoy *et al.* 2021; Hiller *et al.* 2019; Ramanantsalama *et al.* 2018). Therefore, their distribution and abundance were associated with the distribution and abundance of the host (Putra, 2014; Ter Hofstede & Fenton, 2005). The colony size of each bat species could also influence social behavior, leading to differences in the prevalence of ectoparasites infestation. Species that shared the same roosting site in larger groups increased the possibility of ectoparasites transmission between the bats (Putra 2014). Bats in genera *Cynopterus*, *Rousettus*, and *Pipistrellus* were generally known to roost from medium to large colonies (Garg *et al.* 2015; Kumar *et al.* 2015; Gay *et al.* 2014). Different roosting behavior was found in *Macroglossus* species, which tended to roost alone or in small colonies occupying different sites (Putra 2014; Gould 1978). The absence of ectoparasites infestation on *Macroglossus* bats in this study was allegedly related to the behavior of the species.

Several reports showed that ectoparasites infestation in bats had an association with sex. In this study, females tended to have a higher intensity of ectoparasites compared to males, but they had few infested individuals due to the small population. The results were consistent with Nangoy *et al.* (2021) on Pteropodid bats in Sulawesi, where females had a higher intensity due to their high susceptibility caused by several factors. Fluctuations in the reproductive cycle, such as pregnancy and lactation, could suppress immunity and increase susceptibility to parasites. During this period, the female species tended to spend more time in roosting sites, increasing contact with ectoparasites or the other infested bats (Tai *et al.* 2022; Nangoy *et al.* 2021; Webber *et al.* 2015).

A previous study reported that extended stay in roosting sites also increased ectoparasite exposure (Lim *et al.* 2020). Compared to the results of this study, Lim *et al.* (2020) found that male *Cynopterus brachyotis* and *Eonycteris spealea* had a higher level of infestation. This was because they spent more time in the roost site due to defense. Grooming activities commonly carried out to expel parasites also affected infiltration among sexes since males spent more time in grooming activities related to ectoparasites consumption compared to females (Ramanantsalama *et al.* 2018). Meanwhile, Godinho *et al.* (2013) found no association between grooming activity and the number of parasites. Due to the variation in literature, further studies must be carried out to investigate ectoparasites infestation in relation to sex.

Ectoparasites in bats generally had certain specific hosts, and could only be found in some species. Bats flies were obligate and specialized parasitic organisms found on the fur and wing membranes. Furthermore, this study found a genus-specific host pattern in ectoparasites. *Leptocyclopodia ferarri* bats flies obtained had specific hosts from the *Cynopterus* spp. bats. These findings were consistent with several studies, where species from the genus *Cynopterus* were primary hosts for *Leptocyclopodia* spp. (Lim *et al.* 2020; Azhar *et al.* 2015). Based on the results, *Meristaspis* mites tended to infest megabats, while *Spinturnix* mites infested microbats. The results were in line with previous studies, which recorded the infestation of *Meristaspis* spp. mites on megabats from the genus *Macroglossus* and *Rousettus* (Fajri & Armiani 2021; Fajri *et al.* 2018). Meanwhile, the study by Zania *et al.* (2022) reported the *Spinturnix* mite infestation on *Rousettus* bats in Banyuwangi. This variation in findings suggested that the mites did not have a genus-specific pattern.

The presence of ectoparasites in bats contributed to the spread of pathogens between individual members in the colony. Some of the parasites had various hosts and could be vectors for certain pathogens. Several studies found *Bartonella* spp. bacteria in *Leptocyclopodia* bats flies collected from the megabats in Malaysia and the Philippines (Low *et al.* 2022; Morse *et al.* 2012). *Bartonella* spp. was a bacteria that caused bartonellosis and was considered zoonosis (Chomel & Kasten 2010). Bacterium *Bartonella* spp. and *Rickettsia* spp. were also found in mites from the genus *Spinturnix* collected from *Myotis myotis* bats in Poland (Szubert-Kruszyńska *et al.* 2019). Feng *et al.* (2017) found the Khaeng Koi virus in *Eucampsipoda sundaica* from *Rousettus leschenaultia* bats in China. The results of bats ectoparasites in Dramaga proved that ectoparasites infestation was a major health problem in bats. The ability of ectoparasites to act as vectors of various pathogens demands further studies on their distribution in each bats species, as well as their public health importance.

CONCLUSION

In conclusion, ectoparasites were one of the causes of health-related problems in bats with health importance due to their ability to act as vectors of various pathogens. Ectoparasites affecting bats in Dramaga were from the family Nycteribiidae, Streblidae, Spinturnicidae, and Ixodidae. The results showed that the total prevalence of infested samples in the study location was 51.7%. Furthermore, the female samples tended to have a higher intensity of ectoparasites compared to males. The species with the highest prevalence of infestation were *Rousettus leschenaultii* and *Myotis muricola*. This study found no ectoparasites infestation on *Macroglossus sobrinus* and *Scotophilus kuhlii*. Based on these findings, further studies were needed as some species of bats required large sample sizes.

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