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ECTOPARASITES OF CHIROPTERAN SPECIES IN THE MANNAR ISLAND AND POONERYN REGION OF SRI LANKA

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Bats are hosts to a variety of ectoparasites, which may impact their health and the transmission of zoonotic pathogens. However, studies on bat parasites in Sri Lanka are very limited and are mainly restricted to the bats in the wet zone. Therefore, the overall objective of this study was to examine the prevalence, diversity and distribution of ectoparasites associated with selected bat species from the Mannar Island and Pooneryn area of the Northern Province of Sri Lanka. A total of 246 bats were captured using mist nets at dawn and dusk. All captures and handling were permitted by the Department of Wildlife and Conservation, Sri Lanka (WL/3/2/30/2024). Ectoparasites were collected from the captured live bats and preserved in 70% ethanol. Morphological identification of parasites was carried out using published taxonomic keys and guides. Parameters such as parasite prevalence, abundance, mean intensity, Shannon-Weiner diversity index and average parasitic load per host species were calculated. Ectoparasites were found in all five species of bats surveyed. *Scotophilus kuhlii* had ectoparasites in 23 (21.9%) of them, while *Cynopterus sphinx* had ectoparasites only in 2 (3.85 %) of them. A single infection was observed in *C. sphinx*, *Scotophilus heathi* (0.09%), *Pipistrellus coromandra* (2.94%) and *Taphozous longimanus* (25%) bat species while, multiple infections were seen in *S. kuhlii.* Bat flies from family Nycteribiidae, a mite species from family Spinturnicidae and a hard tick from family Ixodidae were found among a total of 183 ectoparasites. The dominance of *Nycteribia* species, including three *Nycteribia* fly species and five other unidentified species from the family was noted. Although parasites in *S. kuhlii* showed the highest diversity (H'=1.77) and parasitic load (175), collectively parasitic loads did not show a significant difference (one way ANOVA, p >0.05) within the five-host species from a single study region or between the two regions: Mannar Islands and Pooneryn. *S. kuhlii* harbor larger numbers of ectoparasites and experience higher frequency of infections as they live in colonies as opposed to other host species sampled. This study suggests that roosting behavior may contribute to differences in patterns of host-parasite associations, while regional factors (arid vs. dry regions) may not. The present study further contributes to bridge the knowledge gap on host parasite associations in bats of arid and dry zones in Sri Lanka, as the first such scientific attempt.

Keywords: Chiroptera, ectoparasites, Nycteribiidae, Mannar, Pooneryn

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INTRODUCTION

Bats are known to carry pathogens such as parasites which could cause zoonoses. Many ectoparasites such as bat flies, mites and ticks serve as vectors for such zoonotic diseases (McKee et al., 2019; Szentiványi et al., 2024)). Therefore, understanding the host - parasite relationships in bats is of great importance for bat conservation as well as public health awareness. Understanding these complex relationships is essential to predicting and mitigating the impacts of emerging infectious diseases in a rapidly changing world. Sri Lanka harbors 31 species of bats which comprise about a third of the country's mammalian diversity. However only a very few studies have been conducted on bat parasites, while most of them have surveyed bats from the wet zone (Weerakkody et al.,1999; Seneviratne et al., 2009; Kotagama et al.,2020). Therefore, the main aim of this investigation was to survey the bat parasites in the Mannar and Pooneryn regions, where no previous parasitic surveys have been conducted despite rapid developmental activities in the area facilitating possible emergence of zoonotic infections.
The specific objectives of the study were to;

- To determine the prevalence and diversity of ectoparasites in the selected bat species from Mannar and Pooneryn.
- To determine the distribution of parasites in bats from Mannar and Pooneryn.

METHODOLOGY

Bats were captured using mist nets erected along flight paths during dawn and dusk. All captures and handling were approved in advance by the Department of Wildlife and Conservation, Sri Lanka (WL/3/2/30/2024). The captured bats were carefully examined for ecto parasites and after collection, the parasites were immediately preserved in 70% ethanol (Whitaker, 1988). Each sample was labeled with appropriate details such as bat species, date, time and location of capture and were transferred to the laboratory for taxonomic identification and further investigation. All bats captured were identified to species level based on morphological characteristics and keys by Dick & Dittmar (2014) and Seneviratne, et al. (2009).
Morphological identifications of parasites were made through examination and imaging specimens using a stereo microscope (Olympus CX21) and identification

keys as well as taxonomic descriptions by Dick & Dittmar (2014), Seneviratne, et al. (2009), Yang et al., (2023) and Dodds (2018). The species and number of parasites per individual host was recorded to investigate the host-specificity of the parasite occurrence, prevalence, diversity and the parasite loads.

Parasite prevalence was determined by the following equation: Parasite prevalence = (number of infected individuals / number of individuals examined) × 100%. The average number of parasites in infected hosts of a sample of hosts was calculated as mean intensity (Schmidt & Roberts, 1981). The average number of parasites per host in a sample, equal to the arithmetic mean, was calculated as abundance (Schmidt & Roberts, 1981). A one-way ANOVA was conducted to test whether there were statistically significant differences at 95% confidence level in average parasite loads between bat species. The Shannon-Weiner Index was calculated to examine parasite diversity among bat species.

RESULTS AND DISCUSSION

A total of 246 bats were captured from Mannar and Pooneryn regions were surveyed for the ectoparasites. This included 5 bat species, namely: *Cynopterus sphinx, Scotophilus kuhlii, Scotophilus heathi, Pipistrellus coromanda, Taphozous longimanus* (Table 1.1). A total of 183 ectoparasites representing flies, mites and ticks were collected from these bats (Table 1). Among the bat species surveyed, *S. kuhlii* had ectoparasites in 23 (21.9%) of them, while *C. sphinx* had ectoparasites only in 2 (3.85 %) of them. A single infection was observed in *C. sphinx*, *S. heathi* (0.09%), *P. coromanda* (2.94%) and *T. longimanus* (25%) bat species while, multiple infections were seen in *S. kuhlii* (Table 1).

Table 1: An overview of ectoparasite presence in bat species captured from Mannar and Pooneryn

Host species		No of hosts captured	No of ectoparasite positive hosts	If multiple infection (M) or single infection (S)	Parasitic load
Cynopterus sphinx	Total sampled	52	2	S	5
	Mannar	26	1	S	4
	Pooneryn	26	1	S	1
Scotophilus kuhlii	Total sampled	105	23	M	175
	Mannar	61	10	M	102

	Pooneryn	44	13	M	73
Scotophilus heathi	All sampled	11	1	S	1
	Mannar	11	1	S	1
	Pooneryn	-	-	-	-
Pipistrellus coromanda	All sampled	34	1	S	1
	Mannar	7	-	-	-
	Pooneryn	27	1	S	1
Taphozous longimanus	All sampled	4	1	S	1
	Mannar	-	-	-	-
	Pooneryn	4	1	S	1

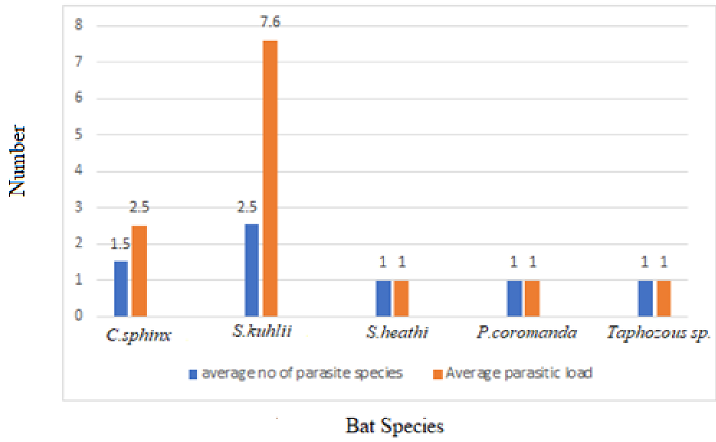

Figure 1: Average number of parasite species and average parasitic load, per bat species

Scotophilus kuhlii harbored the greatest average number of ectoparasite species while the least average number of species was recorded from *S. heathi, P. coromanda* and *T. longimanus* (Figure 1).

The parasitic load in *Scotophilus kuhlii* was shown the highest while *P. coromanda, S. heathi* and *T. longimanus* showed an equal number for parasitic loads which is one. However, none of these differences were statistically significant ($p > 0.05$).

The greatest ectoparasite diversity was also observed in *Scotophilus kuhlii* (H' = 1.77) and the second greatest, following *S. kuhlii*, was in *C. sphinx* (H′ = 0.5002).

Eight species of ectoparasite flies were observed during the study representing family Nycteribiidae. The most abundant species was *Nycteribia spp.2* (table 2). The least abundant was *Stylidia sp* (figure 3.3). One mite species of family *Spincturnicidae* was recorded from 2 bat species only (*S. kuhlii* and *T. longimanus*). One hard tick species (family Ixodidae) was recorded from *S. kuhlii.*

Scotophilus kuhlii harbored all 10 species of ectoparasites recorded in the study. Out of all the parasites recorded, *Nycteribia* spp.2 had the highest prevalence (12.92%) and the highest abundance (0.482) and an average abundance (2.448) across all hosts in this study, indicating that this parasite was the most common by far and most abundant parasite recorded in this study, particularly on *S. kuhlii* (Sk), *S. heathi* (Sh) and *P. coromanda* (Pc).

Stylidia sp. and *Penicillidia* sp., were the least common parasites recorded in this study; and showed the lowest prevalence (0.68% and 1.36%, respectively) with low average mean intensity.

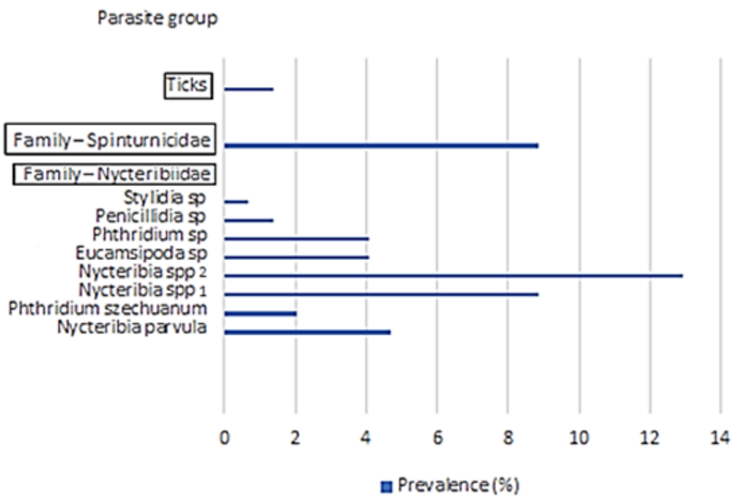

Figure 2: Prevalence of parasite species recorded from all hosts studied

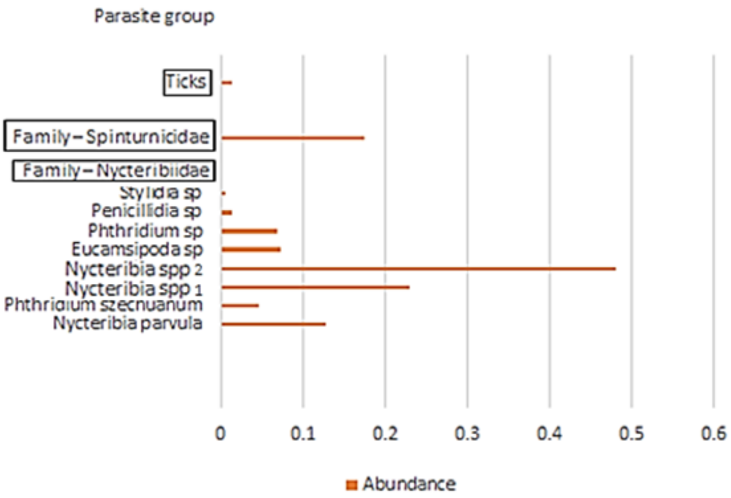

Figure 3: Abundance of parasite species recorded from all hosts studied

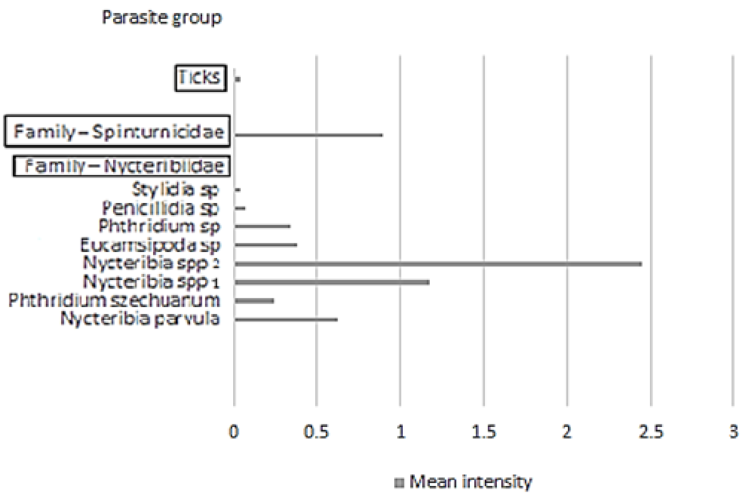

Figure 5: Mean intensity of parasite species recorded from all hosts studied

The differences in the number of parasite species harbored by each host species from the two regions were analyzed separately using ANOVA. However, no significant differences were observed in the number of parasite species harbored in hosts between the two regions ($p > 0.05$).

This study focused on the occurrence and diversity of ecto parasites in bat species from the Mannar Island and Pooneryn in Sri Lanka. These regions are located in the arid and dry zones of the island and are spatially close to southern India. No previous study has examined the diversity of ecto parasites in bats in the area.

Therefore, this study significantly improves our local and regional understanding of host-parasite interactions of bats and provides crucial baseline data for future studies and comparative faunal studies, especially with nearby countries such as India. This study confirmed the occurrence of external parasites in five bat species: *C. sphinx, S. kuhlii, S. heathi, P. coromanda* and *T. longimanus.* The impact of parasitism on external parasites was highlighted by the fact that the highest prevalence of associated parasites was in the *T. longimanus* (25%), but it should be noted that this was based on only 4 samples. In contrast, *S. kuhlii* had a relatively high parasite prevalence (21.9%) in this study, and based on the total ectoparasite load obtained from previous studies, it had the highest ectoparasite load, with 175 ectoparasites counted in 23 of 105 infected individuals (Ragasa et al., 2021) This may indicate that *S. kuhlii* is a major host or vector for ectoparasite transmission in the study area.

Studies from different countries have shown that similar bat species carry different ectoparasite burdens. For example, in Thailand, *S. kuhli* showed a 11% prevalence for *Polychromophilu*s parasites, which was the first report of ectoparasites in this genus (Chumnandi et al., 2021). In contrast, *S. kuhli* from the Philippines had no ectoparasite infections at all (Ragasa et al., 2021). These examples illustrate how parasite burdens can vary greatly across broader geographic areas and may be subject to local environmental or host-specific factors. The habits of these bats also provide insight into the reasons for these differences. The ecology of *P. coromanda* involves colonial breeding. Since colonial breeding bats are located close enough together, allowing relatively easy movement of parasites between bat hosts, living in groups increases parasite transmission rates. So, bats that live in groups have higher numbers of parasites and are more likely to suffer from infections than bats that live alone. This increases the risk of parasitic diseases and the overall risk of transmitting parasitic infections.

Overall, female hosts in our study generally harbored more parasites than males; however, one male individual of *S. kuhlii* from Mannar had a particularly high parasite load. A possible explanation for the observed differences is that sex, and perhaps reproductive behavior are factors in the vulnerability of bat hosts to parasites. This study however did not find significant differences in the number or diversity of ectoparasite species between the Mannar Island and Pooneryn areas

The ectoparasites identified were mainly from the families Nycteribiidae and Spincturnicidae, both of which are specialized families known for their close association with bats as hosts (Dick & Dittmar, 2014). Bat flies were mainly from the Nycteribiidae and included Nycteribia parvula, Nycteribia sichuanum, Penicillidia sp. and Stylidia sp. These bat flies generally have a narrow host range and a specific morphology for the life cycle on bat fur and skin (Dick & Patterson, 2006). The high parasite loads seen in *Scotophilus kuhlii* raise questions about the species' roosting behavior, grooming behavior, and colony sizes, as these factors may mediate ectoparasite transmission (Bhartiy & Elangovan, 2020). In particular, *P. coromanda*, *S. heathi*, and *Taphosus* had low parasite loads (one parasite per infected bat). These results may indicate higher host resistance, lower roost density, or higher roosting efficiency in these bats, but it is difficult to determine the 'true' diversity of parasites and parasite loads among these species, as sample sizes were small for some species, including *Taphosus* and *S. heathi*. Further studies will be conducted to mitigate this drawback.

Bats are increasingly recognized as reservoirs for emerging zoonotic pathogens. Bat parasites (e.g., flies and mites) can act as vectors for pathogens that can infect humans and/or domestic animals. Although our research did not directly assess infection status, documenting the diversity of ecto parasites on different bat species contributes to the overall epidemiological landscape (Tendu et al., 2022). In developing areas such as Mannar and Pooneryn, where human-wildlife interfaces are becoming abundant due to deforestation and habitat encroachment, monitoring bat ectoparasites can provide information as an early warning system for zoonotic disease threats. In addition, bats provide important ecosystem services in an environment by controlling insects, pollinating and dispersing seeds. Ectoparasites can cause adverse impacts on the health and function of bats, which often affects their ability to provide ecosystem services (Korine et al., 2017).

Overall this study provides one of the earliest documented surveys of bat ectoparasites from the arid zone of Sri Lanka, and almost the first study done in Mannar Island and Pooneryn area, Sri Lanka. As per all the knowledge, this study is the first to investigate the ectoparasites of the Sri Lankan bats *S. kuhli and S. heathi*. Although limitations in sample size and some parasite species remain undetected to the lowest taxonomic level, the results of this study support the ongoing monitoring of ectoparasites for bat conservation and public health monitoring.

CONCLUSIONS/RECOMMENDATIONS

This research provides the first baseline data on bat ectoparasites in Mannar Island and Pooneryn, illustrating important host-parasite associations in the dry zone of Sri Lanka. Ectoparasites were reported on *Scotophilus kuhlii* and *Scotophilus heathi* for the first time in Sri Lanka, and also significant ectoparasite families were identified such as Nycteribiidae (bat flies) and *Spinturnicidae* (mites). The study had limitations including sample size and the parasites were identified morphologically rather than molecularly. However, the descriptive data highlighted some trends, with *T. longimanus* being the species with highest parasite prevalence, followed by *S. kuhlii*. *Scotophilus kuhlii* also harbored the highest average parasitic load. In general, higher ectoparasite loads were carried by female bats, and the colonial breeding behavior observed in *Pipistrellus coromanda* may contribute to a higher transmission potential. It is of public health importance to identify bat ectoparasites as reservoirs or vectors of zoonotic pathogens.

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