PREVALENCE OF ECTOPARASITES IN BATS FOUND IN GULUMBE AND MASAMA AREA, KEBBI STATE, NIGERIA

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Abstract

Bats are ecologically valuable and may spur disease transmission; thus, this study aimed to investigate prevalence and identify common ectoparasites in bats in Gulumbe and Masama District in Birnin Kebbi and Danko Wasagu Local Government Areas of Kebbi State. A total of 300 bats were collected. Ectoparasites were investigated with the aid of a dissecting microscope and identified with various identification keys using standard methods. Result shows that *Penicillidia conspicua* as the only ectoparasite detected in the infected bats from both communities. More broad studies should be done to provide more details about possible parasitism with various ectoparasites. More current methodologies in identifying both ectoparasites such as PCR, Molecular characterization and ELISA are needed.

Keywords: Bats, disease, ectoparasites, Kebbi, *Penicillidia conspicua*, *Rousettus aegyptiacus*, species.

1. Introduction

Certainly, bats are mammals, possessing a placenta, and exist as the largest order after the rodents, indeed making about 20% of the total number of the mammalian species. Bats are also nocturnal, and very significant in the existence of ecosystem (Airas, 2003; Oca-Aguilar et al., 2024). Bats are peculiar for being the only flying mammals ever known, they are dwelling everywhere in the regions of the world besides Antarctica and Artic areas; perhaps they are the most rampant (abundant), diverse, and geographically ubiquitous among the entire vertebrates (Bazzoni et al., 2024). Albeit, bats are commonly spotted in diverse forms in the temperate areas, they also exist in diverse forms in the tropical portions (areas) of the world (such as forests). Bats are known to be highly mobile and of the habit of spending sometime flying, covering a long distance; which confers them an ability to properly dispense seeds and equally possibly diseases (Nartey, 2015; Oca-Aguilar et al., 2024).

Bats are diverse in size, the smallest could be bumblebee bat which is about 1.5-2g, while the flying foxes could be about 1kg (there is wingspan of about 2 meters). The largest bats may have a wingspan of about 1.7 meters (weighing about 1.6kg). Bats possessed wings that are in form of modified forelimbs, possessing surfaced integument with skin, and aided by four fingers (Hill & Smith, 1984; da Silva et al., 2023). The flight membrane in the bats springs to the lower part of the body to be attached to the back (hind) limbs. The tail membrane possess by bats is denoted as uropatagium, hind limbs are basically shorter and small, having a short (curved) claws that aid the animal to cling upon surfaces in the roast environments. Bats are displaying specificity in their roosts especially among species. Their roosts could be among trees, crevices, caves, or even logs or human homes (Gosik et al., 2024).

Bats of the *Chiroptera* order are the exclusive groups that are actively flying, and indeed the true placental mammals known in the entire animal kingdom. Traditional view classified bats as microbats or mega bats (Whitaker, 2004; Lack et al., 2010; Adhikari et al., 2020). Microbats predominate as insectivorous feeders, albeit, few of them relied on blood, pollens, fruits, vertebrates, and nectar. While, the mega bats consist of flying foxes, as well the old-world fruit bats, behaving as herbivores while consuming fruits, flowers, pollens, leaves, flowers, etc, (Nowak, 1991; Gosik et al., 2024). There are recorded 1349 bat species across parts of the world, in Nigeria significant diversity of bats show about 72 disclosed species. In this vein, the mega bats (mammalian: Chiroptera:pteropodi-dae) is a typical instance of monophyletic clan (group) that is mostly nonecholocating, and additionally phytophagous bats known with the ability to consume fruit for nectar or pollen. Pteropodids refers to the ones distributed in the olden tropics (from Western part of Africa) to the Eastern Polynesia; therewith, sub-Saharan Africa is largest portion that carries the stated type of bat (Vaughan et al., 2000; Gosik et al., 2024).

The type of megabat found in African (African megabat) consists of species with several clades already existing in the past or the ones that evolved over the course of history. Some bats, specifically, the megachiropterans are sometime not huge (large), the smallest of them has 6cm length or thereabout; but the megachiropterans in general terms are not as smaller as the microchiropterans (Rosevear, 1965; Hill & Smith, 1984; Nowak, 1991; Vaughan et al., 2000; Montana Department of Agriculture, 2024). The megachiropterans possessed forearms of about 40-220mm lengths, 20g-1.5kg in w eight, and 2m in wing length. The described forms of bats are located in sub-Saharan Africa, Western Oceania, and South Asia. The stared bats are having faces called "dog-like" due to similarities, sharp teeth and certainly powerful jaws are present, so that tough-skinned fruits can be consumed. Megachiropterans species are not hibernating, but control the body temperature within a tight range (Prothero, 2016; IUCN, 2017; York et al., 2019).

Microchiropterans should be certainly less than the megachiropterans (4-16cm in length), posessing a forearm that ranges from 22-110mm (Altringham, 1996). All the members of this family used insects as preys (to some extent); but some minorities have evolved into a feeding style that relies on blood, vertebrates, pollen, fruits, and additionally, nectar (Fenton & Simmons, 2015; York et al., 2019). They utilized echolocation during hunting to avoid obstacles, and they utilized hollow trees or caves to roost. They are able to adapt in a wide range of habitats, such as wet forest, dry forest, rainforests, swamps, open farms, and suburban places (Mickleburgh et al., 2009).

Bats are link to variety of internal and external parasites (like all other animals). Ectoparasites linked to bats consist of *Diptera* (flies), *Siphonaptera* (fleas), *Acaris* (ticks and mites), Hemiptera (bugs) and others (Okeke et al., 2020). Most studied parasites linked to bats, include, the bat flies – *Diptera:Streblidae* and *Nycteribiidae* (Okeke et al., 2020). The ectoparasites consume blood from their host, and are known to transmit haemoparasites and other disease-causing agents (like *Bartonella species* and *Trypanosoma species*) to their host (Billetter et al., 2012; Oca-Aguilar et al., 2024). Bats are also known to harbour a number of blood parasites such as *Bartonella, Piroplasms* (Babesia), *Trypanosomes* and *Microfilaria.* They also host a group of haemosorina (Apicomplexa) like *Plasmodium* species, Hepatocystis species, *Polychromophilus* species and *Nyciteria* species (Witsenburg *et al*., 2014; Kamani et al., 2024). Bats are carriers of zoonotic disease agents such as the Ebola virus, Nipah virus (Chua et al., 2002), and Hendra virus (Calisher et al., 2006; Bobrowiect et al., 2024) which are harmful to other animals, especially humans. Despite the multiple pathogens (virus, bacteria, fungi and protozoa) that Bats host, they rarely show clinical manifestation of diseases (Luis et al., 2013; Bobrowiect et al., 2024) because they are believed to have evolved to keep most pathogens in check (Hayman et al., 2008; Schneeberger, 2013; Oca-Aguilar et al., 2024). Bats also are able to harbor nemerous endoparasites including protozoans that cause malaria (eg *Plasmodium, Hepatocystis, Nycteria and Polychromophilus*) (Schaer et al., 2013; Gosik et al., 2024). Intestinal parasites of bats are derived from several species such as trematodes, gastrointestinal (GI) protozoa, nematodes. And equally cestodes have been dominantly reported from the bats of various geographies, therewith, they may remain as one of the major threats for their lives (McAllister *et al*., 2014; Santos and Gibson, 2015; McAllister et al., 2017; Costantini et al., 2019).

For a disease or infection to occur, the principal components of chain of disease transmission/disease triangle such as parasites, hosts (bats), and the environment most be unbroken (Alaka et al., 2020). Bats have similar anatomical structures to humans and are numerously found in regions of the world such as tropics, deserts, subtropics, are known for their behavior etc.; and they are known for their behavior of migrating during certain time of the seasons. They also roost in natural and artificial structures such as buildings; therewith, these behaviors give them the audacity and possibility to carry parasites along with them from one place to another and may have the opportunity to deliver parasites amidst humans. Certainly, in their environment where they live or migrate, their ability to house or shade numerous pathogens or parasites is acknowledged (Kamani et al., 2024). Bats are good in disguising numerous parasites while showing absent or minimal clinical signs of disease due to their adaptation skills and nature of immune systems. They are capable of transmitting dangerous zoonotic infections due to reasons such as similarity with humans, and their ability to dwell in almost every region of the world, etc (Alaka et al., 2020). A study conducted in bats in Southwestern part, Nigeria, shows the presence of haemoparasites such as *Babesia spp, Erhlichia spp, Hemosporidia spp, Anaplasma spp*, and *microfilaria*.

Bats are natural reservoir hosts of several infections. Knowledge is still limited about bats infections. Knowledge of the range of parasites that infest bats is required for better understanding of parasitic diseases in bats as well as human-bat interactions and potential for spillover of zoonotic diseases from bats to humans and domestic animals. Few studies have demonstrated the parasitic fauna in bats community. *Penicillidia conspicua* is an ectoparasite found parasitizing bats fauna. They are regarded as bat flies belonging to the Kingdom *Animalia*, Phylum *Arthropod*, Class *Insecta*, Order *Diptera*, Family *Nycteribiidae,* Genus *Penicillidia*. They are flattened, spiderlike flies without eyes or wings and as much bear very little resemblance to other *Dipterans*. These flies are seldom encountered by general collectors, as they almost never leave the bodies of their hosts.

They take blood meals, thus qualified as real parasites. One key morphological feature of *Penecillidia* is having backward folded legs that resemble that of spider and a dorsally inserted head (Bajić et al., 2023). Bats ectoparasite have vectorial potential. For example, *Polychromophilus species* are transmitted by *Nycteribiids* (Gardener and Molyneux, 1988; Miller- Bhutterworth et al., 2007). *Batronella* was detected in bat flies and their host in the Madagascan fruit bat indicating the potentially crucial role of bat flies in *Batronella* transmission (Brooks et al., 2018). The bat fly *Penicillidia conspicua* is a highly specialized, hematophagous, obligate ectoparasite that is closely associated with its bat hosts. It belongs to the *Nycteribiidae* family, which is characterized by its wingless nature and marked sexual dimorphism. *P. conspicua* has a unique reproductive strategy, known as obligate pseudo-placental unilarviparity, in which a single larva develops inside the female. The larva is deposited at the third instar and immediately undergoes pupation. The pupae are typically found on cave walls near the hosts. This bat fly species is highly specific to the cave-dwelling *Miniopterus schreibersii*, also known as the common bent-wing bat. However, it can occasionally be found on other bat species. Interestingly, *P. conspicua* often co-occurs with another bat fly species, *Nycteribia schmidlii*, which is also highly specific to *M. schreibersii*. The geographical distribution of *P. conspicua* mirrors that of its host, ranging from the Mediterranean region in Europe to northern Africa and the Middle East. Recent studies have discovered the presence of endosymbionts in *P. conspicua*, although the biological role of these endosymbionts remains to be explored. Overall, *P. conspicua* is a fascinating example of a highly specialized parasite that has evolved to thrive in a specific ecological niche. Further research is needed to fully understand the biology and ecology of this intriguing species (Szentiványi et al., 2020). Meanwhile, bats provide humans with some benefits at the cost of some threats. They provide important ecosystem services such as insect control, pollination and seed dispersal (Kamani et al., 2022). Bats dung has been mined as guano from caves and as fertilizers; they are sometimes numerous enough to serve as tourist attractions and are used as food across Asia, Africa and the Pacific. Outcome of this study would add to the existing knowledge of many parasitic diseases that are transmittable to human through the bats including the ectoparasites of bats found in Gulumbe and Masama area, Kebbi state, Nigeria. This study is aimed at investigating the prevalence and identification of common ectoparasites harboured by bats found in Gulumbe and Masama communities in Birnin Kebbi and Danko Wasagu Local Government Areas of Kebbi State, Nigeria.

2. Material and Methods

2.1.Study Area

The study was carried out in Gulumbe community in Birnin Kebbi Local Government Area and Masama community Danko Wasagu Local Government Area of Kebbi State, Nigeria. Gulumbe is located on the geographical coordinates of 12° 24′ 24″ North and 4° 21′ 29″ East. Masama is located on Latitude 11° 22′ 35.04″ North and 5° 47′ 43.30″ East, it has abundance of trees and is described as forests. According to 2006 census, Danko Wasagu Local Government has an estimated population of 265,203. Accordingly, the population of Birnin Kebbi Local Government is estimated to be about 268, 420 (NIPOST, 2009). In the study area, the noted mean annual rainfall was about 20 inches, which is falling during the wet season sandwiched between May and October. There is a Harmattan wind blowing from Sahara Desert of the North-Eastern part (from Niger

Republic side) in the mid-December and mid-February. The area is presumably having the High Plains of Hausaland as land formation, which are part of the pre-Cambrian basement complex consisting of very old crystalline rocks (granites and schists), the river valleys are shallow and wide, and the land is flat. The soil is ferruginous, and as well light in terms of texture. There is reservoir of underground water, and the surface water mostly dries off after the et season. Mostly, the crops grown in the area include, millet, corn, beans, rice, cassava, yam, tobacco, cotton, groundnut, seasame, onion, carrot, vegetables (such as tomatoes, *Amaranthus*), and fruits (such as mango, cashew) (Sokoto State Government, 1976).

2.2. Sample Size Determination

A simple random sampling technique was used in this study. The sample size was determined using the formula described by Suleiman et al., (2022) as follows;

$$\mathbf{n}= \frac{Z2P(1-P)}{d2}$$

Where;

n= sample size

Z= Score on normal standard variance curve that correspond to 95% (1.96) confidence level of significance

d= desired level of precision (5% ie 0.05) d^2

p= estimated prevalence of previous research of 25% as recorded by (Atama et al., 2019)

$$n = 1.96^2 \times 0.25 \times 0.75 / 0.0025 = 288.12$$

Approximately 289 samples of bats

For convenience 300 samples of bats were used for this study.

2.3. Bat Trapping

A total of 300 bats were captured around Mango trees in Gulumbe and Masama forests. The bats were trapped opportunistically using ground level mist nets and canopy nets. The trapped bats were kept individually in perforated cloth and transported to the Department of Veterinary Parasitology and Entomology, Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto. Standard measurement including sex, age, weight, forearm length and reproductive status was recorded and species were identified using the Key of Rosevear (1965).

2.4. Examination and Detection of Ectoparasites

Individual bats were carefully handled and examined for the presence of ectoparasites. The fur, wing membranes and ears of each bat were searched carefully with a lamp and visible ectoparasites were gently picked using fine forceps and placed in plastic Eppendorf tubes half filled with 70 percent ethanol. Placing the ectoparasites in 70 percent ethanol was to ensure that the specimens are not dehydrated and that important features remained intact (Nartey, 2015). Each sample was labeled with a unique number and locality. Ectoparasites that were preserved in ethanol were examined under a dissecting microscope and identified with various identification keys (Soulsby, 1982).

2.5. Data Analysis

Data obtained from this study was analyzed using Chi-square to test for association between prevalence and bat species. The level of significance was set at 5% (95% confidence interval).

3. Results

3.1. Distribution of Bats Captured and Identified from Gulumbe and Masama Communities

A total of three hundred bats were captured, out of this number, 150 were captured from Gulumbe while 150 were captured from Masama community. Of the total number of bats captured, 150 *Rousettus aegyptiacus* species were identified from Gulumbe Community, out of which 44 species of bats were infected with parasites. While in Masama community, 150 bats species were identified, out of which 49 were infected with parasite as shown by the results presented in Table 1.

3.2. Prevalence of Ectoparasites Detected and Identified in Gulumbe and Masama Communities

The prevalence of the ectoparasite detected and identified in Gulumbe and Masama Communities is presented in Table 2. Results show that in Gulumbe Community, of the 150 bats examined, 4 (2.7%) were infected. The ectoparasite detected was *Penicillidia cospicua*. While in Masama Community, 4(2.7%) of the bats were infected with ectoparasite. *Penicillidia cospicua* species of ectoparasite were also identified. Results show that there was no significant difference (p>0.05) in the prevalence of ectoparasite in the two communities.

Table 1. Distribution of Bats Captured and Identified in Gulumbe and Masama Communities

Study sites	Number of Bats Captured	Number of Infected (%)	Bat Species Identified
Gulumbe	150	44 (29.3%)	*Rousettus aegyptiacus*
Masama	150	49 (32.7%)	*Rousettus aegyptiacus*
Total	300	93 (31.0%)	

(Source: Laboratory Work, 2024)

Table 2. Prevalence of Ectoparasites Detected and Identified in Bat from Gulumbe and Masama Communities

Study sites	Number of Bats Examined	Number of Bats Infected (%)	Ectoparasites Species Identified
Gulumbe	150	4 (2.7%)	*Penicillidia cospicua* 4 (2.7%)
Masama	150	4 (2.7%)	*Penicillidia cospicua* 4 (2.7%)
Total	300	8 (2.7%)	

(Source: Laboratory Work, 2024)

$X^2 = 0.00$, df = 1, P-value = 1.000 ($P > 0.05$)

3.3. Prevalence of Ectoparasites Detected and Identified in Gulumbe and Masama Communities According to Sex of Bats

The prevalence of ectoparasite detected and identified in Gulumbe and Masama Communities according to sex of bats is presented in Table 3. Results show that in Gulumbe Community of the 150 bats examined, 66 were males and 84 were females. Out of 66 males 2 (3.03%) were infected and 2 (2.38 %) out of 84 females were infected. In Masama community, 1 (1.85%) out 54 males were infected and 3 (3.13%) out of 96 females were infected with ectoparasite. No significant difference ($P > 0.05$) was observed in the prevalence of ectoparasite according to sex in the two communities.

Table 3. Prevalence of Ectoparasites Detected and Identified in Bat from Gulumbe and Masama Communities According to Sex of Bats

	Gulumbe		Masama		
Sex	Number Examined	Number Infected (%)	Sex (%)	Number examined	Number infected
Male	66	2 (3.03%)	Male	54	1 (1.85%)
Female	84	2 (2.38 %)	Female	96	3 (3.13%)

(Source: Laboratory Work, 2024)

$X^2 = 0.342$, df = 1, P-value = 0.558 ($P > 0.05$)

4. Discussion

In this study, among the two study areas sampled, equal numbers of bats were captured in both Gulumbe and Masama communities. The occurrence and captured of more bats could be due to the abundance of fruits in the areas. The study has revealed that *Penicillidia cospicua* species of ectoparasite were detected in Gulumbe 4(2.7%) similar to what was detected in Masama. The detection of this species of ectoparasite on bats in the study areas is due to the obligate nature of the bat fly *Penicillidia cospicua*, the most specialized from the order diptera. It is an obligate ectoparasite species specialized to live in bat especially because of the roost environment of the bat and urge for blood of the bat.

One of the major concerns about the presence of the *Penicillidia cospicua* in bats is the occurrence of hyperparasitism (that is the parasitism on other parasites) usually by the two major families of *Nycteribiidae* and *Streblidae* (Haelewaters et al., 2021). The work of Haelewaters et al., (2021) also revealed the presence of these ectoparasites. Similarly, the findings in Haelewaters et al., (2017) revealed the presence of *Penicillidia cospicua* from Hungary and Romania. In a similar vein, Bajic et al. (2023) in their study in Serbia while analyzing Polychromophilus parasite infections of bats, show that, there was *Penicillidia species* in bats fly species, signifying the prevalence (and) distribution of Polychromophilus infections among bats in European bat species.

However, the finding of this study in both Gulumbe and Masama communities is not in agreement with the work of Hamidullah et al., (2021) in a study in Pakistan, in which only soft ticks, mites, *Streblidae*, species of ectoparasites were isolated and identified. Additionally, the finding of this study in Gulumbe and Masama communities is not in agreement with the work of Orlova (2011) which only mite species of ectoparasites were revealed. Likewise, Kumar et al., (2018) reported a finding that disagrees with this study in Gulumbe and Masama communities, in *which Basilica spp., Chiroptonyssus spp., Spinturnix spp.,* and *Argas spp*. were detected in India. Contrary to this study in Gulumbe and Masama communities, Sauqi et al., (2021) detected ectoparasites different from the ones identified in this work. Parable, the detection of parasitism is of concern. This may instigate the weakening of body's immunity and encouraging the invasion of other parasites and microbial agents, that could be threatening in two folds, by encouraging extinction of bats species in the area, despite their diverse ecological roles in ecosystem, and diseases to humans (Okeke et al., 2020; Gosik et al., 2024).

5. Conclusion

A study on bats captured from Gulumbe and Masama communities revealed that out of 300 bats, 150 from each community, 44 from Gulumbe and 49 from Masama were infected with parasites. The prevalent ectoparasite detected was Penicillidia cospicua, with a prevalence of 2.7% in both communities. No significant difference was observed in the prevalence of ectoparasites between the two communities or according to the sex of the bats.

6. Recommendations

Base on the available data obtained from this study the following recommendations were made:

- More broad study should be carried out to detail the various ectoparasites.
- That researchers should diverse more current methodologies in identifying both ectoparasites. Such methods include PCR, Molecular characterization and ELISA.
- That communities should be wary of the consumption of bats as bush meat and the consumption of fruits found in places where bats settled. Fruits should be thoroughly washed and clean before consumption and also avoid the consumption of left over to avoid possible transmission of diseases.
- People in the rural areas should be provided with safe drinking water to prevent them from drinking water from streams and rivers closed to bat habitat. Avoid direct contact with bats unless with Personal Protective Equipments (PPEs).

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