UMYU Scientifica, Vol. 4 NO. 2, June 2025, Pp 343 – 349
https://doi.org/10.56919/usci.2542.034
ISSN: 2955 – 1145 (print); 2955 – 1153 (online)
A periodical of the Faculty of Natural and Applied Sciences, UMYU, Katsina

ORIGINAL RESEARCH ARTICLE

A Survey of Haemoparasites of Bats in Lafia Metropolis, Nasarawa State, Nigeria

Alhassan Abdullahi Aliyu[1], Abajih Faith Saanmoyo[1], Mohammed Ahmed Ashigar[1], Akwashiki Ombugadu[1], Hussein Oshomo Ahmed[1], James Ishaka Maikenti[1], Simon A. Odey[1], Peter Osaghele Aimankhu[1], Abdulrazak Muhammad Idris[2] and Innocent Abimiku Polycarp[1]

[1]Department of Zoology, Federal University of Lafia, Nasarawa State, Nigeria
[2]Department of Medical Microbiology and Parasitology, Bayero University, Kano, Nigeria

ABSTRACT

Bats carry various protozoan blood parasites that could potentially be transmitted to humans, making it important to identify these parasites in order to implement effective public health strategies. Therefore, this cross-sectional study was conducted from November 2022 to January 2023 to determine the haemoparasite of bats in six (6) selected areas in Lafia. Standard mist net of 12m and 20m set at ground level were used over 12 non-consecutive nights from 6:15 to 10 pm. Two hundred and three (203) bats were trapped, belonging to five species of four families: *Tadarida brasiliensis*, *Eidolon helvum*, *Afronycteris nanus, Scotophilus leucogaster,* and *Rhinolopus landeri*. A thick and thin blood smear was used to detect the blood parasites of bats. Of the 203 bats examined, 52.21% infection was recorded. *Plasmodium spp* (67.0%), *Babesia* (23.6%), *Litomosoides microfilaria spp* (6.6%), *Trypanosoma spp* (2.8%). Of the six locations sampled, Bukan Kwato recorded the highest prevalence (29.25%), Gimare had the least prevalence (4.72%). Differences in the prevalence of haemoparasites in bats in relation to locations showed a very high variation ($\chi2$=22.826, df = 5, P-value = 0.0003645). Females had a higher prevalence (53.77%) than males (46.23%) and no variation ($\chi2$=0.56852, df = 1, P-value = 0.4508). Species prevalence shows *Tadarida brasiliensis* with the highest prevalence (63.21%), *Eidolon helvum* (16.04%), *Scotophilus leucogaster* (8.49%), *Afronycteris nanus* (6.60%), and *Rhinolophus landeri* (5.66%) and there was a significance difference ($\chi2$=120.02, df = 4, P < 0.0001). The study has established an update on the haemoparasites of bats in the Lafia metropolis. Further studies be conducted on related species identification to have more knowledge of haemoparasites of bats.

ARTICLE HISTORY

Received January 28, 2025
Accepted May 10, 2025
Published June 30, 2025

KEYWORDS

Parasites, Species, Locations, Sex

INTRODUCTION

Bats (order Chiroptera) are a highly diverse group, comprising over 1454 species within 227 genera (Kamani *et al.,* 2022). They serve as mammalian hosts for a wide variety of eukaryotic protozoan blood parasites, which include various species of trypanosomes and haemosporidian parasites (Clement et al., 2020), making them the second most diverse group of mammals after rodents (Austen and Amanda, 2021). These flying mammals are found in many regions around the world and are increasingly acknowledged as significant reservoir hosts for pathogens responsible for emerging infectious diseases, including viruses, bacteria, and protozoa, which can leap across species barriers to infect humans as well as other domestic and wild mammals (Sandor *et al.,* 2021). According to Austen and Amanda (2021), bats have been linked to the spread of high-impact viral zoonosis, including coronaviruses (particularly COVID-19), Ebola, Hendra, and Nipah paramyxoviruses, as well as severe acute respiratory syndrome. According to phylogenetic studies, bats have been crucial to the evolution of haemosporidian parasites, as they are home to the most diverse collection of these parasites among mammals. (Gabiliya and others, 2023). In Africa, the Trypanosoma species Sensu lato, *Trypanosoma vivax, Trypanosoma congolense*, and *Trypanosoma brucei* are dangerous to humans and animals (Kamani et al., 2022). They are incorporated into epidemiological surveys, specifically to identify blood protozoa peculiar to bats (Islam et al., 2020). Given that bats have a remarkable natural resistance to malarial parasites, studying their hemosporidia can further shed light on the evolutionary links between vertebrates and these parasites (Kamani et al., 2022). Due to their resurgence and the fact that several hosts, including bats, have been linked to their transmission, hemoparasites are becoming a global problem that has implications for both health and the economy (Austen and Amanda, 2021).

Correspondence: Alhassan Abdullahi Aliyu. Department of Zoology, Federal University of Lafia, Nasarawa State, Nigeria.
✉ alhasanaliyu2000@yahoo.com.

How to cite: Aliyu, A. A., Saanmoyo, A. F., Ashigar, M. A., Ombugadu, A., Ahmed, H. O., Maikenti, J. I., Odey, S. A., Aimankhu, P. O., Idris, A. M., & Polycarp, I. A. (2025). A Survey of Haemoparasites of Bats in Lafia Metropolis, Nasarawa State, Nigeria. *UMYU Scientifica*, 4(2), 343 – 349. https://doi.org/10.56919/usci.2542.034

Nigeria is a hotspot for bat diversity in Africa, home to around 85 species (Simmons and Cirranello, 2022). However, research on hemosporidian parasites and trypanosomes in Nigerian bats is concerning (Atama et al., 2019). In Lafia, Nasarawa State, earlier bat studies concentrated on zoonotic viral pathogens (Ameh et al., 2022); Ombugadu et al., 2021), with a study conducted in the western part of the state by Kamani et al. (2022) on the zoonotic parasites pathogens. In Lafia, bats have been observed residing on trees, abandoned structures, caverns, and rocks that may harbor parasites. This research focused on the prevalence of bat hemoparasites in Lafia, Southern part of Nasarawa State, Nigeria, an area previously studied for zoonotic viral pathogens but not extensively for hemoparasitic infections. The study employs the Giemsa stain method to identify and analyze the presence of hemoparasites in bats, thereby filling a significant research gap in the understanding of bat-associated blood protozoa in this region. Additionally, this work contributes to the broader knowledge of the role of bats as hosts for hemoparasitic infections, emphasizing their importance in disease ecology and public health within a biodiversity hotspot for bats in Nigeria. It also addresses the implications of these parasites for both human and animal health, highlighting the interconnectedness of bat populations and emerging infectious diseases.

MATERIALS AND METHODS

Study Areas

Nigeria's Nasarawa State capital, Lafia Local Government Area, served as the study's site. The North Central area of Nigeria is where it is situated, about around latitude 80 24I N, 901 IE and longitude 80 13I E, 90 8 I N. Approximately 2797.53 km2 in total, Lafia has borders with Plateau State to the northeast, Obi and Doma L.G.A. to the south, Nasarawa Eggon to the west, and Wamba LGA to the north. Trade, public transportation, and food vending are among the local activities. The bats' roost is located in the Neem tree (*Azadirachta indica*), one of the principal plants. The rainy and dry seasons are the two different seasons of its tropical sub-humid climate. In contrast to the dry season, which runs from November to March, the wet season spans seven months, from April to October. There is moderate rainfall in Lafia, between 1200 and 1600 mm. The average daily temperature during the rainy season is 35°C and 21°C, whereas during the dry season, it is 37°C and 16°C. When the town became the capital of Nasarawa State in 1996, it began to become more urbanized. Most of the habitat depends on subsistence farming, and because it serves as Nasarawa State's administrative hub, it has grown cosmopolitan (Agidi *et al.,* 2022).

Study Site

The study was carried out in six (6) selected areas of Lafia Local Government, Nasarawa State, Nigeria. The sites were selected based on their accessibility and the strong presence of bats.

Sampling Sites

Bats were collected from Mararaba, Gandu, BukanKwato, Phase II, Gimari and Kwandere road (Alamis) in Lafia. Bats were sampled for 12 non-consecutive nights.

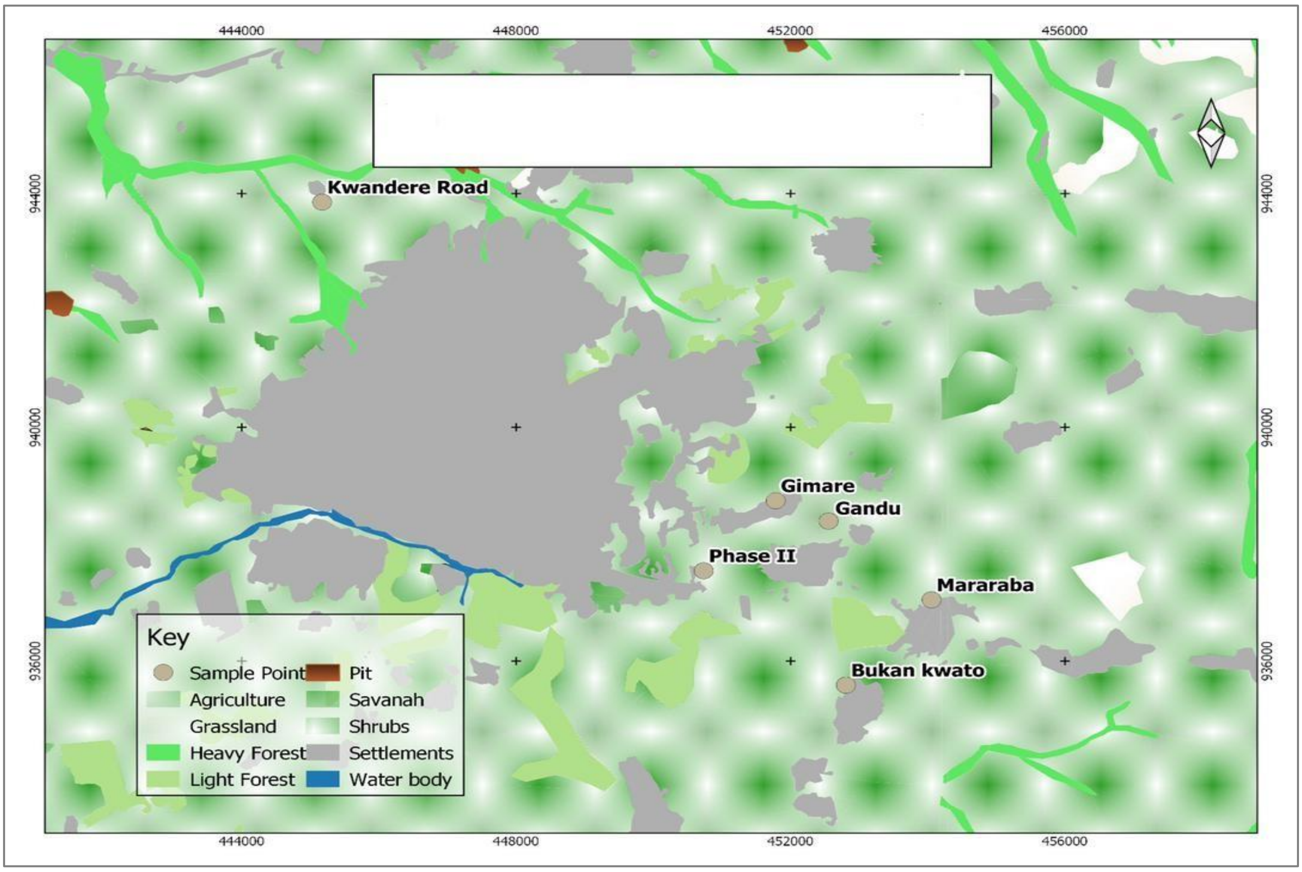

Figure 1: Map of Lafia, Nasarawa State, showing the sampled locations (NGIS, 2023)

Trapping of Bats

Mist nets were set in selected areas with a high presence of bats. The net was opened from 6.15 pm to 10 pm and inspected every 20mins to ensure that the bats captured did not stay too long in the net struggling. Bats hunt at night for food; therefore, it was necessary to work on them quickly and release them to go and feed. Captured bats were removed, and placed in soft sacs and brought to the working area for the collection of Blood. After blood collection, all bats were marked with a maker individually to recognize recaptures. Procedures followed the protocols by Nei and Kumar (2020); BFSM (2022). The bats were released with care to the wing clearances. Recaptures were released at the study site without re-sampling. To avoid any direct contact with bats, Personal Protective Equipment was used in line with the "Code of Ethics for the practice of catching bats" designed as part of the National Plan of Chiropteran Actions 2009-2013. Bats were identified with the help of a field guide, 'Bats of West Africa' by (Ruedas *et al.,* 2017)

Blood Collection

Using a sterile 5ml disposable syringe, blood samples were obtained by puncturing the cephalic vein, a conspicuous vein that runs up the top portion of the propatagium. The samples were then preserved in EDTA vials and sent to the laboratory for diagnosis. As stated by WHO (2016), the blood samples that were not processed right away were kept at 20°C until they were needed.

Haemoparasite Screening

Two types of blood smears were prepared for each bat:

Thin blood smear for parasite morphology analysis

Thick blood smear for increased sensitivity in detecting low parasitemia

Thin Blood Smear Preparation

A small drop of blood was placed near one end of a clean glass slide. A spreader slide was used to evenly distribute the blood at a 45° angle, creating a thin monolayer. The smear was air-dried for 5 minutes and then fixed with absolute methanol for 1–2 minutes (WHO, 2016)

Thick Blood Smear Preparation

A larger drop of blood was placed at the center of a slide. The drop was spread into a small circular area (about 1 cm in diameter) using the corner of another slide. The thick smear was left to air dry for 10–15 minutes without methanol fixation to preserve red blood cells for better parasite detection (WHO, 2016)

Staining Procedure (Giemsa Staining)

Once dried, slides were immersed in a 10% Giemsa stain solution for 10–15 minutes. After staining, slides were gently rinsed with buffered distilled water (pH 7.2) to remove excess stain. The slides were air-dried completely before microscopic examination.

Microscopic Examination

Stained slides were examined under a compound light microscope at X100 magnification using oil immersion. A systematic scan of each slide was conducted to detect haemoparasites, with at least 100 fields examined per slide. Identified parasites were classified based on morphological characteristics using reference taxonomic guides (WHO, 2016). Plasmodium species were identified by the presence of ring forms, schizonts, or gametocytes within red blood cells; *Babesia spp* by the presence of small, round or ovoid trophozoides, pear – shaped merozoites. Other haemoparasites (e.g., *Trypanosoma*, *Microfilaria*) were identified based on distinctive structural features

Data Analysis

Data generated were calculated, expressed as simple frequency and percentages, and analyzed using SPSS software version 20.1. Chi-Square was used to compare the difference between variables.

RESULT

A total number of 203 bats belonging to four families and five species were recorded, with the highest number captured from the species; *Tadarida brasiliensis* 132 (65.02%) of the family molosidae, followed by *Eidolon helvum* 32 (15.76%) of the family Pteropodidae, *Scotophilus* of the family Vespertionidae 16 (7.881%), *Afronycteris nanus* 16 (7.881%) also of the family Vespertitionidae and *Rhinolophus landeri*in the family Rhinolophidae 7 (3.448%) Table 1.

Plasmodium species 71 (34.97%) comprised the most predominant hemoparasites, followed by Babesia 25 (12.31%), Microfilaria 7 (3.448%), and Trypanosoma species 3 (1.477%) respectively had the lowest number of hemoparasites Table 2.

Location-based prevalence revealed the highest prevalence in Bukan Kwato 31(29.2%), followed by Kwandare road 25(23.6%), Gandu 18(16.9%), Mararaba 15 (14.1%), Phase II 12(11.3%) and Gimare had the least prevalence rate of 5 (4.71%) and its statistically significant (χ^2=22.826, df = 5, P-value = 0.0003645 Table 3).

Haemoparasites of bats in relation to bat species showed that *Tadarida brasiliensis* hosted the highest prevalence 67 (63.2%), followed by *Eidolon helvum* 17(16.0%), Scotophilus *leucogaster* 9 (8.94%) and Afronycteris nanus 7 (6.60%). The lowest prevalence of haemoparasites was recorded in *Rhinolophus landeri* 6 (5.66%), and there was a high significant difference (χ^2=120.02, df = 4, P < 0.0001) as shown in Table 4.

Prevalence of haemoparasites in relation to sex showed a higher prevalence 57 (53.8%) in female bats than the male bats 49 (46.2%), and it is not statistically significant (χ^2=0.56852, df = 1, P-value = 0.4508) Table 5.

DISCUSSION

Globally, bats are becoming more and more acknowledged as significant reservoir hosts for diseases that affect both humans and animals. This work adds to the limited understanding of bat hemoplasmidian parasites in Lafia, Nasarawa State, Nigeria. The total prevalence of hemoparasites is 52.22%, which is greater than the prevalence of bat hemoparasites (44%) in Anambra State reported by Okeke et al. (2020) and (25%) respectively, in Amurum forest reserves, Nigeria, reported by Atama et al. (2019). A serious ectoparasite infection in the bats may be the cause of this high occurrence. The likelihood of humans and other animals catching this is high. Bats with hemoplasmidian parasites suggest a risk of zoonotic transmission to people and other animals. Because bats live so near to human settlements in urban areas, there is a greater chance of zoonotic disease outbreaks between people and animals. Infestations of severe ectoparasites, such as mites, fleas, or ticks, might worsen the high frequency of hemoparasites because they can serve as disease-transmission vectors. Ectoparasites can either directly or indirectly help bats spread blood-borne infections to their predators, which can include people.

Table 1. Distribution of Bat Species in Lafia Metropolis, Nasarawa State

Family	Genus	Species	Frequency (%)
Molossidae	*Tadarida*	*brasiliensis*	132 (65.0)
Pteropodidae	*Eidolon*	*helvum*	32 (15.8)
Vespertilionidae	*Scotophilus*	*leucogaster*	16 (7.88)
Vespertilionidae	*Afronycteris*	*nanus*	16 (7.88)
Rhinolophidae	*Rhinolophus*	*landeri*	7 (3.44)
Total			203 (100)

Table 2. Distribution of Haemoparasites identified from Bats in Lafia Metropolis, Nasarawa State

Haemoparasites	Frequency	Percentages
Trypanosoma spp	3	2.8
Plasmodium spp	71	67.0
Babesia Spp	25	23.6
Microfilaria spp	7	6.6
Total	**106**	**100.0**

Table 3 Location based distribution prevalence of haemoparasites of Bats in Lafia Metropolis, Nasarawa State

Location	No. Examined	No. Positive (%)
Mararaba	25	15(13.20)
Gandu	29	18(16.98)
Phase II	20	12(11.3)
Bukankwato	54	31(29.25)
Gimari	11	5(4.72)
Kwandare road (Alamis)	64	25(23.58)
Total	**203**	**106 (100%)**

(χ^2=22.826, df = 5, P-value = 0.0003645,

Table 4: Distribution of Haemoparasites of Bats based on species in Lafia Metropolis

Bats Species	Haemoparasites Examined (%)	Total Examined (%)
Tadarida brasiliensis		
Plasmodium spp	53 (50.0)	67(63.21)
T. spp	2 (1.9)	
Babesia spp	6 (5.7)	
Microfilariae	6 (5.7)	
Eidolon helvum		
Plasmodium spp	9 (8.5)	17(16.04)
Babesia spp	8 (7.5)	
Afronycteris nanus		
Plasmodium spp	3 (2.8)	7(6.60)
Microfilaria spp	1 (0.9)	
Babesia spp	3 (2.8)	
Scotophilus leucogaster		
T. spp	1 (0.9)	9(8.49)
Plasmodium spp	2 (1.9)	
Babesia spp	6 (5.7)	
Rhinolophus landeri		
Plasmodium spp	4 (3.8)	6(5.66)
Babesia spp	2 (1.9)	
Total	106 (100.0)	106(100)

χ^2=120.02, df = 4, P < 0.0001

Table 5. Prevalence of Haemoparasites of Bats based on Sex in Lafia Metropolis, Nasarawa State.

	No. Examined	No. Positive (%)
Male	100	49(46.2)
Female	103	57(53.8)
Total	203	106(100.0)

χ^2=0.56852, df = 1, P-value = 0.4508

Hemoplasmid parasites' capacity to adapt and endure in bat populations raises worries about the potential for the formation of novel infections that might have an impact on the health of humans and animals, particularly in regions with dense human-animal interactions or high bat populations. Enhanced surveillance efforts in public health systems may be necessary due to an increase in hemoparasite prevalence, especially in areas close to bat habitats. This would entail regular bat population monitoring in addition to studies on the ecological dynamics of these parasites to identify any hazards. Bats have an essential ecological function in seed dispersal, pollination, and pest control. Diseases caused by parasites may lead to decreased bat health, disrupting their habitats and impacting local biodiversity and agriculture. Interaction is more likely as metropolitan areas grow and human activity invades bat habitats. Those who interact closely with bats, such as researchers, wildlife handlers, and local residents, may be particularly vulnerable to the spread of zoonotic illnesses due to this human-animal contact.

Plasmodium spp., Trypanosoma spp., Babesia, and Litomosoides microfilariae were found in all bat species that were captured. This finding is in line with Okeke et al.'s (2020) discoveries in the Ogbunike caves in Anambra State, Southeast Nigeria, but it also contradicts Kamani et al.'s (2022) observations of Trypanosoma spp. and Hepatocystis spp. in the western part of Nasarawa State.The expansion of metropolitan areas and human activities' invasion of bat habitats increase the likelihood of interaction. The identification of parasite illnesses in bats, such as those caused by Plasmodium species, Trypanosoma species, Babesia, and Litomosoides microfilariae, presents serious public health issues and draws attention to zoonotic implications that require further investigation. For example, human malaria is known to be caused by Plasmodium spp., yet the species that infect bats might vary.

Nevertheless, there is always a chance of cross-species transmission, particularly if the environment encourages bat-human contact. Trypanosoma species, which cause illnesses like Chagas disease in humans, can be dangerous if they spread through bat-human contact or by insects that bite humans. Babesia species, like Plasmodium, can cause severe sickness in people, especially when transmitted by ticks and perhaps other bat-borne vectors. Lymphatic filariasis may result from Litomosoides microfilariae. Emerging illnesses are more likely in areas where bat habitats and mosquito populations coexist. Bats' numerous parasites underscore the risk of newly developing infectious illnesses. Since animal reservoirs are frequently the source of zoonotic infections, knowledge of bat population dynamics is essential for predicting and averting epidemics in human population (Gashaw and Meseret, 2022).

Bukan Kwato having the highest occurrence (29.25%). Bats aid in the pollination and seed dissemination of several tree species, including cashew and mango trees. Bats also uses these trees as roosts, and arthropod ectoparasites usually transmit hemoparasites to neighboring groups. People may come into direct touch with bats or bat droppings (guano), particularly if they live in regions where bats roost or eat, increasing the community's risk of disease transmission.

Pathogen transmission may result from this. Zoonotic transmissions can occur through indirect touch, ingestion, or interaction with animals that have had bat encounter. For example, wildlife or domestic animals that come into contact with diseased bats may act as vectors. An accumulation of bat guano can provide conditions that allow diseases to proliferate. Guano fungi may release spores into the air, which can be harmful to the respiratory system. Fugivorous bats usually suck the juice of the fruit instead of eating the whole fruit. They might significantly impact the transmission of infectious organisms to rural communities, particularly to small children who collect such bat-discarded fruits. Each year, 600 million people suffer from foodborne disease and 400,000 people die as a result of eating tainted food. These foodborne infections are caused by contaminated water, fruits, vegetables, and animal products (Li et al., 2022). Furthermore, these vectors may thrive and multiply in warmer, more humid environments, which raises the prevalence of hemoparasites in bat populations. Temperature can also directly affect certain parasites' reproduction rates, copulation, oviposition, egg survival, and adult lifetime (Bezera et al., 2023).

Male and female bats differ in the frequency of hemoparasite infection. These investigations show that the prevalence of hemoparasite infections is greater in female bats (53.77%) than in male bats (46.23%). The higher prevalence of hemoparasites in female bats could indicate a larger pathogen reservoir, increasing the risk of spillover to humans or other animals, especially during specific life stages, such as during pregnancy or when raising young. With respect to the impact of host sex on parasitism, the higher prevalence rates in females observed in this study supported the results of Bocchiglieri and Bezera (2018) in Brazil, who discovered greater parasitism rates in females of *A. lituratus* and *Sturnira lilium*. Higher rates of hemoparasitic infections might impact the overall health and survival of female bats, potentially leading to population declines. A decrease in bat populations can disrupt local ecosystems, as bats play critical roles in controlling insect populations, pollinating agents and dispersing seeds. Female bats may serve as more competent vectors for zoonotic pathogens due to the immune modulation effects of hemoparasite infections. This could enhance the transmission potential of other pathogens that co-infect bats.

Because of their more sociable behavior throughout the reproductive stage and when caring for their progeny, certain females may have higher parasitism and stay in the shelter longer. Females may also become less active during reproduction, lessen the intensity of their grooming, and lessen their motor activity during the nesting season. One of the primary causes of parasite death, these conditions raise the likelihood that they may become infected with hemosporidians (van Schaik, 2017).

The prevalence of hemoparasites in Tadarida species, particularly Tadarida brasiliensis, has significant implications for public health and zoonotic risks. Tadarida brasiliensis migrates and roosts in diverse environments, which increases its contact with various vectors and hosts. This widespread interaction heightens the likelihood of these parasites spilling over into new populations, including humans. The migratory behavior of Tadarida species means they inhabit multiple ecosystems, potentially interacting with various wildlife species and domestic animals. Each of these interactions presents a unique opportunity for the exchange of parasites. If Tadarida acquires hemoparasites from other hosts, this could lead to the emergence of more diverse and virulent parasite strains that may pose a higher risk to human health. Moreover, as Tadarida species migrate, they may contribute to the emergence of new diseases in regions previously unaffected by those pathogens (Oyewo *et al.,* 2021). Additionally, increased interactions between bats and humans—driven by urbanization or habitat alteration—can further exacerbate these risks.

CONCLUSION

This study has established an overall prevalence (52.22%) of haemoparasites of bats. Four species of hemoparasites (*Plasmodium spp*, *T. spp*, *Babesia,* and *Limotosoides*) were identified. Therefore, trees and bushes should be trimmed, remove bats food sources, identify and seal all potential entry holes, roof junctions of bats in our environment to avoid human contact by preventing possible transmission of zoonotic diseases. Further studies should be conducted using PCR to differentiate between closely related species of blood parasites in bats that cannot be distinguished morphologically. This approach will enhance our understanding and knowledge of the haemoparasites of bats in the zone.

ACKNOWLEDGMENTS

The authors wish to acknowledge the leaders and community members in the six locations selected for this study. Miss S. A. Saanmoyol who was instrumental in the laboratory.

REFERENCES

Agidi, V. A., Ogah, H., Ulor, C., & Baleri, G. T. (2022). Diurnal temperature range as an index of climate change in Lafia, Nasarawa State, Nigeria. *Journal of Applied Science and Environment, 26*(2), 9. [Crossref]

Ameh, V. O., Chirima, G. J., Quan, M., & Sabeta, C. (2022). Public health awareness on bat rabies among bat handlers and persons residing near bat roosts in Makurdi, Nigeria. *Pathogens, 11*(9), 975. [Crossref]

Atama, N., Manu, S., Ivande, S., Rosskopf, S. P., Matuschewski, K., & Schaer, J. (2019). Survey of Hepatocystis parasites of fruit bats in the Amurum forest reserve, Nigeria, identifies first host record for *Rousettus aegyptiacus*. *Parasitology, 146*(12), 1550–1554. [Crossref]

Austen, J. M., & Barbosa, A. D. (2021). Diversity and epidemiology of bats trypanosomes: A One Health perspective. *Pathogens, 10*(9), 1148. [Crossref]

Biodiversity Research Institute. (2022). *Bat field sampling methods*. 276 Canco Road, Portland, Maine, USA. briwildlife.org

Bezerra, R. H. S., & Bocchiglieri, A. (2023). Ectoparasitic flies of bats (Mammalia: Chiroptera) in urban green areas of northeastern Brazil. *Parasitology Research, 122*(1), 117–126. [Crossref]

Bocchiglieri, A., & Bezerra, R. H. (2018). First record of *Myotis riparius* Handley, 1960 (Chiroptera, Vespertilionidae) in Sergipe, northeastern Brazil. *Check List, 14*(5), 817–821. [Crossref]

Clement, L., Dietrich, M., & Markotter, W. (2020). Out of Africa: The origins of the protozoan blood parasites of the *Trypanosomiasis cruzi* clade found in bats from Africa. *Molecular Phylogenetics and Evolution, 145*, 106705. [Crossref]

Gabiliga, N. T., Magloire, B., Bertrand, A. M. C., Adama, O., Oskar, W., & Juliane, S. (2023). First investigation of blood parasites of bats in Burkina Faso detects *Hepatocystis* parasites and infections with diverse *Trypanosoma* spp. *Parasitology Research, 122*, 3121–3129. [Crossref]

Gashaw, A. E., & Meseret, B. A. (2022). One Health approach for the control of zoonotic diseases, *2*(1). [Crossref]

Islam, S. R. U., Ahmed, M. K., Rahman, J., Ferdous, M. H., Uddin, S., Akter, A. A., Faruq, M. M., Hassan, A. I., & Islam, A. (2020). Detection of hemoparasites in bats, Bangladesh. *Journal of Threatened Taxa, 12*(10), 16245–16250. [Crossref]

Kamani, J., Atuman, Y. J., Oche, D. A., Shekaro, A., Werb, O., Ejotre, I., & Schaer, J. (2022). Molecular detection of *Trypanosoma* spp. and *Hepatocystis* parasite infections of bats in Northern Nigeria. *Parasitology, 149*, 1460–1467. [Crossref]

Kontschán, J., & Mihalca, A. D. (2021). Wide distribution and diversity of malaria-related haemosporidian parasites (*Polychromophilus* spp.) in bats and their ectoparasites in Eastern Europe. *Microorganisms, 9*(2), 230. [Crossref]

Li, Q., Guo, C., Hu, H., & Lu, J. (2022). Towards One Health: Reflections and practices on the different fields of One Health in China. *Biosafety and Health, 4*(4), 23–29. [Crossref]

Nasarawa State Geographic Information System. (2023). Retrieved January 23, 2023, from nagis.na.gov.ng

Nei, M., & Kumar, S. (2020). *Molecular evolution and phylogenetics*. Oxford University Press.

Okeke, O. P., Okeke, J. J., Orjiagu, E. V., Ononye, B. U., Udeh, N., Ike, I. M., & Imakwu, C. A. (2020). A survey on the ectoparasites and haemoparasites of bats trapped in Ogbunike Caves, Anambra State, Nigeria. *South Asian Journal of Parasitology, 3*(4), 183–187. sdiarticle4.com

Ombugadu, A., Abbas, A. A., Namo, J. E., Echor, B. O., & Ahmed, H. O. (2021). Novel Covid-19: Outbreaks status in two main regions of Nigeria and the public health implication of bats population dynamics in urban settlements. *Biomedical Journal of Scientific & Technical Research, 33*(5). [Crossref]

Oyewo, H. O., Adeyanju, A. T., & Adeyanju, T. E. (2021). Abundance, roost characteristics and flora dispersed by African straw-coloured fruit bat *Eidolon helvum* from two sites in southwest Nigeria. *Journal of Research in Forestry, Wildlife & Environment, 13*(3), 1–10. ajol.info

Ruedas, L. A., Silva, S. M., French, J. H., Platt, R. N., Salazar-Bravo, J., Mora, J. M., & Thompson, C. N. (2017). A prolegomenon to the systematics of South American Cottontail Rabbit. *Museum of Zoology, University of Michigan, 205*, 67. [Crossref]

Sándor, A. D., Péter, Á., Corduneanu, A., Barti, L., Csösz, I., Kalmár, Z., Hornok, S., Simmons, N. B., & Cirranello, A. L. (2022). Bats species of the world: A taxonomic and geographic database (Version 1.7). Retrieved November 4, 2022.

World Health Organization. (2016). *Collection of blood and preparation of thick and thin blood films*. Malaria Microscopy Standard Operating Procedure (Technical Document). who.int

Simmons, N. B. Cirranello, A. L. (2022). Bat Species of the World: A Taxonomic and Geographic Database. Available online: batnames.org (accessed on 20 February 2022).

van Schaik, J., Kerth, G. (2017). Host social organization and mating system shape parasite transmission opportunities in three European bat species. *Parasitol Res 116*, 589–599. [Crossref]