Asian Australas. J. Biosci. Biotechnol. 2026, 11(1), 5-17; https://doi.org/10.3329/aajbb.v11i1.85756

**Asian-Australasian Journal of Bioscience and Biotechnology**
ISSN 2414-1283 (Print) 2414-6293 (Online)
https://www.ebupress.com/journal/aajbb/

*Article*

# Ectoparasite burden in mice living in the Abokouamékro fauna natural reserve and border villages in central part of Côte d'Ivoire

Kassi Bohoussou Georges[1]*, Ahouty Ahouty Bernardin[2], Simaro Siriki[3], Oscar Nyangiri[4], Abe Allépo Innocent[1], N'djetchi Kassi Martial[1], Yeboue Kouadio Félix[3], Konan Konan Thomas[1] and Koffi N'goran Mathurin[1]

[1]Science Biologie, UFR Environnement, Université Jean Lorougnon Guédé (UJLoG), Daloa, BP 150, Côte d'Ivoire
[2]Science Biologie, UFR Agroforesterie, Université Jean Lorougnon Guédé (UJLoG), Daloa, BP 150, Côte d'Ivoire
[3]Science Biologie, UFR Biosciences, Université Alassane Ouattara (UAO), BP V 18 Bouaké 01, Bouaké, Côte d'Ivoire
[4]College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University, P.O. Box 7062, Kampala, Uganda

*Corresponding author: Kassi Bohoussou Georges, Science Biologie, UFR Environnement, Université Jean Lorougnon Guédé (UJLoG), Daloa, BP 150, Côte d'Ivoire. E-mail: georgesksi40@gmail.com

Received: 22 November 2025/Accepted: 03 March 2026/Published: 01 April 2026

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**Abstract:** Mice are important pathogen vectors that infect humans and their livestock. They have been described as potential or important carriers for a number of zoonotic pathogens, considered as sources for significant human morbidity and mortality. They live in modified habits as well as natural habits like natural reserves. Abokouamekro, a fauna natural reserve is a prominent tourist spot in the country's political capital which is so anthropized, an investigation into ectoparasite infestation among mice has never been performed. Thus, the aim was to determine the dynamic of ectoparasites infestation in wild mice in this area. Mice sampled by using live-traps baited with smoked fish and carried out from November 2021 to April 2023. Traps placed in evening and visited next day at twilight. Mice were anesthetized and released after determination of sex and age following by ectoparasite collection. 256 mice were trapped of which the majority in villages (63.67 %) with a sex ratio (Male/Female) of 0.94 (124/132). Most captured mice were juveniles, 75.27 % in villages. 288 ectoparasites were counted and collected among which 182 in the forest reserve. Number of mice hosting ectoparasites differs significantly according to the season (OR= 2.66; 95%CI = [1.03-6.87]; $P$ = 0.036). Ectoparasites species belong to four subclasses of two arthropod classes. Constituent Ratio (C) and Prevalence (p) were indices that vary significantly for *Xenopsylla cheopis* specie ($P$ < 0.0001; $P$ < 0.0001) and for *Laelaps echidninus* specie ($P$ = 0.0081; $P$ = 0.04468). In Conclusion, different ectoparasite species injure mice with an important risk during dry season and they may be transmitting bacteria and virus to animals and humans. The findings indicate that, although the risk of injury to mice remains high during the dry season, regular monitoring of both mouse health and the health of surrounding populations is necessary.

**Keywords:** potential reservoir; species; host; vectors; dry season

## 1. Introduction

Mice are important disease vectors capable of transmitting pathogens to humans and livestock (Basiouni *et al*., 2025). They thrive in a wide range of environments, including natural habitats such as savannahs and forests as well as modified environments such as houses and storage facilities (Abdel-Rahman *et al*., 2020). Although the overall impact of mouse-borne zoonoses may sometimes appear limited, it remains far from negligible (Shehata *et al*., 2025). Consequently, mice represent a significant concern for both human and animal health. These rodents can harbor numerous pathogens, including viruses, bacteria, and parasites, encompassing both endoparasites and ectoparasites (Mohd-Qawiem *et al*., 2024).

Ectoparasites are organisms that live on the external surface or appendages of another organism, referred to as the "host," for a certain period of time (Abuzahra *et al*., 2025). Most ectoparasitic species are invertebrates belonging primarily to the arthropod classes Arachnida and Insecta (Mohd-Qawiem *et al*., 2024). The class Arachnida mainly includes mites and ticks, whereas the class Insecta comprises lice and parasitic fleas (Abdel-Rahman *et al*., 2020). Ectoparasites may either remain permanently attached to their hosts or inhabit the host's nest and surrounding environment, periodically visiting the host's body. In both cases, they rely heavily on the host for essential resources required for their survival (Farid *et al*., 2021).

Ectoparasites can transmit numerous skin diseases and infections to humans, including dermato-zoonoses, which require rapid identification to minimize public health risks. The close contact between rodents, humans, and livestock therefore constitutes a significant pathway for disease transmission (Ahmed *et al*., 2025). Understanding the modes of transmission—whether through direct contact, indirect environmental exposure, or vectors—is essential for evaluating the risks to human health and for implementing appropriate hygienic and therapeutic management strategies. As a result, the relationships between ectoparasites and their hosts have been investigated in various ecological contexts, including wildlife reserves, often revealing diverse patterns of infestation (Obiegala *et al*., 2021).

Despite the increasing anthropogenic pressure on natural reserves in Côte d'Ivoire, such investigations remain largely absent. Previous studies in the country have primarily focused on endoparasites, particularly in Abidjan and the West-Central regions (Félix *et al*., 2020; Tuo *et al*., 2023). Therefore, there is an urgent need to document the ectoparasite fauna associated with rodent populations in these evolving environments. Such information is crucial not only for assessing immediate infection risks but also for identifying the ecological drivers of zoonotic transmission and preventing potential disease outbreaks in human populations.

The present study aimed to identify ectoparasite species associated with mice inhabiting the Abokouamékro Natural Reserve and its surrounding villages, an area characterized by intense biological activity (Julien, 2018). Specifically, this research sought to determine the infestation patterns and prevalence of ectoparasites in wild mouse populations within the study area. This study focused on the identification of ectoparasite species in mice inhabiting the Abokouamékro Natural Reserve and its bordering villages, an area characterized by intense biotic activity (Julien, 2018).

Despite the recognized role of rodents as reservoirs and vectors of zoonotic pathogens, information on the diversity and prevalence of ectoparasites associated with wild mice in Côte d'Ivoire, particularly within protected areas and their surrounding human settlements, remains scarce, leaving an important gap in understanding the potential risks of rodent-borne disease transmission in these environments. The central research question of this study was, which ectoparasite species infest wild mice inhabiting the Abokouamékro Natural Reserve and its surrounding villages, and how do the patterns and prevalence of infestation differ across habitats and seasons? We hypothesized wild mice living in the Abokouamékro Natural Reserve and nearby villages host diverse ectoparasite communities, with infestation prevalence and intensity differing according to habitat type and seasonal conditions. The objective of this study was to identify the ectoparasite species associated with wild mice in the Abokouamékro Natural Reserve and its surrounding villages and to determine the patterns and prevalence of ectoparasite infestation within these mouse populations. The findings will contribute to improved knowledge of rodent–ectoparasite interactions in a tropical reserve ecosystem and provide baseline information useful for assessing zoonotic disease risks, supporting public health surveillance, and guiding wildlife and environmental management strategies in the region.

## 2. Materials and Methods

### 2.1. Ethical approval and informed consent

The study protocol was reviewed and approved by the Ethics Committee of the Ivoirian Office of Parks and Reserves under the reference number N°0684/MINEDD/OIPR/DGA/ORA. Verbal informed consent was obtained from the local authorities and from the residents whose houses were used as trapping sites in the case of the villages.

## 2.2. Study area and period

The Abokouamékro Fauna Natural Reserve is located in central Côte d'Ivoire, within the department of Yamoussoukro, the political capital of the country (7°04′13″ N, 5°05′20″ W). The reserve covers approximately 20,400 hectares and is composed of savannah, forest, and transitional vegetation zones. The climate of the area is sub-equatorial, with an average annual rainfall ranging from 992 to 1,365 mm (Lauginie, 2007). In addition, the average relative humidity in the region is approximately 75%, and the mean annual temperature is around 26 °C (Dekoula *et al*., 2018). The reserve experiences four distinct seasons, including two dry seasons and two rainy seasons. The major dry season extends from November to March, while the major rainy season occurs from April to June. A short dry season occurs in July, followed by a short rainy season from August to October. Mouse trapping was conducted in the Abokouamékro Fauna Natural Reserve and in three surrounding villages bordering the reserve, namely Abokouamékro, Labokro, and Gofabo (Figure 1). The study period extended from November 2021 to April 2023.

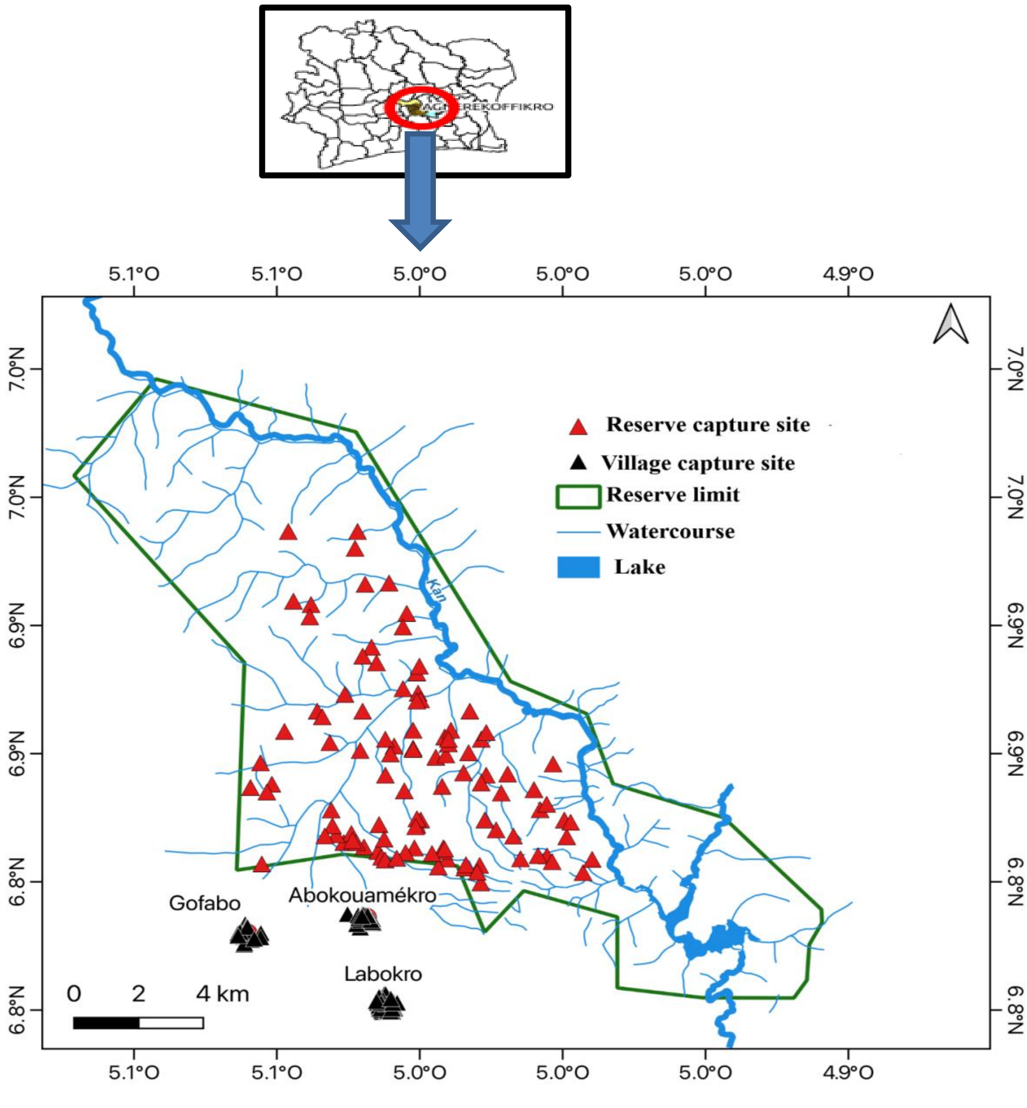


**Figure 1. Map of the study area showing the Abokouamékro Fauna Natural Reserve and the surrounding villages where mouse trapping was conducted.**

## 2.3. Trapping methods

The mouse sampling was conducted from November 2021 to April 2023, with seven trapping days each month, corresponding to a total of 126 trapping nights. Mice were captured using live traps measuring 13.5 × 13.5 × 25 cm, manufactured in Côte d'Ivoire, with an approximate weight of 0.31 g. The traps were baited with smoked fish due to its strong odor and attractiveness to rodents (Figure 2).

**Figure 2. Live trap used for capturing mice during field sampling.**

In each specific zone of the reserve—namely the forest, savannah, and transition areas—four (4) traps were installed at 25 m intervals, forming a square configuration. In the villages, two imaginary lines were used to divide each village into four sectors, and one trap was placed in a house within each sector. In total, trapping was conducted at six (6) sampling sites, including three (3) within the reserve and three (3) in the surrounding villages (Figure 3).

A total of 24 traps were used during the study. The traps were set in the evening and inspected the following day at twilight. After capture, the mice were individually anesthetized by placing them in a hermetically sealed bucket containing cotton moistened with ether (Cooper, Belgium) for approximately 15 minutes prior to subsequent handling and examination.

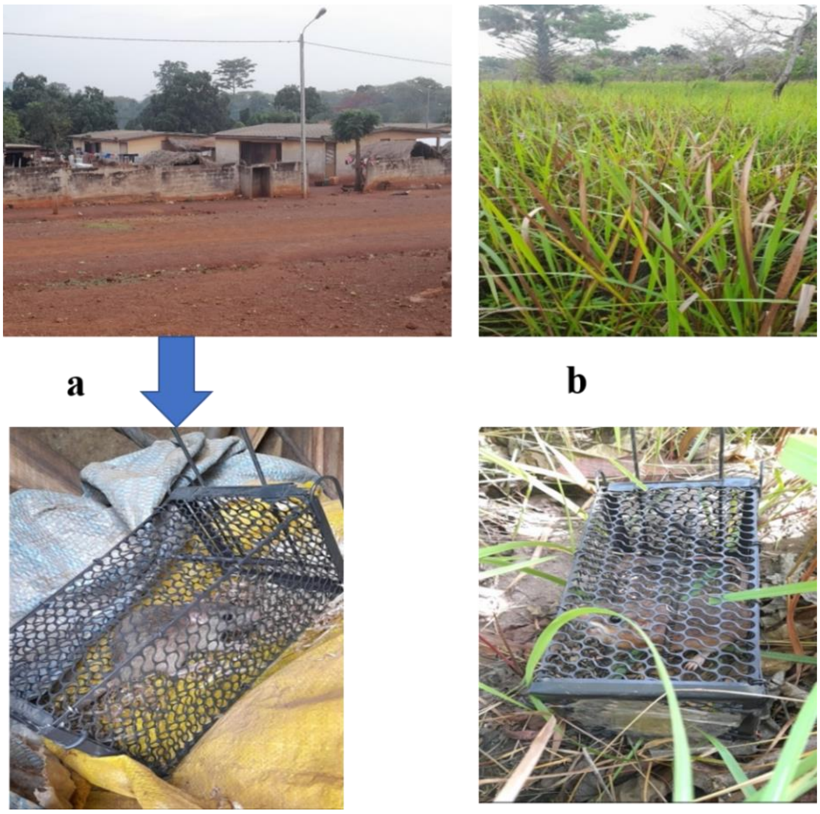


**Figure 3. Trapping sites showing mouse capture locations: (a) trapping in villages and (b) trapping within the reserve.**

### 2.4. Identification of sex and age

Sex determination in mice and rats was performed based on distinct anatomical characteristics of the reproductive organs. Males were identified by the presence of testes and a penis, while females were distinguished by the presence of mammary glands, nipples, and a vaginal opening accompanied by a visible clitoris. Throughout this study, we primarily followed the guidelines provided by Diederich *et al.* (2024) for accurately sexing the captured rodents. For age classification, individuals were categorized based on body size, weight, and reproductive development, allowing the differentiation between juveniles and adults, which is critical for understanding population structure and ectoparasite infestation dynamics.

### 2.5. Collection and identification of ectoparasites

After capture, the pelage of each mouse was carefully brushed over a white sheet using a fine comb to collect ectoparasites. This procedure was repeated several times to ensure the thorough removal of ectoparasites from the host's body. The ectoparasites collected on the white sheet were then transferred into 1.8 mL cryotubes containing 70% ethanol for preservation. In addition, the bucket used for anesthesia was carefully examined to ensure that no ectoparasites remained inside. Each cryotube was subsequently sealed and properly labeled for further laboratory analysis. After ectoparasite collection, the mice were marked with a permanent marker under the neck and released back into their natural environment. The collected ectoparasites were examined under a microscope (OPTIKA B-292, Italy) at 40× magnification. Species identification was performed using established taxonomic keys and relevant literature for different ectoparasite groups, including fleas, lice, ticks, and mites of the family Acaridae (Levytska *et al*., 2020; Aleksandravičienė *et al*., 2021; Herrero-Cófreces *et al*., 2021; Herrera-Mares *et al*., 2022).

### 2.6. Statistical analysis

The collected data were initially recorded using Microsoft Excel and subsequently analyzed using R statistical software (version 3.2.2, 2014). The Chi-square test was applied to compare the number of trapped mice between villages and the reserve according to sex, season, and age group. The G-test of independence was used to compare the number of mice harboring ectoparasites with those without ectoparasites in both villages and the reserve. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to assess the risk of infestation. The strength of association between variables was evaluated using Cramer's V. This statistic ranges from 0, indicating no association, to 1, indicating a perfect association. When statistically significant, the magnitude of Cramer's V was interpreted as follows, ≤ 0.2 indicates a weak association, 0.2–0.6 indicates a moderate association, and > 0.6 indicates a strong association (Lukáčová *et al*., 2025). A two-group comparison test was performed to analyze differences in the distribution of ectoparasite species and the parasitism spectrum of mice between villages and the reserve. The same test was also used to compare the calculated indices describing the impact of ectoparasites on mice in both environments. For all statistical analyses, $P$-values ≤ 0.05 were considered statistically significant. The following parasitological indices were calculated,

$$\text{Parasite intensity (PI)}=\frac{\text{Number of specific ectoparasites}}{\text{Number of infected mice}}$$

$$\text{Average ectoparasite abundance (MA)}=\frac{\text{Number of specific ectoparasites}}{\text{Number total of mice}}$$

$$\text{Constituent ratio (C)}=\frac{\text{Number of specific ectoparasites}}{\text{Number total of ectoparasites}}\times 100$$

$$\text{Prevalence (Pr)}=\frac{\text{Number of mice infected by specific ectoparasites}}{\text{Number total of mice}}\times 100$$

## 3. Results

### 3.1. Population structure of trapped mice

A total of 256 mice were captured during the study period, of which 163 (63.67%) were trapped in the villages and 93 (36.33%) in the reserve. The overall sex ratio (male/female) of the captured population was 0.94 (124/132). In the villages, females were slightly more abundant, with a sex ratio of 0.83 (74/89), whereas in the reserve males were more frequently captured, with a sex ratio of 1.16 (50/43). However, the difference between the number of male and female mice captured in the villages and the reserve was not statistically significant ($P$ = 0.22).

Regarding age groups, juvenile mice were more frequently captured in the villages (75.27%), while adult mice were more commonly trapped in the reserve (67.74%). In the overall sampled population, adult mice represented the majority (60.94%), compared with 39.06% juveniles. Seasonal variation was also observed in trapping results.

During the dry season, a higher proportion of mice was captured in the reserve (67.74%) compared with the villages (44.79%). Conversely, during the rainy season, more mice were captured in the villages (55.21%) than in the reserve (32.26%). Overall, 53.13% of the total captured mice were trapped during the dry season. Statistical analysis indicated that the number of juvenile and adult mice captured in the villages and reserve did not differ significantly (*P* = 0.09). However, the number of mice trapped in the villages and the reserve differed significantly between the dry and rainy seasons (*P* = 0.0004) (Table 1).

**Table 1. Population characteristics of trapped mice in villages and the reserve.**

| Characters | Villages (%) | Reserve (%) | Total population |
|---|---|---|---|
| | | **Sex** | |
| **Male (M)** | 74 (45.40%) | 50 (53.76%) | 124 (48.44%) |
| **Female (F)** | 89 (54.60%) | 43 (46.23%) | 132 (51.56%) |
| **Total** | 163 (63.67%) | 93 (36.33%) | 256 |
| ***P*-value** | | 0.22 | |
| **Sex-ratio (M/F)** | 0.83 | 1.16 | 0.94 |
| | | **Age groups** | |
| **Juveniles** | 70 (75.27%) | 30 (32.26%) | 100 (39.06%) |
| **Adults** | 93 (24.73%) | 63 67.74%) | 156 (60.94%) |
| **Total** | 163 (63.67%) | 93 (36.33%) | 256 |
| ***P*-value** | | 0.09 | |
| | | **Seasons** | |
| **Dry season** | 73 (44.79%) | 63 (67.74%) | 136 (53.13%) |
| **Rainy season** | 90 (55.21%) | 30 (32.26%) | 120 (46.87%) |
| **Total** | 163 (63.67%) | 93 (36.33%) | 256 |
| ***P*-value** | | 0.0004* | |

* = Statistically significant ($P \leq 0.05$).

### 3.2. Diversity and distribution of ectoparasites

During the sampling period, a total of 288 ectoparasites were collected from the captured mice. Among these, 106 (36.81%) were recovered from mice trapped in the villages, whereas 182 (63.19%) were obtained from mice captured in the reserve. All identified ectoparasite species belonged to four subclasses within two arthropod classes, including, Insecta and Arachnida. The class Insecta was represented by fleas (*Xenopsylla cheopis*) and lice (*Dermanyssus gallinae*), while the class Arachnida included mites (*Laelaps echidninus*) and ticks (*Rhipicephalus sanguineus*).

Fleas were the most abundant ectoparasites in the villages, accounting for 86.79% of the collected specimens, compared with 38.46% in the reserve. In contrast, mites were more abundant in the reserve (57.14%) than in the villages (11.33%). Ticks and lice were relatively rare in both environments; however, their proportions were slightly higher in the reserve (3.30% for ticks and 1.10% for lice) compared with the villages (0.94% for both groups). Statistical analysis showed that the average numbers of ticks and lice did not differ significantly between the villages and the reserve (*P* > 0.05). In contrast, the abundance of fleas and mites differed significantly between the two habitats (*P* < 0.0001) (Table 2).

**Table 2. Distribution of ectoparasite species collected from mice trapped in villages and the reserve.**

| | | | Localities | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Villages | | Reserve | | *P* value | Total population | |
| **Classes** | **Subclasses** | **Species** | **Total (Ni)** | **%(Ni/N ×100)** | **Total (Ni)** | **%(Ni/N ×100)** | | **Total (Ni)** | **%(Ni/N ×100)** |
| Insecta | Fleas | *X. cheopis* | 92 | 86.79 | 70 | 38.46 | <0.0001* | 162 | 56.25 |
| | Lice | *D. gallinae* | 1 | 0.94 | 2 | 1.10 | 0.90 | 3 | 1.04 |
| Arachnida | Mites | *L. echidninus* | 12 | 11.33 | 104 | 57.14 | <0.0001* | 116 | 40.28 |
| | Ticks | *R. sanguineus* | 1 | 0.94 | 6 | 3.30 | 0.21 | 7 | 2.43 |
| | **Total (N)** | | **106** | **100** | **182** | **100** | | **288** | **100** |

* = Statistically significant ($P \leq 0.05$).

### 3.3. Patterns of ectoparasite infestation in trapped mice

The association between mice and ectoparasite infestation was evaluated according to sex, age group, and season in both villages and the reserve. The results showed that the proportion of mice harboring ectoparasites did not differ significantly between males and females in either habitat. In the villages, the odds ratio (OR) was 0.87 (95% CI: 0.53–2.75; *P* = 0.70), while in the reserve it was 1.20 (95% CI: 0.43–1.77; *P* = 0.66), indicating no significant sex-related difference in ectoparasite infestation.

Similarly, no significant association was observed between ectoparasite infestation and the age group of mice in either environment. In the villages, the comparison between juveniles and adults yielded an OR of 0.87 (95% CI: 0.43–1.78; *P* = 0.71), whereas in the reserve the OR was 0.59 (95% CI: 0.24–1.45; *P* = 0.24). These results suggest that juvenile and adult mice were equally likely to host ectoparasites in both habitats.

In contrast, seasonal variation significantly influenced ectoparasite infestation in the reserve. Mice captured in the reserve during the dry season were significantly more likely to harbor ectoparasites than those captured during the rainy season (OR = 2.66; 95% CI: 1.03–6.87; *P* = 0.036). However, no significant seasonal difference was observed in the villages (OR = 0.79; 95% CI: 0.39–1.61; *P* = 0.50). The strength of association between the variables was assessed using Cramer's V, which indicated very weak associations for sex and age group in both habitats. A moderate association was observed for seasonal variation in the reserve (Cramer's V = 0.214), suggesting that seasonal factors may influence ectoparasite infestation in that environment (Table 3).

**Table 3. Comparison of the frequency of mice harboring ectoparasites and those without ectoparasites in villages and the reserve.**

| **Areas** | **Villages** | | | | | **Reserve** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Characters** | **Total** | **Ectoparasites (%)** | **OR (95%CI)** | ***P* value** | **Cramer's V** | **Total** | **Ectoparasites (%)** | **OR (95%CI)** | ***P* value** | **Cramer's V** |
| | | | | | **Sex** | | | | | |
| Male | 74 | 18 (24.32 %) | 0.87 | | | 50 | 22 (44 %) | 1.20 | | 0.045 |
| Female | 89 | 24 (26.97 %) | (0.43- | 0.70 | 0.03 | 43 | 17 (39.53 %) | (0.53- | 0.66 | |
| **Total** | 163 | 42 (25.77 %) | 1.77) | | | 93 | 39 (41.93 %) | 2.75) | | |
| | | | | | **Age group** | | | | | |
| Juveniles | 70 | 17 (24.29 %) | 0.87 | | | 30 | 10 (33.33 %) | 0.59 | | 0.120 |
| Adults | 93 | 25 (26.88 %) | (0.43- | 0.71 | 0.029 | 63 | 29 (46.03 %) | (0.24- | 0.24 | |
| Total | 163 | 42 (25.77 %) | 1.78) | | | 93 | 39 (41.93 %) | 1.45) | | |
| | | | | | **Seasons** | | | | | |
| Dry season | 73 | 17 (23.29 %) | 0.79 | | | 63 | 31 (49.21 %) | 2.66 | | 0.214 |
| Rainy season | 90 | 25 (27.78 %) | (0.39-1.61) | 0.50 | 0.051 | 30 | 8 (26.67 %) | (1.03-6.87) | 0.036* | |
| **Total** | 163 | 42 (25.77 %) | | | | 93 | 39 (41.93 %) | | | |

* = Statistically significant ($P \leq 0.05$).

### 3.4. Spectrum of ectoparasite infestation in mice

The pattern of ectoparasite infestation in mice differed between the villages and the reserve. The proportion of mice infested exclusively with fleas was considerably higher in the villages (80.96%) than in the reserve (43.60%). In contrast, mite infestations were more frequent in the reserve (23.08%) compared with the villages (9.52%). Furthermore, mixed infestations involving more than one ectoparasite species were more common in the reserve (33.32%) than in the villages (9.52%). These findings indicate a broader ectoparasite diversity and co-infestation pattern among mice inhabiting the reserve. No mice were found to be exclusively infested with lice or ticks in either the villages or the reserve (0%). Statistical analysis showed that flea infestation was significantly more frequent in village mice compared with those from the reserve (*P* < 0.0001). In addition, mixed infestations were significantly more common in mice captured in the reserve (*P* = 0.01) (Table 4).

**Table 4. Parasitism spectrum of ectoparasite infestations in mice from villages and the reserve.**

| **Ectoparasites infestation state on the mice** | **Villages** | | **Reserve** | | ***P* value** |
|---|---|---|---|---|---|
| | **Number** | **%** | **Number** | **%** | |
| Infested by fleas | 34 | 80.96 | 17 | 43.60 | <0.0001* |
| Infested by lice | 0 | 0 | 0 | 0 | - |

**Table 4. Contd.**

| Ectoparasites infestation state on the mice | Villages | | Reserve | | *P* value |
|---|---|---|---|---|---|
| | **Number** | **%** | **Number** | **%** | |
| Infested by mites | 4 | 9.52 | 9 | 23.08 | 0.10 |
| Infested by ticks | 0 | 0 | 0 | 0 | - |
| Infestation mixes | 4 | 9.52 | 13 | 33.32 | 0.01* |
| **Total** | **42** | **100** | **39** | **100** | |

* = Statistically significant ($P \leq 0.05$).

### 3.5. Ectoparasite infestation indices in mice

The infestation indices, including parasite intensity (PI), mean ectoparasite abundance (MA), constituent ratio (C), and prevalence (Pr), were calculated to evaluate the impact of ectoparasites on mice captured in the villages and the reserve. Overall, PI, MA, and Pr values were higher in the reserve than in the villages, indicating a greater ectoparasite burden among mice inhabiting the reserve. Statistical analysis revealed that PI and MA did not differ significantly between the two localities for most ectoparasite species ($P > 0.05$). However, significant differences were observed for the C and Pr of certain species between the villages and the reserve. Specifically, the C differed significantly for *X. cheopis* and *L. echidninus* between the two habitats ($P < 0.0001$). In addition, the Pr of *X. cheopis* ($P = 0.01$) and *L. echidninus* ($P = 0.04$) showed significant variation between the villages and the reserve. These findings suggest that the distribution and epidemiological importance of these ectoparasite species vary between the two environments (Table 5).

**Table 5. Parasite intensity (PI), mean ectoparasite abundance (MA), constituent ratio (C), and prevalence (Pr) of ectoparasite species collected from mice in villages and the reserve.**

| Ectoparasites | Number of specific ectoparasite | | Number of mice infected by specific ectoparasite | | Total mice | | Total mice infected | |
|---|---|---|---|---|---|---|---|---|
| | **Villages** | **Reserve** | **Villages** | **Reserve** | **Villages** | **Reserve** | **Villages** | **Reserve** |
| *X. cheopis* | 92 | 70 | 38 | 28 | - | - | - | - |
| *D. gallinae* | 1 | 2 | 1 | 2 | - | - | - | - |
| *L. echidninus* | 12 | 104 | 8 | 21 | - | - | - | - |
| *R. sanguineus* | 1 | 6 | 1 | 5 | - | - | - | - |
| **Total** | **106** | **182** | **48** | **56** | **163** | **93** | **42** | **39** |

| | Parasite intensity (PI) | | | Average ectoparasite abundance (MA) | | | Constituent Ratio (C) | | | Prevalence (Pr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Villages** | **Reserve** | ***P*-value** | **Villages** | **Reserve** | ***P*-value** | **Villages** | **Reserve** | ***P*-value** | **Villages** | **Reserve** | ***P*-value** |
| *X. cheopis* | 2.19 | 1.79 | 0.21 | 0.56 | 0.75 | 0.50 | 86.80 | 38.46 | <0.0001* | 23.31 | 30.11 | 0.01* |
| *D. gallinae* | 0.02 | 0.05 | 0.97 | 0.006 | 0.02 | 0.99 | 0.94 | 1.10 | 0.91 | 0.61 | 2.15 | 0.70 |
| *L. echidninus* | 0.29 | 2.67 | 0.23 | 0.07 | 1.12 | 0.52 | 11.32 | 57.14 | <0.0001* | 4.91 | 22.58 | 0.04* |
| *R. sanguineus* | 0.02 | 0.15 | 0.84 | 0.006 | 0.06 | 0.92 | 0.94 | 3.30 | 0.25 | 0.61 | 5.38 | 0.22 |
| **Total** | **2.52** | **4.66** | | **0.64** | **1.95** | | **100** | **100** | | **29.44** | **60.22** | |

* = Statistically significant ($P \leq 0.05$).

## 4. Discussion

In this study, fewer juvenile mice were trapped than adults in both the villages and the reserve, which may be attributed to the relatively smaller home ranges of juvenile individuals. This pattern is consistent with observations from lowland agroecosystems, where adult rodents tend to dominate trap captures because of their greater mobility and larger home ranges (Niang *et al*., 2022). Juvenile rodents generally remain close to their nests during early life stages and only disperse as they mature into adults (Schweinfurth, 2020). The results also showed that significantly more mice were captured in the reserve during the dry season than during the rainy season ($P = 0.0004$). This finding is in agreement with previous studies indicating that seasonal changes strongly influence rodent activity patterns and trapping success (Oyeyiola *et al*., 2025). The higher abundance of mice captured during the dry season may be related to changes in habitat conditions, as environments tend to become drier and more open during this period. Additionally, the scarcity of food and water resources during the dry season may force rodents to move over larger areas in search of food, increasing the likelihood of encountering baited traps and thereby resulting in higher capture rates compared to the rainy season (Maneepairoj *et al*., 2025). Another possible explanation is that during the dry season many mice may move toward nearby human settlements surrounding the reserve, as natural food resources such as flowers, leaves, and grasses become dry or scarce due to reduced rainfall (Assefa and Chelmala, 2019). Rodents are known to migrate or disperse from temporarily unfavorable habitats to nearby areas with more favorable environmental conditions and available resources (Assefa and Chelmala, 2019). This behavior may explain the relatively high abundance of mice observed in villages adjoining the reserve during the dry season, when natural habitats within the reserve become less productive and food resources are limited (Assefa and Chelmala, 2019).

The observed sex ratio (M/F = 0.94) indicates that mice were captured almost equally between sexes, with a slight predominance of females. This finding is consistent with results from a study conducted in Southeastern Brazil, which reported sex ratios close to parity in stable rodent populations (Bovendorp *et al*., 2025). Such a near-equilibrium suggests that both male and female mice likely exhibit similar levels of foraging activity and susceptibility to trapping within this environment. In addition, the slight predominance of females may indicate a relatively high reproductive potential in the study population. This pattern may also suggest the absence of sex-related bias in the trapping process, as previously reported in studies examining rodent capture dynamics (Jankowiak *et al*., 2025).

Seasonal movement and dispersal of mice may explain the significant association observed between ectoparasite infestation and season ($P$ = 0.036), with mice experiencing approximately 2.5 times greater risk of ectoparasite infestation during the dry season. The Cramer's V value (0.214) indicates a moderate association between these variables. During periods of increased movement or dispersal, mice are more likely to encounter environments where ectoparasites are present and can attach to hosts (Waya *et al*., 2025). This observation is further supported by recent studies showing that seasonal variation and habitat characteristics are major drivers of ectoparasite prevalence in wild rodent populations inhabiting mosaic rural landscapes (Benedek *et al*., 2024). Moreover, seasonal rainfall patterns may indirectly influence ectoparasite populations, as humidity combined with the relatively warm conditions of the dry season can promote the development, reproduction, and survival of several ectoparasite species, thereby increasing the probability of host infestation (Peng *et al*., 2018).

In this study, all collected ectoparasites belonged to four subclasses: fleas, mites, ticks, and lice. The total number of ectoparasites was higher in the reserve than in the villages, with 182 individuals (63.20%) recorded in the reserve compared with 106 individuals (36.80%) in the villages. This difference may be explained by the greater mobility and wider spatial range available to mice inhabiting the reserve, allowing them to move more freely across diverse microhabitats than mice living in village environments (Mkomwa *et al*., 2025). These findings are consistent with previous studies showing that ectoparasite infestations in rodents tend to be lower in village environments compared with natural habitats (Little *et al*., 2024). However, when the distribution of individual ectoparasite groups was examined, no significant differences were observed between habitats for ticks and lice ($P$ > 0.05), whereas significant differences were detected for fleas and mites ($P$ < 0.0001). Similar patterns have been reported in a study conducted in South Africa (Smith *et al*., 2023). This distribution pattern may be explained by the ecological characteristics of the different ectoparasite groups. Permanent parasites such as lice and generalist parasites such as ticks are largely dependent on the host, which may explain their relatively stable occurrence across habitats. In contrast, fleas and mites are strongly influenced by environmental conditions and microhabitat characteristics, making their distribution more sensitive to habitat differences (Assefa and Chelmala, 2019).

Regarding polyparasitism, certain ectoparasite species, particularly fleas (*X. cheopis*) and mites (*L. echidninus*), were observed alone on some mice, representing mono-infestations. In contrast, ticks (*R. sanguineus*) and lice (*D. gallinae*) were always found in combination with other ectoparasite species, indicating mixed infestations in this study. Similar observations have been reported elsewhere, where hosts were found to carry up to six ectoparasite species simultaneously, and polyparasitism influenced the prevalence and intensity across groups such as ticks, mites, and fleas (Obiegala *et al*., 2021). This pattern may be explained by host susceptibility such as, ticks and lice may preferentially infest mice with weaker immune systems, which can attract multiple ectoparasite species, thereby increasing the likelihood of polyparasitism. Additionally, the pattern reflects ecological differences among ectoparasites including, environmentally transmitted species such as fleas and mites can establish mono-infestations, whereas contact-dependent species such as ticks and lice are more likely to occur on hosts already harboring other ectoparasites (Obiegala *et al*., 2021). In this study, the number of mice infested by fleas varied significantly between localities ($P$ < 0.0001), as did the occurrence of mixed infestations ($P$ = 0.01). Similar spatial variation in flea infestation among rodent populations has been reported in Tanzania, where prevalence and abundance differed significantly between study sites (Jakoniko *et al*., 2024). Such differences can be attributed to environmental conditions, host density, and habitat characteristics. Localities with stable microhabitats, higher rodent density, and favorable climatic conditions tend to exhibit higher flea prevalence and more frequent mixed infestations, whereas disturbed or less suitable sites show lower infestation rates (Little *et al*., 2024). Furthermore, fleas appear to prefer the pelage of mice living in modified, drier habitats (Assefa and Chelmala, 2019). In contrast, in the reserve, the greater mobility of mice allows them to encounter and host multiple ectoparasite species, resulting in a higher prevalence of mixed infestations in this area (Mkomwa *et al*., 2025).

The parasite intensity and the mean ectoparasite abundance were higher in the reserve than in the villages, indicating a more intense ectoparasite activity within the forested reserve. Similarly, the prevalence of ectoparasites was greater in the reserve than in the villages. These findings align with previous studies conducted in forest reserves, which reported significantly higher ectoparasite prevalence in rodents inhabiting natural habitats compared to more disturbed or human-modified environments, highlighting the strong influence of habitat quality and environmental stability on ectoparasite burden (Babyesiza *et al*., 2023). This pattern may be explained by increased host interactions in natural habitats, which facilitate ectoparasite transmission (Shilereyo *et al*., 2022). The constituent ratio further supports this observation, showing significant variation between the two localities for both ectoparasite genera ($P < 0.0001$). Among the ectoparasites, *X. cheopis* (flea) exhibited the highest constituent ratio, infesting the majority of examined mice. Fleas are predominantly associated with tropical habitats and commonly parasitize rodents, which is why they are considered typical rodent parasites (Boyer *et al*., 2022). Moreover, adult fleas preferentially live on the host rather than in the nest because they are hematophagous, feeding on blood to sustain themselves and support egg maturation (Bland and Hinnebusch, 2016). This host preference contributes to their high prevalence and intensity in rodent populations within natural habitats.

Several studies have reported that rodent ectoparasites recorded in this study—*X. cheopis*, *L. echidninus*, *R.* sanguineus, and *D. gallinae*—are widely distributed worldwide and play important roles in the transmission of zoonotic pathogens affecting both humans and animals (Diarra *et al*., 2020; Ho *et al*., 2021; Waya *et al*., 2025). For instance, *X. cheopis* (fleas) is a primary vector of plague in humans through the bacterium *Yersinia pestis*, while *L. echidninus* (mites) transmits the Junin virus, the causative agent of Argentine hemorrhagic fever (Pauling *et al*., 2024; Blitvich, 2025). In addition, *R. sanguineus* (ticks) transmits rickettsial infections to humans, such as boutonneuse fever caused by *Rickettsia conorii*, whereas *D. gallinae* (lice) can infest humans and cause gamasoidosis, which manifests as skin lesions and may involve bacterial pathogens such as *Coxiella burnetii* (Raele *et al*., 2018; Spernovasilis *et al*., 2021).

## 5. Conclusions

The present study revealed that mice in the study area are parasitized by ectoparasites belonging to four subclasses: fleas, lice, mites, and ticks, with the highest infestation risk occurring during the dry season, indicating a potential for rodent-borne diseases in the region. Among the ectoparasites, *X. cheopis* (fleas) was the most prevalent, and overall ectoparasite prevalence was higher in the reserve compared to surrounding villages. Given the presence of ectoparasites with known zoonotic potential, further research is warranted to evaluate the risk of pathogen transmission to humans and domestic animals near the reserve, including targeted serological surveys and pathogen identification studies.

## Acknowledgements

We deeply thank the environment ministry specially the Director of OIPR (Ivoirian Office of Park and Reserve) for allowing us to make the research in the natural fauna reserve of Abokouamékro and my guide in the reserve for his work and assistance in the field work. We also thank the local service of OIPR located at Yamoussoukro who look after the reserve without forgetting the people of three villages for their endless help, support, and encouragement. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## Data availability

The datasets used and/or analyzed during this study are available from the corresponding author upon reasonable request.

## Conflict of interest

None to declare.

**Authors' contribution**

Kassi Bohoussou Georges: conceptualization, research design, data acquisition, data analysis, writing first draft of the manuscript, review and revise the manuscript; Ahouty Ahouty Bernardin, Simaro Siriki and Oscar Nyangiri: data acquisition, data analysis, data interpretation, review and revise the manuscript; Abe Allépo Innocent, N'djetchi Kassi Martial and Yeboue Kouadio Félix: research design, data analysis, writing first draft of the manuscript, review and revise the manuscript; Konan Konan Thomas and Koffi N'goran Mathurin: statistical analysis, writing first draft of the manuscript, review and revise the manuscript. All authors have read and approved the final manuscript.

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