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Entomological Diversity and Biting Behaviour of Adult Mosquitoes in Three University Halls of Residence in Brazzaville, Congo

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Abstract

Introduction: Culicid mosquitoes, such as Anopheles, Aedes, and Culex, are capable of transmitting vector-borne diseases such as malaria, dengue fever, yellow fever, and Japanese encephalitis. When their density is high, culicid mosquitoes are also a source of nuisance, discomfort, itching, and skin irritation. To control these Culicidae, it is important to understand their bioecology and the composition of the Culicidae fauna. **Objective:** The objective of this study was to assess the diversity of the Culicidae fauna and its aggressiveness in three dormitories at Marien Ngouabi University. **Methodology:** Culicids were collected using two methods: morning collection and collection of species aggressive toward humans. **Results and Discussion:** During this study, 2621 culicids were collected. These belonged to five species: 2519 *Culex quinquefasciatus*; 80 *Anopheles gambiae s.l.*; 16 *Aedes albopictus*; 4 *Aedes aegypti*; 2 *Mansonia uniformis*. The Culicidae fauna consisted primarily of *Culex quinquefasciatus* (96.11%). In terms of nuisance, the highest level was recorded at the ENS I residence, with 400 p/h/n (bites/person/night) for *Cx. quinquefasciatus* outside the bedroom. The presence of mosquitoes in university housing is a major concern due to the nuisance caused by mosquito bites and the risk of vector-borne disease transmission. Several factors could contribute to the presence of Culicidae in these housing units: proximity to a watercourse, weather conditions, and outdoor maintenance, although these variables were not directly measured in this study. **Conclusion:** Management of the nuisance caused by Culicidae in university housing can be achieved through environmental management, vector control, and student awareness campaigns.

Subject Areas

Entomology

Keywords

Disease Vectors, Nuisance, Housing, Brazzaville

1. Introduction

So-called vector-borne diseases are caused by parasites, viruses, and bacteria transmitted to humans by vectors. According to the WHO, more than 700,000 deaths worldwide each year are caused by these diseases, such as malaria, yellow fever, dengue fever, Japanese encephalitis, leishmaniasis, Chagas disease, onchocerciasis, schistosomiasis, and African trypanosomiasis [1].

The WHO African Region is very heavily affected by these diseases; the main vector-borne diseases are dengue, malaria, chikungunya, yellow fever, and Zika virus disease. These diseases affect populations in many countries and cause numerous deaths. In 2020, 228 million cases of malaria were reported there, including 602,020 deaths, 38 million cases of lymphatic filariasis, 15 million cases of onchocerciasis, 12 million cases of schistosomiasis, 220,897 cases of dengue, and 25,064 cases of Rift Valley fever, among others [1].

In the Congo, vector-borne diseases account for a significant portion of the burden of communicable diseases. These diseases include malaria, dengue, chikungunya, and yellow fever. Among them, malaria is by far the most common vector-borne disease in the country. In 2022, 522,266 cases of malaria were reported at health facilities throughout the country. [2].

These diseases are transmitted by blood-feeding arthropods—that is, vectors capable of transmitting them from one host to another. These blood-feeding arthropods can include mosquitoes, sand flies, flies, fleas, ticks, lice, and chiggers [1]. Among these, the Culicidae are the most dangerous, such as Anopheles, Aedes, and Culex [1]. The disease-carrying Culicidae fauna in the Congo consists of numerous species of Culicidae, including *Aedes aegypti*, *Aedes albopictus*, *Anopheles gambiae s.l.*, *An. funestus*, *An. moucheti*, *An. nili*, *An. paludis*, *An. hancocki*, and *Culex quinquefasciatus* [3]-[11].

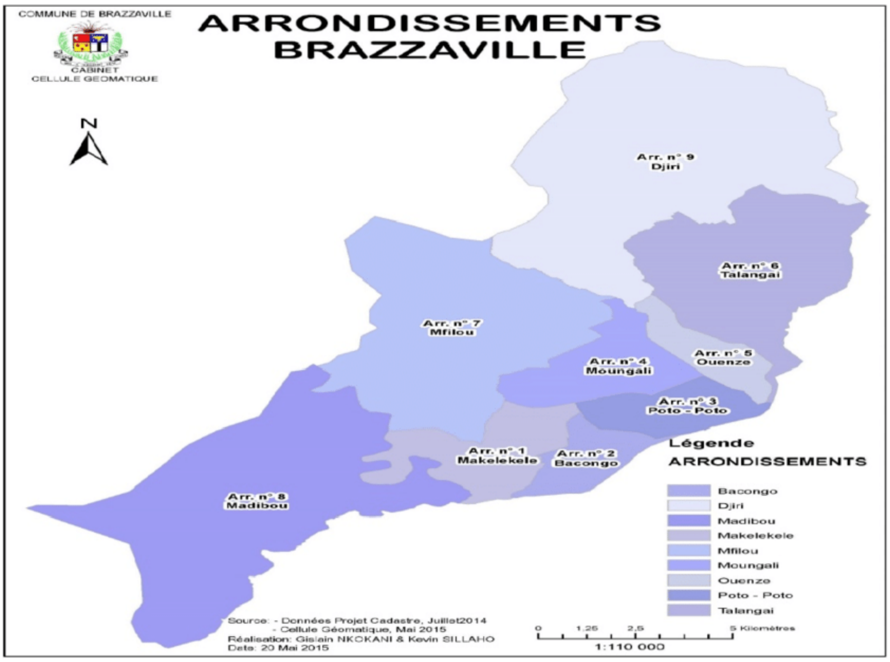
In addition to their role as disease vectors, mosquitoes are a nuisance because of the painful bites they inflict. In university housing, this nuisance disrupts moments of reading, reflection, socializing, and constructive discussions in common areas. Culicidae are naturally present in the environment; however, in these housing facilities, human activities contribute to the creation of larval breeding sites conducive to the development and proliferation of Culicidae, such as pools of stagnant water, open septic tanks, clogged pipes, and poorly maintained gutters.

In this context, it is important to implement a vector control strategy tailored to the specific characteristics of each residence. Thus, the objective of this study was to assess the diversity of the Culicidae fauna and the aggressiveness (nuisance) of Culicidae in the university residences at Tcheullima, ENS I, and ENS II.

2. Materials and Methods

2.1. Study Sites

The study was conducted in three university dormitories located in the city of Brazzaville from January to June 2023. Brazzaville is the political capital of the Republic of the Congo. The geographic coordinates of Brazzaville are −4.267778 degrees south latitude and 15.291944 degrees east longitude [12]. It has an area of 263.9 km^2 and a population of more than 1.4 million [13]. The city has an equatorial climate characterized by two seasons: the dry season from June to September and the rainy season from October to May. It has an average annual temperature of 25.5˚C and an average humidity of 78%. Annual rainfall averages 1095 mm [14]. The river system is fed by numerous streams that flow into the Congo River; among these streams is one called Maladie du sommeil, located behind the ENS I and ENS II housing complexes [13]-[16] (See **Figure 1**).



Note: Source: https://congo-site.com/, 2017.

Figure 1. Map of the city of Brazzaville.

1) Tcheullima Housing Complex

The Tcheullima Housing Complex is located in District No. 2, Bacongo, in the southern part of Brazzaville. It was established in 1978 under Decree No. 78/2079 dated April 19, 1978. It measures 3776 meters in length and 2676 meters in width. It is bordered to the north by the Faculty of Health Sciences (FSSA); to the south by the "1er mai" Commercial High School; to the east by the Embassy of the United

States of America (USA); and to the west by the Commercial and Industrial High School.

2) ENS I Housing Complex

The ENS I housing complex is located in Bacongo District No. 2, south of Brazzaville. It was established in 1978 under Decree No. 78/2079 of April 19, 1978. It covers 7 hectares. It is bordered to the north by the Central School District; to the south by the Jardin d'Essai River; to the east by the ENS II campus; and to the west by the Cité Scientifique.

3) ENS II Housing

ENS I housing is located in District No. 1, Makélékélé, south of Brazzaville. It was established in 1978 under Decree No. 78/2079 of April 19, 1978. It covers 6 hectares. It is bordered to the north by the Alphonse Massamba Débat Stadium; to the south by the Maladie du Sommeil River; to the east by the Marien Ngouabi University administration; **and to the west by the central school district. The ENS I and II housing complexes are crossed by the Maladie du Sommeil River, located in a marshy area that serves as a larval breeding ground.**

2.2. Capture and Processing of Culicidae

Culicidae were captured using two methods. Flying insects were captured using human bait (volunteers) over the course of a single night per residence, from 7:00 p.m. to 6:00 a.m. (11 hours of capture), simultaneously inside and outside the bedroom. The captured Culicidae were sorted by bedroom, time interval, and capture location (outdoors/indoors). Captures using human bait took place in April 2023 in Tcheullima, in May 2023 at ENS II, and in June 2023 at ENS I. Residual morning fauna at rest were collected in the bedrooms at a rate of two consecutive sessions per month; captures were made in 49 bedrooms in Tcheullima, 92 bedrooms at ENS I, and 80 bedrooms at ENS II. The collected Culicidae were identified based on morphological criteria using identification keys (Edwards, 1941; Gillies and Coetzee, 1987) [17] [18].

The bedrooms in which human-baited captures were conducted were selected at random after obtaining the occupants' free and informed verbal consent.

The total number of nights of human-baited trapping was three (including one night per dwelling). There were two trappers per room, one inside and one outside. Trapping took place between 7:00 p.m. and 6:00 a.m.

2.3. Determination of Aggressive Density (ma) or Nuisance Level

This indicator corresponds to the average number of bites from a given Culicidae species that a man receives per unit of time (night). It is calculated using the formula ma = N/(c*n), where N is the total number of females of a given species captured using human bait, c is the number of trappers, and n is the number of trapping nights. The density is expressed in bites per person per night (b/p/n).

Based on the capture of aggressive mosquitoes, aggressiveness was calculated from the total number of females of a given species captured from humans per night.

2.4. Data Analysis

The data were initially recorded on field collection forms. They were entered and recorded using Microsoft Excel 2010. SPSS software (version 20) was used for statistical analyses, specifically the Kruskal-Wallis H test to compare aggressive densities and capture rates by capture month and by study site. The Mann-Whitney test was used to compare the number of exophagous and endophagous Culicidae in each dwelling. The significance threshold was set at $p < 0.05$.

2.5. Ethical Considerations

Ethical considerations during this study applied to daytime captures using an electric vacuum cleaner and nighttime captures using human bait. Prior to the study, free and informed (verbal) consent was obtained from the person in charge of the bedroom. Participation in the study was entirely voluntary and of the participants' own free will.

3. Results

3.1. Morning Residual Fauna and Aggressive Fauna by University Residence

During this study, 2621 adult female Culicidae were collected (1725 specimens from the morning residual fauna and 896 specimens from the fauna aggressive toward humans). These belong to four genera divided into five species. The distribution of these Culicidae by genus and species was as follows:

2519 *Culex quinquefasciatus* (96.11%); 80 *Anopheles gambiae s.l.* (3.05%); 16 *Aedes albopictus* (0.61%); 4 *Aedes aegypti* (0.15%); 2 *Mansonia uniformis* (0.08%).

The species *Culex quinquefasciatus* was the predominant species, accounting for 96.11% of the collections (See Table 1).

Table 1. Abundance and composition of the Culicidae fauna sampled in the three university dormitories from January to June 2023.

Species	Collection methods			
	Residual morning wildlife	Wildlife aggressive towards humans	Total	Percentage (%)
Cx. quinquefasciatus	**1709**	**810**	**2519**	**96.11**
An. gambiae s.s.	**6**	**74**	**80**	**3.05**
Ae. albopictus	**7**	**9**	**16**	**0.61**
Ae. aegypti	**3**	**1**	**4**	**0.15**
Mn. uniformis	**0**	**2**	**2**	**0.08**
Total	**1725**	**896**	**2621**	**100**

1) Morning residual fauna in the Tcheullima residence

In Tcheullima, collections were made in 49 bedrooms, where 237 Culicidae were collected, all belonging to the species Culex quinquefasciatus (See Figure 2).

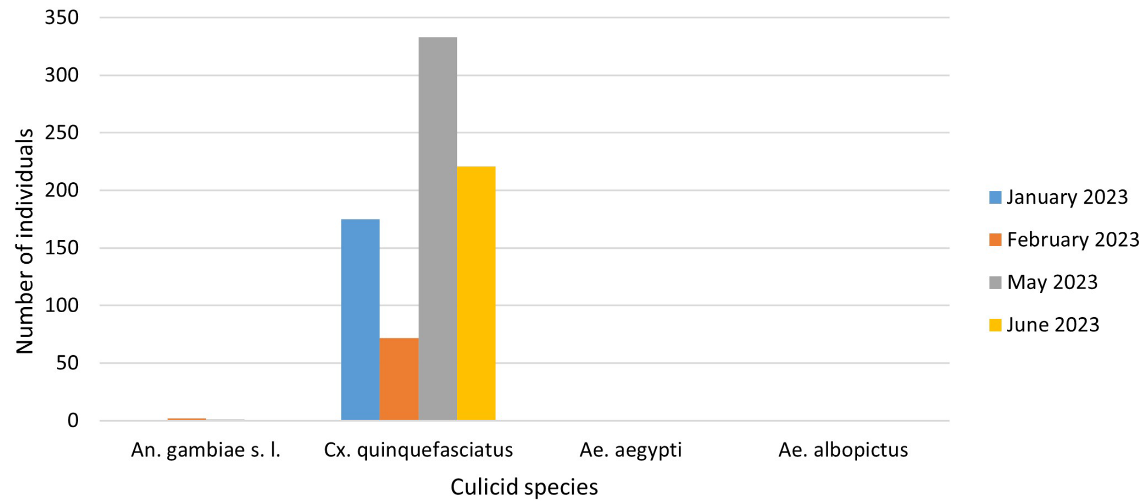


Figure 2. Variation in the number of specimens by species inside the bedrooms on the Tcheulima campus in January, March, and June 2023.

2) Morning residual fauna within the ENS I residence

At ENS I, collections were made in 92 bedrooms, where 804 Culicidae were collected and distributed as follows: 801 *Culex quinquefasciatus*, representing 98.63%; 3 *Anopheles gambiae s.l.*, representing 0.37%. *Culex quinquefasciatus* is the predominant species (See Figure 3).

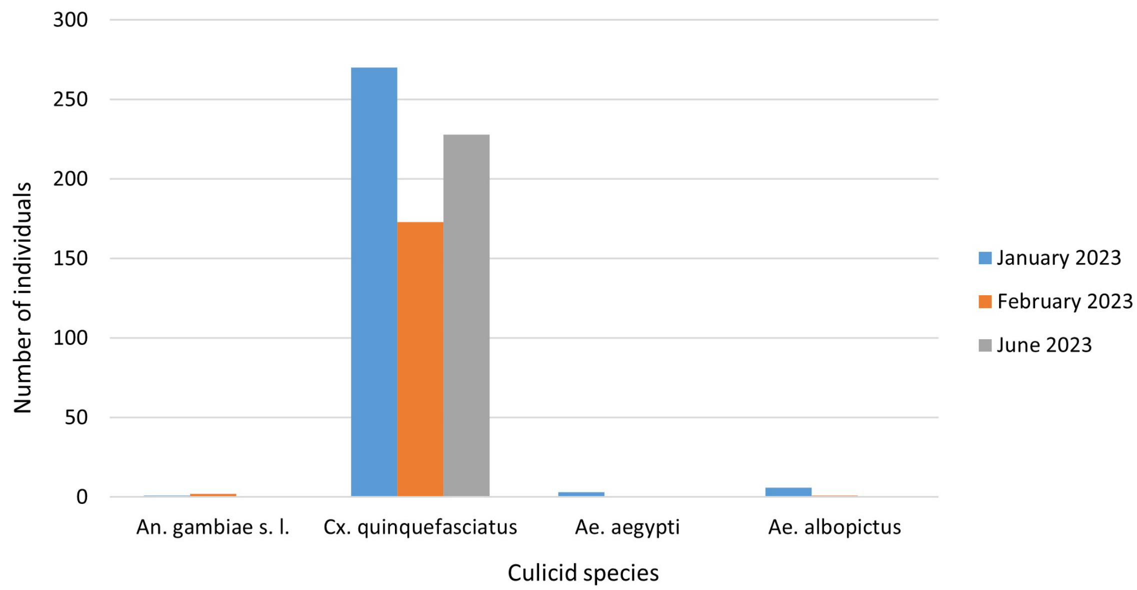


Figure 3. Variation in the number of specimens by species inside the bedrooms at ENS I in January, February, May, and June 2023.

3) Morning residual fauna within the ENS II residence

At ENS II, collections were made in 80 bedrooms, where 684 Culicidae were collected and distributed as follows: 671 *Culex quinquefasciatus*, or 98.1%; 3 *Anopheles gambiae s.l.*, or 0.44%; 7 *Aedes albopictus*, or 1.02%; 3 *Aedes aegypti*, or 0.44%. It is evident that *Culex quinquefasciatus* is heavily represented (See Figure 4).

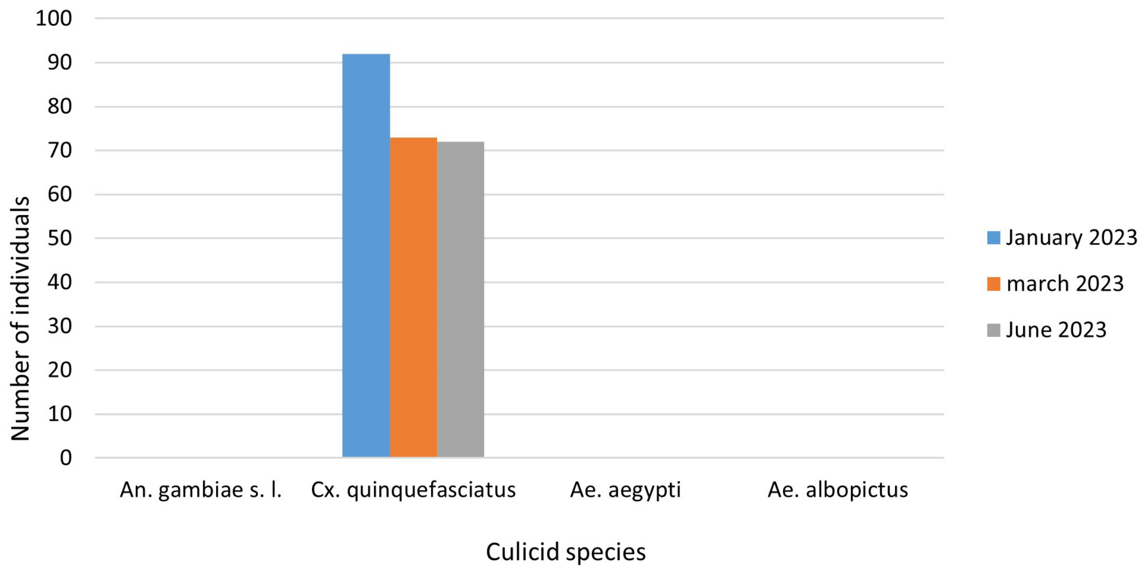


Figure 4. Variation in the number of specimens by species inside the bedrooms at ENS II in January, February, and June 2023.

3.2. Wildlife Aggressive toward Humans, by Housing Type

1) Mosquitoes that bite humans within the Tcheullima dwelling

In Tcheullima, the collection was conducted in a bedroom where 232 Culicidae were captured, distributed as follows: 202 *Culex quinquefasciatus* (87.06%); 24 *Anopheles gambiae s.l.* 10.34%; 6 *Aedes albopictus* 2.58% (See Figure 5).

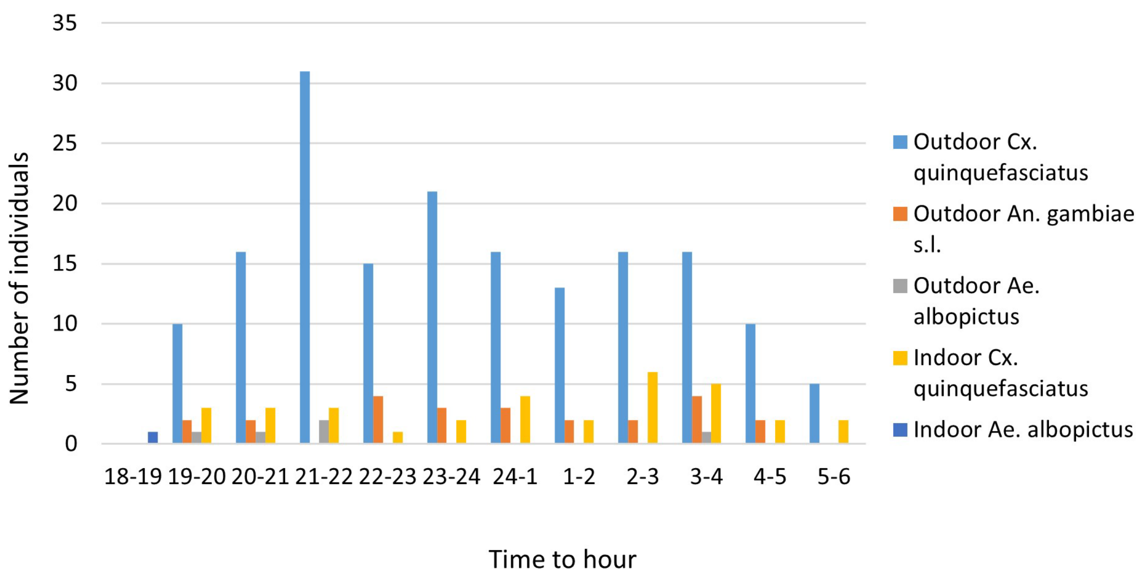


Figure 5. Variation in the number of specimens by species outside and inside bedrooms in Tcheullima in April 2023.

2) Mosquitoes that bite humans inside the ENS II housing unit

At ENS II, the trap was set up in a bedroom where 164 Culicidae were captured and classified as follows: 146 *Culex quinquefasciatus*, or 89.02%; 14 *Anopheles gambiae s.l.*, or 8.54%; 1 *Aedes albopictus*, or 0.61%; 2 *Mansonia uniformis*, or 1.22%; 1 *Aedes aegypti*, or 0.61% (See Figure 6).

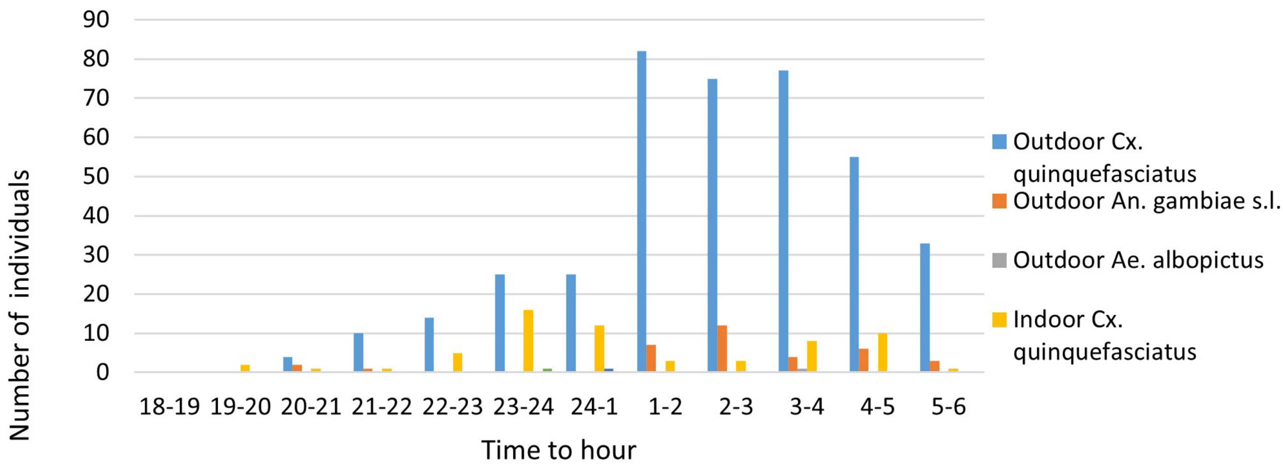


Figure 6. Variation in the number of specimens by species outside and inside bedrooms at ENS II in May 2023.

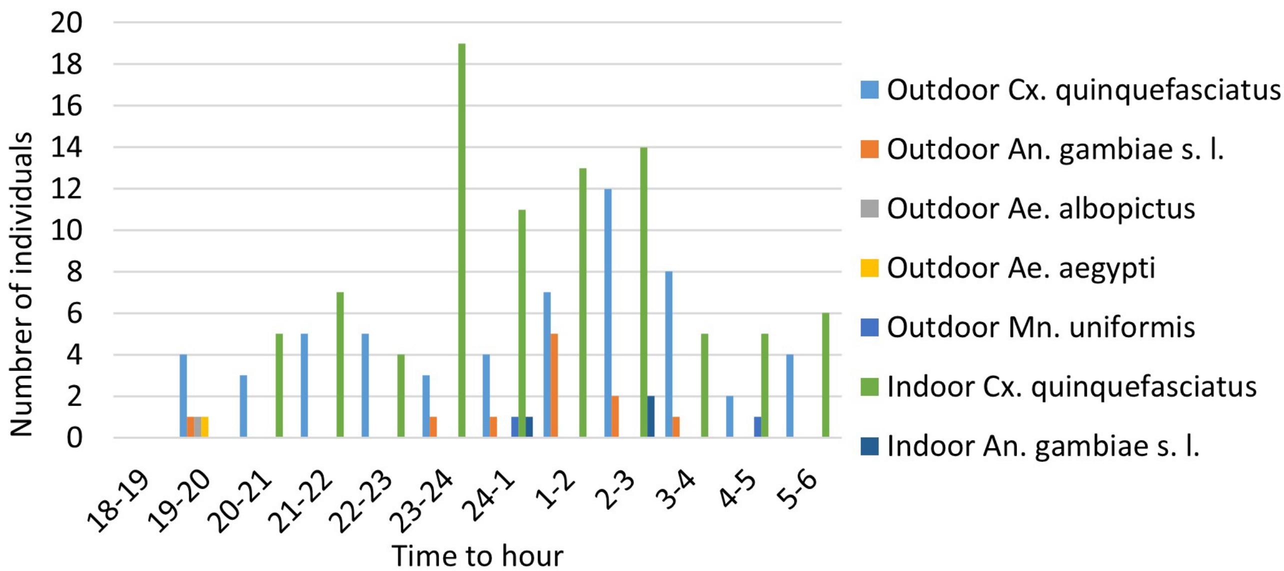


Figure 7. Variation in the number of specimens by species outside and inside the bedrooms at ENS I in June 2023.

3) Mosquitoes that bite humans within the ENS I residence

At the ENS I campus, one trapping session was conducted, resulting in the capture of 500 Culicidae, including: 462 *Culex quinquefasciatus*; 36 *An. gambiae s.l.* captured inside the bedroom; and 2 *Aedes albopictus* (See Figure 7).

The Kruskal-Wallis test showed no significant difference between the aggressive densities of the three university campuses ($p = 0.296$).

The Mann-Whitney test showed no significant difference between the areas outside and inside the bedrooms across the three university campuses ($p > 0.05$).

3.3. Aggressiveness by Species and Housing Type

The aggressiveness of Culicidae varied depending on the residence and the Culicidae species. Culex quinquefasciatus was the main species of Culicidae identified in the residences.

On university campuses, the highest biting rate was recorded at ENS I, with 400 bites per hour per night outside the bedroom, and the lowest at ENS II, with 57 bites per hour per night.

Regarding *Anopheles gambiae s.l.*, by university residence, the highest aggressiveness was recorded at ENS I with 35 bites per hour per night outside the bedroom, and the lowest aggressiveness was recorded at ENS I with 1 bite per hour per night inside the bedroom.

For *Aedes aegypti*, *Aedes albopictus*, and *Mansonia uniformis*, aggressiveness was low, at less than 10 bites per hour per night. The exception was *Aedes albopictus*, for which the highest aggressiveness was 5 bites per hour per night outside the bedroom.

Statistical Analyses

The Kruskal-Wallis test showed no significant difference between the aggressiveness densities of the three university dormitories ($p = 0.296$). The Mann-Whitney test showed no significant difference between the outside and inside of the bedrooms in the three dormitories ($p > 0.05$).

4. Discussion

The objective of this study was to assess the diversity of the Culicidae fauna and the aggressiveness (nuisance) of Culicidae in three university dormitories in the city of Brazzaville.

This study was conducted to inventory the Culicidae fauna on three university campuses in Brazzaville. The two collection methods used resulted in the capture of 2621 Culicidae, comprising five species: 2519 *Cx. quinquefasciatus*, 80 *An. gambiae*, 16 *Ae. Albopictus*, 4 *Ae. aegypti*, and 2 *Mn. uniformis*. The results showed that the Culicidae fauna in these university dormitories was present and dominated by *Cx. quinquefasciatus*. The abundance of Culicidae species is closely linked to the immediate environment of the university dormitories.

The species Cx. quinquefasciatus was the most abundant in all three university dormitories (Tcheullima, ENS I, and ENS II) according to both collection methods used. This observation has also been made by other authors, who showed that this species was the most common in their urban captures [19]-[21].

With regard to the aggressiveness of this species, it was significant in the three housing units at ENS I and ENS II, and Tcheullima. However, the highest level of aggressiveness was recorded at ENS I, with 400 bites per person per night. It was lower at ENS II. Similar results were obtained by other researchers, who recorded high levels of aggressiveness reaching up to 500 bites per person per night in the city of Brazzaville [11] [22].

This aggressiveness could be attributed to the abundance of the species, which may itself be linked to the pollution observed on the three campuses: wastewater stagnating in pipes clogged with solid waste (plastic bags and bottles, various containers), open-air sumps, poorly maintained storm drains, ditches, and gutters. has been attributed to the abundance of this species. This abundance, in turn, has been attributed to the pollution observed on the three campuses ENS I, ENS II, and Tcheullima. This pollution is characterized by the presence of stagnant wastewater in pipes clogged with solid waste, such as plastic bags and bottles and other containers; open-air cesspools; poorly maintained storm drains; ditches; and gutters.

In urban areas, this species can serve as an ecological indicator of uncontrolled urbanization, as waste and wastewater management practices create larval breeding sites conducive to the development of this species' larvae.

The presence of *An. gambiae s.l.* on the three campuses could be explained by the presence of the watercourse known as "sleeping sickness," located behind the ENS I and II housing complexes and less than 2 kilometers from the Tcheullima campus. Numerous larval breeding sites are believed to have formed around this watercourse, consisting of oxbow lakes, shallow areas, or depressions. Other breeding sites may have formed in the marshy areas bordering this watercourse, which are conducive to the formation of larval breeding sites such as puddles, ditches, and ruts. Preferred breeding sites for these species [23] [24].

The low abundance of *An. gambiae s.l.* compared to *Cx. quinquefasciatus* can be explained by the use of Long-Lasting Insecticide-Treated Mosquito Nets (LLINs).

All of the bedrooms surveyed had LLINs. Consequently, Anopheles mosquitoes were more active outside than inside the bedrooms due to the presence of LLINs, whose deterrent and repellent effects prevented them from entering; however, if they did enter these bedrooms, they did not stay long. Previous studies by Bitsindou *et al.* [6] had shown that Anopheles species of the gambiae complex were both exophilic and endophilic. However, following the widespread use of LLINs in bedrooms as part of vector control efforts, these species have become more exophilic and exophagous.

The low density of *Aedes aegypti* and *Aedes albopictus* in three dwellings can be explained by the behavior of these species, which are diurnal, that is, active during the day (very early in the morning and in the late afternoon). They are exophilic, meaning they prefer to rest outside of dwellings. This adaptation would explain the low number of specimens of these species in the morning residual fauna captures. The presence of *Mansonia uniformis* on the ENS II campus can be explained by the presence of the Maladie du Sommeil stream behind this residence, which serves as a larval habitat associated with the presence of aquatic plants whose roots are used by Mansonia larvae to anchor themselves via their siphons in order to obtain oxygen for respiration [24] [25].

5. Conclusion

The results show that the Culicidae fauna consisted of five species: 2519 *Cx. quinquefasciatus*, 80 *An. gambiae*, 16 *Ae. albopictus*, 4 *Ae. aegypti*, and 2 *Ma. uniformis*. The species *Culex quinquefasciatus* was the most abundant. The highest biting activity was recorded at ENS I, with 400 bites per night for *Cx. quinquefasciatus*. The high biting activity attributed to *Culex quinquefasciatus* is likely linked to the presence of this species' preferred larval breeding sites on these campuses. Culicidae can not only cause itching and skin irritation, but they can also transmit serious diseases such as malaria, dengue fever, yellow fever, and the Zika virus, among others. To control Culicidae in these housing complexes, several vector control strategies can be employed, including environmental management to limit breeding habitats by eliminating all standing water around buildings, such as puddles or uncovered water containers. Proper landscaping can help reduce potential breeding sites.

Author Contributions

Grâce Odéra Tainsie Nianga Bikouta: Study conceptualization; methodology development; study coordination and supervision; fieldwork; data analysis and interpretation; drafting of the initial manuscript; manuscript revision and editing; project administration. **Ruth Ernestine Elion:** Fieldwork; collection of mosquitoes in the field; processing and morphological identification of specimens; data acquisition and organization; contribution to manuscript drafting. **Valentin Dibangou:** Contribution to the entomological methodology; data entry and management; contribution to analyses and preparation of results; critical review of the manuscript. **Patrick Bitsindou:** Contribution to the entomological methodology; validation of the identification and interpretation of results; scientific supervision; critical review of the manuscript. **Arsène Lenga:** Scientific supervision; validation of the methodology and results; scientific guidance; critical review and approval of the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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