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Assessment of mosquito larval habitats, species abundance and diversity in Azare, Katagum Local Government Area, Bauchi State, Nigeria

Aliyu Abdulhamid Omar[1], Auwal Alhassan Barde[2], Sam Mao Panda[2], Abdulrasheed Dalhatu[3], Shehu Abubakar Kafi[1], and Umar Aliyu[1]

[1]Department of Biological Sciences, Faculty of Science, Bauchi State University, Gadau, Bauchi State.
[2]Department of Biological Sciences, Faculty of Science, Abubakar Tafawa Balewa University, Bauchi, Nigeria.
[3]Department of Biology, School of Secondary Education (Science), Aminu Saleh College of Education, Azare, Bauchi State.

Correspondence: abdul4real08@gmail.com

Abstract

The study investigated the abundance and diversity of mosquito species larvae in different larval breeding habitats of Azare, Katagum L.G.A., Bauchi State, Nigeria. The selected habitats were surveyed weekly between August and October, 2021 across ten communities. A total of 2,320 mosquito larvae of different instars were collected and reared to adults in which 1,624 successfully emerged as adults comprising of three genera namely: *Anopheles* 464 (20%), *Culex* 928 (40.00%) and *Aedes* 232 (10%). A total of four (4) species were identified; two (2) of which were *Anopheles* spp. (*An. gambiae and An. arabiensis*), one (1) *Culex* spp. (*Cx. quinquefasciatus*), one (1) *Aedes* spp. (*Ae. aegypti*); while the numbers of unidentified individuals for *Culex* and *Aedes* genera down to species level were one (1) species for each respectively. The results of this study found high species abundance and relatively low diversity but a high larval breeding index. There was no significant difference ($p > 0.05$) in larval abundance among the three groups. Most interestingly, the study found out that mosquitoes' larvae co-habit together in relation to the breeding habitats sampled across the study area. The results of this study signify high transmission risk of mosquitoes-borne diseases in the area. Thus, control interventions, to reduce malaria burdens and other arboviruses, in the city should be broadened to target the breeding sites of mosquitoes by implementing a larviciding strategy especially during the wet season is presumably the most cost-effective strategy to consider.

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1.0 Introduction

There are approximately 3,500 species of mosquitoes (Novianto *et al.*, 2021), traditionally placed in 43 genera, all belong to the family *Culicidae*. They are divided into three subfamilies: *Toxorhynchitinae*, *Anophelinae* (anophelines) and *Culicinae* (culicines). Mosquitoes have a worldwide distribution, occurring throughout the tropical and temperate regions. The three most important pest and vector species belong to the genera *Anopheles*, *Culex*, and *Aedes*. *Anopheles* species, are medically important vectors of malaria, lymphatic filariasis and arbovirus infections (Nicoletti, 2020). *Culex* species transmit Japanese encephalitis, lymphatic filariasis and west Nile fever (WHO, 2020). Aedes species are important vectors of yellow fever, dengue, Chikungunya, lymphatic filariasis, Rift valley fever, Zika and other arboviruses. The burden of these diseases is highest in tropical and subtropical areas and they disproportionately affect the poorest population,

claimed lives and overwhelmed heath systems in many countries (WHO, 2020).

Distribution of mosquitoes is determined by a complex set of demographic, environmental and social factors. Anthropogenic activities such as afforestation, deforestation, irrigation desertification agricultural expansion and increased human population have seriously encouraged the breeding successes of mosquito species close to human habitation, thereby increasing the rate of disease transmission. Climatic change such as increased temperature, rainfall, relative humidity also influenced the abundance and diversity of mosquito species (Lapang *et al.*, 2019). Mosquitoes exploit almost all types of lentic aquatic habitats for breeding (Novianto *et al.*, 2021) and have shown high preferences and greater affinity to different habitats. The breeding sites can be very diverse, including ponds, lakes, swamps, mashes, rice field, small rain pools, hoof prints, tyre-tracks, tree holes, plant axils, edge of streams. Artificial breeding sites, which include gutters, ditches, tyre-tracks, construction sites and swimming pools, provides the most abundant sources of mosquito larvae in urban areas of Africa.

Larval habitat characteristics is an important factor which affects the breeding pattern and population growth of mosquitoes (Amini *et al.*, 2020). Information about the larval habitat characteristics and pupal productivity can be utilized for the surveillance of the level of population growth, species diversity, and preferred breeding sites of mosquitoes, which are important aspects of integrated vector control. This study aimed to determine the species larval habitats (breeding index), abundance, and diversity of mosquitoes in Azare, Katagum Local Government Area, Bauchi State, Nigeria.

2.0 Materials and Methods

2.1 Study Area

The study was carried out in and around Azare area of Katagum Local Government, Bauchi State. It is located at 11º40'27"N and 10º11'28"E at an elevation of 436 meters. Azare is characterized by Sudan and Sahel Savannah vegetation pattern with rainy season rainfall forming between May and June and terminate in September to October, with average precipitation of 7.83. The temperature is high with an average daily 31.3ºC - 30.9ºC from April to May. They survey was carried out in ten selected communities namely Azare, Chara-Chara, Daramushe, Duhuwar Kura, Fatara, Gafada, Kujuru, Madangala, Buskuri and Bulkachuwa.

2.2 Larval sample collection

Mosquito larval breeding sites were surveyed in the selected communities, and the larval collection was done weekly from August to October, 2021. The collection was done from early hours of the day around 6:30 a.m. to 10:00 a.m. daily. Samples were taken from, rice-fields, rain pools, tire tracks, gutters, potholes, ponds and animal hoof prints using standard dipping techniques with a plastic dipper. From each habitat type; 2–10 dips were taken and the mosquito larvae collected in plastic barrels and taken to the Laboratory of Biology Department, Aminu Saleh College of Education, Azare, Nigeria.

2.3 Rearing of Larvae to Adults

The cages were arranged and marked according to the ten communities. The larvae collected from the field in each community were distributed into smaller rubber plates and kept into the cage, the larvae were fed with yeast and reared to adults.

2.4 Morphological Identification

All adult mosquitoes were identified morphologically using the taxonomic keys of Gillies and Coetze, (1987).

2.5 Data Analysis

2.5.1 Breeding Index (BI)

The breeding index (BI) formula adopted after Webb (2008), was calculated as follows:

$$BI = \frac{number\ of\ positive\ habitats}{total\ number\ of\ habitats\ inspected} \text{ X } 100$$

An area is at a high risk of transmission of mosquito-borne diseases when this index is above the threshold of 5% World Health Organization (Rozendaal, 1997).

2.5.2 Diversity Index

Shannon-Wiener diversity index adopted after Lamead (2011), was used to determine the diversity level of mosquitoes in the area:

$$H' = - \sum_{i=1}^{S} (Pi)(\ln Pi)$$

Where:

H′ is the diversity index

Pi is the proportion of individual species

S is the total number of species in the habitat and

i is the proportion of S species

Diversity index ranges from 0 - 5. Diversity index of 0 - 2.4 shows a low diversity, while 2.5 – 5 shows high diversity.

2.5.3 Larval abundance among the three mosquito species identified and statistics

Data of larval abundance among the three mosquito species were subjected to one-way analysis of variance (ANOVA) at $p < 0.05$ using SPSS version 26.

3.0 Results

A total of 2,320 larvae were collected, comprising of *Anopheles* 755 (32.54%), *Culex* 1,025 (44.18%) and *Aedes* 540 (23.28%). Out of the 2,320 larvae collected and reared, only 1,624 (70%) emerged to adults which spread across three genera: *Anopheles* 464 (20%), *Culex* 928 (40.00%) and *Aedes* 232 (10%). A total of four (4) species were identified; two (2) of which were *Anopheles* spp. (*An. gambiae and An. arabiensis*), one (1) *Culex* spp. (*Cx. quinquefasciatus*), 1 *Aedes* spp. (*Ae. aegypti*); while the numbers of unidentified individuals for *Culex* and *Aedes* genera down to

species level were one (1) species for each respectively.

3.1 Breeding Index (Bi) of Mosquitoes Larvae

Breeding Index of *Anopheles*, *Culex* and *Aedes* groups in relation to habitat types recorded in the study area is as shown in Table 1. Rice field was the most productive habitat and had the highest breeding index of 51.81 for the *Culex*, followed by rain pools (44.96) breeding index for *Anopheles*, Tire tracks (24.81) for *Culex* and Animal hoof prints (20.85) for *Anopheles*, while potholes and ponds was the least productive habitat type with breeding index of 0.00. The overall average BI recorded for *Anopheles*, *Culex* and *Aedes* larvae were 16.33, 20.41 and 8.16 respectively which are above 5.00% threshold signifying high transmission risk of mosquitoes-borne diseases in the area.

3.2 Mosquitoes Diversity in Azare, Katagum L.G.A., Bauchi State

Shannon-Wiener diversity index (H′) showed that mosquitoes diversity was relatively low (H′ =1.75) as shown in Table 2. *Cx. quinquefasciatus* have relatively high diversity (0.35) than other species; *An. gambiae* (0.32), other *cx. species* (0.31), *Ae. Aegypti* (0.27), An. *arabiensis* (0.26) and the least other *Ae. species* (0.23).

3.3 Larval abundance among the three mosquito species identified

The results of one-way analysis of variance (ANOVA) indicated that there was no significant difference ($p > 0.05$) in the mean abundance among the *Anopheles*, *Culex* and *Aedes* larvae collected, F = 2.37, df = 3, 5, P = 0.24 (Table 3).

Table 1: Breeding Index (BI) of Larvae in relation to habitat types in Azare, Katagum L.G.A., Bauchi State

	Habitat types							
Species	**Rice field**	**Rain pools**	**Tire tracks**	**Gutters**	**Potholes**	**Ponds**	**Animal hoof**	**Av. BI**
Anopheles	26.83	44.96	21.64	0.00	0.00	0.00	20.85	**16.33**
Culex	51.81	35.91	24.81	20.75	0.00	0.00	5.69	**20.41**
Aedes	0.00	21.86	0.00	35.28	0.00	0.00	0.00	**8.16**

Table 2: Diversity Index of Mosquitoes in Azare, Katagum L.G.A., Bauchi State

Species	**S**	**Pi**	**lPi**	**Pi(lPi)**
An. gambiae	468	0.20	-1.61	-0.32
An. arabiensis	287	0.12	-2.12	-0.26
Cx. quinquefasciatus	608	0.26	-1.35	-0.35
cx. species	417	0.18	-1.71	-0.31
Ae. aegypti	307	0.13	-2.04	-0.27
Ae. species	233	0.10	-2.30	-0.23
Total	**2320**			**-1.75**
H′ = -(-1.75)				**1.75**

Table 3: ANOVA table for larval abundance of the three mosquito species in Azare, Katagum L. G. A., Bauchi State

Treatments	Sum of Squares	df	Mean Square	F	*p*-value
Between Groups	109.78	2	54.89	2.37	0.24*
Within Groups	69.46	3	23.15		
Total	**179.23**	**5**			

***not significant, $p > 0.05$**

4.0 Discussion

The study determined the species habitat, abundance, and diversity of mosquitoes in Azare, Katagum L. G. A., Bauchi State, Nigeria. Morphological identification of larval mosquitoes reared to adults during the period of study yielded four species belonging to three mosquito genera. Two species of *Anopheles* (*An. gambiae and An. arabiensis*), one species of *Culex* (*Cx. quinquefasciatus*) and one species of *Aedes* (*Ae. aegypti*). In general, the larval habitats investigated were productive for at least two of the species encountered (particularly, *Anopheles* and *Culex*), with the exception of the ponds and potholes which were void of any species. Also, both the *Anopheles* and *Culex* species encountered were found in all the positive habitats, however, their degree of abundance varied considerably among these habitats.

The results of this study found high species abundance, high larval breeding index but relatively low diversity. This agreed with the findings of Ombugadu *et al.* (2019), while in contrast to the study of Wahedi *et al*. (2020), who reported highest diversity in *Anopheles* than the *Culex* mosquitoes in their study area. This difference may be attributed to several factors of rainfall abundance, tropics temperature, high relative humidity enhances the reason why *Anopheles* are highly distributed and abundant than *Culex*.

The high species abundance and larval breeding index may be due to anthropogenic activities which has created enabling environment for mosquitoes which resulted in more and renewed diversity in the occurrence and proliferation of mosquito species. This corresponds to the findings of Olayemi *et al.* (2014), Mattah *et al.* (2017), Afolabi *et al.* (2019), Lapang *et al.* (2019) and Amini *et al.* (2020) respectively in their separate investigations on mosquitoes' larval diversity in breeding sites and their distribution.

5.0 Conclusion

The findings of this study recorded high breeding index for *Anopheles*, *Culex* and *Aedes* larvae, high species abundance and relatively low diversity. This signify high transmission risk of mosquitoes-borne diseases in the area. Thus, control interventions, to reduce malaria burdens and other arboviruses, in the city should be broadened to target the breeding sites of mosquitoes by implementing a larviciding strategy especially during the wet season is presumably the most cost-effective strategy to consider.

Declarations

Consent for publication

All authors have read and consented to the submission of the manuscript.

Availability of data and material

Not Applicable.

Competing interests

All authors declare no competing interests.

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