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Distribution and Mapping of Mosquito Vectors Breeding Habitats in Some Areas of Jos North, Plateau State, Nigeria

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Abstract: Mosquitoes are primary vectors of infectious agents affecting humans and animals. This study aimed to identify and map mosquito breeding habitats in Jos North Local Government Area, Plateau State. Mosquito breeding habitats were surveyed between October and November 2023 using the dipping method and Global Positioning System (GPS). A total of 3,009 mosquito larvae, comprising 2 genera and 2 species, were collected. *Culex quinquefasciatus* (63.64%) was the most abundant species, followed by *Anopheles gambiae* (36.36%). No significant difference in mosquito larvae abundance was found across locations (P = 0.4098). However, significant differences were observed in *Anopheles* larvae abundance across locations (P = 0.01288). Eight breeding habitats were identified and mapped, with riverbank/bed habitats showing the highest abundance of mosquito larvae. The study's findings highlight the importance of understanding breeding habitats and mapping malaria vectors to inform effective control programs and mitigate the risk of mosquito-borne infections.

Keywords: Mosquitoes, Mapping, Breeding habitats, Jos North, Plateau State.

Introduction

Mapping the spatial distribution of mosquito breeding habitats is crucial for effective deployment of control practices [1]. Geospatial mapping, using remote sensing, offers the potential to identify breeding habitats over large areas, which is difficult to achieve through conventional ground surveys [2]. The integration of Geographic Information System (GIS) and Remote Sensing (RS) technologies has become increasingly important in studying the spatial and temporal patterns of vector distribution [3]. This research aims to combine GIS/RS environmental and entomological data to map the breeding habitats of mosquito species. Mosquitoes are primary vectors of infectious agents in humans and animals, transmitting parasites that cause malaria, filariasis, and various viruses (e.g., dengue, yellow fever, and encephalitis) [4,5]. While many studies have focused on the epidemiological role of mosquitoes, researchers have also highlighted their ecological importance, particularly in providing a food source for fish and aquatic invertebrates [6]. Mosquitoes inhabit various larval habitats, including lakes, pools, stagnant water in artificial containers, and tree holes [7].

However, many habitats are species-specific, requiring specific aquatic parameters [8]. In peri-urban areas, artificial recipients serve as crucial sites for mosquito life cycles, including oviposition, larvae and pupae development, and adult emergence [9]. Studying anopheline larvae is essential for understanding malaria transmission risk [10]. Source reduction through modification of larval habitats is critical for malaria eradication efforts. Effective management of larval habitats can suppress vector and malaria transmission. However, anopheline larval ecology is limited, partly due to the challenges involved in larval sampling from aquatic habitats [11].

Recent advancements in geographic positioning system (GPS) and GIS technologies offer alternative approaches to traditional vector surveillance [10]. Remote sensing (RS) and GIS are valuable tools for assessing the spatial epidemiology of vector-borne diseases and analyzing human risk of infection [12]. This study aims to identify and map mosquito breeding habitats using GPS in some areas of Jos North L.G.A, Plateau State.

Materials and Methods

Study Area

Jos North Local Government Area is situated between Latitude 9°05'N and Longitude 8°05'4"E. The area experiences a high rainfall of approximately 1351 mm, with a temperature range of 20°C (minimum) to 28°C (maximum). Due to its elevated altitude compared to surrounding areas at the same latitude, the relative humidity is relatively low during the dry season and increases during the rainy season. This study was conducted in nineteen selected areas of Jos North Local Government Area, which include: 3 Container, Alheri, Angwan Rukuba, Angwan Rimi, Angwan Suya, Apata, Area command, Atili, Chorbe, Etobaba, Faringada, Gada Biyu, Lamingo, Mazah, Rafin Karfe, Russau, Unijos Permanent site, West of mines, and Zololo (Figure 1).

Sampling Period

A survey of mosquito breeding habitats was conducted between October and November 2023. The surveys were carried out during the early hours of the day, from 6:30 am to 1:00 pm, on a daily basis. To ensure accuracy and comprehensiveness, most breeding habitats were visited twice a week during this period.

Collection of Entomological Data

Mosquito breeding habitats were surveyed using the dipping sampling method. To minimize disruption, the dipper was gently lowered into the water at an angle of approximately 45°. The top layer of water was skimmed, allowing nearby larvae to flow into the dipper. The dipper was then carefully raised from the water to prevent spillage. In cases where breeding habitats featured emerging vegetation, the water was gently disturbed to prompt larvae to swim downwards. Vegetation was then removed using the dipper to create a clear sampling area. Collected larvae were transferred to a white plastic bucket and transported to the laboratory for taxonomic identification. Identification was conducted using the keys of Harbach [13], Harbach [14], and Glick [15].

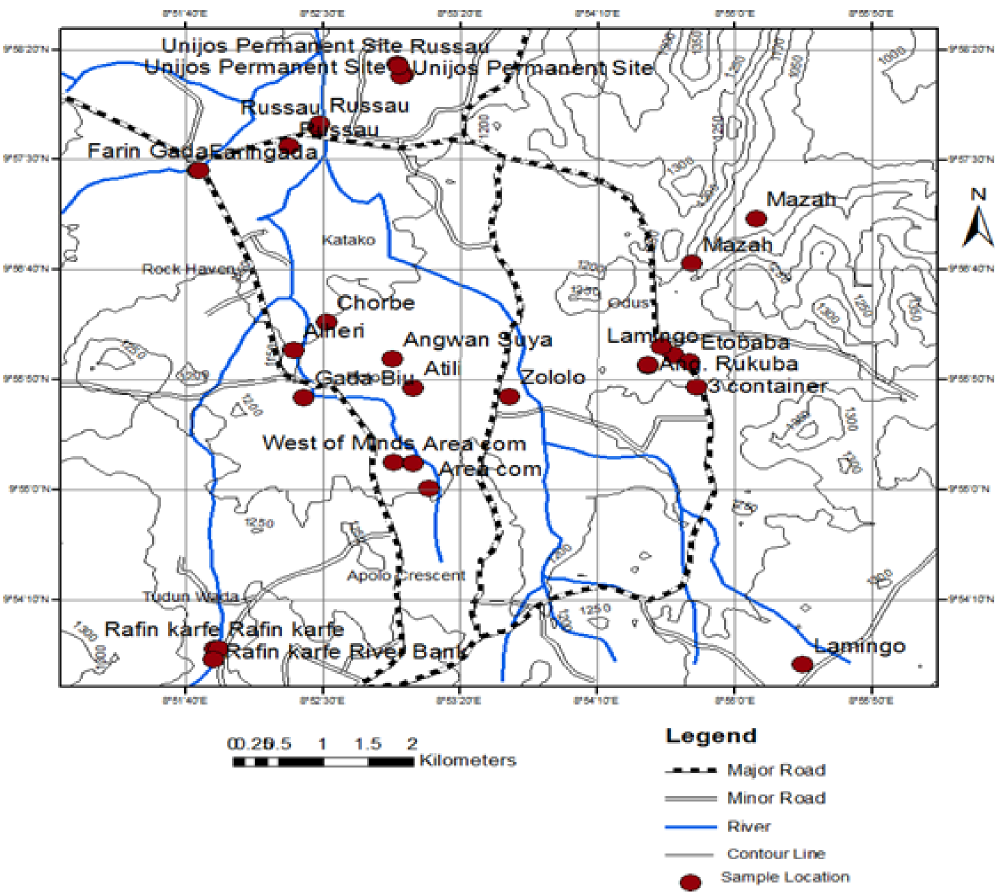

Figure 1: Map of the study areas in Jos North LGA, Plateau State, Nigeria

Determination of Mosquito Breeding Habitats

Breeding habitats positive for mosquitoes were identified and described based on their characteristic features. The habitats were categorized into the following types: Tyre tracks, Swampy areas, Ditches, Riverbank/bed. Wet-lands (featuring grasses, rushes, reeds, Typha, sedges, and other herbaceous plants in shallow water), Gutters, Temporary Water Bodies and Hoof prints. These habitat characteristics provided a framework for understanding the diverse environments that support mosquito breeding.

Mapping of Mosquito Breeding Habitats

The coordinates of habitats containing mosquito larvae were recorded using a hand-held Global Positioning System (GPS) device (Garmin GPSMAP 60CSx). The GPS data were extracted using Map Source software and subsequently integrated into a Geographic Information System (GIS) database using ArcGIS 9.3 software. This integration enabled the quantification of spatial heterogeneity in the associated area and provided a graphical visualization of mosquito-breeding sites. Specifically, it allowed for the identification of zones with high larval abundance and their correlation with nearby water bodies. Raster images of the site were overlaid with feature layers and entomological data in the GIS database, facilitating a comprehensive analysis of the spatial distribution of mosquito breeding habitats.

Statistical Analyses

Data analysis was performed using R version 3.2.2. One-way analysis of variance (ANOVA) was employed to compare the abundance of mosquito larvae across different locations and habitat types. Additionally, Welch's two-sample t-test was used to compare the mean abundance of larvae between mosquito species. Statistical significance was set at $P < 0.05$.

Results

The species composition of mosquito larvae collected during this study is presented in Table 1. A total of 3,009 mosquito larvae were collected, belonging to 2 genera and 2 species. The abundance of larvae differed significantly between mosquito species ($t = -2.4641$, $df = 48.47$, $P = 0.01733$) (Figure 2). *Culex quinquefasciatus* was the most abundant species, accounting for 63.64% (1,915 individuals) of the total larvae collected. *Anopheles gambiae* was the least abundant species, representing 36.36% (1,094 individuals) of the total larvae collected. No significant difference was found in the abundance of mosquito larvae across different locations ($F_{13} = 1.144$, Adjusted $R^2 = 0.0771$, $P = 0.4098$) (Figure 3). However, Russau had the highest abundance of mosquito larvae, with 508 individuals (16.88%), while 3 Container had the lowest abundance, with 17 individuals (0.56%). A significant difference was found in the abundance of *Anopheles* larvae across different locations ($F_{13} = 3.504$, Adjusted $R^2 = 0.5925$, $P = 0.01288$) (Figure 4). Rafin Karfe had the highest abundance of *Anopheles* larvae, while 3 Container and West of Mine areas had the lowest abundance. In contrast, no significant difference was found in the abundance of *Culex* larvae across different locations ($F_{13} = 1.013$, Adjusted $R^2 = 0.007557$, $P = 0.5012$) (Figure 5). Russau had the highest abundance of *Culex* larvae, while 3 Container had the lowest abundance.

A total of 8 breeding habitats of mosquito species were identified across the 19 study areas. The abundance of mosquito larvae varied significantly across these breeding habitats ($F_{24} = 3.79$, Adjusted $R^2 = 0.3865$, $P = 0.006595$) (Figure 6). Riverbank breeding habitats yielded the highest abundance of mosquito larvae, while tyre track breeding habitats had the lowest abundance. The abundance of *Anopheles* larvae did not differ significantly across breeding habitats ($F_{24} = 1.345$, Adjusted $R^2 = 0.07231$, $P = 0.273$) (Figure 7). However, riverbank breeding habitats had the highest abundance of *Anopheles* larvae, while tyre track breeding habitats had the lowest. Similarly, the abundance of *Culex* larvae did not differ significantly across breeding habitats ($F_{24} = 2.22$, Adjusted $R^2 = 0.2159$, $P = 0.06874$) (Figure 8). Riverbank breeding habitats had the highest abundance of *Culex* larvae, while tyre track breeding habitats had the lowest. A density map (Figure 9) represented the 19 study areas and their respective mosquito breeding habitats, with *Anopheles* species indicated by red numbers and *Culex* species indicated by blue numbers.

Table 1: Species Composition of Mosquito larvae in some areas of Jos North LGA, Plateau State.

Area	Mosquito Larvae		Total (%)
	Anopheles gambiae	*Culex quinquefasciatus*	
3 Container	7	10	17 (0.56)
Alheri	60	112	172 (5.72)
Angwan Rimi	60	89	149 (4.95)
Angwan Rukuba	102	358	460 (15.29)
Angwan Suya	30	98	128 (4.25)
Apata	13	43	56 (1.86)
Area command	25	73	98 (3.26)
Atili	8	30	38 (1.26)
Chorbe	32	63	95 (3.16)
Etobaba	10	27	37 (1.23)
Faringada	28	40	68 (2.26)
Gada Biyu	46	96	142 (4.72)
Lamingo	41	15	56 (1.86)
Mazah	146	124	270 (8.97)
Rafin Karfe	267	127	394 (13.09)
Russau	59	449	508 (16.88)
Unijos Permanent Site	138	65	203 (6.75)
West of mine	7	24	31 (1.03)
Zololo	15	72	87 (2.89)
Total	**1094**	**1915**	**3009**

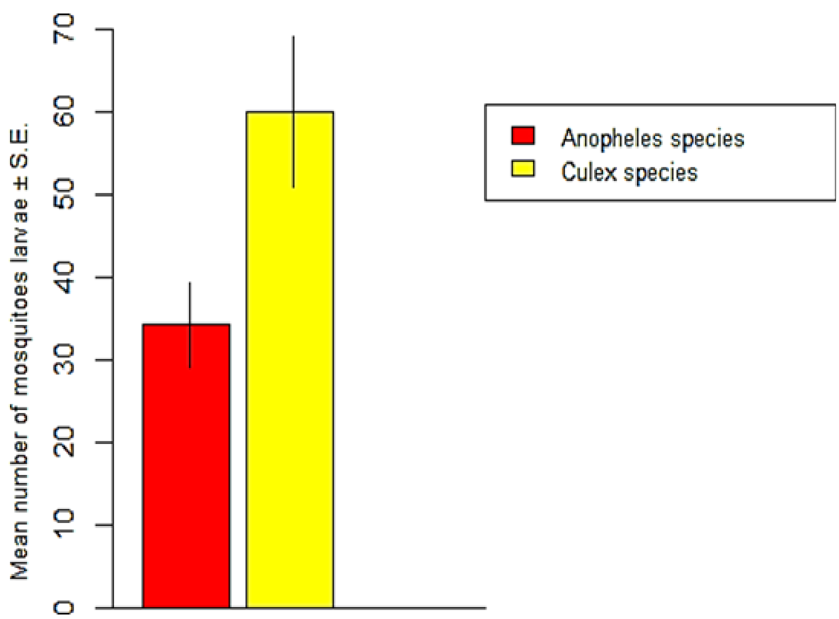

Figure 2: Abundance of larvae in relation to mosquito species.

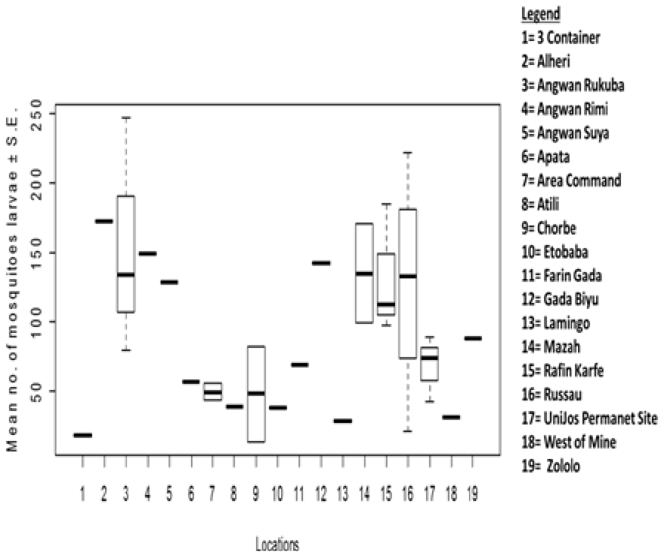

Figure 3: Abundance of mosquito larvae in relation to locations.

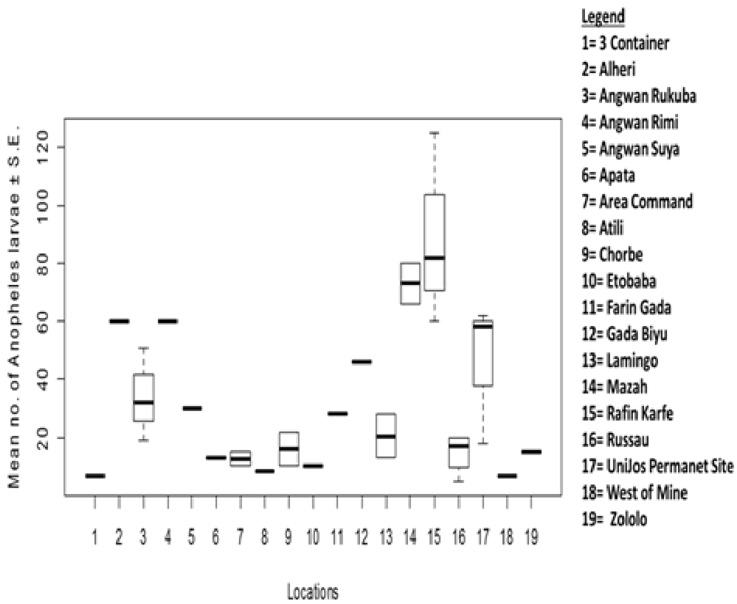

Figure 4: Abundance of Anopheles larvae in relation to locations.

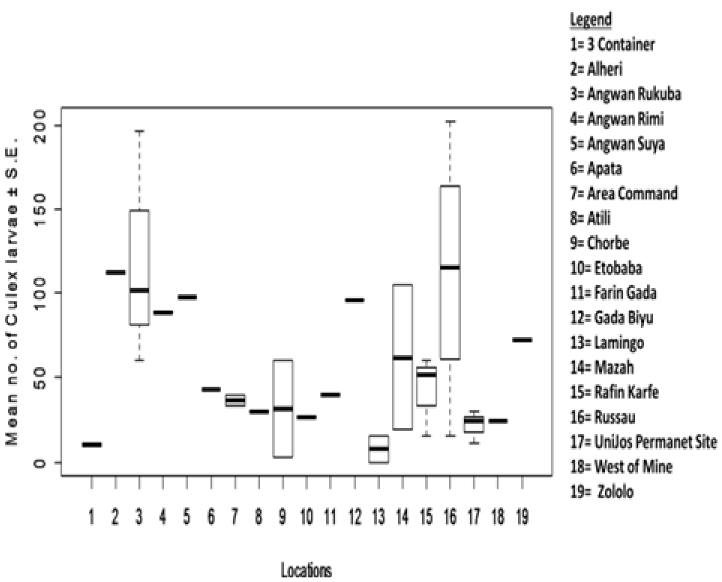

Figure 5: Abundance of Culex larvae in relation to locations.

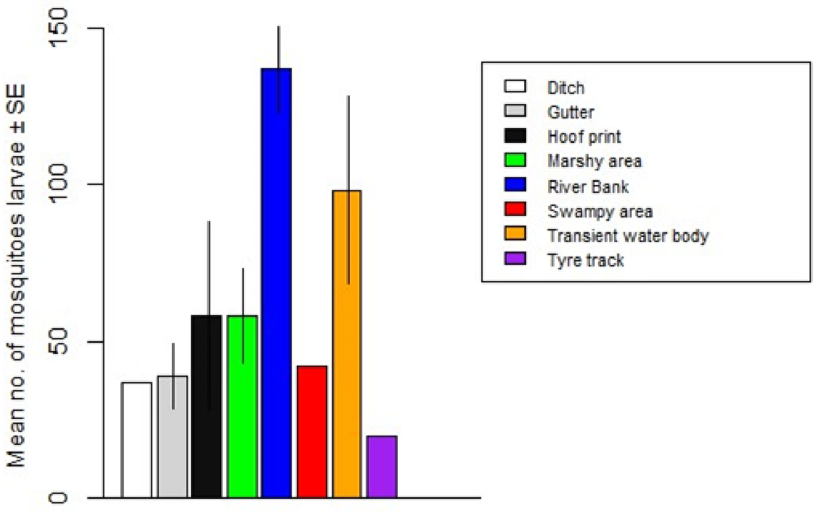

Figure 6: Abundance of mosquito larvae in relation to breeding habitats.

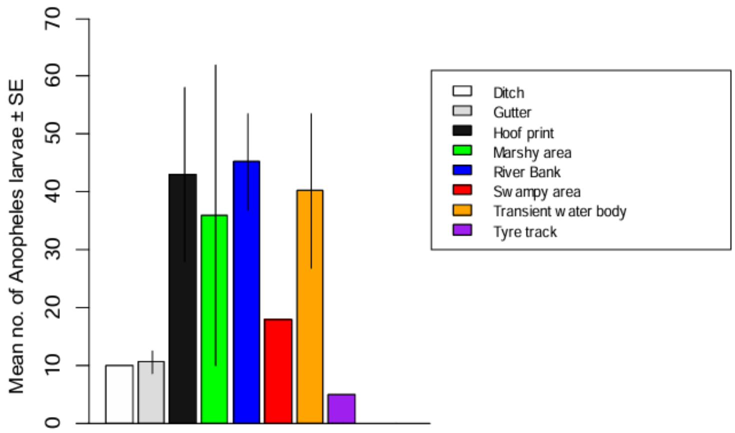

Figure 7: Abundance of Anopheles larvae in relation to habitat types.

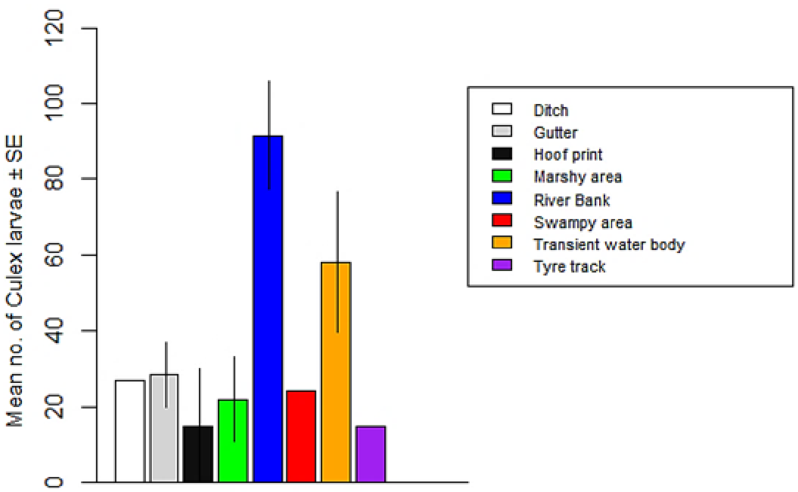

Figure 8: Abundance of Culex larvae in relation to breeding habitats.

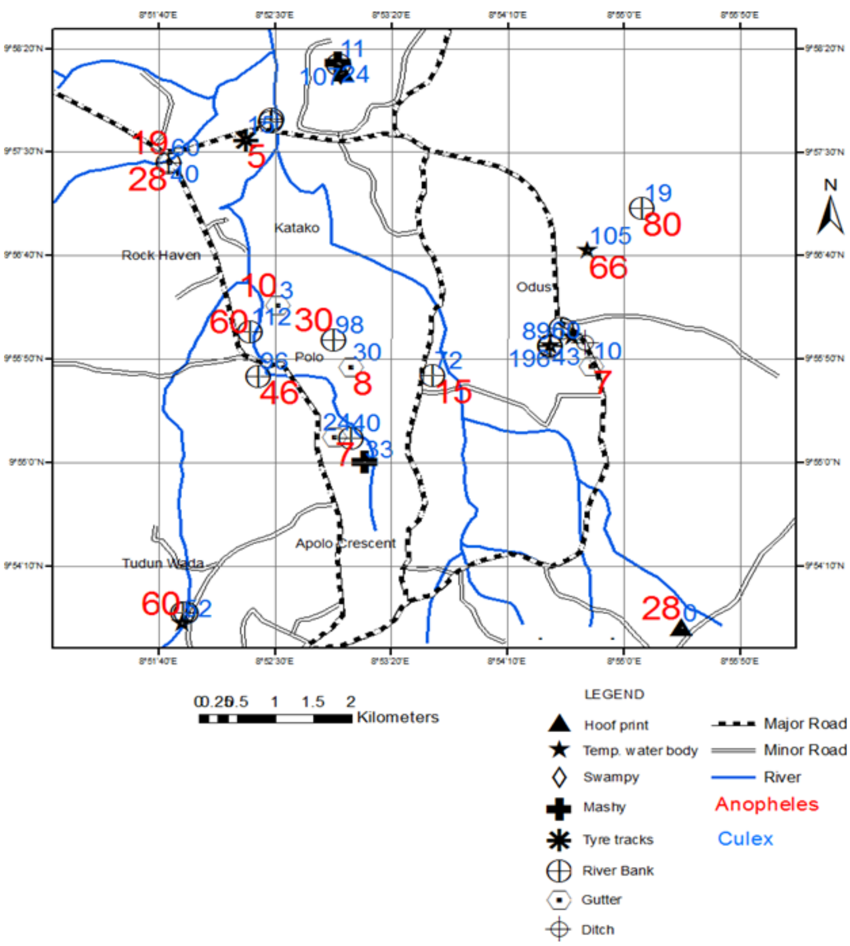

Figure 9: The density map of mosquito species and breeding habitats survey using GPS.

Discussion

The collection of 3,009 mosquito larvae, representing 2 genera and 2 species (Table 1), highlights the impact of unplanned urban expansion on mosquito breeding conditions in Jos North LGA. The lack of infrastructural development has created an environment conducive to mosquito breeding. These findings are consistent with previous research by Klinkenberg et al. [16], which demonstrated that unplanned urban expansion can lead to increased mosquito breeding sites. The study's results suggest that mosquito breeding habitats in Jos North are more prevalent in underdeveloped or poorly planned areas, characterized by high household and population density. These areas include slums and urban business districts. The non-significant difference in mosquito larvae abundance across locations (Figure 3) can be attributed to intensive irrigation farming in areas like Russau, which had the highest number of larvae collected. This finding is supported by Killeen [17], who linked high larvae abundance to agricultural activities. The significant difference in *Anopheles* larvae abundance across locations (Figure 4), with Rafin Karfe having the highest abundance, is consistent with the findings of Odikamnoro et al. [18]. However, the comparison of *Culex* larvae abundance showed no significant difference (Figure 5), with Russau having the highest abundance. This finding is in line with the work of Amerasinghe et al. [19], who reported high abundance of *Culex*, suggesting that the species is an indiscriminate breeder. The distribution of mosquito larvae across breeding habitats showed a significant difference (Figure 6). The highest abundance of mosquito larvae was collected from riverbank breeding habitats, which can be attributed to habitat preferences of the immature stages. These habitats, whether natural or man-made, temporary or permanent [20], provide ideal conditions for mosquito breeding. The high abundance of *Anopheles* larvae collected from riverbank breeding habitats can be attributed to habitat permanency, canopy cover, emergent plant cover, and wastewater [11]. Mutuku et al. [21] also found that *Anopheles* larvae prefer small habitats like hoof prints, temporary water bodies, and riverbanks. Similarly, high abundance of *Culex* larvae was collected from riverbank breeding habitats, consistent with the findings of Okiwelu and Noutcha [22], who recorded high numbers of *Cx. quinquefasciatus* larvae at stagnant polluted water.

Conclusion

This study investigated the spatial distribution and abundance of mosquito larvae in Jos North Local Government Area, Plateau State, Nigeria. The results revealed that *Culex quinquefasciatus* and *Anopheles gambiae* were the dominant species, with a significant difference in their abundance across different breeding habitats. Riverbank breeding habitats were found to be the most conducive for mosquito breeding, with high abundance of both species. The study's findings highlight the need for effective mosquito control measures, particularly in areas with high household and population density.

Recommendations

To effectively manage mosquito populations and reduce disease transmission, we recommend the following

Strategies

1. Implement Integrated Vector Management (IVM) incorporating environmental management, larval control, and adult mosquito control.
2. Modify breeding habitats through proper drainage, removal of stagnant water, and vegetation management.
3. Educate the public on mosquito control importance, particularly in high-risk areas.
4. Conduct regular surveillance to monitor mosquito populations and identify high-risk areas.
5. Foster collaboration among local government, health authorities, and stakeholders to develop effective control strategies.
6. Pursue further research on environmental factors influencing mosquito breeding to inform evidence-based control measures.

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