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Implications of Larval Breeding Sites on Diversity of Mosquito Species in Suleja Metropolis, Northcentral Nigeria

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Abstract

Information on native mosquito species viz-a-vis the nature of their breeding sites can help determine the epidemiology of mosquito-borne diseases in an environment, hence, species of mosquito in breeding sites were surveyed in Suleja metropolis. All accessible larval habitats were surveyed between June and October, 2023 within Suleja township and New (Sabo) Gwazunu both of which are within Suleja metropolis. A total of five species: An. gambiae s.l, Cx. quinquefasciatus, Aedes albopictus, Aedes aegypti, and Cx. papiens were encountered. The mean values of larvae recovered from transient habits such as rock holes and holes on shrubs and tree bark are significantly ($P < 0.05$) higher than larvae recovered from run-off and drums in new (Sabo) Gwazunu. Disused wheel tires had the highest species diversity in Suleja township (Shannon-Weiner index=0.60) while the highest species diversity obtained in New Gwazunu is 0.48 Shannon-Weiner index. The contribution of ecosystems, together with the increasing rate of human activity, may give an abundance of breeding grounds for mosquitoes. It is

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therefore recommended that the human population in Suleja metropolis should maintain environmental sanitation and management.

Keywords: Breeding sites, Epidemiology, New Gwazunu, Shannon-Wiener-index, Suleja

INTRODUCTION

In Sub-Saharan Africa, and especially in Nigeria, mosquitoes are a major vector of diseases such as malaria, dengue, and lymphatic filariasis (WHO, 2012; Hemingway *et al.* 2013; WHO, 2018). Mosquitoes are thus extremely important for public health because they do not only carry lethal and life-threatening diseases but also cause severe biting discomfort (Ughasi, *et al.* 2012; Adeleke *et al.* 2013). The effect of these diseases is felt primarily in Sub-Saharan Africa due to low socio-economic conditions and the vast expanse of aquatic ecosystems that provide ideal breeding grounds for mosquito vectors (Idowu *et al.* 2012).

In endemic locations, vector control has been highlighted as a major technique to reduce the brunt of mosquito-borne diseases. Unfortunately, mosquito vectors have developed resistance to more popular vector control methods and tools (chemical insecticide spray and use of Long-Lasting Insecticide Nets (LLINs), necessitating the search for more viable and environmentally friendly mosquito vector control strategies (Nkya *et al.* 2013; Olagundoye and Adesoye, 2023). Reduction in mosquito breeding grounds is an example of an effective and environmentally friendly method of lowering mosquito vectors. This is accomplished by reducing the quantity of larvae that will develop into adults (Oduola *et al.* 2017).

Various public health issues have arisen as a result of the current realities of demographic growth and urbanization in various parts of Nigeria (Adeleke *et al.* 2013). Environmental changes caused by deforestation, plant clearance for agricultural purposes, and human population development increase the proliferation of malaria vector larval habitats (Sovi *et al.* 2013). Unfortunately, the post-independence era's replacement of sanitary supervisors with environmental management campaigns has exacerbated the issue of mosquito vector control in Nigeria. This is because the understanding of the former was to keep the environment free of mosquito breeding sites and other life-threatening diseases through their regular operations (Aigbodion and Anyiwe, 2005).

Report from Mogba *et al.* (2016) and other research reports revealed that Suleja metropolis, in Northcentral Nigeria is endemic to mosquito-borne diseases (Balarabe *et al.* 2012; Yayock, *et al.* 2021), however, little information is available on the types of mosquito vector species and breeding places in the city. In this context, the current study was conducted to give baseline information on mosquito species and larval breeding sites as they relate to human demography in Suleja, Northcentral Nigeria.

MATERIALS AND METHODS

Study Area

Suleja in Niger State is distinguished by Southern Guinea Savanna vegetation. There are two seasons in the area: the dry season (November to March) and the wet season (April to October) (Akano *et al.* 2016). Mosquito larvae were sampled in two locations:

Suleja township study area is found at latitude 9°10'50.12" N and longitude 7° 10' 45.80" E. This area is thickly populated and provides essential social services like electricity, piped water, and road networks. The density of vegetation cover in the area has been greatly reduced as a result of urbanization. Majority of the present sites found here were permanent ones such slow moving river and water collected under bridge as shown in Plate 1 and Plate 2.

Plate 1. River Kantoma in Suleja Township Breeding Mosquito

Plate 2. Disused Vehicle Wheel-tires Breeding Mosquito in Suleja Township

New Gwazunu is a resettlement area south of Suleja township (Latitude: 9°08'13.18"N; Longitude: 7° 11' 46.79"E). This area is sparsely populated and has limited or no economic activities. However, typical vegetation of lush grassland with many trees, shrubs, and bushes, as well as gallery forests, can be seen. Temporary breeding sites were principally found in New Gwazunu as shown in Plate 3 and Plate 4.

Plate 3. A Water Run-off in New Gwazunu Breeding Mosquitoes

Plate 4. Mosquito Breeding Site on Rock Surface in New Gwazunu

Collection of samples

Larval samples were conducted at all accessible breeding locations in the Suleja metropolis weekly between 7:00 and 11:00 a.m. Identified breeding sites were mapped using Garmin eTrex® GPS 10 personal navigators, following a standard protocol (Service,1971). Using a standardized technique, larval samples were collected by gently submerging white dippers at a 45° angle from identified breeding sites, skimming the water's surface, and then transferring the samples into labeled collection bottles (Adeogun *et al*. 2021). The breeding places were grouped and carried out in the two selected locations of the Suleja metropolis (Suleja township and New Gwazunu). The mosquito larvae were gathered into labeled containers using plastic scoopers and sieves with a mesh size of around 0.55 mm and taken to the laboratory for identification. The larval samples were maintained under controlled insectary conditions (25–28 °C and ~70–80% humidity, with a 12-hour day/night cycle) (Adesoye *et al*. 2023), and yeast was provided daily as food. Adult emergence was fed with a 10% glucose solution soaked in cotton wool.

Larval identification
All larvae were identified with the keys supplied by Hopkins (1956). Some larvae were allowed to mature into adults inside mosquito breeding cages and identified using Gillet's keys (Gillet, 1972).

Data analysis
SPSS version 20.0 was used to analyze the collected data. The student t-test and chi-square were used to identify the significant differences in habitat and species distribution in the study areas. The species diversity of the breeding locations was determined using the Shannon-Wiener Index (SI).

RESULTS

Mosquito Larval Breeding Sites within Suleja Metropolis

Mosquito larval breeding sites encountered varied depending on the two locations: Suleja Township; gutters, septic tanks, ground pools (open drains), abandoned containers, and used wheel-tires. New (Sabo) Gwazunu; run-offs, drums, tree/shrub bark, rock holes, and leaves (sediments). There were 450 larval sites discovered in total, the majority of 310(68.80%) of this value were found in Suleja township, and of which 195.0(63.09%) were positive for mosquito larvae. On the other hand, 90% of the breeding sites in New Gwazunu were positive for larval breeding. The majority of the habitats in Sabo Gwazunu appear more unstable (transient in nature) (Table 1).

Table 1: Distributions Rates (%) of Mosquito Breeding Sites in Suleja Metropolis

Suleja Township						New Gwazunu					
No. of Gutters (%)	No. of Septic tanks (%)	No. Ground pools (%)	No. of Abandoned containers (%)	No. of Wheel-tires (%)	Total (%)	No of runoffs (%)	No. of Drums (%)	No. of tree/shrub bark (%)	No. of leaves (sediments) (%)	No. of rock Holes (%)	Total (%)
20 (10.20)	15(7.60)	15(7.60)	24(12.30)	121 (62.00)	195.0 (63.0)	10(7.70)	8(6.20)	15(9.43)	6(4.65)	90(69.76)	129 (90.0)

Table 2: Mean (± SD) Larval Value Contributions of Mosquito Breeding Sites in Suleja Metropolis

Suleja Township					New Gwazunu				
Gutters	Septic tanks	Ground pools	Abandoned containers	Wheel-tires	run-offs	Drums	tree/shrub bark	Leaves (sediment)	rock Holes
60.1 ±1.50b	59.5 ±1.00b	57.1 ±1.20b	50.00 ±0.00b	200.5±0.50a	94.0 ±0.00c	85.5 ±1.50c	172.00±0.00b	91.1 ±1.50c	227.50±0.50a

Subscript of Mean values with the same alphabets along the row are not significantly different (P>0.05)

Table 2 expresses the mean contributions of the five primary mosquito larval habitats encountered in each of the two selected locations of the study. The number of larvae found among discarded wheel tires was significantly higher ($P < 0.05$) than in the other habitats, but there were no significant differences in the contribution of gutters, septic tanks, ground pools, and abandoned containers to the breeding of the species located in Suleja township. Interestingly, the mean values of larvae recovered from transient habits such as rock holes and holes on shrubs and tree bark are significantly ($P < 0.05$) higher than larvae recovered from run-off and drums in new (Sabo) Gwazunu.

Table 3: Mosquito Occurrence and Species Diversity in Different Larval Habitats within Suleja Township

Nature of breeding sites	Mosquito Species	Shannon-Wiener Index (SI)
Gutters	*Anopheles gambiae s.l*	0.48
	Cx. quinquefasciatus	
	Ae. albopictus	
Septic tanks	*Ae. aegypti*	0.48
	Cx. papiens	
	Cx. quinquefasciatus	
Ground pools	*Ae. albopictus*	0.30
	Cx. quinquefasciatus	
Abandoned containers	Ae. aegypti	0.48
	Anopheles gambiae s.l	
	Cx. quinquefasciatus	
Wheel-tires	*Anopheles gambiae s.l*	0.60
	Ae. albopictus	
	Cx. quinquefasciatus	
	Cx. papiens	

Tables 3 and 4 highlight the species variety (diversity) of the mosquito population encountered in the breeding sites in Suleja township and New Gwazunu, respectively. A total of five species from three genera were discovered: *Aedes, Culex, and Anopheles*. *An. gambiae* s.l., *Cx. quinquefasciatus*, *Aedes albopictus, Aedes aegypti,* and *Cx. papiens* were among the species encountered. *Anopheles* mosquitoes were discovered in three of the five habitats in Suleja township, whereas mosquitoes from the same complex were detected in all habitats in New Gwazunu. Disused wheel tires had the highest species diversity in Suleja township (Shannon-Weiner index=0.60) while the highest species diversity obtained in New Gwazunu is 0.48 Shannon-Weiner index. There was no significant difference in the occurrence of mosquitoes in each habitat ($P>0.05$) except in wheel tires in Suleja township. However, there was no significant difference in species diversity across all habitats in the new Gwazunu (Shannon-Weiner index=0.48)

Table 4: Mosquito Occurrence and Species Diversity in Different Larval Habitats within New Gwazunu

Breeding habitats	Mosquito Species	Shannon-Wiener Index (SI)
run-offs	*Anopheles gambiae s.l*	0.48
	Cx. quinquefasciatus	
	Cx. papiens	
Drums	*Ae. aegypti*	0.48
	Anopheles gambiae s.l	
	Cx. quinquefasciatus	
tree/shrub bark	*An. gambiae s.l*	0.48
	Ae. aegypti	
	Cx. papiens	
Leaves (sediment)	*Ae. aegypti*	0.48
	Ae. albopictus	
	An. gambiae s.l	
rock Holes	*Ae. aegypti*	0.48
	Cx. quinquefasciatus	
	An. gambiae s.l	

Discussion

The presence and productivity of larval habitats have substantial implications for mosquito-borne disease transmission (Kweka *et al.* 2012). Suleja like every other city in Nigeria increased in population due to rural-urban drift, and hence experiencing urbanization with a consequential increase in flooded areas. The flooded environment could provide ample opportunities for waterborne diseases and create conducive breeding sites for mosquitoes (Mwayangi *et al.* 2007). This study indicated that neglected containers abandoned wheel-tyres drainage, and other ma-made sites provided good opportunities for mosquito breeding.

Even though Suleja township has a higher number of encountered larval habitats (195) than New Gwazunu (129), this does not translate into higher larval productivity. Up to 90% of the breeding sites in New Gwazunu were positive for larval breeding, indicating that the area is at a higher risk of mosquito-borne disease transmission. This is in line with a study carried out by Forson *et al.*, (2023) which indicated that little above 50 % of the encountered mosquito breeding sites in two locations in Southern Ghana were positive for mosquito breeding. Adeogun *et al.* (2021) explained that only 600 out of 1200 sampled mosquitoes from various breeding sites were useful for their research work. Man-made breeding habitats (such as wheel-tyres) mostly contributed to larval breeding in Suleja township, where the majority of economic activity occurs in the city. Imbahale *et al.* (2011) reported a similar discovery on Kenya's mainland, where larvae were more likely to be obtained in man-made rather than natural breeding sites.

Mosquito-borne infections, particularly malaria, predictably occur regularly in the Suleja metropolis. This is because no fewer than five mosquito-vector species were discovered in the current investigation for this location. Members of the *An. gambiae s.l* has been implicated in the recent study across Nigeria by Adeogun *et al.* (2023) to be the major constituent of the populations of Anophelines collected during their study and may be responsible for malaria transmission within the country. Therefore, attention should be paid to breeding sites majority of which are transient-temporary ones in New Gwazunu and Suleja township as the majority of them breed *An. gambiae* mosquitoes. Some other studies (Onyido *et al.* 2009; William & Pinto, 2012) have also indicated the temporary breeding sites in the proximity of human dwellings favour *Anopheles* mosquitoes as they find it more convenient to breed in there rather than polluted breeding sites available for other mosquito species such as *Cx. quinquefasciatus*.

CONCLUSION

This research work serves as a warning and emphasizes the importance of taking preventive measures such as using mosquito nets, insect repellents, and other strategies to reduce the risk of contracting mosquito-borne diseases. Larval source management programs should target both permanent and temporary habitats and collaborate closely with land and homeowners. Since the majority of mosquito breeding sites in Suleja township are man-made, human activity contributed to the majority of larval habitats at this study site; thus, population involvement in larval source management measures would be highly helpful. As Suleja and its environs continue to rise in population, the Government will need to maintain environmental sanitation and management to limit the occurrence of mosquito-borne diseases. Residents should also be educated about mosquito breeding areas and the importance of eliminating them.

Conflict of Interest

The authors declare that there is no conflict of interest

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