IJAAR PUBLISHING®

Scholarly Journal of Science and Technology Research & Development | ISSN: **2955-0807**
Vol. 2, Issue 10 (October, 2023) | www.ijaar.org/sjstrd

ASSESSMENT OF MOSQUITO DIVERSITY AND DISTRIBUTION IN FAGGE LOCAL GOVERNMENT, KANO STATE, NIGERIA

Iliyasu Ishaka Muhammad[1*], Shafiu Nafiu Abdullahi[2], Abubakar Haruna[3], Mujiba Nasir Shehu[4], and Bala Usman Abdullahi[5]

[1]Department of Science Laboratory Technology, School of Natural and Applied Sciences, Nigerian Army College of Environmental Science and Technology (NACEST) Makurdi, Benue State, Nigeria
[2]Department of Life Sciences, Kano State Polytechnic, Kano, Nigeria
[3]Department of Science Laboratory Technology, Mai Idris Alooma Polytechnic, Geidam, Yobe State
[4]Department of Pharmaceutical Technology, Kano State Polytechnic, Kano, Nigeria
[5]Department of Science Laboratory Technology, Federal Polytechnic Oko, Anambra State, Nigeria

*Corresponding authors:ishaqailiyasu77@gmail.com, nafiune.sn@gmail.,com+2348060382424

Abstract

Diversity and distribution of mosquito species were examined between June and October, 2022 in Fagge Local Government area of Kano State. Mosquitoes were sampled monthly from fifty (50) clusters communities randomly distributed across the city using standard protocols. The mosquito habitats surveyed were tyre tracks, ditches, domestic run-offs, containers, used vehicle tyres, gutters, containers, footprints and stagnant waters within the sampling stations. The mosquitoes larvae collected were kept until adult emergence and identified using established identification keys. A total of 6559 mosquito species belonging to three genera Anopheles gambiae (70.63%) Culex quinquefasciatus (8.7%), Aedes aegypti (12.51%), and Anopheles arabiensis (8.14%) were collected. Out of these, Anopheles gambiae were the dominant species with 70.63%. September had the highest number of mosquitoes with the peak value of 1789 mosquitoes. Mosquitoes density was highest at site D with 1687(25.73%) and the lowest at site A with 983 (14.98%). The cumulative Biotic Indices analyses of Shannon-wiener Index had its highest value among A. gambiae with 2.56 and Evenness Index of 0.89. The distribution of mosquito species indicated that the mosquitoes occurred in all five clusters with the highest number of mosquitoes found at site D. The presence of these mosquitoes in the study may cause mosquito borne diseases such as malaria and yellow fever in the area. Therefore, there is need for effective mosquito control and public enlightenment on the need to prevent mosquitoes from breeding.

Keywords: Mosquito, Diversity, Distribution; Fagge Local Government, Malaria

Published *21/10/2023*
Muhammad, I.I, Abdullahi, S.N, Haruna, A., Shehu, M.N. & Abdullahi, B.U. (2023). Assessment of Mosquito Diversity and Distribution in Fagge Local Government, Kano State, Nigeria. *Scholarly Journal of Science and Technology Research & Development*, 2(10), 1-9.

Introduction

Malaria is a mosquito-borne infectious disease of humans and other animals caused by protists (a type of microorganism) of the genus *Plasmodium* (Abdulrasheed et al., 2016).Mosquitoes belong to the order Diptera, Family Culicidae and Subfamily Culicinae. They are characterized by having long conspicuous needle-shaped mouthparts comprising the proboscis which, in the female, is used for sucking blood (WHO, 2020). It begins with a bite from an infected female mosquito, which introduces the protists via its saliva into the circulatory system, and ultimately to the liver where they mature and reproduce. The disease causes symptoms that typically include fever and headache, which in severe cases can progress to coma or death. Malaria is widespread in tropical and subtropical regions in a broad band around the equator, including much of Sub-Saharan Africa, Asia, and the Americas (Barde et al., 2019). It is transmitted by *Plasmodium*-infected female *Anopheline* mosquitoes. The disease (malaria) can be attributed almost entirely to some mosquito species namely: *Anopheles gambiae*, *An. arabiensis* and *An. arabiensis*, which are three of the most efficient malaria vectors in the world (Ombugadu et al., 2019). All live almost exclusively in close association with humans and feed on blood, primarily from humans (Ombugadu et al., 2019).

Mosquitoes are small slender biting insects that belong to the order Diptera, sub order Nematocera and family Culicidae, with an approximate number of three and half thousand species (Ikram and Muhammad, 2013). In the modern classification of Culicidae as adopted by Knight and Stone (1977), there are three sub families: Culicinae (with thirty genera), Anophelinae (with three genera) and Toxorhynchitinae (with one genus). Sub family Culicinae, being the largest and most diversified is further divided into a number of tribes: Aedini, Culicini, Culisetini, Mansoniini, Ficalbiini, etc. The tribe Aedini consists of several genera including Aedes and Armigeres. The sub family Anophelinae includes the most important genus "Anopheles" several species of which are malaria vectors (Novianto et al., 2021). Malaria is considered to be one of the most severe infectious diseases worldwide, causing about half a million deaths every year, primarily in the developing world (WHO, 2022). More than two-thirds of malaria deaths globally is found in children under 5 years of age (who, 2022). About 3.2 billion people (almost half of the world's population) are at risk of malaria (WHO/UNICEF, 2015). Fifteen countries mainly in sub-Saharan Africa, accounted for 80 % of cases and 78% of deaths globally in 2015 (WHO/UNICEF, 2015).

Malaria is a mosquito-borne disease which causes major health problems in Nigeria and other part of Sub-Saharan Africa. Malaria accounts for 660,000 deaths worldwide. Every year, more than 200 million cases occur (Barde *et al.,* 2019). According to the WHO world malaria report released in 2022, there were an estimated 247 million malaria cases in 84 malaria endemic countries in 2021, an increase of 2 million cases as compared with year 2020 (WHO, 2022). It is estimated that malaria is responsible for 25% infant mortality, 30% childhood mortality and is associated with 11% maternal deaths Mosquito species are among the most medically important insect group for mankind due to their ability to transmit pathogen causing diseases to man, they are also known for being irritating biting insect. Malaria one of the major public health problem in Nigeria accounting for more cases and deaths with an approximate of 32% of the population were tested positive for the disease in 2015, and 60% of hospital outpatient visits and maternal mortality annually (Nigeria Malaria Fact Sheet, 2017).

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).

Mosquitoes control strategies are aimed on adult mosquitoes including, the promotion of the use of insecticide-treated bed nets and indoor residual sprays (NMEP, 2021). However, these control strategies may have their limitations like insecticide resistance by the vector (WHO, 2020) and difficulties in attaining adequate population coverage (Wahedi et al., 2021), and hence may not be sufficient to achieve the World Health Organization's (WHO) targets regarding mosquito-transmitted diseases. Additional vector control interventions, particularly, those that will target the larval mosquitoes are required. In addition accurate larval control requires clear knowledge of the larval habitat and distribution pattern of the breeding sites. In view of the forgoing this study assessed the diversity and distribution of Mosquito Species in Kano Metropolis, Kano, State, Nigeria.

Materials and Methods

Study Area

Fagge is a local government area in Kano state Nigeria, within the greater Kano Area, its headquarter is located in the Suburb of Faggewaje. It has an Area of 35.27 km^2, with population density of 9,331/km^2 and a population projection of 329,100 by 2022 (Census, 2022). The local government has an annual population change of 3.2%. It is located in 12 24°N, 8 31°E (Saeed and Mahmud, 2014).

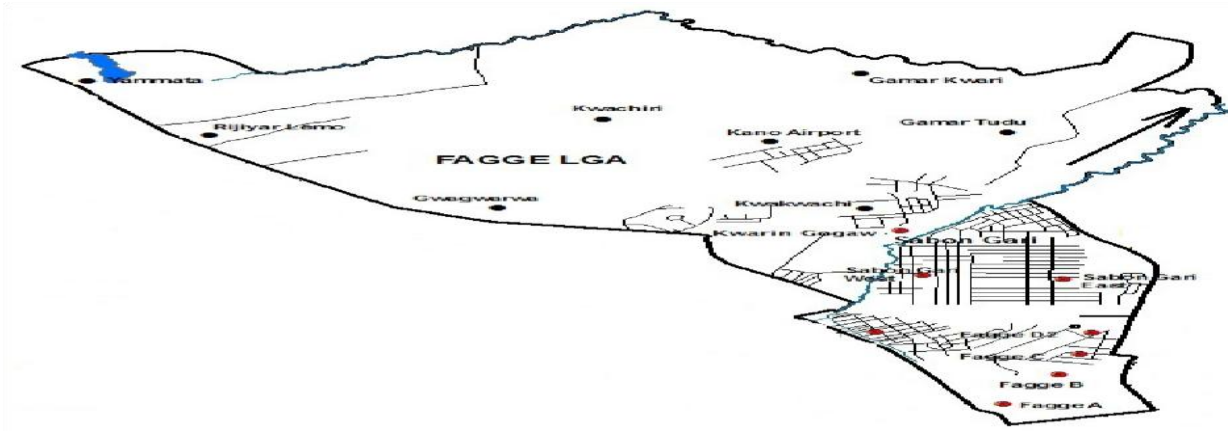

Figure 1. Map of Fagge Local Government Showing the Sampling Stations

Sampling Techniques

Adult mosquitoes were collected fifty (50) communities from five (5) political wards in Fagge Local Government in a cluster of five (5) houses per communities. The five political randomly were Fagge B, Fagge C, Fagge D2, Kwachiri and Sabongari West, designated as A, B, C, D and E. Mosquito adults and larval breeding sites were surveyed in the communities and the collection was done weekly from June to October, 2022. The larval collection was performed from early hours of the day around 6:00 a.m. to 8:00a.m from the sampling sites in each community; which were categorized into groups based on habitat types which include the following; Containers (cans, plastic bottles, tyres, household water storage containers etc); Temporary Ground Pools (tyre tracks, ditches, domestic run-offs, etc); Man-made Reservoirs (Overhead tanks and water storage drums) as described by Aliyu *et al.* (2022). Mosquito larvae were sorted at their 3rd and 4th instars and preserved in 70% ethanol. The larvae collected from the field in each community were distributed into smaller rubber plates and kept into the modified mosquito cage. The immature stages (pupae) were reared in modified mosquito cage where they were fed with yeast until adults emerged. Light traps were fixed indoors by the side someone sleeping under a net mosquito net and outdoor along the canals and on the veranda as adopted by Bamou *et al*. (2021). The same number of houses were used per samplings site for human Landing catches using aspirators by group of two research assistant. The research assistants were shifting positions at each location every 3 hour of the night. The collected mosquitoes were morphologically identified microscopically using the compound microscope at Central Laboratory, BUK. Identification were performed using Mosquitoes taxonomic keys of Gillies and Coetzee (1987). Identified mosquitoes were stored in Eppendorf tubes with no preserving product at room temperature.

Species Diversity Assessment

Shannon-Weaner (1949) diversity index (H) and species richness will be used to determine the mosquito species composition and abundance between sites and seasons. Shannon-Weaner's Index (H) is commonly used to characterize species diversity in a community. Shannon-Weaner's Index accounts for both abundance and evenness of the species present. The proportion of species is relative to the total number of species (*Pi*) calculated and then multiplied by the natural logarithm of the proportion (LnPi). The resulting product is summed across species and multiplied as shown below: Shannon Index (H) =

$$H = \sum_{i=1}^{s} Pi\ InPi$$

Where;

$Pi =$ Total number of individual in the sample

$InPi =$ Total number of individuals of species *ith* in the sample

Species equitability or evenness (E) is determined by the equation:

$$Evenness = \frac{H}{\ln S}$$

Where pi = the proportion of the i[th] species in the sample ($\frac{No.of\ individual\ \ species}{total\ \ number\ \ of\ samples}$)

H = the Shannon – wiener` index of diversity

S= number of species or species richness

Margalef's index (d) measures species richness and diversity in the community structure. The equation described by Margalef (1967) will be applied in the calculation.

d= $\frac{S-1}{In(N)}$

Where: d = species richness index S = Number of species population N= Total number of individual species.

Data Analysis

The abundance of species with respect to the clusters was computed as the number of species per cluster out of the total number of mosquitoes collected and expressed as a percentage. The difference between species composition among the clusters was determined using Analysis of Variance (ANOVA).

Results

Mosquitoes species Composition, Abundance and Their Distribution

A total of six thousand five hundred and fifty nine (6559) mosquitoes were collected from June to October, 2022. Out of these 4633 (70.63%) were *Anopheles gambiae, Anopheles fenustus* 534 (8.14%), *Culex quinquefasciatus* 571 (8.70%) and *Aedes aegypti* had (12.51%) (Table 1). In terms of Shannon diversity *A. gambiae* were recorded the moderate with 2.56, followed by Aedes *aegypti* with 1.64 and the lowest was *A. arabiensis*with1.12 respectively. The evenness of index species distribution followed the same pattern with diversity.

Table 1: Relative Diversity of Mosquito Species Recorded in Fagge Local Government Kano State

Mosquito Species	Number identified	Relative Abundance (%)	Shannon-weiner (H) index	Evenness index (E)
A. gambiae	4633	70.63	2.56	0.89
A. arabiensis	534	8.14	1.12	0.67
Aedes aegypti	821	12.51	1.64	0.78
Culex quinquefasciatus	571	8.70	1.88	0.75

Table 2, illustrates the monthly distribution of mosquito species from the study site. The monthly variation revealed that September had the highest number of number of mosquitoes with the peak value of 1789 (27.27%) mosquitoes while the month of June recorded the lowest number of mosquitoes with 772 (11.77%) mosquitoes.

Table 2: Monthly Distribution and Abundance of Mosquito Species in Fagge Local Government, Kano, Nigeria

Month	***Anopheles gambiae***	*Anopheles arabiensis*	*Aedes aegypti*	*Culex quinquefasciatus*	Total	Relative %
June	1108	72	143	87	1410	21.49
July	943	143	148	121	1355	20.65
August	820	113	193	107	1233	18.79
September	1213	121	312	143	1789	**27.27**
October	549	85	25	113	772	**11.77**

Mosquitoes Diversity and Distribution in Fagge Local Government, Kano State

Mosquito species and their diversity at various collection sites in Fagge, Kano State is presented in Table 3. Site D had the highest of 1687 (25.73%) followed by site E with 1495 mosquitoes and the lowest was site A which had 983(14.98%) mosquito species.

Table 3: Monthly Abundance of Difference Mosquito Species in Metropolis

Site	***Anopheles gambiae***	*A. arabiensis*	*Aedes aegypti*	*Culex quinquefasciatus*	Total	Relative %
A	483	223	128	148	983	**14.98**
B	638	322	118	68	1149	17.47
C	643	286	210	109	1248	19.03
D	843	219	104	521	1687	**25.73**
E	734	121	414	226	1495	22.79

Discussion

Mosquitoes are vital disease vectors and their diversity and abundance determine the course of disease transmission and the ecological status of the habitat (Attaullaha et al., 2023). Morphological examination of mosquitoes identified during the period of study revealed four species belonging to three mosquito genera. One species of *Aedes* (*A. aegypti*), A. *gambiae*, *A. arabiensis* and *C. quinquefasciatus. The sampling area* observed was productive mainly for *Anopheles* and *Culex*. The abundance of mosquito population in the study area may be associated with the rainfall pattern as reported by Rice et al (2021). The population mosquitoes increased with the increase in rainfall from June and a decline in October. This might be attributed to the increase in rain falls within the ecological zone that facilitate the washing away of the developing larvae from their breeding habitats thereby leading to the decline in the population of mosquitoes (WHO, 2017).The dominant species identified were *Anopheles gambiae* and *Culex quinquefasciatus* collected in all the sampling sites while the others like *Anopheles arabiensis* were less frequent. This might be associated with the presence of collections of dirty water in sample sites which serve as their breeding grounds. Similarly, the surrounding around the various residential areas serve as the resting stage for the mosquito and this could be responsible for large number of mosquitoes recorded. Similar findings were reported by Ombugadu et al. (2019), Dad et al. (2021) and Rice et al. (2021). It is also in agreement of the findings of Michael (2014) who reported the presence of similar species of mosquitoes in Zaria where he recorded *Culex quinquefasciatus* and *Anopheles gambiae* as the most dominant. The variation in the mosquitoes available and their diversity could be attributed to factors of rainfall abundance, tropics temperature, high relative humidity enhances the reason why *Anopheles* are highly distributed and abundant than other species. The high species diversity is associated to the anthropogenic activities which favoured the environment for mosquitoes to breed (WHO, 2016). Similar observations were recorded by Afolabi *et al.* (2019). The study revealed that Anopheles species were the dominant species and accounted for 70.63%. This is in agreement with the work Omar *et al.*, (2016) within the same ecological zone. It could also be attributed to the differences of the larval habitat requirement of the species. *Culex* species for instance prefer breeding in polluted gutters, blocked drains and other water retention habitats with organic matter unlike

Aedes and *Anopheles* mosquitoes which prefer clean ground pools and man-made containers respectively.

Conclusion

It can be concluded that different mosquito species of public health significance are found in Fagge Local Government, Kano State. Poor hygiene and drainage system attributed to the diverse mosquitoes species in the study area. Therefore there is a need for public enlightenment and good proper hygiene that will prevent mosquitoes from breeding in the area.

References

Abdullah, M. A., Ataur, M. R., Habibu, M. R., Hoque, K.M., Ferdousi, Z.,Mohammad; M, N and Abu, R. M. (2017) Biochemical and histological alterations induced by the smoke of allethrin based mosquito coil on mice model. *BMC Clinical Pathology*, 17(19): 1-8.

Abdulrasheed, D., Aliyu, A.O and Hafsa B. (2016). Surveillance of Mosquito Species Abundance and Composition in Azare, Katagum Local Government of Bauchi State, Nigeria. *Journal of Pharmacy and Biological Sciences*.11 (6):105 -109.

Abubakar, M and Hassan, L. (2007).Toxicological Effects of Some Mosquito Coils Brands In Experimental Rats. *The Internet Journal of Toxicology*, 4(1):1-4.

Adegnika, A.A and Kremsner, P. G (2012). Epidemiology of Malaria and Helminth Interaction: A Review from 2001 to 2011.*Current Opinion on HIV/ AIDS*,7:221–224,doi:10.1097/COH.0b013e3283524d90

Afolabi, J. O., Akinneye, O. J. and Igiekhume, M. A. A. (2019). Identification, abundance, and diversity of mosquitoes in Akure South Local Government Area, Ondo State, Nigeria. *The Journal of Basic and Applied Zoology*. 80:39. https://doi.org/10.1186/s41936-019-0112-4.

Akunna, G. G., Saalu, L. C., Ogunlade, B.,Ogunmodede, O. S. and Akingbade, A. M. (2013) Anti-fertility role of allethrin based mosquito coil on animal models. *International Journal of Biology, Pharmacy and Allied Sciences*, 2(2):192-207.

Alexandra, J. R., Ian, G., Handel, M. A. (2007). Blood group O protects against severe *Plasmodium falciparum* malaria through the mechanism of reduced rosetting. *PNAS*, 104(44):17471-17476.

Amini, M. Ali, A., Hanafi-Bojd, Aghapour, A. A. and Chavshin, A. R. (2020). Larval habitats and species diversity of mosquitoes (Diptera: Culicidae) in West Azerbaijan Province, Northwestern Iran. *BMC Ecol*. 20:60. https://doi.org/10.1186/s12898-020-00328-0.

Attaullaha, S., Bibia, D, A., Andaleeba, I. I., Siraj, M. Ahmada, I., Ullaha, M., Alia, S and Ullaha, S. (2023).Diversity, distribution and relative abundance of the mosquito fauna (Diptera: Culicidae) of Malakand and Dir Lower, Pakistan. Brazilian Journal of Biology, vol. 83, e247374

Barde, A., Aliyu A.O, Sam, M.P., Suwaiba, H., and Abdulrasheed, D. (2019). Studies on the composition and distribution of the different sibling species of *Anopheles gambiae* complex within Katagum area in Bauchi state, Nigeria. *International Journal of Mosquito Research*, 6(3): 01-04.

Bunza, M.D., Suleiman, A.A., Yusuf, A.M and Bala, A.Y (2010). Relative abundance of Mosquito Species in Katsina Metropolis, Katsina State, Nigeria. *Nigerian Journal of Parasitology*. 31(2).

Dad, O., Attaullah, M., Ullah, H., Ullah, R., Ilahi, I., Ahmad, S., Ahmad, B., Ali, I and Zeb, S. (2021). Prevalence of malaria and status of *Plasmodium* spp. in Dir Lower, Pakistan. *Journal of Biodiversity and Environmental Sciences,* 15(2): 83-87.

Ebenezer A, Noutcha AEM, Agi PI, Okiwelu SN, Commander T. Spatial distribution of the sibling species of *An. gambia e*sensulato (Diptera: Culicidae) and malaria prevalence in Bayelsa State, Nigeria. Parasite and Vectors. 2014; 7(1):32. DOI:10.1186/1756-3305-7-321

Federal Ministry of Health (2009). National framework for monitoring and evaluation of malaria control in Nigeria, Federal Ministry of Health. Abuja, Nigeria, 39.

Gimba, U. N andIdris, H. S. (2014). Morphological Identification and Distribution of Anopheles species in Gwagwalada Town, F. C. T, Nigeria. International of Environmental Science and Toxicology Research. 2014; 2(10):210-216.

Ikram, I. and Muhammad, S (2013). Species Composition and Relative Abundance of Mosquitoes in Swat. *Pakistan. International Journal of Innovation and Applied Studies.* 2 (4): 454-463

Knight, K.L and Stone, A. (1977). "A catology of the mosquitoes of the world (Diptera: Culicidae)", Thomas Say Foundation. E.S. A, vol.6.

Lapang, P. M., Ombugadu, A., Ishaya, M., Mafuyai, M. J., Njila, H. L., Nkup, C. D. and Mwansat G. S. (2019). Abundance and Diversity of Mosquito Species Larvae in Shendam LGA, Plateau State, North-Central Nigeria: A Panacea for Vector Control Strategy. *Journal of Zoological Research,* 3(3) 2019: 25-33.

Mattah, P. A. D., Futagbi, G., Amekudzi, K. L., Mattah, M. M., de Souza, K. D., Kartey-Attipoe, D. W., Bimi L. and Wilson D. M. (2017). Diversity in breeding sites and distribution of *Anopheles* mosquitoes in selected urban areas of southern Ghana. *Parasites* and *Vectors*. 10:25 DOI 10.1186/s13071-016-1941-3.

Nicholas M. Anstey, Bruce Russell, Tsin W. Yeo, Ric N. (2009). Price. The pathophysiology of vivax malaria. *Trends in Parasitology*, 25(5):220-227.

Nicoletti, M. (2020). *Insect-Borne Diseases in the 21st Century*. Elsevier Science Publishing Co. Inc.San Diego, United States of America.

Nigeria Malaria Fact Sheet (2017). Economic Section, United States Embassy in Nigeria (http://nigeria.usembassy.gov).

Novianto, D., Hadi U. K., Soviana, S., Supriyono and Darusman H. S. (2021). Species diversityand breeding site of mosquito larvae (Diptera: Culicidae) in Macacafascicularis breeding area. *The 4th International Conference onBiosciences*. IOP Conf. Series: *Earth and Environmental Science,* 948.

Nyarko, R., Kwasi, T. and Ankomah, A (2018). *Schistosomahaematobium, Plasmodium falciparum* Infection and Anaemia in Children in Accra, *Ghana Tropical Diseases, Travel Medicine and Vaccines, 4(3): 1-6.*

Oduola AO, Adelaja OJ, Aiyegbusi ZO, Tola M, Obembe A, Ande AT *et al*. Dynamics of anopheline vector species composition and reported malaria malaria cases during rain and dry seasons in two selected Communities of Kwara State, Nigeria. Journal of Parasitology. 2016; 37(2):157-163.

Olayemi, I. K., Ukubuiwe, A. C. and Oyibo-Usman K. A. (2014). Mosquito Species Occurrence and Diversity in Conventional larval breeding sites in Minna metropolis, Nigeria. *International Journal of Innovation and Scientific Research.* 9 (1). Pp. 86 – 93. Accessed on 4th August, 2022 from http://www.ijisr.issr-journals.org/.

Omar, A.A, Barde, A.A, Panda, S.M., Dalhatu, A., Kafi, S.A. and Aliyu, U. (2022). Assessment of mosquito larval habitats, species abundance and diversity in Azare, Katagum Local Government Area, Bauchi State, Nigeria. *Gadau J Pure AlliSci*, 1(2): 103-107.

Omar, A.A, Barde, A.A, Panda, S.M., Dalhatu, A., Kafi, S.A. and Aliyu, U. (2022). Assessment of mosquito larval habitats, species abundance and diversity in Azare, Katagum Local Government Area, Bauchi State, Nigeria. *Gadau Journal Pure and Allied Science,*,1(2): 103-107.

Ombugadu, A., Lapang, P. M., Ishaya, M., Mafuyai, M. J., Njila, H. L., Nkup, C. D. and Mwansat, G. S. (2019). Abundance and Diversity of Mosquito Species Larvae in Shendam LGA, Plateau State, North-Central Nigeria: A Panacea for Vector Control Strategy. *Journal of Zoological Research.* 3(3):25-33.

Ombugadu, A., Lapang, P. M., Ishaya, M., Mafuyai, M. J., Njila, H. L., Nkup, C. D. and Mwansat, G. S. (2019). Abundance and Diversity of Mosquito Species Larvae in Shendam LGA, Plateau State, North-Central Nigeria: A Panacea for Vector Control Strategy. *Journal of Zoological Research.* 3(3):25-33.

Rice, A.A., Mbah, C. E., George, B.D.J. (2021).Assessment of Mosquito Diversity and *Plasmodium falciparum* in Female *Anopheles* Mosquito in Students' Hostels, Ahmadu Bello University Zaria, Kaduna State Nigeria*Dutse Journal of Pure and Applied Sciences***,** 7 (3b): 105-114.

Rugemalila, J.B., Wanga, C.L and Kilama, W.L (2006). Sixth Africa Malaria Day: How far have we Come after the Abuja Declaration? *Malaria Journal*. 5:102.

Saeed, M. D and Mahmud, A.M (2014). "Determination of Some Physicochemical Parameters and Some Heavy Metals in Boreholes from Fagge L.G.A of Kano Metropholis Kano State- Nigeria." *World Journal of Analytical Chemistry*, 2(2): 42-46.

Sogoba, N., Doumbia, S., Vounatsou, P., Baber, I., Keita, M., Maiga, M., Traore, S. F., Toure, A., Dolo, G., Smith, T. and Ribeiro, M. C. (2007). Monitoring of larval habitats and mosquito densities in the Sudan savanna of Mali: implications for malaria vector control. *American Journal of Tropical medicine and Hygiene.* 77(1): 82-88

Solomon, M. A., Mulugeta, T., Nigus, FandAbiy, H (2013).*Plasmodium falciparum* and *Schistosomamansoni* Co-infection and the Side Benefit of Artemether-lumefantrine in Malaria Patients *Journal of Infection in Developing Countries* 7(6):468-474.

W.H.O (2017).Vector-borne diseases. Media Center Fact Sheets. Retrieved from http://www.who.int/mediacentre/factsheets/fs387/en/22nd November, 2017.

W.H.O. (2016). World Health Organization. *World Malaria Report 2016*.

Wahedi, J. A., Gambu, J. W., Pukuma, S. M., Elkanah, O. S., ande, A. T., Frank, L. K. and Bitrus F. (2020). Diversity and relative density of larval mosquito species in Mubi metropolis, Adamawa state, Nigeria. *International Journal of Mosquito Research*. 7(4): 21-25.

WHO/UNICEF news release report, (2015). Malaria MDG target achieved amid sharp drop in cases and mortality, but 3 billion people remain at risk. Available at www.who/ int/ mediacentre/ news/releases/ 2015/ malaria-mdg-target/ en/.Organization Geneva.

World health organization (WHO). 2022. World malaria report. Who Geneva, 2022. 372p. http://www.who.int/malaria.

World Health Organization (WHO) (2020). Vector-Borne Diseases. Access on 4th August, 2022

Yayock, H.C, Nicholas, O.O., Bitrus, S., Gimba, H.S and Shehu, R. (2021). Survey of Mosquito Species, Composition and Breeding Habitat in Four Communities of Kaduna Metropolis, Nigeria. *FUDMA Journal of Sciences*. 5 (3): 76 - 81.

Zaim, M and Guillet P. (2002). Alternative insecticides; an urgent need. *Trends in Parasitology*.18: 161-163.