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SEASONAL DISTRIBUTION AND DIVERSITY OF MOSQUITO SPECIESIN A RAINFOREST COMMUNITY OF SOUTHEAST NIGERIA

Irikannu, K.C[1]., Onyido, A.E[1]., Ogaraku, J.C[1]., Umeanaeto, P.U[1]., Nzeukwu, C.I[1]., Obiefule I.E[1]., Aniefuna, C.O[1]., Elosiuba, N.V[1] & Onwuachusi, G.L[1]

[1]*Department of Parasitology and Entomology, Nnamdi Azikiwe University, Awka Nigeria*

Correspondence: kc.irikannu@unizik.edu.ng

ABSTRACT

Mosquitoes are important vector of parasitic diseases. This study was conducted in Awka South LGA, Anambra State, between October 2017 and September 2018to determine the effects of rainfall, temperature, and relative humidity on mosquito species abundance and diversity. Outdoor and indoor adult mosquitoes were collected using the Centers for Disease Control light traps and pyrethrum spray catch methods, respectively. Line graphs were used to show the response of monthly rainfall, temperature, and relative humidity to the abundance of mosquito population. Pearson correlation were used to determine the relationships between rainfall, temperature, relative humidity, and the abundance of the adult mosquitoes. Shannon-Wiener diversity index and Simpson's dominance indices was calculated for all mosquito species collected. Seven mosquito species, composed of 2,663 adult mosquitoes were collected. *Anopheles gambiae*, *An. funestus*, *Aedes aegypti*, *Ae. albopictus* and *Culex quinquefasciatus* were collected both indoors and outdoors while *C. annulioris* and *Eretmapodites chrysogaster* were collected outdoors. At the onset of wet season, adult mosquito population increased rapidly from 279 in April to507 September when the temperature was least at 26.0ºC with outdoor relative humidity of 90%.Adult mosquito population was positively and strongly correlated with rainfall (r=0.897) and relative humidity (r=0.700) but negatively correlated with temperature (r=-0.775).*Culex quinquefasciatus* had the highest Shannon-Wiener diversity index(0.107), and Simpson's dominance index(0.495). Rainfall, temperature, and relative humidity patterns influenced the abundance of mosquitoes and should be considered during control interventions.

Keywords: Mosquitoes, abundance, diversity, dominance, climatic factors, correlation

INTRODUCTION

Mosquitoes are insects with piercing and sucking mouthparts but only the females feed on blood, and many species are vectors of parasitic and viral diseases (Ezihe *et al*., 2017; Onyido *et al*., 2016)such as filariasis, dengue, yellow fever and malaria(Simon-Oke and Olofintoye, 2015). Mosquitoes' ability to adapt and expand their territories increases the spread of mosquito-borne diseases (Drakou *et al*., 2020). Mosquitoes are widespread, their distribution being largely dependent on climatic factors such as rainfall pattern, temperature, and relative humidity (Asgarian *et al*., 2021).In warm and tropical regions, climatic factors have also been associated with relative mosquito abundance and transmission of mosquito-borne infections(Simon-Oke and Olofintoye, 2015).

Rainfall creates breeding sites for mosquitoes and larval development, but high volume of rainfall may decrease mosquito populations(Asgarian *et al*., 2021). It has been observed that rainfall generally brings new opportunistic mosquito breeding sites though rainfall can also destroy existing breeding sites (Onyido *et al*., 2006) by changing breeding pools into streams, impeding development of mosquito eggs or larvae or by simply flushing eggs or larvae out of the pools.

Service (2008) also observed that mosquito population declines in the dry season due to high temperatures and lack of breeding places. Environmental temperature between 16ºC and 36ºCfavours survival of mosquito population which peaks at a temperature range of 28ºC to 32ºC but can decline rapidly at temperature above the range (Craig *et al*., 1999).Increase in temperature may facilitate larval development, enhance vector survivorship and reproductive fitness, as well as increase its blood feeding frequency and parasite sporogonic development rate in previously cooler areas (Ezihe *et al*., 2017).

Relative humidity (RH) affects longevity, blood feeding behavior, mating, dispersal and oviposition of mosquitoes (Rogers and Randolph, 2006;Simon-Oke and Olofintoye, 2015;Drakou*et al*., 2020).It has been noted that relative humidity is one of the vital factors affecting the survival of mosquitoes, and RH between 50-55% is the most appropriate condition for peak abundance of mosquito species, although adult mosquitoes could still survive relative humidity range of 80–85% (Thu *et al*., 1998).

An effective mosquito control intervention plan should be based on the knowledge of the vector's abundance, and how they respond to rainfall, temperature, and RH in an area. This study investigated the seasonal distribution and climatic factors that influenced abundance of mosquito vectors in Awka South Local Government Area (LGA) of Anambra State.

MATERIALS AND METHODS

Study area

The study was conducted in Awka South LGA (Longitude $7^0$04'E and Latitude $6^0$10'N) of Anambra State, Nigeria. The area is in the tropical rainforest zone of Nigeria which experiences about eight months of wet season between March and October, followed by about four months of dry season between November and February. The temperature range is generally 27-30°C between June and December but rises to 32-34°C between January and April. The RH is about 70% in the dry season, reaching 80% during the wet season while the annual rainfall ranges between 2000-3000mm. The LGA, with an estimated population of 189,049 (NPC, 2006) comprises nine communities of Amawbia, Awka, Ezinato,

Isiagu, Mbaukwu, Nibo, Nise, Okpuno and Umuawulu.

Study design and selection of sampled areas

The study was a longitudinal survey of man-biting adult mosquitoes conducted between October, 2017 and September, 2018. Six communities Amawbia, Awka, Okpuno, Nibo, Nise, and Mbaukwu were judgmentally selected to represent urban, sub-urban and rural areas in the LGA (Onuoha *et al.*, 2011). The representative communities are Amawbia and Awka (Urban),Okpuno and Nibo (Sub-urban) while Mbaukwu and Nise are rural communities.

Advocacy visits and community sensitisation

Community members were sensitized through meetings organized with the cooperation of community opinion leaders. At these meetings, the intent and importance of the study were explained to them after which informed consent was obtained for the study in the communities.

Collection of indoor-biting adult mosquitoes

Indoor-biting and resting adult mosquitoes were collected from collected using pyrethrum spray catch method (Onyido *et al*., 2016) from living rooms where people slept the previous night. Briefly, a pyrethroid-based insecticide aerosol (Baygon®) was sprayed in the rooms. At 20 minutes interval after spraying, the white cloth sheets earlier laid on the floor were folded to ensure that no knocked down mosquito escaped. The folded sheets were taken outside the rooms and spread out to collect the knocked-down mosquitoes, with a pair of entomological forceps, into a damped petri dish.

Collection of outdoor-biting mosquitoes

Outdoor-biting mosquitoes were collected using Centers for Disease Control (CDC) light trap as described by Mboera *et al*.(1998). Mosquitoes were collected at hourly intervals between 6.00pm-6.00am local time.

Morphological Identification of mosquitoes

All the mosquitoes collected were properly labeled and sent to the Entomology Laboratory of the Department of Parasitology and Entomology, Nnamdi Azikiwe University for identification using the gross morphology of the species according to standard keys (Gillies and De Meillon, 1968; Gillet, 1972;Gillies and Coetzee, 1987).

Collection of meteorological data

Monthly outdoor temperature, relative humidity and rainfall data for the study period were obtained from Weather Atlas website. Monthly means of rainfall, maximum and minimum temperatures, and relative humidity were also obtained for wet and dry seasons of the study period.

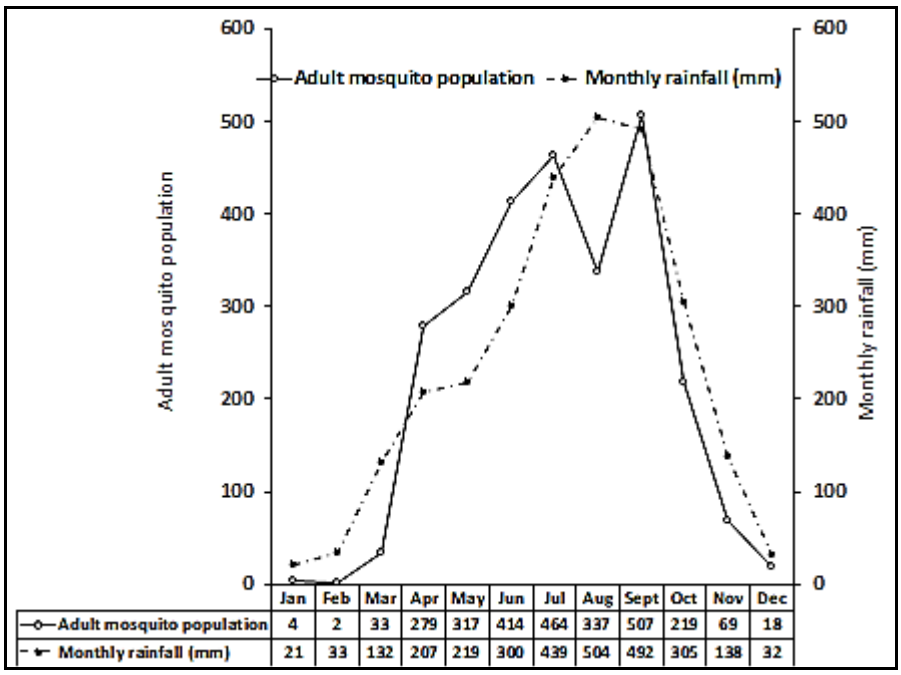
Data analyses

Data were analysed using the statistical package for social sciences (SPSS) version 2.10. The analysis of variance (ANOVA) and line graphs in Excel were used to show the responses of mean monthly rainfall, temperature, and relative humidity to the abundance of mosquitoes while Pearson correlation was used to determine their relationships. Shannon-Wiener diversity index (*H*) was calculated for all mosquito species as: $H = \frac{N\log N - \sum ni \log ni}{N}$, where *ni* is the abundance and *N*, the total number of individuals in the species (Ogbeibu, 2005). Also, Simpson's dominance index (*C*) which evaluated the prevalence of each individual species and measures the probability of picking two organisms at random that are of different species was computed$C = \Sigma \left(\frac{ni}{N}\right)^2$, where *ni* is the number of individuals of *nth*

species, *N*is the total number of individuals for all species (Krebs, 1972).

RESULTS

A total of 2,663 adult mosquitoes comprising of seven species namely, *Anopheles gambiae, An. funestus, Aedes aegypti, Ae. albopictus* and *Culex quinquefasciatus* were collected both indoors and outdoors while *C. annulioris* and *Eretmapodites chrysogaster* were only collected outdoors. The adult mosquito population followed rainfall pattern (Figure 1).At the onset of the rainy season, mosquito population increased rapidly from 279 in April and reached peaked at 464 in July. It then declined slightly to 337 in August before it and rose to its highest peak of 507 in September. It declined rapidly from 219 in October until 18 in December to2 in February at the height of the dry season. Adult mosquito population had a positive significant relationship with rainfall (r=0.897).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Adult mosquito population	4	2	33	279	317	414	464	337	507	219	69	18
Monthly rainfall (mm)	21	33	132	207	219	300	439	504	492	305	138	32

Figure 1: Response of adult mosquitoes to rainfall patterns

Adult mosquitoes were collected between the mean temperature ranges of 26.0ºC-29ºC (Fig. 2). Highest numbers of mosquitoes numbering 507 were collected in September when the temperature was least at 26.0ºC. The least number of 2 mosquitoes was collected in February when the temperature was highest at 29.0ºC. Adult mosquito population had a significant negative relationship with temperature (*r*=-0.775).

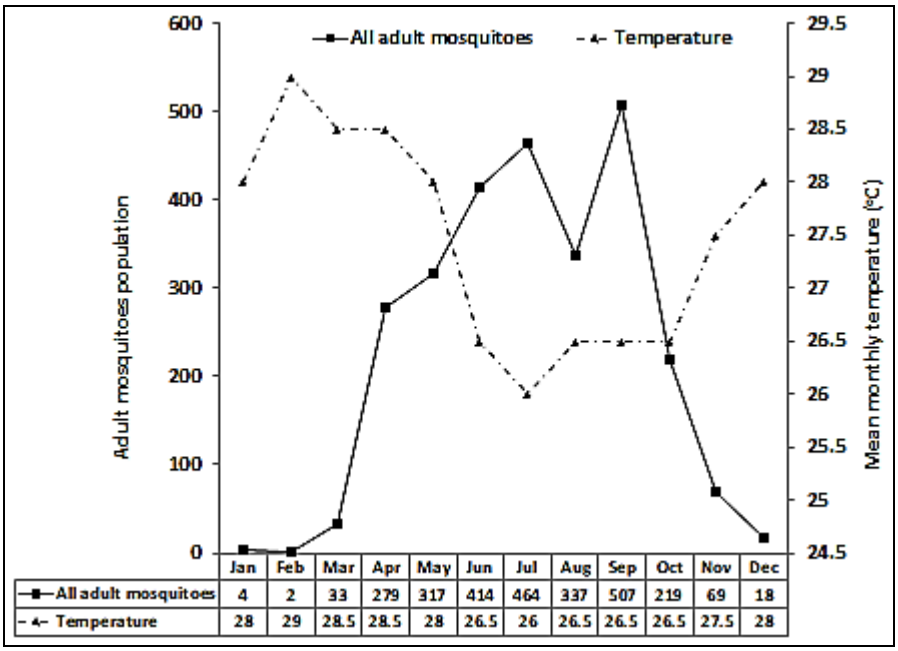


Figure 2: Response of adult mosquitoes to temperature

Adult mosquitoes were collected between relative humidity of 83%-92% (Figure 3).Highest numbers of mosquitoes (*n*= 507) were collected in September when outdoor relative humidity was at 90%. The least number of mosquitoes (*n*=2) was collected in February when outdoor relative humidity was least at 83%. Adult mosquito population had a significant positive relationship with relative humidity (*r*=0.700).

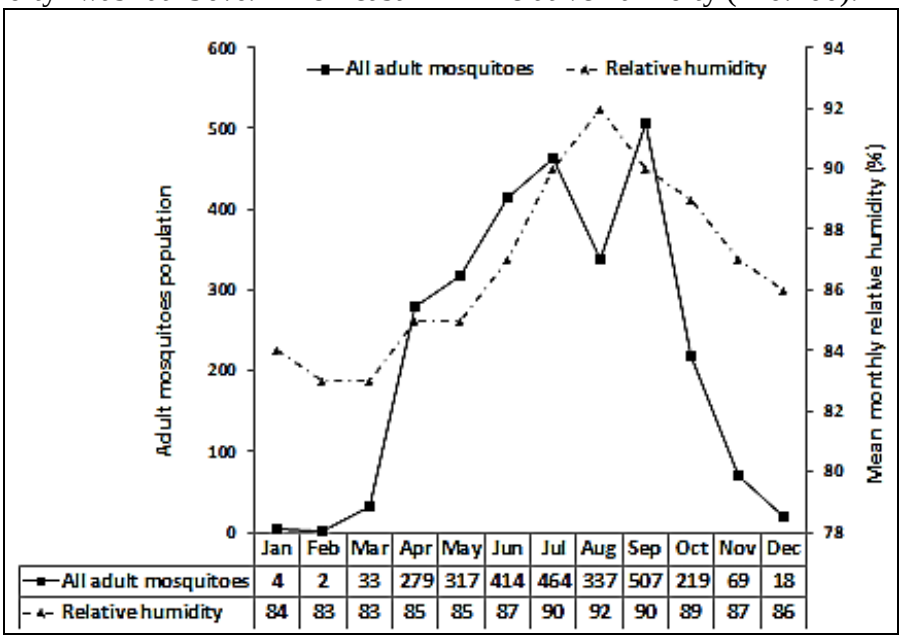


Figure3: Response of adult mosquitoes to relative humidity

From Table 1, it could be observed that *Culex quinquefasciatus* had the highest Shannon-Wiener diversity index of 0.107 while *C. annulioris* and *E. chrysogaster* had the least 0.0000003 each. Others in ascending order were *An. Funestus* (0.057),

Ae. Albopictuss (0.077), *An. Gambiae* (0.089) and *Ae. Aegypti* (0.098). *Culex quinquefasciatus* also had the highest Simpson's dominance index of 0.495 while *C. annulioris* and *E. chrysogaster* had the least 0.00000004 each. Others were *An. Funestus* (0.002), *Ae. Albopictus* (0.004), *An. gambiae* (0.007) and *Ae. Aegypti* (0.009).

Table 1: Species diversity and dominance indices of mosquitoes sampled

Mosquito species	Shannon-Wiener diversity index (*H*)	Simpson's dominance index (*C*)
An. gambiae	0.089	0.007
An. funestus	0.057	0.002
Ae. aegypti	0.098	0.009
Ae. albopictus	0.077	0.004
C. quinquefasciatus	0.107	0.495
C. annulioris	0.0000003	0.00000004
E. chrysogaster	0.0000003	0.00000004
Total	$H = 0.428$	$C = 0.517$

DISCUSSION

The seven mosquito species made up the 2,663 mosquitoes collected from the study has all been reported by other studies in southeastern Nigeria (Irikannu *et al*., 2022; Ikpo *et al*., 2021a; Ikpo *et al*., 2021b; Irikannu *et al*., 2021;Onwuzulike*et al*., 2021a, Onwuzulike *et al*., 2021b;Irikannu*et al*., 2020;Egbuche*et al*.,2020;Irikannu*et al*., 2019). This study identified associations between adult mosquito population and some climatic factors. There was a positive relationship between mosquito populations and rainfall (r=0.897). This was because rainfall provided breeding places for the mosquitoes (Onyido *et al*., 2006;Mutero*et al*. 2004). Adult mosquitoes declined in August before it peaked again in September. Rainfall was highest in August but reduced in September and the breeding water became more stagnant. Mosquito population increased constantly as soon as the rainy season arrives. Uttah *et al*. (2013) reported that repeated rainfall causes severe flooding, resulting in temporary flushing out of mosquito breeding places. Consequently, the breeding of a vector population is greatly reduced, but becomes, re-established when favourable conditions are restored. In February, there were almost no visible mosquito breeding sites due to low rainfall; thus, mosquito populations were least abundant.

In this work, mosquito vectors were more abundant between the temperatures of 27^0C-30^0C. Craig *et al*. (1999) reported that the highest proportion of vector surviving period is observed at temperature between 28ºC and 32ºC. Their report overlaps with our findings., Paaijmans *et al*. (2010)reported that temperature directly affects mosquito behavior and survival. But in contrast, Ezihe *et al*. (2017) noted that they were not able to find any significant association with temperature with abundance mosquitoes in their study using the spearman's rho correlation test. But in this study, adult mosquito populations had negative relationship to the mean environmental temperature(r=-0.775). Mosquito populations decreased as temperature increased. This observation

reveals that, although adult mosquitoes survive more in the tropics than in temperate regions of the world, their population may decline sharply if the temperatures are high above 30˚C.

Adult mosquito populations had positive relationship with the mean relative humidity(r=0.700). Mosquito populations increased with increase in relative humidity within the ranges of 83%-92%. This shows that a certain quantity of water is required in the atmosphere for adult mosquito populations to thrive. Ezihe*et al*. (2017) also noted that they were not able to find any significant association with relative humidity and abundance of mosquitoes. But the observations in this study, and some other previous findings reported that for adult mosquitoes to survive, they need at least 55% relative humidity (Bruce-Ch watt, 1991;Thu *et al*. 1998). Higher levels of relative humidity lengthen the life span of the mosquitoes and enable them to infect more people. Also, Sara (1990) had observed that a constant low relative humidity led to drastic decline in the mosquitoes' populations.

Culex quinquefasciatus had the highest Shannon-Wiener diversity value (0.107) and the highest Simpson's dominance index (0.495) compared with other mosquito species in the area. Okonkwo *et al*. (2014) made similar observation in Oba Anambra State, were *C. quinquefasciatus* had the highest Shannon-Wiener diversity value (0.159) and the highest Simpson's dominance index (0.109) when compared with other mosquito species in their study area. The implication of these finding is that *C. quinquefasciatus* is the most predominant and most frequently encountered mosquito species in the study area. Also, the mosquito has been reported to be a vector filariasis in Nigeria (Umeanaeto *et al*., 2017; Irikannu and Chukwuekezie, 2015). Thus, the mosquito may be actively involved in the transmission of the parasite if infected people live in the area.

CONCLUSION

Findings from the study showed that different genera of mosquitoes namely *Culex*, *Aedes* and *Anopheles* were abundant in the study area, with *C. quinquefasciatus*, a vector of filariasis observed as the most dominant species. The other mosquito species are also known vectors of other parasitic and viral disease and can cause irritation and allergy to their victims by their bite. Also, rainfall, temperature and relative humidity influence their abundance. Mosquito control programmes that will take advantage of accurate timing, based on how these climatic factors influence the vectors abundance is recommended or efficient control.

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REFERENCES

Asgarian, T.S.,Moosa-Kazemi, S.H. and Sedaghat, M.M. (2021).Impact of meteorological parameters on mosquito population abundance and distribution in a former malaria endemic area, central Iran.*Heliyon*7: e08477

Bruce-Chwatt, L.J. (1991). *Essential Malariology*. Heinemann Medical Books Ltd. London 462 pp.

Craig, M.H., Snow, R.W., and Le Sueur, D. (1999).A climate-based distribution model of malaria transmission in sub-Saharan Africa. *Parasitology Today*, 15(3):105-111.

Drakou, K., Nikolaou, T., Vasquez, M., Petric, D., Michaelakis, A., Kapranas, A., Papatheodoulou, A. and Koliou, M. (2020). The Effect of Weather Variables on Mosquito Activity: A Snapshot of the Main Point of Entry of Cyprus. *International Journal of Environmental Research and Public Health,*17:1403

Egbuche, C.M., Onyido, A.E., Umeanaeto, P.U., Nwankwo, E.N., Omah, I.F., Ukonze, C.B., Okeke, J.J., Ezihe, C.K., Irikannu K.C., Aniekwe, M.I., Ogbodo, J.C and Enyinnaya, J.O. (2020).*Anopheles* species composition and some climatic factors that influence their survival and population abundance in Anambra East LGA, Anambra State, Nigeria. *Nigeria Journal of Parasitology,* 41(2):240-250.

Ezihe, E.K., Chikezie, F.M., Egbuche, C.M., Nwankwo, E.N., Onyido, A.E., Aribodor, D. and Samdi, M.L. (2017). Seasonal distribution and micro-climatic factors influencing the abundance of malaria vectors in south-east Nigeria, *Journal of Mosquito Research*, 7(3): 15-26.

Gillet, J.D. (1972).*Common African Mosquitoes and their Medical Importance.* William Heinemann Medical Books Limited, London. Pp. 36

Gillies, M.T. and Coetzee, B.A (1987).Supplementary to Anophelinae of Africa, South of Sahara (Afro- Tropical Region), *South Africa Institute of Medical Research*, 55:1-143.

Gillies, M.T. and De Meillon, B. (1968). The Anophelinae of Africa, South of Sahara, Johanesburg. *South Africa Institute of Medical Research*. 54:343-344.

Ikpo, A.U., Nwaorgu, O.C., Irikannu, K.C., Aniefuna, C.O., Anumba, J.U. and Ezemuoka, L.C. (2021a). Insecticide resistance and target site mutations (G119S ace-1 and L1014F kdr) in *Anopheles gambiae s.l.* in Enugu State, Southeastern Nigeria. *Journal of Entomology and Zoology Studies*, 9(4):111-117.

Ikpo, A.U., Nwaorgu, O.C., Irikannu, K.C., Anumba, J.U., Ezemuoka, L.C and Aniefuna, C.O. (2021b).Molecular characterization of *Anopheles gambiae s.l.* from three senatorial districts in Enugu State, Southeastern Nigeria. *Journal of Entomology and Zoology Studies*, 9(4):106-110.

Irikannu, K.C., Onyido, A.E., Nwankwo, E.N., Umeanaeto, P.U., Onwube, O., Ogaraku, J. C., Ezeagwuna, D.A., Onyebueke, A.C. and Okoduwa A.U. (2020).A Survey of Man-biting Mosquito Species in a Tropical Rainforest Community in the Southeastern Nigeria. *Environment and Ecology*, 38(3):290-299.

Irikannu, K.C., Onyido, A.E., Umeanaeto, P.U., Onwube, O., Ogaraku, J.C., Egbuche, C.M., Oyeniyi, A.T., Adesalu, O.O. and Jimoh, T.R. (2019).Molecular characterization and malaria transmission potential of *Anopheles gambiae* complex in Awka, Anambra State, Nigeria. *International Journal of Mosquito Research*, 6(6):96-101.

Irikannu, K.C. and Chuhwuekezie, O.C. (2015).Malaria and man-biting mosquitoes in tropical Africa. *Lambert Academic Publishing.* ISBN: 978-3-659-76718-0.

Irikannu, K.C., Nwalioba, E.C., Umeanaeto, P.U., Nzeukwu, C.I., Aniefuna, C.O., Obiefule, I.E., Onwuachusi, G.L., Elosiuba, N.V. and Uzochukwu, C.U. (2022).Composition of Mosquito Species and Physiological States of Indoor Man-Biting Mosquitoes at Nteje, South-Eastern Nigeria. *The Bioscientist*, 10(1):113-122.

Irikannu, K.C., Onyido, A.E., Umeanaeto, P.U., Onyebueke, A.C., Nzeukwu, C.I., Ogbonna, C.U., Ezeagwuna, D.A., Ogaraku, J.C. and Asogwa, K.K. (2021). Breeding ecology and physicochemical properties of mosquito breeding sites in Awka South Local Government Area, Anambra State, Nigeria. *Trends in Entomology*. 17:35-42.

Krebs, C.J. (1972). Ecology: The experimental analysis of distribution and abundance. Harper and Row Publishers, New York.

Mboera, L., Kihonda J., Braks., M. and Knols, B. (1998). Influence of centers for disease control light trap position, relative to a human-baited bed net, on catches of *Anopheles gambiae* and *Culex quinquefasciatus* in Tanzania. *The American Journal of Tropical Medicine and Hygiene.* 59:595–596.

Mutero, C.M., Nga'ang'a, P.N., Wekoyela, P., Githure, J. and Konradsen, F (2004).Ammonium sulfate fertilizer increases mosquitoes in rice field *Acta Tropica*,89:187-192.

NPC (2006).National Population Commission. Population Census of Nigeria. Population distribution in Local Government Areas by Sex and Number of Households.

(Ogbeibu, A.E. (2005). Biostatistics: A practical approach to research and data handling. Mindex Publishing Company Limited, Benin City.

Okonkwo, N.J., Obiechina, I.O., Ugha, C.N., Irikannu, K.C., Obianumba, S.N., Okoye-Uzochukwu, C.I., Iwuora, O.I., and Chinweoke, J.O. (2014).Mosquito species composition in Oba, Idemili South Local Government Area of Anambra State. *Researcher*, 6(8):51-56.

Onuoha, J.K., Okparaeke, G., Kalu, I.N., Bassi, B.P., Onyeke, I., Okparaku, U.D., Ozoh, J.E., Okpanku, H.O, and Nkwocha, C. (2011).Research Methodology for behavioural Science. Cape publishers Int'l LTD. Pg 170.

Onwuzulike, I.V., Onyebueke, A.C., Irikannu, K.C., Nzeukwu, C.I., Ogbonna, C.U., Nwangwu, R.L. and Ochiaka, C.S. (2021a). Relative abundance and diversity of man-biting mosquito species before and after indoor residual spraying programme in Awka and Environs, Anambra State, Nigeria. *Trends in Entomology,* 17:57-66.

Onwuzulike, I.V., Onyebueke, A.C., Irikannu, K.C., Nzeukwu, C.I., Ochiaka, C.S. and Nwangwu, R.L. (2021b). Infectivity rate of anopheles mosquito species and the community perception after indoor residual spraying programme in Awka and Environs, Anambra State, Nigeria. *International Journal of Mosquito Research*,8(2):70-76.

Onyido, A.E., Ezeani, A.C., Irikannu, K.C., Umeaneto, P.U., Egbuche, C.M., Chikezie, F.M. and Ugha, C.N. (2016). Anthropophilic mosquito

species prevalence in Nibo Community, Awka South LGA, Anambra State, Southeastern Nigeria. *Ewemen Journal of Epidemiology and Clinical Medicine,* 2(1):14-20.

Onyido., A.E., Ezike, V.I., Nwankwo, E.A. and Ozumba, N.A., (2006). Public health implications of giant trees in the proximity of G.R.A of Enugu Metropolis in South-Eastern Nigeria, Enugu, Nigeria. *Nigerian Journal of Parasitology*, 7:140-143.

Paaijmans, K.P., Imbahale, S.S., Thomas, M.B., Takken, W. (2010) Relevant microclimate for determining the development rate of malaria mosquitoes and possible implications of climate change, *Malaria J*., 9:196-200

Rogers, D.J. and Randolph, S.E. (2006).Climate change and vector-borne diseases. *Advanced Parasitology*, 62:345-381

Sara, E.J. (1990). The bionomic of mosquitoes in selected sites in Maiduguri, unpublished M.Sc. Dissertation University of Maiduguri, Nigeria.118pp.

Service, M.W. (2008). *Medical Entomology for Students Mosquitoes (Culicidae).*Liverpool Science of Tropical Medicine 4th Edition. Pp 16.

Simon-Oke, I.A. and Olofintoye, L.K. (2015).The Effect of Climatic Factors on the Distribution and Abundance of Mosquito Vectors in Ekiti State. *Journal of Biology, Agriculture and Healthcare,* 5(9):142-146.

Thu H.M., Aye, K.M., Thein, S. (1998). The effect of temperature and humidity on dengue virus propagation in Aedes aegypti mosquitos. *Southeast Asian. J. Trop. Med. Pub. Health*, 29:280-284

Umeanaeto, P.U., Asogwa, A.N., Onyido, A.E., Irikannu, K.C and Ifeanyichukwu, M.O. (2017).The Parity Rate of Indoor-Resting Adult Female Anopheles and Culex Mosquitoes and Their Implication in Disease Transmission in Nnamdi Azikiwe University Female Hostels Awka, Southeastern Nigeria. *International Journal of Environment, Agriculture and Biotechnology,* 2(4):1551-1556

Uttah, E.C., Wokem, G.N and Okonofua, C. (2013).The Abundance and Biting Patterns of *Culex quinquefasciatus* Say (Culicidae) in the Coastal Region of Nigeria, *ISRN Zoology*.2013:640691.

Weather Atlas. Available at online at. https://www.weather-nga.com/en/nigeria/awka