IJAGB

International Journal of Avant-Garde Biosciences and Public Health

journal homepage: https://ojs.universityedu.org/index.php/ijagb

Spatial distribution and diversity of mosquito vector in Ndufu-Echara, Southeast, Nigeria

Tobechukwu, Ebele Okeke
Department of Biology, Alex-Ekwueme Federal University, Ndufu-Alike Ikwo, Ebonyi State, Nigeria.
Monday Chukwu Nwanchor
Department of Zoology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
Sunday Ifeanyi Okpani
Department of Zoology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
Emmanuel Okey Umunnakwe
Department of Zoology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

K E Y W O R D S

Mosquito species; relative abundance; distribution; vectors; Ndufu-Echara

A B S T R A C T

Mosquitoes vectors transmit diseases of public health importance such as Dengue fever, Zika virus disease, malaria, lymphatic filariasis, yellow fever, west nile fever and chikungunya. Mosquito distribution significantly influences disease transmission risks. This study investigated the species composition and relative abundance of mosquitoes vector species in two selected villages in Ndufu-Echara, Ikwo LGA, from June to August 2025, to understand their distribution pattern and potential influence on disease transmission. Mosquitoes were collected using two standard methods: the Human Landing Catch (HLC) for outdoor sampling and the Pyrethrum Knockdown Catch (PKC) for indoor sampling. A total of 342 mosquitoes representing three genera and five species—*Anopheles gambiae, Culex quinquefasciatus, Aedes vittatus, Aedes aegypti, and Aedes albopictus*—were identified from two study sites. Culex quinquefasciatus had the highest relative abundance (40.34%) in Site 1, while Aedes vittatus showed the lowest (1.73%) in Site 2. Overall, 333 mosquitoes were collected across both methods, with 189 (97.36%) obtained via PKC and 144 (107.46%) via HLC. Aedes aegypti (20.89%) and Anopheles funestus (8.21%) were more abundant in HLC collections, while Aedes albopictus (14.29%) dominated PKC catches. *Culex quinquefasciatus* was also more frequent in HLC (43.28%) than PKC (28.59%). Diversity analyses revealed that Site 2 exhibited a slightly higher Shannon–Wiener diversity index (1.63) and evenness (0.91) than Site 1 (1.62 and 0.90, respectively). Margalef richness was higher in Site 2 (1.03) than Site 1 (1.02), while Simpson's dominance index was greater in Site 1 (0.26) than Site 2 (0.23). There was significant difference in the populations of different species of mosquitoes collected with PKC and HLC collection method at ($P = 0.001$). These findings demonstrate spatial variations in mosquito distribution to prevent disease outbreaks in the area.

1. Introduction

Mosquitoes are among the most medically important insects in the world (Fu, 2024). They belong to the family Culicidae and are found in nearly every part of the globe where there is standing water including puddles, containers, marshes, rice fields, and even discarded tires. Their medical importance stems from their ability to transmit a variety of pathogens that cause diseases such as malaria, yellow fever, dengue, Zika virus, chikungunya, and lymphatic filariasis (Wei, *et al*., 2026). These diseases contribute substantially to morbidity and mortality

* Corresponding author's E-mail address: okekete15002f@gmail.com
Received June 08, 2026; Received in revised form June 30, 2026; Accepted: July 06, 2026.

in many tropical and subtropical regions of the world, particularly in sub-Saharan Africa, where climatic and environmental conditions are favourable for mosquito breeding and survival (WHO, 2022). In Nigeria, mosquitoes are responsible for a high burden of disease, especially malaria, which remains one of the leading causes of illness and death, particularly among children under five and pregnant women (Afolabi *et al.*, 2020).

Mosquitoes serve as vectors (organisms that carry and transmit infectious agents) for a wide array of diseases. They are responsible for transmitting viruses, parasites, and lymphatic filarial worms that significantly affect global health. Among these diseases are malaria, dengue fever, yellow fever, Zika virus disease, chikungunya, West Nile virus infection, and lymphatic filariasis many of which lead to severe illness, long-term disability, or death. Mosquito-borne diseases contribute significantly to morbidity and mortality worldwide, particularly in tropical and subtropical regions with warm climates that favor mosquito survival and reproduction (Fu, 2024). Mosquito-borne diseases account for a large proportion of the global infectious disease burden (Lin, 2025). These diseases disproportionately affect low- and middle-income countries, where resources for prevention and control are limited and access to effective health care can be restricted. The impact of mosquito-borne diseases extends beyond direct health effects.

The impact of mosquito-borne diseases goes beyond direct health consequences, imposing substantial economic, healthcare, and social burdens (Wei *et al*., 2025). Treatment expenses, loss of productivity, and the cost of vector control place significant financial strain on individuals and governments. Recurrent disease outbreaks often overwhelm health facilities, particularly during peak transmission periods. Additionally, long-term complications such as post-malarial anemia, lymphatic impairment, and neurological disorders from viral infections reduce quality of life and contribute to chronic disability (Branda, *et al*., 2025). There is limited high-resolution spatial data on the distribution of mosquito species across different ecological zones and communities in Ebonyi State, making it difficult to identify vector hotspots for targeted control. In addition, existing studies have not comprehensively documented mosquito species diversity particularly Aedes, Anopheles, and Culex in both urban and rural areas, thereby constraining understanding of vector ecology and associated disease risks.

Materials and Methods

The Study Area

This study was conducted in the community of Ndiechi-Achara (Site 1) and Obeagu (Site 2) in Ndufu-Echara, Ikwo Local Government Area (LGA) of Ebonyi State**,** southeastern Nigeria. According to the 2006 Nigerian census, Ikwo LGA had a population of about 214,969 people. The geographical coordinates of the study area are: latitudes 6°6' 3N, Longitude 8°6'37'E for Site 1 and longitudes 6°7'23''N and 8°10'13''E for Site 2**.** It shares boundaries with Abakaliki, Ezza South, and Izzi LGAs, and is bordered to the east by Cross River State. Ikwo is predominantly agrarian**,** with most residents engaged in the cultivation of rice, yam, maize, cassava, sweet potatoes, and assorted vegetables due to their fertile soils and favorable climatic conditions**.** The area is particularly noted for the production of Abakaliki rice and palm wine. In addition to agriculture, Ikwo possesses notable natural resources such as limestone, lead, salt, laterite, and sharp white sand, which support small-scale mining activities in parts of the LGA. The presence of stagnant water bodies, open gutters, irrigation channels, and poorly drained farmlands, especially during the rainy season, creates favorable breeding habitats for mosquitoes. Additionally, domestic water storage practices and refuse dumps near residential areas contribute to an environment that supports mosquito proliferation. The climate of Ndufu-Echara is tropical, characterized by two distinct seasons: the rainy season (April to October) and the dry season (November to March). The average annual rainfall ranges between 1,900 mm and 2,200 mm**,** while temperatures vary between 25°C and 32°C (Ebonyi State Government, 2024).

Experimental Design

The research was carried out between June and August 2025. Mosquito samples were collected thrice weekly, namely: Monday, Wednesday and Friday for the period of the study and it was done in the night hours, (7pm-6am). The study involved a cross-sectional design employed in mosquitoes survey in the study area and a completely randomised design method. Two sites were selected for this study site (1 and 2). Site 1 is approximately 4 kilometres away from Site 2. The study designs were appropriate for this research since they allowed for data collection on multiple variables at a single, which is important for epidemiological investigation of mosquito prevalence and species distribution at the study area.

Sampling Methods:

Indoor collection (Pyrethrum Knockdown Method)

Indoor mosquito sampling as described by (WHO, 2025) was conducted using the Pyrethrum Knockdown Collection (PKC) method. For each selected household, a clean white sheet was spread evenly on the floor of the chosen room, serving as the collection surface. A commercially available aerosol insecticide, Baygon® (a pyrethrum-based formulation), was sprayed thoroughly throughout the room at exactly 7:20 PM to ensure all potential resting sites were covered.

Immediately after spraying, the room was sealed and left undisturbed for a knockdown period of 40 minutes to allow the insecticide to take full effect on any mosquitoes present. At precisely 8:00 PM, the researcher re-entered the room and carefully inspected the white sheet for knocked-down mosquitoes. Each mosquito found was gently picked by hand to prevent damage to morphological features and was immediately transferred into clean, labeled microcentrifuge tubes for preservation. These tubes were later taken to the laboratory for identification using key by Wilkerson *et al*., (2021) and Rattanarithikul, *et al*., (2025).

This method was particularly useful in recovering indoor-resting mosquito species that tend to remain hidden in corners, under furniture, or on walls during inactive periods. It provided a reliable estimate of the species composition within the indoor environment of the study area.

Outdoor Collection (Human Landing Catch Method)

Outdoor mosquito collection was carried out using the Human Landing Catch (HLC) method (Abong'o, *et al*., 2021). During each session, the researcher remained seated in a fixed outdoor location during the early evening hours, which are known peak biting times for several mosquito species. The lower legs were left partially exposed, allowing mosquitoes to approach and attempt to land.

When a mosquito made contact, it was swiftly killed by hand before it could take a blood meal. Each specimen was then placed in a labelled microcentrifuge tube for later laboratory analysis. For proper documentation, photographs were taken of each mosquito before preservation to serve as visual evidence of collection.

Unlike conventional HLC approaches where ethanol is often used to kill or preserve specimens immediately, no ethanol or other chemical preservatives were applied at the point of capture in this study. Instead, the mosquitoes were stored dry in their containers and subsequently transported to the laboratory for morphological identification Pretorius, *et al*., 2023). This method provided valuable insights into outdoor-biting mosquito populations and their host-seeking activity patterns in Ndufu-Echara.

Statistical Analysis

Friedman test was used to compare the different populations of mosquito species at 5% level of significance. All the analysis was performed using using Statistical Package for the Social Sciences SPSS), statistical software (version 25.0).

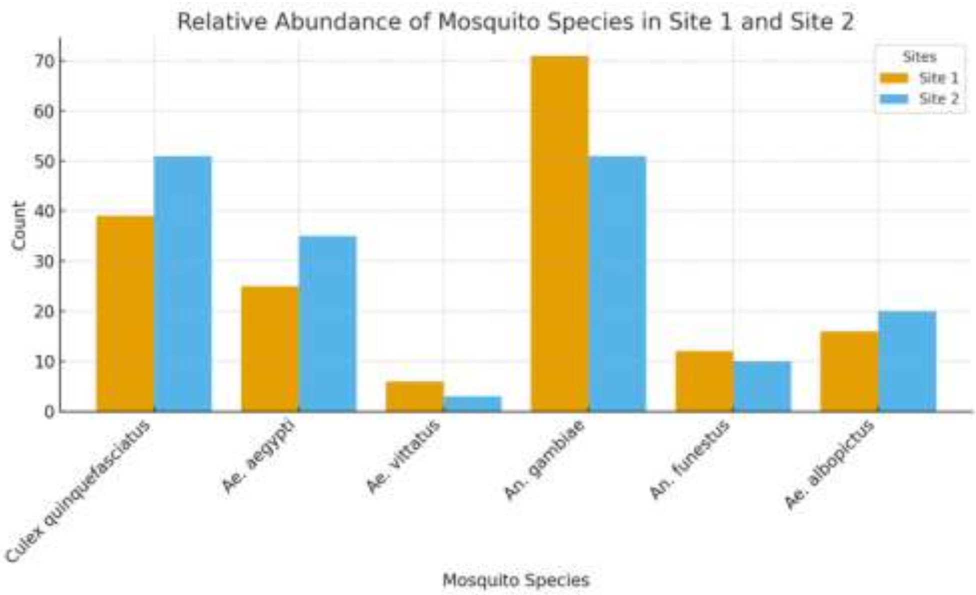
RESULTS

The mosquito vector species found domiciled in the two studied sites is presented in Table 2. Three genera comprising five mosquitoe species were identified in Ndufu-Echara, Ikwo Ebonyi State, namely: *Anopheles gambiae, Culex quinquefasciatus, Aedes vittatus, Aedes aegypti* and *Aedes albopictus.* A total of 342 mosquitoes were collected from the two studied sites in Ndufu-Echara, Ikwo. Of these number, 169 (111.86%) were collected from site 1 and 98.26%) were collected from site 2. from Site 1 and 173 from Site 2. The results showed that Aedes aegypti (20.23%), Aedes albopictus (11.56%) has higher relative abundance in Site 2 than site1 (14.20%, 9.09%). However, *Aedes funestus* recorded higher relative abundance in site 1 (6.82%) than Site 2 5.78%). The results further revealed that *C. quinquefasciatus* recorded the highest relative abundance in Site 1 (40.34%) while Aedes *vitattus* had the least relative abundance (1.73%) in Site 2.

There was significant difference in the populations of different species of mosquitoes collected using PKC as a collection method (P = 0.001).

Table 1: Distribution of Mosquito vector species in the study area

Mosquito Species	Site 1 Count	Site 1 Rel. Abund. (%)	Site 2 Count	Site 2 Rel. Abund. (%)	Total
Culex quinquefasciatus	39	22.16	51	29.48	90
Ae. aegypti	25	14.20	35	20.23	60
Ae. vittatus	6	3.41	3	1.73	9
An. gambiae	71	40.34	51	29.48	122
An. funestus	12	6.82	10	5.78	22
Ae. albopictus	16	9.09	20	11.56	36
Total	**169**	**111.86**	**173**	98.26	**342**

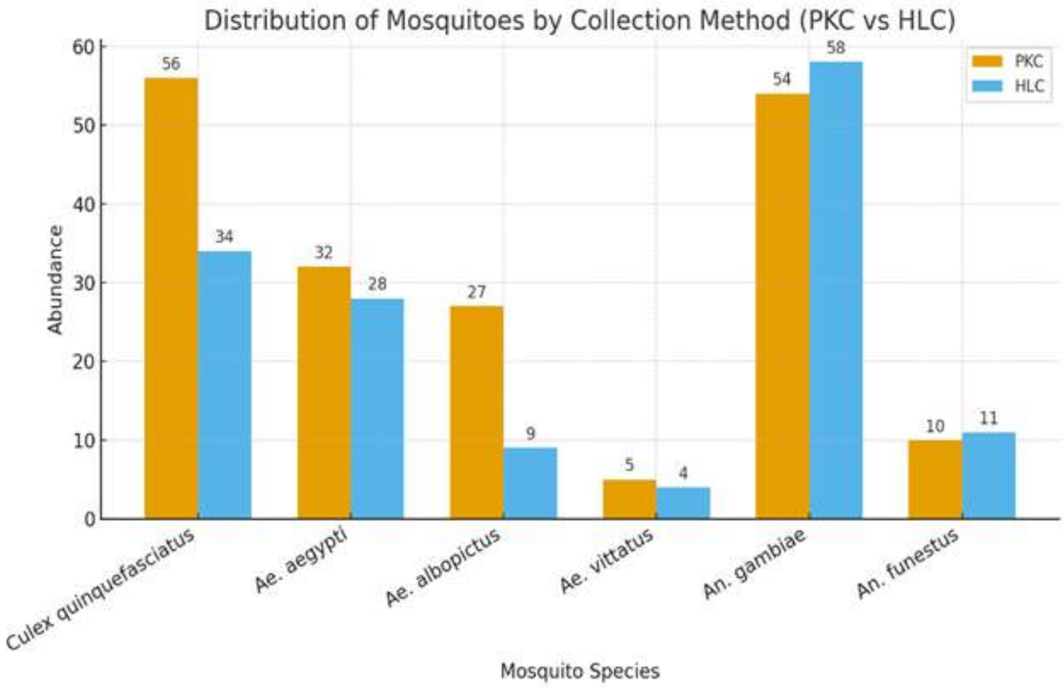


Graph 1: Graph Representation showing the Relative Abundance of Site1 and Site 2 at the study Area

Table 2 shows the distribution of mosquito species by the two collection methods: Pyrethrum Knockdown Collection (PKC) and Human Landing Catch (HLC). A total of 333 mosquitoes were collected using both methods. Out of these, 189 (97.36%) were collected with PKC while 144 (107.46%) were collected with HLC. Ae. aegypti, (20.89%), An. funestus (8.21%) had higher relative abundance with the use of HLC method than PKC method (16.93% 5.29% respectively). The results further revealed that Ae. albopictus (14.29) had higher relative abundance with the use of PKC than HLC (6.72%). However, the results further revealed that Culex quinquefasciatus (43.28%) recorded the highest relative abundance with use of HLC than PKC (28.59%). The findings also revealed that HLC (2.99%) recorded the least relative abundance than PKC (2.65%).

Table 2: Mosquito species Collection by PKC and HLC Methods

Mosquito Species	PKC Count	PKC Rel. Abund. (%)	HLC Count	HLC Rel. Abund. (%)	Total
Ae. gambiae	56	29.63	34	25.37	90
Ae. aegypti	32	16.93	28	20.89	60
Ae. albopictus	27	14.29	9	6.72	36
Ae. vittatus	5	2.65	4	2.99	9
Culex quinquefasciatus	54	28.57	58	43.28	112
An. funestus	10	5.29	11	8.21	21
Total	**189**	97.36	**144**	107.46	**333**



Graph 2: Bar graph showing the distribution of mosquito species across the two collection methods (PKC and HLC).

Table 3. Result of Dominance, Diversity and Richness of Insects in Ndufu-Echara.

The results on dominance, diversity and richness of insects collected from Ohankwu in the two Sites studied are presented in Table 3. The results shows that Site 2 had a higher Shannon–Wiener diversity index (1.63) than site 2 (1.62). Site 2 had a higher Margalef richness index (1.03) than Site 1 (1.02). Site 1 had a higher Simpson's dominance index (0.26) than Site 1 (0.23). Site 2 had higher Shannon Weiner Evenness (0.91) than site1 (0.90).

Table 3: Shannon-Wienwr, Margalef, Simpson's Dominance and Evenness of Insects in Ndufu-Echara

Category	Shannon-Weiner (H)	Simpson Dominance (C)	Margalef Richness (D)	Evenness (E)
Site 1	1.62	0.26	1.02	0.90
Site 2	1.63	0.23	1.03	0.91
PKC	1.64	0.23	1.03	0.92
HLC	1.52	0.26	0.98	0.86

Ethical Clearance

Ethical approval for this study was sought and obtained prior to data collection. Permission was first granted by the traditional authorities and community leaders of Ndiechi-Echara (Site 1) and Obeagu-Nzashi (Site 2) in Ndufu-Echara, Ikwo Local Government Area of Ebonyi State.

Discussion

The findings of this study shed light into the distribution and emergence patterns of mosquitoes vectors in Ikwo, Ebonyi State. The rate of emergence is critical for understanding the potential for disease transmission and for formulating vector control strategies. A total of 342 mosquitoes were collected across the two sites in this study, with varying emergence success rates. This differential emergence rate has been observed in other studies and could be influenced by several factors including environmental conditions and larval habitat quality (Arévalo-Cortés *et al*., 2022). The emergence new uncommon species (*Ae. vittatus*) in the current study is consistent with the findings of other studies in similar ecological zones, where emergence rates have ranged from 70 to 90% (Ndenga *et al*., 2017). There is strong disparity in the distribution of mosquitoes across the two sites (1 and 2). The variations could be attributed to fluctuation in environmental factors that influence mosquito breeding and survival (Meuti, 2023).

Environmental factors such as temperature, rainfall, vegetation cover, and human settlement patterns significantly affect mosquito breeding. Warm temperatures speed up larval growth, rainfall provides temporary breeding sites, and droughts can drive species such as Anopheles gambiae to permanent water bodies, thereby increasing contact between vectors and hosts. This could suggest that although there are more suitable vegetation structure which enhances good habitats in Site 2, yet higher relative abundance (111.86%) compared to Site 2 (98.26%). The difference in prevalence may be attributed to variation in microclimate of the study areas, sample size (human population) and study periods. This is line with the work of Meuti, (2023) who reported that environmental factors such as temperature, rainfall, vegetation cover, and human settlement patterns significantly affect mosquito breeding and warm temperatures speed up larval growth, rainfall provides temporary breeding sites, and droughts can drive species such as Anopheles gambiae to permanent water bodies, thereby increasing contact between vectors and hosts.

Prior research by Langerhans and Kern (2020) found that smaller bodies of water, which are less likely to be disturbed and may harbor fewer predators, can result in higher mosquito adult emergence rates. This finding aligns with those in the current study, where despite fewer larvae being collected, the emergence rate was higher in the two studied sites, suggesting a possible correlation between habitat suitability and emergence success. The most prevalent mosquito collected in this study was *Anopheles gambiae.* This suggests that the environment of the study area is most suitable for this species of mosquitoes than other species also collected. This is in line with the findings of (NMEP; NPopC; NBS and ICF, 2021; U.S. President's Malaria Initiative, 2021) who reported *Anopheles gambiae* as the most abundant mosquito species in Ebonyi State. Their larval population are the most abundant as well possibly because the breeding habitats present in this present study is suitable for their development. On the other hand, this study reported higher occurrence of *Anopheles gambiae indoors* than in outdoor locations, though without any statistically significant difference. This suggests that *Anopheles gambiae is* of great public health importance in disease transmission both in outdoor and indoor locations.

Conclusion

The findings from this study demonstrate that mosquito vectors are widely distributed across varied ecological zones of the state, with significant clustering in areas characterized by standing water, dense vegetation, and human activity. A diverse range of mosquito species, including Anopheles, Aedes, and Culex, were identified, with notable differences in species composition between the two studied areas. Environmental factors such as seasonal rainfall and proximity to water bodies significantly influence mosquito abundance and diversity. Predominance of Anopheles gambiae, the primary malaria vector further underscores the suitability of the local environment for its proliferation and the continued risk of malaria transmission and therefore calls for serious epidemiological surveilance. Differences in emergence success likely result from variations in microclimate, habitat stability, and larval habitat quality. These findings highlight the complex ecology and diverse spatial distribution of mosquito vectors in the study area, emphasizing the elevated risk they pose for mosquito-borne diseases such as malaria, dengue, and lymphatic filariasis. The documented patterns of species diversity provide critical insights for public health authorities, supporting the implementation of location-specific vector surveillance and targeted, integrated control strategies that prioritize high-risk areas tailored to local ecological conditions.

References

Abong'o, B., Gimnig, J. E., Longman, B., Odongo, T., Wekesa, C., Webwile, A., Oloo, B., Nduta, M., Muchoki, M., Omoke, D., Wacira, D., Opondo, K., Ochomo, E., Munga, S., Donnelly, M. J., & Oxborough, R.M. (2021). Title of the article. Parasites & Vectors, 14(1), 320.

Afolabi, B. M., Afolabi, T. M., Ogunwale, A., & Aiyesetenikan, A. (2020). A 2-month intervention study of preventive clothing against mosquito bites among malnourished and well-nourished children under 5 years of age living on the Atlantic Ocean Coast of Lagos, Southwest Nigeria. Malaria Journal, 19(61).

Afolabi, B. M., Aiyesetenikan, A., & Ogunwale, A. (2020). A 2-month intervention study of preventive clothing against mosquito bites among malnourished and well-nourished children under 5 years of age living on the Atlantic Ocean Coast of Lagos, Southwest Nigeria. Malaria Journal, 19, 61.

Arévalo-Cortés, A., Granada, Y., Torres, D., & Triana-Chávez, O. (2022). Differential Hatching, Development, Oviposition, and Longevity Patterns among Colombian Aedes aegypti Populations. Insects, 13(6), 536.

Branda, F., Ali, A. Y., Ceccarelli, G., Albanese, M., Binetti, E., Giovanetti, M., Ciccozzi, M., & Scarpa, F. (2025). Assessing the burden of neglected tropical diseases in low-income communities: Challenges and solutions. Viruses, 17(1), 29. https://doi.org/10.3390/v17010029

Ebonyi State Government. (2024). Citizens' accountability report for the year ended 31 December 2024. Ebonyi State Government. https://www.ebonyistate.gov.ng/storage

Fu, G. L. (2024). Epidemiological patterns of mosquito-borne diseases globally. Journal of Mosquito Research, 14(3), 111–123.

Langerhans, R. B., & Kern, E. M. A. (2020). Urbanization and evolution in aquatic environments. In M. Szulkin, J. Munshi-South, & A. Charmantier (Eds.), Urban evolutionary biology (pp. 157–174). Oxford University Press.

Lin, L., Guo, X., Wu, Y., Sun, Y., Liu, D., Luo, Y., Xiang, Q., Li, T., Li, G., Yu, W., & Gu, D. (2025). Title of the article. Zoonoses, 5(1), 967. L., Guo, X., Wu, Y., Sun, Y., Liu, D., Luo, Y., Xiang, Q., Li, T., Li, G., Yu, W., & Gu, D. (2025). Title of the article. Zoonoses, 5(1), 967.

Lin, L., Guo, X., Wu, Y., Sun, Y., Liu, D., Luo, Y., Xiang, Q., Li, T., Li, G., Yu, W., & Gu, D. (2025). Title of the article. Zoonoses, 5(1), 967.

Meuti, M. E. (2023). Environmental factors that regulate mosquito physiology and behavior. Annual Review of Entomology, 68, 1–24.

National Malaria Elimination Programme (NMEP), National Population Commission (NPopC), National Bureau of Statistics (NBS), & ICF. (2021). Nigeria malaria indicator survey 2021: Final report. Abuja, Nigeria: NMEP, NPopC, and ICF.

National Population Commission. (2011). Annual abstract of statistics 2011 (Table 26.1: Population of Ebonyi State by local government area, 2006 census). National Bureau of Statistics, Federal Republic of Nigeria.

Ndenga, B. A., Mutuku, F. M., Ngugi, H. N., Mbakaya, J. O., Aswani, P., Musunzaji, P. S., and LaBeaud, A. D. (2017). Characteristics of Aedes aegypti adult mosquitoes in rural and urban areas of western and coastal Kenya. *PloS One*, 12(12): 1-8.

Oladipo, E. K., Faleye, T. O. C., Adewumi, M. O., Nwobi, O. C., Adebisi, Y. A., & Adeniji, J. A. (2024). Nationwide surveillance identifies yellow fever and chikungunya viruses transmitted by various species of Aedes mosquitoes in Nigeria. Viruses, 16(2), 270.

Pretorius, E., Kristan, M., Bradley, J., Teixeira da Silva, E., Hutchins, H., Barri, F., Cassama, A., Ceesay, S., Ndiath, M. O., Rodrigues, A., Last, A., & Logan, J. G. (2023). Validation of a method for the dry preservation and rehydration of Anopheles gambiae sensu lato for parity analysis to assess the impact of vector control measures in the field. Parasites & Vectors, 16, 236.

Rattanarithikul, R., Harbach, R. E., Harrison, B. A., Panthusiri, P., Jones, J. W., & Coleman, R. E. (2005). Illustrated keys to the mosquitoes of Thailand. II. Genera Culex and Lutzia. The Southeast Asian Journal of Tropical Medicine and Public Health, 36(Suppl. 2), 1–97.

U.S. President's Malaria Initiative. (2021). Entomological monitoring report: Nigeria, 2019–2020. U.S. Agency for International Development.

Vander Does, A., Labib, A., & Yosipovitch, G. (2022). Update on mosquito bite reaction: Itch and hypersensitivity, pathophysiology, prevention, and treatment. Frontiers in Immunology, 13, Article 1024559.

Wei, Y.-L., Wu, Z., Li, R.-L., & Tang, F. (2026). Review of selected mosquito-borne diseases: arboviruses (dengue, chikungunya, Zika, West Nile, Japanese encephalitis, yellow fever) and parasitic diseases (malaria, lymphatic filariasis). Frontiers in Public Health. https://doi.org/10.3389/fpubh.2025.1712094

Wilkerson, R. C., Linton, Y.-M., & Strickman, D. (2021). Mosquitoes of the world (2-volume set). Johns Hopkins University Press.

World Health Organization. (2022). World malaria report 2022. Geneva, Switzerland: World Health Organization. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2022.

World Health Organization. (2024, September 26). Vector-borne diseases [Fact sheet]. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases.

World Health Organization. (2025). Malaria surveillance, monitoring and evaluation: a reference manual (2nd ed.). World Health Organization.