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Baseline entomological data collections of malaria vectors in three selected local government areas in Rivers State, Nigeria

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Abstract
Malaria is still the biggest killer of children in Africa and highly endemic in Nigeria. The study aims to identify vectors responsible for malaria transmission in the following local government areas (LGAs), Ikwerre, Etche and Emohua, all in Rivers State, Nigeria. There were five representative communities from each of the LGAs. Entomological data collection included pyrethrum spray collection (PSC) of adult female, indoor resting density (IRD) was calculated, larval collection was done and larval density calculated, larvae were reared to adult, morphological and molecular identifications of vector species were done. Ikwerre LGA had the highest mosquitoe population. Peak abundance of mosquitoe was in October. *Anopheles* species had the highest abundance of 69.31% and Ikwerre LGA had the highest number of Anopheles in term of pattern of distribution. During PSC the following mosquitoe vectors were sampled: *An. gambiae sensu stricto, An. arabiensis, An. moucheti, An. funestus, Cu. quinquefasciatus, Cu. annulioris, Conquillettidia azurites, Mansonia africana, Aedes aegypti* and *Aedes albopictus.* The mean IRD and larval density was higher in Ikwerre LGA than in Etche and Emohua LGAs. This baseline data will aid in the development of a more ecologically sound and effective mosquito control strategy.

Keywords: Mosquitoe, density, LGA, Rivers State, anopheles, culex, aedes, emohua, ikwerre, etche

Introduction

Malaria remains the biggest killer of children in Africa as 95% of the world deaths is from Africa and it demands increased attention from control authorities in affected communities (WHO, 2026). In Nigeria, malaria is highly endemic and has claimed thousands of lives, being responsible for 24.3% of the world's deaths (WHO, 2026) and caused massive economic losses. The prevalence of malaria has increased significantly in Nigeria since the failure of the global malaria eradication in the 60s (National Health Statistics Report, 2025) [19].

The scourge of malaria remained a major, unsolved problem in tropical Africa. Priority attention has been given to the disease by World Health Organization (WHO), yet the menace of the disease remains unabated. Many control efforts have been formulated by various international agencies involved in the elimination of the disease, the problem still stare us on our faces.

Malaria vector control that relies on insecticide-based interventions such as indoor house spraying with residual insecticides, need to base their decision-making process on sound baseline data (Coetzee *et al.*, 2011) [7].

Entomological surveys associated with malaria prevention and control efforts require the sampling of adult mosquitoes (Hamza *et al.*, 2024) [11]. Anopheline vectors of malaria consist of various species with unique behavior associated with their biting activities and transmission dynamics (Kiam *et al.*, 2025) [12]. The indoor resting behavior of important malaria vectors such as *Anopheles gambiae* and *Anopheles funestus* are well documented. Because of this behavior, sampling vectors populations resting indoors can be valuable part of surveillance and control programme (Lindblade *et al.,* 2000 [14]; Charlwood *et al*., 2024).

In the present study, an entomological survey was conducted to identify vectors responsible for malaria transmission in the local government areas. The information generated from this study will help for the development of more ecologically sound and efficient mosquito control strategy.

Methodology

The study site

The study was carried out in three local government areas (LGA) of the Rivers State -

1. Ikwerre LGA
2. Etche LGA
3. Emohua LGA

The local government areas were chosen by the National Malaria and Vector Control unit of the Federal Ministry of Health in collaboration with the Rivers State Ministry of Health. The communities chosen for the survey were also selected according to the criteria set aside by the national body.

The rural dwellers are traditional Ikwerre and Etche speaking people of the Rivers State. The total projected population of the three local government areas from 2006 census is 64108, (Ikwerre LGA, 189,726, Etche LGA, 249,454 and Emohua LGA, 201,901). The natives depend mainly on farming as their income. Other economic activities include fishing and trading. The areas are located in the dry upland region of Rivers State and are characterized by tropical rain forest. The topography is flat

and pockets of forest stream and fresh water bodies are found in some communities while others are completely dry. Their sources of drinking water are through rainfall, fresh water bodies and pipe borne water. Those communities that are located in the dry areas construct various forms of drainage pits and large water reservoir tanks around their houses to collect and store water for domestic uses during rainfall. These serve as breeding sites for mosquitoes and hence expose the people to malaria attack.

Drainage in their localities to remove liquid waste is via surface drains on the side of the roads. Some drains are made with concrete and in some instances covered with concrete slabs while some are exposed and sometimes blocked with refuse. In many areas the drains are damaged and are not repaired causing temporary pool of water which serve as breeding sites of malaria vectors.

The vegetation characteristic is that of the tropical rain forest. The climate is characterized with two distinct seasons, the wet and dry seasons, the former taking place from April to October and dry season between November and March.

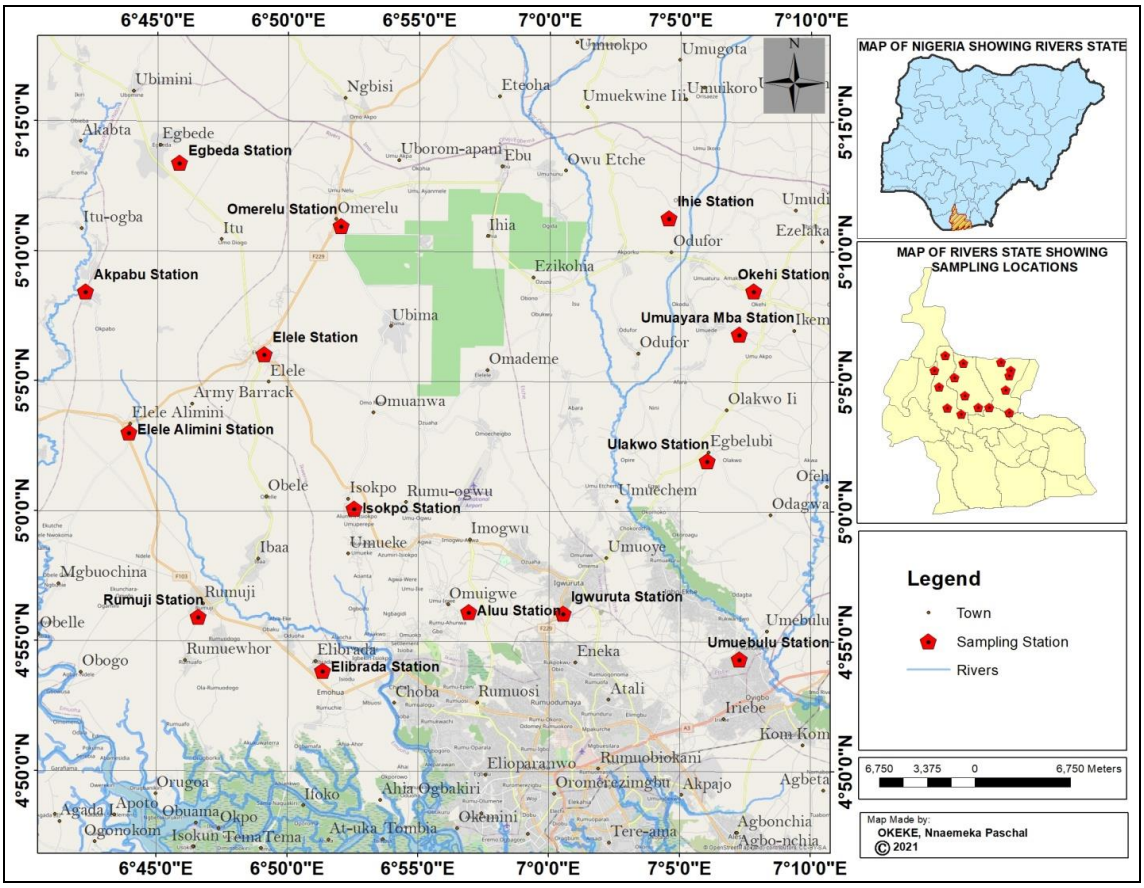

Fig 1: Map of the study areas showing the sampling stations

Selection of the sampling communities

In each of the local government areas, five representative communities were randomly chosen for the survey as follow:

Table 1: List of sentinel communities in each local government areas of Rivers State.

S/n	Ikwerre lga	Etche lga	Emohua lga
1	Igwuruta	Ihie	Eibrada
2	Isiokpo	Okehi	Rumuji
3	Elele (I)	Umuayara – Mba	Elele- Alimini
4	Omerelu	Ulakwo	Akpabu
5	Aluu	Umuegbulu	Ebeda

Entomological data collections

Location of the sampling sites

Before the commencement of the sampling proper, reconnaissance visits were carried out in each of the identified communities to identify the houses to be sampled. During the visits, houses that met the basic requirements for pyrethrum spray collections (PSC) were randomly selected and geo-referenced using a global positioning system (GPS). The house owners were told not to apply any insecticides or local mosquito repellant prior to the commencement of the sampling. The houses were numbered using a white chalk. During the visits, larval breeding sites were equally noted. Sampling commenced in September, 2012 and ended in January, 2013.

Adult female collections

The study was conducted in ten randomly selected houses in each community Standard collection protocols recommended by the Federal Ministry of Health and World Health Organization (WHO, 1975) [27] was used in the collection of Adult anopheline mosquitoes. The mosquitoes were collected using spray sheet (room collection or pyrethrum knockdown collection). At each house selected for PSC, latitude and longitude coordinates and certain other identifiable data were gathered and recorded with a GPS. receiver; a local ID associated with the area was recorded alphanumerically.

After taking the GPS, a member of the household was asked about the number of people who had slept there the previous night. Thereafter, all family members were requested to leave the room and stay outside for a while. All food items were removed from the home including some properties that will hinder insect collections. Fires were also extinguished. White sheets were then spread on the floor of all sprayable rooms and all exits from the house were covered. The eye perimeter was then sprayed from both the inside and outside with pyrethrum. The inside spray men also sprayed the inside room, under tables, chairs. After that the spray men exited the room and closed the door. After 10 minutes, sheets were removed one by one starting from the one close to the door.

The sheets were examined outside for adult *Anopheles* mosquitoes. Magnifying hand lens was used to differentiate between female anopheles and other mosquitoes using morphological characteristics. The female anophelines were preserved individually in a well labelled Eppendorf plastic vial half filled with silica gel and stuffed with white papers. The indoor resting density of mosquitoes in each community was calculated using the formula:

Indoor Resting Density (IRD) = Total number of females collected/No of rooms per household used for the spray-sheet collection

Data about the type of house, the number of people per sampled room of the selected houses, the nature of the environment, climatic conditions, inspectors name, date of inspection, etc were recorded.

Larval collection

Anopheline larvae were collected by searching different types of larval breeding sites, e.g. various types of permanent water bodies-small water pools, or impoundments and drainages using a dipping method described by World Health Organization.

All the above mention potential breeding sites were surveyed for anopheline larvae. A white iron dipper (ladle) was used for the larvae collection. The water containing the larvae was transferred into a white labeled plastic jar and taken to the laboratory for identification, rearing and larval density calculation.

Larval density=Total Number of Larvae/No of Dips

Rearing of larvae

The collected larvae from the field were transferred into another plastic boxes labeled according to the communities they were sampled from. The larvae were fed and then monitored through their developmental stages. On reaching the pupal stages, the pupae were transferred to a small container of water and placed in netted wooden cages for the adult to emerge. The adults that emerged were fed with glucose solution for 3 days before using them for bioassay test.

Morphological identification

The preserved mosquitoes were identified using the morphological keys of Gillies and Coetzee, 1987 [10].The samples were later sent to Nigerian Institute for Medical Research, Yaba, Lagos State, for re-confirmation and further molecular species identification using PCR.

PCR Identification

Anopheles mosquitoes collected from the sites were analyzed for species identification using the Polymerase Chain Reaction (PCR) at the laboratory of Nigerian Institute of Medical Research, Yaba, Lagos State. Sub sample of all monthly collections of both *Anopheles gambiae and Anopheles funestus* from the sampling sites were subjected to Polymerase Chain Reaction (PCR) assay. All *Anopheles* identified as *Anopheles gambiae* complex were analyzed following the procedure of Scott *et al.* (1993) [25]. All unamplified DNA samples were repeated for confirmation.

Results

Mosquito abundance and distribution

A total of 3,689 mosquitoes were sampled from 1946 rooms in Ikwerre, Etche and Emohua local government areas of Rivers State (Table 2). Out of the number, 2,235 were sampled from Ikwerre LGA, constituting 60.59% of the total population of mosquitoes sampled in the entire three local government areas, while Etche and Emohua local government areas had total mosquitoe abundance of 665 (18.03%) and 789 (21.39%) respectively. The differences were not significant (P>0.05).

Monthly distribution pattern of the mosquitoes in the areas surveyed (Fig 2) revealed the peak abundance in the month of October which reduced significantly (P<0.05) towards November and January corresponding to the dry season.

Distribution of mosquito genera

Fig 3 and Fig 4 show the percentage abundance and distribution of the mosquito genera. Of the total number of the mosquito sampled indoors, about 69.31% (2557) belong to the genera Anopheles, 30.69% (1084) Culex and 1.30% (48) Aedes. The distribution pattern revealed that the highest numbers of anopheles mosquitoes were obtained in Ikwerre LGA followed by Emohua LGA and the least was obtained in Etche LGA. The monthly distribution pattern of the mosquito genera in each of the LGAs (Figs. 5, 6 & 7) revealed that the anopheles mosquitoes were more abundant in September, decreased slightly in October and increased again in November and December.

Table 2: Mosquitoes Abundance In The Sampled Houses In Ikwerre, Emohua and Etche Local Government Areas Of Rivers State (October, 2012-January, 2013)

Local govt. Area	Month of sampling				Total no of rooms Sampled	Total no of individuals In the sampled rooms	Total number of mosquitoes Sampled	% abundance
	SEPT	OCT.	NOV	JAN.				
Etche LGA	252	279	95	39	672	1422	665	18.03
Ikwerre LGA	615	1098	415	107	634	1414	2235	60.59
Emohua LGA	331	358	79	21	640	1128	789	21.39
Total	1198	1735	589	167	1946	3964	3689	100

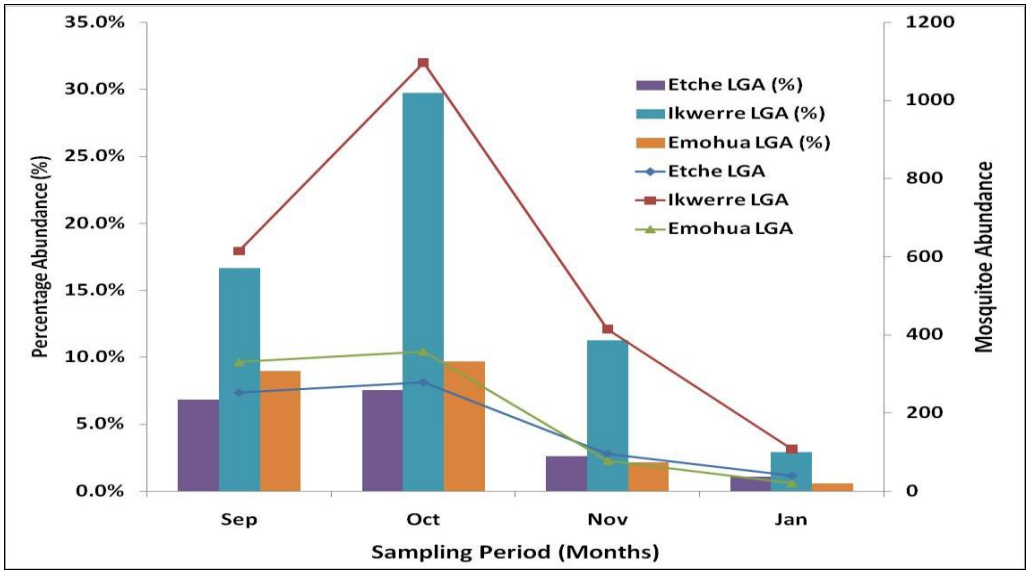

Fig 2: Monthly Percentage abundance and distribution of mosquitoes in the LGAs

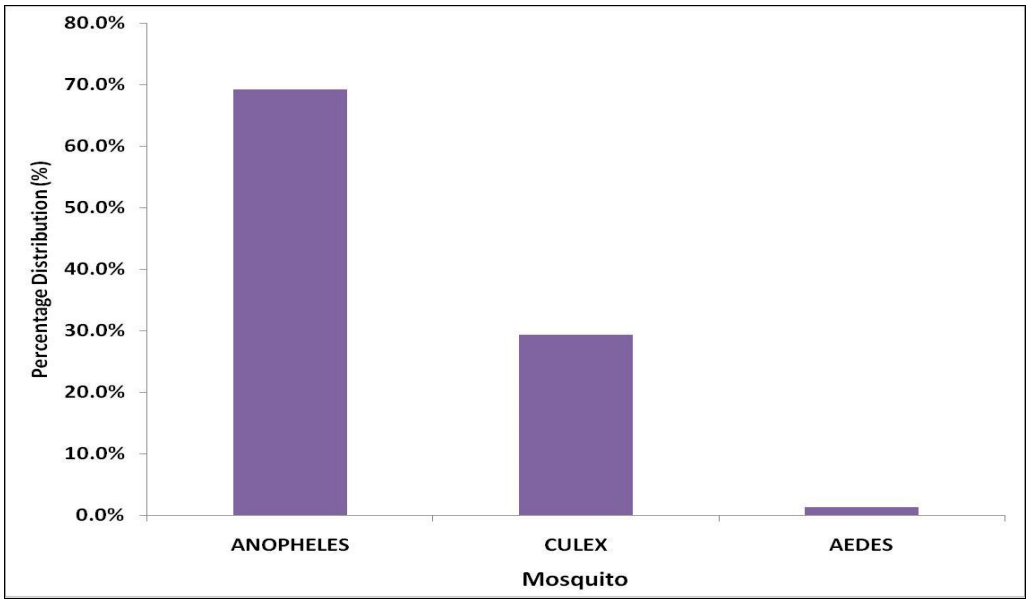

Fig 3: Percentage abundance of Mosquitoes genera sampled indoors in the 3 LGAs

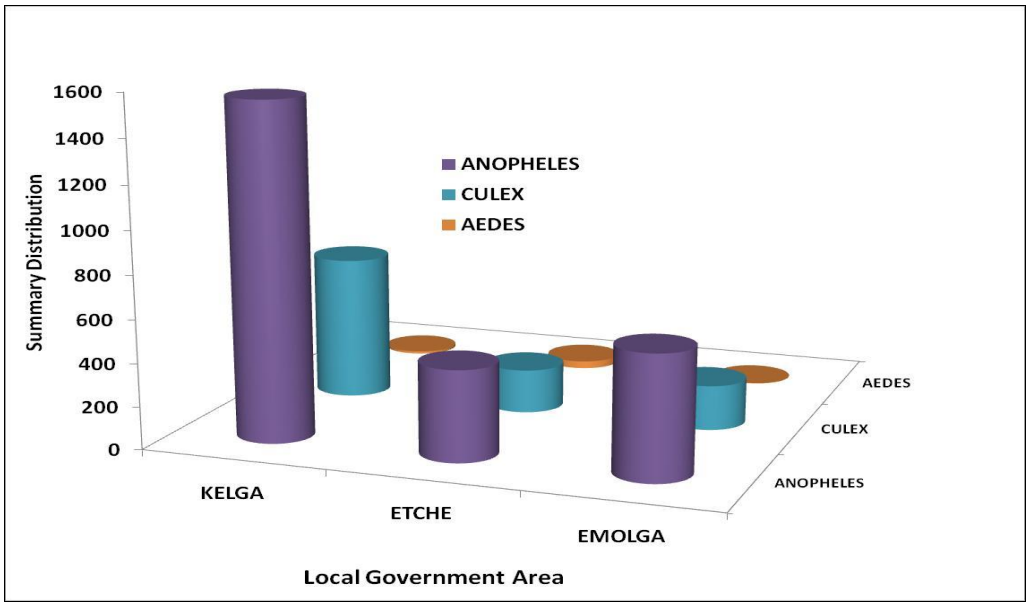

Fig 4: Summary of the distribution of the major mosquito genera in the LGAs

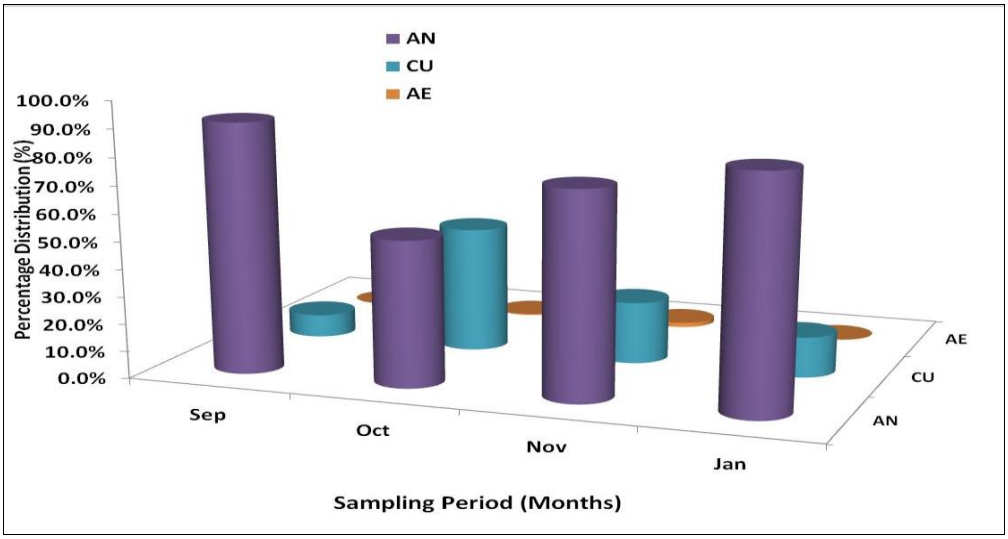

Fig 5: Monthly distribution of mosquitos' genera in Ikwerre LGA

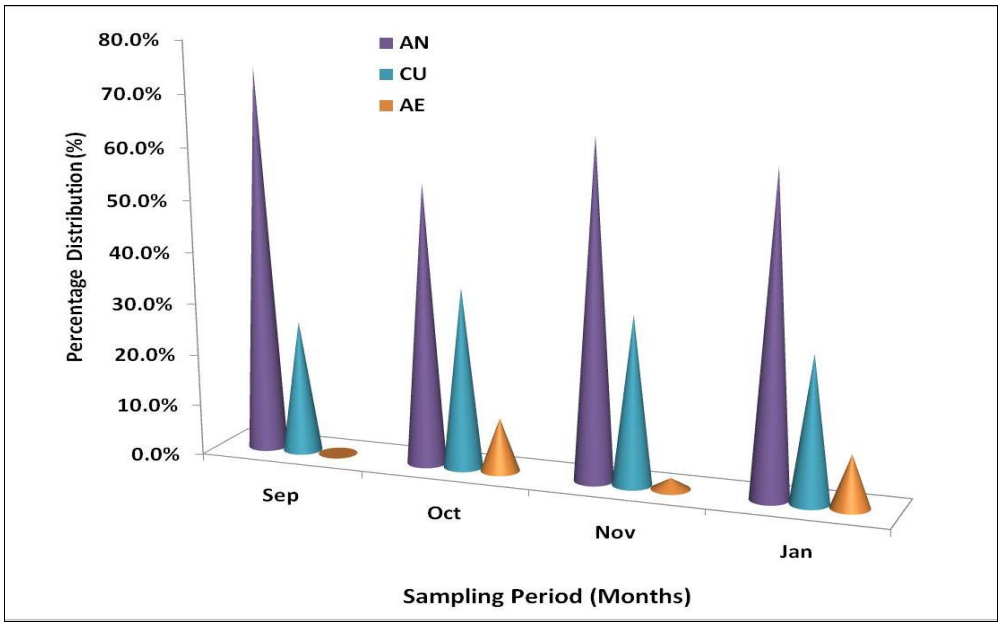

Fig 6: Monthly distribution of mosquitoes genera in Etche LGA

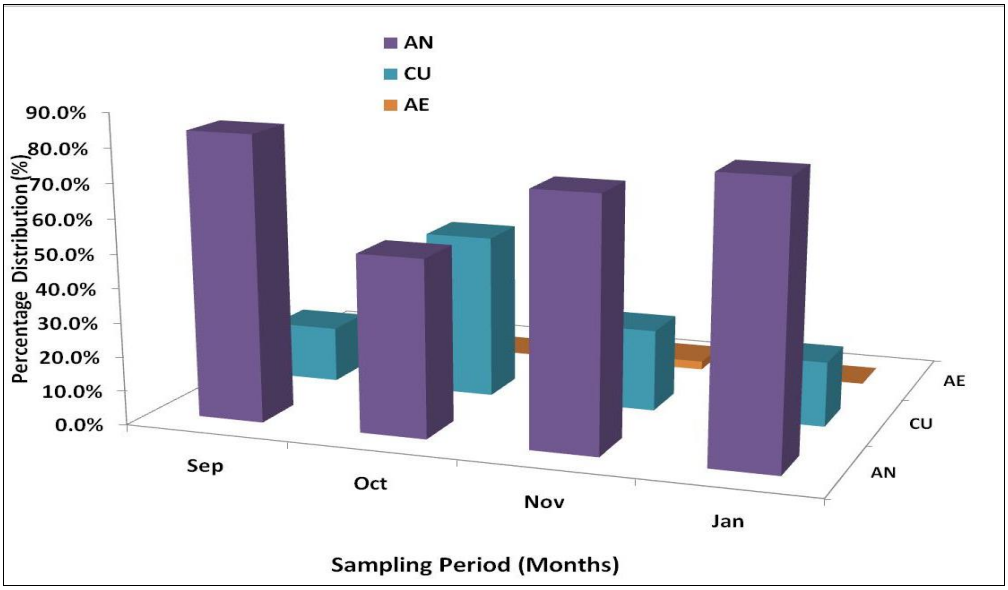

Fig 7: Monthly distribution of mosquitoes genera in Emohua LGA

Species composition and relative abundance

A total of 9 mosquitoes species belonging to 3 genera were sampled from the houses. These include 3 species of Anopheles; *Anopheles gambiae* complex (comprising of 2 sibling species; *An. gambiae sensu stricto* (s.s.) and *An. arabiensis*) *An. moucheti,* and *An. funestus* (fig 7); 4 Culicine species; *Culex quinquifasciatus*, *Culex annulioris, Conquillettidia azurites* and *Mansonia africana* (fig 9); and 2 of Aedes, *Aedes aegypti* and *Aedes albopictus*.

Anopheles gambiae complex, comprising *An. gambiae* s.s (73.89%) and *An. arabiensis* (25.89%) constituted about 99.8% of the entire anopheles collections. While *An. moucheti* and *An. funestus* only constituted about 0.12% (n=2) respectively of the anopheline population.

The distribution pattern revealed that the identified malaria vectors (*An. gambiae* complex) were present in all the LGAs except Etche LGA where one of the sibling species, *An. arabiensis* were absent at the time of sampling.

An. gambiae s.s. was more abundant in Etche than in the other 2 LGAs (fig 8). *An. moucheti* and *An. funestus* were absent in Ikwerre LGA while *An. funestus* and *An. moucheti* were found in Emohua and Etche respectively.

Among Culicines species sampled indoors, *Cx. quinquefasciatus*, constituted the most abundant species 88.16% (n=998), this was followed by *Mansonia africana* 6.54% (n=74), *Ae. aegypti* 3.62% (n=41), *Ae. albopictus* 0.62% (n=7). *Cx. annulioris* and *Conquellettidia azuirtes* were the least abundant and constituted only 0.53% (n=6) respectively (Fig 9).

The distribution pattern in the 3 LGAs shows that greater proportion of *Cx. quniquefascatus* occurs indoors in Ikwerre (634) than in Etche (193) and Emohua (171) respectively (fig 10). *Mansonia africana* and *Ae aegypti* occurred more in Ikwerre and Emohua LGAs.

Cx. annulioris were found only in Emohua while *Ae. albopictus* were found in Etche only.

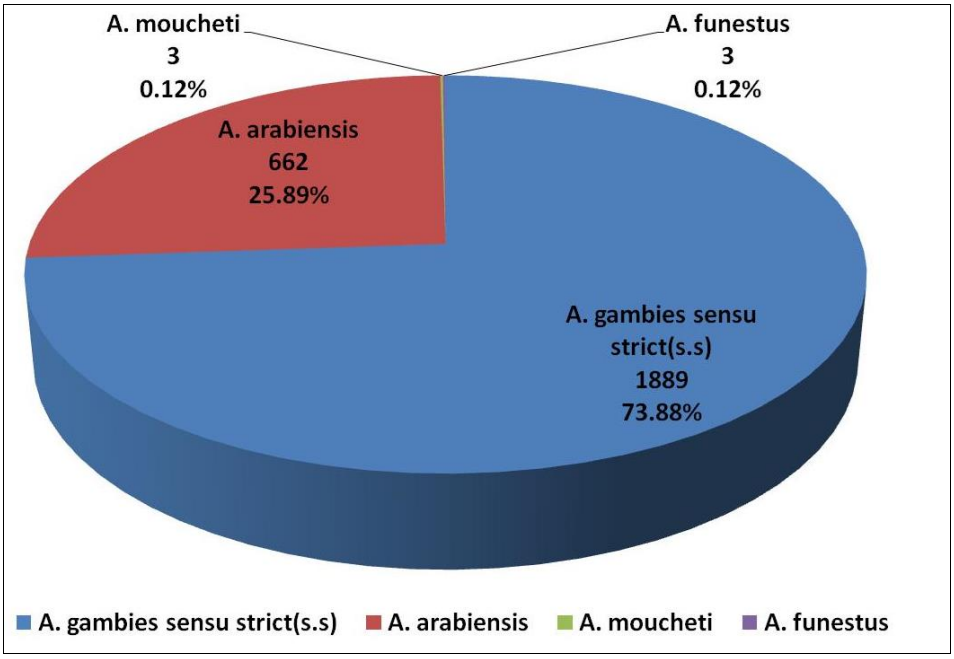

Fig 7: Anopheles Species Distribution in the 3 LGAs

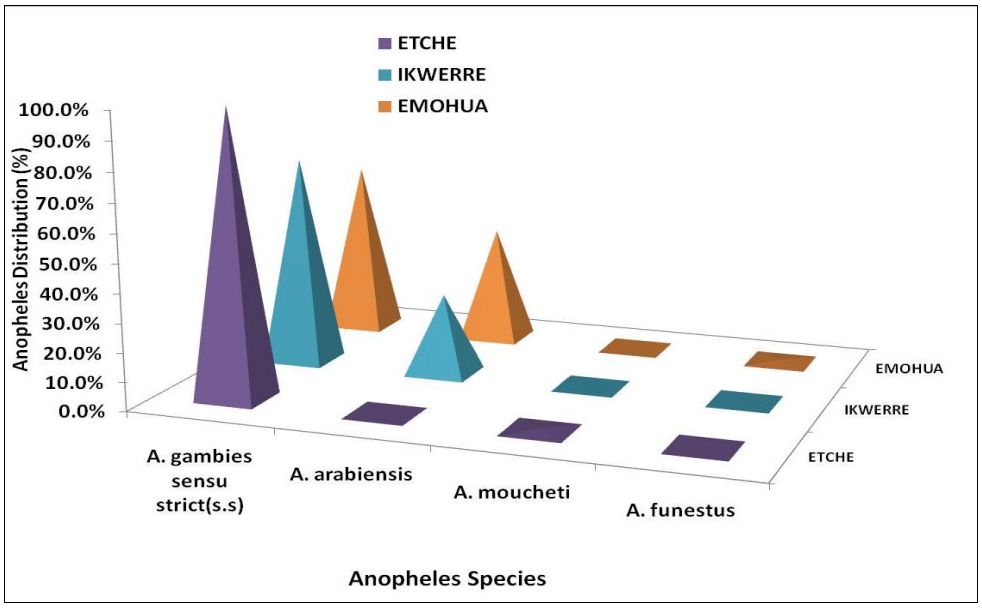

Fig 8: Anopheles species distribution in each of the Local Government Areas

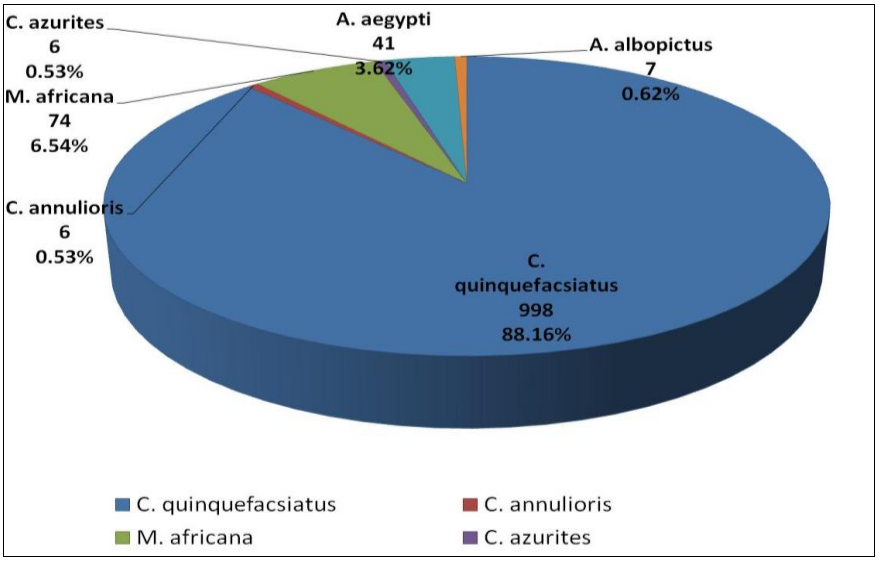

Fig 9 Culicine Species distribution in the sampled houses throughout the period of survey

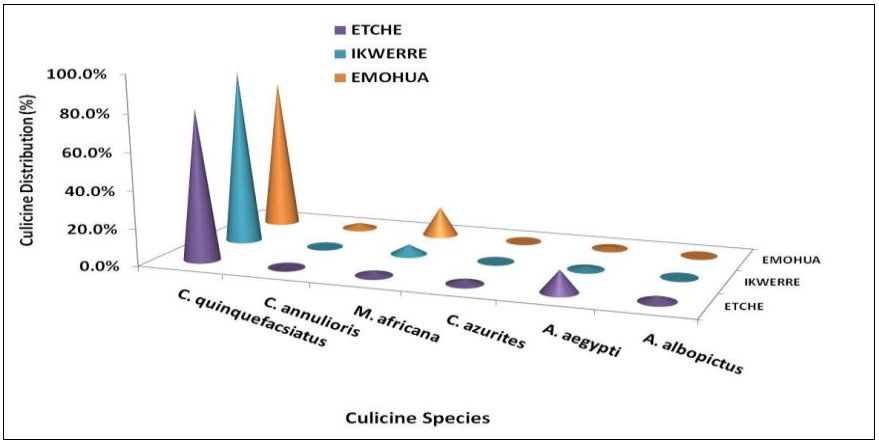

Fig 10: Culicine Species Distribution in the 3 LGAs

Indoor resting densities of anopheles mosquitoes

The indoor resting densities (IRD) of Anopheles mosquitoes in Ikwerre local government area ranged from 0.25 to 9.9 mosquito per room/night, Etche local government area, 0.03 to 2.77 mosquitoes/room per night, while in Emohua the density ranged from 0.0 to 3.41 mosquitoes per room/ night The mean indoor resting densities per room are represented in Fig 11. The mean indoor resting density in Ikwerre is higher than Etche and Emohua LGAs.

The monthly distribution of the mean mosquito densities (Fig 12) exhibits higher peaks in September and October which corresponds with wet season while the lower peaks recorded in November and January which coincided with dry season. The indoor resting densities per community in each of the LGAs are represented in Figs.12A and 12B. Data analysis revealed that the differences in the IRD among communities are significant.

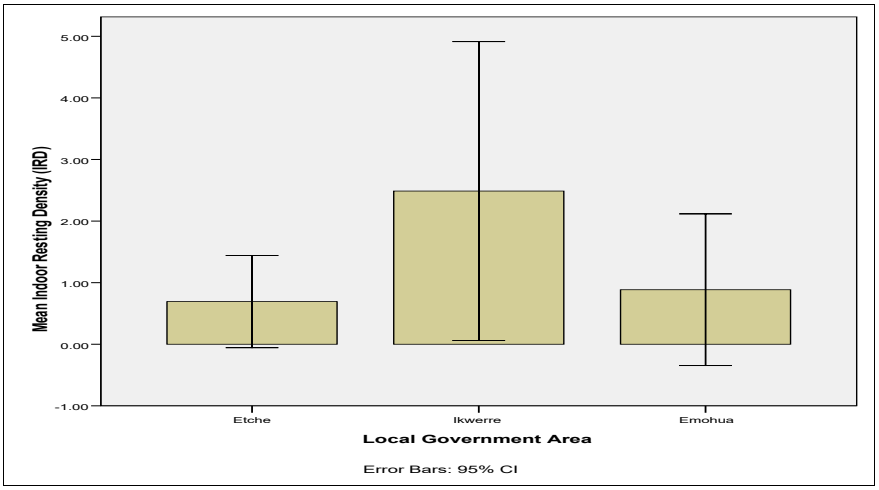

Fig 11a: Mean Indoor Resting Densities (IRD) of Anopheles Mosquitoes in the Three Local Government Areas

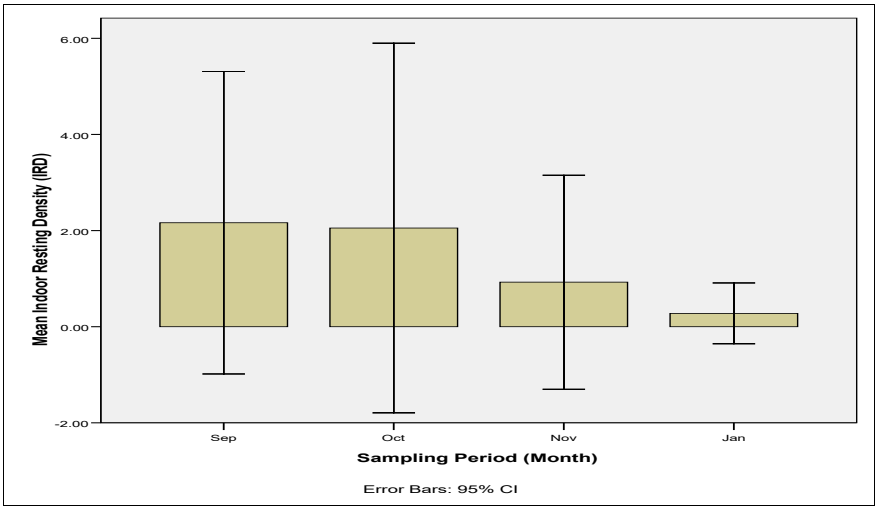

Fig 11b: Mean monthly Indoor Resting Densities (IRD) of Anopheles mosquitoes in the three local government areas

Larval density

A total of 1584.2 larvae density per 10 dips were collected from all the local government area under study. Of this number, 54% (859.0) of the larvae were collected in Ikwerre LGA, 32.92% (521.5) in Emohua while 12.86% (203.7) were collected from Etche LGA (Table 3). The monthly distribution pattern also revealed that the highest larvae density was observed in October. This was followed by November, the least density was revealed in January.

Larvae identification revealed that 3 genera of mosquito larvae were observed. Among these, Culex larvae were the most predominant and had over 90% occurrence among the larvae collected in each LGAs (fig 13). Anopheles mosquitoes constituted less than 8%. Aedes constituted less than 2% of the total larvae collected.

Monthly percentage distribution revealed high and near even distribution of the Culex species throughout the sampling period. Anopheles was mostly observed during the month of September and gradually reduced towards January (fig 14).

A total of nine species of mosquito larvae were observed (Table 4), these include *An. gambiae* 5.67% (n=898), *Cx. quinquefasciatus* 66.18% (n=10485), *Cx. annulioris*, 21.57% (n=3417), *Cx. tigripes* 5.79% (n=917), *E. chrysogaster,* 0.25% (n=40), *A. luteacephalus,* 0.03% (n=6).

Table 4: Distribution and Relative Abundance of Larval Species in Each Local Government Area between September, 2012 - January, 2013 [18].

No	Species	Local govt area			Total	Relative abundance
		ETCHE	IKWERRE	EMOHUA		
	Anopheles					
	Anopheles gambiae sl	155	604	139	898	5.67%
	Culex					
	Culex quinquefasciatus	987	7826	1672	10485	66.18%
	Culex annulioris	508	0	2909	3417	21.57%
	Culex tigripes	317	139	461	917	5.79%
	Eretmapodite chrysogaster	40	0	0	40	0.25%
	Aedes					
	Aedes luteocephalus	6	0	0	6	0.03%
	Aedes aegypti	3	21	34	58	0.37%
	Aedes albopictus	13	0	0	13	0.08%
	Aedes africanus	8	0	0	8	0.05%
	T0tal no. Of species	9	4	6	-	-
	Total no. Of individuals	2037	8590	5215	15842	100%

Discussion

The present study was carried out amongst other things to understand the species composition and the distribution pattern of the malaria vectors in Etche, Ikwerre and Emohua LGAs. The mosquitoe species recorded indoors in the present studies agrees with that of earlier studies in Nigeria and elsewhere (Okeke, 2024; Afolabi *et al*., 2019; Madara & Abdulraheem, 2014) [1, 11, 16] The anopheles species constituted about 69% of the total mosquito collected indoors. The indoor resting behavior of anopheles mosquitoes are well documented (Woyessa & Yewhalaw, 2024; Paaijmans and Thomas, 2011) [24, 29].

An. gambiae sensu stricto (s.s) and *An. arabiensis* (members of the *Anopheles gambiae* complex) were shown to be the main vectors for malaria within the geographical area. *An. gambiae* s.s. cuts across all the LGAs while *An. arabiensis* are localized in high densities in Ikwerre and Emohua LGAs and absent in Etche at the time of survey. The other two species *An. funestus* and *An. moucheti* were found to play relatively minor roles in malaria transmission in the area due to their low densities. Previous studies have also identified these species of Anopheles mosquitoes to be vectors of malaria (Ebere 2009, 2011; Maaji *et al*., 2024; Yokoly *et al*., 2021). Muriu *et al.* (2013) [8, 9, 15, 18, 30] also reported *An.*

gambiae s.s. as the most important vectors of malaria in Africa.

The malaria vector population was more in Ikwerre than in Etche and Emohua LGA probably because of the semi urban nature of the LGA as compared to the other two that are rural. Ikwerre LGA is close to the Port Harcourt metropolis and is characterized by polluted drainages, pot holes, domestic water containers and several other water receptacles that will encourage mosquito breeding. (Okogun *et al*., (2005); Oyewole and Ibidapo, 2017; Ladan & Tukur, 2023) [13, 21, 23] also observed that poor behavioural attitudes and sanitary conditions in Nigerian cities are responsible for the proliferations of mosquito breeding sites.

The observed ranges and mean values of indoor resting density of anopheles mosquitoes per room in the study areas are within the values reported elsewhere in Nigeria and are considered to be high. According to Lindblade *et al.*, 2000) [14], a density of 0.25 Anopheles per house is associated with epidermic.

The entomological variables investigated, i.e. mosquito abundance and densities varied significantly with the season. The density of mosquito was significantly ($P<0.05$) higher in the wet season (September and October) than in dry season (November and January). This finding agrees with those of earlier studies suggesting that mosquito densities and survival rates are influenced by changes in weather conditions. According to Tariq *et al.* (2025) and Bello *et al.* (2025) [5, 26], rainfall provides suitable breeding sites for anopheles mosquito survival and reproductive activities (Megersa & Luo, 2025) [17]. The survey also revealed aggregation of mosquitoes within zones or villages. This could be attributed to many ecological factors. According to experts, this heterogeneity in distribution may have important operational significant for the decision and implementation of control operations to target villages within zones where there is high distribution of mosquitoes.

The predominance of *Anopheles gambiae* complex (*An. gambiae* s.s. and *An. arabiensis*) among the species collected indicates that the local government areas are predisposed to malaria attack and calls for urgent vector control attention.

Larvae density study also revealed the presence of 9 species of mosquitoes. The highest densities occurred in Ikwerre, followed by Emohua LGA and the least was in Etche LGA. The predominance of larvae in Ikwerre can be due to the favourable breeding sites in the area as stated earlier. Etche LGA is quite dry and does not have much breeding habitats for mosquitoes. This also accounted for the low density among the indoor species.

Cx. quinquefasciatus was the most dominant in Ikwerre and Etche LGAs and highly distributed in Emohua LGA. *Cx. annulioris* was the most dominant in Emohua LGA and equally highly distributed in Etche LGA and absent in Ikwerre LGA. Other dominant species include *Cx. tigripes* and *An. gambiae.*

Aedes aegypti density was low but distributed in the three LGAs, *Eretmapodite chrystogaster, Ae. lutcocephalus, Ae. albopictus* and *Ae. africanus* were present in low densities in Etche local government area, but absent in Ikwerre and Emohua. The species composition of the mosquito encountered here was similar to those reported elsewhere in Nigeria (Okogun *et al.,* 2005; Olayemi and Ande, 2008) [21, 22].

The predominance of *Culex* species, especially *Cx. quinquefasciatus* over others could be due to the fact that the sampled breeding sites were mostly drainages which are contaminated by organic pollutants. *Cx. quinquefasciatus* preferentially breeds in organically rich water. Apart from this, *Culex* species are the most widely distributed species in the world (Al-Sarar *et al.*, 2011) [2].

The fact that both Anophelines and Culicines were found in the same habitats calls for larval control programmes targeting all the habitats in this area. This will ensure maximum reduction of mosquitoes in the area and the associated risks of mosquito borne diseases.

The presence of these larvae throughout the months of sampling suggests that mosquitoes breed all year-round in the area, with peak activities during the rainy season.

The serious health implication of the occurrence of the various species of mosquitoes encountered here is the possibility of out breaks and endemicity of diseases like malaria, yellow fever, dengue and filariasis (Bakri and Jadkarim, 2024; Alyasiri and Jassum, 2025) [3, 29]. This further calls for full alert of public health advisory teams to intensify efforts in the mosquito control campaign especially during the rainy season utilizing integrated vector management approaches.

Conclusions and recommendations

The findings suggest that the distribution, abundance and malaria transmission of different malaria vectors are driven by different environmental factors.

The overall mosquito species assemblage in these areas predisposes the inhabitants to the risk of infection of mosquito borne diseases. However, none of the mosquito borne diseases apart from malaria has been reported in the area despite the presence of these vectors.

Acknowledgement

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