American Journal of BioScience
2025, Vol. 13, No. 1, pp. 27-42
https://doi.org/10.11648/j.ajbio.20251301.14

Research Article

Spatial Distribution of Mosquito Vectors in Relation to Physico-chemical Properties of the Breeding Habitats in Ondo State, Nigeria; A Sign for Mosquito Borne Diseases

Adeyekun Akintayo Lanre[1, *], Oniya Mobolanle Oladipo[1, 2], Adeogun Adedapo Olufemi[3], Olusi Titus Adeniyi[1, 2], Akintayo-Adeyekun Wunmi[4]

[1]Department of Animal and Environmental Biology, Adekunle Ajasin University, Akungba Akoko, Nigeria
[2]Parasitology and Public Health Unit, Biology Department, Federal University of Technology, Akure, Nigeria
[3]Nigerian Institutes of Medical Research, Lagos, Nigeria
[4]Disease Surveillance Unit, Ondo State Primary Health Care Development Agency, Akure, Nigeria

Abstract

The abundance and distribution of identified mosquito genera in Ifedore Local Government Area of Ondo State, were studied. Mosquito species were sampled from 3sites per settlement using 200 ml plastic dippers (maximum of 10 dips per site) and collection containers. The habitats sampled included containers, stagnant pools, domestic run-offs, foot and vehicle prints, tyres, and gutters. The larvae and pupae collected were reared to adulthood and preserved in silica gels inside 1.5ml Eppendorf tubes and identified morphologically in accordance to standards after which Polymerase Chain Reaction protocol was conducted on all the *Anopheles* mosquitoes and 156 of the Culex mosquitoes. Larvae were taken from a total 33sites spreading uniformly across the 11 towns and villages making the Local Council to have various stages of larvae and pupae. 2051 immatures grew up to adulthood, after morphological identification 6 genera were recorded namely: *Anopheles gambiae* s.l was 348 (194 males and 154 females) (16.97%), Aedes 394 (248 males and 146 females) (19.11%), *Culex* was 1270 (740 males and 530 females) (61.97%), *Mansonia* was 7 (3 males and 9 females) (0.34%) *Toxorhynchite* was 20 (14 males and 8 females) (1.07%) and *Coquillettidia* was 12 (3 males and 9 females) 0.59%. The 1270 *Culex species* were further identified as *Culex pipiens* complex 1136 (89.45%) and *Culex tigripes* 134 (10.55%). After molecular analyses *Culex pipiens quinquefasciatus* were 154 (98.72%) while After PCR identification of all the 348 *Anopheles gambiae* s.l spoilt 8 (2.30%), *Anopheles arabiensis* 21 (6.05%), *Anopheles gambiae* s.s was 315 (90.52%), *Anopheles merus* 4 (1.15%) while the remaining were spoilt. This study concludes that the residents of the areas are at risk of mosquito-borne diseases most especially malaria whose vector is recorded specifically in the research. The results obtained of this study showed composition in mosquito species present at the study area. This research advocates proper environmental monitoring and source reduction of the breeding sites as the presence of these species also showed that this environment is predisposed to mosquito borne diseases.

Keywords

Mosquito, Abundance, Morphological, Breeding, Larvae, Pupae, Spatial Distribution, Diseases

[*]Corresponding author: akintayo.adeyekun@aaua.edu.ng (Adeyekun Akintayo Lanre)

Received: 10 January 2025; **Accepted:** 27 January 2025; **Published:** 27 February 2025

1. Introduction

Mosquitoes are small, midge-like flies of the family Culicidae, females of most species are haemophagous, whose tube-like mouthparts, proboscis, pierce the hosts' skin to consume blood [1]. Thousands of species feed on the blood of various kinds of hosts, mainly vertebrates, including mammals, birds, reptiles, amphibians, and even some kinds of fish uses an irritating rash that is a serious nuisance [2]. Much more serious though, are the roles of many species of mosquitoes as vectors of diseases, reported that in passing from host to host, some transmit extremely harmful infections such as malaria, yellow fever, west Nile virus, dengue fever, filariasis, and other arboviruses, rendering this dipterous insect family the deadliest animal family in the known world of diseases. Centre for Disease Control (CDC) reported approximately 3,700 species of mosquitoes grouped into 41 genera and that human malaria is transmitted only by females of the genus *Anopheles* which makes approximately 430 *Anopheles* species of which about 30-40 species are malaria vectors [3, 4].

In Nigeria, vector control strategy is focused mainly on measures targeted on adult mosquitoes including, the promotion of the use of insecticide-treated bed nets and indoor residual spraying [5, 6]. These tools have enormous potentials to reduce morbidity and mortality due to mosquito-transmitted diseases when applied properly [6], however, these control tools have their imperfections, such as insecticide resistance and difficulties in attaining adequate population coverage [7] 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 complement existingadulticidingmeasures, such as larval control measures are therefore required to build integrated mosquito-vector control programs where these diseases are prevalent [8, 9]. However, successful larval control requires a good knowledge of the breeding ecology of mosquitoes including, types of and preferences for larval habitats, spatial and temporal distribution of breeding sites, as well as, the physical, biological and chemical characteristics of the habitats [10-12]. Therefore, effective mosquito vector control, in areas of high disease burdens, must be predicated on a good understanding of the occurrence of specific important vector specie composition, their abundance, and hence, potential for disease transmission in the area.

2. Materials and Methods

2.1. Study Area

Ondo State is situated in the south western part of Nigeria with geographical coordinates of $5^0$45 ˈN, $4^0$20ˈE and $7^0$52ˈN, $6^0$05ˈE it is situated in the rainforest region of the Country with aboundant rainfall in at least 6 of the 12 months of the year. The State is bordered by Ekiti State in the north, Osun State by the west, Edo State at the eastern end, Ogun States State and the Atlantic Ocean in the southern area. Ifedore Local Government Area ($5^0$21 ˈN, 5^0 04ˈE,) is one of the eighteen (18) Local Government Areas in the state and it is largely a rural agrarian community with cocoa and kolanut being the main cash crops apart from lumbering, which also thrives in the state (Adeyekun et al 2021). Eleven (11) towns within the local government council were selected for the study viz: Owode-Owena (7.40413101 and 5.015839), Ibuji (7.4268265 and 5.0590556), Igbara-Oke (7.4029373 and 5.0571038), Isharun (7.3966387 and 5.0638127), Eroo Site (7.3991562 and 5.0639352). The administrative map of the area is presented on Figure 1.

2.2. Set-up of the Laboratory Insectary for Mosquito and Rearing

Before larval evacuation at each site, the geographical references were taken with Global Positioning System (GPS) by Garmin Subsequently, the pictures of the breeding sites were taken, immature stages of mosquitoes were collected using standard plastic dippers, collection containers (each specific for a site) and transported to the laboratory. The larvae were reared to adulthood in accordance to standards earlier established [10]. The emerging adults were preserved in 1.5ml Eppendorf tubes containing silica gel.

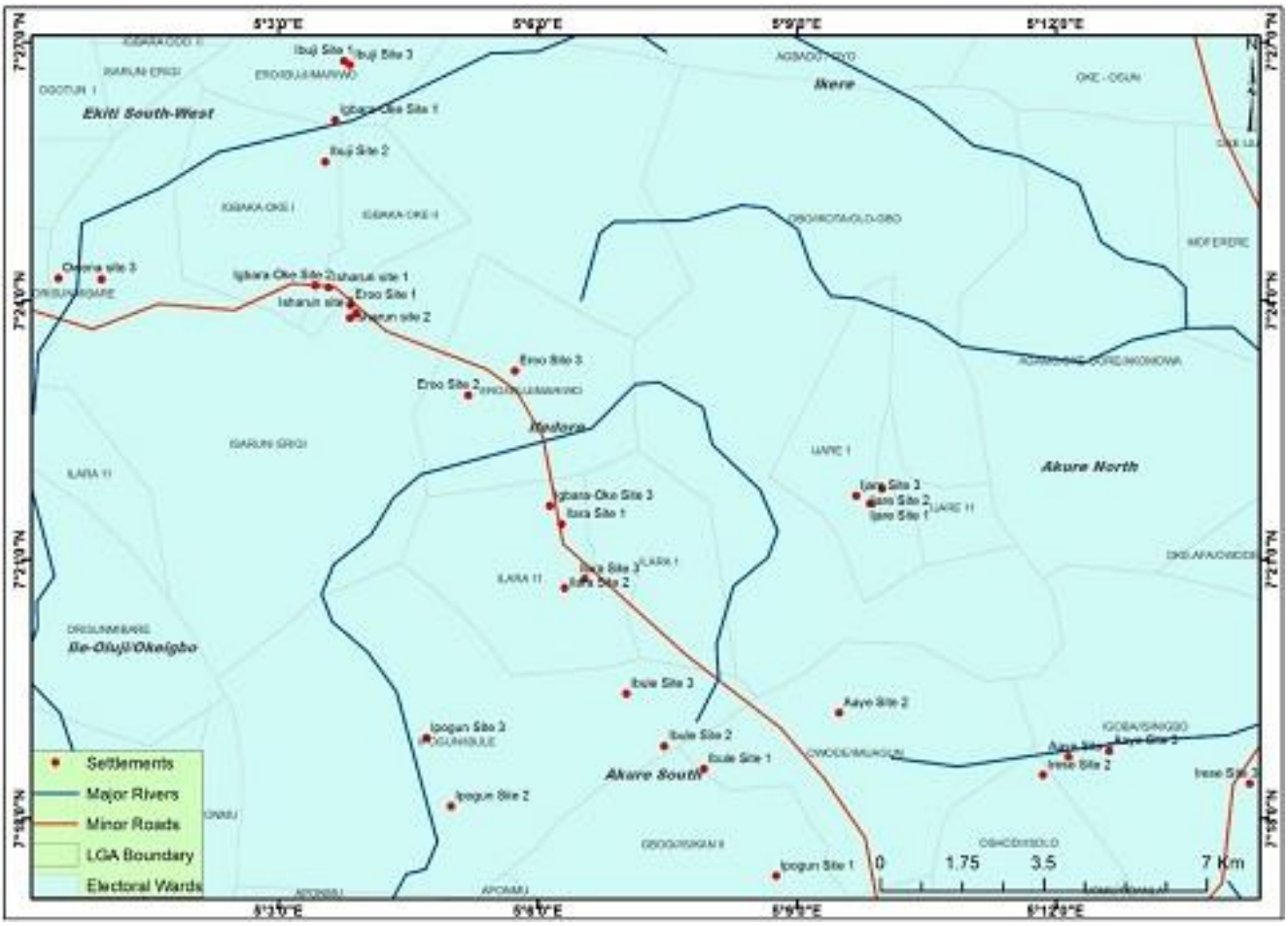
2.3. Mosquito Identification

All specimens were identified morphologically under the compound microscope using Standard keys as guies [13-15]. All morphologically identified *Anopheles* spp and 150 of the *Culex pipiens* were further identified molecularly, using Polymerase Chain Reaction (PCR) protocols in other to know the actual species. In accordance to standard procedure established by Scott and others [16]. GIS technology was used to develop a map showing the sites where the morphological identified species were located.

2.4. Statistical Analyses

Larvae Density, which is the total number of larvae in a particular habitat divided by total volume of water in 10 dips was calculated per site. Larvae Abundance which is the total number of larvae in a town divided by the number of positive sites in that same locality was also calculated. Means of physicochemical factors, physical factors and mosquitos species among different breeding sites were determined using one-way analysis of variance (ANOVA), and where there were significant differences, Tukey test at $p<0.05$ was used to

separate the means using statistical packages for social sciences (SPSS) 24.0 version. Correlation of physicochemical factors with the number of larvae was done using the Pearson's correlation coefficient test.



Note: ● Points of Mosquito Collection

Figure 1. *Administrative Map.*

3. Results

In the 33 positive breeding habitats of the 88 visited. a total of 2610 L1 to L4 larvae stages and 61 pupae making a total of 2711 immature were reared out of which a total of 2051 were morphological identified to the generic level out of 2104 that grew up to Adulthood.

6 Genera recorded in the Local Government Area from the whole study the total number of *Anopheles* was 348 (194 males and 154 females) (16.97%), *Aedes* 394 (248 males and 146 females) (19.11%), *Culex* was 1270 (740 males and 530 females) (61.97%), *Mansoni* was 7 (3 males and 9 females) (0.34%) *Toxorhynchite* was 20 (14 males and 8 females) (1.07%) and *Coquillettidia* was 12 (3 males and 9 females) 0.59%. The 1270 *Culex species* were further identified as *Culex pipiens* complex 1136 (89.45%) and *Culex tigripes* 134 (10.55%) this is shown on Figure 2 and Figure 3. Figure 4 is a Pie Chart showing the total distribution of all identified mosquitoes in the 6 Genera recorded in the Local Government Area.

Tables 1 and 2 show the percentage the distribution of the Genera in the sites and the percentage of each site in the totality of the genus in the whole Local Government Area. Figure 5 shows the administrative map, the Normalized Difference Vegetation Index (NDVI) showing the rural nature of the environment, Digital Elevation Model (the environment is a typical valley) is shown on Figure 6 (Light black spots are areas with low density of Anopheles larvae, Red spots are Areas with High Density of *Anopheles* larvae, the other spots are areas with no *Anopheles* larvae but other mosquito larvae). The pictures of the sites are shown on Figures 7-17.

Mean of Occurrence of Mosquito Larvae in the Sampled Settlements in Ifedore Local Government is recorded on Table 3. The result of the polymerase chain reaction on the all the anopheles gambiae s.l is shown on Table 4, 340 (97.70%) came out positive while 8 (2.30%) were spoilt and all the 148 *Culex pipiens* complex comes out positive to *Culex pipiens*

pipiens (98.72%) except 2 (1.38%) samples that were contaminated before analyses. A sample of the numerous gel electrophoresis for the culicines are presented on Figures 18 and 19.

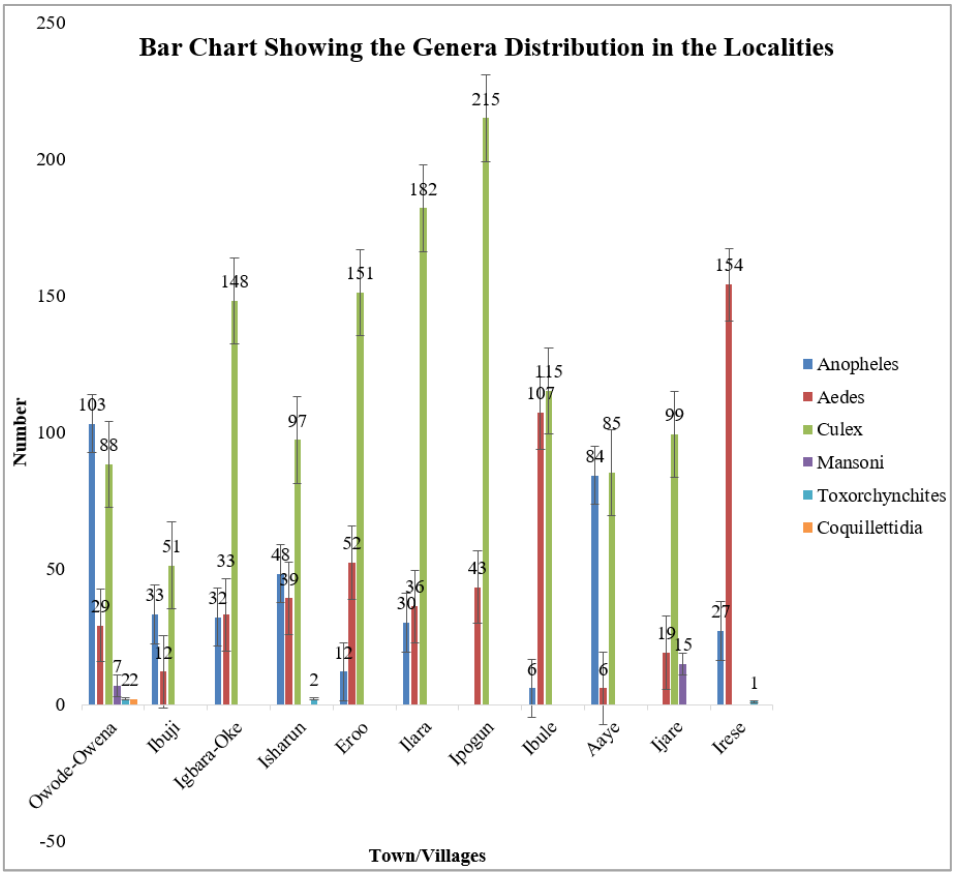


Figure 2. *Distribution of the Genera in the Localities.*

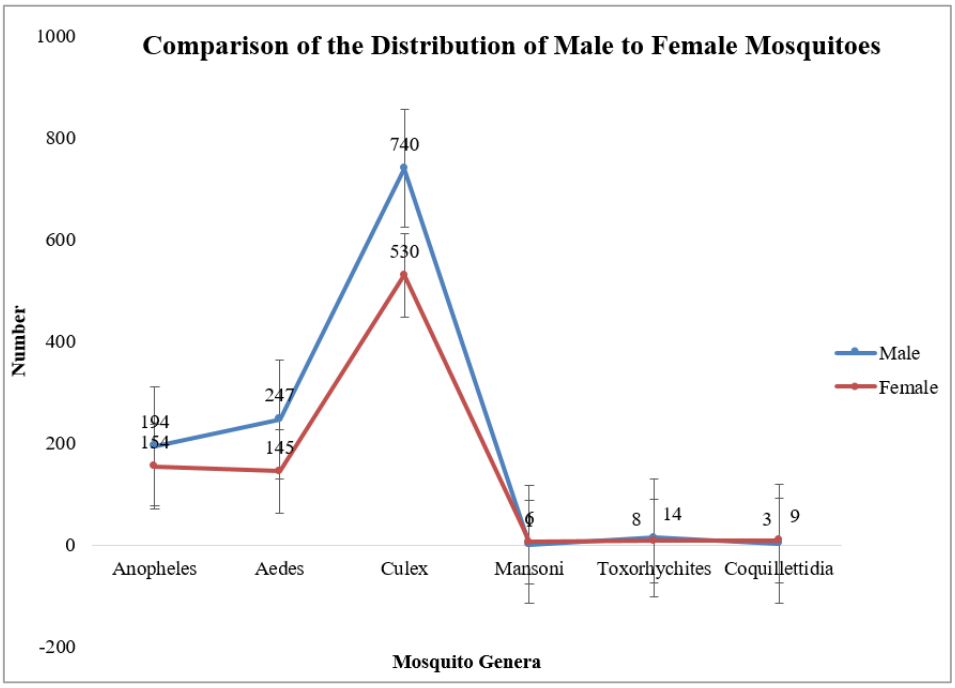


Figure 3. *Comparison of the Distribution of Male to Female Mosquitoes in the Study.*

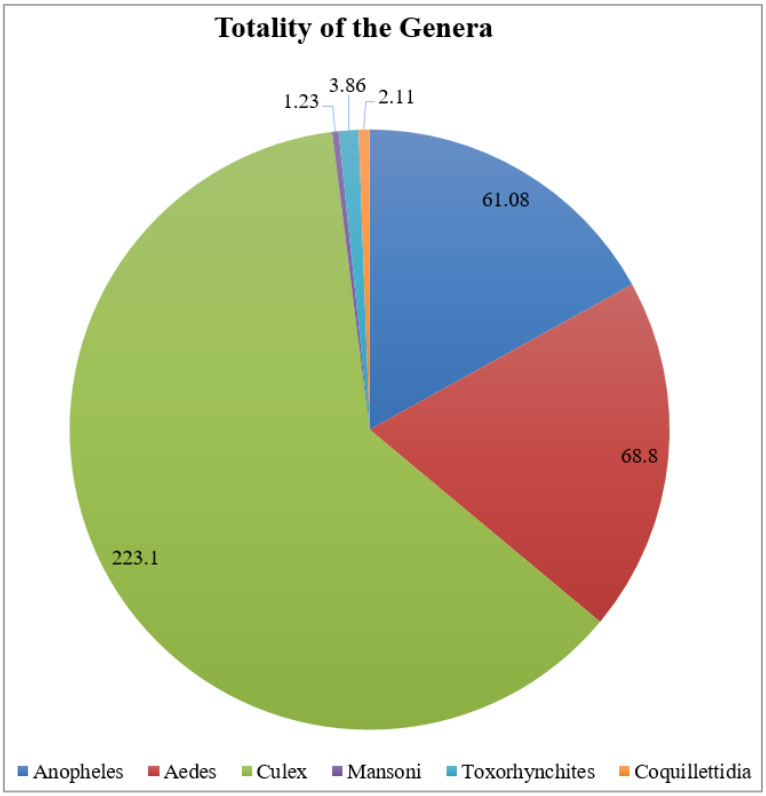
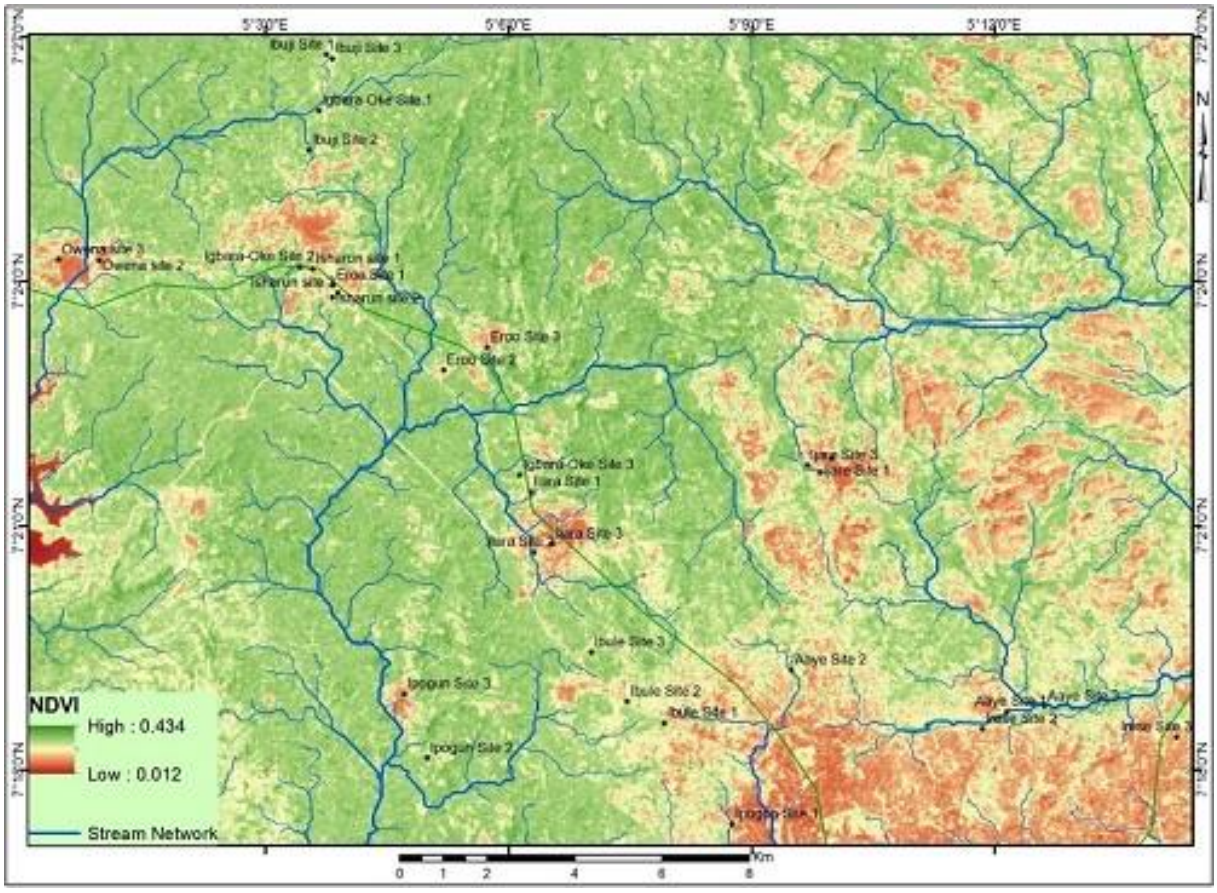


Figure 4. *Totality of all the Genera in the Study.*



Note: ● Points of Mosquito Collection

Figure 5. *Normalized Difference Vegetation Index (NDVI) with stream and Road networks.*

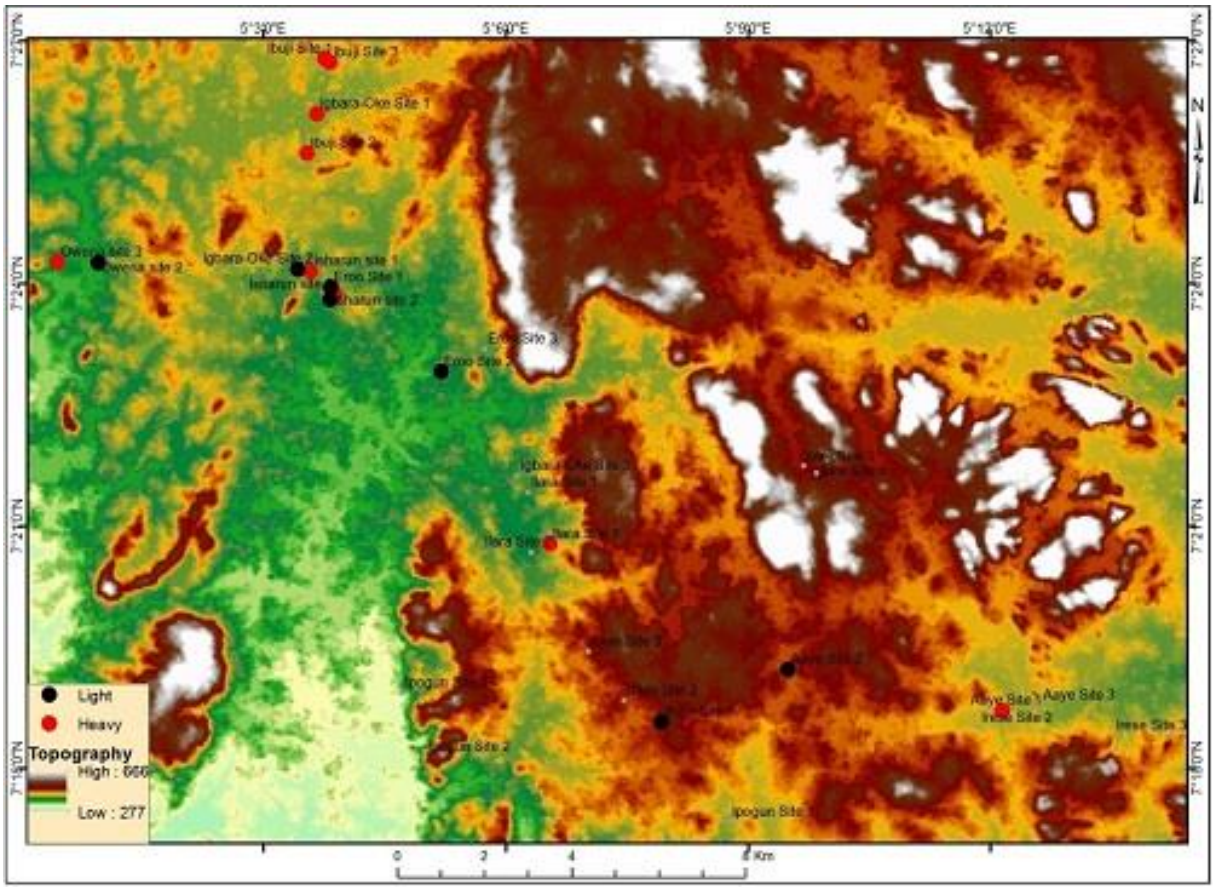


Figure 6. *Digital Elevation Model (DEM) of the terrain Surface Map.*

Note: ● are points with high *Anopheles gambiae* s.l.
● are points with low *Anopheles gambiae* s.l.
● are points with no *Anopheles gambiae* s.l. but presence of other mosquitoes

Figure 7. *Owena site (7.40413101 and 5.015839).*

Figure 8. *Ibuji Site (7.4268265 and 5.0590556).*

Figure 9. *Igbara-Oke Site (7.4029373 and 5.0571038).*

Figure 10. *Isharun Site (7.3966387 and 5.0638127).*

Figure 11. *Eroo Site (7.3991562 and 5.0639352).*

Figure 12. *Ilara Site (7.346225 and 5.1091159).*

Figure 13. *Ipogun Site (7.315477 and 5.078567).*

Figure 14. *Ibule Site (7.3139539 and 5.1244894).*

Figure 15. Aaye Site (7.3129921 and 5.21030121).

Figure 16. Ijare Site (7.3636545 and 5.1665048).

Figure 17. Irese Site (7.3118911 and 5.2024889).

Table 1. Number and Percentage of Each Genera Per Breeding Site.

TOWN/VILLAGE	SITE NO	Anopheles		Aedes		Culex	
		Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
Owode Owena	1	32 (20.13)	42 (26.42)	12 (7.55)	09 (5.66)	36 (22.64)	10 (6.29)
	2	02 (20)	02 (20)	-	-	02 (20)	01 (10)
	3	14 (18.42)	11 (14.47)	05 (6.58)	01 (7.14)	21 (27.63)	18 (12.79)
Ibuji	1	10 (27.03)	01 (2.70)	06 (16.22)	03 (8.12)	10 (27.03)	07 (18.92)
	2	09 (27.27)	04 (12.12)	-	-	06 (18.18)	14 (42.42)
	3	09 (32.14)	-	02 (7.14)	01 (3.57)	08 (28.57)	06 (21.43)
Igbara-Oke	1	19 (22.09)	09 (12.79)	17 (19.77)	10 (11.63)	14 (16.28)	11 (12.79)
	2	04 (66.67)	-	02 (33.33)	-	-	-
	3	-	-	03 (2.36)	01 (0.72)	114 (89.76)	09 (7.09)
Isharun	1	18 (33.96)	03 (5.66)	11 (20.75)	-	14 (25.00)	06 (11.32)
	2	07 (9.33)	02 (2.67)	18 (24.00)	06 (8.00)	18 (24.00)	24 (32.00)
	3	12 (22.64)	6 (11.32)	01 (18.87)	03 (5.66)	15 (28.30)	04 (7.55)
Ero	1	03 (3.37)	-	13 (14.61)	19 (21.35)	32 (35.96)	22 (26.97)
	2	02 (7.14)	07 (25.00)	-	01 (3.57)	06 (21.43)	12 (42.86)
	3	-	-	04 (4.12)	14 (14.43)	38 (39.16)	41 (42.27)
Ilara	1	-	-	11 (14.43)	02 (2.63)	39 (51.31)	41 (31.57)
	2	-	-	02 (4.44)	03 (6.67)	24 (86.67)	16 (53.00)
	3	16 (24.24)	14 (21.21)	06 (9.09)	03 (4.55)	17 (36.36)	10 (24.24)
Ipogun	1	-	-	05 (4.03)	03 (2.42)	80 (64.52)	35 (23.23)

TOWN/VILLAGE	SITE NO	Anopheles		Aedes		Culex	
		Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
	2	-	-	10 (8.93)	14 (12.50)	40 (35.71)	48 (42.86)
	3	-	-	02 (8.70)	09 (39.13)	06 (26.09)	06 (26.09)
	1	-	06 (30.00)	03 (15.00)	-	10 (50)	01 (5.00)
Ibule	2	-	-	-	-	26 (56.52)	20 (43.48)
	3	-	-	86 (83.49)	18 (16.51)	-	-
	1	31 (22.97)	43 (31.85)	-	03 (2.22)	37 (27.41)	32 (31.07)
Aaye	2	03 (18.75)	07 (43.75)	-	02 (12.05)	02 (12.05)	02 (12.05)
	3	-	-	-	01 (7.69)	04 (30.77)	08 (61.54)
	1	-	-	05 (8.93)	08 (14.27)	20 (35.71)	22 (39.29)
Ijare	2	-	-	01 (4.17)	01 (4.17)	09 (37.50)	09 (37.50)
	3	-	-	03 (5.77)	01 (1.92)	24 (46.15)	15 (28.85)
	1	-	-	18 (32.14)	06 (10.71)	08 (14.29)	23 (41.07)
Irese	2	-	-	01 (17.86)	02 (3.57)	18 (32.14)	25 (44.64)
	3	-	-	-	-	41 (51.25)	39 (48.75)

Table 1. *Continued.*

TOWN/VILLAGE	SITE NO	Mansoni		Toxorhynchites:		Coquillettidia	
		Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
	1	-	04 (2.55)	-	02 (1.26)	-	02 (1.36)
Owode Owena	2	01 (10)	02 (20)	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ibuji	2	-	-	-	-	-	-
	3	-	-	01 (3.58)	01 (3.58)	-	-
	1	-	-	-	-	-	-
Igbara-Oke	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Isharun	2	-	-	-	-	-	-
	3	-	-	02 (3.77)	-	-	-
	1	-	-	-	-	-	-
Ero	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ilara	2	-	-	-	-	-	-

TOWN/VILLAGE	SITE NO	Mansoni		Toxorhynchites:		Coquillettidia	
		Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ipogun	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ibule	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Aaye	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	01 (1.79)	-	-	-
Ijare	2	-	-	02 (8.33)	02 (8.33)	-	-
	3	-	-	07 (13.46)	03 (5.77)	-	-
	1	-	-	01 (1.79)	-	-	-
Irese	2	-	-	-	-	-	-
	3	-	-	-	-	-	-

Table 2. *Percentage of Each Genus Per Site to the Total Number of the Same Genus in the whole Study.*

TOWN/VILLAGE	SITE NO	Anopheles		Aedes		Culex	
		Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
	1	32 (16.50)	42 (29.22)	12 (4.86)	09 (6.20)	36 (4.87)	10 (1.87)
Owode Owena	2	02 (1.03)	02 (1.30)	-	-	02 (0.03)	01 (0.19)
	3	14 (17.22)	11 (7.14)	05 (2.02)	01 (0.69)	21 (2.84)	18 (3.40)
	1	10 (5.16)	01 (0.65)	06 (2.43)	03 (2.08)	10 (1.35)	07 (1.32)
Ibuji	2	09 (4.64)	04 (2.60)	-	-	06 (0.81)	14 (2.64)
	3	09 (4.64)	-	02 (0.81)	01 (0.69)	08 (1.08)	06 (1.13)
	1	19 (9.79)	09 (5.84)	17 (19.77)	10 (6.90)	14 (1.89)	11 (2.08)
Igbara-Oke	2	04 (2.06)	-	02 (0.81)	-	-	-
	3	-	-	03 (1.21)	01 (0.69)	114 (15.41)	09 (1.70)
	1	18 (9.28)	03 (1.95)	11 (4.45)	-	14 (1.89)	06 (1.13)
Isharun	2	07 (3.61)	02 (1.30)	18 (7.34)	06 (4.14)	18 (2.43)	24 (4.53)
	3	12 (6.19)	6 (3.90)	01 (0.40)	03 (2.08)	15 (2.03)	04 (0.76)
	1	03 (1.54)	-	13 (5.26)	19 (13.10)	32 (4.32)	22 (4.15)
Eroo	2	02 (1.03)	07 (1.30)	-	01 (0.69)	06 (0.81)	12 (2.26)
	3	-	-	04 (2.72)	14 (9.66)	38 (5.14)	41 (7.74)

TOWN/VILLAGE	SITE NO	Anopheles		Aedes		Culex	
		Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)
	1	-	-	11 (4.45)	02 (1.38)	39 (5.27)	41 (4.53)
Ilara	2	-	-	02 (2.02)	03 (2.08)	24 (3.24)	16 (3.02)
	3	16 (8.25)	14 (9.09)	06 (2.34)	03 (2.08)	17 (2.30)	10 (1.89)
	1	-	-	05 (2.02)	03 (2.08)	80 (10.81)	35 (6.60)
Ipogun	2	-	-	10 (4.05)	14 (9.66)	40 (0.05)	48 (9.06)
	3	-	-	02 (2.02)	09 (6.20)	06 (0.81)	06 (1.13)
	1	-	06 (3.90)	03 (1.21)	-	10 (1.35)	01 (0.19)
Ibule	2	-	-	-	-	26 (3.51)	20 (3.77)
	3	-	-	86 (34.82)	18 (0.12)	-	-
	1	31 (15.98)	43 (27.92)	-	03 (2.08)	37 (5.00)	32 (6.04)
Aaye	2	03 (1.54)	07 (4.55)	-	02 (1.38)	02 (0.03)	02 (0.38)
	3	-	-	-	01 (0.69)	04 (0.54)	08 (1.51)
	1	-	-	05 (2.02)	08 (5.52)	20 (2.70)	22 (4.15)
Ijare	2	-	-	01 (0.40)	01 (0.69)	09 (1.22)	09 (1.70)
	3	-	-	03 (1.12)	01 (0.69)	24 (3.24)	15 (2.83)
	1	-	-	18 (12.25)	06 (4.14)	08 (1.08)	23 (4.34)
Irese	2	-	-	01 (0.40)	02 (1.38)	18 (2.43)	25 (0.05)
	3	-	-	-	-	41 (5.54)	39 (7.36)

Table 2. *Continued.*

TOWN/VILLAGE	SITE NO	Mansoni		Toxorhynchites:		Coquillettidia	
		Male (%)	FeMale (%)	Male (%)	FeMale (%)	Male (%)	FeMale (%)
	1	-	04 (66.68)	-	02 ()	-	02 (100)
Owode Owena	2	01 (10)	02 (33.33)	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ibuji	2	-	-	-	-	-	-
	3	-	-	01 (7.14)	01 (12.50)	-	-
	1	-	-	-	-	-	-
Igbara-Oke	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Isharun	2	-	-	-	-	-	-
	3	-	-	02 (14.29)	-	-	-
Eroo	1	-	-	-	-	-	-

TOWN/VILLAGE	SITE NO	Mansoni		Toxorhynchites:		Coquillettidia	
		Male (%)	FeMale (%)	Male (%)	FeMale (%)	Male (%)	FeMale (%)
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ilara	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ipogun	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Ibule	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	-	-	-	-
Aaye	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	1	-	-	01 (7.14)	-	-	-
Ijare	2	-	-	02 (14.29)	02 (25.00)	-	-
	3	-	-	07 (50.00)	03 (37.50)	-	-
	1	-	-	01 (7.14)	-	-	-
Irese	2	-	-	-	-	-	-
	3	-	-	-	-	-	-

Table 3. *Mean of Occurrence of Mosquito Larvae in the Sampled Settlements in Ifedore Local Government.*

Settlements	*Anopheles gambiae* sl	*Aedes* sp	*Culex* sp	*Manxonia* sp	*Toxorhychites* sp	*Coquilletidia* sp
Owode Owena	34.33±20.74a	9.00±6.25a	29.33±13.32a	2.33±1.20b	0.67±0.67ab	0.67±0.67a
Ibuji	11.00±1.1a	4.00±2.65a	17.00±1.73a	0.00±0.00a	0.67±.67 ab	0.00±0.00a
Igbara-Oke	10.67±8.74a	11.00±8.02a	49.33±37.53a	. 0.00±0.00a	0.00±0.00a	0.00±0.00a
Isharun	16.00±3.61a	13.00±5.86a	27.00±7.51a	0.00±0.00a	0.67±0.67 ab	0.00±0.00a
Ero	4.00±2.65a	17.00±8.9a	63.67±7.75a	0.00±0.00a	0.00±0.00a	0.00±0.00a
Ilara	10.00±10.00a	9.00±2.31a	49.00±15.95a	0.00±0.00a	0.00±0.00a	0.00±0.00a
Ipogun	0.00±0.00a	14.33±4.9a	71.67±30.83a	0.00±0.00a	0.00±0.00a	0.00±0.00a
Ibule	2.00±2.00a	35.67±34.17a	19.00±13.87a	0.00±0.00a	0.00±0.00a	0.00±0.00a
Aaye	28.00±23.8a	2.00±0.58a	28.33±20.46a	. 0.00±0.00a	0.00±0.00a	0.00±0.00a
Ijare	0.00±0.00a	4.67±1.76a	32.33±7.17a	. 0.00±0.00a	5.00±2.65b	0.00±0.00a
Irese	0.00±0.00a	9.00±7.55a	51.33±14.74a	0.00±0.00a	0.33±0.00a	0.00±0.00a

Mean followed by the same letter along the column are not significantly different using ($p>0.05$) Tukey's Test.

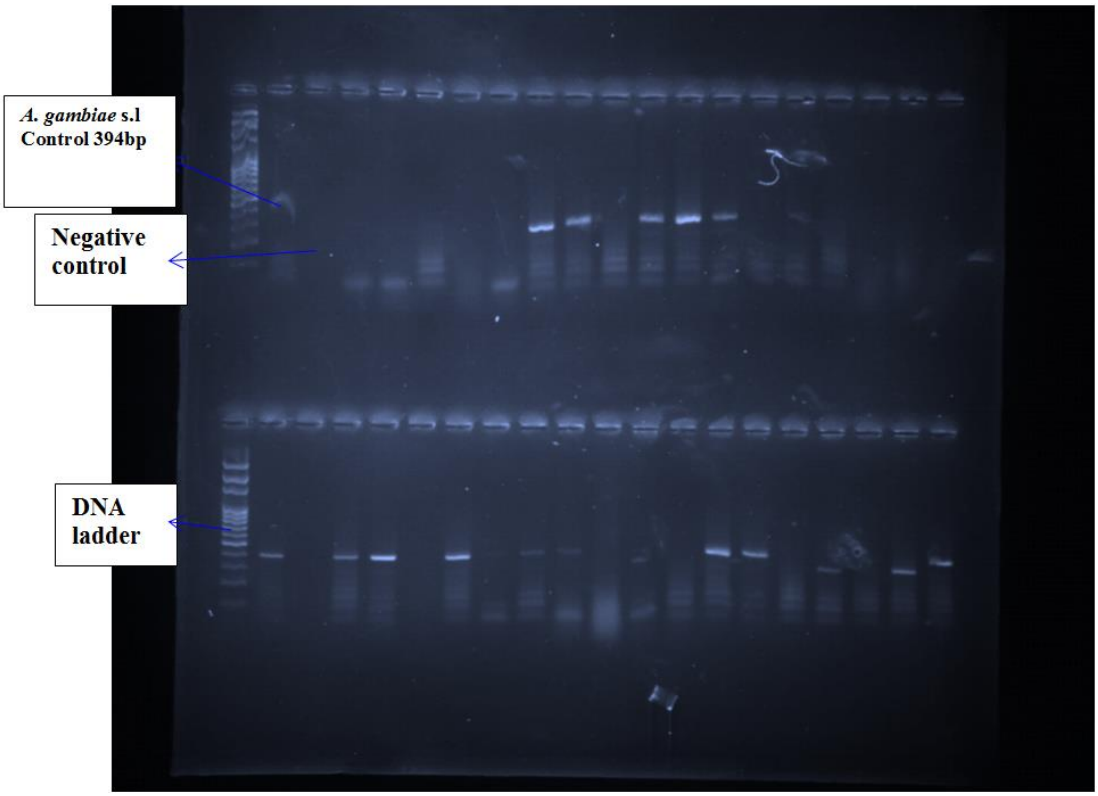


Figure 18. *A Gel of Anopheles gambiae s.l.*

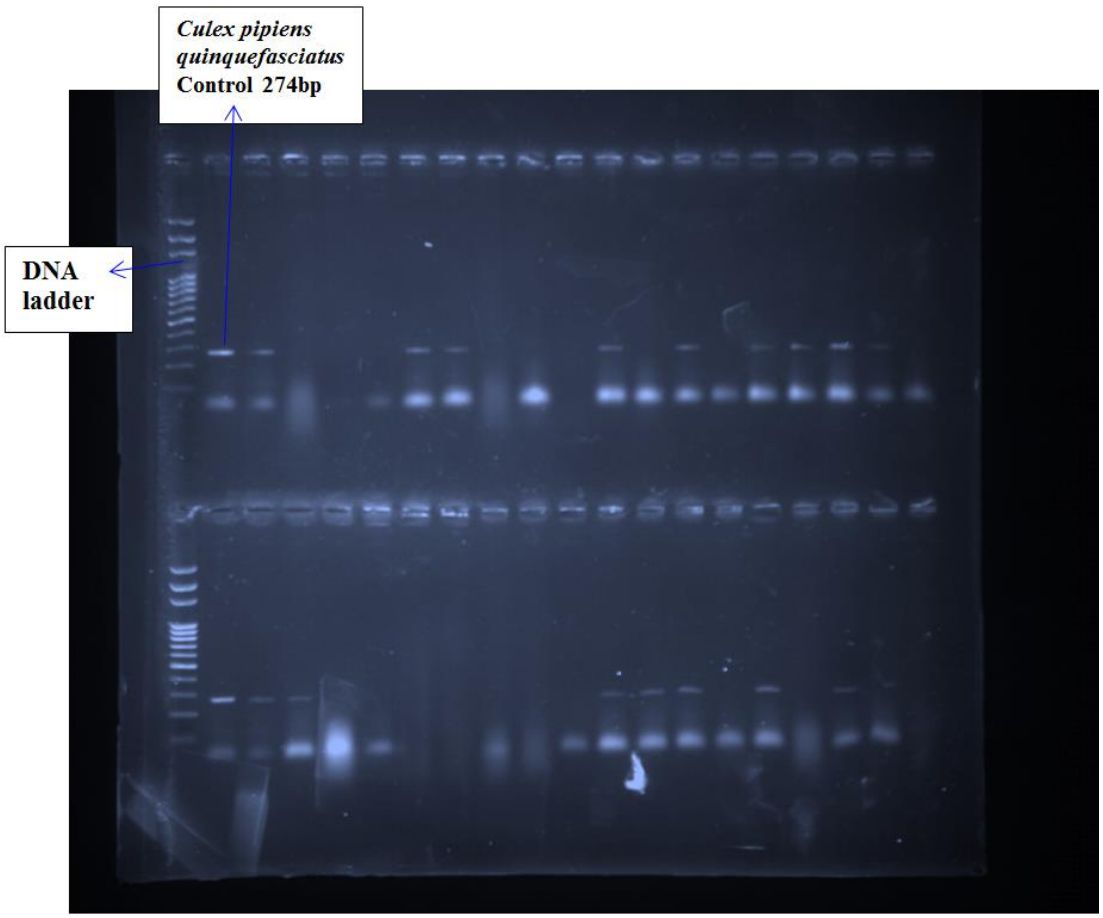


Figure 19. *Gel of Culex pipiens.*

Table 4. PCR analysis on the Distribution of Anopheles gambiae s.l in the Settlements.

Anopheles gambiae s.l	Location	Total (%)
Anopheles arabiensis	Owode Owena 1 (11), Owode Owena 3 (5), Isharun 1 (3), Isharun 3 (1), Aaye 2 (1)	21 (6.05)
Anopheles gambiae s.s	Owode Owena 1 (62), Owode Owena 2 (2), Igbaraoke 1 (28), Igbaraoke 2 (4), Ibuji 1 (11), Ibuji 2 (13), Ibuji 3 (9), Isharun 1 (18), Isharun 2 (9), Isharun 3 (17), Ero 1 (3), Ero 2 (9), Ilara 3 (30), Ibule 1 (6), Aaye 1 (71), Aaye 2 (1)	315 (90.52)
Anopheles merus	Owode Owena 1 (1), Aaye 1 (3)	4 (1.15)
Spoilt	Aaye 2 (8)	8 (2.30)
Total		348

4. Discussion

After the morphological identification of mosquitoes from the Local Government Area, 6 genera were identified with *Culex* with the highest number of individuals. Comparing the result with other morphologically identified works in the same geographical zones confirms that *Culex* is usually of the highest number in the local environments as reported by [9-12, 17]. the result is slightly different from the work of Idowu and others [18]. in the number of sexes because their females were more than the males and the result is totally different in genera abundance from the work of and Simon–Oke and Ayeni [20]. The genera reported in this have been reported by Researchers across the nation [17, 18, 20].

In this study Owode-Owena, Aaye, Igbara-oke, Isharun, Ilara and Aaye were the localities with Anopheles while the remaining 5 localities had other species. It is of note that Toxorhynchites whose larvae feeds on other mosquito larvae and adults don't feed on Animals and can act as biological control agents were found in Owode-Owena, Ibuji, Isharun,

After PCR identification of all the 348 *Anopheles gambiae* s.l total of 340 (97.70%) *Anopheles arabiensis* was 21 (6.05%), *Anopheles gambiae* s.s was 315 (90.52%), *Anopheles merus* was 4 (1.15%) these two sisiter species are major malaria vectors in tropical Africa, hence predisposes the environment to malaria infection [5, 6], the presence of *Anopheles merus* in these localities equally exposes the population to dangers of filariasis as they are noted vectors of the causative nematode [6, 8]. The record of *Anopheles gambiae* s.s as the dominant species in this study corroborates repots of earlier researchers in parts of Nigeria, a region that shares the same ecological characteristics as the study areas in this research [12, 21-24]. In a study by Nikookar and others [24-26], across Mazandaran Province, *Culex pipiens* was the dominant species as also in this study. After selective molecular analyses *Culex pipiens quinquefasciatus* were 154 (98.72%) making it the major species of the *Culex pipiens* Complex examined which corroborate an earlier report [27].

Mean of the mosquito species per location at a significance level (0.05) (Table 3) showed there was no significance difference in the number of mosquito species at each site except for *Toxorhychites* species at Owode-Owena, Ibuji, Igbara-Oke and Isharun which were not significantly different from each other but different from others, and Ijare that were significantly different from others.

In this research mosquito breeding was predominantly in pools (formed by rain), ponds, cemented reservoirs and They were also found in numerous water bodies created by rain in addition to breeding in small water storage containers utilized by people for household chores Tyres, creating abundant temporary but adequate breeding sites for these culicines herby enhancing the spread of mosquito borne diseases easily. In all the sampled towns/settlements, the water supply system was erratic and this explains the use of numerous water storage containers to provide water for domestic chores, Vulcanising, car wash, block making and other purposes. These turned out to be conducive breeding sites for mosquitoes within and near human habitations. preponderance of mosquito breeding sites, which may be linked to the abundance of rainfall and vegetation in the Local Government Area. This may explain why *Anopheles* mosquitoes were highly prolific and thus highly abundant.

Numerous *Anopheles* breeding sites (Owode-Owena, Ibuji, Isharun, Ilara, Eero and Aaye) making 17 out of 33 sites (51.52%) were found exposed to direct sunlight and turbid during the current study; this is consistent with earlier findings [28, 29]. there was predation and more algae which served as food for larvae. Consequently, the presence of *Anopheles* species in turbid and polluted water is an indication that good physical qualities of a water body may not play a role in their proliferation.

5. Conclusion

This study concludes that the residents of the areas are at risk of mosquito-borne diseases. The results obtained of this study showed composition in mosquito species present at the study area. *Culex* species usually breed profusely in polluted gutters, blocked drains and other water retention habitats with

organic matter unlike *Anopheles* mosquitoes which prefer clean ground pools and man-made containers respectively. The presence of these species also showed that this environment is predisposed to mosquito borne diseases.

Abbreviations

PCR	Polymerase Chain Reaction
NDVI	The Normalized Difference Vegetation Index
SPSS	Statistical Packages for Social Sciences
ANOVA	One-way Analysis of Variance
GPS	Global Positioning System

Acknowledgments

Master Sunday Ogunleye and Mr. Timilehin Oluwateru who helped on the field, staffs of Entomological and Parasitological Laboratory of the Nigeria Institute of Medical Research.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] WHO (2023). Malaria report. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2023# *Retrieved 2024-11-12.*

[2] WHO (2024). Vector Borne Diseases. https://www.who.int/newsroom/fact-sheet/details/vector-borne-diseases *Retrieved 2025-01-24.*

[3] CDC (2024a). http://www.cdc.gov/mosquitoes/about/index.html Retrieved 2025-01-25.

[4] CDC (2024b). http://www.cdc.gov/malaria/index.html Retrieved 2025-01-25.

[5] Adeogun, A., Babalola, S. S., and Salako, B. (2023). Spatial distribution and ecological niche spread of Anopheles gambiae. *Scientific Reports, 13, 1–18.* https://doi.org/10.1038/s41598-023-40929-5 Retrieved 2024-11-11.

[6] FMOH. (2025). National Malaria Elimination Programnme (NMEP). https://www.health.gov.ng/source/35/NMEP *Retrieved 2025-01-24.*

[7] Ifeoluwa, K. F., Emmanuel T. I and Taiwo, S., (2020). First report of AChE1 mutation and multiple resistance mechanisms in *Anopheles gambiae s.s* in Nigeria. *Scientific Reports*, 10, 1-9. https://doi.org/10.1038/s41598-020-64412-7

[8] Bartilol, B., Omedo, I. and Mbogo, C. (2021) Binomics and ecology of *Anopheles merus* along East and Southern Africa Coast. *Parasites Vectors* 14(84): 2021. https://doi.org/10.1186/s13071-021-04582-z

[9] Adeyekun A. L., Obimakinde, E. T., Taiwo, E. A., Robiu, S. O., Akinrinlola, O. C., Yekinni, N. B., Salawudeen, N. B. and Oniya, M. O. (2022) Mapping of Malaria Risk Areas in Akoko South West Local Government Area, Ondo State, Nigeria. *Futa journal of life sciences.* 2(1): 1-11. https://journals.futa.edu.ng/home/volume/82/18

[10] Oniya, M. O. Adeyekun, A. L. and Olusi T. A (2019). Ecological factors favouring mosquito breeding in Ifedore local government area of Ondo State, Nigeria. *Journal Of Ecology And The Natural Environment* 11(6): 68-74, https://10.5897/JENE2019.0756

[11] Adeyekun, A. L., Oniya, M. O., Olusi, T. A. and Adeogun, A. O. (2021). Molecular Identification of the Members of *Anopheles Gambiae S. L.* and *Culex* Species in Ifedore Local Government Area of Ondo State. *BioMed Research Journal*, 5(1): 354-359. https://www.scitcentral.com.article/43/2215/molecular-identificati-on-of-the-members-of-anopheles-gambiae-s.l.-and-culex-species-in-ifedore-local-government-area-of-ondo-state

[12] Gbaye, O. A., Afolabi, O. J., Simon-Oke, I. A. and Lasisi, A. O. (2017) Abundance and spatial distribution of mosquitoes acrossthree ecological zones of Ondo State Nigeria. *International Journal of Mosquito Research 4(5): 23-27.*

[13] Gillett JD (1972) Common Africa Mosquitoes and their-Medical Importance with 48 color.

[14] Gillies MT, Coetzee M (1987) A supplement to the*Anopheline* of Africa south of the Sahara (Afrotropicalregion). Publication of South African Institute forMedical Research, Johannesburg. 55: 1-143.

[15] World Health Organization (WHO) (2013) MalariaEntomology and Vector Control. Retrieve: May 22, 2017. Available online at: https://apps.who.int/iris/bitstream/handle/10665/85890/9789241505819_eng.pdf%3Bjsessionid%3D499D39C26B9EE5E5E260FF9D10DD6492%3Fsequence%3D1

[16] Scott, J. A, Brogdon, W. G and Collins, F. H. (1993). Identification of single specimens of the Anopheles gambiae complex by polymerase chain reaction. *The American Journal of Tropical Medicine and Hygiene* 49: 520–529.

[17] Adeyekun A. L. (2021) Flora And Fauna Of Mosquito Breeding Sites In Akoko South West Local Government Area, Ondo State, Nigeria. *Tropical Freshwater Biology, 30(2021) 35-44.* https://dx.doi.org/10.4314/tfb.v30i1.3

[18] Idowu, O. A., Adelabu, M. M. and Babalola, A. S. (2015) Impact of Road Construction on Malaria Abundance in Abeokuta Metropolis. *Nigeria Journal of Parasitology* 36(1). https://doi.org/10.4314/NJPAR.V3611

[19] Simon –Oke, I. A. and Ayeni, F. E. (2015) Relative Abundance and Composition of Endophilic Mosquitoes in Federal University of Technology Akure Hostels, Ondo State, Nigeria. *American Journal of Research Communicatio*n. 3(11): 140-148.

[20] Olorunniyi, O. F. (2016). Abundance and Diversity of Mosquito Genera at Ilokun and Irasa Communities, Ado-Ekiti, Nigeria. Journal of Biological. Innovations. 5(3): 379-385.

[21] Obi O. A., Nock I. H., Adebote D. A., and Nwosu L. C. (2016). Ecological and molecular observations on Anopheles species (Diptera: Culicidae) breeding in rock pools on inselbergs within Kaduna State, Nigeria. *Molecular Entomology.* 8(01): 1-10. http://biopublisher.ca/index.php/me/article/html/2547/

[22] Emidi, B., Kisinza, W. N., Mmbando, B. P. and Mosha, F. W. (2017). Effect of physicochemical parameters on Anopheles and Culex mosquito larvae abundance in different breeding sites in a rural tting of Muheza, Tanzania. (2017) https://www.researchgate.net/publication/317847438

[23] Oyewole, I. O., Ibidapo, C. A., Okwa, O. O., Oduola, A. O., Adeoye, G. O., Okoh H. I. and Awolola T. S. (2010). Species Composition and Role of Anopheles mosquitoes in Malaria Transmission Along Badagry Axis of Lagos Lagoon, Lagos, Nigeria *International Journal of Insect Science* 2010(2): 51-57. http://www.la-press.com.

[24] Nikookar, S. H., Moosa-Kazemi, S. H., Yaghoobi-Ershadi, M. R., Vatandoost, H., Oshaghi, M. A. and Ataei, A. (2015) Fauna and Larval Habitat Characteristics of mosquitoes in Neka County, Northern Iran. *Journal of Arthropod Borne Diseases.* 9: 253-266.

[25] Nikookar, S. H., Fazeli-Dinan, M., Azari- Hamidian, S., Mousavinasab. S. N., Aarabi, M and Ziapour, S. P. (2017) Correlation between mosquito larval density and their habitat physicochemical characteristics in Mazandaran Province, northern Iran. *PLoS Neglected Tropical Diseases* 11(8): e0005835. https://doi.org/10.1371/journal.pntd.0005835

[26] Nikookar, S. H, Azari-Hamidian, S., Fazeli-Dinan, M., Nasab, S. N. M., Aarabi, M. and Ziapour, S. P. (2017) Species composition, co-occurrence, association and affinity indices of mosquito larvae (Diptera: Culicidae) in Mazandaran Province, northern Iran. *Bull of Entomological Research*, 107(5): 598-610. https://doi.org/10.1017/s0007485317000074

[27] Yayock, H. C., Ndams, I. S., Kogi, E., Ahmed A. B. & Vagime, C. G. (2014). Distribution of mosquito species in Kaduna metropolis, Kaduna State, Northern Nigeria. *Nigerian Journal of Entomology.* Vol. 31. https://doi.org/36108/NJE/5102/13.0132

[28] Mutuku, M. F., Alaii, J. A., Bayoh, M. N. Gimning, J. E., Volule, J. M., Walker, E. D., Karibu and Hawley, W. A. (2005). Distribution, description and local knowledge of larval habitats of An. gambiae s.l. in a village in western Kenya. *American Journal of Medicine and Tropical Hygiene,* 74: 44-53

[29] Umar, A. M. (2009). Characterisation of Anopheles mosquitoes Breeding Sites and Retrospective Study of Malaria in Katsina State, Nigeria. PhD/Sci./ 01581/ 2008-09 Department of Biological Sciences, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria.