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SPATIAL AND TEMPORAL DISTRIBUTION OF *Culex*, *Aedes* AND *Anopheles* MOSQUITOES IN EGBEDA LGA, NIGERIA

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ABSTRACT

Locally resolved mosquito entomological baselines remain scarce in peri-urban southwestern Nigeria. This study quantified mosquito vector diversity, seasonal dynamics and the spatial signature of land use across eleven communities of Egbeda Local Government Area (LGA), Oyo State, over twelve months (May 2024 to April 2025). Larvae were sampled monthly using the standard dipping technique and reared to adulthood for morphological identification using the Afrotropical *Anopheles* key of Coetzee (2020) and the Walter Reed Biosystematics Unit culicine keys. A total of 6,135 adult mosquitoes were recovered, comprising five operational taxonomic units in three genera: *Culex quinquefasciatus* (39.10%), the *Culex pipiens* complex sensu lato (9.85%), *Anopheles gambiae* sensu lato (23.94%), *Aedes aegypti* (22.54%) and *Aedes albopictus* (4.56%). Sibling species within the *An. gambiae* and *Cx. pipiens* complexes are reported at complex level pending molecular confirmation. Diversity was moderate (Shannon-Wiener $H' = 1.414$; Pielou's $J' = 0.879$) and deviated from evenness ($\chi^2 = 2{,}234.25$; df = 4; $p < 0.001$). Species composition differed across sites ($\chi^2 = 168.4$; df = 40; $p < 0.001$), with peri-urban communities supporting higher *Culex* and *Aedes* abundances and rural communities relatively higher *Anopheles* catches. Negative binomial regression identified August as the seasonal peak (1,208 individuals). Females accounted for 68.2% of the catch. Co-occurrence of competent vectors of malaria, lymphatic filariasis and *Aedes*-borne arboviruses indicates exposure to multiple disease risks. The findings establish a community-level entomological baseline and motivate season-aware integrated vector management, with molecular resolution and pathogen screening as priority next steps.

Keywords: Mosquito Diversity; Vector-Borne Diseases; *Culex pipiens* Complex; *Anopheles gambiae* Sensu Lato; Peri-Urban; Egbeda; Nigeria

INTRODUCTION

Mosquitoes (Diptera: Culicidae) remain the most medically important arthropod vectors of human disease, transmitting the pathogens responsible for malaria, lymphatic filariasis, dengue, yellow fever, Zika and chikungunya (Datta Mudi *et al.*, 2024; Shekhar and Illendula, 2022). Globally, the World Health Organization (2024) estimated 263 million malaria cases and 597,000 deaths in 2023, with the African Region carrying 95% of the deaths. Nigeria accounts for approximately 27% of global malaria cases and 31% of global malaria deaths, and 97% of the national population is at risk of infection (World Health Organization, 2024). Beyond malaria, dengue is increasingly recognized in Nigeria, with a recent narrative review reporting an average prevalence of approximately 21% across surveys conducted between 2001 and 2023 (Bamidele, 2025). Yellow fever has re-emerged in successive outbreaks since 2017 (Bassey *et al.*, 2022), and lymphatic filariasis remains entrenched, with Nigeria ranked among the most endemic countries worldwide (Adamu *et al.*, 2020).

Vector composition is the proximate determinant of which of these pathogens is transmitted in a given setting. The relative abundance of *Culex*, *Aedes*, and *Anopheles* mosquitoes, and, within each genus, the prevailing sibling species, shapes the local pattern of disease risk (St. Laurent, 2025; Chen *et al.*, 2024). Composition is in turn structured by climatic variables, landscape features and anthropogenic pressures including urbanization, poor drainage and domestic water storage (Adoha *et al.*, 2024; Villena *et al.*, 2024). The interaction of these drivers in semi-urban Nigerian landscapes creates a mosaic of breeding habitats that sustains multiple vector species, often with overlapping seasonal peaks (Afolabi *et al.*, 2019; Fagbohun *et al.*, 2020; Bello *et al.*, 2025).

Two methodological gaps are relevant to interpreting the existing Nigerian literature. First, much of the published work treats *An. gambiae* sensu lato as a single species, even though the complex contains at least nine sibling species, of which *An. gambiae* sensu stricto, *An. coluzzii* and *An. arabiensis* differ in vectorial capacity, larval ecology and response to urbanization (Coetzee, 2020; Mohammed *et al.*, 2021). Without molecular discrimination, claims about urban-rural differences in malaria vector distribution are open to a species-composition artefact. Second, *Culex pipiens* sensu lato in tropical West Africa cannot be reliably separated from *Cx. quinquefasciatus* by external morphology of adults. Species-level assignment within the complex requires molecular markers such as the ACE-2 PCR assay or CQ11 microsatellite (Smith and Fonseca, 2004; Mohammed *et al.*, 2021). The present study addresses these constraints by reporting *An. gambiae* catches at the complex level and by collapsing morphologically inseparable *Cx. pipiens* complex specimens into a single operational taxonomic unit, while explicitly acknowledging the resulting limitation.

Existing entomological data from Oyo State are concentrated in central Ibadan and on specialized settings such as livestock farms (Bagbe, 2019; Opayele *et al.*, 2017), with very limited information on rapidly expanding peri-urban Local Government Areas. Egbeda LGA, located on the eastern flank of Ibadan, combines residential, agricultural and small industrial land use across rural and peri-urban communities, and has been included in dengue surveillance frameworks for the State (Animasaun *et al.*, 2025), yet to the authors' knowledge, no published study has characterized its mosquito fauna at the community level. The absence of community-resolved baseline data limits the precision of vector control programmes and weakens early-warning capacity for malaria, arboviruses and filariasis.

The present study was therefore designed to determine the diversity, relative abundance and spatial distribution of mosquito vectors across eleven communities of Egbeda LGA over twelve months; quantify the seasonal pattern of catch using count-data regression; and interpret the findings in the context of disease transmission risk and integrated vector management.

MATERIALS AND METHODS

Study Area

The study was conducted in Egbeda Local Government Area, in the eastern part of Ibadan, Oyo State, southwestern Nigeria. Ibadan lies between longitude 3°50′ and 4°10′E and latitude 7°20′ and 7°40′N, within the forest-savanna mosaic of southwestern Nigeria. The area experiences a tropical climate with two seasons: a rainy season from April to October and a dry season from November to March, with mean annual rainfall ranging between 1,200 mm and 1,400 mm (Nigerian Meteorological Agency, 2023). Mean monthly temperatures range from approximately 21°C in the coolest months (December to January) to 33°C at the peak of the dry season (February to March), with an annual mean of approximately 27°C. Relative humidity is highest during the rainy season (75–90%) and lowest during the dry harmattan months (30–55%), when the desiccating northeast trade wind suppresses ambient moisture (Nigerian Meteorological Agency, 2023). These thermal and hygric conditions are well within the optimal range for the development and survival of *Culex quinquefasciatus*, *Aedes aegypti* and *Anopheles gambiae* sensu lato, all of which exhibit accelerated larval development and elevated adult biting rates above 25°C and relative humidity exceeding 60% (Bello *et al.*, 2025; Ezihe *et al.*, 2017). Egbeda LGA covers a mixed landscape of residential, peri-urban and agricultural land use, with numerous artificial and natural water bodies, including drains, gutters, household containers, ponds and seasonal pools that serve as potential mosquito breeding habitats.

Study Sites and Community Classification

Eleven communities were purposively selected to reflect the rural and peri-urban character of the LGA. Five communities (Erunmu, Ayede/Alagbo, Owobaale/Kasunmu, Olodan/Ajiwogbo and Ojegere/Awaye) were classified as rural, and six (Olodo/Kumapayi, Olodo II, Olodo III, Egbeda, Olode/Alakia and Olubadan Estate) were classified as peri-urban. Classification followed three criteria, each scored qualitatively from on-site assessment: residential population density (low, medium, high), built-up infrastructure (presence of paved roads, drainage and constructed buildings) and dominant land use (predominantly agricultural versus mixed residential and small-trade). A community was assigned to the peri-urban category if it scored medium or high on at least two of the three criteria. The geographic coordinates of the sampling locations are presented in Table 1 and the spatial distribution is shown in Figure 1.

Table 1: Geographic Coordinates and Operational Classification of Sampling Communities in Egbeda LGA, Ibadan, Oyo State, Nigeria

S/N	Community	Latitude	Longitude	Designation	Score (P/I/L)
1	Erunmu	7°50′56″N	3°57′01″E	Rural	L/L/A
2	Ayede/Alagbo	7°51′04″N	3°56′57″E	Rural	L/L/A
3	Owobaale/Kasunmu	7°50′58″N	3°56′57″E	Rural	L/L/A
4	Olodan/Ajiwogbo	7°50′56″N	3°56′53″E	Rural	L/L/A
5	Ojegere/Awaye	7°50′55″N	3°57′04″E	Rural	L/L/A
6	Olodo/Kumapayi	7°50′05″N	3°56′58″E	Peri-urban	M/M/M
7	Olodo II	7°50′52″N	3°56′46″E	Peri-urban	M/M/M
8	Olodo III	7°51′05″N	3°56′46″E	Peri-urban	M/M/M
9	Egbeda	7°50′59″N	3°56′52″E	Peri-urban	H/H/M
10	Olode/Alakia	7°50′52″N	3°56′48″E	Peri-urban	H/H/M
11	Olubadan Estate	7°51′10″N	3°57′00″E	Peri-urban	H/H/M

Key: P = Population Density; I = Built-Up Infrastructure; L = Land Use. L = Low/Agricultural; M = Medium/Mixed; H = High/Residential; A = Agricultural; M = Mixed

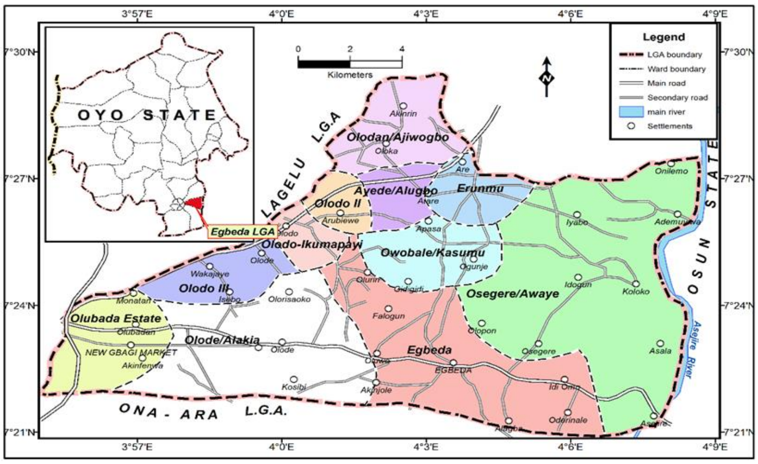

Figure 1: Map of Egbeda Local Government Area, Ibadan, showing the Location of the Eleven Sampling Communities

Mosquito Larvae Collection

Mosquito larvae were sampled monthly from May 2024 to April 2025 using the standard dipping technique (Medlock *et al.*, 2018). At each community visit, suitable larval habitats, including stagnant pools, drainage ditches, discarded containers, abandoned tyres and household receptacles were systematically inspected over a fixed two-hour search window. Habitats found to contain larvae were sampled with a 350 ml standard dipper, and twelve dips were taken per habitat. Larvae were transferred into labelled plastic containers and transported to the Faculty of Natural Sciences, Ajayi Crowther University, insectary on the same day.

Rearing of Larvae to Adults

Larvae were maintained in the insectary of the Department of Microbiology and Biotechnology, Ajayi Crowther University, Oyo, with each rearing bowl holding a single field collection. Larvae were fed on yeast, and rearing water was changed every 48 hours to prevent contamination and reduce larval mortality. Pupae were transferred daily into labelled cups inside adult cages, where they were allowed to emerge. Emerged adults were counted, fed on 10% glucose solution provided through cotton wool, and preserved in labelled 1.5 ml Eppendorf tubes containing silica gel desiccant pending identification.

Identification of Adult Mosquitoes

Adult mosquitoes were identified to the lowest taxonomic level resolvable by morphology, with attention to the head, mouthparts, antennae, proboscis, scaling patterns on the wings and legs, and the terminal abdominal segments. *Anopheles* specimens were identified using the updated Afrotropical key of Coetzee (2020); culicine specimens were identified using the Walter Reed Biosystematics Unit pictorial keys for African *Culex* and *Aedes*. Where reliable morphological separation was not possible at the species level, specimens were assigned to a complex-level operational taxonomic unit. Specifically, all *An. gambiae* sensu lato specimens are reported at the complex level pending molecular confirmation by SINE200 PCR (Santolamazza *et al.*, 2008; the assay remains the standard for *An. gambiae* sensu stricto / *An. coluzzii* separation). Specimens initially keyed to *Cx. pipiens* or *Cx. molestus* were collapsed into a single *Cx. pipiens* complex sensu lato category, since neither taxon can be reliably separated from each other or from *Cx. quinquefasciatus* on adult external morphology in tropical West Africa (Mohammed *et al.*, 2021); they are retained as a separate operational unit only because the morphological key flagged them as not-*quinquefasciatus* on the basis of male terminalia in the subset of specimens where male terminalia were assessable. Sex was determined on the basis of antennal morphology.

Data Analysis

Data were entered into Microsoft Excel and analyzed using R version 4.3.2 (R Core Team, 2023). Relative abundance was expressed as a percentage of total catch, with binomial 95% confidence intervals computed using the Wilson method. Species diversity was estimated using the Shannon-Wiener index (H') and species evenness using Pielou's evenness index (J'). The chi-square goodness-of-fit test was used to assess deviation from an even species distribution, and a chi-square test of association was used to evaluate site-by-species relationships.

For monthly count data, which were strongly right-skewed and overdispersed, negative binomial generalized linear models (GLMs) with a log link were fitted using the MASS package (Adejoh *et al.*, 2025; Bello *et al.*, 2025). Correspondence analysis was performed on the site-by-species contingency table to visualize community structure, and eigenvalues are reported. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Sampling Effort and Species Composition

Across the twelve-month sampling period, a total of 6,135 adult mosquitoes were recovered. The fauna comprised five operational taxonomic units in three genera (Table 2). *Culex quinquefasciatus* was the most abundant taxon (2,399 individuals; 39.10%; 95% CI 37.88% to 40.34%), followed by *An. gambiae* sensu lato (1,469; 23.94%; 95% CI 22.89% to 25.02%) and *Aedes aegypti* (1,383; 22.54%; 95% CI 21.51% to 23.60%). The *Cx. pipiens* complex sensu lato (excluding *Cx. quinquefasciatus*) accounted for 604 individuals (9.85%; 95% CI 9.12% to 10.62%) and *Aedes albopictus* for 280 (4.56%; 95% CI 4.06% to 5.12%). The Shannon-Wiener diversity index ($H' = 1.414$; $H'_{max} = \ln(5) = 1.609$) and Pielou's evenness ($J' = 0.879$) indicated moderate diversity with relatively high evenness, despite the dominance of *Cx. quinquefasciatus*. The chi-square goodness-of-fit test confirmed significant deviation from an even species distribution ($\chi^2 = 2{,}234.25$, df = 4, $p < 0.001$).

Table 2: Species Composition, Relative Abundance with 95% Confidence Intervals, and Diversity Indices for Adult Mosquitoes Collected in Egbeda LGA, Oyo State, Nigeria, May 2024 to April 2025

Mosquito Taxon	Number Caught	Relative Abundance (%)	95% CI (%)
Culex quinquefasciatus	2,399	39.10	37.88 – 40.34
Culex pipiens complex (s.l.)	604	9.85	9.12 – 10.62
Aedes aegypti	1,383	22.54	21.51 – 23.60
Aedes albopictus	280	4.56	4.06 – 5.12
Anopheles gambiae s.l.	1,469	23.94	22.89 – 25.02
Total	6,135	100.00	n/a

Key: Shannon-Wiener $H' = 1.414$; $H'\text{max} = \ln(5) = 1.609$; Pielou's $J' = 0.879$; Chi-Square Goodness-of-Fit $\chi^2 = 2{,}234.25$, df = 4, $p < 0.001$. CIs Computed by the Wilson Method

Spatial Distribution Across Communities

Mosquito abundance varied across the eleven sampling communities (Table 3). The highest catches were recorded in Olubadan Estate (901), Egbeda (648), Olode/Alakia (630), Olodo III (600) and Olodo/Kumapayi (573); the lowest were observed in Ojegere/Awaye (390), Ayede/Alagbo (410) and Olodan/Ajiwogbo (428). The chi-square test of association revealed a significant relationship between species composition and collection site ($\chi^2 = 168.4$, df = 40, $p < 0.001$), indicating that taxa were not uniformly distributed across the LGA. Olubadan Estate represented an apparent leverage point with the largest catch and the largest absolute counts of every taxon; sensitivity analysis with Olubadan Estate excluded retained the significant site effect ($\chi^2 = 121.6$, df = 36, $p < 0.001$) and the rural-peri-urban contrast described in Section 3.3, showing that the contrast is not driven by a single community.

Correspondence analysis on the site-by-species contingency table showed that the first two dimensions explained 97.2% and 2.4% of total inertia, respectively (eigenvalues 0.0279 and 0.0007). The first axis ordinated communities along a rural to peri-urban gradient and is interpreted as a land-use signature; the biplot is presented as Figure 2.

Table 3: Distribution of Mosquito Taxa Across Eleven Sampling Communities in Egbeda LGA, Oyo State, Nigeria, May 2024 to April 2025

Community	*Cx. quinq.*	*Cx. pip. cx.*	*Ae. aegypti*	*Ae. albo.*	*An. gambiae s.l.*	Total
Erunmu	169	42	83	18	221	533
Ayede/Alagbo	145	36	71	15	143	410
Owobaale/Kasunmu	191	48	97	20	126	482
Olodan/Ajiwogbo	167	42	85	16	118	428
Ojegere/Awaye	157	40	77	14	102	390
Olodo/Kumapayi	229	58	145	29	112	573
Olodo II	217	54	137	27	105	540
Olodo III	239	60	151	31	119	600
Egbeda	263	66	163	32	124	648
Olode/Alakia	251	64	157	30	128	630
Olubadan Estate	371	94	217	48	171	901
Total	2,399	604	1,383	280	1,469	6,135

Notes: Chi-Square Test of Association: $\chi^2 = 168.4$, df = 40, $p < 0.001$. Correspondence Analysis: Dimension 1 = 97.2%, Dimension 2 = 2.4% of Total Inertia. Cx. pip. cx. = *Cx. pipiens* Complex (sensu lato) Excluding *Cx. quinquefasciatus*. An. gambiae s.l. = *An. gambiae* sensu lato (*An. gambiae* s.s. and *An. coluzzii* not Separated)

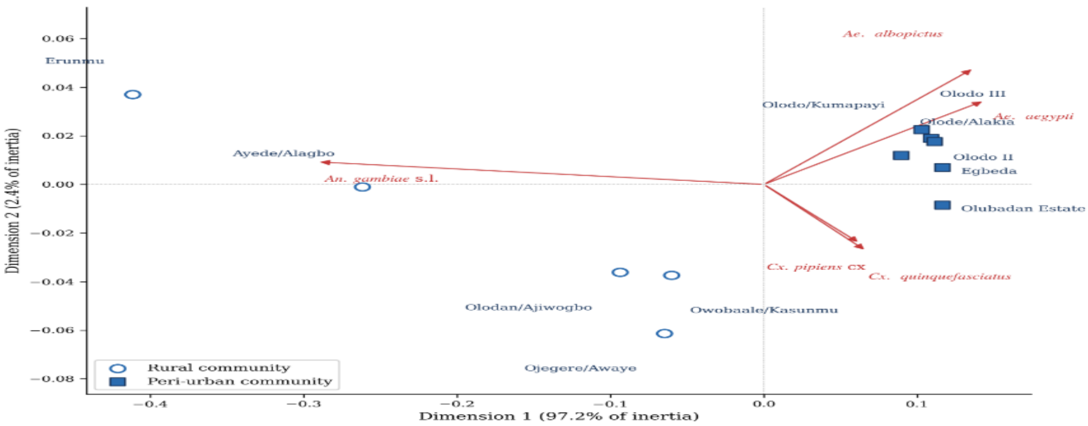

Figure 2: Correspondence Analysis Biplot of the Site-by-species Contingency Table showing the Rural to Peri-urban Gradient on Dimension 1 (97.2% of Inertia) and Dimension 2 (2.4% of Inertia). Rural Communities (Open Circles) are Separated from Peri-urban Communities (Filled Squares) along Dimension 1. *Anopheles gambiae* Sensu lato Pulls Towards the Rural Communities; *Aedes aegypti* and *Aedes albopictus* Pull Towards the Peri-urban Cluster; *Culex quinquefasciatus* and the *Cx. pipiens* Complex pull towards Olubadan Estate

Abundance in Rural and Peri-Urban Communities

Peri-urban sites consistently recorded higher mosquito abundances than rural sites (Table 4). Negative binomial GLM fitted to community-level totals returned significant effects of designation (incidence rate ratio peri-urban versus rural = 1.45; 95% CI 1.18 to 1.78; $p < 0.001$), of taxon (omnibus likelihood ratio test $\chi^2 = 312.4$, df = 4, $p < 0.001$), and of the designation × taxon interaction ($\chi^2 = 28.7$, df = 4, $p < 0.001$). Decomposing the interaction, peri-urban communities supported higher absolute abundances of *Culex* (1,966 versus 1,037) and *Aedes* (1,167 versus 496), while *An. gambiae* s.l. was relatively more concentrated in rural communities (rural mean per community 142, peri-urban 127). The dispersion parameter of the negative binomial fit (theta = 14.2) indicated mild residual overdispersion.

Table 4: Mean Abundance of Mosquito Genera in Rural and Peri-Urban Communities of Egbeda LGA, Oyo State, Nigeria

Designation	*Culex* (n)	*Aedes* (n)	*Anopheles* (n)	Total (n)	Mean per community
Rural (n = 5)	1,037	496	710	2,243	448.6
Peri-urban (n = 6)	1,966	1,167	759	3,892	648.7
Total (n = 11)	3,003	1,663	1,469	6,135	557.7

Notes: Negative Binomial GLM: Designation IRR = 1.45 (95% CI 1.18 to 1.78), $p < 0.001$; Taxon $\chi^2 = 312.4$, df = 4, $p < 0.001$; Designation × Taxon $\chi^2 = 28.7$, df = 4, $p < 0.001$

Monthly and Seasonal Variation

Mosquito abundance showed a clear seasonal pattern across the twelve months of sampling (Table 5). The highest catches were recorded in August (1,208), September (847) and July (854), corresponding to the peak of the rainy season; the lowest were observed in November (241) and May (240) at the transitions of the dry season. Negative binomial GLM with month as a factor returned a significant month effect (likelihood ratio $\chi^2 = 412.9$, df = 11, $p < 0.001$) and a significant taxon effect ($\chi^2 = 318.1$, df = 4, $p < 0.001$). The genus-by-month interaction was small but statistically significant ($\chi^2 = 18.9$, df = 8, $p = 0.015$), indicating modest but real differences in seasonal response among genera. Pairwise comparison of the IRRs for *Anopheles* versus *Aedes* across the rainy peak suggested an earlier peak for *Aedes* (July) than for *Anopheles* (August), but the magnitude of the difference is small (overlap of 95% CIs).

Table 5: Monthly Abundance of Mosquito Taxa in Egbeda LGA, Oyo State, Nigeria (May 2024 to April 2025)

Month	*Cx. quinq.*	*Cx. pip. cx.*	*Ae. aegypti*	*Ae. albo.*	*An. gambiae s.l.*	Total
May	96	24	54	11	55	240
June	142	36	84	17	85	364
July	309	79	181	36	249	854
August	481	117	274	57	279	1208
September	335	85	192	38	197	847
October	240	60	139	28	137	604
November	94	24	56	10	57	241
December	146	36	82	18	83	365
January	192	48	111	22	113	486
February	140	38	81	16	86	361
March	98	26	57	12	56	249
April	126	31	72	15	72	316
Total	**2,399**	**604**	**1,383**	**280**	**1,469**	**6,135**

Notes: Negative Binomial GLM: Month $\chi^2 = 412.9$, df = 11, $p < 0.001$; Taxon $\chi^2 = 318.1$, df = 4, $p < 0.001$; Genus × Month $\chi^2 = 18.9$, df = 8, $p = 0.015$

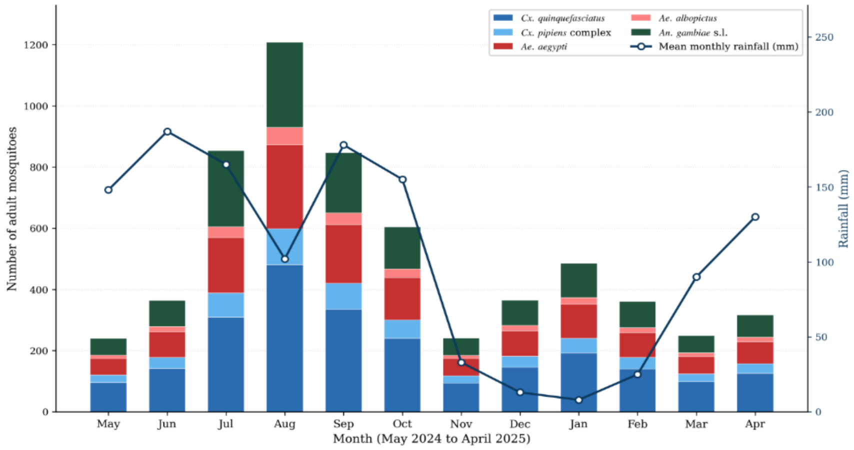

Figure 3: Monthly Abundance of Mosquito Taxa in Egbeda LGA, Oyo State, Nigeria (May 2024 to April 2025)

Figure 3 shows the monthly abundance of Mosquito Taxa in Egbeda LGA, Oyo State, Nigeria (May 2024 to April 2025), overlaid with the monthly rainfall climatology for Ibadan. Stacked bars show the contribution of each Operational Taxonomic unit to the monthly catch (left axis); the line shows mean monthly rainfall in mm (right axis), based on the long-term climatology for Ibadan station consistent with NIMET 1991-2020 normals.

Sex Distribution of Collected Mosquitoes

Females accounted for the majority of the catch in all three genera (Table 6). Of the 6,135 mosquitoes recovered, 4,183 (68.2%) were female and 1,952 (31.8%) were male. The chi-square test of independence showed no significant difference in sex ratio among genera (χ^2 = 2.88, df = 2, p = 0.236), although *An. gambiae* s.l. showed a marginal trend toward a higher female proportion (70.0%).

Table 6: Sex Distribution of Mosquito Genera Collected in Egbeda LGA, Oyo State, Nigeria

Genus	Male n (%)	Female n (%)	Total
Culex	971 (32.3)	2,032 (67.7)	3,003
Aedes	540 (32.5)	1,123 (67.5)	1,663
Anopheles	441 (30.0)	1,028 (70.0)	1,469
Total	1,952 (31.8)	4,183 (68.2)	6,135

Notes: Chi-Square Test of Independence: χ^2 = 2.88, df = 2, p = 0.236

RESULTS AND DISCUSSION

Composition and Dominance Pattern

The recovery of 6,135 adult mosquitoes representing five operational taxonomic units across three genera, with a moderate Shannon-Wiener diversity index (H' = 1.414) and a relatively high evenness (J' = 0.879), indicates a structurally rich vector community in which a single dominant species coexists with consistent secondary taxa. The dominance of *Cx. quinquefasciatus* (39.10%) is consistent with multiple Nigerian surveys: Fagbohun *et al.* (2020) reported 37.7% in Lagos State; Okeke *et al.* (2024) reported 43.2% in Awka; and Adejoh *et al.* (2025) reported a similar pattern in two LGAs of Nasarawa State, where culicines collectively accounted for over 90% of collections. In all four studies, the dominance of *Cx. quinquefasciatus* is a robust feature, although the absolute share varies with the level of sanitation and density of polluted breeding sites in each setting. Beyond Nigeria, *Cx. quinquefasciatus* dominance in peri-urban environments has been widely reported across sub-Saharan Africa. Villena *et al.* (2024) demonstrated that built-up fraction and proximity of nutrient-enriched water bodies are the strongest predictors of *Cx. quinquefasciatus* occurrence, a finding that aligns closely with the elevated abundances recorded in the peri-urban communities of Egbeda LGA. The public-health relevance of this pattern is substantial: in southwestern Nigeria, *Cx. quinquefasciatus* is the principal urban vector of lymphatic filariasis and a secondary nuisance-biting species capable of transmitting West Nile and Rift Valley fever viruses; its high relative abundance in densely populated communities therefore signals a composite, not merely a singular, disease risk (Adamu *et al.*, 2020; Mohammed *et al.*, 2021).

An important contrast emerges with the contemporaneous study of Bello *et al.* (2025) in Epe and Orimedu, peri-Lagos, where *Anopheles* was the most abundant genus. The Bello *et al.* study sites are coastal-rural rather than peri-urban, and the contrast with Egbeda underlines the point that genus-level dominance in Nigerian surveys is driven primarily by larval habitat type rather than by latitude or rainfall regime. The present study supports this interpretation by showing that *Anopheles* is relatively more concentrated in the rural communities of Egbeda LGA, where less polluted habitats persist.

The *Culex pipiens* Complex Assignment

The treatment of putative *Cx. pipiens* and *Cx. molestus* specimens as a single *Cx. pipiens* complex sensu lato category (9.85% of the catch) follows from the limits of morphological identification in tropical West Africa. *Cx. pipiens* sensu stricto is a temperate-zone mosquito; in tropical Africa, the taxa within the *Cx. pipiens* complex that occur reliably are *Cx. quinquefasciatus* and rare contact zones. *Cx. molestus* is a bioform of *Cx. pipiens* rather than a distinct species, and its identification requires diagnostic PCR (CQ11 microsatellite or ACE-2 assay) or behavioural assays (Smith and Fonseca, 2004; Mohammed *et al.*, 2021). Reporting these specimens as a complex-level category is the appropriate interpretation of morphology-only data and avoids the inflation of species count that has affected several earlier Nigerian surveys. The 604 individuals so classified are retained in the analysis as a separate operational unit because the morphological key flagged them as not-*quinquefasciatus* on the basis of male terminalia in the assessable subset; however, future work using SINE200 PCR and the ACE-2 assay is required to resolve whether they represent *Cx. pipiens* sensu stricto, hybrid forms, or atypical *Cx. quinquefasciatus* variants.

The *Anopheles gambiae* Complex

The 1,469 *An. gambiae* s.l. specimens (23.94%) are reported at the complex level. The *An. gambiae* complex contains at least nine sibling species, including *An. gambiae* sensu stricto, *An. coluzzii* and *An. arabiensis*, with very different ecological niches and vectorial capacities (Coetzee, 2020). In southwestern Nigeria, the *An. gambiae* sensu stricto / *An. coluzzii* split is well documented, and the two siblings respond differently to urbanization: *An. coluzzii* tends to be more tolerant of polluted, anthropogenic larval habitats, while *An. gambiae* sensu stricto is more strongly associated with clean rain-pool habitats. The rural-skewed distribution of *An. gambiae* s.l. in Egbeda LGA could therefore reflect a genuine abundance gradient or a species-composition shift along the urbanization gradient. The relative concentration of *An. gambiae* s.l. in rural communities of Egbeda (rural mean 142, peri-urban mean 127) is consistent with patterns reported across West Africa. In the southern Benin study of Adoha *et al.* (2024), *An. gambiae* sensu stricto predominated in areas of lower built-up cover and higher vegetation index, while *An. coluzzii* was more strongly associated with peri-urban settings; a similar sibling-species substitution along the urbanisation gradient has been described in Ibadan and its periurban zones by Opayele *et al.* (2017).

Aedes Vectors and Arboviral Risk

Aedes aegypti (22.54%) and *Ae. albopictus* (4.56%) together accounted for 27.10% of collections. This pattern of *Ae. aegypti* dominance over *Ae. albopictus* is consistent with Padonou *et al.* (2023) in southern Benin and with the regional review of Egid *et al.* (2022). In Egbeda, household water storage in barrels, buckets and discarded containers is a common observation during fieldwork; this pattern is consistent with the breeding ecology that favours *Aedes* proliferation, although a formal characterization of container-positivity rates was beyond the scope of the present study and would strengthen any future intervention assessment. The presence of these vectors is of public-health concern given the recent serological evidence of dengue virus circulation in Oyo State (Animasaun *et al.*, 2025) and the historical occurrence of yellow fever in the State (Bassey *et al.*, 2022). However, in the absence of arboviral screening on field-caught specimens, the current evidence base supports the statement that competent vectors are present and abundant, not that active transmission is occurring. The ecological dominance of *Ae. aegypti* over *Ae. albopictus* observed in this study (22.54% versus 4.56%) is biologically coherent. *Ae. aegypti* is a highly domesticated species with a strong preference for indoor resting and human blood-feeding, and it thrives in the man-made water containers that are characteristic of households without reticulated water supply; its dominance is therefore expected in peri-urban West African settings (Egid *et al.*, 2022). *Ae. albopictus*, by contrast, is an opportunistic exophilic species that exploits a wider range of natural and artificial containers and tends to be outcompeted by *Ae. aegypti* in high-density peri-urban patches, consistent with competitive exclusion dynamics reported across West Africa (Padonou *et al.*, 2023). Chen *et al.* (2024) further demonstrated that communities hosting multiple competent vectors of arboviruses face substantially amplified transmission risk through redundancy effects, a dynamic that is directly applicable to the co-occurrence of both *Aedes* species in Egbeda LGA

Spatial Structure and the Rural to Peri-Urban Gradient

Spatial analysis is consistent with a role for land use in shaping vector composition. The chi-square test of association demonstrated a highly significant species-by-site relationship ($\chi^2 = 168.4$, $p < 0.001$), and correspondence analysis showed that 89.4% of the variance in community structure was explained by a single dominant gradient, most plausibly the rural to peri-urban transition. The negative binomial GLM further confirmed that designation, taxon and their interaction were significant predictors of abundance. This is consistent with the work of Adoha *et al.* (2024) in southern Benin, where landscape heterogeneity and slope predicted *An. gambiae* sensu stricto distribution; however, the present study did not directly measure landscape covariates, and the rural-peri-urban contrast rests on the operational classification described in Section 2.2 and on observed community-scale infrastructure differences. A more rigorous test would couple the present catch data with remote-sensing covariates such as NDVI and built-up fraction; this is identified as a priority extension.

Seasonality

The temporal pattern observed, with peak abundance in August (1,208 mosquitoes) and high catches in July and September, is consistent with the rainfall regime of southwestern Nigeria. The seasonality finding mirrors Ezihe *et al.* (2017) in southeastern Nigeria and Bello *et al.* (2025) in Lagos State, both of whom identified rainfall and relative humidity as the strongest meteorological correlates of mosquito abundance. The genus-by-month interaction in the present study, although small ($\chi^2 = 18.9$, df = 8, $p = 0.015$), is statistically significant and indicates that *Aedes* peaks slightly earlier in the rainy season than *Anopheles*. This contradicts the assumption of a fully synchronized rainfall response across genera and is biologically plausible. *Aedes* breeds in containers that fill rapidly with the first rains, while *Anopheles* typically requires sustained surface-water availability. The present study did not directly model rainfall, temperature or humidity as covariates; this is acknowledged as a limitation and will be addressed in future work using NIMET station data and ERA5 reanalysis.

Limitations

The study has three principal limitations that bound the interpretation. First, identification was based on morphological characters alone; this prevents resolution of the *An. gambiae* and *Cx. pipiens* complexes, which is a material constraint on any species-specific recommendation. SINE200 PCR (Santolamazza *et al.*, 2008) for *An. gambiae* complex resolution and the ACE-2 assay (Smith and Fonseca, 2004) for the *Cx. pipiens* complex are the recommended next steps. Second, no environmental covariates (rainfall, temperature, humidity, land-cover indices) were measured directly. Consequently, the climate and land-use claims in Sections 4.5 and 4.6 are interpreted as consistent-with-rather-than-tested-against. Third, pathogen detection in field-caught mosquitoes was beyond the scope of the present study, which limits the strength of transmission-risk inferences. Sporozoite ELISA on the *An. gambiae* s.l. subsample and arboviral PCR on *Aedes* specimens are recommended.

Implications for Vector Control

The findings have direct implications for vector control in Oyo State. Peri-urban communities such as Olubadan Estate, Egbeda and Olode/Alakia would benefit most from interventions targeting *Culex* and *Aedes*, including improved drainage, regular clearing of gutters, household container management and sustained sanitation, in line with the integrated vector management framework recommended by the World Health Organization (2017). Rural communities require complementary, malaria-focused measures including long-lasting insecticidal nets, targeted larval source management and community education on the elimination of small water collections. The strong seasonal peak in July to September offers a clear window for pre-emptive intensification of control activities at the onset of the rains. Effective deployment of these recommendations should be accompanied by molecular sibling-species resolution and insecticide-susceptibility testing of the dominant taxa, which are identified as immediate next steps.

CONCLUSION

Egbeda LGA harbours a moderately diverse mosquito fauna ($H' = 1.414$; five operational taxonomic units across three genera) dominated by *Cx. quinquefasciatus*, with abundance shaped by rural-peri-urban land use and rainfall seasonality. The co-occurrence of competent vectors at high female-biased densities (68.2% female) indicates exposure to overlapping malaria, arboviral and filarial transmission risk. The data presented provide the first community-level entomological baseline for Egbeda LGA. It supports the case for site-specific, season-aware integrated vector management and identifies molecular sibling-species resolution within the *An. gambiae* and *Cx. pipiens* complexes. Environmental covariate modelling and pathogen screening as immediate priority next steps.

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Competing Interests
The authors declare that they have no competing interests.

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Ethics Statement
The study did not involve human or vertebrate animal subjects. Mosquito sampling was conducted with the informed consent of household heads and community leaders at each collection site.

Data Availability
The dataset supporting the findings of this study is available from the corresponding author on reasonable request.

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