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Mosquito Larval Composition, Abundance, Temperature and Physicochemical Properties of Larval Container Habitats in Ekosodin Community, Benin City, Edo State, Nigeria

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ABSTRACT; Conventionally, *Aedes* and *Culex* mosquito vectors of yellow fever and filariasis, respectively, are known to utilize containers as preferred breeding sites. There are exceptions of *Anopheles* breeding in such habitats in some regions. Effective mosquito vector control measures require precise information, such as mosquito identity and habitat features, to control or eliminate mosquito-borne diseases from a region. Hence, the objective of this paper was to evaluate the mosquito larval composition, abundance, temperature and physicochemical properties of larval container habitats in Ekosodin Community, Benin City, Edo State, Nigeria using appropriate standard procedures. Data obtained reveals that mosquitoes collected differed significantly ($p < 0.05$) and comprised *Aedes* (63.6 %), *Culex* (34.1 %), and *Anopheles* (2.3 %). Containers sized between 20.1 cm and 30.0 cm accommodated representatives of all three mosquito genera. There was no significant difference ($p > 0.05$) in pH, electrical conductivity, salinity, total dissolved solids, and temperature across different container size ranges. Significant positive correlations ($p < 0.05$) were observed between *Aedes* species and salinity (0.69), *Aedes* species and diameter (0.84), *Anopheles* species and pH (0.83), and *Anopheles* species and *Culex* species (0.80). This study demonstrates that containers can serve as significant habitats for crucial mosquito vectors in the Ekosodin Community and need proper consideration for control measures.

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Mosquito-borne diseases are responsible for over 700,000 deaths annually in sub-Saharan Africa and beyond (WHO, 2024), with infants and children accounting for 20-30% of the overall mortality. There are approximately 3,698 species and subspecies of mosquitoes worldwide (Knols, 2021), but only a few are recognized as vector species of significant human and veterinary importance (WHO, 2003a). Parasites transmitted by mosquitoes include *Wuchereria bancrofti*, transmitted by *Culex quinquefasciatus*; Dengue and Viral encephalitis, transmitted by *Aedes aegypti*; and *Plasmodium*, transmitted by female *Anopheles* mosquitoes (Gizaw *et al*., 2024). Mosquitoes spend three-quarters of their life stages in aquatic environments. Mosquito breeding sites are broadly classified based on the environment type and conditions favorable for their development. These sites include artificial containers such as buckets, used tires, flower pots, and discarded containers; natural water bodies; temporary water accumulations;

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vegetation and plant-based sites; domestic and peridomestic areas; and irrigation and agricultural areas (Amini *et al*., 2020; Tsegaye *et al*., 2023; Marubini *et al*., 2025). Consequently, any factor that affects the condition and composition of the water body can cause changes in the water ecosystem, impacting the breeding behavior, diversity, and larval population of mosquito fauna (Mutero *et al.*, 2004).

The physicochemical parameters of water bodies determine the condition, development, and survival of living organisms, including mosquitoes. Water chemistry in aquatic habitats plays a critical role in determining mosquito survival rates (Leisnham *et al.*, 2007). Temperature also plays a key role in the survival and proliferation of mosquito species (Beck-Johnson *et al*., 2013; Shapiro *et al.*, 2017). Container size and diameter affect the productivity and abundance of mosquito breeding. There are reports on the influence of container type and diameter on mosquito oviposition and body size (Harrington *et al.*, 2008; Ouédraogo *et al*., 2022).

Although the basic biology and associations of the major mosquito vectors with various habitat categories are well-known, continuous studies are essential to provide baseline information in unresearched areas or updates in previously studied areas. Such research is vital for effective mosquito control (Killeen *et al.*, 2017). These studies help provide the most recent situational status of vector species, types, and varying larval habitat preferences. They also detail the physical, chemical, and biological characteristics of these habitats, including the existence and disappearance of mosquito species and their relative population densities. There is a scarcity of mosquito larval data from Ekosodin Community in Benin City, Edo State. Hence, the objective of this paper is to evaluate the mosquito larval composition, abundance, temperature and physicochemical properties of larval container habitats in Ekosodin Community, Benin City, Edo State, Nigeria.

MATERIALS AND METHODS

Study Area: The study was conducted in Ekosodin, a prominent community in the Ovia North East Local Government Area of Edo State. The community borders the Ugbowo Campus of the University of Benin, Benin City, Nigeria, located at Latitude 6°20.022'N and Longitude 5°36.009'E. The early settlers of the community were primarily farmers and hunters. Originally, the land was used for agricultural purposes but has since been converted to residential and commercial use due to an influx of students and staff, especially those unable to secure accommodation through the university's school management. This demographic shift transformed the area's character from a rural setting to a more peri-urban environment. The climate in this region is tropical, with two major seasons: the dry season (Harmattan), typically occurring from November to March, and the rainy season (wet season), generally occurring from April to October. The temperature in the state ranges between 25°C and 28°C during the rainy and dry seasons, respectively.

Study Design: In this cross-sectional study, nine randomly selected locations were visited between April and May 2021 in Ekosodin Community (Table 1). The locations, which were over 100 meters apart, included abandoned containers with standing water. These locations were surveyed for mosquito larval abundance, and physicochemical parameters were determined. Containers surveyed for mosquitoes were grouped and differentiated according to their diameter into Container 1, Container 2, and Container 3. The diameters of the container categories were as follows: Container 1 ranged from 10.1 cm to 20 cm, Container 2 ranged from 20.1 cm to 30 cm, and Container 3 ranged from 30.1 cm to 40 cm (Table 2).

Table 1: Coordinates of Localities where containers were sampled for mosquito larvae in Ekosodin Communities

Sampling Localities	**GPS Coordinates**
1	6°24'58" N, 5°37'56" E
2	6°24'46.7" N, 5°37'40" E
3	6°24'36.8" N, 5°37'45" E
4	6°24'48.7" N, 5°37'34.7" E
5	6°24'52.9" N, 5°37'12" E
6	6°24'38.9" N, 5°37'30.5" E
7	6°24'43" N, 5°37'31" E
8	6°24'31.1" N, 5°37'30.7" E
9	6°24'41.2" N, 5°37'23" E

Table 2: Diameter of sampled containers in Ekosodin Community

Container	Diameter (cm)	Locality
Container 1 (10.1 – 20 cm)	13.0	1
	14.0	2
	15.0	3
	17.0	4
Container 2 (20.1 – 30 cm)	23.3	5
	29.9	6
	29.9	7
Container 3 (30.1 – 40 cm)	30.2	8
	32.3	9

Mosquito Larva Sampling and Collection of water samples for Physicochemical Analysis: Mosquito larval sampling followed the standard dipping method (WHO, 2003b). At each sampling location, a 148 ml dipper was used to obtain five dips of the stagnant water in the container into well-labeled bowls. The habitat's temperature was measured using a glass mercury thermometer. Measurements of container diameters and the collection of water samples for physicochemical analysis into separate bottles were done after larval sampling. The bowls containing water samples for larval analysis were taken to the Department of Animal and Environmental Biology, Faculty of Life Sciences, University of Benin, for further processing.

Morphological Identification of mosquito larvae: Larvae, particularly those between the 2nd and 4th instar developmental stages, were identified. Identification was performed first on the day of sampling and again after 3–4 days of maintaining the larval bowls under normal room temperature and relative humidity conditions. Mosquito larvae were identified using morphological identification keys (Service, 2012). Anopheline mosquito larvae possess no siphon and lie parallel to the water surface, distinguishing them from *Aedes* and *Culex* larvae, which possess elongated siphons and lie at an angle to the water surface. *Aedes* spp. siphons are darker and stout in appearance, while *Culex* spp. siphons are longer, lighter in color, and taper towards the tip.

Determination of Physicochemical Parameters: The physicochemical properties of the larval habitats were determined using standard techniques at the University of Benin/Benin Owena River Basin Joint Analytical Research Laboratory, Benin City, Edo state. The parameters assessed were Properties of Hydrogen (pH), Electrical Conductivity (EC), Salinity, Total Dissolved Solids (TDS) and Temperature.

Statistical Analyses: Microsoft Excel 2016 and IBM Statistical Package for the Social Sciences (SPSS 27.0) were used for data analysis of means, standard deviations (SD), one-way Analysis of Variance (ANOVA) test, Chi-Square and Bivariate Correlation test. Statistical comparisons were made at a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

Abundance of mosquito larvae across different container sizes: A total of 173 mosquito larvae belonging to three genera were collected in this study. The difference in their occurrence was statistically significant [X^2 (2, N = 173) = 97.5; $p < 0.01$]. Their ranks in order of descending abundance were: *Aedes* species (63.6 %), *Culex* species (34.1 %), and *Anopheles* species (2.3 %) (Fig.1). In this study, *Aedes* mosquitoes were significantly the most abundant, followed by *Culex* species. Both genera are commonly referred to as container-breeding mosquitoes (Haq and Singh, 2021; Zettle *et al.*, 2022). However, it has been consistently observed that *Aedes* mosquitoes dominate in container habitats compared to other genera (Thete and Shinde, 2013; Getachew *et al.*, 2015; Kabore *et al.*, 2024)

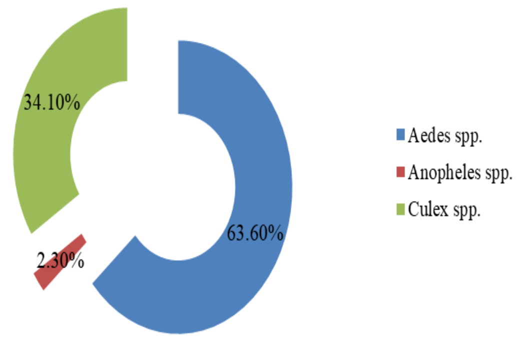

Fig. 1: Total abundance of mosquito Species collected

Apart from container size 1, where the difference in abundance of mosquito larvae was not significant ($p > 0.05$), the abundance of mosquito larvae in container sizes 2 and 3 differed significantly ($p < 0.05$). *Aedes* larvae were the most abundant in both containers (2 and 3). *Anopheles* (100%) occurred only in container size 2 and were the least in occurrence compared to the other mosquito larvae. *Culex* larvae were least abundant in container 3 (Table 3). The overall size of a container significantly influences mosquito species composition (Bartlett-Healy *et al.*, 2011). Container diameter has been reported to correlate positively with the number of eggs laid by *Ae. aegypti*, as demonstrated in a study conducted to determine the influence of container size, location, and time of day on their oviposition patterns in Thailand (Harrington *et al.*, 2008). An increase in oviposition would, expectedly, lead to an increase in larval population within a few hours to days. Ouédraogo *et al*. (2022) also discovered that larger containers were more productive larval habitats compared to smaller ones. *Anopheles* mosquitoes rarely breed in containers and, if they do, are always the least in abundance compared to other collected mosquito species (Amawulu *et al*., 2020; Marubini *et al*., 2025). This is similar to our finding. Carrieri *et al.* (2003) reported the highest frequency of *Ae. albopictus* in small containers, whereas *Cx. pipiens* predominantly colonized larger containers. They concluded that larger containers favoured *Culex* mosquitoes due to the durability of the water, which would remain long enough to benefit the mosquitoes' well-being. This finding, which differs somewhat from ours, reflects how various factors interact to determine the existence and proliferation of mosquito species in an environment.

Table 3: Abundance of mosquito larvae in the different container sizes

Species	Container Size Ranges [No. (%)]			Total
	Container 1	Container 2	Container 3	
Culex	24 (40.7)	31 (52.5)^b	4 (6.8)^b	**59 (34.1)^b**
Aedes	35 (31.8)	62 (56.4)^a	13 (11.8)^a	**110 (63.6)^a**
Anopheles	0 (0.0)	4 (100.0)^c	0 (0.0)	**4 (2.3)^c**
Total	**59 (28.9)**	**97 (57.3)**	**17 (13.8)**	**173 (100.0)**

Mosquito larval abundance on same column with different letter superscript are significantly different ($p < 0.05$)

Physicochemical Parameters in the different habitats: There was no significant difference in the pH, electrical conductivity, salinity, total dissolved solids, and temperature across the different container size ranges ($p > 0.05$) (Table 4). It is common to find significant differences in physicochemical parameters between different types of mosquito breeding sites (Amawulu *et al.*, 2020; Marubini *et al*., 2025). Differences in habitat characteristics can impact the physicochemical properties of the water, including the nature of the habitats, the source and quality of the water, the stability of the water volume, accessibility, the presence of predators, and exposure to sunlight (Amini *et al.*, 2020; Tsegaye *et al*., 2023). The similarity in the physicochemical characteristics of the container sizes observed in our study may be a result of the concurrent similarity in the type of breeding site. This also suggests some level of homogeneity regarding their mosquito larval habitat quality.

Table 4: Physicochemical Parameters in the different container size range

Parameters	Container 1 Mean±SD (Min – Max)	Container 2 Mean±SD (Min – Max)	Container 3 Mean±SD (Min – Max)	ANOVA F-Value	P value
pH	6.95±0.06 (6.90 – 7.00)	7.10±0.30 (6.80 – 7.40)	6.85±0.07 (6.80 – 6.90)	1.239	p > 0.05
EC(µS/cm)	150.00±41.63 (100.00 – 200.00)	110.00±26.46 (90.00 – 140.00)	145.00±49.50 (110.00 – 180.00)	0.985	p > 0.05
Salinity	29.08±6.71 (23.26 – 34.89)	42.64±6.71 (34.89 – 46.52)	34.89±0.00 (34.89 – 34.89)	4.200	p > 0.05
TDS	79.50±22.07 (53.00 – 106.00)	58.30±14.02 (47.70 – 74.20)	76.85±26.23 (58.30 – 95.40)	0.985	p > 0.05
Temperature	23.25±0.96 (22.00 – 24.00)	22.07±1.01 (21.00 – 23.00)	24.50±0.71 (24.00 – 25.00)	4.095	p > 0.05

Relationship between Physicochemical Parameters, container diameter and abundance of Mosquito Larvae: Significant positive correlations were observed between *Aedes* species and salinity (0.69), *Aedes* species and diameter (0.84), *Anopheles* species and pH (0.83), and *Anopheles* species and *Culex* species (0.80) (Table 5). A study conducted under controlled laboratory conditions found that *Ae. albopictus* could develop and survive in brackish waters (Blanco-Sierra *et al*., 2024). *An. gambiae* and pH had previously been reported to have a positive correlation (Amawulu *et al*., 2020). The positive relationship between *Anopheles* and *Culex* mosquitoes is supported by previous reports of their successful coexistence (Kweka *et al*., 2012; Omoregie *et al*., 2019).

Table 5: Correlation between Physicochemical Parameters and abundance of mosquito larvae

	Correlation Coefficient								
	Culex	*Aedes*	*Anopheles*	pH	EC	Salinity	TDS	Temp	Diameter
Culex	1								
Aedes	0.12	1							
Anopheles	0.80**	.52	1						
pH	0.56	0.44	0.83**	1					
EC	-0.04	-0.50	-0.30	-0.35	1				
Salinity	-0.10	0.69*	0.40	0.29	-0.68*	1			
TDS	-0.04	-0.50	-0.30	-0.35	1.00**	-0.68*	1		
Temp	-0.24	-.38	-.51	-.60	0.74*	-0.68*	0.74*	1	
Diameter	-0.07	.84**	.27	.03	-0.23	0.60	-0.23	0.04	1

***Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed)*

Conclusion: This study identified *Aedes*, *Anopheles*, and *Culex* as key mosquito vectors utilizing containers as breeding sites in Ekosodin. *Anopheles* larvae were the least common, found only in containers sized 20.1 to 30.0 cm, while *Aedes* and *Culex* were more abundant, indicating a higher risk of yellow fever and filariasis. Significant positive correlations were observed between *Aedes* and salinity, *Aedes* and container diameter, *Anopheles* and pH and *Anopheles* and *Culex*, suggesting interactions between environmental factors and species distribution. These findings underscore the critical role of containers as mosquito habitats. To mitigate these risks, targeted interventions such as community awareness campaigns, container management, and larvicides are urgently recommended to reduce mosquito populations and the transmission of mosquito-borne diseases.

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability: Data are available upon request from the corresponding author

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