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Original Article

Species composition and characterization of Anopheline mosquito breeding habitats in Jos-South and Shendam Local Government areas of Plateau State, Nigeria

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ABSTRACT

Mosquitoes play a critical role as agents of disease transmission, particularly where the abundance of breeding habitats supports their proliferation. Understanding the ecology of these vectors is crucial in assessing the potential risk of human exposure to the diseases they transmit and in controlling them. In this study, larvae of *Anopheles* mosquitoes were collected using the dip method from different habitats in Shendam and Jos-South Local Government Areas (LGAs) of Plateau State, Nigeria. Water physicochemical parameters were measured on-site using a handheld multi-parameter device. The larvae were reared to adults and identified using standard identification keys. Five breeding habitats, namely gutters, rain pools, rice fields, hoof prints, and puddles, were characterized, and their physicochemical parameters were analyzed. Overall, 2,513 larvae were reared to emergence as adults, with *Anopheles gambiae* as the dominant species, 1,279 (50.90%), and *Anopheles pretoriensis,* 175 (6.95%) ($p < 0.001$), the least collected species of the four Anopheline species encountered. The most abundant larval habitats were rice fields in Shendam LGA (51.09%) and rain pools in Jos South LGA (43.13%) ($p < 0.001$). The water quality parameters analyzed showed a negative correlation with mosquito abundance. The R-squared value indicates that about 65.22% variation in mosquito abundance is accounted for by the water physicochemical parameters: temperature, pH, conductivity, total dissolved solids, and salinity. However, the variation was not significant, $F_{(5, 6)}=2.25$, $p = 0.1759$. For effective larval source management, initial risk mapping of mosquito breeding sites, combined with improved knowledge of vector ecology and their interactions with humans, should be prioritized to inform interventions against these vectors.

Keywords: anopheline larvae, breeding, habitat, physicochemical parameters

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INTRODUCTION

Mosquitoes are arthropod vectors of many known diseases globally, such as malaria and filariasis, as well as arboviral diseases, including Yellow fever, Rift Valley fever, and Dengue fever (Braack et al., 2018; Wilkerson et al., 2021). According to the World Health Organization (WHO), in 2024, more than 17.0% of all infectious diseases were arthropod-borne diseases, and over 700,000 infected individuals die from these infections annually. Malaria is the commonest mosquito-borne parasitic infection transmitted by the female *Anopheles* mosquitoes, accounting for about 249 million cases globally, which result in more than 608,000 deaths annually, out of which Nigeria recorded 30.9% in 2023 (WHO, 2024). In sub-Saharan Africa, the major malaria vectors are members of the *An. gambiae* complex (*An. gambiae s.s., An. coluzzii* and *An. arabiensis*) and *Anopheles funestus* s.s. (Sinka et al., 2020; Kyalo et al., 2017). These same mosquito species are the primary vectors of malaria in Nigeria. They are widely distributed in the country with a broad range of breeding habitat preferences across different ecological zones (Ebhodaghe et al., 2024). The success of the *Anopheles* mosquito as vectors of parasitic diseases is related to their preference to feed on humans; other factors that influence their disease transmission include socio-economic and environmental factors (Belay et al., 2024).

Malaria is an endemic disease in Nigeria; however, not much attention has been given to the breeding sites of the vectors or other environmental factors that favour the breeding success and distribution of the vectors (Okwa & Savage, 2018). With the exception of the Sahel region, *Anopheles* mosquitoes are widely dispersed across Africa and prefer breeding in clean and clear water of temporal sources. While most *Anopheles* prefer to breed in small collections of standing, clean, and sunlit bodies of water (Okoh et al., 2017), *Anopheles melas* in West Africa and *An. merus* in East Africa prefer salt water (Kipyab et al., 2015; Bartilol et al., 2021).

Recently, however, it has been observed that changing environmental and climatic conditions, such as variations in temperature and precipitation, as well as urbanization, have resulted in an adaptation in the mosquitoes' breeding preferences, allowing them to breed in places previously thought unsuitable for survival or thriving. The ability of mosquitoes to thrive in diverse habitats increases the potential risk of exposure to mosquito-borne diseases and widespread disease infection (Okwa & Savage, 2018). This has raised concern to find effective control strategies, targeted at suppressing mosquito larval densities in the breeding habitats particularly in countries where malaria remains a major health concern (Getachew et al., 2020; WHO, 2019). Larval Source Management (LSM) is one of the tools advanced by the WHO for use in Integrated Vector Management (IVM) (Vivekanandhan et al., 2018). This approach is designed to target the immature mosquitoes by removing standing water or adding larvicides to it, and the use of microbial larvicides or natural predators to kill the mosquito larvae. As a prerequisite for finding an effective larvicide, it is imperative to investigate the key determinants of their population dynamics and have accurate knowledge of the vector species composition, breeding habitats, and physicochemical parameters of the habitats. Malaria is endemic in Nigeria, particularly in Plateau State. However, breeding sites and physicochemical factors influencing mosquito vector distribution and breeding success have received relatively little attention.

This study will provide critical tools in controlling these important disease vectors, especially when their breeding habitats can be readily identified and accessed. This will reduce the Entomological Inoculation Rate and, consequently, the reduction in malaria transmission.

This study was conducted to identify the *Anopheles* mosquito breeding in Jos South and Shendam Local Government Areas of Plateau State and the physicochemical parameters that influence their breeding. Samples were collected using the dip method from different mosquito breeding habitats, and water quality parameters were analyzed to ascertain those parameters that favor larval development and hence their abundance in a particular habitat.

MATERIALS AND METHODS

Study Area

The study sites include communities of Jos South (Zawan and Du) and Shendam (Total and Tumbi) Local Government Areas, Plateau State (Figure 1). Jos South Local Government Area (LGA) is located in the northwestern part of Plateau State, with its headquarters at Bukuru, 15km south of the state capital, Jos. Due to its altitude, the Jos Plateau has a unique climatic condition with the coldest period in November and February, experiencing a mean daily temperature of 18°C, while the warmest months are from March to April, which is also the onset of the rainy season, with temperatures as high as 28°C. The rain lasts until October, and peaks in August. The mean annual rainfall ranges from 1347.5 to 1460mm. Similarly, Shendam LGA has a mean annual rainfall of 1250mm. The rainy season commences around late April and increases gradually to a peak in August then declines gradually until October (Nanvyat et al., 2017). Shendam has an elevation of 259m above sea level and is situated in the lower Plateau State. It is characterized by a temperature of 35°C, high relative humidity and high rainfall. The Local Government Area is surrounded by water swamps where different species of mosquitoes breed all year round at altitudes ≤400m above sea level (Nanvyat et al., 2017).

Larval Collection and Rearing

A longitudinal study design was adopted, and mosquito larval collection was done for two months (October and November 2020). Mosquito larvae were collected using a standard dipping method with a mosquito scoop (Bioquip, Gardena, USA). In cases where dipping wasn't feasible (e.g., containers), contents were emptied into plastic bowls for larvae collection, following established methods (Silver, 2007). The collection was done between 6:00 and 10:00 am from all breeding habitats identified that were positive for *Anopheles* larvae. Larval instars were collected during sampling, and the number counted. In each habitat visited, 10 dip samples were taken and transferred into labeled plastic bottles along with water samples from the breeding sites. For smaller habitats such as animal hoof prints, the collections from a particular location were pooled together to give a volume approximately equal to that obtained for a 10-dip sample. The larvae were then conveyed to the Centre for Disease Surveillance, Malaria

Research Unit, University of Jos, Nigeria and reared to adults in the insectary at ambient laboratory conditions while being fed with baker's yeast. The adults emerged within about 1-6 days and were aspirated into clean Wheaton bottles coated with Chloroform to knock down the adult mosquitoes for identification. The knocked-down mosquitoes were then transferred into petri dishes and identified using a dissecting microscope. The identified mosquitoes were then preserved over silica gel in Eppendorf tubes and stored for further analysis.

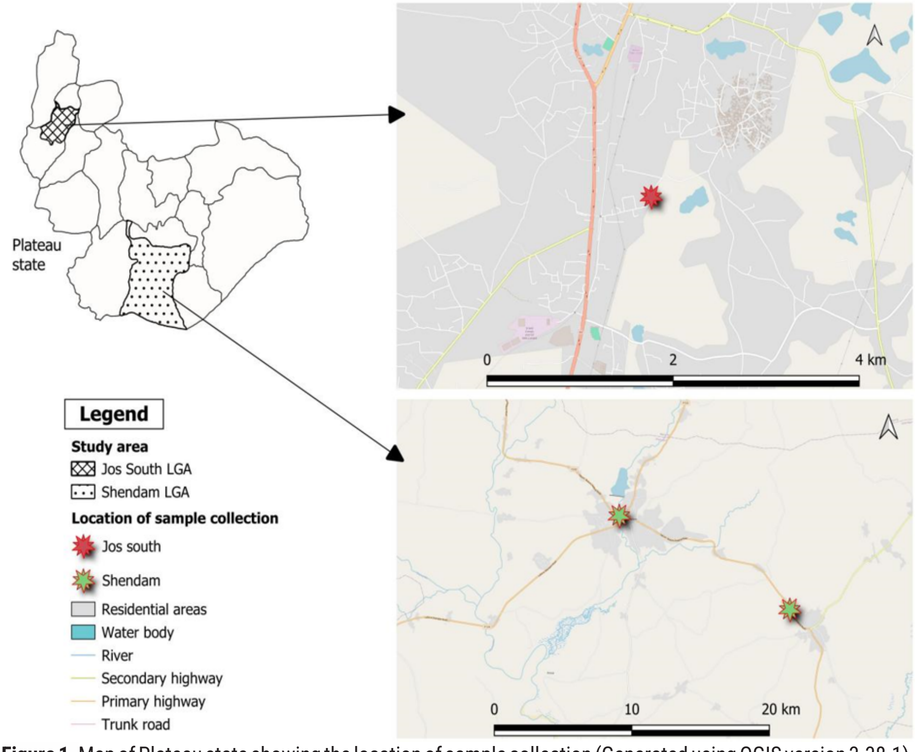

Figure 1. Map of Plateau state showing the location of sample collection (Generated using QGIS version 3.38.1)

Analysis of Water Quality Parameters

While larvae were sampled from the habitats in the field, a handheld Multi-parameter (Eutech PCS Test 35-01X441506/Oakton 35,425. Vemon Hills, Illinois, 60,061, USA) was used to take records of water physicochemical parameters, which were considered crucial for mosquito larvae survival and recorded on site.

Identification of Mosquito Samples

All adult mosquitoes that emerged were identified on the basis of their diagnostic morphological features with the aid of a dissecting microscope as described by Coetzee (2020).

Data Analysis

The data gathered from the study was cleaned and coded in Excel and imported into Stata version 14.0 for statistical analysis. Chi-square test was performed to determine if there was a significant difference in the abundance of each mosquito species collected, and if there was a significant association between mosquito abundance and location, as well as habitats sampled. The Shapiro-Wilk test was used to assess the normality of mosquito larval abundance and the water physicochemical parameters sampled were tested for normality using Shapiro-Wilk's test. Only mosquito larval abundance and water temperature were normally distributed. Consequently, Spearman's rank correlation was used to determine the relationship between larval abundance and the different water physicochemical parameters tested. A Poisson regression model was initially fitted for the relationship between larval abundance and water physicochemical parameters. However, the test of goodness of fit revealed strong overdispersion (Pearson χ^2=217.05, df=6, χ^2/df ≈ 36.18), violating the assumption of equidispersion. As a result, a negative binomial regression model was used to account for the extra-Poisson variation. Statistical significance was determined at $p < 0.05$.

RESULT

Anopheles Species Encountered in the Study

The *Anopheles* species encountered in the two Local Government Areas sampled are shown in Table 1. Overall, 2,513 larvae collected emerged as adults. Morphological identification of these adult mosquitoes shows that four species (*Anopheles funestus, Anopheles gambiae, Anopheles pretoriensis,* and *Anopheles rufipes*) were encountered in the study areas. *An. gambiae* s.l. was the dominant species collected, 1,279 (50.90%), followed by *An. funestus,* 657 (26.14%), and *An. rufipes*, 402 (16.0%) with the least being *An. pretoriensis,* 175 (6.95%). The chi-square test revealed that *An. gambiae* was significantly more abundant ($p < 0.001$) compared to the other mosquito species collected.

Table 1. Species of mosquitoes encountered in Jos South and Shendam Local Government Areas

Species	Frequency	Percent
Anopheles pretoriensis	175	6.96
Anopheles funestus	657	26.14
Anopheles rufipes	402	16.00
Anopheles gambiae s.l.	1,279	50.90
Total	2,513	100

χ^2=1083.85, df=3, $p < 0.001$

Mosquito Species Distribution and Abundance across the Sampled Locations in the Two Local Government Areas

Mosquito distribution and abundance across the sampled locations are shown in Table 2. More mosquitoes were collected in Shendam locations (50.94%) compared to Jos South (49.06%) LGA. In both locations, *Anopheles gambiae* was the dominant species encountered (55.96% in Jos South and 46.02% in Shendam LGA). *An. pretoriensis* was encountered only in Shendam (13.67%), which is the least collected species in the LGA. The chi-square test revealed that mosquito abundance differed significantly ($p < 0.001$) across the two locations.

Table 2. Mosquito species Composition and Abundance across the sampled Locations in the Local Government Areas

Location	Mosquito species collected (%)				Total
	Anopheles funestus	*Anopheles gambiae*	*Anopheles pretoriensis*	*Anopheles rufipes*	
Jos South	462 (37.47)	690 (55.96)	0 (0.00)	81 (6.57)	1,233 (49.06)
Shendam	195 (15.23)	589 (46.02)	175 (13.67)	321 (25.00)	1,280 (50.94)
Total	657 (26.14)	1,279 (50.90)	175 (6.96)	402 (16.00)	2,513 (100)

χ^2=1083.85, df=3, $p < 0.001$

Mosquito Abundance and Habitat Characterization across the two Local Government Areas Sampled

In this study, we encountered mosquitoes breeding in different habitats in both locations that were studied (Table 3). Two habitats were encountered in Jos South: the gutter and the rain pool. More mosquitoes were found in the rain pool (51.09%) than in the gutter (48.91%). *An. gambiae* was the dominant mosquito species collected in both gutter (54.73%) and rain pool (57.14%) ($p < 0.001$). However, in Shendam LGA, three larval habitats were encountered: hoof print, puddle, and rice field. More mosquitoes were collected from rice fields (43.13%) and puddles (30.55%) than from the hoof prints (26.33%). The most dominant species collected from all three habitats was *An. gambiae*: 57.86% from hoof prints, 37.34% in puddles and 44.93% from rice fields ($p < 0.001$).

Table 3. Mosquito abundance in relation to habitats across sampled Locations in the Local Government Areas

Location	Habitat	Mosquito species collected (%)				Total	P-value
		An. funestus	*An. gambiae*	*An. pretoriensis*	*An. rufipes*		
Jos South	Gutter	273 (45.27)	330 (54.73)	0 (0.00)	0 (0.00)	603 (48.91)	<0.001
	Rain pool	189 (30.00)	360 (57.14)	0 (0.00)	81 (12.86)	630 (51.09)	
	Total	462 (37.47)	690 (55.96)	0 (0.00)	81 (6.57)	1,233 (100)	
Shendam	Hoofprint	26 (7.72)	195 (57.86)	0 (0.00)	116 (34.42)	337 (26.33)	<0.001
	Puddle	53 (13.55)	146 (37.34)	83 (21.23)	109 (27.88)	391 (30.55)	
	Rice field	116 (21.01)	248 (44.93)	92 (16.67)	96 (17.39)	552 (43.13)	
	Total	195 (15.23)	589 (46.02)	175 (13.67)	321 (25.08)	1,280 (100)	

Association between Larval Mosquito Abundance and Water Physicochemical Parameters

The mean values of the water parameters sampled across the different larval habitats are presented in Table 4. The relationship between mosquito abundance and water physicochemical parameters is presented in Figure 2. Spearman's rank correlation was used to examine the relationship between larval mosquito abundance and selected water physicochemical parameters from the 12 larval habitats sampled (Figure 2). The result showed that all the water parameters tested were negatively correlated with larval mosquito abundance. However, while conductivity (ρ=-0.678, p = 0.015), total dissolved solids (ρ=-0.638, p = 0.026) and salinity (ρ=-0.629, p = 0.028) were significantly (p < 0.05) correlated with larval abundance, the correlation between larval mosquito abundance and temperature (ρ=-0.371, p = 0.236) and pH (ρ=-0.403, p = 0.192) were not statistically significant (p > 0.05).

Results of the negative binomial regression indicated that the model was statistically significant overall (Likelihood Ratio $\chi^2(5)$=15.81, p = 0.0074), explaining approximately 10.6% of the variance in mosquito larval abundance (pseudo R^2=0.1062). A test for overdispersion yielded a significant result (α=0.088, p < 0.001), supporting the use of the negative binomial model over a Poisson model. Despite the overall model significance, none of the individual predictors were statistically significant (p > 0.05) after adjusting for the others, likely reflecting the combined effect of predictors and multicollinearity among conductivity, TDS, and salinity. Directionally, pH, conductivity, and TDS showed small positive associations with larval abundance (27.4%, 1.2%, and 1.5% increases, respectively), while temperature and salinity showed small negative associations (0.6% and 5.4% decreases, respectively). These effects were not statistically significant, indicating that other environmental or habitat factors may better explain variations in larval abundance in the sampled habitats.

Table 4. Water quality parameters assessed

Location	Habitat	Temperature (°C)	pH	Conductivity (µS/cm)	Total Dissolved Solids (mg/L)	Salinity (ppt)
Jos South	Gutter	21.20±0.20	6.42±0.01	80.00±0.20	57.00±0.10	41.00±0.20
	Rain pool	26.10±0.10	6.62±0.01	14.80±0.10	11.00±0.10	15.65±0.15
Shendam	Hoof print	30.00±1.00	6.75±0.02	59.35±1.35	41.50±1.50	34.50±0.50
	Puddle	30.75±0.56	7.03±0.24	360.50±56.70	257.50±43.43	181.00±29.41
	Rice field	32.00±4.00	6.90±0.20	147.50±67.50	104.50±47.50	75.50±30.50

Table 5. Negative binomial regression analysis for the association between mosquito abundance and water quality parameter

Predictor	Coef. (β)	Exp (β) (IRR)	Std. Err.	z	*P-value*	95% CI
Temperature	-0.006	0.994	0.039	-0.15	0.878	[-0.082, 0.070]
pH	0.242	1.274	1.062	0.23	0.820	[-1.839, 2.323]
Conductivity	0.012	1.012	0.033	0.37	0.711	[-0.052, 0.077]
Total Dissolved Solids	0.015	1.015	0.074	0.20	0.840	[-0.130, 0.159]
Salinity	-0.055	0.946	0.059	-0.92	0.357	[-0.171, 0.062]
Constant	4.801	121.49	5.919	0.81	0.417	[-6.800, 16.402]
Dispersion (α)	0.088		0.037	–	<0.001	[0.038, 0.202]

Note: IRR= Incident Rate Ratio

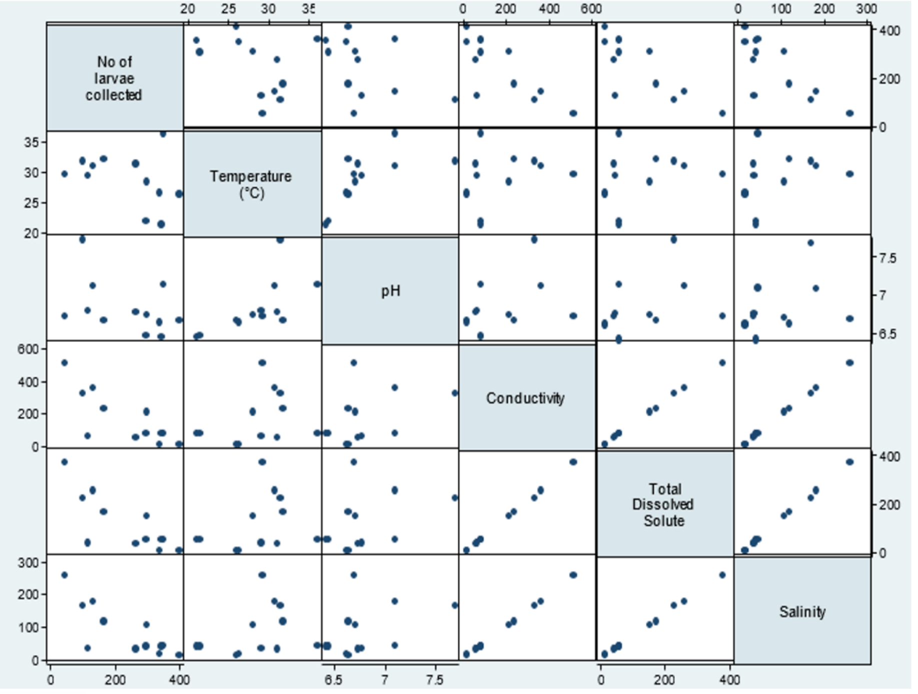

Figure 2. Correlation between mosquito larval abundance and water physicochemical parameters studied.

DISCUSSION

Over time, the menace of malaria infection has continued to raise huge concerns the world over. Although much effort targeted at the vectors, such as the use of Long-lasting insecticide-treated nets, has been put into the control and prevention of the disease, much still needs to be done, particularly in the area of controlling the immature stages that mature and give rise to the adults which constitute the public health problem. In this study, we characterized the breeding habitats of *Anopheles* mosquitoes across two local government areas of Plateau State, Nigeria, and identified the physicochemical parameters that favour their breeding in their respective habitats.

In this study, four *Anopheles* species were encountered, among which were key vectors of the human *Plasmodium* parasites. The fact that *An. gambiae* s.l. and *An. funestus* (the primary vectors of malaria in Nigeria) were the dominant species encountered raises deep concern for malaria transmission in the area. Contrary to this study, however, Lapang et al., (2019) recorded 6 *Anopheles* species in their study in Shendam LGA, even though they also recorded *Anopheles gambiae* as the most abundant *Anopheles* species encountered. Except for *Anopheles pretoriensis,* the two-mosquito species encountered *An. gambiae* and *An. funestus* are significant vectors (Akeju et al., 2022; Odero et al., 2023) of malaria in Nigeria, with *Anopheles rufipes* being a secondary vector (Oduwole et al., 2019). While *An.*

pretoriensis has been documented in Nigeria US Presidential Malaria Initiative (PMI, 2022), there is limited evidence implicating it as a malaria vector, even though it could be a potential vector of the *Plasmodium* parasite. There is a need, therefore, to monitor the vector potency of this species to ascertain the potential public health threat it may pose to the population.

Across the two locations surveyed, mosquito abundance was slightly higher in Shendam compared to Jos South Local Government Area, with *Anopheles gambiae* being the most abundant species encountered. However, *Anopheles pretoriensis* was encountered only in Shendam LGA, which was also reported in an earlier study by Lapang et al. (2019). Wang et al., (2016) have observed previously that agricultural practices such as afforestation, deforestation and irrigation which alters the landscape of the environment providing favorable sites for mosquito breeding. In addition to this, anthropogenic activities have equally favored the breeding of many mosquito species close to human residence, thereby increasing the chances of disease transmission. On the other hand, climate changes, such as varying temperature levels, rainfall, and relative humidity, are major ecological factors that tend to shape the environment, making it conducive for mosquito breeding (Hasnana et al., 2016; Wilke et al., 2019). The weather condition in Shendam, which is usually hot, was likely a key factor favoring the abundance of the vectors in the place (although this was not the focus of the current study) compared to Jos-South, which is colder. The slightly lesser number of larvae observed in Jos South LGA is presumably due to the lower temperature, as was previously reported by Afolabi et al., (2019), who found that no mosquitoes bred in habitats where temperatures were below 25°C.

Different mosquito breeding habitats were encountered in both locations in this study. According to Egbuche et al., (2019), *Anopheles* species show selective preference for the kind of water they breed in. Among the two habitats encountered in Jos South LGA, more mosquitoes were found breeding in rain pools than in gutters. Contrary to our findings, however, Hessou-Djossou et al. (2022) found gutters to have the highest mosquito larval density in their study in Benin. In Shendam LGA, however, while three breeding habitats of *Anopheles* mosquitoes were encountered, higher breeding activities were observed in rice fields, followed by puddles, with the least being hoof prints. It has been reported that *Anopheles* often breed in clean, shallow water (Okoh et al., 2017), which could be the reason for the observations made in the current study. Other reports have also shown that *Anopheles* mosquitoes breed more in rice fields as the rice blades and stalks serve as speed breaks for the water, thereby reducing the rate at which the larvae are washed away during heavy downpours compared to other habitats (Zogo et al., 2019; Mathania et al., 2020). Similar to our study, Mattah et al. (2017) found *Anopheles* larvae breeding in puddles. Also, in agreement with this study is the work by Ondiba et al., (2019), who reported that *An. gambiae* larvae prefer to breed more in habits exposed to sunlight. In this study, we encountered fewer larvae in animal hoof prints. This could be due to the fact that they are transient habitats that tend to dry off quickly; this corresponds to the finding of a study in Ethiopia which reported that mosquito larvae surviving in transient habitats such as hoof prints, rain pools, rock pools and tyre tracks were fewer than in other sites (Getachew et al., 2020).

In this study, it was observed that mosquito larval abundance showed weak negative correlations with all measured water quality parameters (temperature, pH, conductivity, total dissolved solids (TDS), and salinity), implying that increases in these parameters were generally associated with slight declines in larval abundance. The weak association also suggests that these parameters alone are not strong independent predictors of larval abundance in the study area.

The result of the negative binomial regression model, although statistically significant overall, showed that none of the individual predictors significantly ($p > 0.05$) predicted mosquito abundance and the estimated incidence rate ratios (IRRs) were close to 1. This indicates that while the observed physicochemical parameters collectively explained some variation in larval abundance (pseudo-R^2=0.1062), no single parameter exerted a strong independent effect after controlling for the others. The lack of significance for individual predictors likely reflects high intercorrelation among conductivity, TDS, and salinity, as well as the influence of other unmeasured ecological factors.

Temperature is a well-recognised determinant of mosquito development. Musonda and Sichilima (2019) reported the absence of *Anopheles* larvae in habitats exceeding 27°C, while Bayoh and Lindsay (2023) identified a broader range of 18–32°C as generally suitable for breeding. In this study, the recorded water temperatures were mostly within this favourable range; however, in sites such as Shendam, where temperatures approached the upper limit (~32°C), larval abundance declined. This suggests that although temperatures were generally conducive, values at the higher extreme may still suppress larval survival or development.

A similar trend was observed for pH. Previous research indicates that mosquito breeding is favoured within a pH range of 4.0–7.8 (Emidi et al., 2017; Chaiphongpachara et al., 2018). All larval habitats sampled in this study were within this range, suggesting conditions were suitable for development. Nonetheless, the weak negative correlation and non-significant regression coefficient for pH imply that site-specific ecological conditions—such as habitat type, predator presence, organic matter content, and vegetation cover—may modulate the relationship between pH and larval abundance.

Overall, our findings suggest that while physicochemical parameters in the study sites were generally within ranges considered optimal for mosquito breeding, small increases in these values, particularly toward their upper limits, were associated with modest declines in larval abundance. The weak correlations, non-significant regression coefficients, and relatively low explained variance highlight the likelihood that other environmental, biological, and anthropogenic factors could have had an effect on larval abundance in the sampled habitats.

While both temperature and pH showed a weak correlation with mosquito abundance, the other factors, conductivity, total dissolved solids, and salinity, showed a strong negative correlation with mosquito abundance. It has been suggested that mosquito larvae generally thrive within specific environmental thresholds which include temperatures between 20–30°C, pH between 6.5–8.5, conductivity less than 500μS cm^{-1}, TDS between 50–500mg L^{-1}, and salinity below 5ppt. Exceeding these ranges has been shown to significantly reduce mosquito larval survival and abundance (Muturi et al., 2008; Mutero et al., 2000; Musonda & Sichilima, 2019).

Contrary to our findings, Ojianwuna et al., (2021), Obi et al., (2019) and Akeju et al., (2022) found a positive correlation between these factors and mosquito abundance in their study. However, our study agrees with the finding of Soltan-Alinejad et al., (2023) who reported that these parameters were negatively correlated with the density of container-breeding mosquitoes in their studies. The implication of the result of the correlation recorded in this study is that manipulating habitats, so that the various water physicochemical parameters are outside the optimal ranges for larval survival and development, could serve as a suitable means for larval source management. However, the fact that these factors were not significant predictors of larval abundance in the habitats shows that other confounding factors outside the scope of this study could have influenced mosquito breeding and abundance in these habitats. Studying this further will give more insights into the breeding successes of mosquito larvae in their respective habitats.

CONCLUSION

In conclusion, this study highlights the presence of four *Anopheles* species in the surveyed areas, with *An. gambiae* and *An. funestus* posing significant public health concerns as primary malaria vectors in Nigeria. Breeding habitats of *Anopheles* mosquitoes varied between Shendam LGA and Jos South LGA. In Shendam, rice fields were the primary breeding site, followed by puddles and hoof prints. In Jos South, rain pools were found to be more conducive to mosquito breeding than gutters. Our findings suggest that while water quality parameters are essential for larval development, they do not solely predict larval abundance. This indicates that other factors interact with physicochemical parameters to facilitate the breeding of these vectors. Therefore, elucidating these factors is crucial for effective larval source management, a critical component of mosquito control strategies. Further research is warranted to inform the development of targeted and sustainable vector control interventions.

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Author Contributions

MNJ and HBM conceived the project. MNJ, TMA and IL carried out the collections. MNJ, TMA, IL and EOO performed the experiments and organized the data. EOO performed data analysis and interpretation. NN, and MNJ drafted the initial manuscript, with HBM providing critical reviews. All authors contributed to and approved the final manuscript.

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Availability of Data and Materials

Data and materials generated or analyzed during this study are available from the corresponding author upon request.

Ethical Considerations

The study does not involve the use of animals or human.

Competing Interest

The authors declare no competing interests.

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