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ORIGINAL RESEARCH ARTICLE

Mosquito Species Composition in Nasarawa Local Government Area, Nasarawa State, Nigeria

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ABSTRACT
Numerous mosquito species are capable of carrying various tropical diseases. This study ascertained the composition of mosquitoes in Nasarawa Local Government Area, Nasarawa State, Central Nigeria. Adult mosquitoes were collected between 0600 and 0900 hours in the morning using a battery-operated Prokopack aspirator. The mosquitoes were then placed in a petri dish with proper labelling and taken to a laboratory for identification and dissection. Using a dissecting microscope and identification key, mosquitoes were sorted and morphologically classified according to their morphological features. The mosquito midgut was dissected to check for sporozoites infectivity. The man-biting rate (MBR) and indoor resting density (IRD) were computed. A total of 314 adult mosquitoes, spanning four species and belonging to the Anopheline and Culicine mosquito groups, were found to be resting indoors with *An. gambiae* representing 39.2% of the total composition. A significant difference in mosquito abundance ($\chi2$= 58.866, df = 3, P=0.001) was observed between the four species that were reported. There is no discernible variation in the mosquito composition in the research region ($\chi2$= 4.861, df = 2, P = 0.088). A statistically significant variance in sex was noted ($\chi2$=285.235, df = 2, P = 0.000). The biting rate was recorded at 2.6 bites per person per night, and an indoor resting density of 5.23 mosquitoes per room per night was recorded. There was a noteworthy distinction in the abdomen condition of the mosquitoes ($\chi2$ = 45.564, df = 3, $p < 0.001$). Mosquito species abundance in October was 200 (63.7%), compared to 114 (36.3) in September. Nonetheless, a noteworthy distinction was observed in the abundance of mosquito species throughout the research months ($\chi2$= 7.5076, df = 1, P-value = 0.006). Based on the study's findings that provided insight into the species composition of the mosquito population in the study area, it is recommended to remove possible breeding grounds, promote the use of insecticide-treated nets, and prioritize interrupting vector-human contact as a means of halting the spread of malaria parasites.

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INTRODUCTION

An efficient and successful mosquito control program requires mosquito surveillance. An important source of information for assessing the possibility of mosquito-borne illness transmission is the dynamics of fluctuating mosquito populations (Njila et al., 2022). Mosquitos are worldwide in distribution (Ombagadu et al., 2020) and have well-developed adaptations that enable them to thrive during breeding in various environments such as contaminated and clean little water bodies, buckets, tyres, and hoof prints (Williams & Pinto, 2012). Anthropogenic activities such as road construction, mining, and irrigation farming, which are intended to improve the quality of life of people, give rise to breeding sites that are in favorable conditions for disease vectors to thrive (Ombagadu *et al.*, 2020).

Mosquito species composition has been studied and determined in several parts of the world. Numerous mosquito species are capable of carrying various tropical diseases. Only 10% of the more than 4,000 mosquito species that exist today are effective carriers of diseases that affect people's well-being and health (Manguin *et al.*, 2009).

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In their natural habitats, *Anopheles* and *Culex* species are year-round residents, with population abundance maxima corresponding with seasonal variations (Onyango *et al.*, 2013). It is established that Culex quinquefasciatus can spread lymphatic filariasis. By biting people, mosquitoes can also spread the West Nile virus (WHO, 2020). Birds are typically the virus's reservoir, and they contract it from them (WHO, 2020).

Although mosquitoes from other genera can also spread the West Nile virus, *Culex* mosquitoes are the main vectors (Franklinos *et al.*, 2019). Humans and other domestic animals are among the many vertebrate hosts that are afflicted by mosquito-borne diseases (Flies *et al.*, 2016). Mosquitoes can spread a variety of pathogens, including *Plasmodium* species, which causes malaria (WHO, 2016); filarial worms, such as Brugia malayi, Wuchereria bancrofti, and Brugia timori, cause filariasis (WHO, 2016); viruses, like chikungunya, yellow fever, Zika, and dengue fever, are caused by viruses. Just a small percentage of the more than 2,500 species of Anopheles mosquitoes are able to spread parasites (Menard *et al.*, 2013).

Malaria is not only hampering socio-economic development but has remained a primary cause of morbidity and mortality, particularly in the endemic areas, and lack of adequate knowledge of the vector and the disease, especially in Nasarawa LGA. Hence, it's paramount to determine the abundance and transmission potential of malaria vectors because little or no knowledge is known. This work is intended to generate baseline data that could be used as a springboard for further bionomic study or by researchers and other authorities for control or intervention. The research aim is to identify the mosquito population in Nasarawa Local Government Area.

MATERIALS AND METHODS

Study area

The research was carried out in Nasarawa Local Government Area of Nasarawa State, Nigeria. Nasarawa LGA is situated at latitude 7.7013° E and longitude 8.5345°N. One hundred eighty-nine thousand eight hundred thirty-five people call the 5,704 km2 local government area home, according to the 2006 census. Farming and fishing are the main jobs held by residents of Nasarawa LGA. In Nasarawa, the temperature is relatively high (360C), and the relative humidity is 30%. According to Agidi *et al.* (2017), the dry season lasts from November to March, while the wet season is seven months long (April to October). The research work was carried out between September and October 2023.

Selection of houses

Within the study areas, a sample of sixty houses was collected using a stratified random sampling design. The size of each location determined the number selected based on the targeted sixty houses. Twenty-eight (28) homes from Nasarawa Central (which has seven electoral wards), 20 homes from Udege Development Area (which has five electoral wards), and 14 homes from Loko Development Area (which has three electoral wards) were chosen from the sample of 60 homes. Each research area's residences were chosen using a random sample technique (Ombugadu *et al.*, 2022). There was a 200-meter separation between each of the chosen homes. Before being collected, a list of residences was chosen, and the residents were advised to keep their windows and doors closed while the sample was being taken.

Mosquito sample collection

Mosquitoes were collected indoors in the study Areas between September and October 2023 during the late raining season. Throughout the study duration, two visits were made to each household. Using a battery-operated Prokopack aspirator, the adult mosquitoes were trapped in the morning between 0600 and 0900 hours (Ombugadu *et al.*, 2022).

Identification of Mosquito Species

Mosquitoes were identified under a dissecting microscope and identification key, as described by Coetzee (2020) and Buttachon *et al.* (2022).

Dissection of Mosquitoes

Key points of entry and exit for diseases include the salivary glands and midgut of mosquitoes. The dissection procedure was followed in accordance with the methodology outlined by Williams and Pinto (2012).

Entomological Transmission Indices

Mosquito species Indoor Resting Density

Williams and Pinto's (2012) formula was used to calculate the indoor resting density (IRD) of female mosquitoes per building per night.

$$IRD = \frac{\text{Total number of female vectors collected}}{\text{Total number of houses}}$$

Man-biting rate (MBR)

The man-biting rate of a vector species is the average number of bites per person per night, which is governed by both the vector's feeding behavior and the local population's nighttime pattern. The human bite rate per night is determined using the standard approach developed by Williams and Pinto (2012) and Braack *et al.* (2015).

$$MBR = \frac{\text{No. of female mosquitoes collected (F)}}{\text{Total number of occupants (W) in the houses}}$$

Statistical Analysis

The data was analyzed using Minitab Statistical Package version 21.1.3. Simple descriptive statistics were used to calculate the percentages of entomological transmission indices. The proportion of Anopheline mosquitoes in each neighborhood and Entomological transmission indices from the study location were compared using Pearson's Chi-square (χ2). P < 0.05 was set as the significance level.

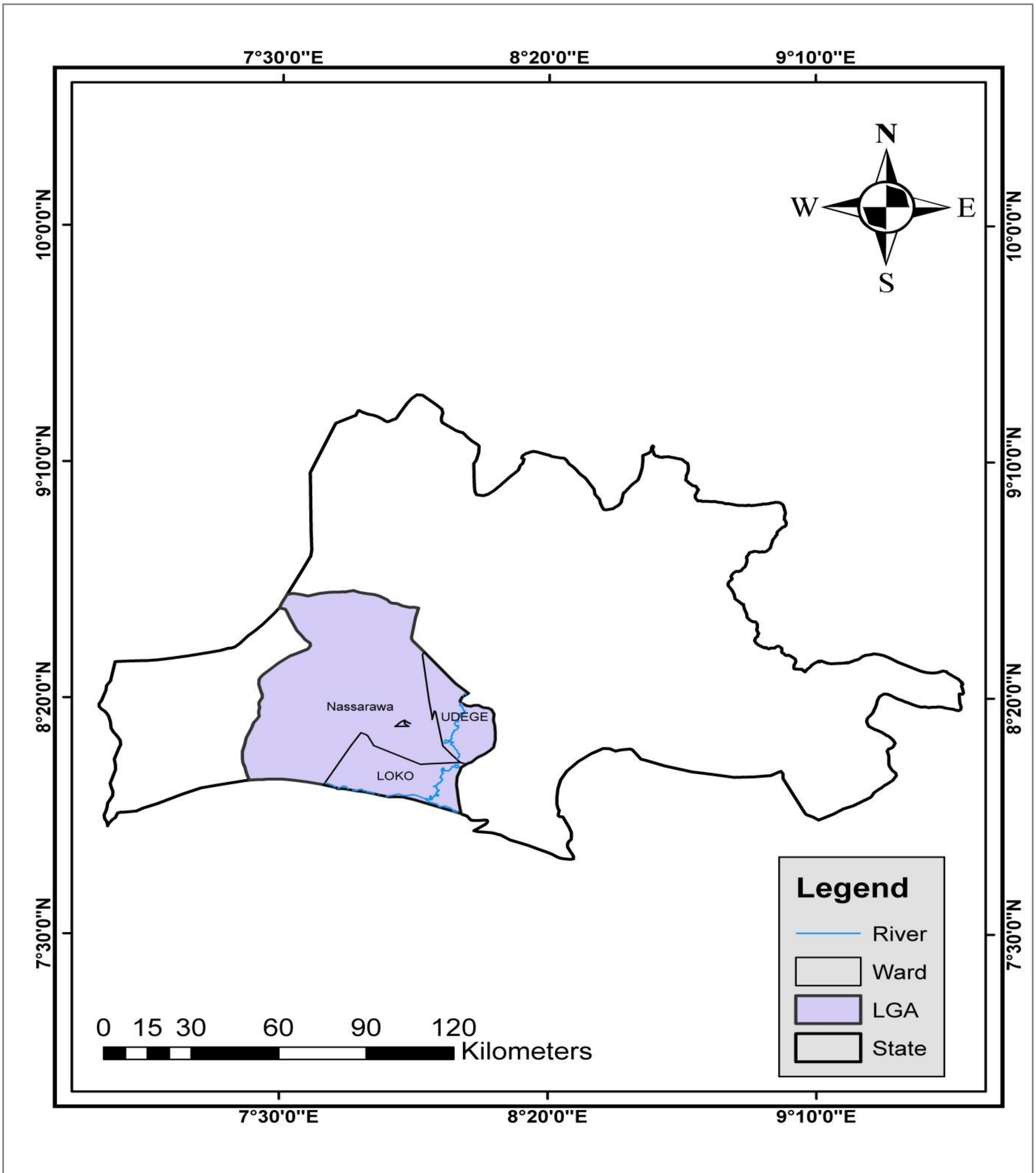

Figure 1: Map of Nasarawa Local Government Area, Nasarawa State (NAGIS, 2024)

RESULTS

Mosquito Species Composition and Abundance in the Sampled Communities

There were 314 adult mosquitoes found resting indoors; they were from four different species and two mosquito families, Anopheline and Culicine (Table 1). *An. gambiae* was the most commonly encountered species of mosquito with 123 (39.2%) followed by *Cx. quinquefasciatus* 100 (31.8%), *Mansonia* species46 (14.6%), while *Anopheles funestus* 45 (14.3%) is the least encountered. However, statistically, there was variation (χ^2= 19.3352, df = 3, P<0.05) in mosquito species encountered. With respect to Sampled communities, Loko had a higher number of mosquitoes, 137 (43.6%), followed by Udege, 93 (29.6%), while Nasarawa had the Least number of mosquitoes, 84 (26.8%) respectively.

However, no difference (χ^2= 4.861, df = 2, P =0.088) in relation to the communities sampled was observed. A great variation (χ^2=285.235, df = 2, P<0.05) in sex-wise variation was observed where female mosquitos were found to be 314 (96.9%) more abundant than males 10 (3.1%).

Mean Abundance of Mosquito Species with Respect to the Type of House

Figure 2 represents the total mean abundance of *Anopheles* species versus the type of house. Houses with thatch roofing had a higher mean abundance of mosquito species, 92.0±29.7, than houses with zinc roofing, 65.0±31.1. However, no significant differences (df =1, F =0.79, P=0.468) were observed with respect to type of house.

Mean Abundance of Mosquito Species and Insecticide Usage

Figure 3 shows the mean abundance of *Anopheles* species versus the use of an insecticide. 118.0±66.5 responded yes for using insecticide in their various rooms, while 39.00±5.66 responded no for not using insecticide in their various homes. However, no significant differences (df =1, F =2.80, P=0.236) in the mean abundance of *Anopheles* species and insecticide usage were observed.

Mean Abundance of Mosquito Species in Relation to Use of Net

Table 2 shows the mean abundance of *Anopheles* species versus the use of net. 84.0±39.6 responded yes, they are using mosquito nets in their various rooms, while 73.0±21.2 answered no to questions regarding the usage of mosquito nets in their various homes. However, no differences (df =1, F =0.12, P=0.762) in the mean abundance of *Anopheles* species and the use of net were observed.

Entomological Transmission Indices of the Mosquitoes across Species

Table 3 represents the entomological transmission indices of mosquitoes across species, i.e., indoor resting density (IRD) and man-biting rate (MBR). *Culex quinquefasciatus* had the highest IRD and MBR compared to the other mosquito species in September, while *An. gambiae* had the highest IRD and MBR of the species of mosquito in October, as shown in Table 3.

Abdominal Condition of Female Mosquitoes

Table 4 shows that the majority of female mosquitoes trapped indoors were fed 166 (52.9%), followed by unfed individuals 73 (23.3%) and gravid ones 46 (14.6%), with half gravid females being the least 29 (9.2%). A significant difference ($\chi2$ = 45.564, df = 3, p < 0.001) in abdominal condition of female mosquitoes was observed.

Mosquito Species Abundance in Relation to the Months of Study

Table 5 displays the abundance of mosquito species by month of study in the area. October had 200 mosquito species (63.7%) more than September, which had 114 (36.3). The abundance of mosquito species varied significantly ($\chi2$= 7.5076, df = 1, P=0.006) during the research months.

Table 1: Species Abundance and distributions of mosquitoes in the study locations

			Communities			Sub-total (%)	Grand Total (%)
			Nasarawa	Udege	Loko		
Anopheline	*Anopheles gambiae*	Male	2	0	3	5(3.91)	128 (39.5)
		Female	33	39	51	123(96.09)	
	Anopheles funestus	Male	0	0	1	1(2.17)	46 (14.2)
		Female	7	18	20	45 (97.83)	
Culicine	*C. quinquefasciatus*	Male	1	0	2	3 (2.91)	103 (31.8)
		Female	44	26	30	100 (97)	
	Mansonia spp	Male	0	0	1	1 (2.13)	47 (14.5)
		Female	0	10	36	46 (97.9)	
	Total (%)		87 (26.85)	93 (28.70)	144 (44.44)	324 (100)	324 (100)

C. quinquefasciatus = *Culex quinquefasciatus*

χ^2 between mosquito species = (χ^2= 19.3352, df = 3, P-value =0.001*)

χ^2 between communities = (χ^2= 4.861, df = 2, P-value =0.088^{ns})

χ^2 between male and female mosquitoes = (χ^2= 285.235, df = 2, P-value =0.001*)

* = Significant

ns = Not significant

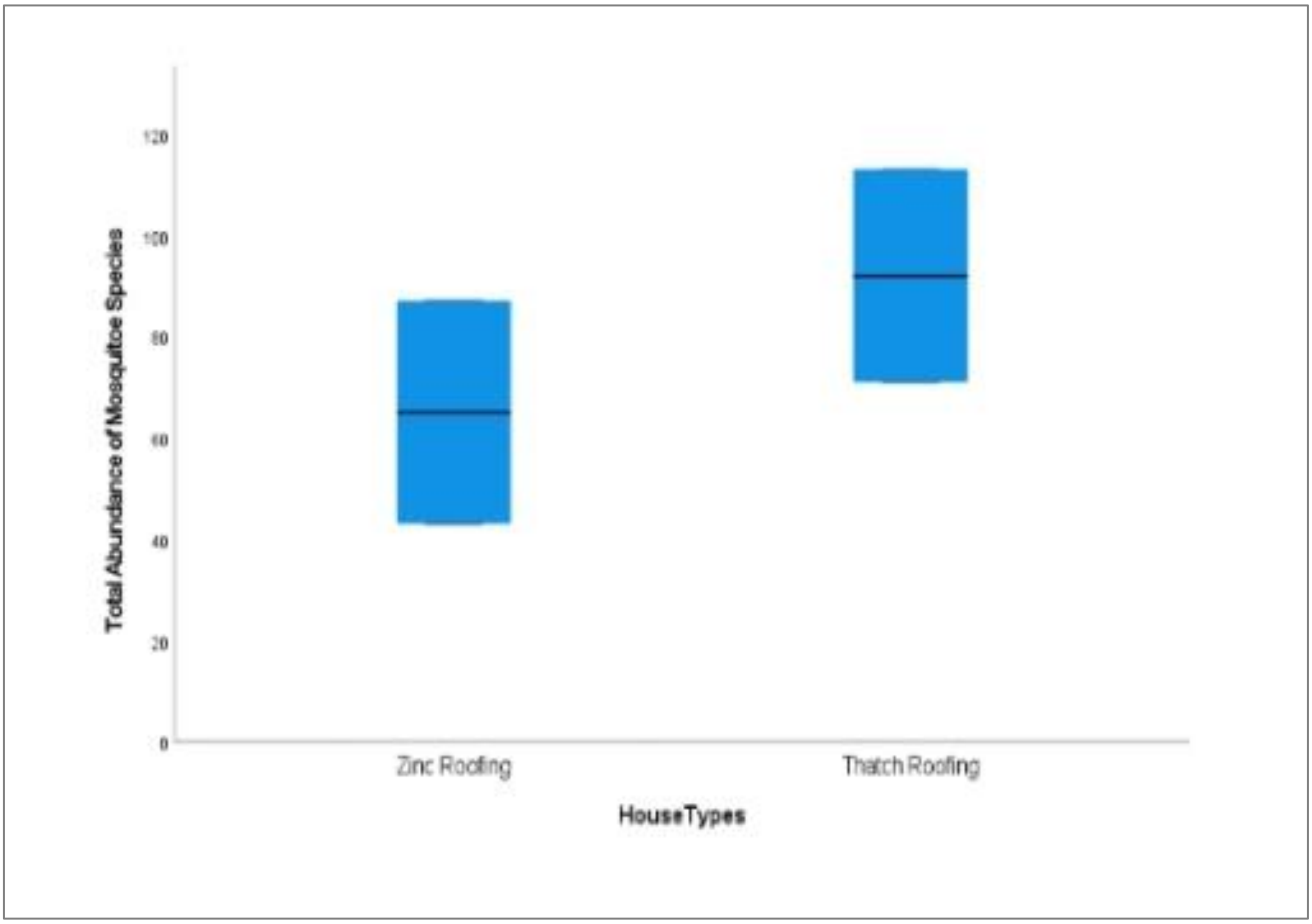

Figure 2: Mean Abundance of *Anopheles* spp and House types

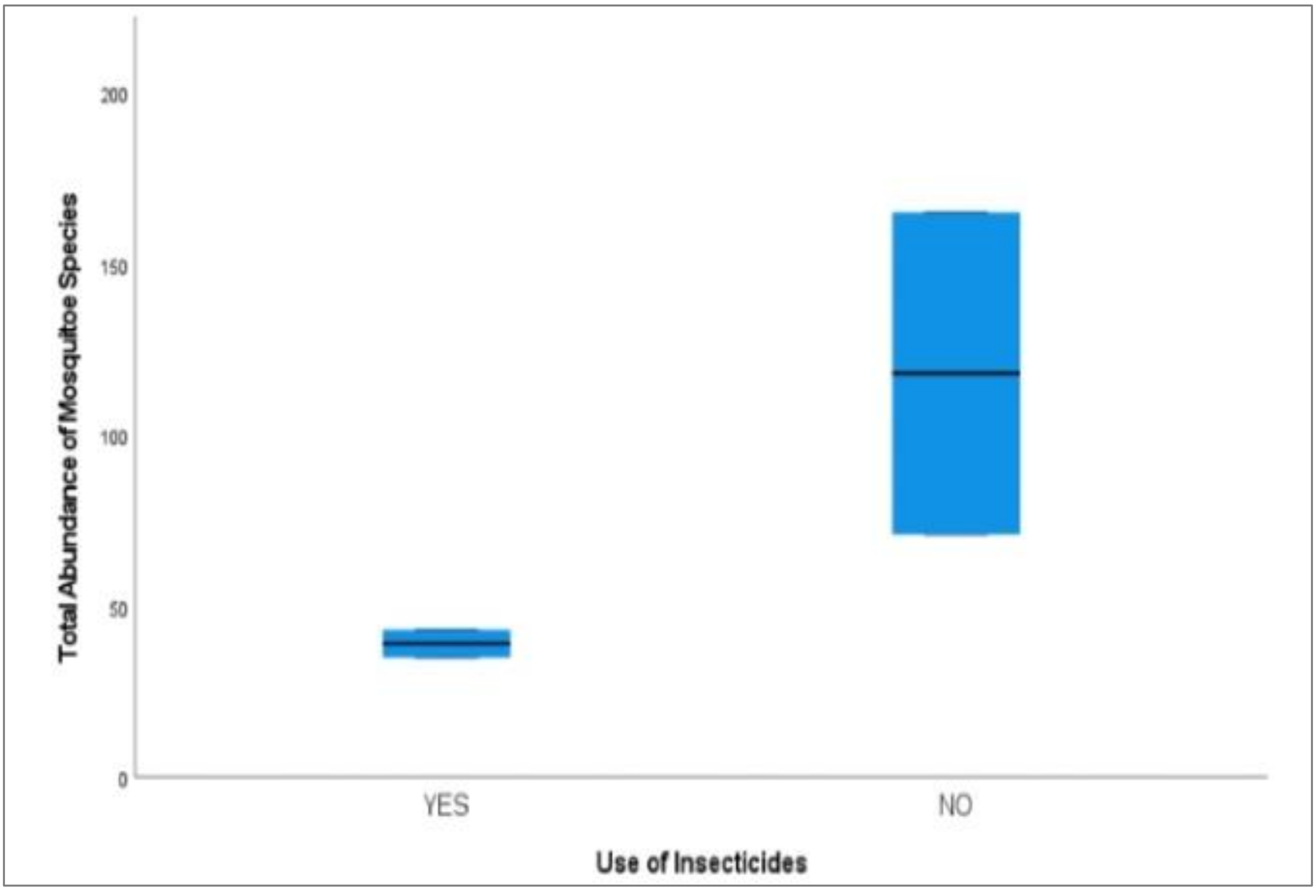

Figure 3: Mean Abundance of *Anopheles* spp versus Use of Insecticide

Table 2: Mean Abundance of *Anopheles* spp in relation to Use of Net

Use of Net	Mean±SEM	Df	F	P-Value
YES	73.0±1.2	1	0.12	0.762[ns]
No	84.0±39.6			

ns= not significant.

Table 3: Indoor resting density (IRD) and Man-biting rating (MBR) of Mosquito species

Months	Mosquito Species	No. Examined	IRD/room (n=60)	MBR/person (n=121 persons)
SEP- 2023	*An. gambiae*	38	0.63	0.31
	An. funestus	4	0.07	0.03
	Culex quinquefasciatus	54	0.90	0.45
	Mansonia spp.	18	0.30	0.15
	Total	**114**	**1.90**	**0.94**
OCT-2023	*An. gambiae*	85	1.42	0.70
	An. funestus	41	0.68	0.34
	Culex quinquefasciatus	46	0.77	0.38
	Mansonia spp.	28	0.47	0.23
	Total	**200**	**3.33**	**1.65**
	GRAND TOTAL	**314**	**5.23**	**2.60**

Table 4: Physiological State or Abdominal condition (freshly fed, unfed, half gravid and gravid)

Abdominal Condition	Number (%)	χ^2	Df	P-value
Fed	166 (52.9)	45.564	3	0.000*
Unfed	73 (23.3)			
Half Gravid	29 (9.2)			
Gravid	46 (14.6)			
TOTAL	314 (100)			

***Significant**

Table 5: Monthly Variation of the Mosquito Species in Relation to Abundance in the Study Area

Months	*Anopheles gambiae*	*Culex*	*Anopheles funestus*	*Mansonia Spp.*	Total (%)
SEP-23	38	54	4	18	114 (36.3)
OCT-23	85	46	41	28	200(63.7)
Total	**123**	**100**	**45**	**46**	**314(100)**

χ^2= 7.5076, df = 1, P-value =0.006

DISCUSSION

The study's findings revealed that the study regions investigated may be susceptible to diseases spread by mosquitoes due to the species of mosquitoes found, and this has been linked to public health concerns. The mosquito species recorded in this study include *An. gambiae* (123) as the most dominant, followed by Culex quinquefasciatus (100), *A. funestus* (45), and *Mansonia* species. Loko had 137 (43.6%) more mosquitos than Udege (93, 29.6%) and Nasarawa (84, 26.8%) of the mosquito species encountered in the communities sampled. The existence of freshwater pools in the communities examined, which are *An. gambiae* preferred breeding locations, which could explain why more Anopheles were observed in this study than culicines, who prefer contaminated water bodies as breeding grounds. *Anopheles* species abundance reported here agrees with the results of Ezihe *et al.* (2019) and Dogara *et al.* (2012), who reported *Anopheles* species to be the most dominant species with 137 and 325, respectively, in their studies. Similarly, higher number of *Anopheles gambiae* was reported by Ezeigwe *et al.* (2015) and Ombugadu *et al.* (2020), both in Nigeria. However, these findings disagree with the results of Yoriyo *et al.* (2013), Okorie*et al.* (2014), and Ombugadu *et al.* (2020), who reported *Culex* species as the most dominant species in their studies and the availability of polluted breeding sites which is preferred by *Culex* species in study areas where the studies were conducted as a factor which makes them dominant over *Anopheles* species which prefer freshwater bodies as their breeding sites.

The monthly variation in mosquito species abundance in the study areas showed more mosquito species 200 (63.7%) were encountered during October compared to the 114 (36.3%) encountered in September. This variation could be attributed to favourable weather conditions in October, which allows more mosquito eggs to hatch. The findings of this study disagree with the findings of Manzoor *et al.* (2020), who recorded more mosquito species in September in a research conducted in Pakistan.

The low population of *An. funestus* encountered in this investigation may be attributed to the notion that *Anopheles gambiae*is far more anthropophilic, endophagic, and endophilic in comparison with *An. funestus,* which is typically zoophilic, exophagic, and exophilic. This is in agreement with the findings of Kilama (2010) and Goupeyou-Youmsi *et al.*(2020) who encountered fewer numbers of *An. funestus* in their studies. However, these research findings are in disagreement with the results of Braack *et al.* (2015) which report higher numbers of *An. funestus* in a study conducted in Ghana, and this could be attributed to the different ecology of their study area.

More female indoor resting mosquitoes were observed than males, which could be attributed to the fact that females require blood meals to provide nutrition for the growth of their fertilized eggs. Thus, this is a public health problem since only female mosquitos bite and suck blood, and diseases spread by mosquitoes are likely to be spread when they feed. Ombugadu *et al.* (2020), Onyido *et al.* (2008), and Madara *et al.* (2013) reported similar results, collecting more female mosquitos than male mosquitos. As a result, Okwa and Sulaiman (2004), Okwa *et al.* (2007), and Oyewole *et al.* (2009) found more female mosquitos resting indoors than males in their research.

The difference in the numbers of indoor resting female *Anopheles* mosquitoes between studied communities may be related to the notion that the Loko area has a more rural setting according to the architectural designs of the buildings, which are made of thatch rooftops, unplastered walls, with uncemented floors, whereas Nasarawa comprises of more contemporary buildings that are well furnished. It has a more organized layout than Loko. However, Howell and Chadee (2007) and Ombugadu *et al.* (2022) discovered mosquitoes resting indoors are substantially more frequent in cement-built buildings, which provide an extremely smooth surface for endophilic mosquitoes to rest, compared to mud or block dwellings.

The total mean abundance of Anopheles species versus net use. A total of 84.0±39.6 respondents said they do not use mosquito nets in their rooms, whereas 73.0±21.2 said they do. However, there were no significant variations in the mean abundance of Anopheles spp. based on net use. The usage of mosquito bed nets is identified to be an efficient, successful, and affordable technique for reducing malaria transmission in endemic nations. The none usage of insecticidal aerosols by community inhabitants explained the observed presence of mosquitoes in all of the rooms evaluated; however, a handful of the occupants used bed nets treated with insecticides and still harboured more mosquitoes but were not bitten while sleeping under the treated bed net. Msugh-Ter *et al.* (2017) reported similar findings in a survey of undergraduates at the Federal University of Agriculture Makurdi.

Anopheles gambiae had the greatest total indoor resting density (IRD) of 2.02 mosquitoes per room/night, indicating it feeds and rests indoors (endophagic and endophilic). This conclusion was consistent with the findings of Onyido et al. (2008) and Ombugadu *et al.* (2020), which observed a reasonably high IRD of 8 and approximately 1 mosquito per room per night, respectively.

In this study, the man-biting rate was 4 mosquitoes per person/night, indicating a high risk of vector-human interaction. The findings of this investigation are consistent with those of Ombugadu *et al.* (2020), who observed a man-biting rate of 2.6 and 3.4 *Anopheles gambiae* per man per hour in both indoors and outdoors, and Abeku *et al.* (2015), who identified a significant MBR of 19.9 mosquitoes per person per night in south-central Ethiopia. However, the results of this research contradict Ombugadu *et al.* (2020), who indicate an MBR of below 0.5 malaria vectors per person per night within an institution's student dorms.

The difference in abdominal (physiological) conditions of the female mosquitos clearly demonstrates that fed females are anthropophilic. The findings of this study are consistent with those of other researchers such as Okwa *et al.* (2007), Adeleke *et al.* (2010), and Ebenezer *et al.* (2013) in Lagos State University, various portions of Abeokuta and Bayelsa States, respectively. However, the findings of this study contradicted the findings of Adeoye *et al.* (2012), who found no variation in stomach conditions of endophilic mosquitos taken in University of Lagos student dorms and the surrounding environment.

CONCLUSION

This study shows the abundance of mosquito species belonging to two groups. *An. gambiae* was the most common species of mosquito found in this investigation. Compared to Udege and Nasarawa communities, Loko had more female *Anopheles* species documented in the study, and more than 90% of the females captured were either fed, unfed, gravid, or half-gravid. *An. gambiae* was found to have high MBR and IRD. The findings of this study are of great public health concern, and the high indoor resting densities and biting rates observed in this study underscore the need for enhanced vector control measures in Nasarawa LGA, including insecticide-treated nets and the elimination of mosquito breeding sites. To break the cycle of malaria parasites spread, it is crucial to promote the removal of potential breeding sites, usage of nets coated with insecticides, and avoidance of vector-human interactions. The monthly variation in mosquito species abundance in the study areas showed more mosquito species 200 (63.7%) were encountered during October compared to the 114 (36.3%) encountered in September. This variation could be attributed to favourable weather conditions in October, which allows more mosquito eggs to hatch.

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REFERENCES

Abeku, T. A., Helinski, M. E., Kirby, M. J., Kefyalew, T., Awano, T., Batisso, E., Tesfaye, G., Ssekitooleko, J., Nicholas, S., Erdmanis, L., & Meek, S. R. (2015). Monitoring changes in malaria epidemiology and effectiveness of interventions in Ethiopia and Uganda: beyond Garki project baseline survey. *Malaria Journal*, 14, Article number 337. [Crossref]

Adeleke, M. A., Mafiana, C. F. & Idowu, O. A. (2010). Population Dynamics of indoor sampled mosquitoes and their implication in disease transmission in Abeokuta, south-western Nigeria. *Journal of Vector Borne Disease* 47(1): 33-38.

Adeoye, G. O., Edeh, I. C., Olayiwola, O. A., Ayodele, E. T. & Adeleke, M. A. (2012). The abundance and composition of endophilic mosquito in the University of Lagos and its Environment. *Nigeria Journal of Parasitology,* 33(1): 21-25.

Agidi, V. A., Hassan, S. M., & Baleri, T. G. (2017). Trends in staple crop yields in Nasarawa State, Nigeria. Agricultural Studies, 2(4), 153-161.

Braack, L., Hunt, R., Koekemoer, L. L., Gericke, A., Munhenga, G., Haddow, A. D., Becker, P., Okia, M., Kimera, I. & Coetzee, M. (2015). Biting behaviour of African malaria vectors: 1. where do the main vector species bite on the human body? *Parasites & Vectors*, 8, Article number 76. [Crossref]

Buttachon, S.; Arikit, S.; Nuchchanart, W.; & Puangmalee, T. (2022) Geometric Morphometric Analysis and Molecular Identification of mosquitoes 2022, 13, 102. [Crossref]

Coetzee, M. (2020). Key to the female of Afrotropical *Anopheles* mosquitoes (Diptera: Culicidae). *Malaria journal*, 19, 70. [Crossref]

Dogara, M., Nock, H., Agbede, R., Ndams, S., & Joseph, K. (2012). Entomological survey of mosquitoes responsible for the transmission of lymphatic filariasis in three endemic villages of Kano state, Nigeria. *The Internet Journal of World Health and Societal Politics,* 7(2), 1-6. [Crossref]

Ebenezer A, Ben HIB, Enaregha EB (2013) Atial distribution and indoor resting density of mosquito species in the lowland rainforest of Bayelsa State, Nigeria. *International Journal of Tropical Medicine* 8(4): 87-91.

Ezeigwe, N., Inyama, P.U., Samdi, L.M., Akila, J.D., Awolola, T.S., Mwansat, G.S., Anyawu, G.I., Yayo, A.M., Ebere, N., Chukwuekezie, O., Seyuom, A., Inyang, U., Kafuko, J., Kolyada, L., Fornadel, C. & Norris, L. (2015). Anopheles Species Diversity, Behaviour, and Sporozoite Rates in Six States of Nigeria. *American Journal of Tropical Medicine and Hygiene,* 93(4), 425-425.

Ezihe, E. K., Egbuche, C. M., Nwankwo, E. N., Ukonze, C., Anumba, J. U., Umenzekwe, C. C., & Ogudu, O. E. (2019). Malaria vector abundance and the incidence of malaria parasite amongst students living in nnamdi azikiwe university hostels. *International Journal of Tropical Disease and Health*, 37(4), 1-10. [Crossref]

Flies, E.J., Flies, A.S., Fricker, S.R., Weinstein, P. and Williams, C.R. (2016). Regional Comparison of Mosquito Bloodmeals in South Australia: Implications for Ross River Virus Ecology. *Journal Medical Entomology.53:902–10*. [Crossref]

Franklinos, L. H. V., Jones, K. E. & Redding, D. W. (2019). The effect of global change on mosquito-borne disease. *Lancet Infectious Disease*, 19(9), e302–e312. [Crossref]

Goupeyou-Youmsi, J., Rakotondranaivo, T., Puchot, N., Peterson, I., Girod, R., Vigan-Womas, I., Paul, R., Ndiath, M. O., & Bourgouin, C. (2020). Differential contribution of Anopheles coustani and Anopheles arabiensis to the transmission of Plasmodium falciparum and *Plasmodium vivax* in two neighbouring villages of Madagascar. *Journal of Parasites & Vectors,* 13, Article number 430. [Crossref]

Howell, P. I., & Chadee, D. D. (2007). The influence of house construction on the indoor abundance of mosquitoes. *Journal of Vector Ecology*, 32(1), 69-74. [Crossref]

Kilama, W. L. (2010). Health research ethics in malaria vector trials in Africa. Mal*aria Journal,* 9, Article number S3. [Crossref]

Madara AA, Abdulraheem NO, Elkanah SO (2013) Relative Abundance of Adult Mosquitoes in University of Abuja Main Campus, Abuja FCT, Nigeria. *Nigerian Journal of Parasitology* 34(2): 79-84.

Manguin, S.; Bangs, M.J.; Pothikasikorn, J. and Chareonviriyaphap, T. (2009). Rewiew on global co-transmission of human Plasmodium species and *Wuchereria bancrofti* by Anopheles mosquitoes. *Infection, Genetics and Evolution*, **10**(2010): 159-177. [Crossref]

Manzoor, F., Shabbir, R.,Sana, M.,Nazir, S., & Aslam Khan, M. (2020).Determination of Species Composition of Mosquitoes in Lahore, Pakistan. *Journal of Arthropod-Borne Diseases,* 14(1), 106-115. [Crossref]

Ménard, D., Barnadas, C., Bouchier, C., & Henry-Halldin, C. (2013). Plasmodium vivax clinical malaria is commonly observed in Duffy-negative Malagasy people. Proceedings of the National Academy of Sciences, 107(13), 5967-5971. [Crossref]

Msugh-Ter MM, Mngurumun AL, Emmanuel OI (2017) Personal Protective Practices Against Mosquito Bites by Undergraduate Students of Federal University of Agriculture Makurdi, North Central Nigeria. *American Journal of Entomology* 1(2): 27-30.

NAGIS (2024). Nasarawa State Geographic Information Service, Nagis. Map of Nasarawa LGA.

Njila, H. L., Ngwa, I. K., Bilham, I. Y. and Ombugadu, A. (2022). Infection Status of Mosquitoes in Kunga Community of Jos North Local Government Area, Plateau State, Nigeria. Nigerian Journal of Parasitology 43(2) 385-391. [Crossref]

Okorie, P. N., Popoola, K. O. K., Awobifa, O. M., Ibrahim, K. T., & Ademowo, G. O. (2014). Species composition and temporal distribution of mosquito populations in Ibadan, Southwest

Nigeria. Journal of Entomology and Zoology Studies, 2(4), 164-169.

Okwa, O. O. & Sulaimon, R. (2004). Dynamics of the transmission of Malaria in Ojo Local Government Area of Lagos Nigeria. *Journal of Research and Review in Science* 3: 16.

Okwa, O. O., Rasheed, A., Adeyemi, A., Omoyeni, M. & Oni, L. (2007). Anopheles species abundance, composition and vectoral competence in six areas of Lagos, Nigeria. *Journal of Cell and Animal Biology* 1(2): 15 23.

Ombugadu, A., Jibril, A. B., Mwansat, G. S., Njila, H. L., Attah, A. S., Pam, V. A., Benson, R. F., Maikenti, J. I., Deme, G. G., Echor, B. O., & Nkup, C. D. (2022). Composition and Distribution of Mosquito Vectors in a Peri-Urban Community Surrounding an Institution of Learning in Lafia Metropolis, Nasarawa State, Central Nigeria. *Journal of Zoological Research*, 4(3), 20-31. **[Crossref]**

Ombugadu, A., Maikenti, J. I., Maro, S. A., Vincent, S. O., Polycarp, I. A., Pam, V. A., Samuel, M.D., Adejoh, V. A., Attah, A. S., Ahmed, H. O., & Angbalaga, G. A. (2020). Survey of mosquitoes in students hostels of Federal University of Lafia, Nasarawa State, Nigeria. *Biomedical Journal of Scientific & Technical Research*, 28(4), 21822-21830.

Onyango, S.A.; Kitron, U.; Mungai, P.; Muchiri, E.M.; Kokwaro, E.; King, C.H. and Mutuku, F.M. (2013). Monitoring malaria vector control interventions: effectiveness of five different adult mosquito sampling methods. *Journals of Medical Entomology* **50**(5): 1140-1151. **[Crossref]**

Onyido, A. E., Deezia, N. P. L., Obiukwu, M., & Amadi, E. (2008). Ecology of man-biting mosquitoes in the development site of Nnamdi Azikiwe University Awka, Anambra State South Eastern Nigeria. *The Internet Journal of Health*, 9(2), 1-7. **[Crossref]**

Osidoma, E. O.1, Pam, V. A.1, Uzoigwe, N. R.1, Ombugadu, A.1, Omalu, I. C. J.2, Maikenti, J. I.1, Attah, A. S.1, Ashigar, M. A.1 and Dogo, S. K. (2023). A study on mosquitoes composition and malaria transmission in some communities in Doma Local Government Area of Nasarawa State, Nigeria. *Journal of Bioscience and Biotechnology Discovery*. 8(1): 10-17. **[Crossref]**

Oyewole, I.O., Awolola, T.S., Ibidapo, C.A., Okwa, O.O. and Obansa, J.A Paaijmans, K. P., Read, AF.and Thomas, M. B. (2009). Understanding the link between malaria risk and climate. Plant National Academic Science USA 106: 13844–13849. **[Crossref]**

WHO (2020). West Nile virus. Geneva. Available from: www.who.int

Williams, J. and Pinto, J. (2012). Training Manual on Malaria Entomology for Entomology and Vector Control Technicians (Basic Level). Integrated Vector Management of Malaria and Other Infectious Diseases Task Order 2Contract GHA-I-02-04-00007-00United States Agency for International Development.

World Health Organization. (2016). Vector-Borne Diseases. Fact Sheet -WHO. (2019) World Malaria Report pp. 232.

World Health Organization. (2019). The world health report 2004 – changing history.

Yoriyo, K. P., Alo, E. B., Napthali, R. S., Pukuma, S. M., Edward, S. A., & Muhammad, I. (2013). A quantitative study on the population of indoor resting density of mosquito species in four Local Government Areas of Gombe State, Nigeria. Journal of Medical and Biological Sciences, 3(1), 61-67.

APPENDIX

Plate i: ***Culex quinquefasciatus***

Plate ii: ***Anopheles gambiae***