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OUR REF..... **Date 26th May 2025**

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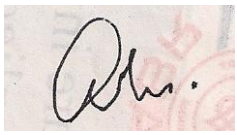
Dear Sir,

MS 010-1-2025

On behalf of the Editorial Board, I write to inform you that the paper titled **"DISTRIBUTION AND ABUNDANCE OF MOSQUITOES IN RELATION TO MALARIA PREVALENCE IN CHANCHAGA LOCAL GOVERNMENT AREA OF NIGER STATE, NIGERIA"** Submitted for publication has been reviewed and the comments of the reviewers are favourable.
The manuscript has been recommended for publication and will be published in the next issue of the journal which is Volume 16 (1) June 2025.

Accept my congratulations.
Best regards.



Omalu ICJ (PhD)
Managing Editor

DISTRIBUTION AND ABUNDANCE OF MOSQUITOES IN RELATION TO MALARIA PREVALENCE IN CHANCHAGA LOCAL GOVERNMENT AREA OF NIGER STATE, NIGERIA

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ABSTRACT

In spite of intensive control measures and intervention in Nigeria, malaria remains a major public health threat. The dearth of information on the diversity and distribution of Anopheline mosquito species, a prerequisite to successful malaria control, informed this study. Indoor adult mosquito populations were sampled using Pyrethrum Spray Catches (PSC). Two hundred and seventy-six (276) human individuals were examined for malaria parasites using Giemsa staining techniques. All individuals were screened for the presence of malaria parasite and classified into four (4) age groups: < 5 years, 6 – 10 years, 11 – 15 years and >16 years. A total of one thousand five hundred and sixteen (1516) mosquitoes were collected and identified as follows; Anopheles species 371 (24.47%) and Culex species 1145 (75.53%). Mosquitoes collected per location was as follows F-layout 399 (26.31%), Tunga 406 (26.28%), Chanchaga 361 (23.81%) and Sauka-Kahuta 350 (23.08%). The distribution of mosquitoes per location showed a significant difference at $p<0.05$. Six species of *Anopheles* mosquitoes were identified. These are *Anopheles gambiae,* 235 (63.34%), *Anopheles funestus,* 111 (29.92%), *Anopheles coustani,10 (2.69%), Anopheles nili, 6 (1.62%), Anopheles squamosus, 6 (1.62%) and Anopheles moucheti,*3 (0.81%). Tunga had the highest number of *Anopheles* mosquitoes of 116 (31.27%), followed by F-layout 93 (25.07%) while Sauka-Kahuta had the least number of *Anopheles* mosquitoes collected 74 (19.95%). Out of the 276 human blood specimens examined, 178 (64.49%) were positive for *Plasmodium falciparum*. Individuals of age group 6 – 10 years had highest infection rate of 40 (78.43%), followed by 16 years 87 (63.50%) while age group 0 – 5 years, had the least infection rate of 6 (56%). Males were more infected 91 (67.91%) with malaria than females 87 (61.27%) which also showed a significant difference at $p<0.05$. This study demonstrated the complex distribution of *Anopheles* mosquito and the considerable variations in the intensity of malaria transmission in Chanchaga Local Government and its environs, hence the need to intensify control strategies to eliminate larva sources of the vectors.

Keywords: Mosquito; *Anopheles* ; Abundance; Prevalence; Malaria; *Plasmodium*

INTRODUCTION

Malaria is a life-threatening disease caused by *Plasmodium* parasites. The parasites are spread to people through the bites of infected female *Anopheles* mosquitoes (WHO, 2015a). Malaria is transmitted throughout Nigeria, with 97% of the population being at risk of being infected with malaria. According to the 2022 World Malaria Report, Nigeria accounts for the highest percentage of the global malaria burden compared to any other country, with 27% of the global estimated malaria cases and 31% of the estimated deaths, as well as an estimated 55% of malaria cases in West Africa in 2022 (WHO, 2025) Nigeria's large population, along with other factors such as sanitation management and vegetation that favor mosquito breeding, account for the persistent rise in malaria transmission (United State President's Malaria Initiative, 2023).

Malaria transmission in most of the African communities is enhanced by environmental conditions such as high humidity and warmth which accelerates mosquito development. Poor quality housing also facilitates malaria transmission as the populations are continually exposed to mosquito bites. Treated nets offer protection from the mosquitoes, although bites can still occur outside the house (Awolola *et al*., 2014).
The duration of the transmission season ranges from year-round transmission in the south to three months or less in the north. *Plasmodium falciparum* is the predominant malaria species. The primary vectors across most of the country are *An. coluzzii* (59.3 percent) and *Anopheles (An.) gambiae s.s.* (39.0 percent) of all the *An. gambiae s.l.* collected, with *An. funestus* as a secondary vector in some areas of Nigeria (United State President's Malaria Initiative, 2023).

Microscopy data from the 2018 Nigeria Demographic and Health Survey (NDHS) show that the prevalence of malaria parasitaemia in children under five years of age is 23% (a decrease from 27% in 2015 and 42% in 2010), although there are significant regional, rural-urban, and socioeconomic differences: prevalence ranges from 16% in the South and South East Zones to 34% in the North West Zone. In rural populations, prevalence is 2.4 times that in urban populations (31% vs. 13%). Compared to the highest socioeconomic group, prevalence among children in the lowest socioeconomic group is seven times higher (38% vs. 6%) (United State President's Malaria Initiative, 2023). The aim of this study is to assess vector distribution and malaria prevalence in the study area.

MATERIALS AND METHODS

Study Area

The research was carried out in Chanchaga Local Government Area (LGA) of Niger state, North Central Nigeria. Chanchaga is a Local Government Area has its headquarter in the state capital of Minna which occupies much of the LGA with in the capital which lies within longitude 6°33F and 9°37N on a land area of 72km^2 and having an estimated population of 201,429 thousand inhabitants (National Population Commission, 2006).

Study Site

Four sites were selected for the study. The study sites are Chanchaga, Tunga, Sauka Kahuta and F-layout. The choice of the four sites is based on epidemiological and practical considerations such as record of high malaria endemicity and relatively high human population.

Collection of Adult Mosquitoes

Collection of mosquitoes was carried out twice a month. Two houses were selected from each study site. Pyrethrum Spray Catches (PSC) (Federal Ministry of Health, 2014) was used for mosquito collection. The indoor mosquitoes were sampled by covering the floor with a white sheet of 3.6m x 3.6m each edge held to the wall by a masking tape. The room

was sprayed with an insecticide (Baygon, Mobil and Mortein) and then left for 10 minutes, with every opening being shut between 06:00hrs - 07:00hrs in the morning hours. The collection spanned seven months. After the 10 minutes mosquitoes found on the sheet were gathered and handpicked with a forceps into Petri dishes and they were conveyed to the Animal Biology laboratory of the Federal University of Technology, Minna for identification.

Preservation of Mosquitoes Sampled

Each mosquito sampled was preserved individually in an Eppendorf tube. The samples were stored dry on silica gel self-indicator. The preserved *Anopheles* mosquitoes were later transported to the USAID/PMI/AIRS Entomological laboratory and insectary, Nassarawa State University, Keffi, for species identification using identification keys

Morphological Identification of Mosquito Species

All adult mosquitoes collected were identified and sorted out under a stereomicroscope (Leica model NSW series IMNS 210) and Olympus Tokyo VT-II 225329 entomological microscope. The female *Anopheles* mosquitoes were identified as far as possible using morphological keys of Gillies and De Meillion (1968), Gillies and Coetzee (1987) by sex and whether they were anophelines or culicines. The following key features were considered for the identification of anophelines: palps, legs, wings, scutella and body size.

Collection of Blood Sample and Staining Procedure

A total number of two hundred and seventy-six (276) blood samples from consenting male and female were collected for malaria screening. The thumb area was swabbed with 70% alcohol and allowed to dry before the collection by gentle pricking of the thumb with needle. The blood droplet was collected in EDTA bottles which were later transported to Biology Laboratory. Preparation and staining of the blood slides followed the procedures of the World Health Organization (WHO, 2003). This was carried out using Giemsa staining with pH 7.2. Two slides were prepared: One with a thick film (for rapid staining 10- 15 minutes with 10% Giemsa stain, and screening while patient is in attendance), the other with a thick and thin film on the same slide for subsequent standard staining (30-45 minutes with 10% giemsa stain).

Determination of Parasitaemia

Parasitological examination of the stained slides was carried out using light microscope. Parasitaemia was measured by counting the number of asexual parasites against a number of leucocytes in the thick blood film, based on a putative mean count of white blood cells density of 8000 white blood cells per µl. The number of asexual parasites was counted against 200+ leucocytes to the end. The final blood cell count was over 200. The parasitaemia per microlitre is calculated by using the formula:

$$\text{Parasitaemia (per µl) blood} = \frac{\text{Number of parasites counted}}{\text{Number of W.B.C counted}} \times 8000 \text{ W.B.C/ µl}$$

Data Analysis

All data obtained from this study were analyzed using Analysis of variance (ANOVA) to compare the mosquito species, abundance, and distribution in the study area. Chi-square ($\chi 2$) test was use to analyzed prevalence of infection between the collection sites. The calculated p-values are tabulated in the ANOVA tables and conclusions drawn at $P<0.05$ level of significant.

RESULTS

Relative Abundance of Mosquito Species Collected in The Study Area

A total of one thousand, five hundred and sixteen (1516) indoor resting adult mosquito species werea collected in four selected sites. Mosquito species distribution according to collection site was as follows: Tunga 406 (26.78%), F-layout 399 (26.31%), Chanchaga 361 (23.81%) and 350 (23.09%). *Anopheles* species detected in Tunga was 116 (31.27%), F-layout 93 (25.07%), Chanchaga 88 (23.72%) and Sauka-kahuta 74 (19.95%). *Culex* species detected in F-layout was 306 (26.72%), followed by Tunga 290 (23.33%), while Sauka-kahuta and Chanchaga had 276 (24.10%) and 273 (23.84%) respectively (Table 1). Tunga recorded the highest number of *Anopheles* species 116 (31.27%), while Sauka-kahuta had the least species of 74 (19.95%). However, F-layout 306 (26.72%) recorded high number of *Culex* species while Chanchaga 273 (23.84%) had the least number of *Culex* species. Chi-square analysis revealed a significant difference ($p<0.05$) in the relative abundance of mosquito species based on sampling site.

Table 1: Relative Abundance of Mosquito Species Collected in The Study Area

Collection site	No. of mosquitoes collected	*Anopheles* Species	*Culex* Species
Tunga	406 (26.78%)	116 (31. 27%)	290 (25.33%)
F-layout	399 (26.31%)	93 (25.07%)	306 (26.72%)
Chanchaga	361 (23.81%)	88 (23.72%)	273 (23.84%)
Sauka- kahuta	350 (23.09%)	74 (19.95%)	276 (24.10%)
Total	**1516 (100%)**	**371 (24.47%)**	**1145 (75.53%)**

$\chi^2_{cal} = 256.5661$; $\chi^2_{tab} = 7.815$; df = 3; $p<0.05$

Monthly Distribution and Relative Abundance of *Anopheles* Mosquitoes Collected Based on Sampled Site

The monthly distribution and relative abundance of *Anopheles* mosquitoes collected based on sampling site is presented in Table 2. The monthly collection revealed that Tunga had 116 (31.27%), followed by F-layout 93 (25.07%) while Chanchaga and Sauka-Kahuta had 88 (23.72%) and 74 (19.95%) respectively. The month of June had the highest number of 68 (18.33%), followed by April 66 (17.79%), May 62 (16.72%), February 46 (12.39%), December 41 (11.05%) while January and March had same monthly distribution 44 (11.86%) respectively. Chi-Square analysis showed that there is no significant difference at ($p>0.05$) in the monthly distribution of *Anopheles* mosquitoes.

Table 2: Monthly Distribution and Relative Abundance of *Anopheles* Mosquitoes Collected Based on Locations

Months/ Location	December 2016	January 2017	February 2017	March 2017	April 2017	May 2017	June 2017	Total
Tunga	14(34.15%)	13(29.55%)	16(34.78%)	12(27.27%)	18(27.27%)	19(30.65%)	24(35.29%)	116(31.27%)
F-layout	10(24.39%)	14(31.82%)	7(15.21%)	10(22.73%)	18(27.27%)	16(25.81%)	18(26.47%)	93(25.07%)
Chanchaga	8(19.51%)	9(20.45%)	10(21.74%)	13(29.55%)	16(24.24%)	17(27.42%)	15(22.06%)	88(23.72%)
Sauka-kahuta	9(21.95%)	8(18.18%)	13(28.26%)	9(20.45%)	14(21.21%)	10(16.13%)	11(16.18%)	74(19.95%)
Total	**41(11.05%)**	**44(11.86%)**	**46(12.39%)**	**44(11.86%)**	**66(17.79%)**	**62(16.72%)**	**68(18.33%)**	**371 (100%)**

$\chi^2_{cal} = 8.5153$; $\chi^2_{tab} = 28.9$; df =18; p>0.05

Monthly Distribution of Identified Members of The *Anopheles* Species in The Study Area

The Monthly distribution of identified members of the *Anopheles* species in the study area is presented in Table 3. A total of 371 *Anopheles* mosquitoes were identified to species level which comprises six (6) species thus; *Anopheles gambiae* 235, (63.34%), *Anopheles funestus*, 111 (29.92%), *Anopheles coustani*, 10 (2.69%), *Anopheles nili* and *Anopheles squamosus* had 6 (1.62%) respectively while *Anopheles moucheti* had 3 (0.81%). In June 96 (25.88 %) *Anopheles* species were collected followed by March, 66 (17.79%), May, 63 (16.98%), February, 58 (15.68%), April 48 (12.94%), January 31 (8.36%) and December 9 (2.43%). There is a variation in species distribution across the months. *Anopheles gambiae* was found dominant in June 59 (25.11%), followed by May 48 (20.43%) while the least *Anpheles gambiae* was recorded in December 5 (2.13%). *Anopheles funestus* June had 34 (30.63%), followed by March 25 (22.52%) while in the month of December 2 (1.80%). *Anopheles nili* May 2 (33.33%). The report in January, February, April and June was 1 (16.67%) each. For *Anopheles coustani*, April had 4 (40.00%), followed by December and February with 2 (20.00%) each, while March and June had the least species of 1 (10.00%) each. *Anopheles moucheti* January, March and June had 1 (33.33%) each respectively. *Anopheles squamosus* May had 3 (50.00%), followed by March 2 (33.33%) while January had 1 (16.67%). Chi-Square analysis revealed a significant difference at ($p<0.05$) between the distribution of *Anopheles* mosquito species based on month of collection.

Table 3: Monthly Distribution of Identified Members of the *Anopheles* Species in The Study Area

Months	*Anopheles* species						
	An. Gambiae	*An. funestus*	*An. Nili*	*An. coustani*	*An. moucheti*	*An. squamosus*	**Total**
December	5(2.13%)	2(1.80%)	0(0%)	2(20%)	0(0%)	0(0%)	9(2.43%)
January	17(7.23%)	11(9.91%)	1(16.67%)	0(0%)	1(33.33%)	1(16.83%)	31(8.36%)
February	36(15.32%)	19(17.12%)	1(16.67%)	2(20%)	0(0%)	0(0%)	58(15.63%)
March	37(15.74%)	25(22.52%)	0(0%)	1(10%)	1(33.33%)	2(33.33%)	66(17.79%)
April	33(14.04%)	10(9.00%)	1(16.67%)	4(40%)	0(0%)	0(0%)	48(12.94%)
May	48(20.43%)	10(9.00%)	2(33.33%)	0(0%)	0(0%)	3(50%)	63(16.98%)
June	59(25.11%)	34(30.63%)	1(16.67%)	1(10%)	1(33.33%)	0(0%)	96(25.88%)
Total	**235 (63.34%)**	**111 (29.92%)**	**06 (1.62%)**	**10 (2.69%)**	**03 (0.81%)**	**06 (1.62%)**	**371 (100%)**

$\chi^2_{cal} = 45.64055$; $\chi^2_{tab} = 43.8$; df = 30; p>0.05

Prevalence of *Plasmodium falciparum* among Human Participants in the Study Area

A total of 276 human blood samples were examined for the presence of malaria parasites. Of the 276 blood samples examined, 178 (64.49%) were infected. Seventy-nine (79) blood samples were collected and examined at Tunga, out of which 61 (77.23%) were positive. In F-layout, 62 blood samples were collected and examined, out of which 27 (43.55%) were positive. In Chanchaga, 51 blood samples were collected and examined, out of which 37 (72.55%) were positive. In Sauka-Kahuta, 84 blood samples were collected and examined, out of which 53 (63.09%) were positive. Tunga recorded the highest prevalence 61 (77.23%) while F-layout had the least of 27 (43.55%). The result showed that males who had an infection rate of 91 (67.91%) were more prone to malaria parasites than the females 87 (61.27%). Chi-Square analysis showed that there is a significant difference ($p<0.05$) in malaria infection based on location (Table 4).

Age And Sex Prevalence of Malaria Infection in Chanchaga

The age and sex prevalence of malaria infection in Chanchaga is presented in the Table 5a and 5b. Of the total of 276 (100%) blood samples collected and examined for *Plasmodium* parasites, 178 (64.49%) were positive for malaria parasites in all age groups. Age group 6 – 10 years had the prevalence rate of malaria parasites 40 (78.43%) followed by age group 16 years and above had the prevalence rate of 87 (63.50%), while age group 1 – 5 years had the prevalence rate of 28 (56.00%). Chi-Square statistical analysis showed that there is significant difference at $p<0.05$ in the prevalence rate of malaria infection based on age groups.

Table 4: Prevalence of *Plasmodium falciparum* among Human Participants in the Study Area

Location	No. Examined	No. + ve (%)
Tunga	79	61 (77.23%)
F-layout	62	27 (43.55%)
Chanchaga	51	37 (72.55%)
Sauka-kahuta	84	53 (63.09%)
Total	**276**	**178 (64.49%)**

$\chi^2_{cal} = 18.99667$; $\chi^2_{tab} = 7.815$; df = 3; $p<0.05$

Table 5a: Age And Sex Prevalence of Malaria Infection in Chanchaga

Age group	Tunga				F-layout			
	No. exam.	Total No. + ve (%)	Male + ve (%)	Female + ve (%)	No. exam.	Total No. + ve (%)	Male + ve (%)	Female + ve (%)
1 – 5	10	6 (60.0)	2 (33.3)	4 (66.7)	9	4 (44.4)	3 (75.0)	1 (25.0)
6 –10	11	9 (81.8)	4 (44.4)	5 (55.6)	9	5 (55.6)	4 (80.0)	1(20.0)
11-15	8	7 (87.5)	5 (71.4)	2 (28.6)	12	5 (41.7)	4 (80.0)	1 (20.0)
16 – above	50	40 (80.0)	17 (42.5)	23 (57.5)	32	12 (37.5)	6 (50.0)	9 (75.0)
Total	**79**	**62 (34.8%)**	**28 (45.2)**	**34 (54.8)**	**62**	**26 (14.6%)**	**17 (65.4)**	**12 (46.2)**

Table 5b: Age And Sex Prevalence of Malaria Infection in Chanchaga

	Chanchaga			Sauka-kahuta				Total	
No. exam.	Total No. + ve (%)	Male + ve (%)	Female + ve (%)	No. exam.	Total No. + ve (%)	Male + ve (%)	Female + ve (%)	No. exam.	**No. + ve (%)**
9	4 (44.4)	3(75.0)	1 (25.0)	22	14 (63.6)	5 (35.7)	9 (64.3)	50	**28 (56.0%)**
14	12 (85.7)	5(41.7)	7 (58.3)	17	14 (82.4)	5 (35.7)	9 (64.3)	51	**40 (78.4%)**
9	7 (77.8)	5 (71.4)	2 (28.6)	9	4 (44.4)	4 (100)	0 (0.00)	38	**23 (60.5%)**
19	14 (73.7)	11(78.6)	3 (21.4)	36	21 (58.33)	8 (38.1)	13(61.9)	137	**87 (63.5%)**
51	**37 (20.8%)**	**24 (64.9)**	**13 (35.1)**	**84**	**53 (29.7%)**	**22 (41.5)**	**31 (58.5)**	**276**	**178 (100%)**

χ^2_{cal} = 17.8663; χ^2_{tab} = 16.919; df = 12; p<0.05
No. exam = Number examined; No. +ve = Number positive; (%) = percentage prevalence

Discussion

A low number (371) of *Anopheles* mosquito species were recorded in the study area. It was inferred that this could be due to the collection period which started in the dry season. This inference is similar to the findings of Oduola *et al.* (2013) in Osun state and Okorie *et al.* (2014) in Ibadan. Likewise, the insignificant differences in the number of *Anopheles* mosquitoes collected in the study areas indicated similarities in their environmental factors. However, the large presence of other non-malaria vectors especially *Culex* mosquito recorded in the study area is suggestive of the level of nuisance experienced by the inhabitants of the area. In this study, *Culex* species were the more abundant than *Anopheles* species. This implies that the ecotype of the study area favours Culicine than the Anopheline mosquito. This is similar to the findings of Felix *et al.* (2013) who carried out similar research in Benin City and Okorie *et al.* (2014) in Ibadan.

The study also investigated the principal vectors of the malaria parasite in Chanchaga Local Government Area and their role in malaria transmission. Species distribution in the four selected sites suggests that members of *An. gambiae, An. funestus, An. coustani, An. nili, An. squamosus* and *An. moucheti* can be found in sympatric. Okwa *et al*, (2009) also reported this sympatric distribution. In this study, *An. gambiae* and *An. funestus* were distributed all over the four selected sites, and *An. gambiae* was the most abundant species, which is consistent with the findings of Bruce-Chwatt (1954) who concluded that *An. gambiae* is omnipresent in Nigeria. Felix *et al*. (2013) reported that due to their indiscriminate breeding habitats, *An. gambiae* complex remains the most abundant constituting 14.4% of the total species recorded. In the same vein, Okwa *et al*. (2006) showed that *An. gambiae* was the most prominent species in Badagry area of Lagos Nigeria.

Moreover, *An. funestus,* reported in this study in substantial numbers has received scanty attention. This is probably due to its inconsistency as a major key player in malaria transmission. Most researches therefore, focused on the member of *An. gambiae* complex. According to Gilles and Cozetee (1987), the *An. funestus* group may be problematic just as the *An. gambiae* group with different biological and vectorial capacity. In some areas of Nigeria, it has been projected that it could replace *An. gambiae* as the major vector of endemic malaria. The preponderance of the *An. gambiae* group in this study is attributable to their anthropophilic behaviour; *An. gambiae* generally increases in density after the start of the long rains, while *An. funestus* density varies in direct proportion to the proximity of permanent breeding grounds rather than rainfall. Similarly, Awolola *et al.* (2002) had earlier identified *An. gambiae* and *An. funestus* as the major vectors of malaria in Nigeria. Relative Abundance of *An. gambiae* over *An. funestus* and their sympatric occurrence in this study is in line with the findings of Ebenezer *et al*. (2014) and Oduola *et al*. (2016a).

In this study, *An. moucheti* was the least abundant and least competent. It had been described as a rainforest zoophilic vector, so it is not surprising as the collections in the four locations were made in the savannah zone and parts of the collection took place in the dry season. Despite its epidemiological importance, very few studies have been carried out on this vector. *An. moucheti* is also a relatively good malaria vector although it is less abundant. It has been known to playing lesser roles compared to *An. gambiae* and *An. funestus* (Antonio-Nkondijo *et al.,* 2002).

A lower number of *An. constani* encountered in this study differs significantly from the findings of Lamidi *et al*. (2017) in Taraba state. A*n. coustani* also has been reported to be a potential vector species for malaria transmission. Although scanty, it is however, present in few of the sites under study. The low abundance of these species of mosquito is attributed to the fact that these mosquito species are associated with human dwellings, indoor resting habits and the

species are mainly anthropophilic (Oyewole *et al*., 2005). *An. nili* was also found scanty; perhaps it is more common in humid/ neighbouring montane zone of the study area which is similar to the finding of Wanji *et al*., (2003) and Lamidi *et al.,* (2017).

The distribution of mosquito in relation to the months of study showed some level of variations. Although it did not appear to follow a particular pattern. It was observed to be generally low in dry season (December – February) in all the study sites, where most of the temporary habitats were dry. This is in line with the findings of Olayemi (2008b), Bagoro *et al*. (2014) and Lamidi *et al.* (2017) but contrary to a study carried out by Okorie *et al.* (2014) in Ibadan, Southwestern Nigeria where he recorded high number of mosquitoes species in dry season (December – February). In Tunga, the *Anopheles* species peaked at the beginning of wet season and low during the dry season. In F-layout, the *Anopheles* species population was higher in the beginning of wet season (April, May and June) but lowest during the dry season (December, January and February). The highest peak of the female Anopheline species occurred in June and the least peaks in January, as observed in Tunga was contrary to the findings of Bagoro *et al*. (2014) and Lamidi *et al*. (2017). Combination of trends of *Anopheles* abundance in both Tunga and F-layout was observed in the study area in which *Anopheles* species, had the highest population as observed in wet months (March, April, May and June), in the middle of wet month (June) and the lowest at the beginning of dry months of (December and January).
The fact that the mosquito abundance coincides to a great extent with period of rainfall is an indication that rainfall plays significant role in mosquito population dynamics. This is similar to the findings of Lamidi *et al.* (2017) in Sahel region of Nigeria. Ototo *et al*. (2015) reported that human activities and behaviours of mosquito of different species affect the population of indoor-resting mosquitoes, among which are exposures of mosquitoes to insecticides, use of insecticide-treated bed nets and exophilic/endophilic behaviours of mosquitoes.
However, in some cases, it was observed generally that the abundance of mosquito was not strongly dependent on rainfall as in Kwara State (Oduola *et al*. 2016b), where the mosquito peaked was in April and as generally observed in this study. The peak values were in April, February and June in Sauka-kahuta, April, May and June in Tunga and June, April and May in F-layout. In the findings of Ototo *et al*. (2015), *An. gambiae* peaked in April/June similar to that in Tunga. These peaks were reached generally one month after the onset of the wet seasons which was reportedly the period of highest transmission and possibly, among other factors, highest malaria season (Ototo *et al*. 2015).
The overall prevalence of 64.49% reported in this study was considered high. The high prevalence of malaria in the study area could be due to some factors such as amount of rainfall, temperature, extent in urbanization, availability of breeding places for vectors, over-crowded human populations as well as the behavioural attitude of the inhabitants of the areas, among others. These findings agree with reports that there has been a marked increase in the number and size of towns and cities in many developing countries without corresponding increase in such services that inhibit the breeding of vectors of malaria resulting in the increase of urban malaria (Fonterille and Simard, 2004). Nigeria has undergone serious environmental modifications over the years owing to rapid growth in human population and urbanization. Such modifications could have led to ecological changes that might have affected human malaria vector population structure. These in turn have impacted on the mosquito efficiency in transmitting malaria.

The result of this study is comparable with the figure obtained by Babamale & Ugbomoiko (2016) who recorded 63.7% prevalence in peri-urban community in North Central Region of Nigeria, Omalu *et al*. (2015) who recorded 65.2% prevalence in Minna, North Central, Nigeria, Olasehinde *et al*. (2015) who reported 62.7% prevalence in Ogun State South Western Nigeria and Dawaki *et al*. (2016) who reported a prevalence of 60.6% in Kano state, Nigeria. The

figures are however lower than the 84% reported by Ali *et al.* (2017) in Kano city of Nigeria. A study carried out in the six (6) geopolitical zones of the country in 2010, concluded that the prevalence of malaria is higher in the Southern part of the country than Northern part (FMoH, 2010).

Prevalence based on gender showed that more female participants were screened, but males has a relatively higher prevalence rate of (67.91%) compared with their female counterparts that has prevalent rate of 61.27%. Similar reports have indicated higher prevalence in males than females (WHO, 2010), but there is no scientific evidence to prove the higher prevalence being related to gender as susceptibility to malaria infection is not influenced by gender. The higher prevalence rate could just be by chance, or due to the facts that males engage in activities which make them prone to infective mosquito bites as compared to their female counterparts that are mostly at home and protected from such infective bites. Millicent *et al*. (2015) reported high prevalence of malaria in male 19.4% than female 16.4% in a study carry out in Makarfi, Kaduna State Nigeria. Abdullahi *et al*. (2009) also reported high prevalence of malaria in male 30.24% than their female counterparts 24.47% in Sokoto. Contrary to the findings of other researchers such as Tukur *et al*. (2010) in Kano Municipal Local Government Area, Olasehinde *et al*. (2014) Southwestern Nigeria, Kolawole *et al*. (2014) in Ilorin and Ali *et al*. (2017) in Kano city who all reported that females have the highest prevalence rates than their male counterparts.

The age distribution of participants under study, for age group category 6 – 10years had the highest prevalence which accounted for 78.4%. High rate of infection in this age group could be due to lack of protection against mosquito bites or lack of knowledge of malaria prevention or both. Moreover, the age group consists of young children who habitually expose themselves to incessant bites of vectors of malaria by remaining bare bodied especially when the weather is hot. This is similar to the findings of Noland *et al.* (2014) in Abia (South east) and Plateau State (North central) Nigeria. Ali *et al*. (2017) in Kano city and Millicent *et al*. (2015) in Makarfi, Kaduna State, Nigeria recorded high prevalence of 37.6% and 19.3% respectively among the same age group. Age group of 1 – 5years has the least prevalence of 56.00%. The low prevalence from this study could be due to the fact that more attention and care are given to children less than five years and may be benefitting more from control measures put in place; such as sleeping under ITN, than the older children. WHO (2010), maintain that children less than five years are more at risk of the disease because they may not have developed protective immunity against the disease and its most severe form. The prevalence recorded from this study is lower than the 84.7% prevalence among children in Ota, Ogun State, Nigeria and also South west with a prevalence of 70.8% as reported by Olasehinde (2015). The prevalence of malaria decreases with increase in age, this could be attributed to the fact that individual of higher age has develop immunity against *Plasmodium* parasites over time.

The differences in malaria risk in the study area can be explained by the distribution of vector species of local importance, availability of breeding habitats, topography, farming activities (Imbahale *et al.,* 2010), terrain characteristics (Atieli *et al.,* 2011), preferred host, and environmental conditions among others. The highest prevalence was observed in Tunga (34.83%), which could be due to the fact that the area is characterized by poor drainage system, pools, and fish ponds, over-crowded human populations, stagnant water, plant growth around the house and the behavioural attitude of the inhabitants in the area. This may correlate with the high abundance of *Anopheles* vectors recorded in the area as well as rate of exposure of the subjects to the bites of the malaria vectors. The presence of breeding habitats throughout the year with favourable temperatures leads to accelerated sporogonic cycle of *P. falciparum* parasites hence posing a higher risk of infection but that was not the case when compared to F-layout. Sauka-kahuta had 29.78% prevalence, the least prevalence was observed in F-layout 14.61%.

Conclusion

The diversity of *Anopheles* mosquito found indoor in the study area is of environmental and public health concern. Six species of *Anopheles* mosquito were encountered during the study period these include; *Anopheles gambiae, Anopheles funestus, Anopheles coustani, Anopheles nili, Anopheles squamosus, and Anopheles moucheti.* The prevalence of malaria parasite in study area is relatively high. It is believed that data generated from this study can be utilized in the planning of novel malaria transmission control programs in the study area. There is need to characterize molecularly the Anopheline mosquitoes in the study area, in order to ascertain their specific sibling species

Authors Contribution

AM and IA conceptualized the study. IA, OICJ, and ASO designed the study. AM, IA, and OIM participated in fieldwork and data collection. OICJ, and AAV performed the data analysis; AM and IA interpreted the data. OIM, AM prepared the first draft of the manuscript, reviewed by OICJ, AAV, and ASO. All authors contributed to the development of the final manuscript.

Ethical approval

Approval was obtained from Niger State Ministry of Health, Minna., Niger state, Nigeria.

Conflict of Interest

The authors declared that no conflict of interest exists.

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