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The distribution pattern and feeding behaviour of malaria vectors in two selected communities of Karu Local Government Area of Nasarawa State

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ABSTRACT: An entomological survey was conducted to determine the malaria vectors density and their distribution. The study was aimed at identifying the distribution and feeding behaviour of major malaria vectors. Mosquitoes were sampled using Pyrethroid Spray Collection (PSC) and CDC light trap methods to collect indoors and outdoors resting mosquitoes for a period of three months (April, May and June) and were identified morphologically. A total of 462(100%) mosquitoes were collected in the study areas, 238(51.5%) were collected in Gitata and 224(48.5%) were collected in Panda. Of the 462 (100%) mosquitoes collected, 433(93.7%) were Anopheline while 29(6.3%) were Culicine. Statistically, there was a statistical difference ($p<0.05$) in the distribution of malaria vectors encountered in the study areas. Out of the 433(100%) *Anopheles* mosquitoes collected, 279(64.4%) feed indoor while 154(35.6%) feed outdoor. The indoor resting density of the mosquitoes were also calculated, the result showed that Panda had the highest indoor resting density of 7.5 than Gitata 7.0. The human biting rate (HBR) of mosquitoes collected in each month at the study areas were also determine and the result showed a high biting rate of 2.515 in Panda compared to 2.321 in Gitata. The parity rate (PR) of the mosquitoes collected in Gitata and Panda for the three months were also analyzed, and the result showed that, out of the 433 *Anopheles* mosquitoes collected, 146(100%) were dissected, 85(58.2%) were parous and 61(41.8%) were nulliparous. This study therefore, will be used as a baseline data to help in designing strategies for the control of malaria vector diseases in Karu Local Government of Nasarawa State and its environs.

Keywords: Gitata, human biting rate (HBR), indoor, Karu LGA, malaria, outdoor, Panda, vectors.

INTRODUCTION

Mosquitoes of the family Culicidae are considered a nuisance and a major public health problem, because their females feed on human blood and thus transmit extremely harmful diseases, such as malaria, yellow fever and filariasis (WHO, 2015). They are estimated to transmit diseases to more than 700 million people annually and responsible for the death of about 1 in 17 people (WECM and WHO, 2000). Effective transmission of mosquito-borne disease requires successful contact between female mosquitoes and their hosts (Xu et al., 2014). Among Anophelinae, the members of the genus Anopheles are best known for their role in transmitting malaria and filariasis worldwide (Service, 2008; WHO, 2013). Of these diseases, malaria caused by Plasmodium parasite is one of the greatest killer diseases in the world (WHO, 2013). WHO (2013) reported an estimated 207 million cases of malaria in 2012 out of which 200 million cases (80.0 %) were in Africa continent? The distribution pattern, transmission and intensity of the disease are dependent on the degree of urbanization and the distance from vector breeding sites (CDC, 2015). The endemicity of malaria in any region is determined by indigenous *Anopheles* mosquitoes, abundance, feeding, resting behavior and their Plasmodium infectivity, among other factors (Molta,

2000; WHO, 2003).

Malaria infection is caused by five Plasmodium species: *Plasmodium falciparum, P. vivax, P. ovale, P. malariae and P. knowlesi* (zoonotic species mainly occurring in Asia) (Cox-Singh et al., 2008; Snow et al., 2005). *P falciparum* is the most fatal malaria parasite (Snow et al., 2005), threatening millions of lives primarily in Africa, south of the Sahara. An estimated 187 million clinical cases of *P. falciparum* were reported in Africa in 2015 (Bhatt et al., 2015). More than 90% deaths and 88% of cases occur in Africa (WHO, 2015), while some species of *Anopheles* are vectors of malaria (Cox, 2010). *Anopheles gambiae, A. coluzzii, A. arabiensis* and *A. funestus* are the major malaria vectors in Africa (Sinka et al., 2012).

Globally, the number of cases and deaths due to *P. falciparum* has substantially declined in Africa and elsewhere (Bhatt et al., 2015; WHO, 2015). Between 2000 and 2012, deaths due to malaria declined by 42% globally, and the reduction was higher (49%) in the World Health Organization's (WHO) African region (WHO, 2013). In 2013, malaria mortality rates declined by 47% globally and 54% in Africa compared to 2000, with malaria causing 584,000 deaths (WHO, 2014). Between 2000 and 2015, the malaria mortality rate was reduced by 60% worldwide and 66% in Africa among all age groups (WHO, 2015). The number of deaths due to malaria declined to 438,000 in 2015, from 839,000 in 2000 (WHO, 2015). The decline in the number of malaria cases and deaths is associated with the widespread use of long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS), rapid diagnostic tools and effective anti-malarial drug artemisinin combination therapies (ACTs). It was reported that in 2015, more than 50% of people in Africa slept under LLINs compared to roughly 2% in 2000 (WHO, 2015). The interventions have averted an estimated 663 million clinical malaria cases since 2000, with insecticide treated bed nets being the largest contributors to reducing deaths, and followed by ACTs (Bhatt et al., 2015; WHO, 2015).

Malaria is one of the most significant infectious diseases in the world. Available statistics suggest that 2 to 5% of all human deaths in the 20th Century were attributed to the disease (Carter et al., 2002), and increasing evidence identifies malaria as the most significant recent selective pressure on the human genome (Kwiatkowski, 2005). In 2000, 20% of all deaths of children under 5 years in Sub-Saharan Africa were attributable to malaria (Black et al., 2003; WHO, 2006). In Nigeria, 18 million clinical malaria cases annually result in approximately 80,000 deaths (WHO, 2006). Most malaria cases in Nigeria are due to *P. falciparum* as in Tanzania (Mboera, 2000). *P. falciparum* is transmitted by female *Anopheles* mosquitoes during a blood meal. Gillies and Meillon (1968) defined 11 out of the 45 anopheline mosquito species as responsible vectors for malaria transmission. The most important malaria vectors in Nigeria as in Tanzania include *A. gambiae* and *A. arabiensis* (Mnzava and Kilama, 1986; Shiff et al., 1995; Kigadye et al., 2010) and *A. funestus* (Mboera et al., 1997, 2010).

A measure of entomological inoculation rates (EIR) is an important tool for estimation of malaria transmission intensity (Drakeley et al., 2003). It is one of the indicators of human exposure to malaria parasites (Killeen et al., 2000). In Nigeria, EIR has been shown to vary with season, altitude, proximity to breeding sites, socio-economic status, agro-ecological systems (Ijumba et al., 2002; Kulkarni et al., 2006; Mboera et al., 2010). The knowledge on malaria transmission indices is important to its control through quantifying the potential risk of infection (Githeko et al., 1993). This calls for the need to accurately determine the mosquito population structure, spatial and temporal variations in malaria transmission within localized areas that will target specific needs in malaria interventions. This study was therefore carried out to determine mosquito population structure, its temporal variation and transmission indices in Karu Local Government Area of Nasarawa State.

MATERIAL AND METHOD

Study area

Karu urban area is an urban area in central Nigeria. The urban area is majorly located in the Nigerian state of Nasarawa (Figure 1), but with some parts stretching into the boundaries of the Federal Capital Territory (FCT). It has an area of 40,000 hectares (400 km^2) and a population of 2 million (Pell, 2009) with annual rainfall range of 1100 to 1600 mm. It is one of the fastest growing urban areas in the world, with a growth rate of 40 percent recorded annually (Tamuno, 2006). It consists of towns that developed as a result of urban sprawl from Abuja (Terkula, 2006). From west to east, the urban area includes towns like Kurunduma, New Nyanya, Mararaba, New Karu, Ado, Auta ba-laifi, Masaka and newer, fast-growing towns such as One Man Village (which contains over 1 million people (Turaki, 2011) and Gidan Zakara. Since the beginning of the 20th century, these districts have grown together into a large urban area and a major commercial centre of central Nigeria. The above locations were choosing due to high availability of breeding sites and high prevalence of malaria cases from previous reports. Karu Local Government Area of Nasarawa State was spotted by google satellite map at a geographical coordinate of 9^0 0' 39" North, 7^0 34' 31" East and its original name (with diacritic) is Karu, situated in Abuja, FCT, Nigeria (Figure 2).

methods

Pyrethrum Spray Collection (PSC)

A total of thirty houses (15 houses in two communities of Karu Local Government Area) were randomly selected for

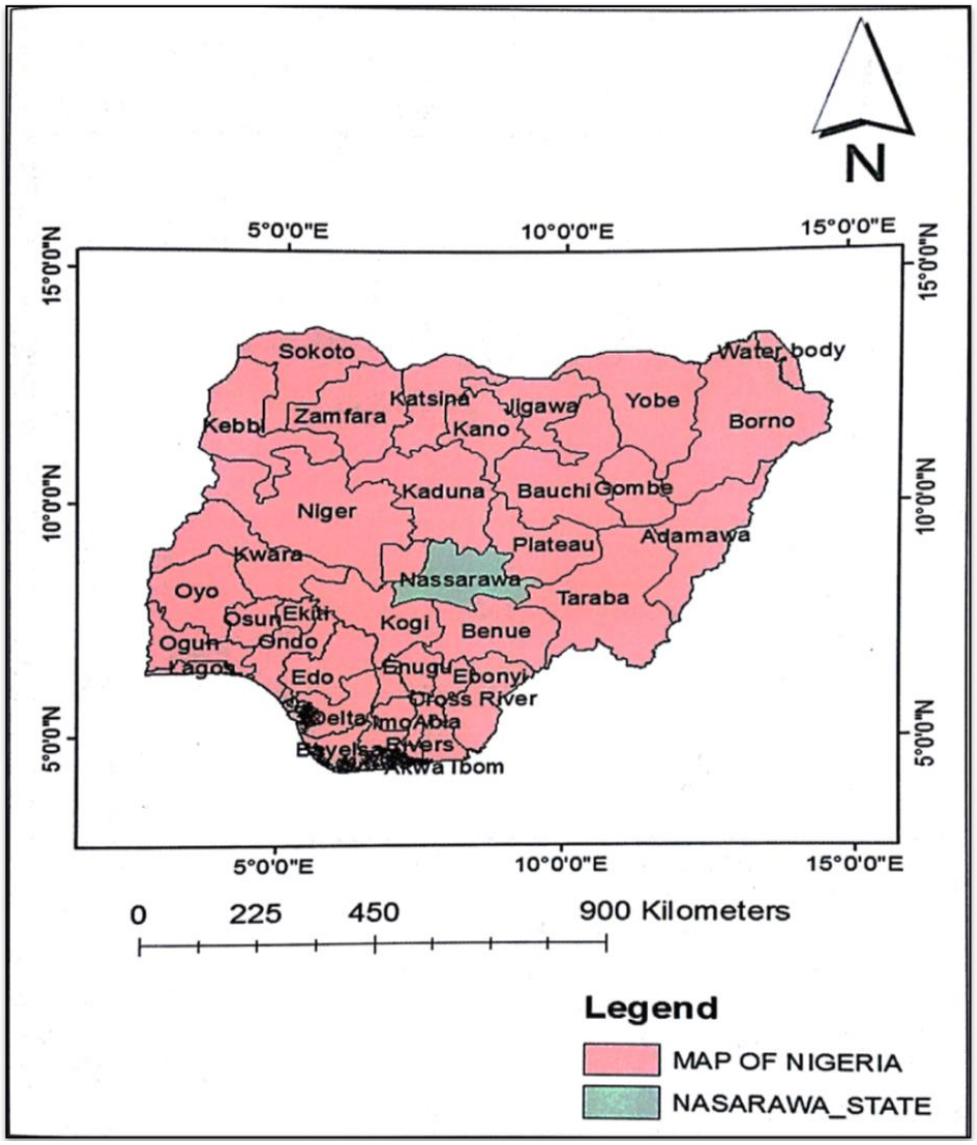

Figure 1. Map of Nigeria showing Nasarawa State (Google Search).

sampling using Pyrethrum Spray Collection (PSC) method as described by WHO (2005, 2008) to sample indoor-resting mosquitoes. The houses were sampled by two persons, using an aerosol insecticide (Baygon) containing the active ingredients of 0.05 percent imiprothrin, 0.05 percent prallethrin, and 0.015 percent cyfluthrin.

Prior to spraying, the floors were covered with clean white bed sheets, outlets were closed and the two sprayers began spraying as they moved in opposite direction spraying inside the room after which the door was closed for 15 minutes and then opened so the sprayers will enter and collect mosquitoes. Mosquitoes that were knocked down were collected from the white cloth that was laid down prior to spraying. The spraying commenced at 6:00 to 9:30 am.

The mosquitoes were collected using feather weight forceps and then placed in petri dishes or paper cups containing damp filter paper. Anopheline mosquitoes were preserved on damp absorbent paper in a cool box, transported to the Department of Zoology Laboratory, Nasarawa State University, Keffi, Nasarawa State and later identified to the species level by morphological criteria (Gillies and De Meillon 1968; Gillet, 1972; Gillies and Coetzee 1987; Kent, 2006).

CDC light trap collection

Centre for Disease Control light trap methods (baited traps, was placed indoors and outdoors) in two different houses monthly for three (3) nights per site to measure mosquito biting time. The light trap bag was replaced every

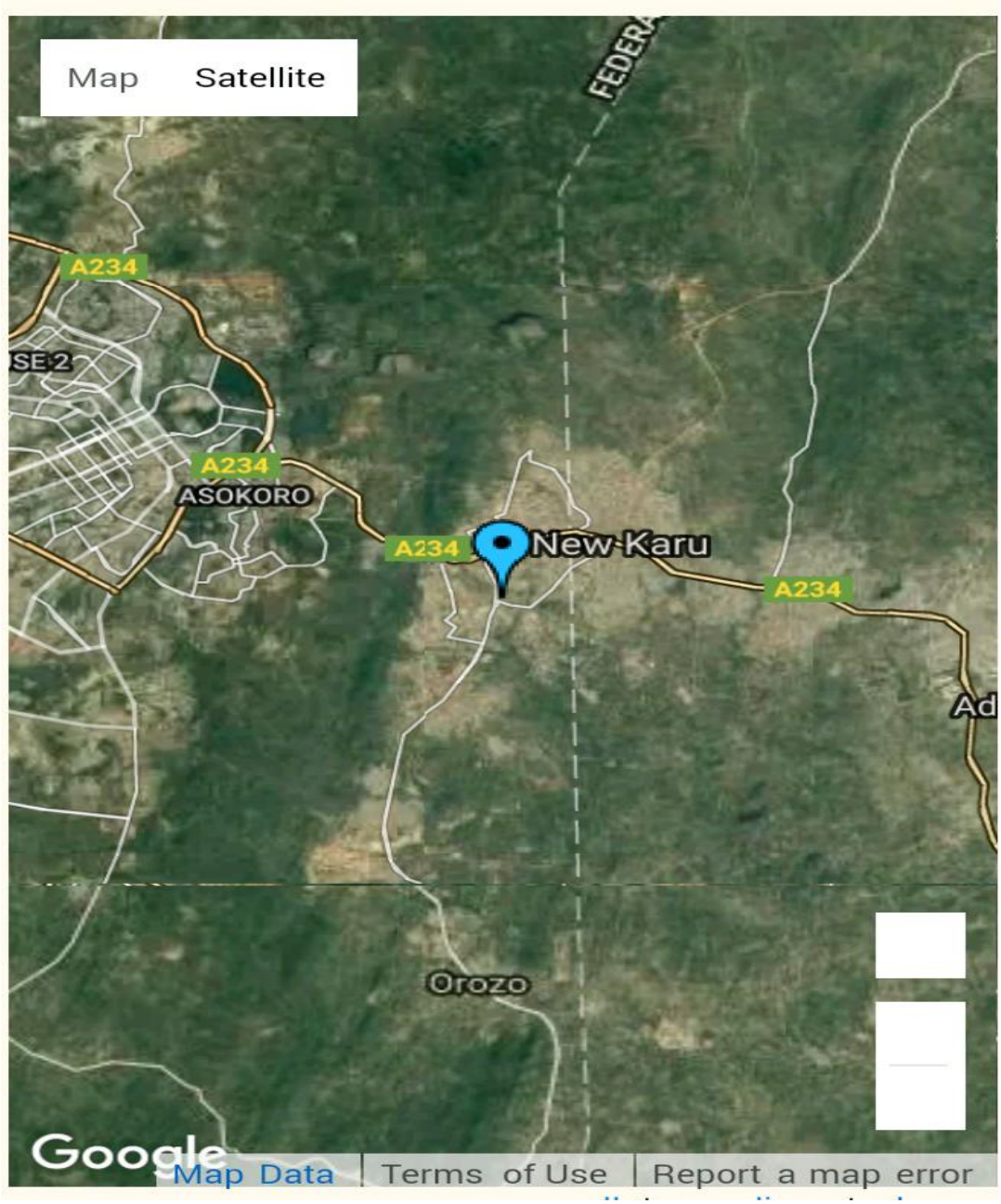

Figure 2. A satellite map of Karu Local Government Area with Major Roads (Google map, 2016).

hour by two mosquito collectors from 18:00 to 06:00 per house per night in order to have proxy estimate on the peak biting time. One collector worked from 18:00 to 24:00 and was replaced by a second collector both indoor and outdoor from 24:00 to 06:00 following the methods of Yohannes and Boelee (2012). The trap was placed close to the legs of a person sleeping under an untreated bed net as bait both indoors and outdoors with the cups changed hourly. The mosquitoes collected were kept in separate labeled paper cups for identification and further analysis as the Indoor resting *Anopheles* were collected using Pyrethrum spray insecticide. Prior to spraying of the rooms, all materials were removed from the rooms to be sampled. All openings like windows, doors, eaves among others were closed. A white sheet was spread to completely cover the whole floor. The pyrethrum insecticide (Raid) was sprayed in a clockwise direction towards the ceiling until the whole room was filled with a fine mist of the insecticide. The door was closed and left for 15 minutes. Thereafter the door was opened and starting from the doorway, the sheets were folded and carried outside. All the mosquitoes on the sheet were

Table 1. The distribution pattern of the malaria vector in two communities of Karu L.G.A.

Site/ Comm.	April		May		June		Total (%)
	Anopheline (%)	Culicine (%)	Anopheline (%)	Culex (%)	Anopheline (%)	Culex (%)	
Gitata	81(49.4)	3(42.9)	72(50.7)	6(66.7)	69(54.3)	7(53.8)	238(51.5)
Panda	83(50.6)	4(57.1)	70(49.3)	3(33.3)	58(45.7)	6(46.2)	224(48.5)
Total	164(35.5)	7(1.5)	142(30.7)	9(2.0)	127(27.5)	13(2.8)	462(100)

Table 2. Feeding behavior of mosquitoes collected indoor and outdoor in the two communities of Karu L.G.A.

Site/Comm.	April		May		June		Total (%)
	Indoor (%)	Outdoor (%)	Indoor (%)	Outdoor (%)	Indoor (%)	Outdoor (%)	
Gitata	53(51.5)	28(45.9)	41(47.1)	31(56.4)	47(52.8)	22(57.9)	222(51.3)
Panda	50(48.5)	33(54.1)	46(52.9)	24(43.6)	42(47.2)	16(42.1)	211(48.7)
Total	**103(23.8)**	**61(14.1)**	**87(20.0)**	**55(12.7)**	**89(20.6)**	**38(08.8)**	**433(100)**

transferred into petri dishes containing damp cotton wool and filter paper to maintain the physiological status of the mosquitoes.

Entomological investigation

Mosquito identification

Each adult raised from the larvae caught indoors and outdoors was individually identified to species and species complex level, using morphological characters of Gillett (2012) and Gillies and Coetzee (1987) under 20x Zeiss light microscope within 24 hour of post emergence.

Identification of feeding status of the vector

Anophelines were first grouped based on their abdominal conditions. They were generally grouped as unfed, freshly fed, half gravid and gravid (WHO, 2003).

Data analysis

Data generated were analyzed using the SPSS software version 22.0 and excel package. Chi-square (χ^2) test was used to compare the distribution of malaria vectors between collection sites and months. $p<0.05$ was considered indicative of a statistically significant difference.

RESULTS

The Distribution of malaria vectors in two communities of Karu L.G.A

A total of 462(100%) mosquitoes were collected in the study areas, 238(51.5%) were collected in Gitata and 224(48.5%) were collected in Panda. 433(93.7%) were *Anopheles* species while 29(6.3%) were *Culex,* which shows that *anopheles* are more distributed in the study area. Table 1 showed the distribution pattern of *anopheles* species over *culex* in the two sites sampled. In month April, 81(49.4%) *anopheles* dominates the *culex* 3(42.9%) in Gitata and 83(50.6%) *anopheles* dominates the *culex* 4(57.1) in Panda. In month of May, 72(50.7%) *anopheles* dominates the *culex* 6(66.7) in Gitata and 70(49.3%) *anopheles* dominates the *culex* 3(33.3%) in Panda. In month of June, 69(54.3%) *anopheles* dominates the *culex* 7(53.8%) in Gitata and 58(45.7%) *anopheles* dominates the *culex* 6(46.2%) in Panda. Statistically, there was a statistical difference ($p<0.05$) in the distribution of malaria vectors encountered in the study areas.

Feeding behavior of mosquitoes collected indoor and outdoor in the two communities of Karu L.G.A

Table 2 showed that, of the 433 *anopheles* species of mosquitoes collected, 53(51.5%) feeds indoor and 28(45.9%) feeds outdoor in Gitata, while 50(48.5%) feeds indoor and 33(54.1%) feeds outdoor in Panda for April. 41(47.1%) feeds indoor and 31(56.4%) feeds outdoor in Gitata, while 46(52.9%) feeds indoor and 24(43.6%) feeds outdoor in Panda for May. 47(52.8%) feeds indoor and 22(57.9%) feeds outdoor in Gitata, while 42(47.2%) feeds indoor and 16(42.1%) feeds outdoor in Panda for June. These analysis shows that, there is a high feeding behavior of the malaria vector Indoor than outdoor.

Table 3 showed the total number of fed, unfed, gravid and half-gravid mosquitoes collected in the two sides (Gitata and Panda). In month of April, 66(39.52%), in May, 48(28.74%) and in June, 53(31.74%) fed mosquitoes, bringing the total to 167(100%) fed mosquitoes for the three months. In month of April, 98(36.8%), in May, 94(35.4%)

Table 3. Shows the total fed and unfed mosquitoes in the two-study area of Karu L.G.A

Months	Gitata	Panda	Total	Fed	Unfed	Half-Gravid	Gravid
April	81	83	164	66	98	30	36
May	72	70	142	48	94	27	21
June	69	58	127	53	74	30	23
Total	222	211	433	167	266	87	80

Table 4. Indoor resting density of mosquitoes in two communities of Karu L.G.A.

Site/ Comm.	Indoor collection		No. of occupants		IRD = (n/N of occ.)	
	Gitata	Panda	Gitata	Panda	Gitata	Panda
April	53	50	23	20	2.3	2.5
May	41	46	20	19	2.1	2.4
June	47	42	18	16	2.6	2.6
Total	141	138	61	55	7.0	7.5

Table 5. Human biting rate of mosquitoes in two communities of Karu L.G.A.

Site/ Comm.	Indoor collection		No. of Occupants		No. of Days/Month	HBR=n/Occu./days	
	Gitata	Panda	Gitata	Panda		Gitata	Panda
April	53	50	23	20	3	0.768	0.833
May	41	46	20	19	3	0.683	0.807
June	47	42	18	16	3	0.870	0.875
Total	141	138	61	55	9	2.321	2.515

Table 6. Number of parous mosquitoes dissected from the two communities of Karu L.G.A.

Site/comm.	No. of mosq. collected	No. dissected	No parous (%)	No. nulliparous (%)	(%)
Gitata	222	76	47(55.3)	29(47.5)	0.618
Panda	211	70	38(44.7)	32(42.5)	0.543
Total	433	146	85(58.2)	61(41.8)	1.161

and in June, 74(27.8%) unfed mosquitoes, bringing the total to 266(100%) unfed mosquitoes for the three months. In month of April, 30(35.0%), in May, 27(30.0%) and in June, 30(35.0%) half-gravid mosquitoes, bringing the total to 87(100%) half-gravid mosquitoes for the three months. In month of April, 36(45.0%), in May, 21(26.2%) and in June, 23(28.8%) gravid mosquitoes, bringing the total to 80(100%) gravid mosquitoes for the three months.

Table 4 shows the indoor resting density of mosquitoes collected in each month for the two sites. 2.3 indoor resting density rate in Gitata and 2.5 indoor resting density rate in Panda for the month of April. 2.1 indoor resting density rate in Gitata and 2.4 indoor resting density rate in Panda for the month of May. 2.6 indoor resting density rate in Gitata and 2.6 indoor resting density rate in Panda for the month of June. This result shows that Panda has the highest indoor resting density of 7.5 totals than Gitata 7.0.

Table 5 showed the human biting rate (HBR) of mosquitoes collected in each month for the two sites. 0.768 HBR in Gitata and 0.833 HBR in Panda for the month of April. 0.683 HBR in Gitata and 0.807 HBR in Panda for the month of May. 0.870 HBR in Gitata and 0.875 HBR in Panda for the month of June.

Table 6 showed the parity rate (PR) of mosquitoes collected in Gitata and Panda for the three months. Out of the 76 mosquitoes dissected, 47(55.3%) were parous and 29(47.5%) were nulliparous in Gitata. Out of the 70 mosquitoes dissected, 38(44.7%) were parous and 32(42.5%) were nulliparous in Panda.

DISCUSSION

The heterogenic nature and behavior of malaria vectors,

the *Anopheles* mosquitoes has caused a lot of hindrances to malaria control strategies and interventions deployed as noticed in this research work with high abundance of mosquito species of malaria vector parasites among the individuals within the study areas as indicators of malaria transmission. *Anopheles* mosquito's distribution pattern was very high than the *culex* though the use of some insecticides and usage of long lasting insecticide treated nets can reduce vector infectivity as well as vector survival rate and the length of the sporogonic cycle. Both Gitata and Panda had high 433(93.7%) *Anopheles* species than the *culex* 29(6.3%) in their distribution pattern which may be due to the availability of temporary breeding sites as reported by Angerilli (1980) and some of the environmental practices within the study areas which include disposing of containers, receptacles, water storage jars, unused tyres, abandoned cans etc. Also, the anopheles species found in this study areas were also reported by Coluzzi et al. (2002) which is the most important vector of the malaria parasites in the Sub-Saharan Africa, in connection with certain climatic factors most especially the annual precipitation appears to influence the range and the relative abundance of the mosquito species.

For the feeding behaviour of these mosquitoes, of the 433 *anopheles* species of mosquitoes collected, 53(51.5%) feeds indoor and 28(45.9%) feeds outdoor in Gitata, while 50(48.5%) feeds indoor and 33(54.1%) feeds outdoor in Panda for April, 41(47.1%) feeds indoor and 31(56.4%) feeds outdoor in Gitata, while 46(52.9%) feeds indoor and 24(43.6%) feeds outdoor in Panda for May, 47(52.8%) feeds indoor and 22(57.9%) feeds outdoor in Gitata, while 42(47.2%) feeds indoor and 16(42.1%) feeds outdoor in Panda for, which shows that, there is a high feeding behavior of the malaria vector Indoor than outdoor. The indoor feeding behaviour was very high than outdoor feeding behaviour which makes the occupants living in those houses more quick at risk of infection of the malaria vector in the study area. This result is similar to the findings of Atting et al. (2016) who reported higher feeding behaviour of mosquitoes indoor than outdoor in Uyo, Akwa Ibom State, Nigeria.

The indoor resting density of mosquitoes collected in each month for the two sites shows that there were 2.3 indoor resting density in Gitata and 2.5 indoor resting density in Panda for April, 2.1 indoor resting density in Gitata and 2.4 indoor resting density in Panda for May. 2.6 indoor resting density rate in Gitata and 2.6 indoor resting density rate in Panda for June. This result shows that Panda has the highest indoor resting density of 7.5 totals than Gitata 7.0, therefore individuals or occupants should be prompt on using long lasting insecticides treated mosquitoes net and other approved insecticides by the Centre for Disease Control and Prevention (CDC). The findings of this research work disagree with the work of Umar et al. (2015) who reported IRD during the dry season in Bauchi State, Nigeria.

The human biting rate (HBR) of mosquitoes collected in each month for the two sites shows that there is 0.768 HBR in Gitata and 0.833 HBR in Panda for April, 0.683 HBR in Gitata and 0.807 HBR in Panda for May, 0.870 HBR in Gitata and 0.875 HBR in Panda for June, which shows that occupants do not really use the LLIN given to them. This result is similar to the findings of Atting et al. (2016) who in their own research recorded a higher HBR in Uyo, South – South Nigeria.

The parity rate (PR) of mosquitoes collected in Gitata and Panda for the three months however shows that out of the 76 mosquitoes dissected, 47(55.3%) were parous and 29(47.5%) were nulliparous in Gitata and out of the 70 mosquitoes dissected from Panda, 38(44.7%) were parous and 32(42.5%) were nulliparous which shows that these mosquitoes feeds and lay eggs most frequently in the study area unlike in other studies in Ghana and even Lagos State in South West Nigeria (Appawu et al., 2004 and Awolola et al., 2003). It showed that anopheles mosquitoes selected in the study areas are effective vectors of malaria transmission.

The distribution pattern of the mosquito species within the study areas was also associated with the availability of suitable breeding habitats within the locations as described by Minakawa et al. (2005). The breeding sites ranges across the various types of water bodies such as temporary ground pools to large permanent water bodies found within the study areas. More so, the high rate of malaria infection within the study area could be attributed to the fact that the infection is already a looming endemic problem in Nigeria, including Nasarawa State as the sampling and surveying period coincided with the peak of raining season when mosquitoes are breeding due to the amount of rainfall. Moreover, Karu and its environment including the study areas are relatively water logged and poorly drained areas, gutters and other drainages are also routinely clogged with wastes as a result of an inefficient public waste disposal system. All these provide good breeding sites for mosquitoes which help to fuel stable and continuous malaria transmission, even beyond the peak rainy season in the months of November and December respectively.

Conclusion

In conclusion, the morphological identification of these mosquitoes shows that, *Anopheles* is the most predominant genera than *Culex* in the study area. The vector is anthropophilic (preference for humans) and endophagic (bites indoors) than exophagic (bites outdoors). This may help narrow down vector control measures in Karu Local Government Area to a selective, targeted, site specific, ecologically sound and cost effective (malaria) vector control strategy suited to the local environment and epidemiological conditions of Karu Local Government.

The findings of this study also indicates that both the

entomological and parasitological indices of malaria transmission which includes their Species Distribution, Feeding Behavior and the sporozoites found in the salivary glands of the female Anopheles as well as their parous nature and the Plasmodium parasites found in the blood samples of the patients are well established in the study areas, thus explaining the endemicity of malaria in Karu Local Government Area of Nasarawa State and its environment.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

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