Annals of West University of Timişoara, ser. Biology, 2018, vol. 21 (1), pp.85-92

PARITY AND INFECTIVITY STATUS OF FEMALE *ANOPHELINE* MOSQUITOES IN IRRIGATION AND NON-IRRIGATION AREAS, NORTH CENTRAL NIGERIA

Ebube Charles AMAECHI[1, 2]*, Onyinye Mkpola UKPAI[2], Carmelita Chima OHAERI[2], Onyekachi EGWU[2], Ozioma Prisca IROLE-EZE[2], Chioma Ada IHEMANMA[3]

[1]Department of Zoology, Faculty of Life Sciences, University of Ilorin, Ilorin, Nigeria.
[2]Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[3]Department of Biology/Microbiology, Abia State Polytechnic, Aba, Abia State, Nigeria.
**Corresponding Author e-mail: ebubeamechi@yahoo.com*
Received 7 May 2018; accepted 9 June 2018

ABSTRACT

For a successful decision-making process relating to malaria control strategies, entomological surveys are of valuable importance. This is because they help to identify associations between vector abundance and disease intervention in relation to malaria transmission. Sporozoite infectivity rates, parity rates and physiological status of Anopheles species were assessed in this study. A longitudinal survey was conducted in five locations each from intervention and control villages. Monthly mosquito sampling was done for 12 months. Malaria vectors were sampled using pyrethrum spray catch and human landing catch. Sampling was done two days simultaneously each month at both intervention and control villages. Mosquitoes collected were identified morphologically to species level. Parity was determined using the conventional technique while the presence of malaria sporozoites was determined by examining the salivary glands under a microscope. Mosquito infectivity rates between villages showed that more of the Anopheles species caught from intervention village (An. gambiae, 38.4%; An. funestus, 20.5%) were more infected as compared to those from control village (An. gambiae 22.6%; An. funestus 3.1%). Dry season mosquitoes were more parous (48.1%) than those in the rainy season (31.4%). In the intervention village more of the mosquitoes were fed (46.8%) as compared to those caught in the control village (18.3%). The detection of more sporozoites in An. gambiae s.l mosquitoes indicates that it is the most efficient malaria vector species in the study area and environs. The risk of infection is higher in the intervention village than the control village.

KEY WORDS: *malaria, Anopheles, entomological, parity, sporozoite, irrigation, Omi, Kogi State.*

INTRODUCTION

One important disease of poverty that has huge public health relevance particularly in sub Saharan Africa is malaria. Human malaria parasites are transmitted by mosquitoes of the genus *Anopheles* which include 465 species of which approximately 70 are able to transmit malaria. In Africa, *Anopheles gambiae sensu stricto(s.s)* and *sensu lato(s.l), Anopheles funestus*

and *Anopheles arabiensis* are the major vectors of malaria and lymphatic filariasis (Awolola *et al.,* 2002).Malaria is known to affect the resource poor communities especially in Africa where pregnant women and children under five years are at high risk. Global prevalence rate of malaria was estimated to be 216 million cases with 445 000 deaths in 2016 where 3.2 billion are at risk of the infection (WHO, 2017). The situation is worst with sub-Saharan Africa with 90% of the deaths occurring in Africa where it remains the principal reason for ill-health and deaths (Smith *et al.,* 2007; Okorie *et al.,* 2011). Nigeria suffers the greatest malaria burden globally, with approximately 100 million cases and over 300,000 deaths reported annually, where 97% of its total population is at risk of the infection (Federal Ministry of Health, 2014).Water development projects that serve for irrigation purposes have been linked to facilitating the proliferation of breeding grounds for mosquito vector (Gujja & Perrin, 1999; Kibret *et al.,* 2015). This area of water management has not been given the much needed attention. Information on the epidemiology of malaria is key to an efficient control of the disease. Entomological studies provide useful information on the characteristics of malaria transmission in a locality especially in relation to the vector species (Noutcha &Anumudu, 2009; Oduola *et al.,* 2013; Ikpa *et al.,* 2017). Sporozoite rates provide information on the number of female *anopheles* mosquitoes that carry the infective stage of malaria parasites. To date no entomological study on malaria transmission in Omi and surrounding communities in Yagba West LGA of Kogi State has been carried out despite its importance in the characterization of local malaria. The result of the study would be a baseline data for the planning of malarial intervention control strategies in the area.

MATERIALS AND METHODS

Study area. This study was conducted in Omi reservoir irrigation area and surrounding communities. Omi reservoir irrigation project is located in Yagba West Local Government Area (L.G.A) of Kogi State, north central Nigeria. It is about 146 km from Ilorin the capital of Kwara State. A detailed description of the study area has previously been published by Amaechi *et al.* (2016, 2017). Ten communities were divided into two groups. The first group was communities close to the reservoir (Ogga, Iddo, Ogbo, Ejiba and Omi communities) which formed the Intervention study area. The second group was communities which were far away from the reservoir (at least 4Km away) which is greater than the flight of mosquitoes. The communities (Mopa, Okagi, Ilai, Amuro and Ijowa) formed the control study area. The study communities had very similar environmental factors with high relative humidity ranging between 85% and 90% with an annual mean daily temperature ranging between 28 ^{0}C and 35 ^{0}C. There are two main seasons in the area. The annual rainfall is between 1100 mm and 1300 mm. The vegetation is guinea savannah while the soil is hydromorphic, containing a mixture of coarse alluvial and colluvial deposits. Most of the inhabitants in the study area depended on the water body for drinking and for domestic use. The communities have schools, hospitals and dispensaries where the inhabitants seek treatment. Most of the houses have unscreened windows, holes in the walls, and large open eaves that provide easy entry for mosquitoes. The houses are separated from one another either by agricultural land or small patches of natural vegetation.

Omi dam is located in one of the five villages (Omi) with canals linking the dam water to the other four communities. Fishing and irrigational farming are the activities most concentrated on Omi whereas gardens for vegetable farming and rice fields are created and served by the canal water running through the rest of the four communites (Ogga, Iddo, Ogbo, Ejiba). These formed the intervention villages, while those that were far away from the dam (Mopa, Okagi, Ilai, Amuro and Ijowa) formed the control villages (Figure 1).

Houses in the control and intervention villages were numbered. Those with even numbers in the intervention village served as the study population, while those with odd numbers served as the study population in the control villages. Monthly mosquito sampling was done between November, 2013 and October, 2014.

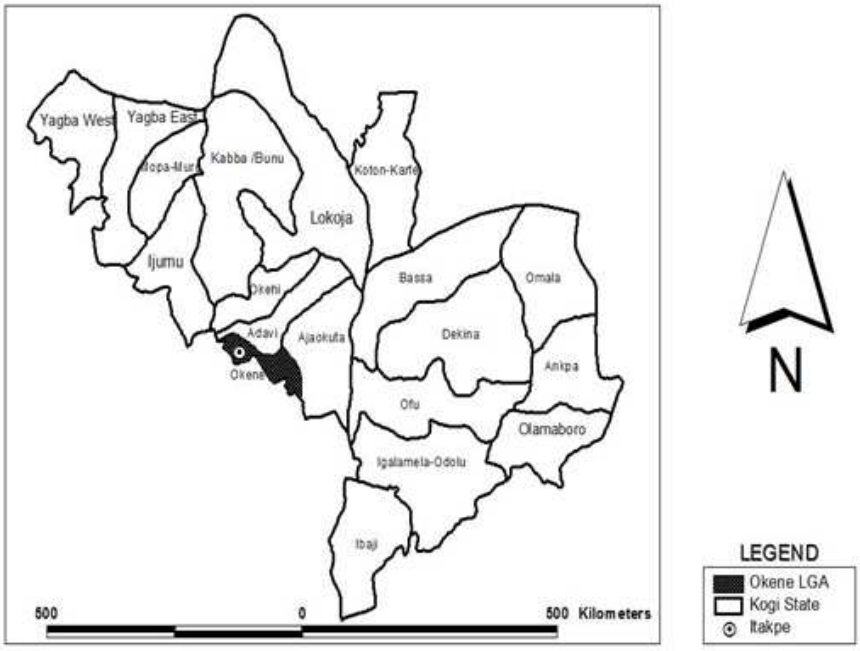

FIG. 1. Map of Yagba West Local Government Area in Kogi State (Source: Google Map, 2016)

Ethical consideration. Permission to conduct the study was obtained from authorities of Lower Niger River Basin Authority, Ilorin. Approval was granted by the Kogi State Ministry of Health and the local government health authority. Meetings were held in the villages to explain the purpose of the study to the inhabitants. It was made clear that participation in the study was voluntary and that it was possible to withdraw from the study at will. The post-graduate committee board of the Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, gave approval to the study. The community leaders gave their full support and cooperation. A verbal consent was obtained from the owners of the houses where mosquito trapping was done.

Field sampling of mosquitoes. Adult mosquitoes were collected over a period of 12 months (November 2013 to October 2014) using both human landing catch (HLC) and pyrethrum spray catch (PSC) methods (WHO, 1992).Two day catches of mosquitoes were carried out simultaneously each month at the two villages (Intervention and control). Both indoor and outdoor HLC were conducted.

Anopheline **mosquito identification and processing.** Mosquitoes collected were kept in cool boxes and brought to a field laboratory for identification and further processing. In the laboratory, mosquitoes were anaesthetized, sorted, identified morphologically to species level (Gillies and De Meillon, 1968; Gillies and Coetzee, 1987) and counted. Parity of female *An. funestus* and *An. gambiae s.l* from a sample of unfed mosquitoes were determined using the conventional technique as described by Detinova (1962). The presence of malaria sporozoites was determined by examining the salivary glands under a microscope (WHO, 1975).

Statistical analysis. The data obtained from this research was analyzed using Statistical Package for Social Sciences, version 16.0, Chicago, IL, USA (SPSS).The data were double checked to ensure for correctness of the imputed figures before the analysis.

Sporozoite rate (Sporozoite Index). This was estimated as the percentage of *Anopheles* mosquitoes (collected by vector collectors within the study period from November, 2013 to October, 2014); that had sporozoites in their glands after dissection.

Parity rate determination. The parity rate was determined by dissection, and the parous mosquitoes (those that have taken a blood meal at least once and laid eggs at least once) were separated from the nulliparous mosquitoes (those that had not taken a blood meal yet and had never laid eggs). It was determined as the proportion (percentage) of parous female *Anopheles* specie amongst the total number of mosquitoes dissected.

RESULTS AND DISCUSSIONS

Infection rate amongst *Anopheles* species dissected. *A. gambiae* and *A. funestus* were found to be infected with the sporozoite of *Plasmodium falciparum*. Of the 1350 *Anopheles* mosquitoes that were dissected, 488 (25.0 %) were found with sporozoite infections.The majority of 307 (38.4%) occurred in the intervention village while 181 (22.6%) were found in the control village. *An. gambiae* harbored more sporozoite (25.0%) as compared to *An. funestus* (6.7%) (Table 1)

TABLE 1: Sporozoite infection rates in female *Anopheles* mosquitoes collected in Intervention and Control villages

Village	Mosquito species	No Examined	%Positive for sporozoites
Intervention	*Anopheles gambiae s.l*	400	307(38.4)
	Anopheles funestus	400	113(20.5)
	Culicines	400	0
Control	*An. gambiae s.l*	400	181(22.6)
	An. funestus	150	17(3.1)
	Culicines	200	0
Total	*An. gambiae s.l*	800	488(25.0)
	An. funestus	550	130(6.7)
	Culicines	600	0

(F=3.29, df=2, P>0.05)

Note: All values in brackets are expressed as percentages

Parity rates. In order to assess the age and longevity of the vectors identified, the proportions of parous females were determined. Seasonal variations in parity rates were observed, with more parous females caught in the dry season than in the rainy season (Table 2). Dissections of female *Anopheles spp* collected during the dry season showed that parous females made up 48.1 % (164 of 341) of mosquitoes caught whereas a lower percentage collected in the rainy season 31.4 % (144 of 459) were parous (x^2=15.342,df=3,p=0.001).

Physiological status of *An. gambiae* and *An. Funestus.* The physiological status of *An. gambiae s.l* and *An. funestus* are shown in Table 3.In the intervention village, more *An. gambiae* were blood fed as compared with those in the control villages. No significant difference (P>0.05) was observed in the blood fed status of *An. funestus* in both villages.

TABLE 2: Number of parous and nulliparous *Anopheles* mosquitoes dissected between November 2013 and October 2014

Dry season			**% parity**
Period of study	**No dissected**	**No of parous female *Anopheles***	
November 2013	75	32	
December 2013	71	29	
January 2014	62	36	
February 2014	68	38	
March 2014	65	29	
Total	**341**	**164**	**48.1**
Rainy season			
April 2014	61	16	
May 2014	59	19	
June 2014	57	13	
July 2014	78	24	
August 2014	81	17	
September 2014	64	21	
October 2014	59	34	
Total	**459**	**144**	**31.4**

(F=4.87, df =5, P>0.05)

TABLE 3: Physiological status of *Anopheles* species in intervention and control villages

Villages	**Mosquito species**	**Blood fed status**		**Gravid status**		
		Unfed	**Blood fed**	**Half gravid**	**Gravid**	**Total**
Intervention	*A. gambiae s.l*	29(7.3)	187(46.8)	116(29.0)	68(17.0)	400
	A. funestus	134(67.0)	2(1.0)	45(22.5)	20(10.0)	200
Control	*A. gambiae s.l*	112(28.0)	73(18.3)	153(38.3)	62(15.5)	400
	An funestus	87(87.0)	0(0.0)	12(12.0)	1(1.0)	100

(F=19.25,df=1, P>0.05)

Note: All values in brackets are expressed as percentages

In any given locality, good knowledge of the local malarial vectors and its infectivity status is vital for a better control and elimination strategy. No report of sporozoite infectivity rates, parity rates and physiological status of female *Anopheles* species exist in Yagba West L.G.A, Kogi State, north central Nigeria. The study was carried out in irrigated and non-

irrigated areas of Yagba West L.G.A to ascertain sporozoite and infectivity rates in the study area. In both Intervention and Control study areas, *An gambiae s.l* and *An. funestus* are the most prevalent vectors. Overall, the sporozoite rate of *An. gambiae* collected from intervention area (38.4%) was significantly higher when compared with those collected from the control sites (22.6%).In both intervention (38.4%) and control (22.6%) study areas, *An gambiae* showed greater potential for malaria transmission, although a higher value in the intervention sites. This was within the range obtained in another study by Manyi *et al*., 2014 in Makurdi, north central Nigeria who obtained a sporozoite infection rate of 31.5% for *An. gambiae*. The results obtained however, was in variance with the reports of Oduola *et al.,*2012 who worked in Oyo, south Western Nigeria who found sporozoite infection rate of *An. gambiae s.s* that varied between 1.5% to 4.5% in the study communities. A similar work carried out in Western Kenya by Shililu *et al.,* 1998 found sporozoite rate of *An.gambiae* to be 6.3%. Salako (1997) had earlier reported that sporozoite infection rates tend to be higher in the rural areas than urban areas. The present study was carried out in rural communities that had conducive breeding areas for the mosquito vector to proliferate. The sporozoite infectivity status for *An. funestus* obtained in both intervention (20.5%) and control (3.1%) study areas in the present study were within the range of values obtained by other researchers within the same geographical locations. In Makurdi, Benue State north central Nigeria, Manyi *et al*., 2014 obtained a 17.9% sporozoite infection rate for *An. funestus.* Also, in Gboko, Benue State, north central Nigeria, Ikpa *et al.,* 2017 obtained 16.0% sporozoite infection rate in *An. funestus*. The result obtained in this study has added to the fact that *An.funestus* show great potential for malaria transmission in both intervention and control study areas. This agrees with the findings of Awolola *et al. (*2002). The presence of permanent pools with water bearing plants favours breeding of anopheles species. In the intervention site, the existence of the irrigation scheme allowed for the presence of rain pools which favoured the availability of breeding places for mosquito vector.

The parous rate of 48.1% recorded in the dry season was higher than that reported by Saotoing *et al*. (2014) in the city of Maroua, Cameroon whereas the parous rate of 31.4% observed in rainy season was lower than 54% reported by the same author. The parous rate recorded during the dry season during the study period was higher than that obtained during the rainy season which was similar to the findings of Uttah *et al.,* 2013 in Ekorinim area of Calabar. Factors that affect the epidemiology of vector-borne diseases such as malaria may include the age and vectorial ability to survive at a given time and place. The present study which recorded a high rate of parous female anopheles mosquito indicates high longevity of female anopheline mosquito in the study area. Epidemiologically, the significance is that these female anopheles mosquitoes would be actively involved in the transmission of malaria (Uttah *et al*., 2013; Umeanaeto *et al*., 2017)

The need for blood by adult female anopheles mosquitoes to develop their eggs is a vital reason which makes them to be a successful vector of most tropical diseases in the world. Results from the study shows that a remarkable number of the female Anopheles mosquitoes were blood fed. The high proportion of the fed female *An. gambiae* in both intervention (46.8%) and control (18.3%) study areas could be due to the fact that the populace exposes them during the night to mosquito bite. The high vector-human contact could lead to greater tendency of the infected mosquitoes to transmit *Plasmodium* parasites that cause malaria. The greater number of *An. gambiae* being blood fed is because they are anthropophilic.

CONCLUSION

This study shows that irrigation and other agricultural practices have greater influence on mosquito breeding habitat. A greater number of *Anopheles* mosquito caught in the irrigated communities (intervention) was found to be more infected as compared to non-irrigated communities (control).

REFERENCES

- Amaechi E.C., Ohaeri C.C., Ukpai O.M., Nwachukwu P.C., UkohaU.K. 2016. Lymphatic filariasis: Knowledge, attitude and Practices among inhabitants of an irrigation project community, north central Nigeria. *Asian Pacific Journal of Tropical Disease,* 6(9):709-713.
- Amaechi E.C., Ohaeri C.C., Ukpai O.M., Ukoha U.K., Nwachukwu P.C., Ejike B.U. 2017. Prevalence and clinical aspects of *Wuchereria bancrofti* among inhabitants of a resource limited irrigation project community, north central Nigeria. *Asian Pacific Journal of Tropical Disease,* 7(1):32-35.
- Awolola T.S., Brooke B.D., Hunt R.H., Coetzee M. 2002. Resistance of the malaria vector *Anopheles gambiae* s.s to pyrethroid insecticides in Nigeria. *Annals of Tropical Medicine and Parasitology,* 96:849-852.
- Detinova T. S. 1962. Age grouping methods in Diptera of medical importance, with special reference to some vectors of malaria. *World Health Organization Monographs Series*, 47.
- Federal Ministry of Health (2014). National Malaria Program Plan.
- Gillies M. T., De Meillon B. 1968. The Anophelinae of Africa south of the Sahara.*South Africa Institute of Medical Research, Johannesburg*, 13(54).
- Gillies M. T., Coetzee, M. 1987. A supplement to the Anophelinae of Africa south of the Sahara (Afro-tropical region). Johannesburg. *Publication of the South African Institute of Medical Research* 55: 1-143.
- Gujjei B., Perrin M. 1999. *A place for dams in the 21st century.*World wildlife fund.Pp108.
- Ikpa G.I., Mafuyai H.B., Ikpa T.F. 2017. Distribution and infectivity of anopheles mosquitoes and asymptomatic malaria infections in a home setting of Gboko, Nigeria. *Nigerian Journal of Parasitology*, 38(1):98-103.
- Kibret S., Lautze J., McCartney M., Wilson G.G., Nhamo L. 2015. Malaria impact of large dams in sub-Saharan Africa: maps,estimates and predictions. *Malaria Journal*, 14:339.
- Manyi M.M., Imandeh G.N., Azua E.T. 2014. Vectorial potential of Anopheles and Culex species in the transmission of bancroftian filariasis in the localities of Makurdi, north central Nigeria. *Journal of Entomology and Zoology Studies*, 2(5):171-177.
- Noutcha M.A.E., Anumudu C.I. 2009. Entomological indices of Anopheles gambiae sensu lato at a rural community in south-west Nigeria. *Journal of Vector Borne Disease,* 46(1):43-51.
- Oduola A.O., Otubanjo O.A., Olojede J.B., Oyewole I.O., Awolola T.S. 2012. Malaria transmission risk indices of three Anopheles species in selected rural communitis in Oyo State south- western Nigeria. *International Journal of Tropical Medicine*, 7(1):42-48.
- Oduola A.O., Obembe A., Adeogun A., Awolola T.S. 2013. Entomological and transmission risk indices of malaria vectors in selected communities in Osun State, *Nigeria. Animal Research International,* 10(3):1805-1808.
- Okorie P.N., Mckenzie F.E., Ademowo O.G., Bockarie M., Kelly-Hope L. 2011. Nigeria anopheles vector data base: An overview of 100 years of research. *PLos One,*6(12).e28347.
- Salako I. 1997. Malaria the unending saga. Keynote address. In: Coping with treatment failures in malaria.Obi C.C(Ed). Mayer and Baker, Lagos.pp 13-25.
- Saotoing P., Fohouo-Tchuenguem F. N., Njan-Nloga A. M. 2014. Study of entomological parameters involved in the transmission of *Plasmodium* parasite in *Anopheles gambiae* in the city of Maroua, Far North Region Cameroon. *Journal of Entomology and Zoology Studies*, 2(5):381-386.
- Shililu J. I., Maier W. A., Seitz H. M., Orago A. S. 1998. Seasonal density, sporozoite rates and entomological inoculation rates of *Anopheles gambiae* and *Anopheles funestus* in a high-altitude sugarcane growing zone in western Kenya. *Tropical Medicine and International Health,* 3(9):706-710.
- Smith D.L., Guerra C.A., Snow R.W., Hay S.I. 2007. Standardizing estimates of the *Plasmodium falciparum* parasite rate. *Malaria Journal*, 6:131 doi: 10.1186/1475-2875-6-131.
- Umeanaeto P.U., Asogwa A.N., Onyido A.E., Irikannu K.C., Ifeanyichukwu M.O. 2017. The parity rate of indoor-resting adult female *Anopheles* and *Culex* mosquitoes and their implication in disease transmission in Nnamdi Azikiwe University female hostels Awka, south eastern Nigeria. *International Journal of Environment, Agriculture and Biotechnology*, 2(4):1551-1556.

- Uttah E.C., Iboh C.I., Ajang R., Osim S.E., Etta H. 2013. Physiological age composition of female anopheline mosquitoes in an area endemic for malaria and filariasis. *International Journal of Scientific and Research Publications*, 3(7):1-6.
- WHO. 1975. Manual on Practical Entomology in Mlalaria, part II.Methods and Techniques. Geneva.
- WHO.1992.Expert Committee on malaria.19th report. WHO Technical report series No.735.Geneva.
- WHO.2017. World Malaria Report. World Organization Press. Geneva, Switzerland