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Distribution and seasonal abundance of Anopheline mosquitoes and their association with rainfall around irrigation and non-irrigation areas in Nigeria

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ABSTRACT: The abundance of *Anopheline* mosquito species is the most common entomological measurement to determine the relationship between vectors and malaria incidence. We conducted an entomological survey to determine mosquito species diversity and abundance in relation to rainfall in Omi reservoir irrigation area, Nigeria. We collected adult mosquitoes from 10 randomly selected residential houses using *Pyrethrum* spray sheet and Human Landing Catch methods. We grouped the samples into irrigated (intervention) and non-irrigated (control) communities. During the 12-month sampling period, we collected a total of 4 285 mosquitoes belonging to 10 species in one family. The three most common species during this study were *Anopheles gambiae*, *Anopheles funestus* and *Culex quinquefasciatus*. Irrigated community has higher numbers of mosquitoes (69,4%) compared to those collected in non-irrigated community (32,0%). Comparing the two collection methods used, *Pyrethrum* spray sheet has a greater number 2 225(75,4%) of mosquitoes than those with Human Landing Catch method 724(24,6%). During dry season, we collected fewer mosquitoes. The lowest number was collected in February (114) and the highest occurring during the wet season in July (445).

Key words: Mosquitoes, Omi reservoir, collection method, abundance, Kogi.

RESUMEN: Distribución y abundancia estacional de los mosquitos anofelinos y su asociación con la lluvia en las áreas de riego y sin irrigación en Nigeria. La abundancia de mosquitos anofelinos es la medida entomológica mas común para determiner la relación entre vectores y la incidencia de malaria. Realizamos un muestreo entomológico para determinar la diversidad y la abundancia de las especies de mosquitos en relación con las precipitaciones en el área de riego del embalse de Omi, Nigeria. Recogimos mosquitos adultos de 10 residencias elegidas al azar usando láminas de rociado de *Pyrethrum* y métodos de captura humano. Agrupamos las muestras en comunidades irrigadas (intervención) y no irrigadas (control). Durante el período de muestreo de 12 meses, recolectamos un total de 4 285 mosquitos pertenecientes a 10 especies en una familia. Las tres especies más comunes durante este estudio fueron *Anopheles gambiae, Anopheles funestus* y *Culex quinquefasciatus*. La comunidad irrigada tiene un mayor número de mosquitos (69,4%) en comparación con lo recolectado en comunidades no irrigadas (32,0%). Comparando los dos métodos de recolección utilizados, la lámina de rociado de *Pyrethrum* tiene un número mayor de 2 225 (75,4%) de mosquitos que aquellos con el método de captura humano 724 (24,6%). Durante la estación seca recolectamos menos mosquitos. El número más bajo se recolectó en febrero (114) y el más alto durante la temporada lluviosa en julio (445).

Palabras clave: mosquitos, embalse de Omi, método de colecta, abundancia, Kogi.

Mosquitoes are responsible for the spread and transmission of several harmful diseases such as malaria and lymphatic filariasis. It is known to infect over 700 million people causing 1 million deaths each year especially in developing regions of the world including sub-Saharan Africa (WHO, 2016). Despite years of control efforts, malaria continues to be a major threat to public health in parts of sub-Saharan Africa, Nigeria inclusive. About 97% of Nigeria's population is at risk of malaria where 60% of hospital outpatient visits and 30% of hospitalization among children under five years and pregnant women occur due to malaria (Nigeria Malaria Fact Sheet, 2011). Entomological studies focused on the diversity, density, behavioral patterns and temporal variations of

Anopheles species have long been found to be beneficial in the identification and monitoring of malarial vectors (Tadei et al., 1998). A combination of factors that determine the capacity of a vector to transmit malaria include; abundance, anthropophily, zoophily, susceptibility to infection by the malaria parasite, infection rates and female longevity (Aniedu,1992; Lounibos & Conne, 2000).

Recent studies have shown that the abundance of *Anopheline* mosquito species is the most common entomological measurement used to determine the relationship between vectors and malaria incidence in any locality (Muturi et al., 2006; Zimmerman, Galardo, Lounibos, Arruda & Wirtz, 2006). Changes that occur in the environment especially in climate have a great bearing on breeding habitats of different mosquito species that influences the population density of adult mosquitoes (Bashar & Tuno, 2014). Climatic factors such as rainfall affect adult mosquito abundance by drastically altering the quality and quantity of breeding habitats. To determine parasite activity levels and associated disease risk, the relationship between rainfall and mosquito abundance must be ascertained (Bashar & Tuno, 2014). A proper understanding of the relationship between rainfall and the abundance of mosquito vector will help to develop an efficient and feasible vector control program in the study communities hence the need to establish the seasonal abundance of mosquito population (Alten, Bellini, Caglar, Sinsek & Kaynas, 2000; Bashar & Tuno, 2014).There is no recorded information on the seasonal abundance of anopheline mosquitoes in Omi community, an agricultural irrigated area in Kogi State, north central Nigeria. Therefore, this study was conducted to investigate the species composition and seasonal population dynamics and their possible association with rainfall and disease transmission in the irrigated communities, prior to the implementation of a National malaria vector control.

MATERIALS AND METHODS

Study area: This study was conducted in Omi reservoir irrigation area and surrounding communities. Omi reservoir irrigation project is in Yagba West Local Government Area (L.G.A) of Kogi State, north central Nigeria. It is about 146Km from Ilorin the capital of Kwara State. It lies between latitudes 8˚34´and longitudes 6˚42´E (Areoye, Owolabi & Eniola, 2004). The project is in Omi village, a farming community of about 10 000 people (Oyeyinka et al., 2003). The primary aim of establishing this dam is to promote agriculture through irrigation activities involving more than 5 000 farming households both within and outside Yagba West Local Government Area. Ten communities were divided into two groups. The first group were communities close to the reservoir (Ogga, Iddo, Ogbo, Ejiba and Omi communities) which formed the Intervention study area. The second group were 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 1 100mm and 1 300mm. 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.

Mosquito collection and identification: Mosquitoes were collected once a month in 10 randomly selected houses in each community using *Pyrethrum* spray sheet collection (WHO, 1975), for 12 months. During collection five of the ten selected houses were sprayed in the morning between 0600hrs and 0800hrs while the remaining five houses were sprayed the following day at the same time. In each house, food items and drinking water were temporarily removed. White sheets were then spread on the beds and floor before spraying the house with 0,3% solution of *Pyrethrum* in paraffin. After 10 minutes, the knocked down mosquitoes from different households were picked up on the sheets, placed into labeled petri dishes lined with moist cotton wool and transported to the laboratory in a cool box for identification and dissection.

Mosquitoes were identified morphologically to species level using taxonomic keys of Gillett (1972) and Gillies and Coetzee (1987). They were further classified according to physiological status as unfed, blood-fed, half-gravid or gravid by examining the abdomen for the extent of distension (WHO, 1975).

Statistical analyses: Microsoft Office© Excel© was used for plotting all graphs. All statistical analyses were

performed using SPSS software (Version 16.0 for windows, SPSS Inc., Chicago, IL). Analysis of variance (ANOVA) was used to assess level of significance in the proportion.

RESULTS

Species composition and abundance: A total of 4 285 female mosquitoes belonging to ten species were collected in the two study sites (Table 1 and Fig. 1). Out of these, 2 913(68,0 %) were collected in intervention communities and the rest 1 372(32,0 %) in control communities. *A. gambiae s.l* was the most predominant species at both sites among the anophelines, whereas among culicines, *C. quinquefasciatus* was the most predominant species in both sites (F=11,070, P<0,05). Of the ten mosquito species that were collected, eight occurred in both sites while the remaining two (*A.moucheti* and *A. ziemani*) were collected from the intervention site. Overall, *A. gambiae, A. funestus* and *C.quinquefasciatus* were the most common species in both intervention and control communities.

TABLE 1
Number of mosquitoes and species collected in the intervention and control villages.

Mosquito species	Intervention		Control	
	No collected	%	No collected	%
Anopheles gambiae	1 565	53,7	782	57,0
Anopheles funestus	418	14,3	184	13,4
Anopheles nili	38	1,3	5	0,4
Anopheles coustani	17	0,6	14	1,0
Anopheles rhodesiensis	13	0,4	7	0,5
Anopheles ziemani	17	0,6	0	0
Anopheles longipalis	2	0,07	2	0,1
Culex quinquefasciatus	803	27,6	374	27,3
Aedes aegypti	11	0,4	4	0,3
Anopheles moucheti	29	1,0	0	0
Total	2 913	100	1372	100

F=11,070, P<0,05.

Seasonal abundance of mosquitoes and their association with rainfall: A total of 4 285 adult mosquitoes comprising 3 073 *Anopheles* spp. and 1 177 culicines were collected over the 12 months study period (Nov 2013 to Oct 2014). Relatively fewer numbers of mosquitoes were caught during the dry season (Nov 2013-March 2014) than wet season (April 2014-October 2014) (Figure 2). The lowest number was collected in February. However the number increased from May to July. The highest number in the wet season occurred in July.

A total of 2 949 *A. gambiae s.l* and *A. funestus* mosquitoes were collected between November 2013 and October 2014. The numbers of mosquitoes collected were 2 225 (75,4%) using the PSC method and 724 (24,6%) using the HLC method (Table 2).

DISCUSSION

The results of this study showed the relative abundance and composition of mosquito vectors and its relationship with rainfall in Omi village an irrigated area in Kogi State, Nigeria. The presence of three genera of mosquitoes, *Anopheles*, *Aedes* and *Culex* in this study is an indication that the climatic and environmental conditions of Omi irrigation area are conducive for the survival and development of a wide range of mosquito species. Eight species from anopheline mosquitoes were encountered in the study, indicating that the species composition in Omi irrigation area is reach, as (Depinay et al., 2004) have put the usual number at less than five within a given area, and this has been confirmed in different localities

TABLE 2
Comparison of two method collection of anopheline mosquitoes in Yagba West Local Government Area, Kogi State, Nigeria, between November 2013 and October 2014

Village	Anopheline species	Collection method		Total
		HLC	PSC	
Intervention	*Anopheles gambiae* s.l	253(12,8)	1 312 (66,2)	1 565 (78,9)
	An. Funestus	114 (5,7)	304 (14,3)	418 (21,1)
Control	*An. gambiae* s.l	284 (29,4)	498 (51,6)	782 (81,0)
	An. Funestus	73 (7,6)	111 (11,5)	184 (19,0)
OVERALL		724 (24,6)	2 225 (75,4)	

(F=3,37, df=1, P>0,05), HLC: Human Landing Catch, PSC: *Pyrethrum* Spray Catch.

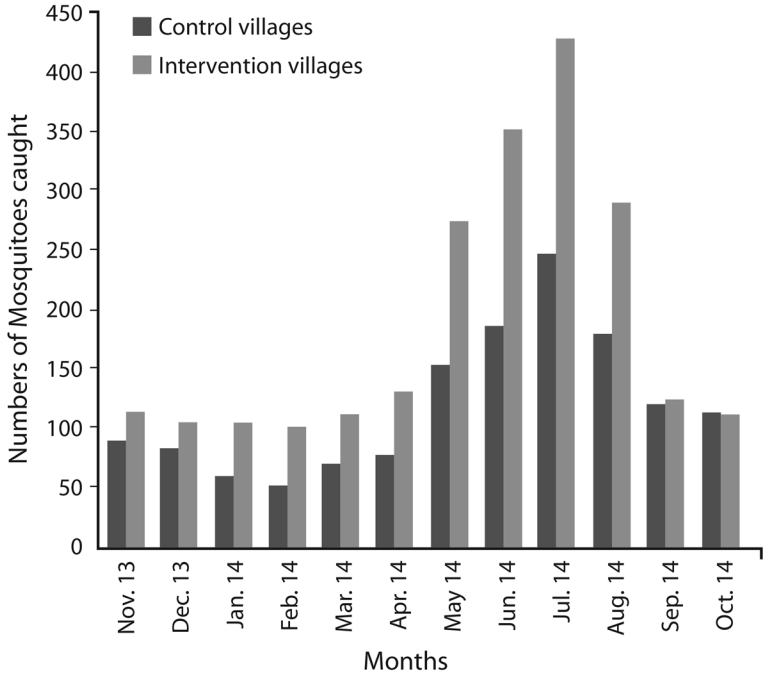

Fig. 1. Monthly distribution of mosquitoes in intervention and control communities in Yagba West Local Government Area of Kogi State, Nigeria.

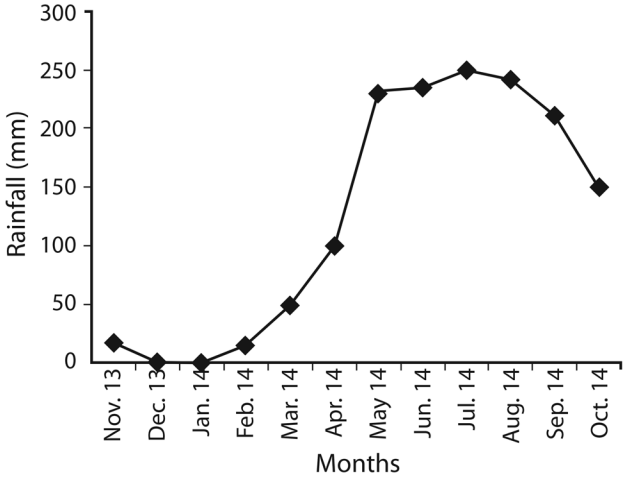

Fig. 2. Monthly distribution of rainfall in intervention communities.

in Africa (Muturi et al., 2006; Manga, Toto & Carnevale, 1995; Appawu et al., 2004). The relatively higher number of anopheline species in the area may be as a result of the favorable tropical weather and breeding conditions. Of the eight anopheline species encountered in Omi, only two namely, *Anopheles gambiae* and *An. funestus* were vectors of malaria. The high abundance of malaria and filariasis vector (*Anopheles gambiae*) encountered in this study means that there is a risk of malaria and filariasis in Omi irrigation area and its environs. The unequal distribution of the *Anopheles* species within the area further suggests that the occurrence of the species truly varies according to macro and micro environmental differences exhibited by different bio-ecological areas, as was found in studies conducted by (Keateng et al., 2003). The environmental conditions of the area were favorable to support the continual breeding and survival of the mosquito vectors. The predominance of *An. gambiae* could be attributed to the adaptability of these species making it possible for them to survive in diverse environment as previously reported by (Dondorp et al., 2009). This result is similar to the findings of (Okwa, Carter & Hurd, 2006) and (Oguoma & Ikpeze, 2008) who in Lagos and Kano respectively, reported that *Anopheles gambiae* was the most predominant species. However, this result contrasts with the findings of (Simon-Oke & Ayeni, 2015) who reported high incidence of *Aedes aegypti* in Akure. The other species collected occurred in very low densities. The proximity of the intervention village to the Omi dam, could have accounted for the high density of the different mosquito species recovered. The prevalence of adult mosquitoes showed trend of twice increases in the intervention compared to the control villages.

Communities close to the Omi reservoir are prone to malaria infection since *Anopheles gambiae* has been

incriminated as an efficient vector of malaria (Awolola, Ibrahim, Okorie, Hunt & Coetzee, 2003).

In the present study, a significant correlation was found in the number of anophelines caught by the two methods, suggesting that human landing catch are adequate to monitor seasonal trends. However, the numbers caught in Human Landing Catch were significantly (P<0,05) smaller than in *Pyrethrum* Spray Catch. This is consistent with the findings of (Yasmin & Curtis, 1992) in western Venezuela where similar result was observed. Significantly higher densities of mosquitoes were collected in the rainy (May-July) than the dry season (January-March). This is like the findings of (Lamidi, 2009) who reported that the highest number of *Anopheles* mosquito was recovered in the months of July. A study in Kenya opined that the rainy season presents favorable environmental conditions that enhance mosquito breeding and survival, through the proliferation of larval habitats and improved humidity respectively (Minakawa, Sonye, Mogi, Githeko & Yan, 2002). Rainfall contributes to increasing the number of breeding sites (stagnant water, used containers, gutters) as *Anopheles* species need clean water with adequate oxygen and sunlight for breeding (Service, 1980).This is however not in agreement with the findings of (Shililu, Maier, Seitz & Orago, 1998) in Western Kenya who reported no significant correlation between the monthly rainfall and relative densities of *Anopheles gambiae* s.l and *Anopheles funestus*. The study however confirms the fact that there is a correlation between rainfall and mosquito abundance.

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