Early Wet Season Distribution of *Anopheles* Mosquitoes in Keffi Area, Nasarawa State, Nigeria

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Abstract

Anopheles mosquitoes are the vectors of *Plasmodium* species, the causative agent of malaria, and a major cause of death in tropical Africa. The distribution of *Anopheles* species in time and space is a function of ecological factors in a given habitat. This study investigated the distribution of anopheles mosquitoes in the early wet season of 2017, in Keffi Area, Nasarawa State, Nigeria. Mosquito's collection was carried out in four locations in the study area using two methods: Pyrethrum Spray Catch (PSC) and Centre for Disease Control (CDC) light traps. Indoor and outdoor mosquitoes were collected. All mosquitoes collected were morphologically identified using standard procedures. A total of 973 mosquitoes were collected and identified. This comprised *culicines* 742 (76%) and *anophelines* 231 (23%). There was a progressive increase in number of anophelines from April 93 (40.3%) to May 138 (59.2%). Four species of *Anopheles* mosquitoes were identified in the study area: *An.gambiae* 221 (95.7%). *An.coustani* 7 (3.0%), *An.squamosus* 2(0.9%) and *An.pharoensis* 1(0.4%).More *Anopheles* mosquitoes collected showed a statistical significant difference between the 2 months and between indoors and outdoors collection ($P<0.05$). These findings show the presence of the vector of malaria in the study area during the early wet season and recommends early vector control before and during the season to reduce incidence of malaria in Keffi area of Nasarawa State, Nigeria.

Keywords: *Anopheles* mosquitoes, Distribution, Malaria, Vector and Wet season.

Introduction

Human malaria is caused by *Plasmodium* species, a protozoan parasite. Malaria is the world's most important parasitic disease with estimated 247 million cases, 881,000 deaths most of them children under the ages of five (WHO/UNICEF, 2003). It poses a major threat to over 2.4 billion people, about 4% of the world population. Malaria is a persistent ailment in tropical Africa especially among children under five years due to their low level of resistance (Appawu *et al.,* 2011). Malaria transmission in Africa communities is enhanced by environmental conditions such as high humidity and warmth which accelerate mosquito development. Treated nets offer protection from the mosquitoes, although bites can still occur outside the net (Awolola *et al.,* 2014).

It is estimated that, about half of Nigerian adults have at least one episode of malaria each year and seven (7) out of every 10 patients seen in hospitals are ill of malaria (FMOH, 2005). WHO/UNICEF (2003) reported that countries with heavy malaria burden accounted for over 30 to 50 percent of inpatient admissions and up to 50 percent of outpatient visits. Studies in Nigeria have shown that there was increase in number of malaria deaths from 4,123 in 1999 to 6,052 in 2004 and 10,239 in 2007 (WHO, 2008). Malaria accounts for 13 to 15 percent of medical reasons for absenteeism from school (WHO, 2008). *Anopheline* mosquitoes are responsible for transmitting malaria. The World's most dangerous and efficient malaria vector, *An.gambiae* is closely associated with man, breeding in aquatic habitats found around houses. The transmission of malaria requires the interaction between the host, the vector and the parasite. The four species of parasites responsible for human malaria are *Plasmodium falciparum, P.ovale, P.malariae* and *P. vivax* (Olumese, 2008, WHO, 2015).

Materials and Methods

Study Area

The study was conducted in Keffi area, north central Nigeria. Keffi Local Government Area is located in Nasarawa West Senatorial District with latitude and longitude coordinates of 8.8558^0 N, and 7.8694^0 E. It has an area of $138km^2$ and a population of 92,664 at the 2006 census. It is bounded by Karu to the North and Nasarawa to the South and Garaku to West. Keffi has two distinct seasons, wet season that begins around March and runs through October and dry season which begins from October and ends in March. The temperature ranges between $23\text{-}33^0$C while the humidity ranges between 64-96%. The dry season is accompanied by a brief harmattan period occasioned by the north-east trade wind and the attendant dust haze, increased cold and dryness (Obaje *et al.*, 2007).

Weather conditions in Keffi are influenced by its location within the Niger Benue trough on the windward side of the Jos Plateau and at the climate transition zone between the essentially humid south and the 'sub-humid' north of the country. The high temperatures and the relative humidity in the Niger Benue trough give Keffi a heating effect Rainfall. The annual rainfall is 602mm, while the monthly rainfall distribution intensifies during the months of July, August and September (Obaje *et al.*, 2007).

Sample Collection

Informed consent was obtained from the leaders of the communities and household heads before mosquito sampling started. Mosquitoes were collected from four locations namely British Cotton Ground, TudunArnama, Karofi and AngwanWaje. Indoors and outdoors mosquitoes were collected between April and May, 2017, Two methods were used namely, Center for Disease Control (CDC) Light Traps and Pyrethrum Spray Catch (PSC). Center for Disease Control light traps were fixed in a room once a week in all the four locations. Traps were fixed between 06:00pm to 06:00an and 1.5 meters above the ground next to a bed where a person slept. They were removed hourly by tying the collection cup and disconnecting the batteries to avoid mosquitoes from escaping. The collected mosquitoes were transferred into well labeled paper cups and transported to the entomology laboratory for identification.

Pyrethrum Spray Catch (PSC) adult mosquito collections were carried out between April and May, 2017 within the study area. Indoor resting mosquitoes were collected using Pyrethrum Spray Catch (PSC) from 6:00a.m. - 9:00a.m. A total of 160 houses were selected among different available building types (sand

screed blocks, mud, thatched etc.) using North-South, West-East transects. In each household, one room where people slept the previous night was selected for mosquito collection. Pyrethrum Spray Catch were performed using Raid® and white bed sheets spread on the floor to collect knocked down mosquitoes, which were picked using forceps into petridish and later preserved in a well labeled eppendorf tubes containing silica gel for laboratory identification

Morphological Identification of Mosquitoes

All mosquitoes collected were sorted and identified using a binocular microscope. The *Anopheles* mosquitoes were identified using morphological keys of Gillies and DeMeillon (1968) and Gillies and Coetiee (1987).

Analysis of Data

Data obtained were analyzed using R Console software (version 3.2.2). Pearson's Chi-square test was used to compare proportions of mosquitoes between species, months, and as well as between siblings of anopheline species collected within the 2 months of study. The P-values <0.05 were considered statistically significant.

Results

Table 1 shows mosquito species caught using Center for Disease Control light traps and Pyrethrum Spray Catch methods. A total of 973 adult mosquitoes comprising 231 (23%) anophelines and 742 (76%) *culicines* were recorded over the two month period. The differences in abundance between mosquito species varied significantly (P<0.05). Relatively fewer numbers of mosquitoes were caught for the month of April but increased in the month of May. The highest mosquito density (51%) occurred during the month of May. However, there was no significant difference (P>0.05) in the abundance of mosquitoes between the two months. A total of 198 (85.7%) and 244 (25.1%) adult mosquitoes were sampled using PSC method and CDC light traps (indoors) respectively while 304(31.2%)adult mosquitoes sampled outdoors using CDC light traps. The abundance of mosquitoes between indoor and outdoor feeding points showed a significant difference (P<0.05).

In table 2, the different species of *Anopheles* mosquito recorded during the study period showed a total of 231 *Anopheles* mosquitoes belonging to four (4) different species sampled between April and May, in the study area. They included 221(95.6%) *An. gambiae*, 7(3%) *An. coustami*, 2(0,8%) *An. squamosus*, and 1(0.4%) *An. pharoensis*.*An. gambiae* were caught in all the four locations within the two months of the study but *An. coustain*, *An. squamosus*, and *An. pharoensis* were caught only in the month of May, in the study area. Therefore, there was a significant difference (P <0.05) in the abundance of *Anopheles* sibling species.

Anopheles species were more abundant in May 138 (60%) than in April 93 (40%). Hence there was a significant difference (P<0.05) in the abundance of *Anopheles* between April and May

Table 1: Mosquito specie caught using CDC light and PSC methods

Month	**Methods**			**Mosquito species**		**Total (%)**
		CDC LT				
	PSC	**Indoor**	**Outdoor**	***An.***	***Cu.***	
April	198(20%)	117(42%)	164(17%)	93(9%)	386(40%)	479(49)
May	226(23%)	127(13%)	140(14%)	138(14%)	356(37)	494(51)
Total(%)	**424(10)**	**244(25)**	**304(31)**	**231(24)**	**742(76)**	**973**

χ^2 = 268.37
df = 1
P-value = 0.0001
Key:
PSC = Pyrethrum Spray Catch
CDC LT = Centers for Disease Control and Prevention Light Trap
An.=Anophelines, Cu - Culicines

Table 2: *Anopheles* species identified between April and May

Month	*An.gambiae*	*An.coustani*	*An.squamosus*	*An.pharoensis*	Total
April	93(40%)	0(0.0%)	0(0.0%)	0(0.0%)	93(40%)
May	128(55%)	7(3%)	2(0.8%)	1(0.4%)	138(60%)
Total	221(96%)	7(3%)	2(0.8%)	1(0.4%)	231(24%)

χ^2 = 615.67
df = 3
P-value = 0.0001
Key: An: *Anopheles*

Table 3 shows the collection time of the mosquitoes and the variations in their biting activities (biting cycle) from dusk todawn. Female *An. gambiae* were more in abundance in the study sites. Their peak of biting activity was recorded between 12am – 3am (44%) followed by 9pm - 12am (29%). The biting activity of *An.coustani* occurred between 8:00pm and 11:00pm.*An. squamosus* that was collected was trapped at 12:00midnight by the CDC light trap. *An.pharoensis* was caught just after 3am.The species caught showed great variation in their biting time in all the four major collection sites throughout the period of the study.

The feeding of *Anopheles* peaked between 12am to 3am103 (45%) followed by 9pm - 12am 73 (32%) then 6pm - 9pm 43(19%) and 3am - 6am 12 (5%) was the least. Therefore, the abundance of *Anopheles species* across time intervals showed a significant difference ($P < 0.05$).

Table 3: Feeding behavior of mosquitoes in relation to time

Time range	*An.gambiae*	*An.coustani*	*An.squamosus*	*An.pharoensis*	Total
6-9 p.m	40(17%)	5(1%)	0	0	43(19%)
9-12 p.m	67(29%)	4(2%)	2(0.8%)		73(32%)
12-3 a.m	102(44%)	0	0	1(0.4%)	103(45)
3-6 a.m	12(5%)				12(5%)
Total	221(96%)	7(3%)	2(0.8%)	1(0.4%)	231(24%)

χ^2 = 79.494 df = 3 P-value = 0.0001

Discussion of Findings

The abundance and the diversity of anophelines and culicines caught in this study may possibly be due to availability of breeding sites as a result of early rainfall. Transient and stagnant water bodies that serve as a good breeding habitat for mosquito-vectors may influence the transmission of vector-borne diseases during the wet season. This is in agreement with the findings of Malar *et al*. (2015) who observed high abundance and diversity of mosquitoes during the wet season in Madurai, India. Ebenezer *et al*. (2013) on the study of spatial distribution and indoor resting density of mosquito species in the lowland rainforest of Bayelsa State, Nigeria showed that over 80% of mosquitoes collected were during wet season. On the contrary, Umar *et al.* (2015) recorded low abundance of mosquitoes between April and May in human dwelling at malaria vector sentinel sites in Bauchi State, Nigeria. This may be possible due to change in weather conditions of the two State. Nasarawa State usually experience rainfall around April to October while Bauchi State normally experienced rainfall from June to November.

The high abundance of culicine species may be due to availability of polluted stagnant water bodies in the urban and peri-urban areas of Keffi. This is in agreement with the findings of Ebenezer *el al.* (2013), Oyango (2013). Malar *et al.* (2015) and Umarei *et al.* (2015).

The similarity in mosquitoes distributions between the months possibly suggest that weather conditions in the two months were similar. This agrees with the finding of Umar *et al.*, (2015) who found no variation in mosquito's abundance between April and May at malaria vector sentinel sites in Bauchi State, Nigeria. The observed variation in feeding behaviour in favour of outdoor points may be due to high temperature

and outdoor nocturnal activities. Kabbale (2013) reported that the outdoor biting densities of *Anopheles gambiae* sensual to exceeded the indoor biting densities throughout the night in Kamuli district of Uganda. However, Ezeigwe *et al.* (2015) recorded no variation in the abundance of mosquitoes between feeding points.

The variation in the dominance of *An. gambiae* s. l. over other anopheline possibly suggest availability of clear transient water bodies due to early rainfall and other environmental conditions that favor their breeding success. This supports the findings by Ebenezer *et al.* (2013), Ezeigwe *et al.* (2015), and Umar *et al.* (2015) who reported *An. gambiae* as the dominant anophelines species in Bayelsa State and Bauchi State respectively.

The observed variation in relation to feeding pattern of anopheline peaked at 12am to 3am possibly indicates decrease in temperature and an increase in relative humidity influences their number. Dinglong (2015) reported feeding peaked of *An. gambiae* at the hours of 11pm - 12am and lam -3am for indoor and outdoor points respectively. The finding of AIRS Nigeria (2013) showed that *An. gambiae* peak biting time across intervention and control areas is between 2am and 4am.

Contribution to Knowledge

Of the two sampling methods namely Pyrethrum Spray Catch & Centers for Disease Control Light Trap used for this study, CDCLT caught more mosquitoes than the Pyrethrum Spray Catch methods. Therefore, CDCLT is most likely useful for mosquitoes sampling in Keffi area. There is relative abundance of mosquitoes in Keffi area. Four major *An.* species capable of causing malaria were caught in the study area and the *An. pharoensis* recorded in this study were not reported in any similar study carried out in Keffi.

Conclusion

The abundance and diversity of anophelines and culicines species seen within the study area is due to the presence of transient and stagnant water and other environmental factors observed at the beginning of the wet season. The predominant of *An. gambiae* among other species of *Anopheles* which is the principal vectors for malaria transmission, and their feeding behavior experienced within human dwellings, though the infectivity rates of the vectors was not determine in this study strongly suggest their involvement in malaria cases in Keffi and its surroundings.

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