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BREEDING HABITATS OF *ANOPHELES* MOSQUITOES IN A RIVERINE LOCALITY OF ANAMBRA STATE: TYPES, PREFERENCES, AVAILABILITY AND PRODUCTIVITY

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Abstract

Malaria is caused by protozoan parasites of the genus *Plasmodium*. The malaria parasites are transmitted naturally by *Anopheles* mosquitoes. The survival and capacity of *Anopheles* mosquitoes to transmit malaria parasites is partly linked to their breeding ecology. Thus, survey of breeding habitats of *Anopheles* mosquitoes has become one of the important metrics needed for effective control of malaria. The aim of this research was to determine the types, preferences, availability and productivity of *Anopheles* mosquitoes breeding habitats in Anambra East LGA, Anambra State. Longitudinal study design that lasted for one year was adopted in this study. Larvae of *Anopheles* mosquitoes were collected from their potential breeding habitats using dipping method. The larvae were reared to adults and their species identified morphologically using standard keys. The breeding habitats identified were basin, clay pot, canoes, drainage channel / gutter, head pan, plastic containers / drum, puddle, riverbank, and swamp. Of these, canoe, plastic drums/containers and riverbanks showed 100% (12/12) monthly and seasonal availability. *An. gambiae* s. l. and *An. funestus* larvae were found in 100% (9/9) of the breeding habitats. *An. moucheti* and *An. nili* larvae were found in 66.7% (6/9) of the breeding habitats. Mean abundance of *An. gambiae* s. l. larvae were highest (45.8±3.2) in the Riverbanks and least

(0.8±0.8) in head pans ($p < 0.05$). Mean abundance of *An. funestus* larvae was highest (12.4±3.1) in the drainage channel / gutter and least (0.8±0.6) in head pans ($p < 0.05$). Mean abundance of *An. moucheti* larvae was highest (17.1±2.8) in the Riverbanks and least (0.3±0.2) in drainage channel / gutter ($p < 0.05$). Mean abundance of *An. nili* larvae was highest (7.8±2.3) in the Riverbanks and least (0.2±0.2) in drainage clay pot and plastic containers / drum ($p < 0.05$). This study has revealed that species of *Anopheles* mosquitoes in the study area have multiple breeding habitats. The overlap in their choice of breeding habitats shows that they can occur in sympatry, with riverbanks being the most productive habitat. All year round availability of riverbank, canoe and plastic drums/containers sustain their population, and this can contribute to stable malaria transmission in the study area.

Keywords: *Anopheles* mosquitoes, breeding habitats, types, preferences, availability, productivity.

INTRODUCTION

Malaria is a vector borne disease caused by protozoan parasites of the genus *Plasmodium* (Family: Plasmodiidae). The malaria parasites are solely transmitted in nature through the bites of infected female anopheline mosquitoes. There are more than 400 *Anopheles* species world-wide, but approximately 70 of them are capable of transmitting malaria parasites under natural conditions, with 40 species considered major vectors of importance (Service and Townson, 2002). A large number of *Anopheles* species have been reported in Nigeria, but the main vectors of malaria belong to *An. gambiae* s. l and *An. funestus* complex. The secondary vectors include *An. moucheti* and *An. nili* (Molineaux and Gramiccia, 1980; Gilles and Coetzee, 1987). In other malaria endemic areas, different species of *Anopheles* mosquitoes are responsible for malaria transmission. Anophelines like all other mosquitoes have four stages in their life cycle: egg, larvae, pupae and adult. The first three stages are aquatic, lasting for 5 to 14 days depending on temperature (Service and Townson, 2002). The location of *Anopheles* mosquito larvae in a habitat is due to selection of oviposition site by gravid females. Thus, the survival and capacity to transmit malaria by *Anopheles* mosquitoes are directly linked to the availability of breeding habitats (Onyido *et al*., 2006).

Different sizes of water collections have been reported to provide suitable habitats for abundant and diverse populations of Anopheline mosquitoes (Adeleke *et al*., 2008; Ndenga *et al*., 2011). Generally, *An. gambiae* s. l. breed in sunlit stagnant water collections around our homes, streets, and streams or other quiescent water collections, from where they fly into the houses to bite man (Onyido *et al*., 2014). *An. gambiae* s. l., the principal transmitter of malaria in Nigeria is closely associated with the sunlit water collections close to human dwellings. On the contrary, *An. funestus* which is another important malaria vector in Nigeria tends to breed

more in cool, clear, shaded, permanent water bodies relatively undisturbed by man in rural areas (Onyido *et al.*, 2009). Though *Anopheles* mosquitoes are known to be ground pool breeders, a large number of them have been observed in clean collections of water in gutters and domestic containers (Mafiana *et al.*, 1998; Aigbodion and Odiachi, 2003). They can also be found in fresh or saltwater marshes, mangrove swamps, rice fields and grassy ditches as well as the edge of streams and rivers (Egbuche *et al.,* 2016). Some species breed only in freshwater; some prefer brackish water, some like standing water around human habitations such as puddles, broken coconut shells or trash that collects water (Robert and Janovay, 2009). Nevertheless, an *An. gambiae* female can use multiple breeding habitats and sites for oviposition (Chen *et al*., 2006).

Anopheles mosquitoes are well known to be very adaptable to increasing ecological and environmental conditions. *Anopheles* mosquitoes have been reported to adapt themselves to the various ecological circumstances provided by all stages of rice culture including nursery, watering, planting, growing, tillage, maturation, harvesting and land fallow (Onyido *et al*., 2014). *Anopheles* mosquitoes breeding in refuse dump have also been reported (Ezihe *et al*., 2017). In many areas of Africa, including Nigeria, *An. gambiae* breeds in exposed, often muddy sunlit ground pools of water of various sizes ranging from brick pits, animal footprints and vehicle tyre prints. It is occasionally found in man-made containers such as wheelbarrows, mortar, pans, open tanks, canoes and abandoned concrete mixers (Onyido *et al*., 2014). *An. funestus* complex has uneven distribution throughout Nigeria. It breeds in cool shady freshwater swamps along rivers and streams and other water pools often associated with water lettuce, *Pistia stratiotes* and grasses at the edges of rivers. *An. melas*, a member of *An. gambiae* complex are essentially coastal species. *An. arabiensis* survives better under drier conditions in lowlands than *An. gambiae* s. s (Minakawa *et al*., 2002; White *et al*., 1972), and it has been found to dominate irrigated areas such as rice fields (Mwangi and Mukiama, 1992) among other habitats. Some oviposit in plant axils such as those formed by banana, pineapple, *Ravanella*, bromeliads, grass, and in cavities of pitcher plants (Service, 1970). A few species were reported to breed in tree holes or the leaf axils of some plants (CDC, 2004; Omlin *et al*., 2007). Some of these habitats are deviations from the earlier knowledge that *Anopheles* species breed in clean pool of water and this could mean an expansion in the range of breeding habitats utilized by them.

Availability and stability of these aquatic habitats are very crucial in determining year round transmission of malaria (Himeidan *et al*., 2009). This is because some of the breeding habitats are permanent (stable), and some others are temporary as they tend to dry up or are cleared alongside with refuse. Minakawa *et al* (2005) found out that habitat stability and abundance of *An. gambiae* s. l. was positively correlated with habitat size. Smaller habitats normally have low

abundance of mosquito larvae and are easily lost than bigger habitats. Larval counts and density of *Anopheles* mosquitoes are known to be high during rainy seasons and decline during dry seasons (Lamidi, 2009; Oyewole *et al*., 2010; Donovan *et al*., 2012). This is obviously due to loss of some habitats and decline in mosquito populations during the dry season. However, during the dry season, limited rainfall can create pools of water along the riverbank, thereby providing good breeding site for *Anopheles* mosquitoes (Gubler *et al.,* 2001). Proximity of human dwellings to the breeding habitats of mosquitoes can actually affect the pattern of malaria parasite transmission (Greenwood *et al.*, 2008; Onyido *et al.*, 2009). Therefore, survey of breeding habitats of *Anopheles* mosquitoes has become one of the important metrics needed for effective control of malaria. For this to be successful, good knowledge of the types, availability, preferences and distribution of *Anopheles* mosquito breeding habitats is required.

METHODOLOGY

Study area

The study was conducted in Anambra East Local Government Area, Anambra State (Latitudes 6.16^0N to 6.58^0N and Longitudes 006.49^oE to 006.93^0E), in the tropical rainforest zone of the Southeastern Nigeria (Figure 1). The altitudinal range of the LGA is 25m to 145m above sea level. The LGA has two large water bodies: Omambala and Ezu Rivers with their confluence in Aguleri. There are also other small water bodies, streams and large expanse of freshwater swamps. The inhabitants are mostly farmers and fishermen. Their major agricultural products are yam, cassava, maize, rice, fish, banana, plantain and vegetables. Other inhabitants are traders, artisans, drivers, civil servants, students and other professionals. The economic activities in the LGA include trading, road and water transportation, house construction, farming, fishing, milling of rice and sand mining. Cattle are also herded by Fulani herdsmen around the communities in the study area.

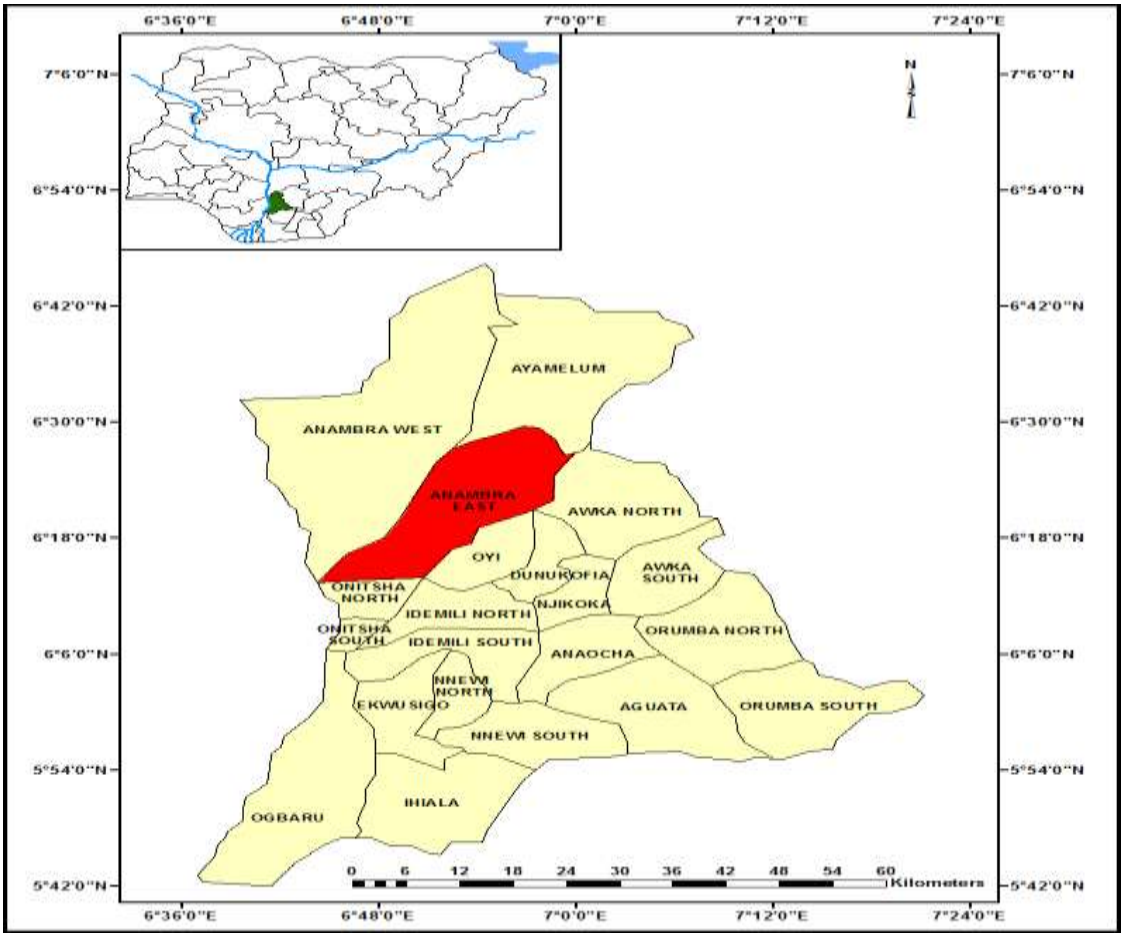


Figure 1: Map of Anambra State showing the location of Anambra East Local Government Area. Insert is the map of Nigeria showing the location of Anambra State (Made by a cartographer at the Department of Geography, Nnamdi Azikiwe University, Awka).

Study design

Longitudinal study design that lasted for a period of 12 months (October 2016 to September 2017) was used. In the study *Anopheles* mosquito species and their breeding habitats were identified. Species of *Anopheles* mosquitoes present in those breeding habitats were also identified and reported.

Sampling techniques

Systematic sampling technique was used to select the communities included in the research. Along the longest stretch of roads that cut across the LGA, the 1st, 3rd and 5th (last) communities were selected. With that, Igbariam, Aguleri and Nsugbe were selected to represent the LGA. In each town, breeding habitats of mosquitoes were surveyed using the standard of WHO (2003).

Identification of breeding habitats of *Anopheles* mosquitoes

This was achieved through mosquito larvae survey. Potential breeding habitats of

mosquitoes in the selected communities were surveyed for *Anopheles* larvae from October 2016 to September 2017 (WHO, 2003). Only habitats with *Anopheles* mosquito larvae were considered a breeding habitat. Collections of the larvae were made with a ladle or dipper and white plastic bowls. *Anopheles* larvae were identified in the field by their parallel positions on water surfaces as well as the characteristic sharp backward movement they exhibit. When collected, they were transferred into a well labeled plastic container and transported to the Laboratory unit of the Department of Parasitology and Entomology, Nnamdi Azikiwe University, Awka Nigeria.

Determination of breeding habitat preferences

Anopheles mosquito larvae from different breeding habitats were separately reared to adult for proper identification to species level according to WHO (2003). In the laboratory, larvae collected from different breeding sites were put into separate transparent plastic bowls of 2cm depth and labeled appropriately. The plastic bowls were covered with mosquito nettings held in position with rubber bands. This was a precaution to prevent emerging mosquitoes from escaping and also prevent wild mosquitoes from laying eggs into the container. The larvae were reared at room temperature and fed with a mixture of biscuits and yeast. They were closely monitored, and the pupae were collected into different plastic cups using Pasteur pipette and placed in labeled cages for adult emergence.

Using a Stereo microscope, morphological identification of the adult mosquitoes that were raised from the immature stages was done with identification key by Gillett (1972) and Gillies and Coetzee (1987). Live mosquitoes were anaesthetized with chloroform before identification. Different species of *Anopheles* mosquitoes were identified using the characteristic banding patterns of their palps, the scales on their wings as well as their legs. Presence of a particular species of *Anopheles* mosquito in a given habitat is indicated with plus (+) sign, while the absence is indicated with negative (-) sign.

Determination of breeding habitat availability and distribution

This was achieved through monthly survey of the breeding habitats. The exact habitat that was checked in the previous month survey, habitats of the same types and new habitats were surveyed in the study area. Plus sign (+) was used to indicate the presence of a breeding habitat, while negative sign (-) was used to indicate the absence of a breeding habitat.

Determination of breeding habitat productivity.

This was also achieved through monthly survey of breeding habitats. The exact habitat that was checked in the previous month survey, habitats of the same types and new habitats were checked for presence of *Anopheles* mosquito larvae. Productivity was measured in terms of larvae count and abundance in each of the breeding habitat (Filinger *et al.,* 2009; Kweka *et al.,* 2011); since adult emergence

from breeding habitats is primarily determined by larval density (Mutuku *et al.*, 2006).

Data summary and statistical analysis

Data collected were summarized using Plates and Tables. Test of statistical significance was conducted using ANOVA at 5% level. The statistical package used was SPSS version 25.0

RESULTS

The following breeding habitat of *Anopheles* mosquitoes were identified in the study area: Basin, clay pot, canoe, drainage channel / gutter, head pan, plastic container, puddle / ground pool, riverbank and swamp (Plates 1 to 9).



Plate 1: Basin



Plate 2: Clay pot



Plate 3: Canoe



Plate 4a: Drainage channel / gutter



Plate 4b: Drainage channel / gutter



Plate 5: Head pan



Plate 6: Plastic container



Plate 7: Puddle / Ground pool



Plate 8: Riverbank



Plate 9: Swamp

Monthly and seasonal availability of *Anopheles* Mosquito breeding habitats.

The monthly and seasonal availability of *Anopheles* mosquito breeding habitats is shown in Table 1. Of the nine breeding habitats of *Anopheles* mosquitoes encountered in the study area, canoe, plastic drums/containers and riverbanks showed 100% (12/12) monthly and seasonal availability. Basins showed 75% (9/12) monthly availability; 40% (2/5) availability in the dry season and 100% (7/7) availability in the wet season. Broken clay pots showed 91.7 (11/12) monthly availability; 80% (4/5) availability in the dry season and 100% (7/7) availability in the wet season. Drainage channels showed 83.3% (10/12) monthly availability; 60% (3/5) availability in the dry season and 100% (7/7) availability in the wet season. Head pans showed 16.7% (2/12) monthly availability; 20% (1/5) availability in the dry season and 14.3% (1/7) availability in the wet season. Puddles and swamps showed 66.7% (8/12) monthly availability; 40% (2/5) availability in the dry season and 85.7% (6/7) availability in the wet season.

Table 1: Monthly and seasonal availability of *Anopheles* mosquito breeding habitats

Breeding habitats	Dry season					Wet season						
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct
Basin	-	-	+	-	+	+	+	+	+	+	+	+
Broken clay pots	+	-	+	+	+	+	+	+	+	+	+	+
Canoes	+	+	+	+	+	+	+	+	+	+	+	+
Drainage channel / gutter	+	-	+	-	+	+	+	+	+	+	+	+
Head pans	-	-	-	-	+	+	-	-	-	-	-	-
Plastic drum/ containers	+	+	+	+	+	+	+	+	+	+	+	+
Puddles	-	-	+	-	+	+	+	+	+	+	+	-
Riverbanks	+	+	+	+	+	+	+	+	+	+	+	+
Swamps	-	-	+	-	+	+	+	+	+	+	+	-

Key: + means available, - means not available.

Table 2: Habitat preferences of *Anopheles* mosquito species in the study area.

Breeding habitat	*An. gambiae* s. l.	*An. funestus*	*An. moucheti*	*An. nili*
Basin	+	+	-	-
Clay pot	+	+	+	+
Canoes	+	+	+	+
Drainage channel / gutter	+	+	+	+
Head pan	+	+	-	-
Plastic drum/ containers	+	+	+	+
Puddles	+	+	-	-
Riverbanks	+	+	+	+
Swamps	+	+	+	+

Distribution of *Anopheles* Mosquito larval habitats in the selected communities
A total of 9 *Anopheles* mosquito breeding habitats were encountered at Aguleri, 8 at Igbariam and 8 at Nsugbe (Table 3).

Table 3: Distribution of *Anopheles* mosquito larvae breeding habitats within the communities studied.

Breeding habitat	Communities in the LGA		
	Aguleri	Igbariam	Nsugbe
Basin	+	+	+
Broken clay pot	+	+	+
Canoe	+	+	+
Drainage channel	+	+	+
Head pans	+	-	-
Plastic drum/ container	+	+	+
Puddle	+	+	+
Riverbanks	+	+	+
Swamp	+	+	+

Determination of habitat productivity.

Habitat productivity was measured in terms of larvae abundance. The mean ± se abundance of different species of *Anopheles* mosquitoes collected from different breeding habitats is shown in Table 4. Mean abundance of *An. gambiae* s. l. larvae were highest (45.8±3.2) in the Riverbanks and least (0.8±0.8) in head pans. There was significant difference in the distribution of *An. gambiae* s. l. larvae in various breeding sites (P = 0.000). Mean abundance of *An. funestus* larvae was highest (12.4±3.1) in the drainage channel / gutter and least (0.8±0.6) in head pans. There was significant difference in the distribution of *An. funestus* larvae in various breeding sites (P = 0.000). Mean abundance of *An. moucheti* larvae was highest (17.1±2.8) in the Riverbanks and least (0.3±0.2) in drainage channel / gutter. There was significant difference in the distribution of *An. moucheti* larvae in various breeding sites (P = 0.000). Mean abundance of *An. nili* larvae was highest (7.8±2.3) in the Riverbanks and least (0.2±0.2) in drainage clay pot and plastic containers / drum. There was significant difference in the distribution of *An. nili* larvae in various breeding sites (P = 0.006).

Table 4: Abundance and distribution of species of *Anopheles* mosquitoes as a measure of breeding habitat productivity in Anambra East LGA, Anambra State.

Breeding habitat	*An. gambiae* s. l.		*An. funestus*		*An. moucheti*		*An. nili*		Total
	Abundance	Mean±SE	Abundance	Mean±SE	Abundance	Mean±SE	Abundance	Mean±SE	
Basin	103	$8.6\pm2.3^{c,d}$	11	0.9 ± 0.9^{c}	-	-	-	-	114
Clay pots	273	$22.8\pm4.6^{b,c}$	81	$6.8\pm1.6^{b,c}$	7	0.6 ± 0.4^{c}	2	0.2 ± 0.2^{b}	363
Canoes	291	$24.3\pm2.4^{b,c}$	93	$7.8\pm1.2^{b,c}$	27	2.3 ± 0.8^{c}	60	$5.0\pm1.7^{a,b}$	471
Drainage channels	403	$33.6\pm6.9^{a,b}$	149	12.4 ± 3.1^{b}	4	0.3 ± 0.2^{c}	30	$2.5\pm1.6^{a,b}$	586
Head pans	9	0.8 ± 0.8^{d}	9	0.8 ± 0.6^{c}	-	-	-	-	18
Plastic drum/ containers	399	$33.3\pm4.3^{a,b}$	143	11.9 ± 3.4^{b}	9	0.8 ± 0.6^{c}	2	0.2 ± 0.2^{b}	553
Puddles	287	$23.9\pm6.5^{b,c}$	130	11.2 ± 3.0^{b}	-	-	-	-	421
Riverbanks	549	45.8 ± 3.2^{a}	259	21.6 ± 2.2^{a}	205	17.1 ± 2.8^{a}	94	7.8 ± 2.3^{a}	1107
Swamps	180	$15.0\pm4.3^{c,d}$	122	10.2 ± 2.9^{b}	119	9.9 ± 3.5^{b}	90	$6.1\pm2.3^{a,b}$	494
Total	2494	207.8±28.3	1001	83.4±11.4	371	30.9±3.1	261	21.8±3.8	4127

N/B: For a given species of *Anopheles* mosquito, breeding habitats with the same superscripts attached to the larval density have the same level of productivity and differs in productivity from habitats with different superscript.

DISCUSSION

Anopheles mosquitoes were found to breed in the following habitats within the study area: basin, clay pots, canoes, drainage channels / gutter, head pans, plastic drums/containers, puddles, riverbanks and swamps. It shows that different sizes of both natural and artificial water collections provide suitable breeding habitat for *Anopheles* mosquitoes in the study area. This is supported by the findings of Adeleke *et al*., (2008), Ndenga *et al*., (2011) and Onyido *et al.* (2014). All these breeding sites fall into the category of open larval habitats that have large exposure to sunlight. This is in line with the well known fact that *Anopheles* mosquitoes breed in sunlit stagnant water collections around our homes, streets, and streams or other quiescent water collections (Onyido *et al*., 2014; Robert and Janovay, 2009). It was also evident in the study that the *Anopheles* mosquitoes encountered in this study used multiple breeding habitats for oviposition; a finding similar to that of Chen *et al*. (2006).

Nevertheless, different species of *Anopheles* mosquito may show distinct preference for certain types of water sources in which to lay their eggs. Both *An. gambiae* s. l. and *An. funestus* larvae were found to utilize all the identified habitats. *An. moucheti* was absent in the following breeding sites: basin, head pans, and puddles. *An. nili* was also absent in basin, head pans, and puddles. It implies that *An. gambiae* s. l. and *An. funestus* have a greater number of breeding sites than *An. moucheti* and *An. nili.* *An. gambiae* s. l. and *An. funestus* utilize exactly the same breeding habitats; similarly, *An. moucheti* and *An. nili* utilize exactly the same breeding habitats. The overlap in the habitat preferences of the four species *of Anopheles* mosquitoes encountered in this study could imply that those species can be found in sympatry in some breeding habitat. This is similar with report of Levine *et al*. (2004) who reported *An. gambiae* s. s. and *An. arabiensis* to be broadly sympatric in his study. There is similarity in the distribution of the breeding sites within the communities studied. This is because the communities are all riverine, in addition to other manmade habitats that could be obtained in any other location.

Availability and stability of *Anopheles* mosquitoes breeding habitats is very crucial in determining year round productivity of malaria vectors (Himeidan *et al*., 2009). Apart from head pans, other breeding habitats were available in all the months within the wet season. Canoes, plastic drums / containers and riverbanks, were also available in all the months within the dry season. This simply means that Riverbanks, canoe and water storage containers like plastic drums are the most stable breeding habitats encountered in the study area. The riverbanks constitute the natural habitats whereas broken plastic containers / drum and canoes are manmade habitats. The natural habitats are available all year round. The manmade habitats are also available all years round because they are utilized by man regularly for water storage. Canoe as a manmade habitat is always used in water bodies for transportation and can retain some quantity

of water that constitutes breeding site for *Anopheles* mosquitoes. Dugout canoes that are unused for days can be partially filled with rainwater or water that seeps through the joints between woods at the base of the canoe to become mosquito nurseries. Other breeding sites encountered in the study area were present only at certain months of the year especially during the wet season. It is either that they dry up or are removed during environmental sanitation.

Even among the available breeding habitats, malaria vectors are often present, abundant and their adults produced in large numbers in some habitats and not in others. *An. gambiae* s. l. was found to breed in basins, clay pot, canoe, drainage channels, bank of river, head pans, plastic drums / containers, puddles and swamps. Nevertheless, *An. gambiae* s. l. was present and more abundant in some breeding sites and not in others. Riverbank was generally the most productive habitat for *An. gambiae* s. l. Within late wet season and the dry season, *An. gambiae* s. l. breeding was sustained by riverbanks. At the peak of rainy season, drainage channels and clay pot sustained the breeding of *An. gambiae* s. l. This is similar to the report of Onyido *et al*., (2014) that *An. gambiae* s. l. larvae are occasionally found in man-made containers such as wheelbarrows, mortar, pans, open tanks, canoes and abandoned concrete mixers.

An. funestus was found to breed in basin, clay pots, drainage channels / gutter, riverbanks, head pan, plastic drum / container, puddles and swamps. Nevertheless, *An. funestus* were present and more abundant in some breeding sites and not in others. Riverbank was generally the most productive habitat for *An. funestus*. In the rainy season, swamp, puddle, drainage channels and plastic containers alongside riverbanks contributed significantly to the breeding of *An. funestus*. Productivity of puddles for *An. funestus* overlaps between the late wet season and the middle of dry season.

An. moucheti was found to breed in clay pot, canoe, plastic drum / containers, bank of rivers and swamps. Nevertheless, *An. moucheti* were present and more abundant in some breeding sites and not in others. Riverbank was generally the most productive habitat for *An. moucheti*. They prefer the banks of river during the dry season and swamps during the wet season.

An. nili was found to breed in clay pots, canoe, drainage channels, bank of rivers, plastic tank drum / container and swamps. Nevertheless, *An. nili* were present and more abundant in some breeding sites and not in others. Riverbank was generally the most productive habitat for *An/ nili*. In the dry season, riverbank and canoe were the most productive habitat for *An. nili*. In the wet season, drainage channel alongside other breeding habitats were the most productive habitat for *An. nili.*

High productivity or abundance of *Anopheles* species larvae in the riverbanks may be attributed to its size in addition to its stability. Minakawa *et al.* (2005) found out

that habitat stability and abundance of *An. gambiae* s. l. was positively correlated with habitat size. This is because smaller habitats normally have low abundance of mosquito larvae and are easily lost than bigger habitats. Frequent use and scooping of water out of canoe also could have contributed to its lower productivity as a breeding site. Otherwise, canoe parked for a long time by travellers can contribute largely to the breeding of *Anopheles* mosquitoes. Even though other man made containers are used regularly to store water, they are being put in use from time to time, thereby reducing the population of mosquito larvae in them.

CONCLUSION

They utilize both natural and man-made habitats for breeding. The habitats include basin, broken clay pots, plastic drums / containers, canoes, drainage channels, riverbanks, head pans, plastic drums, plastic tank cover, puddles and swamps. Most of the breeding habitats identified were available all year round and were utilized by all the *Anopheles* species. Each species of *Anopheles* mosquito encountered in the study area used multiple breeding sites for oviposition but may show distinct preference for certain type of breeding habitat over the other, *An. gambiae* s. s. and *An. funestus* utilize exactly the same breeding habitats. The breeding sites of *An. moucheti and An. nili* were just slightly different. Drainage channel was generally the most productive habitat for *An. gambiae* s. l. and *An. funestus*. Swamp was generally the most productive habitat for *An. moucheti* and *An. nili*.

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