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Ecology of Malaria Vectors in a Rainforest Suburban Community of Nigeria (Pp. 293-305)

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Abstract

The ecology of malaria vectors in a suburban community of Umudioka, Dunukofia Local Government Area (LGA), Anambra State was studied between May and July 2009. Umudioka is an agrarian community in the rainforest zone of Nigeria and it is situated between longitude 6^o85'E and Latitude 6^o10'N of Equator. Mosquito larvae were collected from ground water pools, discarded old tyres and domestic water containers using ladles,

bowls, sieves and specimen bottles. Indoor biting and resting adult mosquitoes were collected from 30 houses using pyrethroid-based insecticide knockdown method (PKC). Discarded tyres yielded the highest number of mosquito larvae 204 (54.84%) but ground pool yielded the highest number of Anopheles mosquito larvae 117 (31.45%). Of 263 adults mosquitoes collected from inside houses, 243 (92.40%) were from houses with ceilings and 20 (7.60%) from houses without ceilings. Of the 3 mosquito species collected indoors, A. gambiae 156 (59.3%), had the highest number with a room density of 5.2 mosquitoes/room/night. Ground water pools sustained by streams, tap overflows and flooding due to heavy rainfall patterns of the area, were the most favourable breeding ground for malaria vectors in the area.

Key words: Malaria, Mosquito, Vectors, Ecology, Suburban, Community.

Introduction

Malaria is an infectious protozoan disease that torments primarily the tropical and subtropical areas of the world. It is the most important and widespread human parasitic disease (Warrell, 1999). The human malaria parasites viz: *Plasmodium falciparum*, *P. malariae*, *P. vivax* and *P. ovale*, are transmitted solely by anopheline mosquitoes. In sub-Saharan Africa, five *Anopheles* mosquito species namely *Anopheles gambiae*, *A. arabiensis*, *A. funestus*, *A. nili* and *A. mouchetti* have been described as major vectors of regional importance while 8-9 other species are secondary or local vectors (Fontenille and Lochouart, 1999).

Anopheles mosquitoes differ remarkably in their distribution habitats and habits. Gordon and Lavoipierre (1976) observed that almost every species of *Anopheles* mosquito has its own requirements as regards to the physical conditions of the larval habitats. Sometimes these requirements are similar for different anopheline species but others have such highly specialized requirements that it is unusual to find them in association with other species and therefore useless to search for them in more commonly favoured habitats. These authors further observed that, in Africa, while *A. funestus* breeds in weedy parts of large collections of more or less permanent clear water such as swamps, edges of streams, rivers, ditches and ponds under shades, *A. gambiae* breeds in small collections of water particularly temporary collection of water completely or partially exposed to direct sunlight (Gordon and Lavoipierre, 1976).

Apart from the differences in their ecological habitats, adult female mosquitoes generally differ in their behaviour especially biting habits including host bloodmeal preferences, time and place of biting and resting sites, which are very important in the epidemiology of disease transmission. Sometimes, mosquitoes are strictly zoophilic (feeding on animals only), or strictly anthropophilic (biting humans only), while others bite both man and animals indiscriminately. Also some mosquitoes bite and rest indoors (endophagic and endophilic) but others bite and rest outdoors (exophagic and exophilic). Furthermore, some mosquitoes are crepuscular and nocturnal and others are diurnal (Service, 1980).

The more important vectors of human diseases are those that show close association with man and prefer man to animals as source of food. Most anophelines are night feeders and the diseases they transmit (filariasis and malaria) are most commonly acquired at night when the victims are at rest, and are often acquired indoors. Most species of *Aedes* feed both during the day and night periods and the disease they transmit such as yellow fever may be acquired at any time of the day or night and usually outdoors. The mosquito species which bite man and animals indiscriminately do not only play a part in transmitting from man to man certain diseases which also exist in animal reservoirs but in addition play a part in transmitting these diseases from animal reservoirs to human hosts.

Ecological studies are usually undertaken to elucidate the habitats and behaviour of the vectors before embarking on control programs. This is important to avoid waste of resources in combating harmless species. Fontenille and Lochouarn advised that before using any vector control measure, it is necessary to obtain as much knowledge as possible of the target vector (Fontenille and Lochouarn, 1999). Earlier, World Health Organisation pointed out that planning, execution and evaluation of antivector measures have to be based on a perfect knowledge of the bionomics of the vector species. They further suggested that knowledge of the breeding, resting, biting habits and longevity of vector species is essential for antivector measures and the evaluation of such measures (WHO, 1975). This is important as the control of any vector-borne disease, either by direct reduction of the parasite reservoir in man, by reduction of vector longevity or by diminution of man-vector contact is dependent upon the effectiveness of materials used and the degree and quality of coverage (FMOH, 1990; Onyido *et al*, 2010). This work is therefore aimed at studying the ecology of malaria

vectors in such holoendemic malaria zone (Onyido *et al*, 2010), so as to provide baseline data for the effective control of malaria in the area.

Materials and Methods

Study Area

The study was carried out in Umudioka Community in Dunukofia L.G.A. of Anambra State, South-east Nigeria. Umudioka is situated between longitude $6^{\circ}85'E$ and Latitude $6^{\circ}10'N$ of Equator (Microsoft Encarta, 2009). It is within the tropical rainforest zone of Nigeria with well marked wet and dry season periods. It has about 8 months of wet season (April to November) and 3-4 months of dry season (November to March) with a short period of dry cold harmattan (December to January) within the dry season. The relative humidity of the area is about 70% in the dry season reaching 80% during the wet season. The annual rainfall is between 2000-3000mm. The average temperature of the area during the dry season ranges from 26° - $30^{\circ}C$ and 21.1° - $30^{\circ}C$ in wet season.

The town is an Igbo community living happily with people from other ethnic groups in Nigeria. The inhabitants are predominantly farmers with few traders and civil servants. Umudioka town has 10 village communities namely: Okpuru, Akpom, Uruagu, Umuchigbo, Uruowelle, Umuezechua, Umuezekwo, Umuajana, Umueze and Ugwu. The town has a good number of small streams found in different villages. In Umuezekwo, there are four streams namely: Mmili-Ogwe, Nkisi-Umunya, Mmili-Mkpikpa and Mmili-Ama-Theo. Nkisa-Uruowelle is found at Uruowelle village while Nkisi-Olioba is found at Umuezechua village. Other villages have at least one stream each and are all located near human habitations. The streams are the sources of drinking and domestic water supply for the community and are common sites for various activities especially washing of clothes, bitter leaf, bread fruit and household utensils. They are also recreational centres as some people wash and swim in them especially children. Most of the streams have freshwater swamps for mosquito breeding. Also the people's method of farming allows collections of water pools within the farmlands.

Collection of Mosquito Larvae

The mosquito breeding habitats were subdivided into three broad groups as follows:

- a. Ground water pools which included rain water collections on the ground, water pools around public taps, collections of water in

potholes along the roads and ground water from farmlands around houses.

- b. Discarded used tyres and
- c. Domestic water containers including earthen pots, water drums, plastic buckets and containers, metal basins and cans.

The mosquito larvae from different habitats were collected at random from all the 10 villages of the community. The larvae in ground pools were collected with the aid of ladles into the bowls. The larvae in discarded used tyres were collected with the aid of suction tubes or pipettes. The larvae in large domestic water containers such as metal and concrete tanks were collected using ladles while those in small containers were completely overturned into the sampling bowls. A sieve of about 0.55mm mesh size was used to separate the larvae from debris. Coarse debris like sticks and plant leaves were handpicked and thrown away. All the larvae collected were transported with little water in large transparent clean jam-jars, properly labeled for easy recognition, to the laboratory. The larvae were reared to adult stages and sent to the National Arbovirus Research Centre Laboratory for proper identification.

Collection of Indoor-Biting and Resting Adult Mosquitoes

Indoor biting and resting adult mosquitoes were collected from the villages using pyrethroid-based insecticide knock down method (PKC). The adult mosquitoes were collected from living rooms where at least one person slept the previous night. Collections were made in 30 houses (3 houses/village). Two rooms were used in each house. In each living room, the doors and windows were short, and white spread sheets were laid from wall to wall covering furnitures and other immovable items in the room. Food items and household eating utensils were carried outside to avoid contamination with insecticide. A pyrethroid-based insecticide aerosol (Baygon), was sprayed in the room and allowed to remain for 20 minutes before collection. In houses without ceiling, the eaves of the houses were quickly sprayed from the outside before the inside. Cracks or any escape routes from the walls, doors and windows were either closed up with rag, papers or sprayed from the outside before the inside.

At the end of 20 minutes interval after spraying, the spread sheets were folded starting from the edges to ensure that no knocked down mosquito escaped. They were taken outside the room and spread out again to collect

the knocked down mosquitoes using a pair of entomological forceps. All the mosquitoes were placed in damp Petri dishes and taken to the laboratory of National Arbovirus Centre Enugu for proper identification. The mosquitoes were identified using the gross morphology of the species, external morphology of the palps, antennae, proboscis, patches of pale and black scales on the wings and legs and the terminal abdominal segments (Gillet, 1972).

Results

A total of 82 sampling sites made up of 37 (45.12%) ground pools, 38 (46.34%) used tyres and 17 (20.73%) domestic water containers were surveyed in the 10 villages of Umudioka (Table 1). Also a total of 372 mosquito larvae were collected from the sampling sites, of which 127 (34.14%) were from ground pools, 209 (56.18%) from used tyres and 36 (9.68%) from domestic water containers. Of the 372 mosquito larvae collected, 39 (10.48%) were collected from Akpom, Umuezekwo and Okpuru villages respectively. 35 (9.41%) were collected from Umuchigbo village, 23 (6.18%) were collected from Ugwu and Umueze villages respectively; 36 (9.67%) were collected from Umuezechua village; 34 (9.14%) were collected from Uruowelle village; 51 (13.71%) were collected from Uruagu village and 53 (14.25%) were collected from Umuajana village. The highest number of mosquito larvae were collected from Umuajana village 53 (14.25%), while the least 23 (6.18%) were collected from Ugwu and Umueze villages respectively.

The mosquito species identified from the larval collection were shown in table 2. Five species of mosquitoes namely *Aedes albopictus*, *Culex tigripes*, *Culex quinquefasciatus*, *Toxorhynchus* spp and *Anopheles gambiae* were collected from the different mosquito breeding sites in the 10 villages of Umudioka. Of the 372 mosquito larvae collected, 204 (54.8%) were *A. albopictus* collected largely from old tyres 188 (89.95%). This was followed by *A. gambiae* 117 (31.45%) and *C. quinquefasciatus* 44 (11.85%). Others were *C. tigripes* 5 (1.34%) and *Toxorhynchites* spp 2 (0.54%). *A. gambiae* was collected mainly from ground pools 111 (87.40%), and few from domestic containers 6 (16.67%). *A. albopictus* and *C. quinquefasciatus* were collected in the 3 categories of the breeding sites.

A total of 263 indoor-biting and resting adult mosquitoes were collected from 30 houses in the ten villages of Umudioka (Table 3). Of the 263 adult mosquitoes collected, 243 (92.4%) were from houses with ceilings while 20

(7.60%) were from houses without ceilings. Adult mosquitoes were collected in all the houses with ceilings while only 4 houses without ceilings yielded mosquitoes. The number of mosquitoes collected in houses without ceilings were lower than those from houses with ceilings. Of the 263 mosquitoes collected, the highest number 39 (14.83%) were collected from Umuezechua village while the least 17 (6.47%) were from Ugwu village.

The mosquito species identified from the adult collections were shown in table 4. Three mosquito species, *A. gambiae* 156 (59.3%), *C. quinquefasciatus* 53 (20.2%) and *A. aegypti* 54 (20.5%) were collected from the ten villages of Umudioka. *A. gambiae* which is an efficient vector of malaria accounted for 59.30% of the indoor collections with a room density of 5.2 mosquitoes per room per night.

Discussion

Of the three major mosquito breeding sites at Umudioka, ground water pools 37 (45.34%) and discarded used tyres 38 (46.34%) yielded very large population of mosquito larvae while domestic water containers 17 (20.73%) yielded relatively few. This shows that people have adequate water supplies for drinking and domestic chores and may have little need for water storage hence mosquito yield from water storage containers were relatively fewer than those of ground water pools and discarded used tyres. On the other hand, the large numbers of discarded tyres indicates indiscriminate dropping of this commodity that is a good breeding site for *Aedes* mosquitoes. The high number of *A. albopictus* 188 (89.95%) is enough proof and possess a potential danger of epidemic should any arboviral infection be introduced in the community (Onyido *et al*, 2009a; Onyido *et al*, 2009b). The ground water pools are favourable breeding sites for *A. gambiae* species (Service, 1980; Gordon and Lavoipierre, 1976).

The highest number of mosquito larvae, 53 (14.25%), were collected from Umuajana village while the least, 23 (6.18%), were collected from Ugwu and Umueze villages respectively. Umuajana village has both ground water pools and discarded used tyres. The village is bisected by trunk A Federal Road passing through the area with a lot of mechanic and motor tyre vulcanizer workshops along the road leading to the accumulation of discarded tyres that form breeding grounds for the mosquitoes (Savage *et al*, 1991; Onyido *et al*, 2009b).

Of a total of 635 mosquitoes collected from the area, 372 (58.58%) were larvae and 263 (38.27%) adults. Also out of the 635 mosquitoes collected,

273 (42.99%) were *A. gambiae*. This indicates that virtually a half of the mosquito population in the area are malaria vectors, especially *A. gambiae* and were collected from the ground pools and very few in domestic water containers. The ground pools were sustained by constant availability of water in fresh water swamps due to overflow of the streams and flooding during the rains. This forms the major breeding ground for the malaria vectors in the area.

WHO (1995), noted that in places like Nigeria, there are higher breeding rates of malaria vectors due to rainfall patterns of the area and the amount of rainfall determines the abundance of mosquito breeding sites. *A. gambiae* which is an efficient malaria vector accounted for 59.3% of the indoor collections with a room density of 5.2 mosquitoes/room/night. This is very high when compared with the critical density of 0.02 per man per night required for maintaining transmission. This might account for high malaria prevalence in the area (Onyido *et al*, 2010). Earlier, WHO (1975) observed that *A. gambiae* has high human blood index, high sporozoite index and typically longlived mosquitoes connected with stable malaria in equatorial Africa.

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Table 1: Larvae Collected From the Various Mosquito Breeding Sites in the Ten Villages of Umudioka

S/N	Study Village	Ground Pool		Used Tyres		Domestic containers		Total larvae collected	%larvae collected
		No of breeding sites	No of larvae collected	No of breeding sites	No of larvae collected	No of breeding sites	No of larvae collected		
1	Akpom	3	12	2	23	1	4	39	10.48
2	Umuchigbo	4	13	5	16	2	6	35	9.41
3	Ugwu	4	9	4	11	1	3	23	6.18
4	Umueze	5	10	3	13	2	0	23	6.18
5	Umuezechua	4	11	3	25	3	0	36	9.67
6	Umuezekwo	5	19	5	12	2	8	39	10.48
7	Umujana	3	14	5	34	3	5	53	14.25
8	Uruagu	4	15	3	30	1	6	51	13.71
9	Uruowelle	3	14	4	20	1	0	34	9.14
10	Okpuru	2	10	4	25	1	4	39	10.48
	Total	37 (45.12%)	127(34.14%)	38(46.34%)	209(56.18%)	17(20.73%)	36(9.68%)	372	100

Table 2: Mosquito Species Collected as Larvae from the 10 Villages of Umudioka

Mosquito Species	Breeding sites			Total	%
	Ground Pool	Used Tyres	Domestic Containers		
<i>Aedes albopictus</i>	6	188	10	204	54.84
<i>Culex quinquefasciatus</i>	10	14	20	44	11.83
<i>Toxorynchites</i>	0	2	0	2	0.54
<i>Culex tigripes</i>	0	5	0	5	1.34
<i>Anopheles gambiae</i>	111	-	6	117	31.45
Total	127	209	36	372	100
%	34.14	56.18	9.68	100	

Table 3: Indoor-Biting and Resting Mosquitoes Collected By Pyrethrum Knockdown Method from the Different Villages

S/N	Study Village	N0 Houses involved	Total number of mosquitoes collected	Number of mosquitoes collected from houses with Ceiling	Number of mosquitoes collected from houses without Ceiling	% of mosquitoes collected from villages
1	Akpom	3	18	16	2	6.85
2	Umuchigbo	3	24	24	0	9.13
3	Ugwu	3	17	17	0	6.47
4	Umueze	3	20	20	0	7.61
5	Umuezechua	3	39	39	0	14.83
6	Umuezekwo	3	36	29	7	13.69
7	Umuajana	3	30	30	0	11.41
8	Uruagu	3	34	23	11	12.93
9	Uruowelle	3	21	21	0	7.95
10	Okpuru	3	24	24	0	9.13
	Total	30	263	243	20	100

Table 4: Pyrethrum Knockdown Collection (Pkc) of Indoor Biting and Resting Adult Mosquitoes at Umudioka Community.

Mosquito Species	Number of Malaria Vector collected in various villages												
	Akpom	Umuchigbo	Ugwu	Umueze	Umuezechua	Umuezekwo	Umuajana	Uruagu	Uruowelle	Okpuru	Total	%	Room density
<i>Anopheles gambiae</i>	16	14	13	10	22	28	12	18	10	13	156	59.3	5.2
<i>Culex quinquefasciatus</i>	1	8	3	6	13	4	6	5	2	5	53	20.2	1.8
<i>Aedes Aegypti</i>	1	2	1	4	4	4	12	11	6	9	54	20.5	1.8
Total	18	24	17	20	39	36	30	34	18	27	263	100	8.8
%	6.8	9.1	6.5	7.6	14.8	13.7	11.4	12.9	6.8	10.3	100		