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EPIDEMIOLOGICAL IMPLICATIONS OF PREFERENCES OF BREEDING SITES OF MOSQUITO SPECIES IN MIDWESTERN NIGERIA

Godwin R.A. Okogun[1], Bethran E.B. Nwoke[2], Anthony N. Okere[2], Jude C. Anosike[2], Anegbe C. Esekhegbe[3]

[1]Department of Medical Laboratory Sciences, College of Medicine, Ambrose Alli University, Ekpoma, Nigeria
[2]Department of Environmental Biology, Imo State University, Owerri, Nigeria
[3]Department of Zoology, Ambrose Alli University, Ekpoma, Nigeria

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Abstract: The relative abundance of the aquatic stages of mosquito species distribution in two macrohabitats was studied between August 2001 and July 2002 using four different microhabitats (plastic cups, metal cans, bamboo cups and earthenware pots). The macrohabitats were subdivided into Areas of Derived/Secondary Vegetation (ADSV) and Areas of High Human Activities (AHHA). The results revealed mosquito species belonging to three genera (*Anopheles*, *Culex* and *Aedes* species), which are known vectors of four different human diseases (yellow fever, arboviruses in general, bancroftian filariasis, and malaria). Mosquito abundance in the three foci studied related to types of vegetation cover, amount of rainfall and its seasons, levels of human activities and population. *Anopheles* species were most abundant in both habitats, with a less marked effect of vegetation and human population. *Culex* species were relatively more abundant than *Aedes* in AHHA than in ADSV. Plastic containers supported 57,391 (47.4%) and metal cans 42,782 (35.4%) of larva species harvested. There is a significant difference in mosquito larva abundance in the two macrohabitats and different microhabitats studied ($p < 0.05$). A combination of factors account for abundant mosquitoes breeding in rural areas with their associated diseases implications. The result of the findings are discussed with respect to their public health implications.

Address for correspondence: Godwin R.A. Okogun, Department of Medical Laboratory Sciences, College of Medicine, Ambrose Alli University, P.M.B, 14, Ekpoma, Nigeria. E-mail: graokogun@yahoo.com

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INTRODUCTION

Various factors affect mosquito abundance and their species distribution. They include climatic influences, vegetation cover and the right type of environmental breeding sites [10]. Some aspects of human ecology also greatly influence mosquito distribution [8]. The geo-climatic effects of a tropical environment on mosquito distribution in Midwestern Nigeria include: optimal breeding temperatures, two distinct seasons: a dry, harsh, growth limiting period with higher temperatures, relative humidity and rainfall (November-February), followed by a wet season with abundant rainfall and flooding (April-October), supporting the growth and development of the aquatic (larva and pupa) stages and abundant recruitment of young adults. The wet seasons are associated with higher prevalence levels of mosquito vector-borne diseases.

The onset of rainfall supports the development of additional mosquito breeding sites, hatching of eggs following oviposition, high relative humidity [10], and

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growth of vegetation cover and cool shaded environment for the development of aquatic stages and the recruitment of young adults and their survival [7]. Mosquito species, once established in an ecological zone, are difficult to dislodge. Even when the enabling environmental factors that support their growth, development and survival are lacking they only tend to temporarily disappear, only to return to a thriving status once these factors are re-established. This is a factor of considerable importance in the control of mosquito vector diseases. An abundance of vegetation cover also provides shade for adult mosquitoes resting positions and breeding activities. Mosquitoes generally prefer a cool shaded area in their biting and breeding activities [8]. Human ecological activities and population abundance differently affect the vegetation type and cover, as well as mosquito abundance and disease causation.

Studies in various micro and macrohabitats in Nigeria have demonstrated the abundance of various mosquito species. They include mosquitoes of the genera *Anopheles*, *Culex*, *Aedes* and *Eretmapodites* [10, 11, 14, 19]. Various mosquito species from these genera are possible vectors of human diseases, including yellow fever, arboviruses in general, malaria and bancroftian filariasis [12, 13, 18]. Knowledge of the species abundance and disease relationship in the area is of importance in disease forecasting and monitoring.

This study is aimed at providing information on the mosquito abundance and their possible vector-borne diseases in rural and semi-urban parts of Midwestern Nigeria for possible public health planning and disease forecasting.

MATERIALS AND METHODS

The study area for the research was the Esan and Etsako region of Edo State, Midwestern Nigeria; located between approximately latitude $05^0\ 44^N$–$07^0\ 34^N$ and longitude $05^0\ 04^E$–$06^0\ 43^E$, covering an estimated area of 20,000 km^2 with a projected population of 2.7 million people by 2002 (at a 3.17% growth rate from 1991 population census) [20].

Two macrohabitats were chosen, subdivided into:

(1) Areas of Derived/Secondary Vegetation (ADSV), mainly on the outskirts of the towns. They have thick vegetation cover with trees of the *Celtis* species, *Peptade meatrum*. Extending to areas where the vegetation is not dense, mostly of grass and bushland, with species such as *Eupathrium adoratun*, and areas forested by plantation (with rubber, orange and plantain trees and stems). They include areas with trees such as *Alastonia* sp., *Hevea brasiliensis*, and thick undergrowths composed principally of siam weeds (*Chromolaena odorata*) and a few climbers, to farm lands consisting of yams, maize, rice farms/paddy and botanical gardens with their characteristic flora.

(2) Areas of High Human Activities (AHHA): These extend from densely populated, nucleated settlements where people still store water in all sort of containers around their homes because of public water supply failure. Areas with scanty vegetation, except for a few flower hedges around homes, made up of species like the milk bush (*Theveria* sp.), Hibiscus (*Rosa sinesis*) and a few scattered Indian almond trees which provide shade in front and sides of homes, represented in Ekpoma (Eguare), Uromi (Ewoyi) and Auchi (Sabo) areas. It also include areas encompassing high/moderate human activities including student hostels (males/females), faculties/ departmental buildings and administrative blocks of the Ambrose Alli University, Ekpoma, Federal Technical College Uromi, and Federal Polytechnic Auchi. Also included are areas of sparse settlement with moderate human population, with economic trees such as the kola nut (*Garcinia cola*), orange trees, mango trees (*Magnifera indica*) and alvocado pears, as well as weeds such as siam weeds (*C. odorata*), *Perotis indica* and *Lophiva lanceolata*.

Each of the macrohabitats was further divided into five ecological sites based either on the level of human activity or vegetation cover. Sampling containers-pots made of clay, metal cans, and plastic containers were bought from the market and bamboo cups were obtained by cutting between any two nodes on a bamboo pole [15]. These were cylindrical and each about 22 cm long and 8.5 cm in diameter and able to hold about 1 litre of water. Pre- experiment treatment of bamboo cups was as described by Okorie [15]; clay pots were pre-treated to enable them to hold water by heating on a coal fire and kept red hot for two hours and allowed to cool down, washed with soapy water, rinsed, and tested overnight by filling with water. Clay pots were able to hold up to 3 litres of water. Plastic containers holding up to 3 litres of water were washed with soapy water and rinsed with clean water. Similar treatment was given to metal containers able to hold up to three litres of water. The study was carried out in the three towns (ecological foci) of Ekpoma, Uromi and Auchi. Ten of each type of container were kept in each macrohabitat in each of the designated towns (foci). They were spaced singly, at least 5 meters apart, in the two macrohabitats according to the vegetation, levels of human activity and settlements patterns described.

The containers were filled with tap water and examined fortnightly for mosquito larvae. The contents of each container were passed through a strainer of about 60 mm meshes per cm, made of mosquito nylon netting to retain larvae/pupae and debris. The larvae were transported to the laboratory in separate vials containg 70% ethanol and later counted under microscope and identified according to the method of Igbinosa [10].

Larva identification was aided by published keys [3, 5, 6] and recorded against each habitat and container. The water passed through the strainer was returned to its containers and filled up to the previous level with tap water. Sampling was carried out fortnightly between August 2001–July 2002. Temperature, relative humidity and rainfall was monitored during the study.

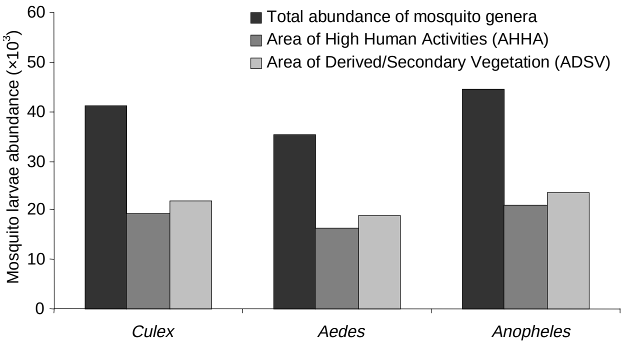

Figure 1. The annual abundance of mosquito genera in the two habitats studied (AHHA & ADSV).

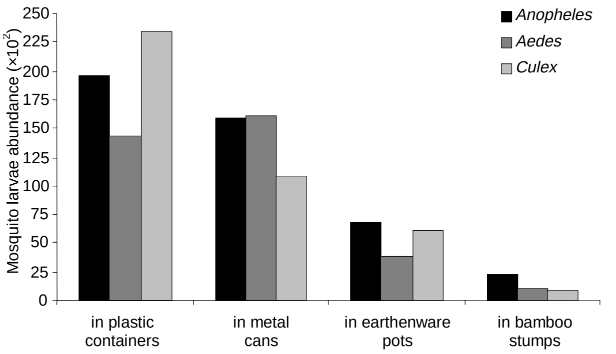

Figure 2. Mosquitoes larva species abundance according to the various microhabitats.

Statistics. The difference in distribution of mosquito larvae in the macro habitats, ecological foci and containers were subjected to statistical analysis by the Student's *t*-test to determine their levels of significance.

RESULTS

A total of 120,917 mosquito larvae belonging to three genera were isolated and identified. Of this number, 57,391 (47.4%) were from plastic containers, 42,782 (35.4%) from metals containers, 16,624 (13.8%) from earthenware pots and 4,120 (3.4%) from bamboo containers microhabitats respectively. There was a marked significant difference among the microhabitats ($p < 0.001$). Area of High Human Activities (AHHA) accounted for 56,759 different mosquitoes larvae and Area of Derived/Secondary Vegetation (ADSV), 64,158 respectively. There was a significant difference between the mosquito larva harvest from AHHA and ADSV ($p < 0.001$). Ekpoma accounted for 43,168 (35.7%) of larva harvested, while Uromi accounted for 41,928 (34.7%) and Auchi 35,821 (29.6%). There was no significant difference between larvae harvested in Ekpoma and Uromi ($p > 0.05$). However, there was a high significant difference between the larva harvested at Auchi, and both Uromi and Ekpoma ($p < 0.001$). Auchi had more of the guinea savannah vegetation in the region. There was no harvest of *Anopheles funestus* at all in Ekpoma and Uromi, while Auchi had 1,428 *Anopheles funestus* larva (100%). Figure 1 represents the records of mosquito larvae, pooled fortnightly over one year, in the habitats studied.

Table 1 gives the abundance of mosquito types in the study area. The *Anopheles* complex was the most abundant prevalent group encountered in earthenwares and bamboo, while the *Aedes* complex was the most prevalent in metal cans, followed by the *Anopheles* complex. *Culex* complex was the most prevalent in plastic cups, followed by the *Anopheles* complex (Fig. 2). The pooled group total abundance shows *Anopheles* 44,496 (37%) followed by *Culex* 41,242 (34%) and *Aedes* 35,179 (29%). There is a high significant difference in all the group of mosquito complex larva abundance ($p < 0.001$).

Figure 3 shows the abundance of mosquitoes larva according to the various microhabitats and species. Plastic containers tend to be the most favourable for mosquito

Table 1. Abundance of mosquito larva species in the different ecological habitats and containers studied.

Microhabitats	Mosquito complex	Ekpoma			Uromi			Auchi			Total		
		AHHA	ADSV	Subtotal	AHHA	ADSV	Subtotal	AHHA	ADSV	Subtotal	AHHA	ADSV	Total
Plastics	*Culex*	4256	3965	8221	3343	4536	7879	3267	4154	7421	10866	12655	23521
	Aedes	2303	2762	5065	2652	2595	5247	1876	2170	4046	6831	7527	14358
	Anopheles	2530	3142	5672	3250	3620	6870	3792	3178	6970	9572	9940	19512
Metal cans	*Culex*	2281	2267	4548	1538	1726	3264	1655	1365	3020	5474	5358	10832
	Aedes	3054	3585	6639	2924	3260	6184	1353	1919	3272	7331	8764	16095
	Anopheles	2485	3354	5839	2476	2872	5348	2088	2580	4668	7049	8806	15855
Earthenware	*Culex*	1022	1157	2179	1058	1142	2200	749	954	1703	2829	3253	6082
	Aedes	680	814	1494	588	727	1315	430	519	949	1698	2060	3758
	Anopheles	1010	1111	2121	1003	1099	2102	1199	1362	2561	3212	3572	6784
Bamboo	*Culex*	125	157	282	134	152	286	98	141	239	357	450	807
	Aedes	156	167	323	192	192	384	114	147	261	462	506	968
	Anopheles	341	444	785	379	470	849	358	353	711	1078	1267	2345
Total		20243	22925	43168	19537	22391	41928	16979	18842	35821	56759	64158	120917

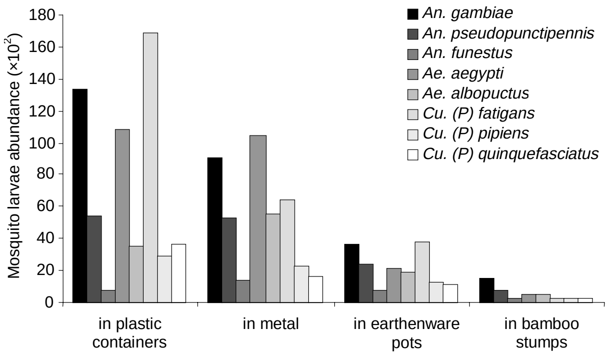

Figure 3. Mosquitoes larva abundance according to the various microhabitats and species.

larva breeding. *Culex* predominantly *Culex (P) fatigans* is the most abundant, while among the *Anopheles* and *Aedes* complex it was predominantly *An. gambiae* and *Ae. aegypti* respectively. *Ae. aegypti*, *An. gambiae* and *Cu. (P) fatigans* were the most abundant species respectively in metal cans. In earthenware pots mosquitoes larvae abundance had more growth of *Cu. (P) fatigans* and *An. gambiae* respectively. Bamboo stump mosquito cultures had more growth of *An. gambiae* species.

The lowest mean monthly temperatures during the study was 23ºC (August 2001) rising to a maximum of 38ºC in April of the same year. A maximum relative humidity of 80 was obtained in August falling to a low level of 20 in December through February 2001.

DISCUSSION

The four microhabitats studied generally tend to be favourable for the oviposition and breeding of the three mosquito genera identified. These are possible vectors of four human diseases *viz*: yellow fever, bancroftian filariasis, arbovirusis in general, and malaria. The occurrence of large numbers of the mosquito larva in plastic containers, especially *Anopheles* and the *Culex* complex, is of public health significance in this study.

Plastic containers and bowls are widely used for water storage in the Edo (Esan and Etsako) parts of Midwestern Nigeria owing to public water supply failure. Mosquito larvae, mainly *Anopheles* (*An. gambiae* and *An. pseudopunctipennis*), breed in these containers in and around homes. The resultant vector abundance, all year round breeding foci and the vectorial capacity of the three *Anopheles* species identified makes for such a high breeding potential and transmission threshold of malaria, making the disease endemic in the study area. Domestic water supply in the study area has become a veritable tool for vector-borne diseases, mainly malaria with its devastating consequences. The breeding potential of Anopheline species support the holoendemicity of malaria, especially in rural areas where parasite rates of up to 100% have been reported [16]. Further away from homes plastic containers found in gutters, on refuse dumps, discarded in surrounding bushes, in gardens and farms used for agricultural purposes, discarded automobile tubes and tyres where they have an organic content to largely support the growth of *Culex* species, especially *Cu. (P) fatigans*. Past reported cases of elephantiasis and the commonly associated morbid effect on the lower limbs and scrotum were rare in the study area; environmental modification has led to the breeding of *Culex* species including known vectors of elephantiasis and bacroftian filariasis e.g *Cu. (P) quinquefasciatus*, and arboviruses in general. Plastic containers also breed *Aedes* species, especially *Ae. aegypti*, a potential vector of yellow fever. A continous monitoring of this vector potential by the authorities in the study area is of importance to avoid potentials that may lead to a possible outbreak of yellow fever in the area

Metal cans supported more growths of *Aedes* species, predominantly *Ae. aegypti*, and less of *Ae. albopuctus*. This microhabitat also support the growth of *Anopheles* species especially *An. gambiae* and *An. pseudopuncti-pennis*, but less of *Culex* species. Metal cans including drums are also widely used for water collection, and tin cans indiscriminately discarded in surrounding bushes making them widely available for mosquito breeding, especially in cool, shaded environments. Earthenware containers are widely used in these parts of Nigeria to store drinking water and as cooking pots. They are heat resistant and keep water cool for long periods despite mild environmental temperature changes. Earthenware containers are preferred by *Anopheles* mosquitoes as breeding sites probably because of its cool temperature and the near neutral pH of such stored water meant for domestic use. It breeds *An. gambiae* and *An. pseudo-punctipennis* very well. This species is the major malaria vector in the rain forest parts and *An. funestus* the major malaria vector in the savannah parts of Nigeria, as earlier reported by Service [18]. The reports in our study differ from the findings of Igbinosa [10], that *Anopheles* species lack preference for breeding in containers. Whether ground pools as reported by Okorie [15] or containers, *Anopheles* breeds in clear water of a suitable pH, temperature and nutrients composition as predominantly found in the study area. Earthenware containers also breed *Culex* species more than the *Aedes* complex. Bamboo stumps also breed predominantly *Anopheles* species, especially *An. gambiae* in the study area. The indications of this report is that there is a high vector breeding potential for the four human vector-borne diseases transmitted by mosquitoes belonging to the three genera *Anopheles*, *Culex* and *Aedes* species. Vector control remains the most plausible management method for vector-borne diseases, hence the control of the vector-borne diseases above requires proper environmental planning and environmental audit.

Mosquitoes abundance in this study is related to population and human activities. The university town of Ekpoma occupied predominantly by farmers and students has a higher relative abundance of mosquito larva species (35.7%) in this study. This is followed by Uromi, predominantly occupied by traders and farmers, with

(34.7%) of mosquito larva species harvested, and Auchi lying in the savannah part of the area and with better public facilities and civil culture, occupied mainly by civil servants, students and farmers, with (29.6%) of mosquito larva isolated in the study. This suggests a positive impact of education and public facilities on vector-borne diseases epidemiology and control.

High relative humidity and cool shade are environmental factors preferred by mosquitoes for breeding. In this report there were more mosquitoes breeding in ADSV than AHHA, which supports the work of Igbinosa [10], and suggests the clearing of bushes around human habitation to reduce mosquito breeding and biting activities. The capacity for *Culex* and *Aedes* species to breed in nearly all microhabitats is attributable more to the availability of nutrients and competition for food [2]. *Culex* and *Aedes* mosquitoes on the other hand breed in high organic compound containing water environments, including polluted water, soakage pits, septic tanks, domestic run-off and gutters, as reported by Nwoke *et al.* [14], Clement [4] and Aigbodion *et al.* [1]. Seasonal influences of temperature, relative humidity and source of nutrients contributes to mosquito abundance during the wet/raining season while lack of all or any of these factors and extremes of temperature (high) reduce mosquito breeding and abundance in the dry season; this agrees with an earlier report by Igbinosa [10]. This means higher infection rates of these mosquito borne-vector diseases in the wet seasons, especially malaria as reported by Salako [16]. Hence, proper environmental management including adherence to basic architectural requirements are imperative to prevent sewage effluents, soakage pits and domestic water run-offs from becoming breeding sites of mosquito disease vectors. The WHO [21], however, reported that *Aedes* mosquitoes living in human environments are small container breeders. That report was not specific on the impact of this on their relative abundance and disease causation.

The public health implications of the various mosquitoes species identified in this study are numerous. The prime value of the study of the ecology and behaviour of *Anopheles* species is its importance as a malaria vector [9]. *Anopheles gambiae* are also potential vectors of arboviruses in general. Malaria is holoendemic in Nigeria and three species (37%) of the mosquitoes identified in this study are possible malaria vectors. The level of morbidity and mortality due to malaria in Africa and parts of Asia makes the *Anopheles* complex a health implication and a killer of great magnitude as well as its noise and biting nuisance.

Aedes species are potential vectors of yellow fever, dengue fever and helminths infections, including bancroftian filariasis and elephantiasis, due to the nematode *Wuchereria bancrofti* [10]. The model for the sylvanic urban and rural circles of yellow fever transmission and possible *Aedes* vector species is provided by Service [17]. Since possible *Aedes* vectors breed indiscriminately in several habitats in the area, the health authorities must continually carry out surveillance and monitoring of the populace for yellow fever virus to avoid densities of infected mosquitoes capable of giving rise to yellow fever epidemics. These proactive measures are particularly important due to the high mortality rates associated with previous yellow fever epidemics in Nigeria. Apart from *Aedes* species, *Cu. (P) quinquefasciatus* and *Anopheles gambiae* species are possible vectors of bancroftian filariasis. The associated morbidity includes disfiguring of the lower limbs and elephantiasis of the lower limbs and scrotum [8]. The recent increase in the number of reported cases of elephantiasis (unpublished data) is a sign of increasing vector abundance that requires monitoring.

Much of the problem of domestic mosquito breeding and manmade malaria in the study area is due to lack of pipe-borne water. Provision of pipe-borne water is a responsibility of government and society which will help reduce mosquitoes breeding around dwelling places. Domestic water storage should be in vessels that will discourage mosquito breeding, e.g. cap-fitted jerry cans.

Apart from incinerating discarded containers, bush clearing around homes, tree hole filling, and drainage clearing, tropical diseases vector control should include elements of specific vectors and associated diseases control such as the use of Insecticide Treated Bed Nets (ITBN) (malaria), vaccination (yellow fever), wearing of protective clothing for bush and insecticide spraying of susceptible mosquito vectors. Vector disease control activities must pay special attention to people who live and work in rural areas, especially farmers, due to their high level exposure to disease vectors and low level empowerment in Nigeria.

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