DISTRIBUTION AND OCCURRENCE OF MOSQUITO SPECIES IN THE MUNICIPAL AREAS OF IMO STATE, NIGERIA

Ifeyinwa Celestina MGBEMENA[*], Tochi EBE[**]

[*]*Department of Biotechnology, Federal University of Technology, Owerri, Imo State, Nigeria*
[**]*Department of Environmental Technology, Federal University of Technology, Owerri, Imo State, Nigeria*
Corresponding author: I.C. Mgbemena, Department of Biotechnology, Federal University of Technology, Owerri, Imo State, Nigeria, email: drifeyinwac@gmail.com

Abstract. A study of the ecology of drainage - breeding mosquito vectors was conducted in the three urban centers (Owerri, Orlu and Okigwe) of Imo State, Nigeria. Four drainage sites located around markets, residential, stream and hotel premises were selected in each urban centre. Dipping method of sampling was employed and a total of 8,820 mosquitoes comprising eight species namely; *Aedes aegypti*, *Aedes vittatus*, *Culex quinquefasciatus*, *Culex tigripes*, *Culex horridus*, *Culex cinereus*, *Culex annuliorus* and *Anopheles gambiae* were encountered; in Owerri and Orlu with *Cx. cinereus* being completely absent in Okigwe. *Cx. quinquefasciatus* was predominantly present in all drainage sites with the highest occurrence of 4,474(50.74%) followed by *Aedes aegypti* 1814 (20.57%), *An .gambiae* 945(10.71%), *Cx. tigripes* 484 (5.48%) *Ae. vittatus* 420 (4.76%), *Cx. horridus* 264 (02.99%), *Cx. cinereus* 261 (2.96%), *Cx. annuliorus* 159 (1.88%). Of all sites sampled, market drainages had the highest abundance of mosquitoes which was significantly higher than (ANOVA, $P \leq 0.05$) those found in the residential, streams and hotel premises. Residential drainages recorded the second highest density followed by stream/vegetation drainages and hotel drainages which had the least. The abundance and distribution of mosquitoes in Owerri (130.06) the State Capital was significantly higher (ANOVA, $P \leq 0.05$) than those for Orlu (93.44) and Okigwe (52.13). The mosquito species identified in this study are of public health importance and there is an urgent need to desilt and clean up these drainages for free flow of water. This will not only rid these species of breeding sites but also free the State of the diseases associated with these organisms.

Keywords: Drainage, Distribution, *Culex*, Vectors, Markets

INTRODUCTION

Vector – borne diseases particularly mosquito – borne diseases have been the most important worldwide health problems for many years and still represent a constant and serious risk to a large part of the world's population. Mosquitoes are vectors of plasmodium that cause malaria, nematode worms that cause filariasis (e.g *Wuchereria brugia*) and a large number of arboviruses (e.g yellow fever and dengue viruses) including two of great impact in the tropical and subtropical regions (i.e yellow fever and dengue viruses). It is believed that mosquitoes rank as man's most important pests. Most of the challenges posed by mosquito - borne diseases consist not only in their cosmopolitan nature and ability to survive in air, aquatic and terrestrial habitats but their ability to breed in any collection of standing water such as wheelbarrows, cesspits, flower vests and drainage systems make such a prolific source of mosquito production. Mosquito vectors breed in any available aquatic environment and different species have different habitat preferences e.g. rice fields, tree holes, pools, puddles, borrow pits etc. Though these breeding sites of vectors are naturally available in most places, human activities and behaviors and the resultant changing environment have continued to create more (and renewed) disease transmission and prevalence. Zarechnaia and Sevein [36] have noted that man during his industrial, agricultural and economic activities produced considerable effect on the *Anopheles* urban population by changing the characters of the breeding sites as well as urban conglomerate microclimate. WHO/TDR[33] reported that the unplanned and haphazard growth of urban settlements; stagnant water in ditches and drains, cesspits, septic tanks, water tanks, barrels and all sorts of containers all of which have increased the *Culex* breeding surface areas. Staurt [28] opined that the incidence of malaria; filariasis and yellow fever were associated with the presence of their Dipteran vectors while Habluelezel and Esposite [14] stated that the correct identification of these local vectors was necessary so that effective control measures could be employed. Therefore, the present research aims at investigating whether or not these drainages actually constitute prolific sources of mosquitoes in these urban areas, and based on this provide necessary baseline data on mosquitoes in Imo State.

MATERIALS AND METHODS

Study Area

The study was carried out in Imo State, Nigeria. Imo State is situated in the central part of the southeastern region of Nigeria. The State is located in the tropical rain forest zone of West Africa with climatic conditions favoring the proliferation of arthropods including mosquitoes. Imo State occupies a landmass of 5,100sq kilometers with a population of 2.4 million persons and an annual growth of 2.8%, distributed in the 27 Local Government Areas (LGA). The three geopolitical zones comprise of Owerri zone, Orlu zone and Okigwe zone with Owerri (where the state capital is situated), Orlu and Okigwe constituting the major urban centers in the State. The map of Imo State showing the 27 LGAs and the three study sites is displayed in Fig. 1.

Preliminary assessment to identify and map out the sampling sites in these areas was made. Visits were also made to obtain useful information from relevant bodies like the Ministry of Health and National Population Commission.

Experimental design

Selection and categorization of sampling sites were based on human activities involved:

Locations Considered

- Markets – Intense human activities
- Residential - moderately high human activities
- Vegetation/stream – moderately low human activities
- Hotels/ Hospitals – lowest human activities

THE EXPLANTION: Site H had the lowest human activities in that those areas were neat and not crowded; therefore the impact of human activities on the drainages around them was not so much as in others

1. **Markets**	**Codes**
Owerri (main market) – Douglas Road	OW M
Orlu (main market - Market Road	OR M
Okigwe (main market) – Market Road	OK M
2. **Residential Houses**	
Njeribeako Street	OW R
Bob Ihedioha Street	OR R
Okpara Road	OK R
3. **Vegetation/ Stream**	
Amakohia - Egbeda – Nwaorie	OW S/V
- Nwanzaza Road	OR S/V
- Ubaha Road – Iyichu	OK S/V
4. **Hotels**	
Modotel –Bank Avenue	OW H
Orlu Hotel – Umuna Road	OR H
Cho Genesis – Okigwe Owerri Road	OK H

Sampling Collection

During sampling, a fabricated dipper 20cm wide and 10cm deep holding 1.5 liters of water was dipped ten times at a sampling point of each of the selected systems/sites for collection of larvae and pupae. Every electric pole constituted a sampling point in these systems.

The contents were passed through a strainer of 20 meshes / cm mosquito nylon netting to retain larvae and debris. The larvae were then transferred to specimen bottles (which were half - filled with breeding site water) using pipette and subsequently taken to the laboratory for rearing and identification.

Larvae scooped from the different points of a system were pooled together and carefully labeled in a plastic container indicating the particular system, date and time of collection. Sampling was done fortnightly from February 2007 to January 2008 between the hours of 6.00a.m – 9.00a.m. Larvae were collected by the standard dipping procedure as described by O'Malley [24].

Rearing

On arrival at the laboratory, the larval collections contained in the container were transferred into rearing buckets (5 liters size) whose open sides were covered with mosquito net. An opening was made from the side through which a netting sleeve was fixed to enable things to be taken in and out.

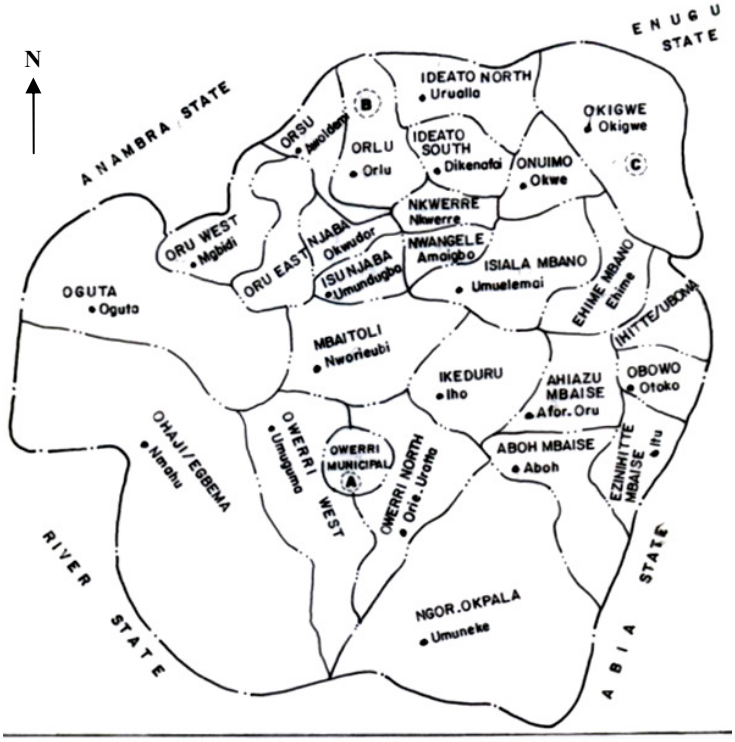

Figure 1. Map of Imo State showing the 27 Local Government Areas and three study areas

The larvae were reared to the fourth instars until they pupated with each bucket containing a single collection from a particular system. Quaker oats was used as larva's feed. Rearing was done according to the method described by Pecor and Gaffigan [26] and Gerberg [9].

The purpose of rearing the larvae was to confirm identification into *Anopheles*, *Culex* and *Aedes* species. At the end of each day emerged adults were counted and recorded. The adults were killed by spraying with insecticide (Raid) for identification.

Identification

The adult mosquitoes were carefully removed from the rearing buckets with a pair of forceps and identified under the microscope using standard morphological and taxonomic keys. Distinguishing characters as reported by Gillet and Smith [8], Gordon and Lavoipierre [12] and Service [27] were used for the identification. In addition the specimens were matched with previously confirmed specimens and microscopic slides maintained by the WHO/Arbovirus Vector Research Center in Enugu. The following records were taken:

1. the different species of mosquitoes encountered
2. different drainage breeding sites.

Statistical Analysis

The data obtained were analyzed with ANOVA and Correlation using SPSS package.

RESULTS

Twelve drainage sites were selected around markets, residents, stream/vegetation and hotels. A total of 8820 mosquito larvae were collected, comprising 8 different species encountered in Owerri and Orlu while 7 species occurred in Okigwe. These comprised of two species of Aedes 2234(25.33%), five species of Culex 5641(64.0%) and one Anopheles species 945(10.71%) Out of this number, *Cx. quinquefasciatus* was predominantly present in all the drainage sites with the highest occurrence 4474 (50.73%) followed by *Ae aegypti* 1814(20.57%), *An. gambiae* 945(10.71%) *Cx. tigripes* 484(5.48%), *Ae. vittatus* 420(4.76%), *Cx. horridus* 264(2.99%), *Cx. cinereus* 261(2.96) and *Cx. annuliorus*159(1.86%). The distribution of mosquitoes in the drainage sites showed that 3433(38. 92%) of mosquito species occurred around markets (M), 2369(26.86%) in residential (R), 1636(18.55%) in stream/ vegetation drainages (S/V) and 1382(15.67%) in hotels drainages (H) (Fig. 2 - 5). *Cx. quinquefasciatus* had the highest distribution and occurrence in market drainages 2517(56.26%) . Hotel drainages had the least occurrence 200 (4.47%) of *Cx. quinquefasciatus* (Table 1).

Ae. aegypti was recorded most in the hotel drainages758(41.79%) followed by S/V 515(28.39%), M 289(15.93%) and R 252(13.89%). *Ae vittatus* occurred most in the hotel drainages (H) 152(36.19%) and least in markek (M) drainages28(6.67%). *Cx.tigripes*, *Cx horridus* and *Cx. cinereus* occurred most in market drainages followed by residential, stream/vegetation and least in hotel drainages while *Cx. annuliorus* occurred more in H followed by S/V and finally R. Surprisingly this particular species was not encountered in market drainages in the three areas. *An. gambiae* was distributed most in residential drainages with highest occurrence of 447(47.30%) followed by S/V 265(28.04%) and least in M 83(8.78%).Surprisingly too *Cx. cinereus* was completely absent in all drainage sites in Okigwe.

Of all the sites surveyed, markets had highest abundance of sampled mosquito species, which was significantly higher (ANOVA, $P \leq 0.05$) than the mosquito species present in the residential, stream/vegetation and hotels (Table 2). However, residential drainages had the second highest, followed by streams/vegetation, while hotels drainages recorded the least in the abundance of mosquitoes. Also, Owerri recorded highest number of mosquito species while Okigwe had the least, which was significantly different from the distribution of mosquitoes in Owerri and Orlu respectively.

Means in the same column under the different sites and urban locations, and having the same letter (superscript) are not significantly different at $P \leq 0.05$ (LSD).

DISCUSSION

Mosquito occurrence in various habitats has been investigated by different researchers (2, 18, 34). Mukhturl et al [21] stated that the occurrence and abundance of mosquito larvae in different habitats reflect the egg – laying preference of females as well as the ability of the immature mosquito to survive under the prevailing conditions. It has also been established that the underground portions of the drainage systems with stable microclimatic conditions offer ideal habitats for breeding of larvae and resting of adults of domestic and peri - domestic mosquitoes [11, 29].

In this study, a total of eight species comprising of *Aedes aegypti*, *Ae. vittatus*, *Culex quinquefasciatus*, *Cx. tigripes*, *Cx horridus*, *Cx. cinereux*, *Cx annuliorus* and *Anopheles gambiae* were encountered in Owerri and Orlu respectively, while seven species were found in Okigwe where *Cx. cinereus* was completely absent in all the sampled sites. *Culex quinquefasciatus* was the most predominant species followed by *Aedes aegpti*, *Anopheles gambiae*, *Cx tigripes*, *Aedes vittatus*, *Cx horridus*, *Cx cinereus* and *Cx annuliorus* was the least in the 3 urban centres of Imo State. Of all the species, *Cx. quinquefasciatus* constitutes the most abundant in the 3 locations of the state. Calson and Knight [5] recorded extremely high *Cx. quinquefasciatus* population in wastewater treatment ponds in Florida. Similarly, Calson *et al.* [4] reported very high *Cx. quinquefasciatus* population in untreated wastewater and at a later stage of wastewater treatment, *Anopheles gambiae* species became dominant. *Cx.*

Table 1. The distribution and occurrence of mosquito species in drainage sites in Owerri, Orlu and Okigwe from February 2007 to January 2008

	R				M				S/V				H				
Species	**Ow**	**Or**	**OK**	**Subbotal**	**Ow**	**Or**	**Ok**	**Subtotal**	**Ow**	**Or**	**Ok**	**Subtotal**	**Ow**	**Or**	**Ok**	**Subtotal**	**Total**
Ae. aegypti	129 (44.64)	86 (29.76)	74 (25.61)	**289 (91.17)**	154 (61.11)	59 (23.41)	39 (15.48)	**252 (71.39)**	248 (48.16)	162 (13.46)	105 (20.39)	**515 (78.75)**	333 (43.93)	250 (32.98)	175 (23.09)	**758 (83.30**	**1814 (20.57)**
Ae. vittatus	2 (7.14)	18 (64.29)	8 (28.57)	**28 (8.83)**	31 (30.69)	50 (49.50)	20 (19.48)	**101 (28.61)**	52 (37.41)	76 (54.68)	11 (7.91)	**139 (21.25)**	75 (49.34)	33 (21.71)	44 (28.95)	**152 (16.70)**	**420 (4.76)**
Subtotal	131 (41.33)	104 (32.81)	82 (25.87)	**317 (9.23)**	185 (52.41)	109 (30.99)	59 (16.71)	**353 (14.90)**	300 (45.87)	238 (36.39)	116 (17.74)	**654 (39.98)**	408 (44.93)	283 (31.17)	219 (24.12)	**910 (65.85)**	**2234 (25.33)**
Cx, quinque-fasciatus	1226 (48.71)	903 (35.88)	388 (15.42)	**2517 (82.99)**	667 (54.85)	383 (31.50)	166 (13.65)	**1216 (77.50)**	288 (53.23)	183 (33.83)	70 (12.94)	**541 (20.42)**	126 (63.00)	58 (29.00)	16 (8.00)	**200 (62.11)**	**4474 (50.73)**
Cx. tigripes	132 (52.17)	78 (30.83)	43 (17.00)	**253 (8.34)**	74 (48.05)	40 (25.97)	40 (25.97)	**154 (9.82)**	30 (46.15)	26 (40.00)	9 (13.84)	**65 (2.45)**	11 (100.00)	0 (0.00)	0 (0.00)	**11 (3.42)**	**483 (5.48)**
Cx. horridus	53 (33.97)	57 (36.54)	46 (29.49)	**156 (5.14)**	21 (29.58)	34 (47..89)	16 (22.54)	**71 (4.53)**	8 (28.57)	16 (57.14)	4 (14.29)	**28 (10.57)**	5 (55.56)	4 (44.14)	0 (0.00)	**9 (2.79)**	**264 (4.68)**
Cx. cinereus	72 (67.29)	35 (32.71)	0 (0.00)	**107 (3.53)**	60 (60.00)	40 (40.00)	0 (0.00)	**100 (6.37)**	26 (65.00)	14 (35.00)	0 (0.00)	**40 (15.09)**	10 (71.43)	4 (28.57)	0 (0.00)	**14 (4.35)**	**261 (2.96)**
Cx. annuliorus	0 (0.00)	0 (0.00)	0 (0.00)	**0 (0.00)**	10 (35.71)	15 (53.57)	3 (10.71)	**28 (1.79)**	12 (27.91)	26 (60.47)	5 (11.63)	**43 (16.23)**	20 (22.73)	49 (55.68)	19 (21.59)	**88 (27.33)**	**159 (1.80)**
Subtotal	1483 (48.90)	1073 (35.38)	477 (15.73)	**3033 (88.35)**	832 (53.03)	512 (32.63)	225 (14.34)	**1569 (66.23)**	364 (50.77)	265 (36.96)	88 (12.27)	**717 (43.83)**	172 (53.42)	115 (35.71)	35 (10.87)	**322 (23.30)**	**5641 (6.40)**
An. gambiae	29 (34.93)	22 (26.51)	32 (38.55)	**83 (2.42)**	129 (28.86)	139 (31.10)	179 (40.04)	**447 (18.87)**	78 (29.43)	86 (32.45)	101 (38.11)	**265 (16.20)**	51 (34.00)	44 (29.33)	55 (36.67)	**150 (10.85)**	**945 (10.71)**
Total	**1643 (47.86)**	**1199 (34.93)**	**591 (17.22)**	**3433 (38.92)**	**1146 (48.37)**	**760 (32.08)**	**463 (19.54)**	**2369 (26.86)**	**742 (45.35)**	**589 (36.00)**	**305 (18.64)**	**1636 (18.55)**	**631 (45.66)**	**442 (31.98)**	**309 (22.36)**	**1382 (15.67)**	**8820**

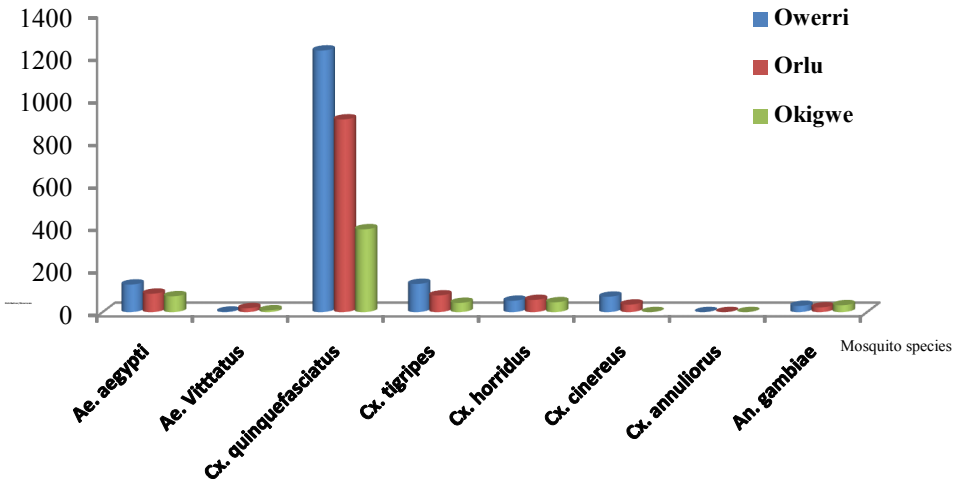

Fig. 2. Distribution and occurrence of mosquito species in market place drainage sites in Owerri, Orlu and Okigwe (Feb. 2007 - Jan. 2008)

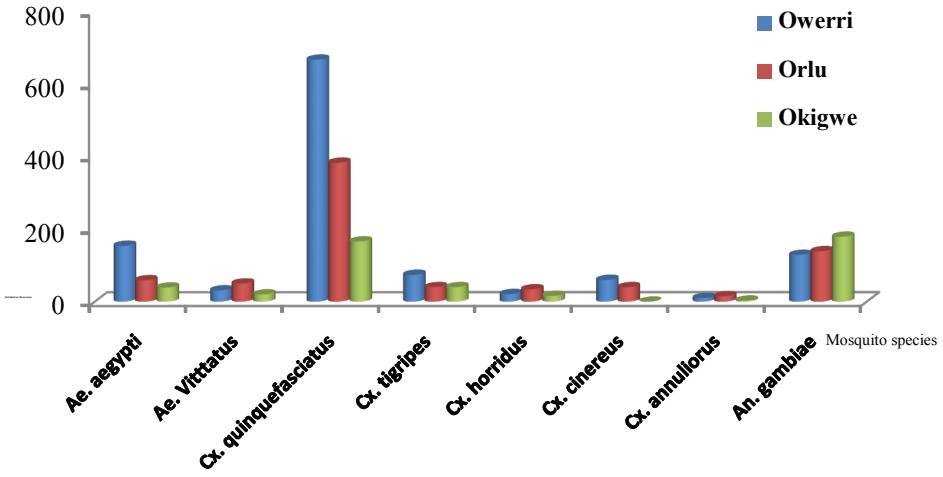

Fig. 3. Distribution and occurrence of mosquito species in residence drainage sites in Owerri, Orlu and Okigwe (Feb. 2007 - Jan. 2008)

Table 2. Mean distribution of mosquitoes in the different sites among the three urban locations of Imo State

Different drainage sites of Urban areas	Mean mosquito distribution
Markets	143.04[a]
Residential	98.71[b]
Stream/ Vegetation	68.17[bc]
Hotels	57.58[c]
Urban locations of Imo State	
Owerri	130.06[a]
Orlu	93.44[b]
Okigwe	52.13[c]

quinquefasciatus as well as *Ae. aegypti* have been reported to breed naturally in open drains, open cracked cesspits, pit latrines, water storage containers especially when these breeding sites are polluted with organic matter [6]. Iwuala [16] found them in high number in cassava fermentation pots and drums in some parts of eastern Nigeria. *Ae aegypti* was next in abundant. The indiscriminate preference of all microhabitats by this species supports the findings of Okorie [23], in which *Ae. aegypti* was found in all the microhabitats. However, the ubiquity of Ae. *aegypti* could be explained by considering the structure of the egg. The eggs of *Ae. aegypti* possess hardened endochorion which enables the eggs to resist desiccation. Hence the environmental conditions of microhabitat do not have adverse effect on these species as they would do to other mosquito species with no resistant endochorion [7]. *An. gambiae* which is unlikely to be found in polluted environments was surprisingly encountered in these study sites. This supports the result of Gimming et al. [10] who found increasing number of *An. gambiae* s.i larval densities with increasing turbidity while Ye – Ebiyo et al [35] equally reported that the production of *An arabiensis* was favored by moderately turbid water while excessive turbidity limited the production of larvae.

The presence of other mosquito species which are not commonly associated with drainage systems was equally surprising. *Cx. horridus*, *Cx. tigripes*, *Cx. cinereus* and Cx. *annuliorus* have not been previously

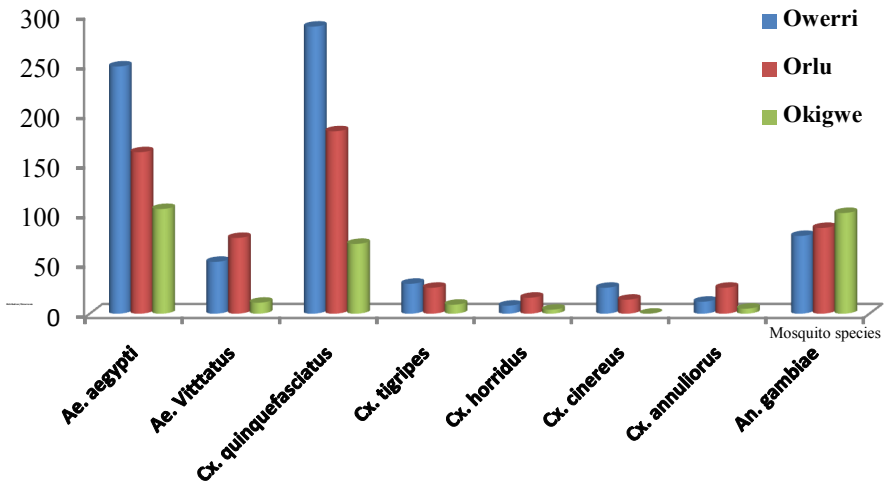

Fig. 4. Distribution and occurrence of mosquito species in stream and vegetation drainage sites in Owerri, Orlu and Okigwe (Feb. 2007 - Jan. 2008)

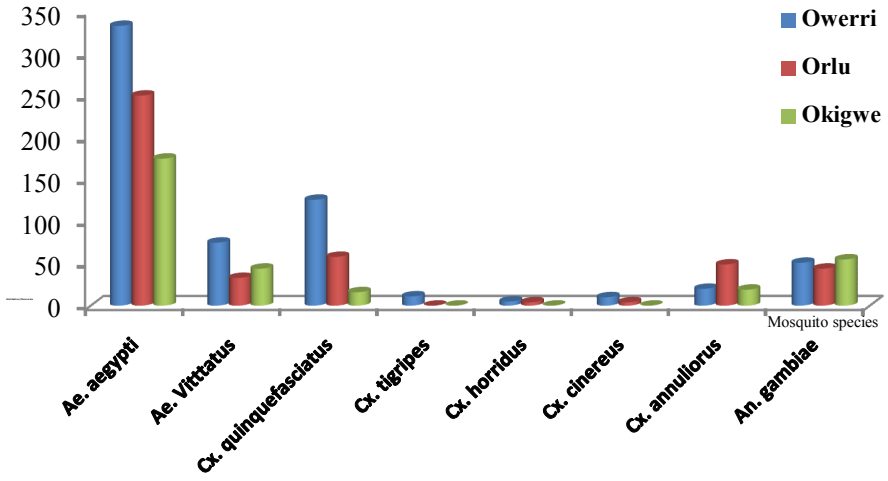

Fig. 5. Distribution and occurrence of mosquito species in hotels and hospitals drainage sites in Owerri, Orlu and Okigwe (Feb. 2007 - Jan. 2008)

reported as breeding in ammonia rich waters in Southeastern Nigeria and many other countries except the work of Irving – Bell et al [15] that reported the presence of these species in such habitat in Jos North Central, Nigeria.

Of all the sites surveyed, market drainages recorded the highest abundance of sampled mosquitoes which was significantly different (ANOVA, $P \leq 0.05$) from mosquito species present in the residential, stream/vegetation and hotel drainages. However, residential gutters had the second highest abundance of mosquito specie followed by stream/vegetation while hotel sites recorded the least. Occurrence and distribution of mosquitoes in these sites can be linked to the activities in and around these sites. Selection and categorization of sampling sites showed market places are characterized with intense human activities particularly with business transactions of all forms, noted with buying and selling. The residents have moderately high human activities where every individual present in the 3 other sites must necessarily retire at the end of each day's activities. The stream/vegetation drainages on the other hand are of low human activities like bathing, washing and disposal of wastes while hotels have very low human activities characterized with hospitality activities. The markets and residential drainages harbored most of *Culex* species encountered in this study. This could be attributed to their preferences for polluted sites. On the other hand, *Culex annuliorus* was exceptionally different in their occurrence. This particular species seemed to breed in unpolluted environment as they were found mainly around hotel and stream/vegetation drainages which were moderately polluted and completely absent in market drainages which happened to be the most polluted of all the study sites. *An. gambiae* had highest occurrence in the residential drainages followed by stream/vegetation and hotel while market drainages were the least. The high density of *Anopheles* larvae in the residential drainages could be explained in connection with behavioral activities of mosquitoes. Emergence, mating, feeding and

oviposition are activities known to take place at a particular time of the day and night which vary between species. In addition, adult mosquitoes do not travel far from the water in which they spent their larval stage [13]. Notably, when adult females of *Anopheles* emerge, they will go to their sources of blood meal and this usually coincides with their biting period which is readily available in residential areas. It is not surprising to find this species occurring more in sites in close proximity to their biting places that will enable them to find blood source as soon as emergence takes place. Hotel drainages had more *Aedes* species than others.

Owerri recorded highest mean abundance (130.06) of mosquitoes which varied significantly (ANOVA, $P \leq 0.05$) with the two other areas, that is Orlu (93.44) and Okigwe (52.13). Owerri being a capital city of Imo State, has the highest human population density with its attendant activities. The presence of industries and infrastructural facilities (such as piped - borne water and electricity) could account for this. However, the occurrence of mosquitoes has been associated with the presence and activities of humans which was highest in Owerri. O'Meara *et al* [25] reported that human activities are responsible for the establishment of vast majority of aquatic habitats used by *Cx quinquefasciatus*. On the other, Orlu and Okigwe are rather semi – urban centers, and also possess undulating terrains and topography, have shallow drains which were relatively of smaller sizes. These together with low population size along with irregular supply of water may have direct bearing to the low density of mosquitoes recorded in these areas. *Cx cinereus* was completely absent in Okigwe in all sites of study. It is possible that this species was unable to establish or breed in Okigwe on account of the topographic features. Report has shown that topography of an area is an important factor in determining the breeding sites and the type of mosquito that will occur [30]. However, the result of this study closely relates to the findings of Bunza *et al* [3] who studied relative abundance of mosquito species in Katsina, Nigeria, where two of the mosquito species: *Culex quinquefasciatus* and *Anopeleles gambiae* were also identified. Abundance of mosquito species responds to the presence of both organic and inorganic material in the environment. In their previous studies, Mgbemena *et al.* [20] reported a significant correlation between sulphate the mosquito abundance in their area of study while Yee et al(34) reported an association of congenerics and environmental factors, with *Aedes* associating with detritus type and *Culex* associated with factors related to the surrounding habitat of human population density, canopy cover, tire size) or microorganisms.

Mosquitoes produced in or harbored by drain systems can cause considerable public health concerns from the standpoint of arbovirus transmission [17, 19, 27]. The presence and occurrence of established vectors such as *Ae.aegypti*, *Cx. quinquefasciatus* and *An. gambiae* in these drainage systems is an indication that such habitats could contribute to vector disease risks in these urban areas. These mosquitoes have been incriminated in the transmission of important human diseases such as yellow fever, dengue, lymphatic filariasis and malaria. *Aedes aegypti* is known vector of yellow fever while *Cx. quinquefasciatus* is known to transmit filariasis. In East Africa, however it is a major vector of urban Bancroftian filariasis [32]. Ogunba [22] incriminated *Culex pipiens fatigans*, *Cx. nebulensis*, *Cx. decens*, *Cx tigripes* and *Cx. cinereus* as principal vectors of filariasis due to *Wuchereria bancrofti*. Mosquitoes of the genus *Anopheles* are primary malaria vector worldwide. In Nigeria, the most common are *Anopheles gambiae* complex. This species carry the parasite *Plasmodium falciparum* which causes malaria and has also been associated with the transmission of filariasis [31]. The other species encountered in this study that included *Ae. vittatus*, *Cx. horridus*, *Cx. annuliorus* are potential vectors of arbovirus pathogens.

The mosquito species identified in this study are of public health importance, there is need to desilt and clean up these drainages for free flow of water. This will not only rid these species of breeding sites but also free the State of the diseases associated with these organisms.

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