Surveillance Studies Of Aedes Stegomyia Mosquitoes In Three Ecological Locations Of Enugu, South-Eastern Nigeria.

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Citation

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Abstract

A surveillance study of Aedes Stegomyia mosquitoes in three ecological locations in Enugu Southeastern Nigeria was undertaken between January and December 2006. The study sites were No. 33 Park Avenue Compound GRA, Gmelina forest canopy and Ekulu River banks. Twelve CDC ovitraps were set weekly at each location. Each trap was left for 48 hours before collection. At collection, each paddle was wrapped with a clean duplicating white sheet and later sent to the National Arbovirus and Vectors Research laboratory Enugu, for examination under the microscope for the presence of mosquito eggs. A total of 5,251 mosquitoes made up of four species, (Aedes stegomyia aegypti, A. Stegomyia africanus, A. Stegomyia inteocephalus and A. Stegomyia simpsoni) were collected. A. aegypti were 5,191 mosquitoes (98.86%) and formed the bulk of the collection. Mosquito yields from the three ecological locations were 3,186(60.67%) from No.33 Park Avenue, 927 (17.65%) from the Gmelina forest and 1,138 (21.67%) from Ekulu River banks. In all the locations, the mean number of mosquitoes collected, the number of egg- positive paddles and the mean number of eggs hatching out per paddle were least in hot dry and cold dry periods but were significantly higher in warm humid wet period. Graph plots of monthly mosquito collection revealed high mosquito population peaks between April and June and minor peaks around September and November periods.The public health implications of the findings were discussed, and suggestions for regular monitoring and control of the mosquitoes, and protection of individuals and the public were made.

INTODUCTION

Yellow fever is transmitted mainly by the mosquitoes belonging to the Aedes Stegoymia subgenus. Specifically Aedes aegypti; A. africanus, A. luteocephalus, A. albopictus and A. vittatus, are well known yellow fever vectors, in Nigeria and West African subregion (1,2). They were responsible for the various yellow fever epidemics in Nigeria (3,4,5,6,7). Besides yellow fever, these mosquitoes are involved in the transmission of other parasitic diseases and arboviral infections elsewhere throughout the world. Aedes aegypti and A. africanus are responsible for the transmission of Chikunguya, Lunyo, Rift valley and Zika viruses in East Africa (8). In Southeast Asia, A. aegypti and A. albopictus transmitted dengue and haemorrhagic fever (1). Outside Africa, some species of Aedes namely Aedes togoi, A. poecilus, A. polynesiensis, and A. pseudoscutellaris are important vectors of Wuchereria bancrofti (1). In the USA, California encephalitis (CAL), is spread by Aedes melanimon.

These aedes mosquitoes normally breed in transient water collections such as waters in tree holes, or in plant leaf axils, bamboo stumps, rock pools, and artificial containers including tin cans, coconut shells, water storage containers, discarded vehicle tyres, broken earthen and ceramic wares, as well as other water containers around houses (9,10,11). Nwoke and Nwoke (12) observed that the habit of littering the environment with discarded containers among urban dwellers provides good breeding sites for these mosquitoes. These authors further noted that lack of regular supply of potable water in the urban centres forces the inhabitants to habitually store water in many homes and these water storage containers constitute breeding grounds around our homes.

The increasing importance of culicine mosquitoes in the transmission of arboviruses, filarial and other vector-borne diseases demands a system of continuous surveillance and control. This becomes increasingly more important when the species have very high avidity for feeding on man, high

reproductive potential and remarkable longevity (5,13). Although regular control measures have not been adopted in the country probably due to costs and logistics, but a system of year to year monitoring of aedes mosquito populations using CDC ovitraps is already adopted.This work was aimed at determining the populations of aedes mosquitoes at three ecological sites in Enugu, Nigeria from January to December 2006 using the CDC ovitraps. The study also determined whether the adult females survived all the year round to lay eggs.

MATERIALS AND METHODS

THE STUDY AREA

Enugu, the study area, is geographically located between latitudes 6 and 7 North of Equator and between longitudes 7 and 8 East of the Greenwich Meridian. It is a cosmopolitan city and the political capital of Enugu State in Southeastern Nigeria. It lies in the rain forest belt of Nigeria although it has derived savannah vegetation resulting from urbanization and other human activities. It has eight months of rainfall (April to November) and four months of dry season (November to March). The mean annual rainfall is 2000mm while the mean daily temperature varies from 22 - 28C in the rainy season to 28 - 32C in the dry season. Enugu is surrounded by Udi hills. It has an undulating topography with good natural drainage systems.

Enugu metropolis also serves as the commercial nerve centre of Enugu State and the administrative headquarters of many National and State Institutions. In addition, it has many secondary and tertiary institutions of higher learning. Also found within the metropolis are many privately owned clinics, primary health centers, general hospital and tertiary health institutions including the University of Nigeria Teaching Hospital, National Orthopedic Hospital and Parklane General Hospital. The city has a teeming population of about 3 million people.

THE STUDY SITES

The study sites were No.33 Park Avenue compound at GRA, which also served as the office compound of the National Arbovirus and Vectors Research Centre Enugu, a subsidiary of the Federal Ministry of Health. It is situated in a low-density area of the metropolis and it was intended to represent a typical residential home in Enugu. The second ecological site was the Gmelina Forest Reserve of the Coal Corporation of Nigeria. The Gulf Course separates it from the GRA. It was used by the coal corporation to produce logs for the support of coal mines. It was intended to represent a forest condition throughout the year. The third ecological site was the Ekulu Riverbanks between the GRA and Trans-Ekulu Area of the metropolis. It was assumed to provide water for the breeding of the mosquitoes throughout the year.

COLLECTION OF THE MOSQUITOES

Aedes mosquito populations were monitored using CDC ovitraps. Twelve CDC ovitraps were set weekly from January to December 2006 at each of the three ecological areas viz No.33 Park Avenue, the Gmelina forest and Ekulu River banks. Each trap consisted of a black jam jar three-quarter filled with clean tap water and a fibrous paddle with the smooth surface facing upwards and rough surface in water. The traps were set in strategic positions under tree shades and forest edges making sure that animals looking for water or children playing around the area did not overturn them. The traps were left in position for 48 hours (2days) before collection. At collection, each paddle was wrapped separately with a clean duplicating white sheet while the water was poured away. Each paddle was examined under the dissecting microscope for the presence of Aedes mosquito eggs. Positive paddles were dried under room temperature for one week and soaked for 2 days in white jam jars for the eggs to hatch. The hatched larvae were reared to adults for proper identification into species. The process was repeated 3 times for each positive paddle to ensure that all eggs hatched out.

RESULTS

Table 1 shows the monthly collection of mosquitoes from the selected 3 ecological locations. A total of 5,251 mosquitoes made up of four species namely, Aedes Stegomyia aegypti, A. Stegomyia africanus, A. Stegomyia luteocephalus and A. Stegomyia simpsoni, were collected. Out of this number, 3,186 mosquitoes (60.67%) were collected at No.33 Park Avenue Compound, 927 mosquitoes (17.65%) were collected from the Gmelina forest canopy and 1,138 mosquitoes (21.67%) were collected along the Ekulu River banks.

Out of 588 traps set at each location, 303 ovitrap paddles (51.53%) were positive with aedes egg at Park Avenue compound, 152 ovitrap paddles (25.85%) from the Gmelina forest were positive with aedes eggs, while 188 ovitrap paddles (31.97%) from the Ekulu-River banks, were positive of aedes eggs.

Mosquito yield from the paddles were as follows: the 303 egg-positive paddles from Park Avenue yielded 3,186 mosquitoes at a rate of 10.51 eggs per positive paddle. The 152 egg-positive paddles from the Gmelina forest canopy yielded 927 mosquitoes at a rate of 6.09 eggs per egg positive paddle. The 188 egg-positive paddles from the Ekulu River banks yielded 1,138 mosquitoes at the rate of 6.05 mosquitoes per egg-positive paddle. From these results, each paddle set at Park Avenue compound yielded almost twice as much mosquitoes hatched out from each egg-positive paddles from the Gmelina Forest and Ekulu River banks respectively.

Out of the four mosquito species collected, A. aegypti were 5,191 mosquitoes (98.86%), constituting the bulk of the collection. A breakdown of the collections from the various locations showed that 3,175 Aedes aegypti (60.46%) were collected from the Park Avenue compound, 896 A. aegypti (17.06%), were collected from the Gmelina Forest canopy while 1,120 A. aegypti (21.33%), were collected from the Ekulu River banks.

Also 57 A. africanus mosquitoes representing 1.08% of the total collection were obtained in the studies, 10 of them were collected from the Gmelina forest canopy, 17 from the Ekulu River banks while 30 were from No. 33 Park Avenue compound. Two Aedes luteocephalus mosquitoes were also collected, one from Ekulu River banks and the other from No.33 Park Avenue compound. Only one Aedes simpsoni mosquito was collected in the study from Ekulu River banks in the month of May.

Table 2 shows the variations in mosquito populations, egg-positive paddles and the mosquito yields per paddle at the various periods of the year. At No.33 Park Avenue GRA, the mean egg-positive paddles per month varied from 22 egg-positive paddles between January and March (hot dry period of the year), to 29 egg-positive paddles between April and September (warm humid period /wet season), and 21 egg-positive paddles between October and December (cold dry period). The mean monthly mosquito yields from the paddles varied from 148 mosquitoes in the hot dry period to 324 mosquitoes per month, during wet season and 240 mosquitoes during cold-dry periods. The mean number of mosquitoes hatching out per egg-positive paddle ranged from 6.7 mosquitoes per paddle in hot dry period, to 11.2 mosquitoes per paddle in the wet period and 11.4 mosquitoes per paddle in cold dry period.

At the Gmelina forest, the monthly egg-positive paddles ranged from 8 egg-positive paddles per month in the hot dry period to 17 egg-positive paddles in the wet season and 8 egg-positive paddles in the cold dry period. The mean numbers of mosquitoes per month collected were from 37 mosquitoes per month in hot dry period, to 87 mosquitoes per month in wet season and 70 mosquitoes in cold dry period. The mosquito yield per egg-positive paddle was from 4.6 mosquitoes per paddle in hot dry periods to 5.2 mosquitoes per paddle in wet months and 8.6 mosquitoes per paddle in cold dry months.

At the Ekulu River banks, the monthly egg-positive paddles varied from 9 egg-positive paddles per month in hot dry period to 19 egg-positive paddles in the wet months and 10 egg-positive paddles in cold dry months. The mean numbers of mosquitoes collected per month varied from 27 mosquitoes per month in the hot dry period, to 125 mosquitoes per month in the wet months and 68 mosquitoes per month in the dry cold months. The mosquito yields per egg-positive paddle varied from 3 mosquitoes per paddle in hot dry months to 6.6 mosquitoes per paddle in the wet months and 6.8 mosquitoes per paddle in cold dry months.

In all the locations, the mean number of egg-positive paddles, the mean number of mosquitoes collected and the mean number of mosquitoes hatching out per egg-positive paddle were least in the hot dry periods (January – March), followed by those of the cold dry period (October to December). The numbers were significantly higher during the wet months (April to September).

Figure 1 shows the monthly variation in the numbers of mosquitoes collected during the study period. At Ekulu River banks, a population of about 450 mosquitoes was obtained in the month of April, which sharply declined but showed two minor peaks in September and November months. At the Gmelina forest, a peak population was obtained in May, which again declined but showed two minor peaks in September and November months respectively.

At Park Avenue, a minor peak was obtained in the month of February, which declined and rose again to a major peak in May. This population sharply declined again in the month of June and rose to a minor peak in July and October. The October peak was maintained until December when the study ended. In general, a high peak of mosquito population was obtained between April and June in the 3 ecological

locations, followed by a sharp decline in population between June and August and a small peak in September and November periods.

DISCUSSION

Egg-positive paddles were collected from the three ecological locations in all the months of the year. This suggests that aedes mosquitoes may survive certain adverse weather conditions as adults and continue to oviposit provided there is water in the environment. Chandler and Reads (14) observed that many mosquitoes of temperate or tropical climate hibernate or pass the dry season as adults, the females stowing themselves away in hollows in trees, caves, crevices in rocks, cellars, barns, and other conducive environments, to come forth by their eggs in the spring. This is contrary to the general opinion that Aedes mosquitoes lay eggs capable of withstanding desiccation and therefore survives adverse weather conditions as eggs (1,13). It is likely that these mosquitoes depending on the severity of the prevailing weather conditions, may adopt the two methods of surviving adverse weather conditions.

The mosquito collections from Park Avenue compound were about twice the collections from the other ecological locations. The Park Avenue compound was intended to represent a normal compound in the city operating under water scarcity and abundance depending on water supply from the water cooperation. However the preponderance of aedes mosquitoes in Park Avenue compound could be explained by the fact that it is the Research Laboratory compound of National Arbovirus and Vectors Research Centre where mosquitoes especially Aedes species, are maintained in colonies. It is likely that some of these mosquitoes must have escaped from the colonies during the feeding period, or through faulty cages or before the pupae were separated from larvae to be placed in the cage for adult emergence. Such escaping mosquitoes may not have sufficient water for breeding due to the sloppy terrain of the compound but rather have to compete for the few CDC ovitraps set in the compound. Also the adjacent compounds to the Research Centre at Park Avenue were government guest houses with strong storage water tanks that hold water regularly and as such may form a major breeding ground for the mosquitoes. These mosquitoes could through natural dispersal by flight or through wind effects, be spread to other compounds including the Park Avenue compound. The teeming population of workers, guests and residents in the area including domestic animals that roam about were large enough to maintain mosquito populations. Gouck (15) have shown the preference of strains of Aedes aegypti and A. simpsoni.

All the mosquitoes collected belonged to the Aedes stegomyia subgenus and Aedes aegypti constituted 98% of the total collection. Members of the Aedes stegomyia subgenus are receptacle breeders. They breed in small water containers including tree holes, tin cans, tyres and discarded or broken household utensils (1,11,16). CDC ovitraps consisted essentially of black jam jars that are but mimics of receptacles where the mosquitoes breed. The large population of A.aegypti does not only reveal its high capacity as a receptacle breeder (11) but intense breeding of this species within the study environment. Also among the Aedes Stegomyia subgenus, some are forest canopy breeders (1,2,13) while Aedes aegypti is a well-known ground breeder in household receptacles (17), hence the high population of the species in CDC ovitraps placed at ground level.

Figure 1

Table 1: Mosquito abundance at the three ecological locations of Enugu metropolis

Location	Month	No. of paddle set	No. of +ve paddles	% of +ve paddles	Mosquito collected			
					A. aegypti	*A. africanus*	*A. leuteocephalus*	*A. simpsoni*
Park Avenue	Jan	48	24	50.00	236	-	-	-
	Feb	48	17	35.42	60	1	-	-
	March	48	24	50.00	149	-	-	-
	April	60	54	90.00	668	-	-	-
	May	48	24	50.00	189	3	1	-
	June	48	29	60.42	335	-	-	-
	July	60	34	56.67	361	-	-	-
	Aug	48	17	35.42	224	-	-	-
	Sept	60	18	37.50	168	-	-	-
	Oct	48	18	50.00	260	-	-	-
	Nov	48	23	47.92	252	4	-	-
	Dec	24	21	87.50	273	2	-	-
Subtotal		588	303 (51.53%)		3,175 (99.65%)	10 (0.31%)	1 (0.03%)	
Gmelina Forest	Jan	48	8	16.67	33	2	-	-
	Feb	48	8	16.67	62	-	-	-
	March	48	8	16.67	16	4	-	-
	April	60	31	64.58	243	-	-	-
	May	48	22	45.83	133	-	-	-
	June	48	21	43.75	74	5	-	-
	July	60	24	40.00	56	18	1	-
	Aug	48	1	2.08	5	-	-	-
	Sept	60	3	5	17	-	-	-
	Oct	48	3	6.25	5	-	-	-
	Nov	48	17	35.42	190	1	-	-
	Dec	24	6	50.00	62	-	-	-
Subtotal		588	152 (25.83%)		896 (96.66%)	30 (3.24%)	1 (0.11%)	
Ekulu River bank	Jan	48	10	20.83	35	-	-	-
	Feb	48	2	4.17	2	-	-	-
	March	48	15	31.25	42	3	-	-
	April	60	41	68.33	430	3	-	-
	May	48	29	60.42	126	1	-	1
	June	48	9	18.75	73	1	-	-
	July	60	15	25.00	37	-	-	-
	Aug	48	7	14.58	17	3	-	-
	Sept	60	15	25.00	60	-	-	-
	Oct	48	16	33.33	45	4	-	-
	Nov	48	18	37.50	168	2	-	-
	Dec	24	11	22.92	85	-	-	-
Subtotal		588	188 (31.97%)		11.20 (98.42%)	17 (1.49%)		1 (0.09%)

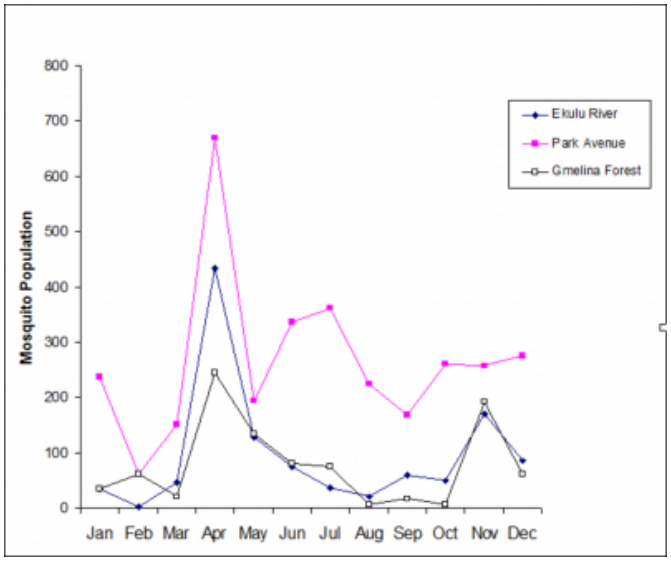
Figure 2

Table 2: Mean variations in mosquito yield at the 3 ecological locations during wet, hot and dry-cold months of the year

PERIOD OF YEAR	MONTHLY AVE OF EGG +VE PADDLES		MONTHLY AVG OF MOSQUITOES COLLECTED	AVG MOSQUITO PER PADDLE/MONTH
Jan – March (Hot – dry period)	P/Avenue G/Forest E/River	22 8 9	148 37 27	6.7 4.6 3.0
April – Sept. (Warm – humid period)	P/Avenue G/Forest E/River	29 17 19	324 88 125	11.2 5.2 6.6
Oct – Dec. (Cold-dry period)	P/Avenue G/Forest E/River	21 8 10	240 70 68	11.4 8.6 6.8

Figure 3

Figure 1: Abundance of mosquitoes in the three ecological locations from January to December



Aedes africanus, a tree hole breeder in the forest canopy (9,10,18,19,20) was collected in a fairly large numbers in the CDC ovitraps set on the ground level. This may be suggestive of the breeding readjustment of this species (20). It is also suggestive that ovitraps set at various heights in the forest canopy may be used as substitutes for tree hole breeding mosquitoes.

The collection of more A. africanus in Gmelina forest and Ekulu River banks is illustrative of its sylvatic nature (1) while the collection at 17 Park Avenue may be partly due to the escape of the mosquitoes from the laboratory or due partly to their breeding in tree holes found in ornamental and fruit trees scattered within the compound.

The mean number of egg positive-paddles, the mean number, of mosquitoes collected and the number of eggs hatching out per paddle were found to be low during the hot-dry and cold-dry periods but significantly high during warm humid periods. The cold dry period (October to December) comes at the end of rains and usually marks the beginning of dry season. This period varies from place to place and year to year and sometimes may not be pronounced and therefore passes unnoticed. It is usually characterized by cold spells and dry dusty winds that may be deleterious to the survival of many organisms. The hot dry period (January to March) is usually marked with hot sunny days, high temperatures and low relative humidity with little or no rainfall during this period. This also makes the survival of many organisms difficult and therefore accounts for low figures within the period. The warm humid period or wet season (April to October) is usually characterized by rains, high relative humidity and moderate temperatures favorable for the survival of organisms during this period.

From the graphs, a high peak of mosquito population was obtained between April and June in all the three ecological locations. A sharp decline in mosquito populations between June and August, and a small peak followed this in September to November. The major mosquito population peaks obtained between April and June correspond with the beginning of the warm humid weather favorable to the growth of organism. Also the rains came at intermittent intervals giving sufficient time for the mosquitoes to hatch out and develop within the small pools of water. The sharp decline from June depicts heavy rains, which flushes and destroys developing mosquito eggs and larvae leading to fall in population. The small peak in September may be as a result of short intervals in August break while the November peak corresponded with the end of rains in which rains were again at intervals giving sufficient time for immature stages to develop, while the final decline were due to the drying up of the little pools of water left by the rain, thereby limiting reproduction and development.

This study thus reveals that adult female aedes mosquitoes could survive certain adverse weather conditions as adult and will continue to oviposit using any available water source. The public health implications is that since these aedes mosquitoes are vectors of many viral and parasitic diseases of man and livestock, which must continue to take blood meals before oviposition, it means that an infected

adult mosquito will continue to transmit diseases to its host at any period of the year. Also the peak population periods of these mosquitoes between April and June and at end of rains are indicative of high fly-man contact within these periods and possibly high rate of disease transmission. This implies that outbreaks of mosquito-borne diseases are likely to be associated with these periods. It calls for caution for self and public protection against these mosquito-borne diseases at every moment of the year. Also, since only mosquitoes belonging to Aedes stegomyia subgenus was collected, yearly monitoring of aedes mosquitoes using CDC Ovitraps should be adopted by government and organizations to determine appropriate period of control. The peak periods of the mosquito populations corresponded to the periods when maximum man-fly contact possibly occurs and therefore demands a system of control to reduce man-fly contacts in the communities.

References

1. Service, M.W. (1980). Guide to Medical Entomology. Macmillan Press Ltd., London.
2. WHO (1986). Prevention and control of yellow fever in Africa. World Health Organisation Geneva 1986, Printed in Belgium, 85/6452 Macmillan / Centrick- 7000.
3. Lee, V.H. and Moore, D.L. (1972). Vectors of the 1969 yellow fever epidemics on Jos Plateau, Nigeria. Bulletin of World Health Organisation 46: 669-673.
4. Lee, V.H., Monath, R.P., Tomori, O., Fagbani, A and Wilson, D.C. (1974). Arbovirus studies in Nupeko Forest: A possible natural focus of yellow fever in Nigeria: Entomological investigations. The Royal Society of Tropical Medicine and Hygiene, 68: 39-43.
5. Service, M.W. (1974). Survey of relative prevalence of potential yellow fever vectors in Northwest Nigeria. Bulletin World Health Organisation 50: 487-494.
6. Fagbani, J., Attah, E.B., Fabiyi, A., O'Connor, E.H. (1975). Yellow fever outbreak in Southwestern State of Nigeria. Virological and Serological Studies. Nigeria Medical Journal 6: 34-41.
7. Savage, H.M., Ezike, V.I., Nwankwo, A.C.N., Spiegel, R., Miller, R.R. (1992). First record of breeding mosquitoes of Aedes albopictus in continental Africa: Implications for arboviral transmission. Journal of American Mosquito Control Association 8(1): 101-103.
8. Gillet, J.D. (1972). Common African mosquitoes and their medical importance. William Heinemann Medical Books Limited, London.
9. Onyido, A.E., Ezike, V.I., Nwankwo, E.A., and Ozumba, N.A. (2006a). Public health implications of giant trees in the proximity of human dwellings: tree-hole breeding mosquitoes of the Government Reservation Area (GRA) of Enugu metropolis in Southeastern Nigeria. In proceedings of 3rd National Conference of the Society for Occupational Safety and Environmental Health (SOSEH), 8-11th November 2006, Main auditorium, Nnamdi Azikiwe University Awka, page 140-143.
10. Onyido, A.E., Ezike, V.I., Nwankwo, E.A., and Ozumba, N.A. (2006b). Water-borne disease vectors of public health importance. Mosquitoes of Onu Anyi Agbaja-Izzi in Abakaliki Local Government Area of Ebonyi State. In proceedings of 3rd National Conference of the Society for Occupational Safety and Environmental Health (SOSEH), 8-11th November 2006, Main auditorium, Nnamdi Azikiwe University Awka, 144-147.
11. Onyido, A.E., Ozumba, N.A., Ezike, O.C., Nwosu, E.O. Nwaorgu, O.C. and Ikpeze, O.O. (2008). Mosquito fauna of a tropical museum and zoological garden complex. Animal Research International 5(2): 852-858.
12. Nwoke, B.E.B. and Nwoke, E.A. (2006). Contributions of occupational hazards and environmental degradation on emergence and re-emergence of diseases. Book of proceedings, 3rd Annual National Conferenceof Occupational Safety and Environmental Health Management in Nigeria, November 8-11th , 2006, Nnamdi Azikiwe University Awka, Anambra State Nigeria. Pp 7-16.
13. Gordon, R.M. and Lavoipierre, M.M.J. (1976). Entomology for Students of Medicine, 4th Printing. Blackwell Scientific Publications, Oxford.
14. Chandler, A.C. and Reads, C.P. (1961). Introduction to Parasitology with special reference to parasites of man, 10th edition, John Wiley and Sons, Inc. New York, London Sydney.
15. Gouck, H.K. (1972). Host preference of various strains of Aedes aegypti and Aedes simpsoni as determined by an olfactory. Bulletin World Health Organisation. 47: 680-683.
16. Onyido, A.E., Okolo, P.O., Obiukwu, M.O. and Amadi, E.S. (2009). A survey of vectors of public health diseases in undisposed refuse dumps in Awka town, Anambra State, Southeastern Nigeria. Research Journal of Parasitology. 4(1), 22-27.
17. Snow, W.F. (1975). The vertical distribution of flying mosquitoes (Diptera: Culicidae) in West African Savanna. Bulletin of Entomological Research 68: 695-706.
18. Service, M.W. (1976). Mosquito ecology: Field Sampling Methods. Applied Science Publishers Ltd., London pp 582.
19. Bang, Y.H., Bown, D.N. and Arata (1980). Ecological Studies of Aedes africanus (Diptera Culicidae) and associated species in Southeastern Nigeria. Journal of Medical Entomology 17: 411-416.
20. Bang, Y.H., Bown, D.N., Onwubiko, A.O. (1981). Prevalence of larvae of potential yellow fever vectors in domestic water containers in Southeastern Nigeria. Bulletin World Health Organization 59: 107-114.

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