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Population dynamics of indoor sampled mosquitoes and their implication in disease transmission in Abeokuta, south-western Nigeria

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Abstract

Background & objectives: A longitudinal study was carried out to investigate the species composition, seasonal abundance, parity and feeding preference of indoor sampled mosquitoes in Abeokuta, south-western Nigeria.

Methods: The mosquitoes were sampled weekly from five stratified locations using Center for Disease Control (CDC) light-traps between August 2005 and July 2006. The mosquitoes were examined for abdominal condition and dissected for age composition. Microscopic and precipitin techniques were also employed for the determination of host blood source.

Results: A total of 2969 mosquitoes which belong to 10 species of mosquitoes were collected during the study period. *Mansonia africana* (35.65%) constituted the most abundant species followed by *Culex quinquefasciatus* (32.23%) and *Anopheles gambiae* complex (13.52%). Other species in decreasing order of abundance were *Coquilletidia maculipennis* (8.2%), *Aedes albopictus* (5.9%), *Ae. aegypti* (1.93%), *M. uniformis* (1.81%), *Cx. duttoni* (0.25%), *Cx. tigripes* (0.25%) and *An. funestus* (0.25%). Seasonal abundance revealed a significant difference ($p < 0.05$) in the population of mosquito vectors collected during the wet season as compared to the dry season and their abundance was positively correlated with rainfall. The results showed that the majority of the vector species collected were unfed and nulliparous. Moreover, the blood meal test was positive for human blood.

Conclusion: The preponderance of mosquitoes observed in the study is of public health concern since they serve as vectors of most tropical diseases including malaria.

Key words Mosquitoes; Nigeria; parity; seasonal abundance

Introduction

Mosquito-borne diseases are major health problems in Nigeria as in other parts of sub-Saharan Africa. Statistics show that malaria accounts for >300,000 deaths from >20 million clinical cases annually while 10–20% of hospital admissions are due to malaria[1]. Apart from malaria, other mosquito-borne diseases have also accounted for huge economic loss, social disgrace, low productivity, absenteeism, sleeplessness, etc. in many parts of the country[2]. Mosquitoes have been observed to have temporal and spatial distribution depending on the species and the prevailing climatic and environmental conditions[3,4]. Several factors have been reported to influence the vectorial role of mosquitoes in disease transmission like abundance, biting behaviour, host preference and longetivity[5]. A full understanding of these factors is a prerequisite in planning effective vector control measures.

Abeokuta is one of the urban areas in Nigeria which has witnessed tremendous growth in terms of human population and resource development in recent

time[6]. The increase in environmental modification as a result of urbanization is usually being accompanied by creation of more breeding sites for mosquitoes which most often lead to the increase in the incidence of mosquito-borne diseases[7]. The previous epidemiological studies showed that Abeokuta is prone to mosquito-borne diseases[8,9] and the environmental condition of the city supported the prolific breeding of mosquito vector species.

The present study therefore provides information on species composition, seasonal abundance and parity of the indoor sampled mosquitoes with the view of understanding the possible implications on the transmission of mosquito-borne diseases and in planning effective control strategies in Abeokuta, Ogun State Nigeria.

Material & Methods

Study area: The study locations comprise Ago-Ika, Ijaye, Kugba, Ibara and Obantoko which are within Abeokuta City, located on approximately latitude 7°10' N and longitude 3°21' E in the transitional zone between the tropical rainforest and derived Savannah zone in the south-west Nigeria. Abeokuta, the state capital of Ogun State is rocky with rapid construction of roads and drainage systems across the city. It experiences two seasons, the dry season (November to March) and the wet season (April to October). Goats, dogs and chickens could be found in few areas but not commonly seen in town. The ratio of human to other vertebrates is 1: 500.

Sampling of adult mosquitoes: Adult mosquitoes were collected in three randomly selected houses in each of the study areas once a week using Center for Disease Control (CDC) light-traps model 512 between August 2005 and July 2006. Only one trap was used in each house on each catching night. The trap was suspended from the roof about 1.5 m above the floor and 0.5 m from a bed occupied by an adult sleeper using untreated bednet. Each trap was operated with 6 volt rechargeable battery every week. The sleeper in each house was instructed to switch on the trap at 2000 hrs and switch it off at 0500 hrs after the neck of the collection bag has been properly tied. The mosquitoes trapped were identified using gross morphological keys as described by Gillet[10]. Only the female mosquitoes were retained, the males were subsequently discarded since they do not transmit diseases.

The gonotrophic stages of the species were examined according to the external appearance of the stomach contents using hand lens as described by WHO[11]. The female mosquitoes were classified as fed, unfed and gravid. The ovaries of the unfed and freshly fed mosquitoes were dissected using entomological dissecting pin. The wings and the legs of each mosquito were removed while the remaining part was dissected by placing it on a slide containing distilled water. The degree of coiling of ovarian tracheoles was then observed to determine if the female is parous or nulliparous. The blood meal source was identified by microscopic examination and precipitin technique using human antiserum as described earlier[11].

Rainfall data from August 2005 to July 2006 were collected from the Department of Water Resources and Agro-meteorology of the University of Agriculture, Abeokuta.

Statistical analysis: Analysis of variance was used to test significant difference in abundance and monthly collection of mosquito species. Correlation was also used to determine the association between rainfall and mosquito abundance.

Results

In all, 2693 mosquitoes were caught between August 2005 and July 2006 in five locations within Abeokuta metropolis. The mosquitoes caught belong to five genera, namely; *Aedes, Culex, Anopheles, Mansonia* and *Coquilletidia*. Out of the 10 species encountered, *M. africana* was the most abundant species (35.65%), followed by *Cx. quinquefasciatus* (32.23%). Other species encountered in decreasing

order of abundance were *An. gambiae s.l.* (13.52%), *Coq. maculipennis* (8.2%), *Ae. albopictus* (5.9%), *Ae. aegypti* (1.93%), *M. uniformis* (1.81%), *Cx. duttoni* (0.25%), *Cx. tigripes* (0.25%) and *An. funestus* (0.25%). The difference in abundance was statistically significant (p <0.05). *Mansonia africana* occurred and dominated other vector species for most part of the year except April, May and June when *Cx. quinquefasciatus* and *An. gambiae s.l.* predominated. Apart from *M. africana, Cx. quinquefasciatus, An. gambiae s.l., Ae. albopictus* and *Coq. maculipennis* also occurred throughout the year. *Anopheles funestus* was caught only in April, June and September while *Cx. duttoni* and *Cx. tigripes* occurred only in October and November respectively (Table 1).

The seasonal abundance of main vector species showed that the abundance of *An. gambiae s.l., Cx. quinquefasciatus, Ae. albopictus, M. africana, Ae. aegypti* and *M. uniformis* increased as the season progressed from January with a drastic decline between June and July and further increased in August and September and finally declined between October to December. However, *M. uniformis* was only encountered between January and July while the population of *Ae. aegypti* declined to nil between December and February (Fig. 1). Positive correlation and significant relationship was observed between the rainfall pattern and the seasonal abundance of the species (p <0.05).

The results of abdominal condition of the flies revealed that majority of the vector species collected were unfed except *An. gambiae s.l.* and *Ae. albopictus*. Most of the *An. gambiae s.l.* trapped were either fed (66.64%) or gravid (22.19%). Majority of *Ae. albopictus* collected were blood fed (66.22%) but only small number were gravid (4.05%) (Table 2). Moreover, the parous rate of the mosquitoes dissected showed that majority was nulliparous. However, *An. gambiae s.l.* recorded the highest number of pa-

Table 1. Species diversity of mosquitoes collected between August 2005 and July 2006 in Abeokuta

Mosquito species	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Total
Mansonia africana	110	157	177	128	75	42	56	76	44	17	10	68	960
Mansonia uniformis	0	0	0	0	0	3	15	15	7	3	4	2	49
Culex quiquefasciatus	74	95	96	70	62	32	24	50	113	107	61	84	868
Culex duttoni	0	0	7	0	0	0	0	0	0	0	0	0	7
Culex tigripes	0	0	0	7	0	0	0	0	0	0	0	0	7
Anopheles gambiae	23	24	25	21	9	5	12	26	47	50	76	46	364
Anopheles funestus	0	4	0	0	0	0	0	0	2	0	1	0	7
Aedes aegypti	2	8	4	6	0	0	0	8	3	12	7	2	52
Aedes albopictus	19	18	31	17	2	2	4	6	14	14	19	12	158
Coquilletidia macullipennis	18	20	30	29	21	11	13	19	22	19	06	13	221
Total	246	326	370	278	169	95	124	200	252	222	184	227	2693
Percentage	9.13	12.11	13.74	10.32	6.28	3.53	4.60	7.43	9.36	8.24	6.83	8.43	

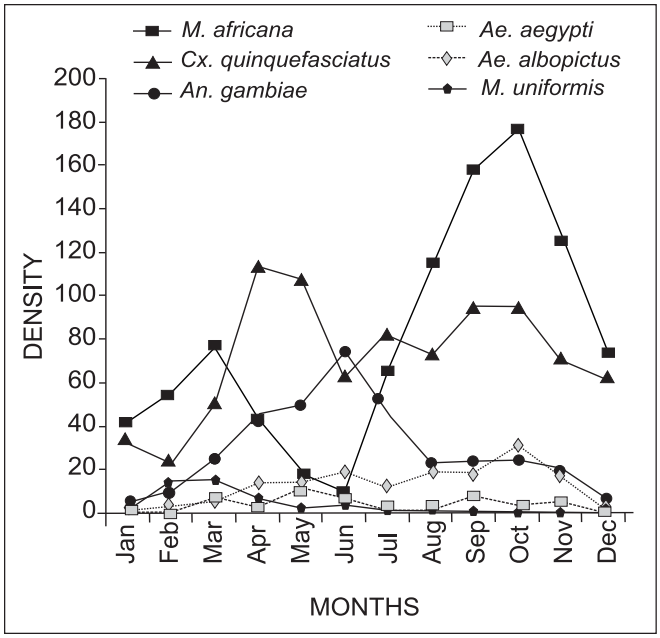

Fig. 1: Seasonal abundance of mosquito vectors collected at the study locations in Abeokuta

rous females, while *M. uniformis* recorded the lowest. Despite the high number of *M. africana* encountered, the large proportion of the mosquitoes was nulliparous (Table 2). The blood meal obtained from the abdomen of all fed mosquitoes was of human host, therefore, the human blood index of each species was 1.

Discussion

Mosquito-borne diseases still remain the major public health problem in Africa and their transmission is becoming frequent on a daily basis due to widespread of the insects. The presence of five genera of mosquitoes, *Aedes, Culex, Anopheles, Mansonia* and *Coquilettidia* in this study is an indication that the climatic and environmental conditions of Abeokuta are condusive to support the survival and development of wide range of mosquitoes. The seasonal abundance of the mosquitoes showed that most of the vectors were collected during the wet season which could be associated to the availability of more breeding sites created by the rainfall. This observation may invariably suggest that the incidence of mosquito-borne diseases will be high during the wet season than the dry season. However, there was reduction in abundance of the mosquitoes between May and June which increased back in July. The marked reduction in numbers during this period may be due to the heavy rainfall. Heavy rainfall is likely to flush breeding sites, strand larvae, cause mechanical damage and egg mortality, therefore, reduces the abundance of adult mosquitoes[3].

The high abundance of the bancroftian vectors encountered in the present study should be a source of concern as this could translate to the risk of bancroftian filariasis by the residents. *Mansonia africana, M. uniformis* and *Cx. quinquefasciatus* have been incriminated as efficient vectors of filariasis in Ogun state[4]. *Anopheles gambiae s.l.,* the major malaria vector in Africa has also been found in recent time as an efficient transmitter of filariasis[2]. Moreover, the proportion of *Ae. aegypti* and *Ae. albopictus* collected by light-trap during this study also have many epidemiological implications. These species would have been caught during the earlier part of the night as *Aedes* are generally regarded as day biters but their high proportion had also been reported in night catches in a suburb of Abeokuta.

Table 2. Gonotrophic stages and parity rate of mosquito species at the study locations in Abeokuta

Species	Unfed (%)	Fed (%)	Gravid (%)	Parity rate (No. dissected)
Mansonia africana	479 (49.8)	379 (39.4)	102 (10.63)	14 (855)
Mansonia uniformis	25 (51.02)	19 (38.78)	5 (10.20)	11 (44)
Culex quiquefasciatus	435 (49.77)	346 (39.48)	93 (10.64)	15 (775)
Anopheles gambiae	59 (16.16)	225 (61.64)	81 (22.19)	33 (284)
Aedes aegypti	28 (50.19)	20 (36.36)	07 (12.72)	21 (47)
Aedes albopictus	44 (29.73)	98 (66.23)	06 (4.05)	2 (142)

Ae. aegypti and *Ae. albopictus* are known vectors of yellow fever in Africa[3,5,6,10]. Though, yellow fever epidemic has not been recorded in recent time, but history had it that the residents of Abeokuta had once witnessed the epidemic of the disease[9]. Apart from transmitting yellow fever virus, *Ae. aegypti* has been incriminated in harbouring filarial worms and could as such transmit the infective stage to the potential host[10,12].

The preponderance of unfed mosquitoes might have been influenced by some host-seeking factors. The reproductive success of mosquitoes depends on host defensive behaviour[13]. Most mosquitoes could have been trapped indoor while searching for host after their emergence from the breeding sites. However, the high number of fed mosquitoes observed in some species contradicts the earlier report on mosquitoes in some rural areas of Ogun State[7]. The differences in human sleeping habits could have been responsible for this. In urban areas, many residents usually keep indoors as early as 1900 hrs, therefore, exposing them to indoor appetitive mosquitoes before going to bed unlike the rural dwellers who usually spend the larger part of the night outdoors. Moreover, it could plausibly be that the fed females were attracted to the light source on their exit of the house during ovipositional flight[14]. This could also be the reason accounting for the appreciable proportion of gravid mosquitoes collected by the trap.

The dissection of the species for parity also showed that the majority of the mosquitoes was nulliparous which indicates a low survival rate and thus, low vectorial capacity in transmitting disease as the only parous flies could transmit disease. On the other hand, the high number of nulliparous mosquitoes could plausibly be an indication of high productivity of the mosquito breeding sites. However, the relatively high parous rate of *An. gambiae s.l.* could have probably accounted for high prevalence rate of malaria in Abeokuta[8] since only aged mosquitoes have chance of transmitting parasites.

Though, all the blood meals of the fed mosquitoes in all the dominant species were of human origin, the earlier reports on some of these species showed different view. Apart from *An. gambiae s.l.* that feeds primarily on human blood, other species have been reported to be catholic in the host-seeking, utilizing both man and animal bloods[12,13]. The ability of these mosquitoes to utilize both man and animal bloods could be related to host availability and acceptability. Though all the blood meal tested was positive for human blood, this may not indicate that the mosquitoes were completely anthropophilic in their feeding but could be a reflection of availability of human host as compared to other alternative hosts. However, the high human blood index observed in the mosquitoes is of vectorial importance.

We, therefore, recommend that the large-scale distribution of insecticide-treated nets should be instituted in Abeokuta and the residents should be encouraged to avoid man-mosquito contact. The Government of Ogun State should also embrace clean environment policy and clearing of blocked drainages as part of the measures to reduce mosquito breeding sites. All these measures will go a long way to reduce the incidence of mosquito-borne diseases in the city.

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