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Mosquitoes at the University of Port Harcourt Teaching Hospital Nigeria: A Threat to Caregivers and Patients

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Abstract
Anopheles gambiae sensu lato is the most important malaria vector in Nigeria. Referral hospitals have a mandate to provide patients with the best health care. The persistent complaints of the nuisance caused to patients, professionals, and visitors by mosquitoes at the University of Port Harcourt Teaching Hospital (UPTH), a referral Hospital, prompted the design of this study to assess the species composition, density, and man-biting rates of endophilic mosquitoes at the UPTH. A longitudinal entomological survey covered dry and wet seasons, February–July 2017, with sampling done thrice weekly, using the aspiration method. Caught mosquitoes were identified by standard keys using a dissecting microscope and classified according to their gonotrophic status. A total of 1,307 mosquitoes in two genera (*Culex*, *Anopheles*) and three species (*Culex quinguefasciatus, Anopheles gambiae s.l.* and *Anopheles mouchetti*) were caught, comprising 150 (11.5%) males and 1,157 females. The most abundant species was *Culex quinguefasciatus* (98.01%), *An. gambiae s.l.* (1.64%), and the least abundant, *An. mouchetti* (0.35%). Gonotrophic examinations of caught females revealed 52.8% blood-fed and 40.1% unfed. *Culex quinquefasciatus* had higher man-biting rates (1.26 bites/patient/night) than *Anopheles* (0.2 bites/patient/night). The Accident and Emergency ward, 595 (45.5%), and the Obstetrics and Gynecology ward, 328 (25.1%), had the highest records of caught mosquitoes among the four wards visited for collections. No significant difference ($F_{cal} = 1.0722$, $F_{tab} = 13$, $p > 0.05$, df = 2) existed between wet and dry seasons' collections. Because of the high numbers of blood-fed *Anopheles*, an urgent need for intervention is required to reduce the case of vector/human contacts; notably, larval source management will be a principal approach toward control.

Keywords: Teaching hospital; *Culex quinquefasciatus*; *Anopheles gambiae s.l.*; Physiological status; Man-biting rate; Intervention.

1. INTRODUCTION

Globally, the largest malaria burden is borne by Nigeria, Africa's most lymphatic filariasis endemic country [1]. Malaria and lymphatic filariasis account for 97 and 70%, respectively, of the infections. Malaria is responsible for 67% of all clinical attendance, 30% of admissions, 25% of preschooler mortality, 30% of childhood mortality, and 11% of maternal mortality, while the endemicity of lymphatic filariasis is estimated at 91% in Nigeria [2, 3]. The Nigerian Federal Ministry of Health's target populations for malaria are children (0-59 months) and women of reproductive age (15-49 years) [2]. The dominant vector species of malaria in Nigeria are *Anopheles gambiae* complex and *Anopheles funestus* group, while the minor vectors include *An. moucheti, An. nili,* and *An. melas* [2]. Globally, persons afflicted with lymphatic filariasis exceed 120 million, and those debilitated and defaced are approximately 33% of the affected population [4]. In the debilitated/disfigured population, 21% of the men have genital disorders and 12% develop lymphoedema. Thirty percent of the afflicted populations live in African regions [4]. Among the five genera of that vector, the causative agents of lymphatic filariasis, the two most important species, are in genera *Culex* and *Anopheles* [5]. The endemicity of mosquito-borne disease depends on the incidence of vector species and the suitability of the environment for their survival and proliferation [6]. To understand the intensity of threats imposed on countries by mosquito vector species, it is crucial that data on public health significance of those vectors are collected [7].

The Nigerian health system is made up of the private and public health sectors, where the public sector care facilities include large referral hospitals, classified as tertiary health facilities, secondary health facilities, and primary health centers [2]. These tertiary health facilities are congested by patients with simple and complicated ailments who report directly to the hospital through emergencies and self-referrals [8]. However, the goal of the National Health Policy is to provide adequate access to primary, secondary, and tertiary care services for all Nigerians through a functional referral system, while the National Health Act was designed to help Nigeria reduce maternal and infant mortality by allowing children free access to standard

pediatric services [2]. The first phase in the proposed reduction should stem from the reduction of mosquito vector contact on patients in large referral hospitals and not exposing them to more risk of contamination. The persistent complaints of high mosquito abundance at the University of Port Harcourt Teaching Hospital (UPTH) prompted the initiation of studies to determine the seasonal variations in species composition, relative abundance, densities, and man-biting rates of endophilic mosquitoes at the UPTH.

2. METHOD(S)

2.1. Study Setting

This study was executed at the UPTH located on the outskirts of Port-Harcourt, 4°49′27″N and 7°2′1″E. It is Nigeria's second principal seaport: the center of the Petroleum and Gas industry and the capital city of Rivers state [9]. The city lies in the freshwater swamp forest eco-vegetational zone with a population of 1,960,000 residents [10].

The UPTH is a leading tertiary health-care training facility in Rivers State, located on the East–West Road [11]. The medical center has a capacity of 750 beds with daily outpatient visits exceeding 1000 [12]. Annual outpatient and inpatient visits to the hospital are approximately 200,000 patients [13]. The swampy and undulating terrain of the environment of the Hospital provides mosquito-breeding sites. The hospital is built on a tunnel harboring organic waste.

Before the commencement of the study, Ethical approval (Reference No: UPH/CEREMAD/REC/04) was obtained from the Research Ethics Committee of the Centre for Research Management and Development, University of Port Harcourt, on September 22, 2016. Mosquito collections were undertaken with the prior written consent of the management of the UPTH. Furthermore, there was informed consent from the caregivers of the wards where collections were made.

2.2. Collection Sites

Adult mosquitoes were collected in four departments of the hospital:

(1) Accident and Emergency Department (male and female wards),
(2) Pediatrics Department: the wards in this department include the Children's Emergency Ward, Children's Medical Ward 1 and Children's Medical Ward 2.
(3) Special Baby Care Unit (SCUBU) with the wards Inborn II and Out born.
(4) Obstetrics and Gynecology Department: antenatal wards and postnatal wards.

There were a total of nine wards in these departments.

2.3. Sampling Technique

A monthly longitudinal entomological study was undertaken over a 6-month period, February–July 2017. The 6 months covered dry (February–March) and wet (April–July) seasons. Collections were made thrice weekly (Tuesday, Thursday, and Friday) at 06.00-10.00 h during the period. Collected mosquitoes were taken to the laboratory for analyses.

Indoor resting mosquitoes were collected with the aid of flashlight by the WHO-approved aspiration method [14]. Mosquitoes were collected from the walls, ceiling, behind and under furniture, on the curtains, and under beds at the various hospital wards [14]. Collected mosquitoes were stored in perforated paper cups covered with nettings that were held in place with rubber bands at the upper side and closed at the underside with cotton wool. One or two paper cups were used for each hospital ward. These were subsequently taken to the laboratory for identification, physiological status grading, and analyses.

Mosquitoes collected from the field were taken to the Entomology Laboratory, Department of Animal and Environmental Biology, University of Port Harcourt, for identification with the keys of Gillies and Coetzee [15] and Service [16]. Identification was done under a Dissecting Microscope by placing the mosquitoes on a slide. Morphological keys of Gillies and Coetzee [15] were used to distinguish the *Anopheles gambiae s.l* from other *Anopheles species*. *Anopheles mouchetti* were identified using the morphological features described by Gillett [17]. *Culex genera* were identified by their yellowish color, lack of ornamentation, and blunt nature of the tip of their abdomen [16]. Additionally, the keys of Gillet were used to categorize *Culex* into species [17]. The identified mosquitoes were subsequently classified as blood-fed, unfed, half gravid, and gravid according to the state of their abdomen. They were preserved in Eppendorf tubes containing silica gel as a desiccant. The storage bottles were labeled appropriately.

2.4. Methods of Data Analyses

Descriptive statistics (tables) were used to represent the monthly mosquito population and the age categories of the populations across the departments at the hospital. The relative abundance of each species was computed by the formula: (RA) = $n/L \times 100$ [18], where n = number of each species specimen and L = total number of specimens. Per man hour density (PMHD) of the adult mosquitoes per hospital ward was calculated as PMHD = TM/$P \times T$, where TM = total number of mosquitoes collected, P = no. of persons involved in the collection and T = time spent in hours [19]. The population density of the mosquitoes and

the man-biting rates of the two species (*Anopheles* and *Culex*) were determined and represented in the tabular form by methods of Noutcha and Anumudu [20], where man-biting rate = (no. of blood-fed + half gravid)/no. of occupants who slept in the room the preceding night. Inferential statistics – Analysis of variance (ANOVA) was used to estimate the differences/associations between the wet season population means of mosquitoes and those of the dry season.

3. RESULTS

The total number of mosquitoes caught from the four departments of the hospital over the 6-month period was 1,307. Among the four departments, the Accident and Emergency ward had the highest number of mosquitoes, 595 (45.5%), followed by the Obstetrics and Gynecology ward, 328(25.1%), while the least was from the SCUBU 62 (4.7%) (Table 1).

The total number of female and male mosquitoes was 1157 (88.5%) and 150 (11.5%), respectively. Female *Culex quinquefasciatus* was dominant 1134 (98%) and *Anopheles* were 23 (2%): *An. gambiae s.l.* (Plate 1) constituted 19 (1.64%) and *An. mouchetti* 4 (0.35%). The highest number of female *Anopheles* (14) was collected at the Pediatrics Department; the Accident and Emergency Department recorded 7. No female *Anopheles* was caught at SCUBU, while only one *Anopheles* was recorded at the Obstetrics and Gynecology ward (Table 1).

Neonates, 0-3 weeks old, were found in two departments: SCUBU and Obstetrics and Gynecology (postnatal wards). Children, 1-59 months old, occupied the Pediatrics Department. The other risk groups of patients, pregnant women, were in the antenatal ward. However, the patients in the prereproductive/reproductive age groups, patients' relatives, and hospital caregivers were widely dispersed. The populations at risk of mosquito bites were 1,259 persons (493 patients, 439 patient's relatives, and 327 caregivers) (Table 1).

The Accident and Emergency Department recorded the highest PMHD (33.1) followed by the Obstetrics and Gynecology Department (18.2). PMHD was 17.9 at Pediatrics and 3.4 at SCUBU.

3.1. Gonotrophic Stages of Identified Mosquitoes

The abdominal condition of the mosquitoes showed that the highest proportion of the females fed on blood 555 (52.8%), unfed females 455 (40.1%), half-gravid females 42 (3.7%), and gravid females 36 (3.2%) (Table 2).

3.2. Spatial and Temporal Occurrences of Mosquitoes

Four wards were visited in the first month (February) and nine wards in each of the 5 months (March–July), forming a total of 49 wards. The mean monthly percentage of wards with *Anopheles* was 29.98% and *Culex quinquefasciatus* recorded 100% (Tables 3a and 3b). The number of wards where *Anopheles* were collected was 11, while *Culex quinquefasciatus* was more widespread, 49. The mean monthly number of patients in wards harboring *Anopheles* was 7.8, while the mean monthly number of patients in wards with *Culex quinquefasciatus* was 9.5 patients (Tables 3a and 3b). The mean monthly *Anopheles* man-biting rate was 0.2 bites/patient/night, while the mean monthly *Culex quinquefasciatus* man-biting rate was 1.26 bites/patient/night (Tables 3a and 3b). The highest number of *Anopheles* species 12(52.2%) was collected in June; May recorded 6 (26.1%). The month that recorded the least number of *Anopheles* species was July 0(0%) (Table 3a). The abundance of *Culex quinquefasciatus* followed a similar pattern, with June 292 (25.7%) recording the highest number and May 282(24.9%). However, the least number of *Culex quinquefasciatus* was collected on February 37(3.3%) (Table 3b). *Culex quinquefasciatus* was collected in all months, while *Anopheles* species was not recorded in July (Tables 3a and 3b).

Wing and head regions of *Anopheles gambiae s.l.* caught during the study

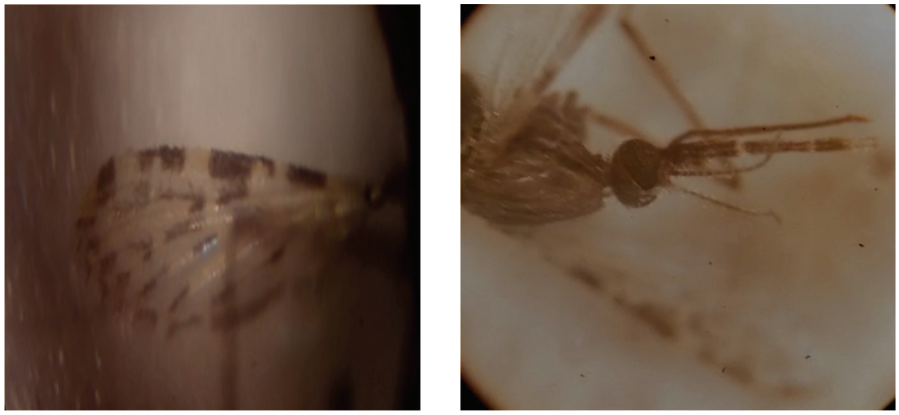

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Table 1: Age categories of mosquito vectors affected population across the study departments at UPTH and density of the mosquitoes caught per man per hour.

Hospital departments	Age categories of the affected population	Important Age categories	Number of patients	Number of patients relatives	Total number of caregivers	Total number of mosquitoes	No of female *Anopheles*	No of female *Culex quinquefasciatus*	Number of hours spent over 6 months	No of mosquitoes caught per man per hour
Accident and emergency	Reproductives, prereproductives, and old (80+)	15-49 years,	102	169	59	595	7	517	18	33.1
Pediatrics	Children (6 months to 14 years old), Adults (18-45)	6 months to 5 years	193	214	136	322	15	281	18	17.9
***SCUBU**	Neonates	0-3 weeks old	113	14	36	62	0	48	18	3.4
Obstetrics and Gynecology	Reproductives and neonates	Pregnant/ nursing mothers and 0-4 weeks old kids	85	42	96	328	1	288	18	18.2
Total/Mean			**493**	**439**	**327**	**1307**	**23**	**1134**	**72**	****18.2**

*SCUBU = Special Baby Care Unit.
** = mean.

Table 2: Numbers in gonotrophic stages of the identified mosquitoes.

Mosquito species	Blood fed	Unfed	Half gravid	Gravid
Culex quinquefasciatus	585	447	42	35
An. gambiae s. l.	10	8	0	1
An. Mouchetti	4	0	0	0
Total	599	455	42	36
% Abundance of total	52.8	40.1	3.7	3.2

Table 3A: Population densities/man-biting rates of *Anopheles (gambiae s.l.* and *mouchetti)* at the UPTH over the two seasons of the study.

Variables	Sampling period						
	*Dry		*Early wet		*Mid wet		
	February	March	April	May	June	July	Total/Mean
No. of wards visited	4	9	9	9	9	9	49
No of patients at risk in the entire wards visited	42	102	92	98	88	71	493
***Anopheles* density**							
No of wards containing *Anopheles*	2	1	1	3	4	0	11
% of wards with *Anopheles*	50	11.1	11.1	33.3	44.4	0	29.98*
No of female *Anopheles*	2	1	2	6	12	0	23
Monthly abundance of female *Anopheles* (%)	8.7	4.3	8.7	26.1	52.2	0	100
No of fed + half gravid *Anopheles*	1	1	2	4	6	0	14
No of patients in wards containing *Anopheles*	5	6	5	26	67	0	109
Monthly *Anopheles* man-biting rate	0.2	0.17	0.4	0.15	0.09	0	0.20*
Mean number of patients in wards harboring *Anopheles*	2.5	6	5	8.7	16.8	0	7.8*
No. of caregivers in wards containing *Anopheles*	2	1	4	9	20	0	36

* = Mean values.

When the data were pooled into three categories: two dry months (February–March), early wet (April–May), and mid-wet (June–July) seasons. The mid-wet season recorded the highest number of mosquitoes (542); the early wet season had (509), and the dry season had 106 (Table 4). Variation in seasonal abundance was not insignificant ($F_{Cal} = 1.0722$, $F_{Tab} = 13$, $p > 0.05$ and df = 2).

4. DISCUSSION

The dominance of *Culex quinquefasciatus* corresponds to the findings of Ebenezer *et al*. [21], Okiwelu and Noutcha [22], and Okorie *et al*. [23] who demonstrated the inversion of *Culex quinquefasciatus* into the rural areas.

The most vulnerable age groups (0-4 weeks, <5 years, pregnant and nursing mothers) were widely dispersed and most likely to succumb to malaria. PMHD of 33.1 at the Accident and Emergency Department was enormously high, while PMDH of 3.4 at SCUBU was also high compared to the result of the studies from a region in India where PMHD of 3.3 was seen as the critical density [19]. High PMHD in all the departments of the UPTH highlights the need to intensify control measures to avert more risks on patients, particularly, on the neonates at SCUBU and the children at the Pediatrics Department.

The high number of blood-fed females indicated that patients and caregivers were easily accessible to these females. Torn nettings on windows and the absence of mosquito-treated nets allowed these vectors into the wards.

Table 3B: Population densities/man-biting rates of *Culex quinquefasiatus* at UPTH.

Variables	Sampling period						
	*Dry		*Early wet		*Mid wet		
	February	March	April	May	June	July	Total/Mean
No. of wards visited	4	9	9	9	9	9	49
No. of patients at risk in the entire wards visited	42	102	92	98	88	71	493
No. of wards containing *Culex quinquefasciatus*	4	9	9	9	9	9	49
% of wards with *Culex quinquefasciatus*	100	100	100	100	100	100	100*
No. of female *Culex quinquefasciatus*	37	66	219	282	292	238	1134
Monthly abundance of female *Culex* (%)	3.3	5.8	19.3	24.9	25.7	21	100
No. of fed + half gravid *Culex quinquefasciatus*	19	30	117	211	151	99	627
No. of patients in wards containing *Culex quinquefasciatus*	42	76	89	93	88	71	459
Monthly *Culex quinquefasiatus* man-biting rate	0.45	0.39	1.31	2.27	1.72	1.39	1.26*
Mean number of patients in wards harboring *Culex*	10.5	8.4	9.9	10.3	9.8	7.9	9.5*
No. of caregivers in wards containing *Culex*	44	39	40	38	41	31	233

* = Mean values.

Table 4: Seasonal variation in the number of mosquitoes.

Seasons	No. of *Anopheles* (*An. gambiae s.l.* and *An. mouchetti*)	No. of *Culex quinquefasiatus*	Total
Dry	3	103	106
Early wet	8	501	509
Mid wet	12	530	542
Total	23	1134	1157

The abundance of mosquitoes during the rainy season was also established by investigations in Bayelsa State and other ecological zones [24-29]. However, okorie *et al*. observed a decline in mosquito abundance during the rainy season [23]. The increase could be associated with the expansion of breeding sites.

5. CONCLUSION

As a result of the high numbers of blood-fed *Anopheles*, there is an urgent need for intervention to reduce the case of vector/human contact by replacing torn nets on windows, provision of screens on doors, and long-lasting insecticide-treated nets, etc. Larval source management will be principal in reducing mosquito vector contact at the hospital. More attention should be paid to *Culex species* because of the increase in numbers and their role as vectors of lymphatic filariasis.

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Special thanks also go to the patients present at the wards during the period of the study, who readily accepted the collection of the mosquitoes.

Presentation

The article has not been presented at any conference/meeting/seminar/symposium. Although the abstract was accepted for presentation at the Entomological Society of America in 2018, the presentation was not made owing to logistic issues.

Author Contributions

The article is produced from the collective work of the authors. Author MAEN conceived and designed the study, supervised the work and assisted in the manuscript preparation. CEO conducted the field and experimental survey, acquired data for the study, wrote the first outline of the manuscript, and effected the recommended corrections. COU took part in the concept, supervised the laboratory studies, and contributed to the statistical analysis and manuscript preparation. SNO defined the intellectual content, supervised, edited, revised, and enhanced the paper to its present state.

Conflict of Interest

None.

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