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Atial Distribution and Indoor-Resting Density of Mosquito Species in the Lowland Rainforest of Bayelsa State, Nigeria

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Abstract: Spatial distribution is one of the key elements in disease epidemiology and implementation of vector control strategy. The study investigated the species composition and indoor resting density of mosquito species in seven communities in Bayelsa State, Nigeria. Adults were collected twice quarterly using Pyrethrum Spray Catch (PSC) technique in 54 houses during September 2008 and August 2010. Mosquitoes were identified morphologically and characterized based on their gonotrophic status as fed, unfed, gravid and half gravid. The Indoor Resting Density (IRD) and Man Biting Rates (MBR) were determined. A total of 4566 female mosquito belonging to 5 species in 3 genera (*Culex, Aedes and Anopheles*) were collected. Species compositions in their increasing order of abundance were: *Culex quinquefasciatus* (45.6%), *An. gambiae* (24.2%), *Ae. aegypti* (18.1%), *An. funestus* (8.6%) and *An. nili* (3.5%). Differences in species distribution across locations were significant (fcal = 21.644, $p<0.05$). Over 80% of the mosquitoes were collected during wet season. Indoor resting density of the mosquito species were: *Cx quinquefascistus* (38.6 mosquito/room), *An. gambiae* (20.5 mosquito/room), *Ae. aegypti* (15.3 mosquito/room), *An. funestus* (7.3 mosquito/room) and *An. nili* (2.9 mosquito/room). About >40% of *Cx quinquefasciatus* and 70% of *An. gambiae* were fed. Their Man-biting rates were 9.8 bites/person/night and 8.7 bites/person/night, respectively. This study has contributed to the understanding of the distribution and indoor resting behavior of mosquitoes in Bayelsa State. The population of Culex and Aedes highlights the foci of filariasis and yellow fever in this location. This is a cause for public health concern.

Key words: Indoor resting, man-biting rates, gonotrophic status, mosquitoes, distribution, Bayelsa State, Nigeria

INTRODUCTION

Mosquitoes are important vectors of several human diseases in tropical and subtropical Africa (Beier and Vanderberg, 1988; Adeleke *et al*., 2010). Over 3000 species of mosquito have been described; 100 are known vectors that transmit diseases in human (Gillet, 1972; WHO, 2003; Black and Kondratieff, 2005; Mullen and Durden, 2009). *Wuchereria bancrofti* is transmitted by *Culex quinquefasciatus* and Mansonia; Yellow fever virus, dengue and viral encephalitis are transmitted by *Aedes* species; *Mansonella perstan* is transmitted by *Culiciodes* (midges) species; *Loa loa* is transmitted by *Chrysops dimidiata* while Malaria parasite is transmitted by female *Anopheles* mosquito species.

Over 500 million people have been infected by mosquito borne diseases annually around the globe (WHO, 1995). The infections resulted in huge economic losses, social disgrace, low productivity and sleeplessness in different parts of Africa (Nwoke *et al*., 1989). Despite considerable national and international implementation of control efforts, mosquito still represent a significant threat to human health; accounting for >20-30% infants and childhood death in Nigeria (FMH, 2000). Poor environmental sanitation, host seeking behavior, host preference, resting density and environmental modification are factors that influenced their role in disease transmission (Breman *et al*., 2004; WHO, 2002; Black and Kondratieff, 2005; Mboera *et al*., 2010).

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Understanding the distribution patterns and indoor-resting behavior of mosquito vectors are important pre-requisite for designing appropriate long lasting control interventions (Sindato *et al*., 2011). Studies have been carried out on the species composition and spatial distribution of mosquito vectors in different ecological zones in Nigeria (Amusan *et al*., 2005; Afolabi *et al*., 2006; Adeleke *et al*., 2010). There is paucity of data in Bayelsa State. The objective of the study is to provide a base-line data on the distribution and indoor-resting density of mosquito species across the 3 eco-vegetational zones in Bayelsa State, Nigeria.

MATERIALS AND METHODS

Study area: Bayelsa State (5° 22'-6°45'E and 4°15'-5°23'N) is located within the lower delta plain of the Niger Delta Area. Vegetation is dynamic in composition and comprises of three eco-vegetational zones (fresh water, brackish water and mangrove water forest). The rain fall is between 2000-400 mm annually. The topography of the study area is characterized by a maze of effluent creeks and swamps crossing the low lying plain of the Niger Delta in varying directions.

The study towns/villages in three eco-vegetatonal zones were: Fresh water forest; Yenagoa (4°53'N and 5°17'E), Sagbama (5°09'N and 6°14'E), Kaiama (5°07'N and 6°19'E); Brackish water forest; Ogbia (4°36'N and 5°45'E), Oporoma (6°15'N and 6°14'E) and Ekeremor (5°02'N and 5°48'E); Mangrove water forest; Nembe (4°27'N and 6°26'E). Houses are of traditional architecture with mud walls and thatched roofs (Amadi and Ebenezer, 2009) while few are built blocks and corrugated iron sheets. The major occupations of the people are fishing and petty trade.

Mosquito sampling: Consent was obtained from village and household heads before the commencement of mosquito collection. Adult mosquitoes were collected twice from 54 houses in two overlapping seasons; wet (April to November) and dry (December to March). The same houses were consistently used throughout the sampling years. The Pyrethrum Spray Catch (PSC) Method for mosquito collection was adopted (Afolabi *et al*., 2006). In each house, at least one person must have slept in the selected room, a night prior to the sampling morning. The method of preparations of a PSC room has been described by Ebenezer. The knocked down mosquitoes were picked with a pair of forceps into labeled petri-dishes.

Collected mosquitoes were identified morphologically with standard keys (Gillet, 1972). The equal length of the palps and proboscis, speckled legs and banded veins of the costa and sub-cost were used to confirm members of the genus *Anopheles*. A pattern of wings and number of bands on the palps were used to separate *Anopheles gambiae* from *Anopheles funestus* and *An. nili*. The short palps in relation to the proboscis in females were used to identify the genus *Culex*. Identified mosquitoes were also separate according to their gonotrophic stage: fed, unfed, gravid and half gravid based on the abdominal conditions.

Data analysis: The Indoor-Resting Density (IDR) and Man-Biting Rates (MBR) of the mosquito species were calculated as per WHO (2003). The mosquito abundance was expressed as percent of the total mosquito collected. The relationship between mosquito abundance and locations and seasons were determined by χ^2-test and ANOVA in SPSS Software Version 17.1 (SPSS, 2006).

RESULTS

Mosquitoes were collected from the 54 houses with a mean occupant of 1.8 per room. A total of 4566 female mosquitoes representing five species in 3 genera (*Anopheline*, *Culicine* and *Aedes*) were recorded across the study locations. The species in the order of increasing abundance were: *Culex quinquefasciatus* (45.6%), *Anopheles gambiae* (24.2%), *Aedes aegypti* (18.1%), *An. funestus* (8.6%) and *An. nili* (3.5%). Differences in species distribution across study locations were significant (F_{cal} = 21.644, df = 24, p = 0.00, p>0.05) (Table 1). When the mosquito species were pooled in season, >80% were recorded during wet season. Differences in seasonal abundance were significant (χ^2 = 590.04, df = 4, χ^2_{tab} = 9.4) p<0.005 (Table 1).

The indoor-resting density of the mosquito species across the study locations ranged (2.9-38 mosquito/ room/night/). *Cx quinquefasciatus* had the highest IRD followed by *An. gambiae*. *Anopheles nili* had the least IRD. Differences in the indoor-resting density of the mosquito species were significant (F_{cal} = 22.130, df = 24, p = 0.00, p<0.05) (Table 2). When mosquitoes in their gonotrophic stage were pooled, 41.3% were fed and 45.9% were unfed; 10.5% were gravid and 2.2% were half gravid. About >40% of *Culex quinquefasciatus* and 70% of *Anopheles gambiae* were fed while >50% of *An. funestus*, *An. nili* and *Ae. aegypti* were unfed. Relatively few mosquitoes were gravid and half gravid. Variation in the gonotrophic stages of the mosquito were significant (F_{cal} = 18.174, df = 3, p = 0.00, p<0.05) (Table 3). Man-biting rates ranged (0.02-9.8 bites per person per

Table 1: Spatial and seasonal distribution of mosquito species across study location; August 2008 to September 2010

	Mosquito species					
Location/Season	*An. gambiae*	*An. funestus*	*An. nili*	*Cx. quinquefasciatus*	*Ae. aegypti*	All species
Locations						
Yenagoa	56 (6.2)	-	-	199 (9.6)	85 (10.3)	352 (7.8)
Sagbama	201 (18.2)	-	-	329 (15.3)	125 (15.2)	655 (14.3)
Kaiama	36 (3.3)	174 (44.2)	158 (100)	369 (17.7)	190 (23.0)	927 (20.3)
Ogbia	184 (16.7)	90 (22.8)	-	337 (16.2)	92 (11.2)	703 (15.4)
Southern Ijaw	102 (9.2)	-	-	292 (14.0)	107 (13.0)	501 (11.0)
Ekeremor	167 (14.2)	-	-	290 (13.9)	76 (9.2)	533 (11.7)
Nembe	317 (31.4)	130 (33.0)	-	268 (12.8)	150 (18.2)	895 (19.6)
Total	1105 (24.2)	394 (8.6)	158 (3.5)	2084 (45.6)	825 (18.1)	4566
Season						
Dry	190 (37.3)	49 (9.6)	11 (2.2)	160 (31.4)	99 (19.4)	509 (11.1)
Wet	915 (22.6)	345 (8.5)	147 (1.2)	1924 (47.4)	726 (17.9)	4057 (88.9)
Total	1105	394	158	2084	825	4566

The number in parenthesis is the percentage of mosquito species caught; the number not in parenthesis is the total mosquito species caught

Table 2: Number of sampling houses and mosquito density per room per night in the study locations

	Location and indoor resting density							
Site/Mosquito density	Yenagoa	Sagbama	Kaiama	Ogbia	Southern Ijaw	Ekeremor	Nembe	Total
Site data								
Number of houses visited	8.0	7.0	8.0	8.0	7.0	7.0	9.0	54.0
Number of occupants	14.0	11.0	17.0	12.0	12.0	14.0	19.0	99.0
Mean person per room	1.8	1.6	2.1	1.5	1.7	2.0	2.1	1.8
Species density/Room								
An. gambiae	3.5	28.7	4.5	23.0	14.6	23.9	38.6	20.5
An. funestus	-	-	21.8	11.3	-	-	14.4	7.3
An. nili	-	-	19.8	-	-	-	-	2.9
cx. quinquefasciatus	24.9	47.0	46.1	42.1	41.9	41.4	29.8	38.6
Ae. aegypti	10.6	17.9	23.6	11.5	15.3	10.9	16.7	15.3

Table 3: Gonotrophic status and Man-Biting Rates (MBR) of mosquito species

	Mosquito species					
Abdominal condition	*An. gambiae*	*An. funestus*	*An. nili*	*Cx. quinquefasciatus*	*Ae. aegypti*	All species
Fed	860 (78.3)	36 (9.1)	10 (6.3)	975 (46.8)	2 (0.2)	1888 (41.3)
Unfed	63 (5.7)	222 (56.3)	99 (62.7)	1010 (48.5)	704 (85.3)	2098 (45.9)
Gravid	145 (13.1)	127 (32.2)	45 (28.5)	51 (2.4)	110 (13.3)	478 (10.5)
Half gravid	32 (2.9)	9 (2.3)	4 (2.5)	48 (2.3)	9 (1.1)	102 (2.2)
MBR/person/night	8.70	0.40	0.10	9.80	0.02	19.10
Mean MBR/person/room	4.83	0.22	0.06	5.44	0.01	10.61

The number in parenthesis is the percentage of mosquito species in each gonotrophic stage; the number not in parenthesis is the total mosquito species in each gonotrophic stage

night); *Cx. quinquefasciatus* and *An. gambiae* were 9.8 bites/person/night and 8.7 bites/person/night, respectively.

DISCUSSION

The presence of the 5 species (*An. gambiae*, *An. funestus*, *An. nili*, *Cx. quinquefasciatus* and *Ae. aegypti)* is an indication that the 3 eco-vegetational zones support the breeding and development of these vectors. Similar spatial distribution patterns of these species had been reported elsewhere (Amusan *et al*., 2005; Mboera *et al*., 2006; Wanji *et al*., 2009; Adeleke *et al*., 2010; Kigadye *et al*., 2010). The spatial patterns of these vectors are affected by seasons (Kigadye *et al*., 2010; Okiwelu and Noutcha, 2012). The high proportion of the mosquito during wet season could be associated with the increased breeding sites created by rainfall. This may possibly account for more vector-borne diseases during the rainy season. Decrease in mosquito abundance during dry season could be attributed to flush larval in the breeding site because of prolonged rain. Amusan *et al*. (2005) noted that heavy rainfall flooded the breeding sites, leaving larva stranded.

Variations in the mosquito abundance across locations are comparable to similar studies in different ecological zones in Nigeria (Afolabi *et al*., 2006). The high number of *Cx. quinquefasciatus* encountered in all the locations is an indication that there is increasing distribution of the species from urban areas to colonized rural pocket (Mullen and Durden, 2009; Okiwelu and Noutcha, 2012). The proportion of *Ae. aegypti* caught indoor is surprising as the species is known to bite outdoor before night fall (Gillet, 1972). *Anopheles funestus* was restricted to Ogbia, Kaiama and Nembe. This limited distribution was probably related to its preference for breeding in shaded clean fresh water (Bockarie *et al*., 1994; Ilboudo-Sanoga *et al*., 2001). The thick vegetation with canopy in these locations was probably favourable to their breeding. *An. nili* was recorded exclusively at Kaiama. Reasons for this limited distribution are not available at this time. The high proportion of *An. gambiae* in Nembe is noteworthy. The intertidal wave at the coastal mangrove forest may have provided water pockets that are suitable for their breeding. Their limited number in Yenagoa may be due to the level of urbanization-related pollution. The species is known to breed in pollution-free water body.

The indoor-resting density of the mosquitoes varied significantly with locations (Oyewole *et al*., 2005). The low proportion of Anopheline than Culicine mosquito in this present study could be attributed to the trapping techniques used (Mboera *et al*., 2006; Sindato *et al*., 2011). Although, Pyrethrum Spray Catch technique gave estimate of the mean density of all kinds of mosquitoes yet it tends to miss out indoor resting mosquito that left the house immediately after feeding. Studies by Mnzava (1984) showed that *An. arabieensis*, a member of *An. gambiae* complex are endophilic and exophilic. Most of these species could probably rest outdoors after a blood meal, hence only few of them are likely to be caught by indoor Pyrethrum spray. The high density of *Cx. quinquefasciatus* highlighted the high proportion of emerged adult as a result of extensive distribution of breeding sites at the locations (Adeleke *et al*., 2008; Okiwelu and Noutcha, 2012). Housing architecture and settlement pattern may have also positively influenced the house entering and resting behavior of the mosquito. Many houses around the study locations were clustered near streams and rivers where the mosquito breeding occurred.

More mosquitoes were fed. This observation which agreed with Amusan *et al*. (2005) high lightened the facts that some of the mosquito (especially, *An. nili* and *Ae. aegypti*) were not host seeking. They were caught searching for resting place. The proportion of fed *An. gambiae* and *Cx. quinquefasciatus* were many folds higher than other species. This was not surprising because *An. gambiae* and *Cx. quinquefasciatus* are anthropophilic (Adeleke *et al*., 2010). Man-biting rates of *An. gambiae* and *Cx. quinquefasciatus* were comparable with the reports of Mboera *et al*. (2010). This observation could be connected with the combined effects of ecological factor and the density of the mosquitoes around the living homes, consequently resulting in high transmission index.

CONCLUSION

The studies have contributed to the understanding of the distribution, composition and indoor resting behavior of mosquito vectors. The proportion of the 5 mosquito species in close association with living homes highlights their epidemiological importance. The density of *Culex quinquefasciatus* and *Aedes aegypti* is a bio-indication of filariasis and yellow fever foci in this locality. This is a cause for public health concern.

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