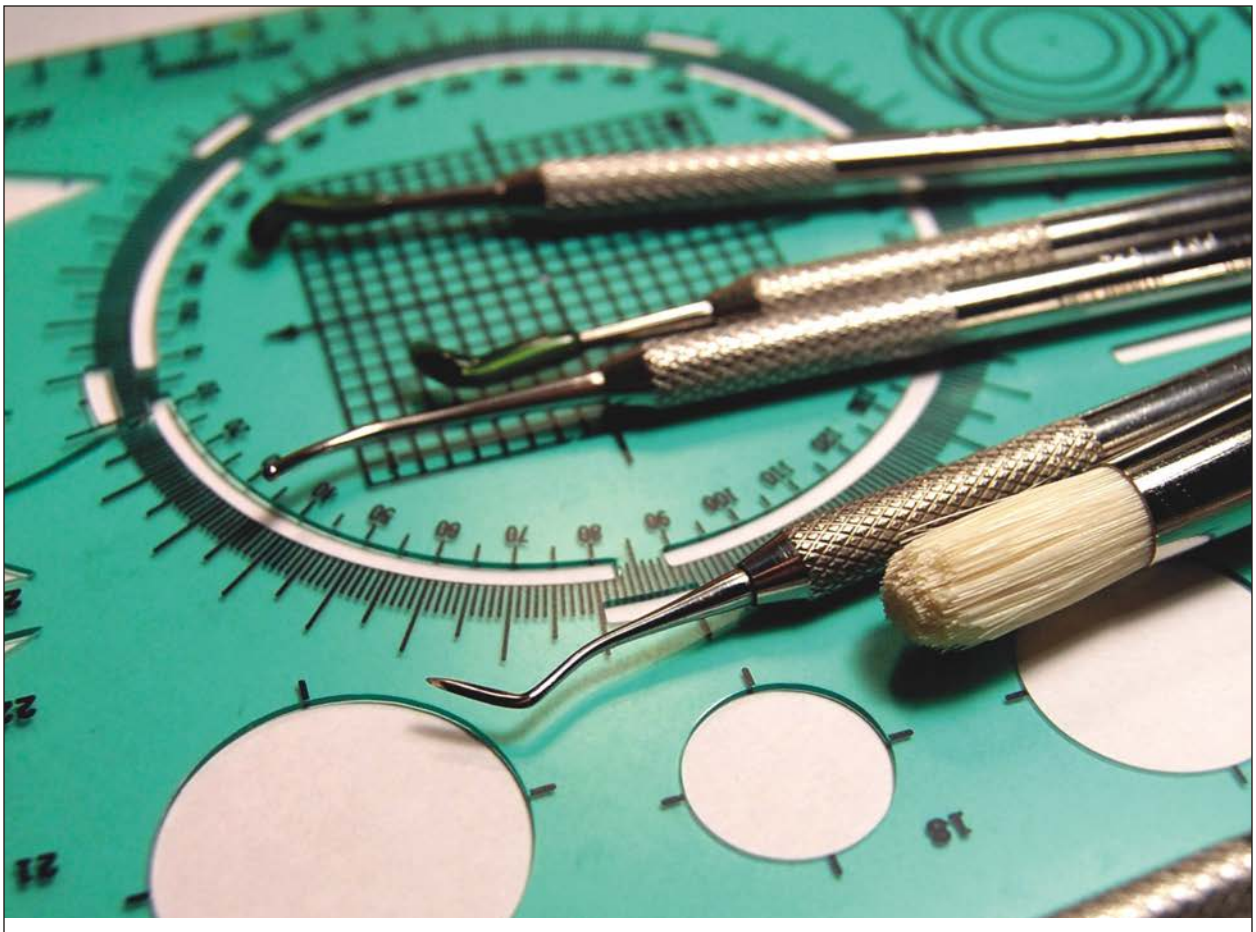

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Seasonal Variations of Nocturnal, Endophagous and Anthropophagous *Anopheles* Species of Rural Communities in Abia State, Nigeria

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ABSTRACT

Transmission of human malaria requires contacts between vectors of malaria, *Anopheles* spp. and human hosts. In the present study, the abundance of nocturnal and endophagous anthropophagous anophelines species in Umuchieze and Uturu, rural communities in Abia State, Southeast, Nigeria, was investigated using "all-night human-bait indoor insecticide spray sheet catches" method for two consecutive years. Catch was made once a week in each community. A total of 500 adult mosquitoes (all female anophelines) was captured, 170 (34.00%) in Umuchieze Community and 330 (66.00%) in Uturu. Three *Anopheles* species: *Anopheles gambiae*, *Anopheles funestus* and *Anopheles moucheti* were found in the studied communities except in Umuchieze Community where *Anopheles moucheti* was never caught. *Anopheles gambiae* was dominant in both study communities with the species relative abundance of 55.29 and 51.82% recorded in Umuchieze and Uturu Communities, respectively. The relative abundances of various prevalent *Anopheles* species were higher during rainy season than the dry season. This periodic occurrence of the important malaria vectors explains periodicity of malaria epidemiology in the study communities. The high abundance rates of nocturnal and endophagous anthropophagous anophelines recorded in the two communities predispose inhabitants of the areas to incessant contact with the human malaria vectors resulting in the study areas being malaria endemic.

Key words: *Anopheles* species, human bait, prevalence, Umuchieze, Uturu

INTRODUCTION

The roles of insects in the incidence and transmission of human diseases have been recognized from antiquity (Sharma, 1999). The tropical areas of the world are more than blessed with an abundance of insect vectors (Service, 1997; Horsfall, 1962). Of all the insect vectors mosquitoes are the most important single disease vectors in the tropics (Abdoon and Alshahrani, 2003) and are of immense public health importance. Man-biting mosquitoes transmit from infected to uninfected humans the disease-causing agents (parasites) of several serious diseases, including malaria, filariasis, yellow fever, dengue and encephalitis.

Anopheles is the best known genus of mosquitoes and has noxious species that are vector-hosts of malaria (Abdoon and Alshahrani, 2003), filariasis (Anosike *et al*., 2003) and a host of other

locally named human diseases (Gillet, 1972) in the tropical and temperate parts of the world. Malaria takes the pride of place as the outstanding human disease in which some 300-500 million people the world over are at risk (Wanji *et al*., 2003). *Anopheles* mosquitoes are of species complexes with each sympatric population varying in capacity to transmit malaria parasites (Cohuet *et al*., 2004). Fontenille and Lochouarn (1999) have discussed the complexity of malaria vectorial systems in Africa, with different species involved in transmission in different bio-geographical zones.

The principal vectors of malaria in Nigeria are *Anopheles gambiae* and *Anopheles funestus* which are widespread. *Anopheles arabiensis* is restricted to the western part of the country and *Anopheles squamosus* to the northern part and the coastal zones of the southern part. *Anopheles moucheti* and *Anopheles ziemani* play a secondary role in the transmission of malaria in southeastern and northern parts and their relative importance may vary from one bio-ecological zone to another (Kalu *et al*., 2007; Gadzama, 1983).

Female adults of all mosquitoes require at least a blood meal for the maturation of each batch of eggs. Whereas some species are zoophagous, others are anthropophagous. Different *Anopheles* species exhibit marked preference for feeding in particular habitats. Most female *Anopheles* is nocturnal and indoor feeders, feeding and resting inside human habitations. These nocturnal and endophagous anthropophagous *Anopheles* species are often important vectors of human malaria parasites, *Plasmodium* species (Fontenille and Lochouarn, 1999; Le Menach *et al*., 2005).

Umuchieze and Uturu which are rural areas in Abia State of Nigeria, can be considered as communities of hyperendemic malaria. Malaria parasitaemia studies recently revealed prevalence rates of 72.58% (225 out of 310) and 74.19% (230 out of 310) in inhabitants of the areas, respectively (Kalu *et al*., 2012). Despite these high incidences of malaria in the communities, no research has been carried out on malaria transmission and on the roles played by different vectors at different seasons of the year. Nigeria is characterized by several bio-geographical zones and the national programme for malaria control under the Roll-Back Malaria Initiative requires information on the malaria transmission from all the bio-geographical zones of the country. This study reports on work carried out in two rural communities of Abia State, South-Eastern Nigeria on the abundance of nocturnal and endophagous anthropophagous *Anopheles* species during two seasons of the year.

MATERIALS AND METHODS

Study areas: The present study was carried out in Umuchieze and Uturu, rural communities in Abia State, South-Eastern Nigeria. The areas are located in the same bio-geographical region as well as belong to the same climatological regime. The vegetation in Umuchieze and Uturu is ordinarily considered part of tropical rain forest which is the dominant natural vegetation in most parts of south eastern Nigeria. The economic trees of the rainforest community are extremely numerous but the oil palm appears to be the most important. Thus, most of the areas are generally covered by oil palm.

The communities have tropical climate. The mean daily maximum air temperature ranges from 28-35°C and mean minimum temperature ranges from 19-24°C. The areas have a long rainy season that starts in late March and ends in late October with maximum rainfall in August and September. The dry season commences in early November and terminates in March. Mean relative humidity ranges from 80 to 85% and above during the rainy season but drops to 60% or lower during the dry season (Igbozurike, 1986).

Umuchieze (5°42'23" N, 7°10'35"E) is a rocky area located in Umunneochi Local Government Area of Abia State. Extensive stone mining activities by quarry mining companies created and

abandoned some quarry pits in the community. The pits later became filled with water as rains progressed. Though the water-filled abandoned quarry pits serve the community various purposes, they may be potential breeding habitats for vectors of malaria parasites.

Uturu (5°51'22"N, 7°30'54"E) is a community in Isuikwuato Local Government Area of Abia State. The Abia State University main campus is cited in the community. Two streams, namely, Ihiku and Atuma, provide all year round drinking water to the inhabitants of the area. These stream over flow their banks during the rainy season. They are likely to provide all year round breeding places for vectors of malaria parasites in the community.

Mosquito collection: The study was carried out in 2 successive years, from January 2005 to December 2006. Four houses (2 per study community) were randomly selected as sampling sites. Adult mosquitoes were caught in all-night human-bait indoor insecticide spray sheet, as described by Service (1993).

Mosquitoes were collected in an empty bedroom selected from each sampling site. The researcher opened the bedroom door and window from 6:00 p.m. (18:00 h) Nigerian time to the time of collection of mosquitoes, covered the floor with a white sheet and allowed himself/herself to be bitten by mosquitoes in the bedroom from 9:00 p.m. (21:00 h) Nigerian time to the collection time. Catches were carried out between 10:00 p.m. (22:00 h) and 2:00 a.m. (02:00 h) Nigeria time using an insecticide spray contained in an aerosol can (RAID brand). Catch in each site was made once in a week throughout the 24 months of the study. Paper cups internally padded with soft tissue paper were used to store the collected mosquitoes before identification.

Identification of mosquitoes: The morphological identification of different species of *Anopheles* approach described by Gillet (1972) was used to identify collected mosquitoes.

Data analysis: Chi-square statistic was used to compare Anophelines abundance while student t-test was used to test research hypothesis that sought the significance differences of species. The significance was fixed at <0.05.

RESULTS

***Anopheles* mosquitoes: nocturnal and endophagous anthropophagous species, distribution and abundance:** In total, 500 *Anopheles,* all females, were collected: 170 (34.00%) in Umuchieze and 330 (66.00%) in Uturu (Table 1), between early January, 2005 and late December, 2006. Three nocturnal and endophagous anthropophagous Anopheles species were identified: *A. gambiae*, *A. funestus* and *A. moucheti*. *Anopheles moucheti* was rare and found only

Table 1: Nocturnal and endophagous anthropophagous *Anopheles* species composition for year 2005 and 2006

	Umuchieze		Uturu			
Anopheles species	NC	RA	NC	RA	Species totals	Species relative abundance (%)
A. gambiae	94	55.29	171	51.82	2.65	53.00
A. funestus	76	44.71	56	26.06	162	32.40
A. moucheti	0	0.00	73	22.12	73	14.60
Grand total	170	34.00	330	66.00	500	-

NC: Number caught, RA: Relative abundance per Community

Table 2: Monthly abundance of nocturnal and endophagous anthropophagous anophelines found in Umuchieze for Year 2005 and 2006

	A. gambiae		*A. funestus*			
Months	NC	PA	NC	PA	Anophelines abundance	Anopheliness percentage abundance
January	0	0.00	0	0.00	0	0.00
February	0	0.00	0	0.00	0	0.00
March	0	0.00	0	0.00	0	0.00
April	5	62.50	3	37.50	8	4.71
May	8	72.73	3	27.27	11	6.47
June	10	52.63	9	47.37	19	11.18
July	9	52.94	8	47.06	17	10.00
August	18	52.94	16	47.06	34	20.00
September	28	60.87	18	39.13	46	27.06
October	13	52.00	12	48.00	25	14.71
November	3	30.00	7	70.00	10	5.88
December	0	0.00	0	0.00	0	0.00
Grand totals	94	55.29	76	44.71	170	

NC: Species number caught, PA: Percentage abundance

Table 3: Monthly abundance of nocturnal and endophagous anthropophagous anophelines found in Uturu for year 2005 and 2006

	Anopheles species							
	A. gambiae		*A. funestus*		*A. moucheti*			
Months	NC	SPA	NC	SPA	NC	SPA	Anophelines abundance	Anophelines percentage abundance
January	0	0.00	0	0.00	0	0.00	0	0.00
February	0	0.00	0	0.00	0	0.00	0	0.00
March	0	0.00	0	0.00	0	0.00	0	0.00
April	16	69.57	3	13.04	4	17.39	23	6.97
May	15	53.57	2	7.14	11	39.29	28	8.48
June	17	48.57	8	22.86	10	28.57	35	10.61
July	20	52.63	8	21.05	10	26.32	38	11.52
August	28	56.00	12	24.00	10	20.00	50	15.15
September	44	61.11	17	23.61	11	15.28	72	21.82
October	20	41.67	19	39.48	9	19.75	48	14.55
November	10	32.26	13	41.94	8	25.89	31	9.39
December	1	20.00	4	80.00	0	0.00	5	1.52
Grand totals	171	51.82	86	26.06	73	22.12	330	

NC: Number captured, SPA: Species percentage abundance

in Uturu (Table 3). *A. gambiae* was the dominant species with overall relative abundance of 53.00% (n = 265). The species common to both study communities were significantly more abundant in Uturu (χ^2, p>0.05).

There were monthly and seasonal variations in species abundance in both study areas. Monthly data on prevalence and abundance of *Anopheles* species in each study area are presented in Table 2 and 3. *Anopheles* population was established in April in both communities and their abundance increased progressively from month to month thereafter until a population peak was reached in the month of September during the present study period. Population drops were recorded in October and November. In Umuchieze, the vectors were not found from January to

Table 4: Seasonal abundance of anopheles species found in Umuchieze and Uturu communities for year 2005 and 2006

	Number captured								
Anopheles species	April	May	June	July	August	September	October	Species total	Species RA
Rainy season									
A. gambiae	21	23	27	29	46	72	33	251	50.20
A. funestus	6	5	17	16	28	35	31	138	37.60
A. moucheti	4	11	10	10	10	11	9	65	13.00
Seasonal *Anopheles* total							454	90.80%	
	Number captured								
Anopheles species	January	February	March	November	December			Species total	Species RA
Dry season									
A. gambiae	0	0	0	13	1			14.0	2.8
A. funestus	0	0	0	20	4			24.0	4.8
A. moucheti	0	0	0	8	0			8.0	1.6
Seasonal *Anopheles* total					46			9.2	

RA: Relative abundance

March as well as in November, while they were absent in Uturu only from January to March. However, *Anopheles* were scarce in the months of November and December in Uturu community during which period the relative abundance of the vectors was 7.20% (36 of 500). The monthly abundance of *A. gambiae,* the predominating species, was significantly higher (χ^2, $p<0.05$) in Uturu than Umuchieze.

Anopheles were abundantly captured during the rainy season. Out of the 500 *Anopheles* collected during the study period 454 (90.80%) and 46 (9.20%) were caught during the rainy and dry seasons, respectively (Table 4). All the three species were found from April which was the onset of rainy season, to late October, the end of rainy season. The various species were found in small numbers at the onset of rains. Abundance of the anophelines increased progressively as the rains intensified. Species population densities reached a climax in September in both study communities followed by a drop in their abundance in October. In all, 251 (50.20%) *A. gambiae,* 138 (37.60%) *A. funestus* and 65 (13.00%) *A. moucheti* were collected during the rainy season (Table 4). Anophelines were scarce during dry season in the study areas. They were found in low population only in November and December, being completely absent from January to March of the study period (Table 4). A total of 14 (2.80%) *A. gambiae,* 24 (4.80%) *A. funestus* and 8 (1.60%) *A. moucheti* were captured during the dry season.

DISCUSSION

The main endophagous and nocturnal anthropophagous *Anopheles* species in some rural areas of Abia State, Nigeria are *A. gambiae*, *A. funestus* and *A. moucheti*. These results confirm the confinement of *A. gambiae* complex to the forested areas of Africa (Coetzee *et al*., 2000). *A. gambiae* and *A. funestus* may be the major vectors of malaria in these study areas as they are well known as efficient vectors of malaria in other areas of Africa and Madagascar (Shililu *et al*., 2003; Jambou *et al*., 2001). The presence of *A. moucheti* in Uturu community and its probable implication in malaria transmission is noteworthy; *A. moucheti* has only rarely been found in Nigeria and its relative abundance of 22.12% (73 of 330) in this study area is relatively high. Data on the malaria transmission potential of *A. moucheti* in the region are lacking. However, being endophilic and

anthropophilic species it should be considered an important malaria vector there. The present finding may be the baseline information about the prevalence of the species in the eastern part of Nigeria. Moreover, Ihiku and Akiyi streams which are located in the proximity of the study sites in Uturu, possess features favourable for breeding of *A. moucheti* and thus, might be the breeding places for the species.

Both larval and adult stages of *Anopheles* mosquitoes are influenced by their immediate environments, the influence of which leads to variations in the prevalence and abundance of the vector species (Aigbodion and Anyiwe, 2005). Results of the present study conform to this fact. The occurrence and abundance of *Anopheles* encountered during the period of this study varied from community to community, monthly and seasonally. All the three *Anopheles* species were found in Uturu, while only two of them: *A. gambiae* and *A. funestus*, occurred in Umuchieze community. The relative abundance of these two species was higher in Uturu than Umuchieze. The greater species richness and abundance recorded in Uturu than Umuchieze might be attributed to the fact that environmental conditions favourable for breeding and survival of adult anophelines were more abundant in one study area than the other.

The *Anopheles* species encountered during this study were abundantly found during the rainy season (April-October), scarce during early dry season (November and December) and completely absent in the other months of the dry season (January-March). Pronounced variations in monthly abundance of *Anopheles* species were observed in both study areas. *Anopheles* mosquitoes were established in early April in both communities and the abundance of the species increased as rainfall intensified. A population peak of *A. gambiae* and *A. funestus* was observed in September in Umuchieze, while the species were most abundant in September and October, respectively, in Uturu. *A. moucheti*, found only in Uturu had population peaks in May and September but was absent from December through January to March. The presence of *A. gambiae* and *A. funestus* in dry months of November and December in Uturu indicates that the species breed in natural and permanent water bodies. Ihiku and Akiyi streams, each situated at a distance less than 0.50 km away from the sampling sites, might be the breeding places for the species.

The seasonal variations in the vectors abundance in both study locations may probably be due to the fact that some *Anopheles* species display variations in their biting behaviour according to time of the year, being more endophagous during the rainy season and exophagous during the dry season (Wanji *et al*., 2003). Climate operates directly in determining the seasonal availability of breeding places for mosquitoes (Service, 1997). The low species abundance in November (in Umuchieze) and December (in Uturu) might be due to setting in of climatic factors detrimental to survival of *Anopheles*, while the complete absence of Anophelines from December (in Umuchieze) and January (in Uturu) to March might be due to lack of rainfall as well as the disappearance of their breeding places through evaporation. On the other hand, the malaria vectors might have hibernated during the dry months because climate operates directly in determining the requirement for their hibernation and aestivation (Service, 1997).

The findings of the present study have certain interesting implications for transmission of human malaria and control of the vectors of malaria parasites in the study areas and Abia State in general: All the Anopheles species recorded are efficient vectors of human malaria in Africa (Fontenille and Lochouarn, 1999); *A. gambiae* which is the most noxious and most efficient malaria vector in Africa (Gillet, 1972) was the most abundant species in both Umuchieze and Uturu communities; high population densities of the prevalent *Anopheles* species in these areas predispose the inhabitants to incessant contact with the vectors; and the vectors were more abundantly found during rainy season in the study areas.

This study shows that Umuchieze and Uturu are rural areas inhabited by the major and efficient vectors of malaria in Africa and are expected to be areas of high malaria transmission intensity. The abundance of *Anopheles* species, their highly anthropophagous behaviour and their biting humans when they are asleep in the night indicate the necessity of introducing vector control measures in the area and other malaria endemic areas of Abia State as one of the strategies of fighting malaria. Each vector control needs to focus on providing an effective personal protection for the most susceptible age groups at least, against vector contact rather than aiming at reducing the potential for transmission at the community level. The most appropriate vector control option in the study areas could be the use of insecticide treated bed net (ITN) as these tools are currently the most effective and practical vector control option in areas where malaria is highly transmitted (Guillet, 2001; Diallo *et al.*, 1999).

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