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ARTICLE

Composition and Distribution of Mosquito Vectors in a Peri-Urban Community Surrounding an Institution of Learning in Lafia Metropolis, Nasarawa State, Central Nigeria

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ABSTRACT

Vector surveillance is very key in solving mosquito-borne health problems in Nigeria. To this end, the composition and distribution of mosquito vectors in a peri-urban community surrounding an institution of learning in Lafia metropolis, Nasarawa State, Central Nigeria was carried out between December 2016 and June 2017. The Prokopack Aspirator was used to collect indoor resting mosquitoes between 6:00 a.m. and 9:00 a.m. from 30 randomly selected houses. Mosquitoes collected were knocked down and transferred into a well labelled petri-dish and taken to the laboratory for processing. A total of 664 mosquitoes were collected which spread across *Culex quinquefasciatus* 572 (86.14%), *Anopheles gambiae* 88 (13.25%) and *Aedes aegypti* 4 (0.60%). The abundance of mosquitoes in relation to seasons, species, sex, abdominal conditions as well as transmission indices across seasons significantly varied ($P < 0.05$). But, the distribution of mosquito in relation to house types showed no significant difference ($P > 0.05$). The inhabitants of the area should ensure that all drainages flow through so as to reduce mosquito breeding grounds. Also, members of the community should always protect themselves by sleeping under insecticide treated bed nets.

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1. Introduction

Mosquitoes are small insects with piercing and sucking mouthparts belong to the order Diptera (True flies), belongs to the family Culicidae. There are 3 subfamilies; Anophelinae, Culicinae and Toxorhynchitinae [1]. Only Culicinae and Anophelinae mosquitoes are able to spread diseases [2]. According to Service (1993) [3], various species of mosquitoes transmit some of the most harmful human and livestock diseases. Viral diseases, such as yellow fever, dengue fever, and chikungunya, transmitted mostly by *Aedes aegypti* [4]. The parasitic disease collectively called malaria, caused by various species of *Plasmodium*, carried by female mosquitoes of the genus *Anopheles*. Lymphatic filariasis (the main cause of elephantiasis) which can be spread by a wide variety of mosquito species. West Nile virus is a concern in the United States, but there are no reliable statistics on worldwide cases [5]. Tularemia, a bacterial disease caused by *Francisella tularensis*, is variously transmitted, including by biting flies. *Culex* and *Culiseta* are vectors of tularemia, as well as arbovirus infections such as West Nile virus [6]. The recent global health issue on alert is the emergence of mosquito-borne arbovirus, the Zika Virus which is transmitted by *Aedes* mosquitoes [7-9].

Mosquitoes have a worldwide distribution, occurring throughout the tropical and temperate region and are only absent in Antarctica [10]. However, some genera have restricted distribution and may be confined to certain areas, for instance, the genus *Haemagogus* is only found in central and South America [11]. The report by Bates (1949) [12] showed that certain mosquito species are ubiquitous but are more widespread in the tropical and sub-tropical regions and are also found in temperate climates and even in the Arctic during summer. Several factors which includes habitats, weather, physico-chemical parameters accounts for the distribution of mosquitoes [13,14]. Amusan *et al.* (2004, 2006) [15,16] opined that mosquitoes breed in rice field, ground pools and artificial containers.

Mahesh and Jauhari (2004) [17] found *An. subpictus* abundant in wet season and less in early dry season in Doiwala area of Uttaranchal. Also, Husainy (1986) [18] reported more number of *An. annularis* in rainy season (68%) than dry season in old Bastar district of Chhattisgarh in Central India. *Anopheles culicifacies*, the major vector of malaria in India was high during wet season and rarely observed in dry season [19]. Similar observation was made by Bansal and Singh (1993) [20] in Bikaner district of Rajasthan on the prevalence and seasonal distribution of anopheline fauna. Malakar *et al*. (1995) [21] reported high density of *A. culicifacies* during early wet season between April and May in the foot-hills of Darjeeling district.

Homes within a community are not often uniform in their designs, therefore occupants have heterogeneous exposure levels based on the quality or completeness of their primary residence. This micro-level heterogeneity in human-vector contact has been shown to be facilitated by several factors, including lack of window screening [22], open eaves [23], or the failure to use personal protective measures such as bed nets or insect repellants [24,25]. Paul and Dave (2006) [26] did a research in two countries between June 2002 and April 2003 on the influence of house construction in Trinidad and the Dominican Republic on the indoor abundance of mosquitoes using xenomonitoring surveys and found out that the mean number of *Culex quinquefasciatus* was greater in cement homes than in either wood or other poorer quality homes.

According to Micheal (2014) [27] in a study on the abundance of indoor resting mosquito populations and *Plasmodium falciparum* infection of *Anopheles* species in settlements around the Zaria dam, Zaria, Kaduna State found out that female mosquitoes were higher than males and this may be associated with the fact that the females seek for blood meal for ovarian development. Unlike studies done by Ideozu (1987) [28] and Nendangtok (1991) [29] where more males were collected than females based on outdoor collection.

Ebenezer *et al.* (2013) [30] showed that unfed female mosquitoes were the highest 2098 (45.9%), followed by fed 1888 (41.3%), then gravid 478 (10.5%) and the least was half gravid 102 (2.2%). This may be due to the established position that species with blood meals are strongly anthropophilic and those without blood in the abdomen had not fed by the time they were collected [31].

The study on spatial distribution and indoor-resting density (IRD) of mosquito species in the lowland rainforest of Bayelsa State, Nigeria by Ebenezer *et al.* (2013) [30] revealed the predominant species to be *Culex quinquefasciatus* (45.6%) followed by *An. gambiae* (24.2%), *Ae. aegypti* (18.1%), *An. funestus* (8.6%) while the least was *An. nili* (3.5%). Also, Arum (2021) [32] recorded very high abundance of indoor resting adult *Anopheles gambiae* over *An. funestus, An. coustani* and *An. pharoens is* in a semi-arid ecosystem of Baringo district, Kenya. Tiwari *et al*. (1997) [33] while working on indoor resting *Anopheles* in stone quarry area of Allahabad district, Uttar Pradesh state of India encountered 14 *Anopheles* species with *An. subpictus* being dominant followed by *An. culicifacies*, *An. annularis* and *An. pallidus*.

The indoor resting density of mosquitoes in Bayelsa State ranged from 2.9 ~ 38 mosquito/room/night [30]. Umar *et al.* (2014) [34] recorded high IRD (9.10 ~ 14.0 mosquito per house) of female *Anopheles* mosquitoes in wet season but low IRD (5.5 mosquito per house) during the dry season. The trend of IRD of mosquito species in decreasing order according to Ebenezer *et al.* (2013) [30] was *Cx. quinquefasciatus* (38.6/room), *An. gambiae* (20.5/room), *An. funestus* (7.3/room) and *An. nili* (2.9/room). Baghel *et al.* (2009) [35] recorded high incidence of mosquitoes during the late wet season (58.27 mosquito/man per hour) as compared to early wet season (41.72 mosquito/man per hour) and late dry season (35.65 mosquito/man per hour). Ebenezer *et al.* (2013) [30] showed that the overall man biting rate (MBR) of mosquitoes in Bayelsa State was 19.10 bites/person/night. Also, the overall MBR was 10.61 bites/person/room, though species specific MBR was 9.8 bites/person/night for *Cx. quinquefasciatus* while *An. gambiae* 8.7 bites/person/night.

Survey of mosquitoes in academic environment [36,37] and surrounding environs [38] is of very high significance. The presence of mosquitoes in peri-urban areas pose a great threat to the well-being of people living there most especially children [39]. To this end, an assessment on the composition and distribution of mosquito vectors in a peri-urban community surrounding a higher Institution of learning in Lafia metropolis, Nasarawa State, Central Nigeria was carried out in order to generate mosquito species checklist, determine their abundance across seasons, house types, sex, abdominal conditions as well as entomological transmission indices.

2. Materials and Methods

2.1 Study Site

The study was conducted in Mararraba-Akunza, with the coordinates 8°28’11.6004”N- 8°28’25.3524”N and 8°35’3.8364”E - 8°34’48.774”E in Lafia Local Government Area of Nasarawa State, Nigeria (Figure 1). Average temperature is about 26.8 °C, humidity is relatively high and rainfall is 456 mm [40]. The site is a peri-urban settlement where agricultural activities take place.

2.2 Ethical Consent

The chief, elders and head of households in Mararraba-Akunza community were visited and adequately informed on the importance of the research. Thereafter, the people consented and the chief granted permission for the research to be carried out by endorsing the ethical consent form.

2.3 Duration of the Study

The study period was between December 2016 and June 2017.

2.4 Sample Collection

Mosquito day catch was carried out in line with the World Health Organization procedure. Prior to the day of sampling, thirty (30) houses were randomly selected and the head of households were informed to keep their doors and windows closed during the morning hours until the rooms were sampled. Selected houses were revisited throughout the period of this study. The Prokopack Aspirator is a battery powered equipment for insects collection [41]. The Prokopack Aspirator operation is simple. It was used in the collection of mosquitoes early in the morning from 6:00 a.m. to 9:00 a.m. for three days, ten households per day. The battery in the outer compartment of the backpack was attached to the power cord (red indicates positive polarity and black indicates negative polarity). The aspirator was turned on with a rotary switch located by the handle. After collection was made, the lid on the collection cup was properly covered before turning off the unit. Afterwards, cotton wool soaked with chloroform was used to knockdown mosquitoes for a period of five minutes and then samples in the collection cup were transferred into a well labeled petri dish and transported to Zoology laboratory of Federal University of Lafia for morphological identification. Collection of mosquitoes spread across early dry (December 2016), late dry (March 2017) and early wet (June 2017) seasons.

2.5 Morphological Identification and Preservation

All collected mosquitoes in petri dishes were later sorted out and morphologically identified using a dissecting microscope and identification keys by Gillies and Coetzee (1987) [42] and Kent (2006) [43].

2.6 Statistical Analysis

The indoor resting density of female *Anopheles* per structure per night was calculated using the formula by Williams and Pinto (2012) [44]:

$$\text{Indoor Resting Density (IRD)} = \frac{\text{Total number of female vectors collected}}{\text{Total number of houses}}$$

All the females (F) collected are separated by species and counted. The total number of collected females of each species was then divided by the total number of occupants (W) who spent the previous night in the rooms that were used for the collection [44].

$$\text{Man Biting Rate (MBR)} = \frac{\text{No.of female mosquitoes collected (F)}}{\text{Total number of occupants (W) in the houses}}$$

Data obtained were analyzed using R Console version 2.9.2. One way analysis of variance was used to compare the mean abundance of mosquitoes in relation to seasons as well as house types. Pearson’s Chi-square test was used

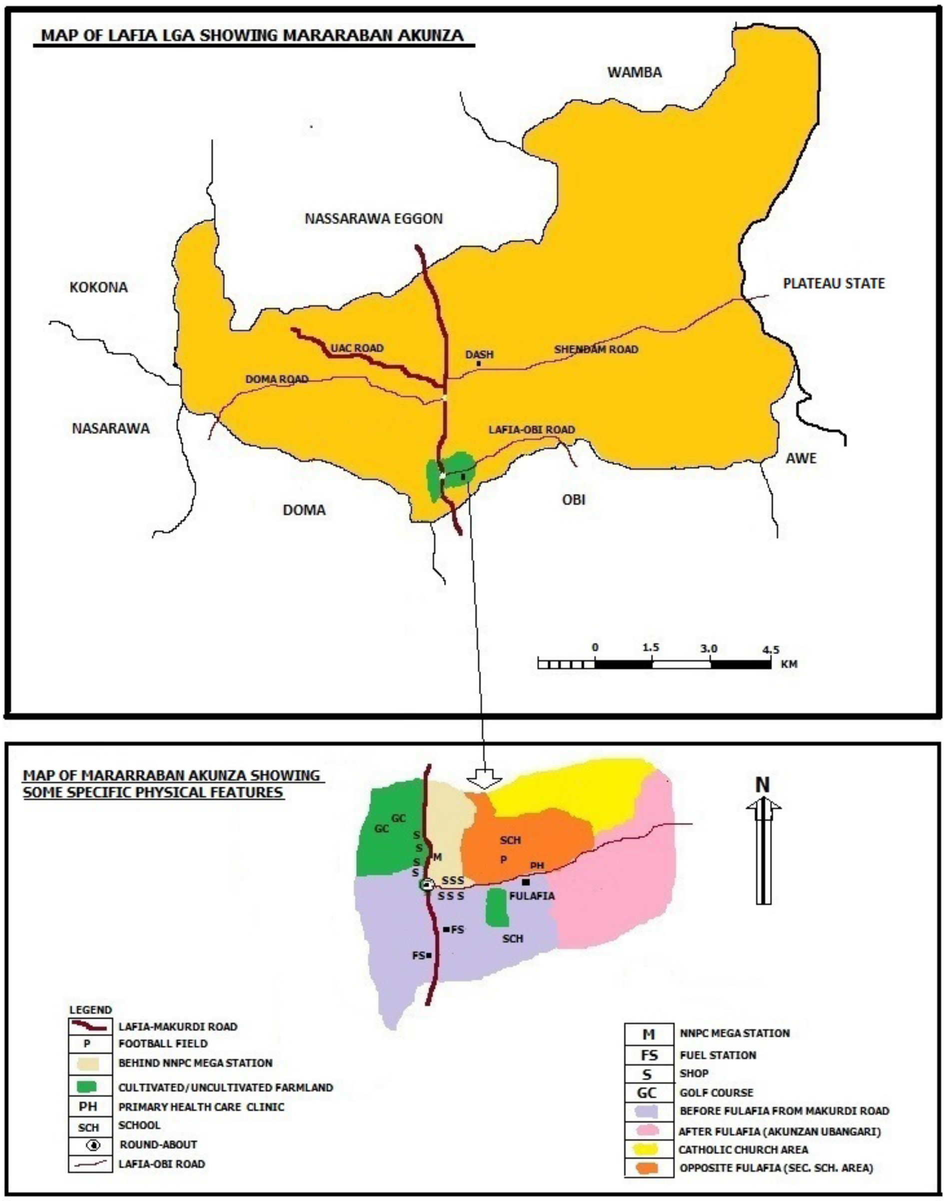

Figure 1. Map of Lafia L.G.A. of Nasarawa State, Nigeria showing Mararraba-Akunza

to compare proportions of mosquitoes in relation to seasons, species, house types, sex, and abdominal conditions. Level of significance was set at $P < 0.05$.

3. Results

3.1 Composition of Mosquito Species in Mararraba-Akunza Community

Mosquito species checklist generated at the end of this study is shown in Table 1. An overall total of 664 mosquitoes were caught resting indoors. The 664 mosquitoes spread across a family, two sub-families, three genera and three species (Plate 1). The highest number of resting indoors mosquitoes was *Culex quinquefasciatus* 572 (86.14%), followed by *Anopheles gambiae* 88 (13.25%) and the least was *Aedes aegypti* 4 (0.60%). Therefore, the abundance of mosquitoes in relation to species showed a very high significant difference ($\chi^2 = 849.3$, df = 2, $P < 0.00001$).

3.2 Abundance of Mosquitoes in Relation to Seasons

The abundance of mosquitoes in relation to seasons showed a very high significant difference ($F_{87} = 20.42$, Adjusted $R^2 = 0.3038$, $P = 0.0000000535$, Figure 2). *Culex quinquefasciatus* was the most abundant in each seasons, the early wet season had the highest number of mosquitoes 573 (86.30%) then late dry 64 (9.64%) and early dry 27 (4.07%) respectively.

Table 1. Composition of mosquitoes in Mararraba-Akunza, Lafia LGA, Nasarawa State

Species	Seasons			Total (%)
	Early Dry	**Late Dry**	**Early Wet**	
Aedes aegypti	0(0.00)	0(0.00)	4(100.00)	**4(0.60)**
Anopheles gambiae	5(5.68)	1(1.14)	82(93.18)	**88(13.25)**
Culex quinquefasciatus	22(3.85)	63(11.01)	487(85.14)	**572(86.14)**
Total (%)	**27(4.07)**	**64(9.64)**	**573(86.30)**	**664**

Comparison of mosquitoes abundance between species: χ^2 =849.3, df = 2, P < 0.00001

a. *An. gambiae* b. *Cx. quinquefasciatus* c. *Ae. aegypti*

Plate 1. Mosquitoes species collected indoors from Mararraba-Akunza area, Lafia L.G.A., Nasarawa State, Central Nigeria

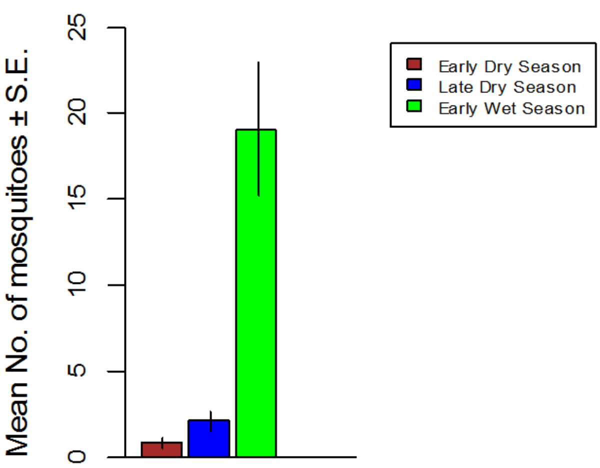

Figure 2. The mean abundance of mosquitoes in relation to seasons

3.3 Abundance of Mosquitoes in Relation to House Types

The cement block house had the highest number of indoor resting mosquitoes 412 (62.05%) followed by mud house 239 (35.99%) and was least 13 (1.96%) in house built with both cement block and mud. However, there was no significant difference (F_{87} =0.0886, Adjusted R^2 = –0.02091, P = 0.9153, Figure 3) in the abundance of mosquitoes in relation to house types.

3.4 Abundance of Mosquitoes in Relation to Sex

A very high significant difference (χ^2 = 97.163, df = 1, P < 0.00001) was observed in the abundance of mosquitoes in relation to sex. The female indoor resting mosquitoes were higher 459 (69.13%) than the males 205 (30.87%) as shown in Table 2.

3.5 Abundance of Mosquitoes in Relation to Abdominal Conditions

Table 3 shows that the fed female mosquitoes were the most abundant 308 (67.10%) followed by unfed ones 65 (14.16%), gravid 45 (9.80%), while the least were the half gravid (8.93%). Therefore, the abundance of mosquitoes in relation to abdominal conditions showed a very high significant difference (χ^2 = 436.82, df = 3, P < 0.00001).

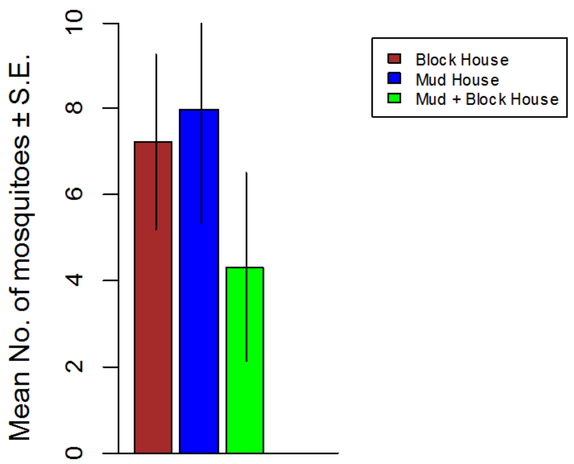

Figure 3. Mosquitoes abundance in relation to house types

3.6 Entomological Transmission Indices of Mosquitoes in Relation to Seasons

Figure 4 shows the entomological transmission indices of mosquitoes in relation to seasons. The overall indoor resting density (IRD) of mosquitoes per house was highest in early wet 13.23 followed by late dry 1.3 whereas it was least in early dry season 0.77. Thus, a very high significant difference (χ^2 =19.468, df = 2, P = 0.00005924) in IRD of mosquitoes in relation to seasons was recorded. Similar trend was observed for man-biting rate (MBR) in the order 4.09, 0.40, and 0.24 per man/night in each household in early wet, late dry and early dry season respectively (Figure 4). Also, MBR in relation to seasons showed a significant difference (χ^2 =6.0178, df = 2, P = 0.04935).

Table 2. Abundance of mosquitoes in relation to sex

	Sex (%)	
Species	**Female**	**Male**
Aedes aegypti	3(0.65)	1(0.49)
Anopheles gambiae	76(16.56)	12(5.85)
Culex quinquefasciatus	380(82.79)	192(93.66)
Total (%)	**459(69.13)**	**205(30.87)**

Comparison of mosquitoes abundance between sex: χ^2 = 97.163, df = 1, P < 0.00001

Table 3. Blood digestion stages of female mosquitoes

Species	**Abdominal Conditions (%)**				**Total (%)**
	Unfed	**Fed**	**Half Gravid**	**Gravid**	
Aedes eagipti	0(0.00)	3(100.00)	0(0.00)	0(0.00)	**3(0.65)**
Anopheles gambiae	5(6.58)	68(89.47)	3(3.95)	0(0.00)	**76(16.56)**
Culex quinquefasciatus	60(15.79)	237(62.37)	38(10.00)	45(11.84)	**380(82.79)**
Total (%)	**65(14.16)**	**308(67.10)**	**41(8.93)**	**45(9.80)**	**459**

Mosquitoes abundance between abdominal conditions: χ^2 = 436.82, df = 3, P < 0.00001

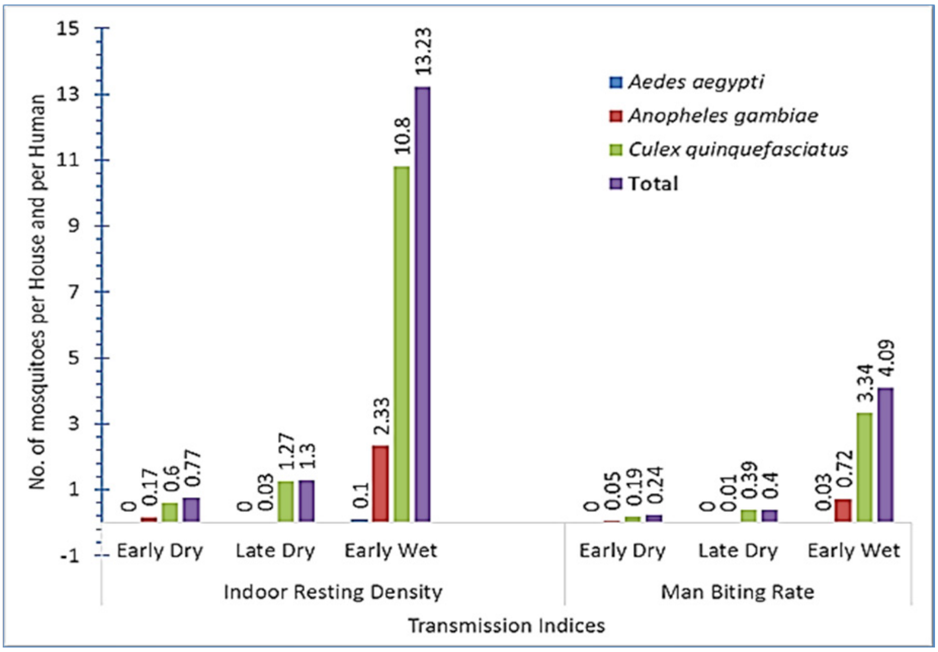

Figure 4. Entomological transmission indices of mosquitoes in relation to seasons

4. Discussion

4.1 Mosquito Species Composition in Peri-Urban Area Surrounding an Institution

The abundant and diverse mosquito species recorded in the study area which cut across a family, two sub-families, three genera and three species probably suggest that the area is a good breeding site for mosquito vectors that may likely transmit disease if they bite any infected individual within Mararraba-Akunza community. This is similar with the finding of Ebenezer *et al.* (2013) [30] who recorded a family, two sub-families, three genera and five species in a study of spatial distribution and indoor resting density of mosquito species in lowland rainforest of Bayelsa State, Nigeria. Also, Ifeyinwa and Tochi (2012) [45], in a study of the distribution and occurrence of mosquito species in the municipal areas of Imo State, Nigeria recorded three genera and eight species.

The observed variation in the abundance of *Culex quinquefasciatus* over other indoor resting mosquito species in the study site possibly suggest a likelihood for transmission of filariasis if they bite any infected person by chance. This agrees with the finding of Gillet (1972) [46] who described *Culex quinquefasciatus* as the commonest nuisance mosquitoes in most parts of Africa and it is a potential vector of filariasis. Also, the indoor resting populations of mosquitoes in some selected areas of Kaduna metropolis was surveyed by Suleiman (2012) [47] who recorded higher number of *Culex* species 99.74% over other species 0.26%. On the contrary, Adeleke (2010) [48] in a study on population dynamics of indoor sampled mosquitoes and their implication in disease transmission in Ikenne area, Abeokuta, Ogun State, South-western Nigeria observed that *Ae. aegypti* was generally predominant indoors.

Furthermore, the preponderance of *Culex quinquefasciatus* over other species clearly shows that the study area has a lot of polluted water bodies that supports breeding success of *Culex quinquefasciatus* in Mararraba-Akunza community. Similarly, Adebote *et al.* (2006) [49] and Afolabi *et al.* (2010) [50] observed that the larvae of culicine mosquito was the most predominant in Zaria. The low proportion of the anophelinae to the culicine mosquito in this present study could be attributed to the location and seasons covered [51,52]. On the other hand, the study by Ebenezer et al. (2014) [53] caught more *An.gambiae* s. l. and implicated it as the vector of malaria parasite in Bayelsa State. Previous study by Umar (2014) [34] on the molecular characterization of *Anopheles* and *Plasmodium* species and retrospective study of malaria in Katsina State, Nigeria showed excess of *Anopheles gambiae* over other species of mosquitoes.

The very low number of *Aedes* species suggests that they are diurnal and mostly feed outdoor. This is similar with the finding by Amusan *et al.* (2005) [54] who caught few *Aedes* species and has a ubiquitous mode of feeding.

4.2 Mosquitoes Distribution in Relation to Seasonality

The high proportion of mosquitoes during early wet season could be associated to the increase of breeding sites created by rainfall which may possibly account for more vector-borne diseases during the wet season. Similarly, Malar *et al.* (2015) [55] in a study on influential inflicts of monsoon and agricultural practices among the population density of mosquitoes in the agro-rural villages of Madurai recorded higher number of mosquitoes during the wet season. Also, Overgaard *et al.* (2002) [56] showed that the abundant occurrence of mosquitoes are more diverse in the rainy season than during the dry season. The decrease in mosquito abundance in dry season could be attributed to the flushing of larvae in breeding sites due to prolonged rainfall which leads to a decrease in mosquitoes population and will require sometime to resurge. This is in agreement with the finding of Amusan *et al.* (2005) [54] who observed a decrease in mosquitoes larvae due to continuous rainfall which spans into the early dry season causing high larval flush. The variation in mosquitoes abundance across seasons is similar to the studies by Afolabi *et al.* (2006) [57] who recorded variation in the abundance of mosquitoes in relation to seasons in different ecological zones in Nigeria. This study corroborates with the findings of Amusan *et al.* (2005) [54] and Malar *et al.* (2015) [55] who showed that rainfall, relative humidity and temperature accounts for fluctuations in abundance of mosquitoes. In some cases, increased rainfall may increase larval habitat and vector population by creating new habitats, while excess rain would eliminate habitats through flooding, which decreases the vector population [54,55,58,59]. Relative humidity is a critical factor affecting the life cycle pattern of mosquitoes [60].

4.3 Mosquitoes Association with House Types

The mosquitoes caught showed no preference for a particular house type. Although the observed variation in mosquitoes proportions across house types possibly suggests that cement block house type provides a very smooth surface for endophilic mosquitoes to rest. This in line with the finding of Paul and Dave (2006) [26] on the study of the influence of house construction on the indoor abundance of mosquitoes who recorded homes that are made of cement significantly had the highest abundance of mosquitoes resting indoors compared to mud and mud/block house.

4.4 Sex-Wise Mosquitoes Abundance

The high variation in the abundance of mosquitoes in relation to sexes favoured females which possibly suggest that females easily access human host blood meal at indoor point in large volume. This is in agreement with Micheal (2014) [27] who recorded high number of female mosquitoes than males in a study of the abundance of indoor resting mosquito populations and *Plasmodium falciparum* infection of *Anopheles* species in settlements around the Zaria dam, Zaria, Kaduna State. Also, Suleiman (2012) [47] found that the sex ratio of mosquitoes favoured females with 78.68% while males constituted 21.32%. On the contrary Ideozu (1987) [28] and Nendangtok (1991) [29] reported that there were more males collected than females which can be attributed to the collection made outdoors.

4.5 Mosquitoes Physiological Conditions

The number of fed mosquitoes showed high variation over unfed, gravid and half gravid physiological conditions thereby suggesting high indoor human-vectors contact and transmission risk of diseases. This is expected due to the fact that a large proportion of resting females are usually fed. This is in concordance with the finding of Suleiman (2012) [47] who found more fed female population 94.31% while the unfed was 5.69%. This disagrees with the finding of Ebenezer *et al.* (2013) [30] on the study of distribution and indoor resting density of mosquito species in the lowland rainforest of Bayelsa State who recorded the unfed mosquitoes as the highest followed by fed, gravid and half gravid. The proportion of fed *Anopheles* and *Culex* were higher than *Aedes aegypti*. This was not surprising because they are anthropophilic [48]. The high number of female mosquitoes caught shows that they are strongly anthropophilic and those without blood in the abdomen had not fed as at the time they were collected.

4.6 Entomological Transmission Indices

The indoor resting density of mosquito changed significantly in favor of early wet season which suggests that households are more likely to be infected with mosquito-borne diseases. The early wet season in the area showed that each house will have thirteen mosquitoes. This is in agreement with the finding of Oyewole *et al.* (2005) [61] who found variation in IRD across seasons. The high indoor resting density of *Culex* mosquito is line with the study by Adeleke *et al.* (2008) [62], and Okiwelu and Noutcha (2012) [63] who recorded a high IRD due to number of emerged adult as a result of wide distribution of breeding sites during the early wet season.

Man-biting rate of *Anopheles* and *Culex* was four mosquitoes per individual in a room during the early wet season. This is in accordance with the report by Mboera *et al.* (2010) [64] who recorded high IRD during wet season than dry season.

5. Conclusions

This study clearly shows that Mararraba-Akunza area has got good breeding sites for mosquito vectors. The population of mosquito in the area across seasons was dynamic in favour of the early wet season. *Culex quinquefasciatus* was predominant throughout the season. The mosquitoes in the area showed no preference for a particular house type. The sex ratio of the mosquito was in favour of females. Most of the female mosquitoes collected were blood fed, which implies a high likelihood of transmission of mosquito-borne infections. The transmission indices peaked during the early wet season. The inhabitants of the area should maintain a high sense of hygiene by clearing all blocked drainage water ways. Also, they should sleep under insecticide treated bednets (ITNs). Lastly, the government and non-governmental organizations (NGOs) concerned in Nasarawa State should distribute more ITNs to the people.

Conflict of Interest

There is no conflict of interest.

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