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Seasonal Distribution and Abundance of Culicine Mosquito species in three selected areas of Taraba State, North-east Nigeria

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Abstract: *Mosquitoes are generally divided intotwo main subfamilies: the Anophelinae and Culicinae. The study was conducted between September 2015 and August 2017 to investigate Culicine species distributions in Taraba state, Nigeria. Indoor mosquitoes in Ardo Kola, Bali and Donga were collected using Spread Sheet Collection method. 1110 Culicine mosquitoes were identified to 9 species level: Culexpipiens 373 (33.6%), Culexpilosus 266 (24.0%), Culexquinquefasciatus 250 (22.5%), were major species. 8 species collected from Ardo Kola79 (7.1%) were dominated by Culexpipiens20 (5.4%). Bali had 428 (38.6%) composed of 7 species, dominated by Culexquinquefasciatus 130 (52.0%). Donga had the highest 603 (54.3%) composed of 8 species, dominated by Culexpilosus 134 (50.4%) and were more abundant in wet season than dry season.Analysis of Variance showed significant differences in species distributions (P < 0.05). This means that the study area has a diverse culicine species*

Keywords*: Culicine species, Seasonss, Guinea savanna, Nigeria*

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I. Introduction

Mosquitoes (Order: Diptera, Suborder: Nematocera) are family of small midge –like flies: the Culicidae. Although a few species are harmless or even useful to humanity, most are considered a nuisance and a major public health problem, because they consume blood from living vertebrates, including humans. In feeding on blood, some of them transmit extremely harmful human and livestock diseases, such as malaria, yellow fever and filariasis [4]. Mosquitoes are estimated to transmit diseases to more than 700 million people annually and responsible for the death of about 1 in 17 people [1]. The blood sucking habits of female mosquitoes make them prone to acquiring pathogens and parasites from vertebrate hosts.

Over 3,500 species of the Culicidae family have already been described. They are generally divided into two subfamilies which in turn comprise some 43 genera. The two main subfamilies are the Anophelinae and Culicinae [2]. Among Anophelinae, the genus *Anopheles* is best known for its role in transmitting malaria worldwide, but in some areas it can also transmit filariasis[3]. The culicines, which include the genera *Culex,* are vectors of filariasis, Japanese encephalitis and some viral diseases. *Aedes* are vectors of dengue haemorrhagic fever, yellow fever and other viral diseases and sometimes filariasis, while *Mansonia* are vectors of brugianfilariasis. *Haemagogus* and *Sabethes*are vectors of yellow fever in the forests of South and Central America [4].

The distribution pattern, transmission and intensity of the disease are dependent on the degree of urbanization and the distance from vector breeding sites [5]. In the absence of effective control, these diseases have a major impact on public health and socio-economic development. The standard chemical, biological and physical control measures used to kill mosquitoes and other insects vectors, as well as active and passive case-detection and treatment of human infection, have a long and proven track-record of saving lives[6]. However, the potential benefits of integrating vector control strategies into national health and community systems have not been fully realized.

Factors that determine the occurrences of malaria and other mosquito-borne diseases are mosquito’s presence, contact with human and ability to complete the invertebrate half of their life cycle [7]. The degree of endemicity in any region is determined by species of indigenousmosquitoes, relative abundance, feeding, resting behavior and their individual suitability as hosts for different pathogens, among others [8].

People living in poor rural areas are confronted with a multitude of barriers when assessing prevention and treatment of mosquito-borne diseases, especially lack of skilled Health Personnel and equipment, insufficient knowledge about health care, insufficient knowledge of the biology and ecology of the vectors, among others [9].

The mapping of mosquito vectors is important in the control of malaria and other mosquito-borne diseases. Our National Centre for Disease Control lack detailed culicids maps to guide intervention. This is because the species composition and distribution and other biological parameters of the mosquitoes are poorly known in different ecological zones of Nigeria (10, 11).

Mosquitoes are both a nuisance and vectors of diseases and the importance of mosquitoes in human and animal diseases has made them an important target of medical and veterinary research. The success of any intervention strategy depends on the community understanding of the biology and ecology of the vectors.

In a situation where various control measures are being put in place the ecology of adult mosquitoes would be useful in assessment of the effectiveness or otherwise of such control measures. A lots of works have been done on *Anopheles* mosquitoes in Taraba state and Nigeria generally [12, 13, 14, 15, 16]. Although Mosquito species diversity and prevalence in Taraba have also been reported [17, 18], there is little or no reports on detailed spatio-temporal distribution of the sub family culicinae. Therefore, the aim of this study was to investigate the *Culicine* mosquito speciesspatio-temporal distribution and abundancein major riverine communities of three selected areas of Taraba state, Nigeria.

II. Materials And Methods

2.1 Study area:

Taraba State is located between longitude 8.5^{o} -11.6^{o}E and latitude 6.5^{o}-9.5^{o}N (8^{o} OO'N and10^{o} 3O'E coordinates) in the north eastern geopolitical zone of Nigeria with a size of 54,473 square kilometers representing 5.89% of the country landmass(Figure 6).It has an estimated population of 2,688,944 based on 2006 census, giving a population density of 27 people perkm^2, representing 1.9% of the total population of Nigerians. Inhabitants of Taraba state are of different ethnic groups speaking different languages and dialects. Rivers Benue, Donga, Taraba and Ibi are the main rivers in the state. They rise from the Cameroonian mountains straining almost the entire length of the State in the north and south direction to link up with River Niger [19)]

Majority of the inhabitants usually engaged in farming. Crops produced include cash crops and food crops. Some also engage in petty trading and livestock herding for living. Apart from cattle, sheep and goats are also reared in large numbers on Mambilla plateau and along the Benue and Taraba valleys. Communities living on the banks of River Benue, River Taraba, Rivers Donga and Ibi engage in fishing all year round. The houses are constructed with either block cement or mud with corrugated iron sheet, bamboo or palm fronds. The residents often keep domestic animals with their houses or nearby sheds.

The State lies largely within the middle of Nigeria and consists of undulating landscape dotted with a few mountainous features. These include the scenic and prominent Mambillaplateau with a temperate climate all year round; and although predominantly occupied by guinea savanna vegetation, it has vegetation of low forest in the southern part and grassland in the northern part.

Taraba experiences a typical tropical continental climate with distinct seasonal regimes, oscillating between cold and hot, dry and wet, typical of predominantly guinea savanna (semi-arid) zone of Taraba State. These two seasons reflect the influences of tropical continental (dust-laden north east trade winds) and equatorial maritime (moisture-laden south westerlies) air masses which sweep over the country. Rainy season is between April and October and dry season between November and March. The year can be divided into:a hot, wet season (late April – October); a cold, dry season (November – February) and a hot, dry

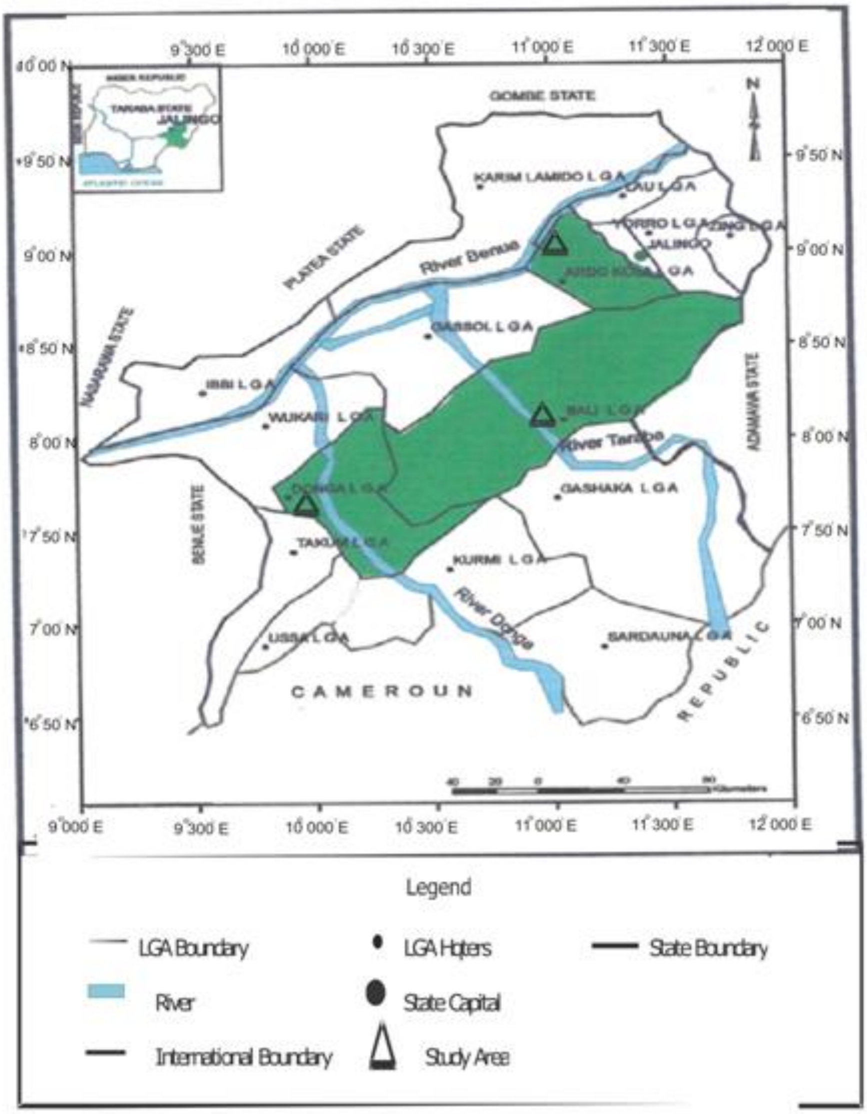

Fig. 1: Map of Taraba state, Nigeria showing the study area (20)

season (March – April). Mean day temperature varies from 37°C to 40°C during the hottest months of March/April. It also varies from 32°C to 37°c during the coldest months of December/January. The relative humidity is about 23% during the hot, dry weather and can reach 80% during the peak of wet season in August [19].

2.2Research design

The study was carried out in three riverine sub-urban Local Government Areas of the State. These are Ardo Kola (Northern zone, 8° 40'– 9° 12' N; 10° 58'– 11° 33'E), Bali (Central zone, 7° 22'- 8° 48'N; 10° 17' – 11° 49'E), and Donga (Southern zone, 7° 15' – 7° 56'N; 9° 47'- 10° 42'E) within a period of 24 months from September, 2015 to August, 2017. Mosquito samplings took place in the three selected areas, taking into consideration locations of the town representing the major settlements- Ardo Kola, Bali and Donga. These areas are usually characterized by periodic flooding largely due to River Benue, River Taraba and River Donga flooding its bank especially during the raining seasons. This results in excess water flowing into communities and settlements along the course of the rivers. Mosquito collections were carried out every month of the study period in each of the areas. Before embarking on the sampling exercise, community leaders of the selected stations and head of the houses selected were contacted and significance of the study explained for their cooperation.

The study communities were selected based on dense population, house types, presence of water bodies, both permanent slow running ones and stagnant prevailing pools of water that serve as breeding places for mosquitoes.

Ten bedrooms were selected randomly from each locations with at most three bedrooms from the same house every month of the study period. Seven hundred and twenty (720) (24months x10 bedrooms x3 locations) rooms were sprayed during the entire period of study.

2.3Mosquito Sampling Technique

A House-resting collection (Spray Sheet Collection) was used for the collection of mosquitoes monthly within 2015 to 2017 in the three selected locations. Collection of indoor resting mosquitoes by use of non-residual insecticide- pyrethrum was employed using World Health Organisation (WHO) standard procedure [21] with little modification, which is by including electronic mosquito trap.

2.4Laboratory Examination of Mosquitoes

Collected and preserved mosquitoes were brought to the laboratory to be sorted, identified and dissected for further processing

2.5Morphological Identification and sorting out of mosquitoes

Anopheline were separated from Culicine mosquitoes according to the morphological characteristics of their maxillary palps and identified mosquito genera were sexed based on the presence or absence of plumose (feathery) antennae [2, 4]. The morphological identification of different species of female mosquitoes was done by studying the scales and colour of the palps at the head region, the patterns of spots on the wings, thorax, terminal abdominal segments, scales of the legs and striations on the body using dissecting microscope following the taxonomic keys [22, 23]

2.6Data analysis

Relative frequencies (percentage) were used for the presentation of data in tables. Analysis of Variance (ANOVA) was used to analyze Culicine abundance in selected areas and months/seasons using SPSS at P =0.05

III. Results

3.1 Distribution and Abundance of Mosquito Genera in Relation to Study Areas

A total of 4,370 Indoor- Resting mosquitoes belonging to six genera, *Anopheles* 2,186 (50.0%), *Culex* 1,987 (45.5%), *Aedes* 15 (0.3%), *Mansonia* 127 (3.0%), *Sabethes* 36 (0.8%) and *Toxorhynchites* 19 (0.4%) were collected (Table 1).

Abundance of the Indoor -Resting mosquitoes in relation to study areas showed that Ardo Kola had the highest abundance of all mosquitoes with 1,562 (35.8%), followed by Bali 1,409 (32.2%) and the least was Donga 1,399 (32.0%)(Table 1). *Anopheles* was the most abundant species in Ardo Kola 1319 (60.3%) of the entire *Anopheles* collected in the areas, whereas *Culex* was most abundant in Donga 999 (50.5%). In all the study areas *Aedes* was low in abundance 15 (0.3%) with Donga recording 9(60.0%), Bali 6(40.0%) while Ardo Kola had none. Analysis of variance showed significant differences in mosquito genera in relation to study areas (P < 0.05) (Table 1)

Table 1: Distribution of Abundance of Culicinemosquito genera in relation to study area, Taraba State, Sept. 2015 to August 2017

		Study Area		
Mosquito genera	Total (%)	Ardo-kola No(%)	Bali No(%)	Donga No (%)
Anopheles	2,186(50.0)	1319(60.3)[a]	555(25.4)[b]	312(14.3)[c]
Culex	1987(45.5)	165(8.3)[a]	823(41.4)[b]	999(50.3)[c]
Aedes	15(0.3)	0(0.0)[a]	6(40.0)[b]	9(60.0)[c]
Mansonia	127(3.0)	30(23.6)[a]	24(18.9)[b]	73(57.5)[c]
Sabethes	36(0.8)	36(100)[a]	0(0.0)[b]	0(0.0)[c]
Toxorhynchites	19(0.4)	12(63.2)[a]	1(5.3)[b]	6(31.6)[c]
Total	4,370	1562(35.7)	1409(32.2)	1399(32.0)

Numbers and percentages on the same row with different alphabet superscripts are significantly (P<0.05) different

3.2 Distribution and Abundance of female Culicine species in the study areas

One thousand, one hundred and ten (1110)culicine mosquitoes identified to species level contained 9 species: *Culexpipiens* 373 (33.6%), *Culexpilosus* 266 (24.0%), *Culexquinquefasciatus* 250 (22.5%), *Culexmolestus* 75 (6.8%), *Culextarsalis* 62 (5.6%), *Aedesaegypti*5 (0.4%), *Mansoniauniformis* 68 (6.1), *Sabethescyaeneus* 5 (0.4%) and *Toxorhnychitespeciosus* 7 (0.5%). Among the 1110 culicine species, Ardo Kola had 79 (7.1%) composed of 8 species, dominated by *Culexpipiens* 20, but made up of the least 5.4% in all study areas. The least culicine species was *Toxorhnychitesspeciosus*, but was the highest 57.1% in all the areas (Table 2).

Out of 1110 identified 9 culicine species 79 (7.1%), composed of 8 species were collected from Ardo Kola dominated by *Culexpipiens*20 (5.4%), followed by *Culexmolestus* 19 (25.3%) and *Mansoniauniformis* 11 (16.2%) (Table 2).

Of the 1110 culicine species, Bali had 428 (38.6%) composed of 7 species, dominated by *Culexquinquefasciatus* 130 (52.0%) (Table 2).Of the 1110 culicine species, Donga had the highest 603 (54.3%) composed of 8 species, dominated by *Culexpilosus* 134 (50.4%) No *Aedes* mosquito was collected in Ardo Kola(Table 2). Analysis of variance showed significant difference in the abundance of Culicine species in the study area (P<0.05).

Table 2: Distribution of female Culicine mosquito species in Study Areas

Culicine species	Ardo Kola	Bali	Donga	Total (%)
Culexquinquefasciatus	5(2.0)^{a}	130(52.0)^{b}	115(46.0)^{c}	250(22.5)
Cxmolestus	19(25.3)^{a}	26(34.7)^{b}	30(40.0)^{c}	75(6.8)
Cxpipiens	20(5.4)^{a}	113(30.0)^{b}	240(64.3)^{c}	373(33.6)
Cxtarsalis	5(8.1)^{a}	27(43.5)^{b}	30(48.4)^{c}	62(5.6)
Cxpilosus	10(3.7)^{a}	122(45.9)^{b}	134(50.4)^{c}	266(24.0)
Aedesaegypti	0(0.0)^{a}	2(40.0)^{b}	3(60.0)^{c}	5(0.4)
Mansoniauniformis	11(16.2)^{a}	8(11.8)^{b}	49(72.0)^{c}	68(6.1)
Sabethescyaeneus	5(10.0)^{a}	0(0.0)^{b}	0(0.0)^{c}	5(0.4)
Toxorhynchitespeciosus	4(57.1)^{a}	1(14.3)^{b}	2(28.6)^{c}	7(0.5)
Total (%)	79(7.1)	429(38.6)	603(54.3)	1110

Numbers and percentages on the same row with different alphabet superscripts are significantly (P<0.05) different

3.3 Monthly/Seasonal distribution of Culicine species in the study area

Culicine species in Ardo Kola were most abundant in the months of February 20 (25.3%), September 22 (27.8%) and October 13 (16.5%). Culicine species were least recorded in the months of November 2 (2.5%), December 1 (1.3%), January 1 (1.3%), May 2 (2.5%), July 2 (2.5%). The predominant culicine species throughout the year were *Culexpipiens*20 (25.3%), *Culexmolestus* 19 (24.0%), *Mansoniauniformis* 11 (13.9) and *Culexpilosus* 10 (12.6%), while the least observed were *Culexquiquefasciatus* 5 (6.3%), *Culextarsalis* 5 (6.3%), *Sabethescyaeneus* 5 (6.3%) and *Toxorhnychitespeciosus* 4 (5.1%) (Table 3).

Differences observed in the monthly distribution of Culicine mosquito species in Ardo Kola isstastistically significant (P<0.05).

Monthly distribution of Culicine species in Bali showed that culicine species were most abundant in the months of October 118 (27.6%) and December 68 (15.9%)September 60 (14.0%)July 56 (13.1%). Culicine species were least recorded in the months of May 9 (2.1%), April 8 (1.9%),March 6 (1.4%), The predominant culicine species throughout the year were *Culexquinquefasciatus* 130 (30.4%), followed by *Culexpilosus* 122 (28.5%), *Culexpipiens* 113 (26.4%) and *Culextarsalis*27 (6.3%), while the least observed were *Culex*molestus 26 (6.1%), *Aedesaegypti* 2 (0.5%) and *Mansoniauniformis* 8 (1.9%) and *Toxorhynchitespeciosus* 1 (0.2%)(Table 4). Analysis of Variance showed significant differences in culicine species monthly distribution (P < 0.05)

Distribution of Culicine species in Donga showed that culicine species were most abundant in the months of August 135 (22.4%), June 115 (19.1%) and July 71 (11.8%) (Table 5) Culicine species were least recorded in the months of February 12 (2.0%) March 0 (0.0%), April 8 (1.3%). The predominant culicine species throughout the year were *Culexpipiens*240 (39.8%), followed by *Culexpilosus*134 (22.2%) and *Culexquinquefasciatus*115 (19.1%), while the least observed were *Culexmolestus*, *Culextarsalis* each 30 (5.0%), *Aedesaegypti*3 (0.5%) and *Toxorhnychitespeciosus*2 (0.3%). Analysis of Variance showed significant differences in culicine species distribution in months of the year (P < 0.05).

Table 3: Monthly Distribution of identified Culicine species in Ardo-kola

Culine Species	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL(%)
Culexquinquefasciatus	3	0	0	0	0	2	0	0	0	0	0	0	5 (6.3)
Cx. molestus	3	7	0	0	0	4	5	0	0	0	0	0	19 (24.0)
Cx. Pipiens	2	2	0	0	1	11	1	0	2	0	0	1	20 (25.3)
Cx. Tarsalis	2	2	0	1	0	0	0	0	0	0	0	0	5 (6.3)
Cx. Pilosus	2	0	0	0	0	3	5	0	0	0	0	0	10 (12.6)
M. uniformis	4	0	2	0	0	0	0	0	0	0	2	3	11 (13.9)
Sab. cyaeneus	5	0	0	0	0	0	0	0	0	0	0	0	5 (6.3)
Tox. Specious	1	2	0	0	0	0	1	0	0	0	0	0	4 (5.1)
Total (%)	22	1	2	1	1	20	12	0	2	0	2	4	79
	(27.8)	3(16.5)	(2.5)	(1.3)	(1.3)	(25.3)	(15.2)		(3.5)		(2.5)	(5.1)	

Number and percentages on the same row are significantly (P<0.05) different

Table 4: Monthly Distribution of identified Culicine species in Bali

Culicine Species	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL(%)
Culexquinquefasciatus	24	49	5	16	5	5	0	4	4	4	9	5	130(30.4)
Cx. molestus	8	6	0	0	0	0	0	0	0	0	6	6	26(6.1)
Cx. Pipiens	10	24	9	29	3	4	5	4	5	3	12	5	113(26.4)
Cx. Tarsalis	13	5	0	0	0	0	0	0	0	0	4	5	27(6.3)
Cx. Pilosus	5	30	20	23	4	2	1	0	0	11	25	1	122(28.5)
Ae. Agegypti	0	0	0	0	1	0	0	0	00	0	0	1	12(0.5)
M. uniformis	4	0	0	0	1	0	0	0	2	0	1	0	8(1.9)
Tox. Specious	0	0	0	0	0	0	0	0	0	0	0	1	1(0.2)
Total (%)	60	118	34	68	13	12	6	8	9	20	56	25	429
	(14.0)	(17.6)	(7.9)	(15.9)	(3.0)	(2.8)	(1.4)	(1.9)	(2.9)	(4.7)	(13.1)	(5.6)	

Number and percentages on the same row are significantly (P<0.05) different

Table 5: Monthly Distribution of identified Culicine species in Donga

Culine Species	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL (%)
Culexquinquefas ciatus	6	0	2	20	14	9	0	2	4	22	10	26	115(19.1)
Cx. molestus	10	0	0	12	8	0	0	0	0	0	0	0	30(5.0)
Cx. Pipiens	15	5	20	15	17	2	0	2	5	69	31	59	240(39.8)
Cx. Tarsalis	0	0	18	10	0	0	0	0	2	0	0	0	30(5.0)
Cx. Pilosus	0	0	9	12	5	1	0	2	4	23	28	50	134(22.2)
Ae. Agegypti	0	0	0	0	0	0	0	1	0	0	2	0	3(0.5)
M. uniformis	2	45	0	0	0	0	0	1	0	1	0	0	49(8.1)
Tox. Specious	2	0	0	0	0	0	0	0	0	0	0	0	2(0.3)
Total (%)	35 (5.8)	50 (8.3)	49 (8.1)	69 (11.4)	44 (7.3)	12 (2.0)	0	8 (1.3)	15 (2.5)	115 (19.1)	71 (11.8)	135(22.4)	603

Number and percentages on the same row are significantly (P<0.05) different

IV. Discussions

4.1 Distribution and Abundance of mosquitoes in the study area

Mosquitoes of the genus *Anopheles*, *Culex, Aedes*, *Mansonia*, *Sabethes* and *Toxorhynchites* were found in the study area. Among these mosquito genera, *Anopheles*, *Culex*, *Toxorhychites*and *Mansonia* were common to all areas. *Sabethes* were found in Ardo Kola only. With the fact that the study areas fall within the same ecological zone of guinea savanna, there might be variations in the physico-chemical and biological characteristics of the breeding habitats that brought about differences in the distribution and abuudance of mosquitoes [24]

The abundance of *Culex* species in both Donga (71.1%) and Bali (62.1%) locations could be attributed to the level of organic pollution and high Biochemical Oxygen Demand in the study areas which favour breeding of the species and *Aedes* mosquito as against *Anopheles* which prefer open clean, clear and sunlight water for breeding. Similarly, abundance of some *Culex* species has been attributed to the ability of the mosquito to breed in virtually any available space that can hold water such as tanks, pits, ditches, culvert and any other available water body due to urbanization and free rearing of livestocks [25]. Most of the mosquito species encountered in this study area are potential vectors of one mosquito-borne diseases or the other

Aedesaegypti and *Sabethes* species found in the study area are proven vectors of yellow fever and other arbovirus disease (Service, 2012). *Culex* species found especially in Bali and Donga sites are known vectors of bancroftianfilariasis [26].

This study showed that adult mosquito of different species (Anophelines and Culicines) were found indoor in the study area which shows that some mosquito species of sub-families anophelinae and culicinae exhibit some similar behaviour/habit.

4.2 Monthly/Seasonal Distributions of mosquito species in the study area

The fact that the mosquito abundance coincides to a great extent with period of rainfall is an indication that rainfall plays significant role in mosquito population dynamics. This implies that in all the study areas, abundant rainfall and duration, temperature and relative humidity are probable factors that determine abundance of mosquito due to availability of breeding sites throughout the year. This is similar to findings of researchers who reported higher population of mosquito in wet than in dry season in Sahel region of Nigeria [12, 13]. It was observed that *Sabethes* species was only found in Ardo Kola towards the end of wet season and has not been reported anywhere in Nigeria. The ‘elephant mosquito’, *Toxorhnychites*, though don’t feed on blood was found in study areas towards the end of wet season, the end of dry season and peak of wet season (hot season) [plate 1] Such mosquito had only been reported to have been found in one village in Oba town, Idemili South LGA of Anambra state, Nigeria (27).

Another noteworthy finding about this study is the observed gravid *Culextarsalis* infected with larva of hydracarine mite collected in Bali, one of the study location during wet season which have not been reported elsewhere, although the case of the hyper parasitism was described by the World Health Organisation handbook [28] [plate 1A]

V. Conclusion

The diversity of the culicine mosquitoes in the study area is an indication that the inhabitants are at the risk of mosquito-borne diseases. This calls for further investigation on the ecology of this sub family and review of management strategies that will enhance the control

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