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Mosquito Species Diversity And Distribution in Three Riverine Communities in Taraba State, North-Eastern Nigeria

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Abstract: *Mostmosquitoes are nuisance and public health problem because the females consume blood and transmit diseases. Studies were carried out between September, 2015 and August 2016 to determine the composition and abundance of mosquito species in Taraba state, Nigeria. Indoor mosquitoes in riverine communities of Mayorenewa (Ardo Kola), Bali and Gyatanaure (Donga) were collected using Pyrethrum-Spray Catch complemented with electronic mosquito bat.A total of 3369 mosquitoes were collected comprising five genera: Anopheles 1686 (50.0%), Culex 1587 (47.1%), Mansonia 67 (2.0%), Sabethes 18 (0.5%), Toxorynchites 6 (0.2%) and Aedes 5 (0.2%). Species were identified using morphological and PCR-Restriction Length Fragment Polymorphism assay. Among the 2179 identified species 758 (34.7%) were An.gambiaesensulato..Characterisation of sibling species and molecular forms of An.gambiaes.l by PCR-RLFP* ***showed:*** *An.coluzzii 725 (95.6 %,), An.gambiae 24 (3.2%), An. coluzzii/An.gambiae hybrid 9 (1.2%) and Anopheles arabiensis 1 (0.19%). Shannon-Wiener and Simpson's biodiversity index analysis showed that An. coluzzii was most predominant (indices 0.159 and 0.110) followed by Cx.pipiens(indices 0.13 and 0.029) and Cx. pilosus (indices 0.11 and 0.075). The least encountered species were An. pariensis, An.arabiensis and An. hancoki (indices 0.0015 and 0.0000002).Ardo Kola had the least diversity but highest dominance (0.6302 and 0.458), Bali had highest diversity, but moderate species frequrency (0.875 and 0.1425), whereas Donga had moderate diversity and dominance (0.8383 and 0.1936). Ardo Kola, Bali and Donga contributed 33.0%, 33.4% and 33.5% of identified mosquito species in the sudy area respectively. Analysis of variance showed no significant difference in abundance of species in study areas (P>0.05)*

Keywords: *mosquito, Shannon-Wiener and Simpson's indices, speciesdiversity,Taraba state*

I. Introduction

Insects are the most successful and abundant class among the arthropods.. Their wide distribution can be attributed to a number of factors especially their powers of flight and their highly adaptable nature. Although insects are beneficial to man, some are vital players in the transmission of certain diseases to humans. Some insects such as fleas, sandfly, tsetse fly, lice and mosquitoes are vectors of human and domesticated animal disease pathogens either directly or indirectly as they transmit such pathogens (1,2,3).

Mosquitoes (OrderDiptera, Suborder Nematocera) are family of small midge –like flies: the Culicidae.Most are considered a nuisance and a major public health problem, because the females consume blood from living vertebrates, including humans and in doing so transmit harmful diseases such as malaria, yellow fever and filariasis (4).The behavior of mosquitoes determinewhether they are important as nuisance insects or vectors of disease. Species that prefer to feed on animals are usually not very effective in transmitting diseases from person to person. Several mosquito vectors in different genera and species have been incriminated with the transmission of serious diseases (5).Mosquitoes are estimated to transmit diseases to more than 700 million people annually and responsible for the death of about 1 in 17 people (6). Effective transmission of mosquito- borne disease requires successful contact between female mosquitoes and their hosts. These contacts are established whenever mosquitoes by means of a feeding behavior, locate the host by responding to chemical, physical and visual cues emanated by the host from which they obtain blood meals necessary for egg development (7).

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 (8,9). Among Anophelinae, the genus Anopheles is best known for its role in transmitting malaria worldwide, but in some areas it can also transmit filariasis (1, 11, 12 13). The culicines, which include the genusCulex, 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 Sabethesare vectors of yellow fever in the forests of South and Central America (5).

A number of surveys have been carried out on mosquito species using different methods.Sixteen mosquito species were reported in Imo state, South-east Nigeria including Anophelesconstani and Toxorhnychiteviridibasis (13).Eight mosquito species in Oba, Anambra state comprising four genera: Anopheles

gambiae, Anopheles funestus, Aedesaegypti, Aedesalbopictus, Aedesafricanus, Culexquinquefasciatus, Culextigripes and Toxorynchitesviridibasis (14). While ten specieswere collected in Abeokuta, Ogun state, Nigeria includingMansonia Africana and Mansoniauniformis (15).

Anopheles gambiaes.l., Anopheles funestus complex, Anopheles pharoensis,Anopheles rhodensiensis, Culexquinquefasciatus,Culexpipiensfatigans and Cx. tigripewere collected in Yola, Adamawa state, North-eastern Nigeria (16), while in three areas of Adamawa state An. gambiae complex, An. funestus, An. pharoensis,An. rhodensiensis, An. rufipes, Cx. quinquefasciatus, Cx. fatigans, Cx. tigripes, Ae.albopictus, Ae. africanus, Ae. aegypti, Ae. simpsoni and Mansoniaafricanus.were recorded (17).Four mosquito species (Anopheles gambiae, Anopheles funestus,Anopheles arabiensis and Culexpipiens) were however recorded in Katsina state, Nigeria (18)

This study was carried out to investigate mosquito species composition, distribution and relative abundance in three riverine communities of Taraba state, North-eastern Nigeria. It will contribute to the epidemiology of mosquito-borne diseases in the areas

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 and 10^{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. It has an estimated population of 2,688,944 based on 2006 census, giving a population density of 27 people per km^{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 The study was carried out in three riverine communities: Mayorenewo, Bali and Gyatanaure located in three sub-uban local government areas of Taraba state, Northern Nigeria. These are Ardo Kola (Northern zone, 8^{o} 40' – 9^{o} 12' N; 10^{o} 58' – 11^{o} 33'E), Bali (Central zone, 7^{o} 22'- 8^{o} 48'N; 10^{o} 17' – 11^{o} 49'E), and Donga (Southern zone, 7^{o} 15' – 7^{o} 56'N; 9^{o} 47'- 10^{o} 42'E) respectively(Figure 1)

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.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 the state. Rainy season is between May and early October and dry season between November and April. Mean day temperature varies from 37^{o}C to 40^{o}C during the hottest months of March/April. It also varies from 32^{o}C to 37^{o}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 peak season in July/August

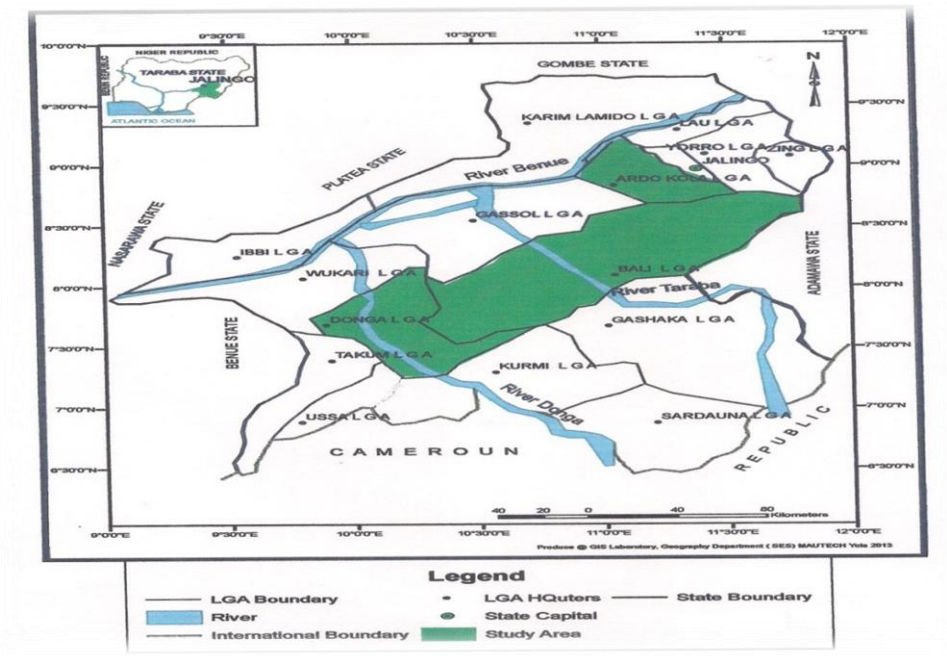

Figure 1: map of Taraba state, Nigeria showing the study areas

2.2 Mosquito sampling

Indoor mosquito collections were carried out every month of the study period, September 2015 to August 2016 in each of the areas. Ten bedrooms were selected randomly from each station with at most three bedrooms from the same house. 360 (12 months x10bedrooms x3 stations) rooms were sprayed during the entire period of study.

Collection of mosquitoes by use of non-residual insecticide- pyrethrum (Spread Sheet Collection) was employed using World Health Organisation (WHO) standard procedure (19, 20,) and complemented with electronic mosquito bat. All knocked down mosquitoes were collected in properly labelled Eppendorf tubes and preserved over silica gel.

2.3 Identification of mosquitoes

2.3.1 Morphological 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 (5). 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 both digital compound and dissecting microscope following the taxonomic keys (21, 22, 23, 24, 25)

2.3.2 Molecular identification of the Anopheles species complex

The multiplex PCR tehnique was used for the identification of sibling species of collected Anopheles gambiae complex (26, 27). PCR-Restriction Fragment Length Polymorphism (RFLP) analysis was done for amplication of a fragment containing the variation followed by treatment of the amplified fragment with an appropriate restriction enzyme. The formation of restriction fragments of different sizes (alleles) and their identification was done by electrophoretic resolvement (28.). The PCR-RFLP analysis was carried out at the molecular entomology and vector control research laboratory, Nigerian Institute of Medical Research, Yaba Lagos

2.4 Data analysis

Analysis of variance (ANOVA) was used to determine the significant difference between mosquito abundance in relation to study areas. Shannon-Weiner Index was used to analyse the species diversity in the study area. It takes account of the total number of species in the sample expressed as richness and how the species abundances are distributed among the species, expressed as evenness. It is expressed as $\mathbf{H = (N\ logN - \sum n_i logni)/N}$, where $n_i$is the abundance and N the total number of of individuals in the species. Also, Simpson's dominance indices was used to evaluate the prevalence of each individual species and it measures the probability of picking two organisms at random that are of different species. It is expressed as $\mathbf{C = \sum (ni/N)^2}n_i$ = number of individuals of nth species, N = total number of individuals for all species (29, 30, 31)

III. Discussion

Most of the species reported in this study have also been reported elsewhere in Nigeria by different researchers.This finding is in agreement with those of Katsina stateKwara state where Anopheles species were the most abundant mosquito species generally (18, 32). Although in Donga study area of this study Culex species were predominant as observed in Anambra state, Mid Western Nigeria and Yola (14, 33, 34) However, none had reported the presence of Sabethes mosquito in Nigeria before this finding. In Imo state and Anambra state presence of Toxorynchite species had been reported (13, 14) as in the present study . It should be noted that species in Bali were most diverse and the least was Ardo Kola (indices of 0.875 and 0.636 respectively) because of uneven distribution of species in the latter (Table 3) (29, 30, 31)

Most of the species encountered in this study are potential vectors of one mosquito-borne disease or the other of which their high prevalence has been reported in neighbouring states of Benue state (34) where Culexspecies peaked (80%) as found in Donga area (82.5%) of Taraba state and Yola (16). At similar ecological zone of Kwara state there was report of predominant Anopheles species (93.3%) (32) close to that of Mayorenewa (Ardo Kola) (89.0%) of Taraba state. The high prevalence of Anophelesgambiaes.l species in the study area is of epidemiological importance because they are proven vectors of malaria and lymphatic filariasis (33, 36). Aedesaegypti and Sabethes species found in this study are proven vectors of yellow fever and other arbovirus diseases (Service, 1986). Culex species identified during the study especially in Bali and Donga sites are known vectors ofbancroftianfilariasis (37)

Sibling species of Anopheles gambiae complex in the study areas were fresh water species of Anopheles gambiaesensustricto and Anopheles arabiensis occurring in sympatry. Relative Abundance of Anopheles gambiaes.s over Anopheles arabiensis and their sympatric occurrence had been reported by other

reserchers (26, 32, 38, 39). The only report of the occurrence of the Anophelescoluzzii/Anopheles gambiae hybrid in Nigeria 1 (0.5%) was in forest zone of Ibadan, Western Nigeria (40).

Toxorynchites larvae species whose adult does not bite humans are known to prey on other mosquito species larvae (13). This is a welcome development since this species as found in Ardo Kola and Donga sites can serve as effective biological control agents for source reduction of other mosquito species. Therefore the availability of Aedes, Sabethes, Culex, Mansonia and Anopheles which are known vectors of yellow fever (Aedes and Sabethesonly), filariasis (Culex, Mansonia and Anopheles) and malaria (Anopheles only) suggests that the residents of the study areas are at risk of mosquito-borne diseases.

4.1 Conclusion

The diversity of mosquito species found indoor in the study areas and the hybridization of Anopheles gambiae and Anopheles coluzzii in one of the area as an adaptation to the environment are of public health concern. This calls for further investigation and review of policies and management strategies based on emerging knowledge in these localities

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References

[1]. Service, M. W. Medical entomology for Students 3rdEd(Cambridge Univeristy press, UK,.Ed by Soper, R 2004)
[2]. Tyagi, B.K..Medical entomology:A Handbook of Medically important Insects and other Arthropods. (Pawan Kumar Scientific Publishers, India, 2003)
[3]. Segun, A.O; (1989). Tropical Zoology University Press Limited, Ibadan
[4]. Wikipedia (2014a). Mosquito.www.wikipedia.com. Accessed on 27/5/2014
[5]. Service, M.W.A Guide to Medical Entomology(The Macmillan Press Ltd., London and Basingstoke 1980)
[6]. World Health Organisation. Technical Report series 892, WHO expert committee on Malaria. Geneva, 2000
[7]. Clement, A.N.: The physiology of Mosquitoes.(Pergamon Press, London. 393, 1963)
[8]. Wikipedia (2014b). Ecology of Malaria. Centers for Disease Control and Prevention, CDC 24/7. www.wikipedia.com
[9]. Wikipedia (2014c): Mosquito control. www.wikipedia.com
[10]. Godfray, H.C.J. Mosquito ecology and control of malaria, Journal of Animal Ecology, British Ecological Society.2013: 82, 15 – 25
[11]. Awolola, T.S; Okwa, O; Hunt, R.H; Ogunrinade A.F; and Coetzee M. Dynamics of the malaria-vector populations in coastal Lagos, south-western Nigeria, Annals of TropicalMedicine and Parasitology, 96 ((1), 2002, 75-82
[12]. World Health Organisation. World Malaria Report (2013). WHO, Geneva, 2013, http://www.rbm.who.int/htm
[13]. Anosika J.C. Nwoka B.E., Okere A.N., Oku E.E., Asor J.E., Emmy-Egbe I.O., Adimike D.A. Epidemiology of Tree-hole Breeding Mosquitoes in The Tropical Rainforest of Imo state, Southeast Nigeria. Annals of Agric and Environ. Medicine 14, 2007, 31-38
[14]. Okwokwo, N.J., Obiechina, I.O, Ugba, C.N,Irikanu, K.C., Obianunba, S.N., Okoyo- Uzochukwu, C.I., iwuora, O.I and Chinweke, J.O. Mosquito species composition in Oba, Idemili South Local Government Area of Anambra state. Researcher 6 (8), 2014, 51-56
[15]. Adeleke, M.A; Mafiana, C.F; Idowu, A.B; Adekunle, M.F; Sam-Wobo, S.O. Mosquito larva Habitats and Public health implication in Abeokuta, Ogun state, Nigeria.TanzanianJournal of Health Reseearch10 (2), 2008, 103-107
[16]. Umaru N.F., Akogun O.B., OwuamaC.J . Species identification of Anopheles and Culexmosquitoes and its epidemiological implications in Yola, Nigeria. Nigerian Journal ofParasitology 27(1), 2006, 22-31
[17]. Pukuma, M.S.Habitat Characterisation, Mosquito species diversity and Distribution inrelation to Malaria transmission in three locations of Adamawa State, Nigeria.Phd thesis, ModibboAdamaUniveristy of Technology, Yola, 2011
[18]. Bunza M.D., Suleiman A.A., Yusuf A.M., Bala A.Y.Relative abundance of mosquito species in Katsina metropolis Nigeria. Nigerian Journal of Parasitology31(2), 2010, 73-78
[19]. World Health Organisation.Malaria Entomology and Vector Control. WHO Learners Guide, WHO/CDC/CPE/SMT/2002.18 Rev.1, 2003
[20]. World Health Organisation.Manual on practical entomology in Malaria, WHO Division of malaria and other parasitic diseases, Geneva, part 1, chap 1-5, 1975
[21]. Gilles, M.T. and Coetzee, M.A. supplement to the Anophelinae of Africa South of theSahara. South African Institute for Medical Research, Johannesburg, No 55, 1987
[22]. Gilleth, J.D and Smith, J.G. Common African mosquitoes and their Medical Importance,(William Heinemann Medical Books Ltd, London, 1972)
[23]. Anon. Identification of Anopheles and Culex mosquitoes28 (2), 2001 www.ajol.info.journal
[24]. Anon (N.D): Highton Key for identification of Afro-tropical mosquito www.researchgate.net/publications
[25]. Leopoldo, M.R (2004): (ZOOTAXA 589) - Pictorial Key for the Identification of Mosquitoes (Diptera: Culicidae) associated with Dengue Virus Transmission. Magnolia press Auckland, New Zealand. www.mapress.com/ZOOtaxa/
[26]. World Health Organisation. World Malaria Situation 2003 – 2006 part 1, Population at risk, Weekly epidemiological Record 72(36), 2006, 269-274
[27]. WHO/CDC/ATCC/NIH. Methods in Anopheles Research. 2nd edition, Atlanta, USA, 2010

[28]. Henrik, B.R. Restriction Fragment Length Polymorphism Analysis of PCR-Amplified fragment (PCR-RFLP) and Gel Electrophoresis-Valuable Tool for Genotyping and Genetic Fingerprinting. Gel Electrophoresis – Principles and Basics, 2012. Available at www.intechopen.com/books pp 315-334
[29]. Hill, M.O. 'Diversity and eveness: a unifying notation and its consequences'. Ecology, 54, 1973,427 - 432
[30]. Molles, M.C. Species abundance and diversity, Ecology: Concepts and Applications 4th ed. (Mc GrawHill New York, 2008) pp 370-390
[31]. Wikipedia (2017): Student Hand out: How to Calculate Biodiversity Index. www.protectingusnow.org. Accessed 07/02/2017
[32]. Oduola, A. O., Adelaja, O. J., Aiyegbusi, Z.O., Tola, M., Obembe, A., Ande, A.T. and Awolola, S. Dynamics of anopheline vector species composition and reported malaria cases during rain and dry seasons in two selected communities of Kwara state. Nigeria Journal of Parasiotlogy,37(2) September, 2016
[33]. Okogun G.R., Anosike J.C., Okere A.N., Nwoke B.E. Ecology of mosquitoes of Midwestern Nigeria.Journal of Vector-Borne Disease 42, 2005,1-8
[34]. Aju-Ameh, C., Awolola, T., Mwansat, G. and Mafuyai, H. The Dominant Anopheles Vectors of Human Malaria InGboko and Otukpo Local Government areas of Benue state, North Central Nigeria. Paper delivered at 3rd Annual Conference of Pan-African Mosquito Control Association, Ikeja, Lagos, 6-9 September, 2016, Abstract book pp 32-33
[35]. Awolola, T.S; Okwa, O; Hunt, R.H; Ogunrinade A.F; and Coetzee M. Entomological survey and infection rates of Plasmodium falciparum and W. bancrofti in mosquito populations in the kainji lake area, Nigeria. Nigeria Journal of Parasitology27, 2006, 58-61
[36]. Amusan A.A., Mafiana C.F., Idowu A.B and Oke O.A. A survey of adult mosquitoes in the hostels of the University of Agriculture, Abbeokuta, Ogun state Nigeria. Nigerian Journal of Parasitology24, 2003, 167-172
[37]. Oyewole, I.O., Ibidapo, C.A., Oduola, A.O., Obansa, J.B. and Awolola, T.S.Anthropophilic Mosquitoes And Malaria Transmission In A Tropical Rain Forest Area of Nigeria. Journal of Life and Physical Sciences, www.actasatech.com, actaSATECH: 2(1), 2005, 6-10
[38]. Ebenezer, A., Noutcha, A.E., Agi, P.I., Okiwelu, S.N.and Commander, T. Spatial Distribution Of The Sibling Species Of Anopheles gambiaesensulato And Malaria Prevalence In Bayelsa State, Nigeria. Parasites and Vectors2014: 7: 32
[39]. Ototo, E.N., Mbigi, J.P., Wanjala, C.L., Zhou, G., Githeko, A.K. and Yan, G.Survellance of malaria vector population density and biting behavior in Western Kenya. Malaria Journal, 2015: 14:244
[40]. Okorie, P.N., Ademowo, G. O., Irving, H., Hope, L. A and Wondi, C.S. (2015): Insecticides susceptibility of Anopheles coluzzii and Anopheles gambiae mosquitoes in Ibadan, South-West Nigeria. Med. Vet. Entomol. 29(1),2015, 44-50

Table 2: Comparisons of Species Diversity and Dominance Indices for Mosquitoes collected from **the three study areas in Taraba state**

mosquito species	Ni	Pi= ni/N	P^2= $(ni/N)^2$	Pi Log Pi	Shannon- Wiener diversity index	Simpson's dominance index $C=\sum(ni/N)^2$
Anopheles coluzzii	725	0.332	0.11	-0.16	0.16	0.11
An. gambiae	24	O.011	0.00012	-0.021	0.021	0.00012
An. gambiae M/S	9	0.0041	0.000016	-0.0098	0.0098	0.000016
An. arabiensis	1	0.0005	2.1E-07	-0.0015	0.0015	0.00000021
An. pharoensis	4	0.0018	0.0000034	-0.005	0.005	0.0000034
An. garrhami	10	0.0046	0.000021	-0.011	0.011	0.000021
An. rufipes	21	0.0096	0.000093	-0.019	0.019	0.000093
An. Salbaii	37	0.017	0.00029	-0.029	0.029	0.00029
An. caliginosus	2	0.0009	8.4E-07	-0.0028	0.0028	0.00000084
An. concolor	2	0.0009	8.4E-07	-0.0028	0.0028	0.00000084
An. constani	86	0.039	0.0015	-0.055	0.055	0.0015
An. rhodensiensis	4	0.0018	0.0000034	-0.005	0.005	0.0000034
An. maculipalpis	6	0.0027	0.0000076	-0.0069	0.0069	0.0000076
An. rivulorum	124	0.057	0.0032	-0.071	0.071	0.0032
An. aruni	7	0.0032	0.00001	-0.008	0.008	0.00001
An. funestus	4	0.0018	0.0000034	-0.005	0.005	0.0000034
An. tenebrosus	3	0.0014	0.000002	-0.004	0.004	0.000002
An. hancoki	1	0.0005	2.1E-07	-0.0015	0.0015	0.00000021
An. nili	2	0.0009	8.4E-07	-0.0028	0.0028	0.00000084
An. pariensis	1	0.0005	2.1E-07	-0.0015	0.0015	0.00000021
Cxquinquefasciatus	250	0.115	0.013	-0.108	0.108	0.013
Cx. molestus	75	0.034	0.0012	-0.05	0.05	0.0012

Cx. pipiens	373	0.171	0.029	-0.13	0.13	0.029
Cx. tarsalis	62	0.028	0.00079	-0.043	0.043	0.00079
Cx. pilosus	266	0.122	0.015	-0.11	0.11	0.015
Aedesaegypti	5	0.002	0.0000046	-0.0054	0.0054	0.0000046
Mansoniauniformis	68	0.031	0.00097	-0.047	0.047	0.00097
Sabethescyaeneus	5	0.002	0.0000046	-0.0054	0.0054	0.0000046
Toxorhynchitespeciosus	6	0.0027	0.0000076	-0.0069	0.0069	0.0000076
Total	N = 2182	∑ 0.988	∑ 0.175	∑ -0.928	H = 0.928	C = 0.175

Key: ni = abundance of individual species in the ith

Pi = Proportion of individuals in the ith species i.eni/N

N = total number of individuals of all species

C = Simpson's dominance index

H = Shannon-Wiener index of diversity, H = (NlogN - ∑nilogni)/N

Table 3: Summary of Index of Diversity for mosquito species composition in the three areas of Taraba state

Mosquito species	Shannon - Wiener Index of Diversity		
	Ardo Kola	Bali	Donga
Anopheles coluzzii	0.117	0.14	0.11
An. gambiae	0	0.049	0
An. gambiae M/S	0	0.023	0
An. arabiensis	0	0.004	0
An. pharoensis	0.01	0.004	0
An. garrhami	0.019	0.0098	0
An. rufipes	0.047	0	0
An. Salbaii	0.06	0.007	0.0069
An. caliginosus	0	0.004	0.004
An. concolor	0.004	0.004	0
An. constani	0.081	0.062	0.0069
An. rhodensiensis	0.01	0	0
An. maculipalpis	0.01	0.0098	0
An. rivulorum	0.056	0.019	0.064
An. aruni	0.01	0	0.012
An. funestus	0.01	0.004	0
An. tenebrosus	0	0.0098	0
An. hancoki	0.0041	0	0
An. nili	0.0041	0.004	0
An. pariensis	0	0	0.004
Cxquinquefasciatus	0.015	0.133	0.127
Cx. molestus	0.04	0.052	0.057
Cx. pipiens	0.043	0.125	0.16
Cx. tarsalis	0.015	0.053	0.057
Cx. pilosus	0.026	0.13	0.134
Aedesaegypti	0	0.0069	0.0096
Mansoniauniformis	0.027	0.022	0.079
Sabethescyaeneus	0.015	0	0
Toxorhynchitespeciosus	0.013	0	0.0069
Total	0.6362	0.8753	0.8383

Mosquito species	**Shannon - Wiener Index of Diversity**		
	Ardo Kola	**Bali**	**Donga**
Anopheles coluzzii	0.447	0.044	0.015
An. gambiae	0	0.0011	0
An. gambiae M/S	0	0.00015	0
An. arabiensis	0	0.0000019	0
An. pharoensis	0.000017	0.0000019	0
An. garrhami	0.000094	0.0000017	0
An. rufipes	0.00095	0	0
An. Salbaii	0.0021	0.0000074	0.0000074

An. caliginosus	0	0.0000019	0.0000019
An. concolor	0.0000019	0.0000019	0
An. constani	0.0048	0.002	0.0000074
An. rhodensiensis	0.000031	0	0
An. maculipalpis	0.000017	0.0000017	0
An. rivulorum	0.0016	0.0084	0.0014
An. aruni	0.000017	0	0.000296
An. funestus	0.000017	0.0000019	0
An. tenebrosus	0	0.0000017	0
An. hancoki	0.0000019	0	0
An. nili	0.0000019	0.0000019	0
An. pariensis	0	0	0.0000019
Cxquinquefasciatus	0.000048	0.032	0.025
Cx. molestus	0.00007	0.0013	0.0017
Cx. pipiens	0.00079	0.024	0.11
Cx. tarsalis	0.000048	0.0014	0.0017
Cx. pilosus	0.00019	0.028	0.034
Aedesaegypti	0	0.000004	0.000017
Mansoniauniformis	0.00023	0.00012	0.0045
Sabethescyaeneus	0.0007	0	0
Toxorhynchitespeciosus	0.000031	0	0.0000075
Total	0.4587557	0.1424979	0.1936391

Table 4 shows the summary for indices of dominanace (abundance) for mosquito species in the three study areas. The result indicates that some species (of a subfamily) were most often encountered at Ardo Kola (Total Simpson's index of 0.458), another (of a subfamily) at Donga (Total Simpson's index of 0.194) and fair (generally moderate) at Bali (Total Simpson's index of 0.143). *Anopheles coluzzii* was the most predominant species in both Ardo Kola and Bali with indices of 0.447 and 0.044 respectively, followed by *Anophelesconstani* (index 0.0048) in Ardo Kola and *Culexquinquefasciatus* (index 0.032) in Bali. The predominat species in Donga was *Culexpipiens* followed by *Culexpilosus* with indices of 0.11 and 0.034 respectively. As stated earlier one or more species were totally absent in one or two areas, but present in other area(s).

Table 3: Summary of Index of Diversity for mosquito species composition in the three areas of Taraba state

Mosquito species	Shannon - Wiener Index of Diversity		
	Ardo Kola	Bali	Donga
Anopheles coluzzii	0.117	0.14	0.11
An. gambiae	0	0.049	0
An. gambiae M/S	0	0.023	0
An. arabiensis	0	0.004	0
An. pharoensis	0.01	0.004	0
An. garrhami	0.019	0.0098	0
An. rufipes	0.047	0	0
An. Salbaii	0.06	0.007	0.0069
An. caliginosus	0	0.004	0.004
An. concolor	0.004	0.004	0
An. constani	0.081	0.062	0.0069
An. rhodensiensis	0.01	0	0
An. maculipalpis	0.01	0.0098	0
An. rivulorum	0.056	0.019	0.064
An. aruni	0.01	0	0.012
An. funestus	0.01	0.004	0
An. tenebrosus	0	0.0098	0
An. hancoki	0.0041	0	0
An. nili	0.0041	0.004	0
An. pariensis	0	0	0.004
Cxquinquefasciatus	0.015	0.133	0.127
Cx. molestus	0.04	0.052	0.057
Cx. pipiens	0.043	0.125	0.16
Cx. tarsalis	0.015	0.053	0.057
Cx. pilosus	0.026	0.13	0.134
Aedesaegypti	0	0.0069	0.0096
Mansoniauniformis	0.027	0.022	0.079
Sabethescyaeneus	0.015	0	0
Toxorhynchitespeciosus	0.013	0	0.0069
Total	0.6362	0.8753	0.8383
Mosquito species	**Shannon - Wiener Index of Diversity**		

	Ardo Kola	**Bali**	**Donga**
Anopheles coluzzii	0.447	0.044	0.015
An. gambiae	0	0.0011	0
An. gambiae M/S	0	0.00015	0
An. arabiensis	0	0.0000019	0
An. pharoensis	0.000017	0.0000019	0
An. garrhami	0.000094	0.0000017	0
An. rufipes	0.00095	0	0
An. Salbaii	0.0021	0.0000074	0.0000074
An. caliginosus	0	0.0000019	0.0000019
An. concolor	0.0000019	0.0000019	0
An. constani	0.0048	0.002	0.0000074
An. rhodensiensis	0.000031	0	0
An. maculipalpis	0.000017	0.0000017	0
An. rivulorum	0.0016	0.0084	0.0014
An. aruni	0.000017	0	0.000296
An. funestus	0.000017	0.0000019	0
An. tenebrosus	0	0.0000017	0
An. hancoki	0.0000019	0	0
An. nili	0.0000019	0.0000019	0
An. pariensis	0	0	0.0000019
Cxquinquefasciatus	0.000048	0.032	0.025
Cx. molestus	0.00007	0.0013	0.0017
Cx. pipiens	0.00079	0.024	0.11
Cx. tarsalis	0.000048	0.0014	0.0017
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Table 4 shows the summary for indices of dominanace (abundance) for mosquito species in the three study areas. The result indicates that some species (of a subfamily) were most often encountered at Ardo Kola (Total Simpson's index of 0.458), another (of a subfamily) at Donga (Total Simpson's index of 0.194) and fair (generally moderate) at Bali (Total Simpson's index of 0.143). *Anopheles coluzzii* was the most predominant species in both Ardo Kola and Bali with indices of 0.447 and 0.044 respectively, followed by *Anophelesconstani* (index 0.0048) in Ardo Kola and *Culexquinquefasciatus* (index 0.032) in Bali. The predominat species in Donga was *Culexpipiens* followed by *Culexpilosus* with indices of 0.11 and 0.034 respectively. As stated earlier one or more species were totally absent in one or two areas, but present in other area(s).