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CONTRIBUTIONS OF COMMERCIAL WATER-BASED HUMAN ACTIVITY VENTURES, TO MOSQUITO (DIPTERA: CULICIDAE) IN MINNA METROPOLIS, NIGERIA

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ABSTRACT

Mosquitoes thrive in almost all aquatic habitats of which most are human induced; and inherent prevailing physicochemical parameters are important factors in the productivity of Mosquitoes. This premise formed the basis of the present study in Minna, North–Central, Nigeria. Four kinds of peri-domestic commercial ventures were selected for the study namely, (Fish pond, Block industry, Flower garden and Car wash centres) during April-June 2014. Sampling of mosquitoes and physicochemical analysis were carried out following standard protocols. A total of 6101 mosquitoes comprising of 3 genera: *Aedes, Culex and Anopheles,* were collected in order of preponderance; *Cx. pipiens* (3,077, 50.43%), *Cx. territans* (1,455, 23.85%), *Cx. salinarius* (595, 9.75%), *An. fransicanus* (267, 4.38%), *Ae. aegyti* (243, 3.98%), *Cx nigripalpus* (184, 3.02%), *Cx. tarsalis* (140, 2.94%), *An.quadrimaculatus* (124, 2.03%) and *Ae. albopictus* (16, 0.26%),. Flower gardens were the most productive, distantly followed by Block industries, Fish ponds and Car wash centres, which accounted for 45.25%, 28.96%, 13.67% and 12.11% respectively, of the Mosquito species collected. Analysis of Physicochemical parameters of the various water bodies, showed that apart from pH (7.05±0.15 - 8.24±0.51) and Nitrate (mg/l)(0.08±0.02 - 0.14±0.07) which shows no significant variation ($p>0.05$), other parameters investigated conductivity (mS/cm)(92.50±32.50-172.50±23.50), DO (mg/l)(8.00±1.0010.00±2.00), Alkalinity (39.00±9.00 -11.00±2.00m/l), Hardness (mg/l),(111.00±3.00-133.00±15.00), Total dissolve solids (mg/l) (48.70±30.90-67.70±18.90), Nitrate (mg/l)(0.08±0.02-0.14±0.07), Phosphate (mg/l) (0.50±0.00-2.52±1.91), BOD (mg/l)(3.50±1.50-8.00±2.00) and Carbonate (mg/l) (3.28±0.12-5.87 ±0.59) varied significantly among the larval habitats. The information can be incorporated in the development of site-specific and cost-effective mosquito vector control strategies.

Keywords: *Culex, Anopheles, Aedes, Productivity,Vectors*

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INTRODUCTION

Mosquito-borne diseases have remained the world leading health problem over the decades and, according to reports, it is estimated that at least 500 million people suffer from mosquito-borne diseases, and more than 1.1 million people die of malaria annually (Rueda, 2008). Others bite humans routinely acting acts as vectors for a number of infectious disease affecting millions of people per year (Molavi, 2003). These diseases have accounted for huge economic loss, mortality, low productivity and social discrimination in many developing countries (Adeleke *et al.*,2010). Mosquitoes are cosmopolitan vectors which breed in any available aquatic environment, though different species have different habitat preferences. While, mosquito breeding habitats can be natural or manmade (Vanek *et al.*, 2006), others are indoor breeders, some preferred breeding outside. As more people move into cities and industrialization proceeds, urban malaria increases in Nigeria (Brieger *et al.*, 2001). Human peri-domestic water based commercial centres are creating more suitable habitats free from predators such as Rice fields, Pools, Puddles, Wheelbarrows, plastic and metal cans Cesspits, Flower vests, Ponds, Construction site, Tyres and Drainage systems (Okogun, *et al.*, ;2005;. Sattler, *et al.*, 2005: Yee, 2008). Thus, making available numerous habitat options for different species of mosquitoes. Therefore, it is of paramount importance that these vectors be controlled, especially in their larval stages thus preventing them from growing into adult biting mosquitoes. Such strategic interventions, particularly, those that will complement existing adulticiding measures, are required to build truly integrated mosquito-vector control programs. To this end, larval control measures are being reappraised and recommended for immediate adoption in areas where these diseases are prevalent (Fillinger *et al.*, 2004; Sogoba *et al.*, 2007). The physicochemical nature of water bodies plays important roles in mosquito abundance and survival (Chen *et al.*, 2007). The concentration of nutrients in water fosters the growth of micro organisms such as bacteria, fungi, protozoa, yeast, etc, which serve as food source to mosquitoes.

However, successful larval control requires a good knowledge of the breeding ecology of mosquitoes including, types of and preferences for larval habitats, spatial and temporal distribution of breeding sites, as well as, the physical, biological and chemical characteristics of the habitats. Some of these variables have been systematically investigated in Nigeria (Das and Chandra, 2012; Joseph *et al.*, 2010; Kovendan *et al.*, 2012; Olayemi *et al.*, 2010; Opoku *et al.*, 2005; Reisen and Meyer 1990).

Thus, this study was carried out to assess the types of mosquito species, and establish the relationships between the physicochemical characteristics and larval abundance breeding in water-based human activity centres in the area.

MATERIALS AND METHODS

Description of Study Site

Minna is the capital of Niger state, north central Nigeria. Minna is located within longitude 6^0 33 E and latitude 9^0 27 ' N, covering a land area of $88km^2$ with an estimated human population of 1.2 million. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20^0C, 61.00% and 1334.00mm, respectively. The climate presents two distinct seasons; a rainy season between May and October and a dry season (November - April). The vegetation in the area is typically grass-dominated savannah with scattered trees.

Selection of Water-based Human Activity Area

Four areas in Minna and environs were selected in carrying out this research. Bosso Local Government, River Basin area, Maikunkele and Tunga. A total of four conventional habitats created by human commercial activities were used, namely Car wash centres, Fish ponds, Block industries, Horticulture gardens. Two replicate of each type of mosquito collection sites were selected.

Collection, Processing, Identification and Analysis of Mosquitoes

Larvae were sampled weekly from the month of April-June 2014. Sampling was done between the hours of 6.0-8.0 am and 4.0-6.0 pm. Using a standard 350 ml capacity Dipper, mosquito larvae were randomly collected and where this was not possible, especially with flower Containers, water from a number of breeding sites was pooled to make-up the required volume. Ten dipper samples were taken randomly from each sampling site, and the mosquito larvae were preserved immediately in 10% formaldehyde solution. The larval specimens were identified to species with the aid of standard Taxonomic keys (Gillies and De Meillon, 1968; Highton, 1983; Gillies and Coetzee 1987).

Collection and fixation of Water Sample for Analysis

Water samples for physicochemical analysis were collected from the four habitat types investigated, using 500ml capacity specimen bottles. The water was fixed immediately following the techniques of APHA (1997). However, water Temperature was determined at the sites during larval collection using Alcohol in glass Thermometer.

Physicochemical Analysis of Water Samples

Water samples were analyzed for the following Physicochemical Parameters: Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Alkalinity, Hardness, Conductivity, pH, and concentrations of Nitrate (NO3), Phosphate (PO4), Sulphate (SO4) and Carbonate (CO3). Analyses of these parameters were carried out following the methods described by APHA (1997).

Data Analysis

The abundance of each mosquito species was determined as the mean frequency of occurrence. Differences in physicochemical properties among habitat types were determined using standard error.

Table 1: Occurrence of Mosquito Species from Water-Based Human Commercial Activity Sites in Minna, Nigeria

+ Indicate the presence of specie

Location	*Anopheles*		*Culex*					*Aedes*		Aggregate
	An quadrimaculatus	*An. Franciscanus*	*Cx. salinaruis*	*Cx. nigripalpus*	*Cx. tarsalis*	*Cx. territens*	*Cx. pipens*	*Ae. aegypti*	*Ae. albopictus*	
Fish pond	+	+	+	+	+	_	+	+	_	7
Block industry	_	+	+	_	_	+	+	+	+	6
Flower garden	_	_	+	_	_	+	+	+	_	4
Car wash	_	_	+	_	_	_	+	_	_	2
Aggregate	1	2	4	1	1	2	4	3	1	19

-Indicate the absence of specie

Table 2a: Distribution and Relative Abundance of Mosquito Species in Commercial Man-made habitat Sites in Minna, Nigeria

Sites	*Anopheles*		*Culex*					*Aedes*		Grand Total
	An .quadrimaculatus	*An. frnaciscanus*	*Cx. salinarus*	*Cx. nigripalpus*	*Cx. pipiens*	*Cx. territans*	*Cx. tarsalis*	*Ae. aegypti*	*Ae. albopictus*	
FP	124 (14.87)* (100.00)	262(31.41) (98.13)	8 (0.96) (1.34)	184(22.06) (100.00)	105(12.59) (3.41)	0(0.00) (0.00)	140(16.79) (100.00)	11(1.32) (4.53)	0(0.00) (0.00)	834 (13.67)
BI	0(0.00) (0.00)	5(0.28) (1.87)	529(29.9) (88.90)	0(0.00) (0.00)	255(14.43) (8.29)	755(42.73) (51.89)	0(0.00) (0.00)	207(11.71) (85.19)	16(0.91) (100.00)	1767 (28.96)

FG	0(0.00) (0.00)	0(0.00) (0.00)	31(1.12) (5.21)	0(0.00) (0.00)	2005(72.62) (65.16)	700(25.35) (48.11)	0(0.00) (0.00)	25(0.91) (10.68)	0(0.00) (0.00)	2761 (45.25)
CW	0(0.00) (0.00)	0(0.00) (0.00)	27(3.65) (4.54)	0(0.00) (0.00)	712(96.35) (23.13)	0(0.00) (0.00)	0(0.00) (0.00)	0(0.00) (0.00)	0(0.00) (0.00)	739 (12.11)
AGGREGATE	124	267	595	184	3077	1455	140	243	16	6101

*Values in Parenthesis are Percentage Proportion
FP-Fish pond
BI-Block industry
FG-Flower garden CW-Car wash

Table 2.2a Cross Correlation among Abundance of Mosquito Genera in Block Industries in Minna, Nigeria

	Anopheles	*Aedes*	*Culex*
Anopheles	1		
Aedes	-0.009	1	
Culex	-0.250	-0.498	1

Table 2.2b: Cross Correlation among Abundance of Mosquito Genera in Fish Ponds Minna, Nigeria

	Anopheles	*Aedes*	*Culex*
Anopheles	1		
Aedes	-0.143	1	
Culex	-0.093	-0.042	1

Table 2.2c: Cross Correlation between Abundance of mosquito Genera in Flower Gardens in Minna, Nigeria

	Aedes	*Anopheles*
Aedes	1	
Anopheles	-0.184	1

Table 2b: Distribution and Relative Abundance of Mosquito Genera in Commercial Man-made Sites in Minna, Nigeria

Sites	*Anopheles*	*Culex*	*Aedes*	Grand total
FP	386	437	11	834
BI	5	1539	223	1767
FG	0	2736	25	2761
CW	0	739	0	739
AGGREGATE	391(6.41)	5451(89.34)	256 (4.25)	6101

TABLE 3: Variation in Physicochemical Parameters Among Mosquito Breeding Habitats In Man-made Sites in Minna Nigeria

SAMPLE	TEMPERATURE	pH	CONDUCTIVITY (mS/cm)	DISSOLVE OXYGEN (mg/l)	ALKALINITY (mg/l)	HARDNESS (mg/l)	TOTAL DISSOLVE SOLIDS (mg/l)	NITRATE (mg/l)	PHOSPHATE (mg/l)	BIOCHEMICAL OXYGEN DEMAND (Mg/l)	CHEMICAL OXYGEN DEMAND (mg/l)
FP	21-23	$8.24\pm0.51^{a*}$	150.50 ± 83.50^{c}	9.00 ± 1.00^{a}	112.00 ± 2.00^{d}	128.50 ± 14.50^{b}	67.70 ± 18.90^{d}	0.08 ± 0.02^{a}	0.56 ± 0.24^{a}	5.50 ± 1.50^{a}	5.31 ± 1.09^{b}
BI	23	7.47 ± 0.44^{a}	92.50 ± 32.50^{a}	8.00 ± 1.00^{a}	39.00 ± 9.00^{a}	111.00 ± 3.00^{a}	48.70 ± 30.90^{a}	0.14 ± 0.07^{a}	0.50 ± 0.00^{a}	3.50 ± 1.50^{a}	3.78 ± 0.03^{a}
CW	22-23	7.05 ± 0.15^{a}	172.50 ± 23.50^{c}	800 ± 2.00^{a}	47.50 ± 2.50^{b}	125.00 ± 5.00^{b}	59.22 ± 5.22^{b}	0.09 ± 0.01^{a}	0.58 ± 0.05^{a}	4.50 ± 1.50^{a}	5.87 ± 0.59^{b}
FG	21-22	7.05 ± 0.15^{a}	130.50 ± 25.50^{b}	10.00 ± 2.00^{b}	45.00 ± 19.00^{b}	133.00 ± 15.00^{b}	64.63 ± 9.23^{c}	0.08 ± 0.04^{a}	2.52 ± 1.91^{b}	8.00 ± 2.00^{b}	3.28 ± 0.12^{a}
TOTAL		7.61 ± 0.22	136.50 ± 21.29	8.75 ± 0.67	60.88 ± 11.92	124.38 ± 5.14	60.06 ± 7.64	0.10 ± 0.02	1.04 ± 0.49	5.38 ± 0.89	4.56 ± 0.47^{s}

*Values followed by the same Alphabet in a Column are not Significantly Different at $p>0.05$

RESULTS

Table 1 showed the occurrence of mosquito species from water based human commercial activity sites in Minna, Nigeria. The Frequency of mosquito larval species occurrence in the habitats occurred in the following order of decreasing abundance: Fish ponds > Block industries > Flower gardens > Car wash centres. *Culex pipiens* and Cx. *Salinaruis* occurred more frequently in the four habitats while, *Aedes albopictus* appeared only in one Block industry.

Table 2a shows the distribution and relative abundance of mosquito species in water-based human commercial activity sites in Minna. A total of six thousand one hundred and one mosquitoes (6101) were collected during the sampling period, comprising of 9 species and 3 Genera. Flower gardens had the highest abundance of mosquitoes with 4 species and a total of 2761 (45.25%) individuals, followed by Block industry with a total of 1767 (28.96%) mosquito with six species; next is the fish ponds with 834 (13.67%) mosquitoes and 7 species. Car wash centres had the least, 739 (12.11%) mosquitoes and one species. Although, the flower gardens were productive, they had only four species and the highest occurrence in *Culex pipiens* 2005 (72.62); following distantly was *Cx. territans* with *Cx. Salinarius* and *Aedes aeqypti* almost in the same range. Car wash centres had the least species and least number of occurrence with *Cx.pipiens*, 712 (96.35) and *Cx. salinarius*, 27 (3.65).

Table 2b shows the distribution and relative abundance of mosquito Genera in water-based human commercial activity sites in Minna Nigeria. The Genus *Culex* contributes most as it accounts for over (89.34%) of the total species encountered, this was distantly followed by *Anopheles* (6.41%) and *Aedes* (4.19%).

As can be seen in tables, 2.2a, 2.2b, 2.2c, the Cross Correlations among Abundance of Mosquito Genera in fish ponds, block industries, flower gardens and car wash centres respectively, showed a weak relationship among all the genera of mosquitoes encountered.

Table 3 shows the variation in physicochemical parameters among mosquito breeding habitats in water-based human commercial activity sites in Minna, Nigeria. Analysis shows that apart from pH and Nitrate content of the water samples, other parameters varied significantly at ($p>0.05$) among the sites. There is significant difference between the result from block industries (92.50±32.50mS/cm) and flower gardens (130.50±25.50mS/cm) in the values of conductivity. However, there is no significant difference in such value between fish ponds (150.50±83.50s/m) and car wash centres (172.50±23.50mS/cm). Apart from flower garden which had (9.00±1.00mg/l) in the values of Dissolve Oxygen and differed significantly, differences in fish ponds, block industries and car wash centres were not statistically significant. For Alkalinity, block industries had the lowest value (112.00±2.00mg/l) while, fish ponds (112.00±2.00mg/l) had the highest alkalinity value. In contrast, apart from block industries (111.00±3.00mg/l) there was no significant variation in the hardness values of the habitats investigated. The values of Dissolved Oxygen ranged from block industries (48.70±30.90mg/l) having the least, followed by car wash centres (59.22±5.22mg/l). Fish ponds had the highest value of Dissolved Oxygen (67.70±18.90mg/l).There was no significant difference ($p>0.05$) for phosphate content among fish ponds, car wash centres and block industries, but flower gardens (2.52±1.91mg/l) were significantly different. The values of Bio-chemical Oxygen Demand showed no significant difference among fish ponds, block industries and car wash centres. However, flower gardens (8.00±2.00mg/l) differed significantly. While, the values of Chemical Oxygen Demand showed no significant difference between car wash centres (5.87±0.59mg/l) and fish ponds (5.31±1.09mg/l).Similarly, block industries (3.78±0.03mg/l) and flower garden (3.28±0.12mg/l) showed significance in COD.

DISCCUSSION

The nine (9) species and three genera of mosquitoes encountered are *Anopheles* Species (*An. quadrimaculatus and An. franciscanus*), two *Aedes* species (*Ae. aegypti and Ae. albopictus*), five *Culex* species (*Culex tarsalis, Cx salinarius, Cx. nigripalpus, Cx. quinquefasciatus and Cx. territans*). While the *Anopheles* and *Aedes* species were selective in their breeding habitats, *Culex pipens* breed in all the habitats sampled. The species were specific in their choice of habitat as there was species variation in s occurrence and distribution in the habitats studied. *An. franciscanus* and *Cx. nigripalpus* occurred in fish ponds, while *Cx, salinarius* and *Cx. pipens* were catholic in their occurrence.

The frequency of larval occurrence varied considerably in the habitats. Flower garden (plastic container water reservoir) was the most productive habitat and had the highest numbers of larvae encountered (45.28%) with four species of mosquito namely, *Cx. salinarius, Cx. territians, Cx.pipiens and Aedes aegypti* there by making it the most preferred breeding habitat. This Finding is in agreement the result of Mwangangi *et al.*(2007) and Okogun *et at.*(2005), who opined that relatively high larval densities colonize domestic containers due to the reduced predation by mosquito's natural enemies in such habitats.

Block industries were the next most productive habitats, as they harboured six species of the mosquitoes; *An. franciscanus, Cx. salinarius, Cx. territans, Cx. pipiens*, *Aedes aegypti,* and *Ae. albopictus.* Very few *Anopheles* mosquitoes were found in this site (1.87%). It was observed that habitats which favoured the breeding of *Anopheles* mosquitoes were characterised by high dissolved oxygen and low nutrient levels, and this confirms the assertion that *Anopheles* are normally found in habitats with high quality. Most mosquitoes collected from this site were from unattended interlocking block moulders and plastic containers for holding water. The main ground water reservoirs used in the sites were not productive.

Fish ponds were the third highest productive habitat sites, although about seven species of mosquitoes were found here; their abundance was low. This might be due to submission of Service (1977), Mogi (1981), and Sunahara *et al.*(2002) that, larval predation is usually high in large permanent mosquitoes habitats. As fishes are known to feed actively on mosquito larvae, the functional fish ponds might not be expected to be highly productive. The occurrence of seven species of mosquitoes is an indication that physicochemical parameters played no significant role in determing larval abundance in this habitat.

Car wash centres proved to be non-productive for mosquito larvae. The conductivity level (172.50±23.50mS/cm) indicates a measure of pollution. Chemical Oxygen Demand and Biochemical Oxygen Demand are used to measure the susceptibility to oxidation and biochemically degradability of organic and inorganic materials present in water bodies. The results from car wash centres indication that the physicochemical parameters played a significant roles in hindering mosquito productivity. This may be due to the chemical detergent used by these commercial centres

Culex mosquito species were the most abundant in the study area and this is in agreement with the observations in Midwestern Nigeria by Okogun *et al*. (2005). However, the results contrasted with findings from Katstina state, Nigeria (Bunza *et al*. 2010) and Kano State, Nigeria (Oguoma and Ikpeze, 2008), where *Anopheles* species were the most abundant mosquitoes species. The occurrence of the *Culex* species in all the five (5) locations suggests that they are very versatile and highly adapted to the different types of environments found in the sampling sites. *Culex quinquefasciatus* was the predominant and most frequently encountered species. On the other hand, the least predominant and least frequently encountered species was *Ae. albopictus* which occurred only in the block industries. *Ae. aegypti* occurred in three (3) out of the four sites.

Different mosquito species make use of different types of water quality and habitats for breeding (Onyido *et al.,* 2009). This observation agrees with the findings of the present study. The preferences of the mosquito species for breeding sites were not only for the site in question but also for the water quality, depth, light and vegetation (which serves as sources of food and shelter appropriate for their survival and development) (Sattler *et al*., 2005; Chen *et al.,* 2007). For example, while *Cx. quinquefasciatus* preferred water with high organic content and high algae growth*, Aedes* and *Anopheles* species preferred clear or turbid water with little or no algae growth. *Anopheles* species are known to show preference for sunlit water against semi shaded and shaded breeding habitats of *Culex* and *Aede*s. (Joseph *et al*., 2010; Anitha *et al*., 2013; Okopu *et al*., 2007).

Some physicochemical parameters of the breeding sites varied. The significantly pH range, between 7.05±0.15 and 8.24±0.5, established at the breeding sites is favourable mosquito immature development. The Dissolved Oxygen range of 8.00±1.0 to 10.00±2.00mg/l and the Biochemical Oxygen Demand value of 3.50±1.50 to 8.00±2.00 mg/l range recorded at the different sites indicate the varied levels of pollution encountered in the mosquito habitats.

CONCLUSION

The Commercial water-based human activity ventures in Minna are active in the production of mosquitoes species, among which are serious vectors namely; *Aedes aegypti, Ae. Albopictus, Culex pipens.* The rate of mosquito production among ventures varies significantly with Flower gardens more active and least in Fish ponds. Dominant mosquito species encountered in the sites was *Culex pipens* and the least predominant was *Aedes albopictus*. Physicochemical parameters condition which supported the growth in Flower gardens includes phosphate, Nitrate, Temperature, Dissolve Oxygen. Therefore this water based commercial venture pose serious threat to human health and should be made prime target in mosquito vector control for optimum result.

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