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Distribution, abundance and diversity of mosquitoes in Akure, Ondo State, Nigeria

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The distribution, abundance and diversity of mosquitoes in Akure, were studied between April, 2012 and March, 2013. Twenty (20) locations randomly distributed across five geographical zones of the city were sampled using sweep nets, aspirators, dippers and pipettes. The habitats sampled include containers, stagnant pools, domestic run-offs and gutters. The larvae collected were preserved in 70% ethanol and identified to species level using X40 dissecting microscope and morphological keys. 30 species distributed among 5 genera were identified during the study. The distribution and abundance of the 30 species of mosquitoes varied significantly ($p<0.05$). *Culex andersoni* was found to be most abundant in the study area with 23.1% abundance followed by *Culex fatigans* (21.9%) while *Toxorhynchites brevipalpis* was the least abundant (0.05%). Combination of factors such as temperature, pH, dissolved oxygen, relative humidity, conductivity and anthropogenic related factors contributed to the increasing abundance of mosquitoes in the study area. The occurrence of *Aedes, Anopheles* and *Culex* is suggestive of the prevalence of vector-borne diseases such as malaria, yellow fever, dengue fever and filariasis in the area. Therefore, intensive vector control programmes and public enlightenment especially on human activities that encourage mosquito breeding are recommended.

Key words: Mosquitoes, *Culex andersoni, Toxorhychite brevipalpis*, abundance.

INTRODUCTION

For any vector control measures to be successful, good knowledge of the breeding ecology of mosquitoes including, the types and preferences for larval habitats, spatial and temporal distribution of breeding sites, as well as, the physical, biological and chemical characteristics of the habitats are required (Olayemi et al., 2010). Studies have also revealed that convenient aquatic breeding sites for certain mosquito species may be inconvenient for other species (Adebote et al., 2008; Afolabi et al., 2010). Mosquitoes exploit almost all types of lentic aquatic habitats for breeding and larvae of mosquitoes have been found to thrive in aquatic bodies such as fresh or salt water marshes, mangrove swamps, rice fields, grassy ditches, the edges of streams and rivers and small, temporary rain pools. Many species prefer habitats with vegetation while some breed in open, sunlit pools. A few species breed in tree holes or the leaf axils of some plants (Kitching, 2001). According to Mutero et al. (2004) and Okorie et al. (1978), mosquitoes show preference to water with suitable pH, optimum temperature, dissolved oxygen, concentration of ammonia, nitrate. These physico-chemical parameters have been found to affect larval development and survival in breeding water. These physicochemical parameters vary from one species to another. For instance, pH of 7.4 was found to be suitable for *Aedes* mosquitoes (Adebote et al., 2006;

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Afolabi et al., 2010). Similarly, the work of Okogun et al. (2005) established that water of a near neutral pH 6.8 to 7.2 was found most optimal for the weakening of the egg shells for the first instar larval stage to emerge. Service (1993) and Adebote et al. (2006) suggested that pH less than 5.0 and slightly higher than 7.4 produced a lethal effect on mosquito species.

Mosquitoes are well known group of insects, which transmit many dreadful diseases causing serious health problems to human beings. The females biting habit during their search for blood meal shortly before oviposition increases their propensity to transmit various diseases associated with high morbidity and mortality. Such diseases vectored by mosquitoes include: malaria, filariasis and yellow fever, which affect hundreds of millions of people every year, causing immense suffering and hindering development. Mortality due to malaria peaked at 1.82 million in 2004 and fall as a result of more sensitive diagnostic tools, effective use of antimalarial drugs, improved personal protection and mosquito control to 1.24 million in 2010 (714,000 children <5 years and 524,000 individuals ≥5 years) and over 80% of the malaria mortality occur in sub-Saharan Africa (Murray et al., 2010; WHO, 2011). Nigeria is known for high prevalence of malaria and the disease remains one of the leading causes of childhood and maternal morbidity and mortality, low productivity and reduced school attendance in Nigeria (Aribodor et al., 2007). Filariasis also has been shown to be a public health problem in Africa, particularly in the northern savannah and in the south-western coastal parts of Africa (Dunyo et al., 1996). Yellow fever transmission is under control in many parts of Africa as a result of mass immunisation undertaken in the countries (Godal et al., 1998). In the study area (Akure), being an urban area where commercial activities are predominant, anthropological activities such as open drainage system and littering of environments with various peridomestic containers encourage the breeding of mosquitoes and consequently increase mosquito-borne diseases in the area. Therefore, a study of the biology of mosquitoes and physicochemical parameters of the breeding sites will be essential to determine their influence on mosquito distribution, abundance and diversity. Hence, the overall goal of this work is to study the diversity of mosquitoes and physicochemical parameters of the habitat that support breeding in the study area.

MATERIALS AND METHODS

A cross-sectional study was carried out in Akure city, the capital of Ondo State, which lies in the forest zone, with latitude 7° 16^{l} 48°N, and longitude 5° 14^{l} 41°E. The study area was further divided into five geographical regions namely: Akure North, Akure South, Akure West, Akure East and Akure Central. Twenty (20) locations randomly distributed across each of the geographical zones were sampled using sweep nets, aspirators, dippers and pipettes. The habitats sampled include containers, stagnant pools, domestic run-offs and gutters. Habitat evacuation method as described by Service (1993) was adopted in collecting the larvae from different habitats. Larvae collected were concentrated on a fine sieve in a white enamel bowl. The larvae were preserved in 70% ethanol and transported to the laboratory for identification. The larvae were identified to species level using X40 dissecting microscope and guided by the morphological keys of Hopkins (1952), Gillies and de Meillon (1968) and Koekemoer et al. (2002). Water samples collected from different locations were kept in clean, dry 5 L jerry cans prior to use. One litre of each water sample was analyzed for physicochemical constituents in the laboratory. Parameters such as temperature, pH and conductivity were measured *in situ* using HANNA Meter (Model No: HI 991300). The dissolved oxygen was determined in the laboratory using dissolved oxygen meter.

Statistical analysis

Data collected were expressed as percentages and relative abundance was expressed as the ratio of larval population to positive habitats. One way analysis of variance (ANOVA) at $P < 0.05$ was used to test the significant difference while Duncan Multiple Range was used to separate the means.

RESULTS

The average physicochemical parameters in which breeding was observed in the study area include: temperature range of 26.5 to 29.3°C, pH range of 7.1 to 7.3, dissolved oxygen of 1.4 to 2.7 mg/L and conductivity range of 66.3 to 108.0 µs (Table 1). Although, these physico-chemical parameters were not significantly different across the locations ($p>0.05$). The highest relative abundance and larval number per pool (98 and 88.2, respectively) were recorded in Akure Central which predominantly comprises of major markets in the city. While the lowest relative abundance (31.45) was recorded in Akure East, which majorly consists of administrative buildings (Table 2). Thirty species of mosquitoes distributed among five genera were identified during the study. Twelve of the species were *Aedes* with *Aedes aegypti* having the highest distribution and abundance (13.5%, n=573) while *Aedes apicoargenteu* having the least abundance (0.01%, n=40). Two species of *Anopheles* (*Anopheles arabiensis* and *Anopheles gambiae*) with the latter having higher abundance than the former (Table 3). Similarly, 14 species of *Culex* were encountered during the survey with *Culex andersoni* having the highest species abundance (23.1%, n=984) across the group and in general. One species of *Eretmapodite* was encountered in the study. *Toxorhynchites brevipalpis* was the least abundant species (0.05%). *Aedes* and *Culex* were evenly distributed across the study area, but the abundance of *Culex* (71.7%, n=3053) was more than that of the *Aedes* (26.8%, n=1139) (Table 2). The distribution and abundance of the thirty species of mosquitoes varied significantly ($p<0.05$).

Table 1. Occurrence and physico-chemical parameters of larval mosquitoes in peridomestic containers and drainages in Akure, Nigeria.

Location	Temp (°C)	pH	Dissolved oxygen (mg/L)	Conductivity (µs)	Number of pool		Number larvae collected (%)	Relative abundance	Larval no./ pool
					Examined	Positive (%)			
North	28.3	7.2	1.92	87.0	20	05 (25)	288	57.60	14.4
Akure South	27.5	7.3	1.56	66.3	20	13 (65)	616	47.38	30.8
Akure Central	29.3	7.1	1.44	72.8	20	18 (90)	1764	98.00	88.2
Akure West	26.5	7.3	2.70	108.0	20	16 (80)	1242	77.63	62.1
Akure East	28.8	7.3	1.90	84.0	20	11 (55)	346	31.45	17.3
Total	140.4	36.2	9.52	418.1	100	59 (59)	4256	72.14	42.56

Table 2. Geographical distribution of mosquito larvae in Akure, Nigeria.

Location	Mosquito genera					Total (%)
	Aedes	*Anopheles*	*Culex*	*Eretmapodite*	*Toxorhychite*	
Akure North	142^{c}	0^{a}	146^{c}	0^{a}	0^{a}	288 (6.8)
Akure South	263^{e}	12^{b}	291^{e}	10^{b}	0^{a}	616 (14.5)
Akure Central	198^{d}	18^{b}	564^{g}	0^{a}	2^{a}	1764 (41.4)
Akure West	414^{f}	14^{b}	828^{h}	0^{a}	0^{a}	1242 (29.2)
Akure East	122^{d}	08^{b}	224^{e}	0^{a}	0^{a}	346 (8.1)
Total (%)	139 (26.8)	52 (1.22)	3053 (71.7)	10 (0.2)	2 (0.05)	4256 (100)

DISCUSSION

The breeding temperature observed during the study suggested that mosquitoes breed at water temperature of 26.5 to 29.3°C. This finding was supported by the works of other authors. For instance Afolabi and Ndams (2010) stated that female mosquitoes preferred water temperature range of 24.7 to 28.3°C. The pH range of 7.1 to 7.3 supported breeding in all the habitats sampled. This result concurred with the findings of Adebote et al. (2006) and Afolabi et al. (2010). Both authors agreed that mosquitoes especially *Aedes* breed in water with pH 7.4. Okogun et al. (2005) in his findings showed that water near pH 6.8 to 7.2 is suitable for the weakening of the egg shells for the first instar larval to emerge. Similar result was recorded by Service (1993) and Adebote et al. (2006) that pH less than 5.0 and higher than 7.4 have lethal effect on mosquito species. In the study, it was observed that Akure Central has the highest relative abundance compare to others, and this location is known for heavy social and anthropological activities such as markets and event centres. This finding was in accordance with the work of Simon-Oke et al. (2012) which observed that mosquito distribution and abundance are related to population, land use and human activities. The distribution and abundance of mosquito species was significantly different across the five locations in Akure city ($p<0.05$) with *A. aegypti*, *Aedes vittatus*, *A. gambiae*, *Culex fatigans* and *C. andersoni* evenly distributed in all the locations, while others were sparsely distributed. In addition, *C. andersoni* has the highest abundance in the study area. This significant difference may be due to the difference in social and anthropological activities as within the locations as areas with high activities may have high population density of mosquitoes and vice versa. The predominance of *C. andersoni* in the study area suggests that the species is an

Table 3. Species distribution and abundance in Akure, Nigeria.

Species distribution	Akure North	Akure South	Akure West	Akure East	Akure Central	Total (%)
Aedes aegypti	94±0.53^{b}	68± 1.37^{e}	76±1.39^{d}	223±3.39^{g}	112±2.10^{e}	573 (13.5)
Aedes apicoargenteu	0±0.0^{a}	0±0.0$^{a(}$	0±0.0$^{a(}$	0±0.0^{a}	4±0.32^{a}	4 (0.1)
Aedes arabiensis	0±0.0^{a}	62±1.15^{e}	0±0.0^{a}	24±0.79^{d}	65±0.70^{d}	151 (3.5)
Aedes cumminsi	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	9±0.62^{ab}	0±0.0^{a}	9 (0.2)
Aedes fraseri	11±0.70^{a}	2±0.31^{b}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	13 (0.3)
Aedes keniensis	8±0.70^{a}	0±0.0^{a}	1±0.27^{a}	1±0.22^{a}	0±0.0^{a}	10 (0.2)
Aedes langata	7±0.49^{a}	0±0.0^{a}	7±0.44^{ab}	1±0.27^{a}	8±0.57^{a}	23 (0.5)
Aedes luteocephalus	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	9±0.74^{ab}	9 (0.2)
Aedes metallicus	0±0.0^{a}	36±1.50^{c}	2±0.31^{ab}	4±0.5^{ab}	18±1.29^{b}	60 (1.4)
Aedes palpalis	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	16±0.93^{bcd}	0±0.0^{a}	16 (0.4)
Aedes stokesi	5±0.54^{a}	2±0.31^{a}	6±0.67^{ab}	14±0.70^{abcd}	11±0.78^{ab}	38 (0.9)
Aedes vittatus	9±0.74^{a}	52±1.63^{d}	4±0.32^{ab}	123±6.59^{f}	45±2.41^{c}	233 (5.5)
Anopheles arabiensis	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	20±1.23^{cd}	0±0.0^{a}	20 (0.5)
Anopheles gambiae	5±0.55^{a}	6±0.68^{ab}	10±1.17^{ab}	8±0.68^{abc}	3±0.37^{a}	32 (0.8)
Culex quinquefasciatus	154±7.28^{d}	195±12.37^{g}	230±17.22^{g}	57±2.89^{e}	298±15.19^{g}	934 (21.9)
Culex andersoni	108±4.98^{c}	114±3.49^{f}	103±9.67^{e}	426±22.68^{h}	233±11.41^{f}	984 (23.1)
Culex laticinctus	0±0.0^{a}	10±1.17^{b}	7±0.49^{ab}	0±0.0^{a}	0±0.0^{a}	17 (0.4)
Culex thalassius	0±0.0^{a}	0±0.0^{a}	3±0.37^{ab}	0±0.0^{a}	0±0.0^{a}	3 (0.1)
Culex theileri	0±0.0^{a}	0±0.0^{a}	4±0.32^{ab}	0±0.0^{a}	0±0.0^{a}	4 (0.1)
Culex pipiens	0±0.0^{a}	32±1.32^{c}	7±0.49^{ab}	0±0.0^{a}	0±0.0^{a}	39 (0.9)
Culex pruina	0±0.0^{a}	0±0.0^{a}	2±0.31^{ab}	0±0.0^{a}	0±0.0^{a}	2 (0.05)
Culex perfidiosus	0±0.0^{a}	0±0.0^{a}	2±0.31^{ab}	0±0.0^{a}	0±0.0^{a}	2 (0.05)
Culex stellatus	0±0.0^{a}	0±0.0^{a}	2±0.31^{ab}	0±0.0^{a}	0±0.0^{a}	2 (0.05)
Culex univittatus	0±0.0^{a}	0±0.0^{a}	2±0.31^{ab}	0±0.0^{a}	0±0.0^{a}	2 (0.05)
Culex decens (a)	720±23.07^{e}	0±0.0^{a}	139±4.32^{f}	0±0.0^{a}	0±0.0^{a}	859 (20.2)
Culex decens (b)	110±2.76^{c}	0±0.0^{a}	40±1.63^{c}	0±0.0^{a}	10±1.17^{a}	160 (3.8)
Culex arbieeni	0±0.0^{a}	0±0.0^{a}	13±0.38^{b}	0±0.0^{a}	0±0.0^{a}	13(0.3)
Culex guiarti	0±0.0^{a}	0±0.0^{a}	10±1.17^{a}	0±0.0^{a}	0±0.0^{a}	10(0.2)
Culex ingrami	22±1.25^{d}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	22(0.5)
Eretmapodite chrysogaster	10±1.17^{a}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	10(0.2)
Toxorhychite brevipalpis	02±0.31^{a}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	0±0.0^{a}	02(0.05)
Total (%)	1267 (29.8)	577 (13.6)	670 (15.7)	936 (22)	806 (18.9)	4256 (100)

Numbers immediately after ± sign are standard errors. Letters in superscripts are used to separate the means and the means increase from a-h. Means with the same letters are not significantly different from one another while means with different letters are significantly different from one another.

indiscriminate breeder as the species was found in all the peridomestic containers sampled across the locations with significant population. This result was established by similar work in Ekiti State by Simon-Oke et al. (2012), although the authors observed that *Culex* and *Aedes* have a codominance in the area. In contrary, Adeleke (2010) observed that *A. aegypti* was generally predominant in Ikenne, Ogun State, Nigeria. Likewise, Adebote et al. (2006) and Afolabi et al. (2010) observed that *Aedes* mosquito was the most predominant in Zaria and indiscriminately breeds in various habitats including the tree holes. Variations observed in different geographical zones of the country might be as a result of differences in physico-chemical factors. As combination of factors such as temperature (26.5 to 29.3°C), pH (7.1 to 7.3), dissolved oxygen (1.44 to 2.7 mg/L), relative humidity, conductivity (66.3 to 108.0 µs) and anthropogenic related factors (such as opened drainage system) contribute to the increasing abundance of mos-quitoes in the breeding sites. The occurrence of *Aedes, Anopheles* and *Culex* is suggestive of the prevalence of vector-borne diseases such as malaria, yellow fever, dengue fever and filariasis in the area. Therefore, intensive vector control programmes and public enlightenment especially on human

activities that encourage mosquito breeding are recommended.

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