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The Role of Urbanization on Larval Population and Ecology

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ABSTRACT: The effects of urbanization on larval population and ecology in three selected communities in a highly malarious region were studied. The Ashanti region is in the forest belt of Ghana and the study took place from December 2010 to December 2011 using mosquito immature surveillance. A total of 154 water bodies were identified and sampled for immature mosquito, 75 water bodies in the wet season and 79 water bodies in the dry season. The highly urbanized study areas (Ayeduase and Adum) recorded the highest number of breeding sites and breeding index compared to the least urbanized Akropong. Cage rearing of mosquito larva showed higher population of Culex compared to Anopheles and Aedes in all the three study areas. Habitat depth and presence or absence of canopy cover influenced larval type and abundance. Culicines were highest in over 70% of breeding sites with co-abundance. That is in each water body type that colonizes both Anopheles and Culex immature, densities of Culicine immature were much higher than densities of *Anopheles* immature.

Temperature of breeding sites and physico-chemical parameters did not statistically influence the occurrence of mosquito larva.

1.0 INTRODUCTION

In urban environments of Sub-Saharan Africa, ecological characterization of larval habitats for Afro-tropical mosquitoes is necessary to understand the dynamics by which various vector species interact and thrive in urban areas [5].

The ecological changes associated with these development activities often entail negative health impacts due to the creation of new mosquito breeding sites and thus altered human vector-parasite contact patterns [6].

The process of urbanization creates water impoundment through dam construction, building construction, construction of drainage channels, etc. and recent study in Ethiopia has shown that, the abundance of adult Anopheles mosquitoes in areas near water impoundments (dams) was 5.9–7.2 times higher than areas further away [13].

Anopheles and culicines have different requirements for their immature survival [7] and their interaction may have implications for the ecology of *Anopheles* mosquitoes in urban environments.

Studies in North America with mosquito species known to favor urban environments have demonstrated that competitive interactions exist among mosquitoes when reared together under laboratory and particular natural conditions [2].

Mosquitoes will breed in practically any collection of water that stands longer than five to seven days. Different kinds of mosquitoes vary in their choice of breeding places. Some like sunlit places whereas others prefer the shade. Some prefer fresh water to stagnant water [9].

Physico-chemical factors that may influence oviposition and survival of vector species include salts, dissolved organic and inorganic matter, turbidity, presence of suspended mud, presence or absence of plants, temperature, light and shade, and hydrogen ion concentration [9]. Understanding how these factors affect the distribution of a particular vector species and how they influence larval abundance is an essential component of larval biology and of great importance in the design and implementation of integrated vector management plans. It is commonly assumed that urbanization leads to a decrease in malaria prevalence, however, there is a concern that areas with rapid, unplanned urbanization, typically associated with low income, poor education, poor health care and poor housing/sanitation, may not experience such marked decrease in malaria transmission [6].

The objective of this study was to determine the influence of urbanization, physico-chemical and biotic factors of these mosquito larval habitats on larval density, distribution and abundance.

2.0 MATERIALS AND METHODS

2.1 Study Areas

The selected areas for the study were Adum and Ayeduase under the Kumasi Metropolitan Assembly and Akropong is within the Atwima district. Populations of KMA, Ayeduase and Akropong as at year 2000 were1170270, 7438 and 4358 respectively (GSS, 2000). In terms of population size and levels of development, levels of urbanization is in the order Adum> Ayeduase> Akropong.

All the three study areas have two main seasons, a major rainy season (which falls on March – August), minor rainy season (September-November) and dry season (November-March).

2.2 Larval Collection

An inventory of potential breeding sites was made in each study area. Parameters recorded include temperature, pH, turbidity, conductivity, total dissolved solids, alkalinity, colour, hardness, chlorine and sulphate. Temperature, turbidity and depth were taken in situ. Water samples from breeding sites were subjected to physico-chemical analysis in the chemistry department of KNUST. Analysis was made according to WHO standard methods. Global Positioning System (GPS) was used to record the various breeding sites sampled and the coordinates represented on the GPS mapping of the study areas.

Along with the collection of larvae and pupa, data on the characteristics of the larval breeding habitats such as depth, permanency, exposure to sunlight, presence of vegetation, were recorded.

2.3 Data Analysis

The Entomological Parameter calculated was Breeding Index.

3.0 ANALYSIS OF RESULTS

3.1 LARVAL STUDIES

A total of 154 water bodies were identified and sampled for immature mosquito (75 water bodies in the wet season and 79 water bodies in the dry season), of which 51 (68%) and 37 (46.8%) were positive for the presence of mosquito immature.

In Adum and Ayeduase, majorities of breeding sites (75% and 77.8%) were man-made in origin, 30.5% and 65.2% were construction associated, and the remainders (25% and 22.2%) were naturally occurring. In Akropong, 71.4% of all habitats were man-made and 28.6% naturally occurring. 58.3% of breeding sites sampled were permanent and 41.7% were temporary.

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Table 3.1: Type of Breeding Sites and Immature Mosquitoes Collected

Type of habitat	No. Sampled			No. Positive With Larva			No. of dips			Total No. of larva			No. Anopheles			No. Culicines		
	Adum	Ayeduase	Akropong	Adum	Ayeduase	Akropong	Adum	Ayeduase	Akropong	Adum	Ayeduase	Akropong	Adum	Ayeduase	Akropong	Adum	Ayeduase	Akropong
Concrete Channel	8	14	4	4	6	1	5	5	5	101	108	33	0	0	0	101	108	33
Earthed Channel	3	16	6	2	10	3	5	5	5	81	100	58	18	35	19	63	65	39
Dugout	4	14	5	4	7	0	5	5	5	174	141	0	34	12	0	140	129	0
Car /Truck Tyre Pools	13	21	5	10	17	3	3	3	2	123	118	51	92	96	39	31	22	12
Construction site	3	7	3	3	4	2	3	3	4	63	61	39	20	26	15	43	35	24
Swamp	2	6	4	0	4	2	5	5	5	0	72	36	0	0	8	0	72	28
Vegetation	4	4	8	0	2	4	2	2	2	0	49	74	0	0	10	0	49	64

Naturally occurring breeding sites contributed 18 Anopheles and 213 Culicines whiles manmade larval habitats produced 406 Anopheles and 845 Culicines. Water temperature of breeding sites was not associated with the occurrence of *Culex* and *Anopheles larva*. Both high and low densities of mosquito larva were found at various temperatures ($p = 0.063$, $p > 0.05$).

3.2 Co-abundance of mosquito larva

Proportion of water bodies with and without immature mosquitoes in the study areas are presented in Table 3.2

In each water body type that colonizes both Anopheles and Culex immature, densities of Culicine immature were much higher than densities of *Anopheles* immature (Tab. 3.2).

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Table 3.2: Co-abundance of mosquito larva

Water bodies with immature mosquitoes	Water body types								
	Total	**Car/ truck tyre pools**	**Concrete channels**	**Dug-outs**	**Vegetation**	**Swamps Subin, Bene, Nwabi rivers**	**Construction sites**	**Block well for construction**	**Earth channel**
	N = 88	**n = 30**	**n = 11**	**n = 9**	**n = 6**	**n = 6**	**n = 9**	**n = 2**	**n = 15**
Anopheles positive	76.1% (67)	100% (30)	0% (0)	55.6% (5)	66.7% (4)	33.3% (2)	100% (9)	100% (2)	100% (15)
Culicine positive	100% (88)	23.3% (7)	100% (11)	100% (9)	100% (6)	100% (6)	100% (9)	100% (2)	100% (15)
Both sub-families present	76.1% (67)	23.3% (7)	0% (0)	55.6% (5)	66.7% (4)	33.3% (2)	100% (9)	100% (2)	100% (15)
Anopheles present only	28.4% (25)	70% (21)	0% (0)	0% (0)	0% (0)	0%(0)	0% (0)	0% (0)	26.7% (4)
Culicine present only	23.9% (21)	0% (0)	100% (11)	44.4% (4)	33.3% (2)	66.7%(4)	0% (0)	0%(0)	26.7% (4)
Neither sub-family present	42.9%(66)	23.1%(9)	57.7% (15)	47.1% (8)	62.5% (10)	50% (6)	30.8% (4)	0.% (0)	40 %(10)

3.3 Influence of Shade on Breeding Sites

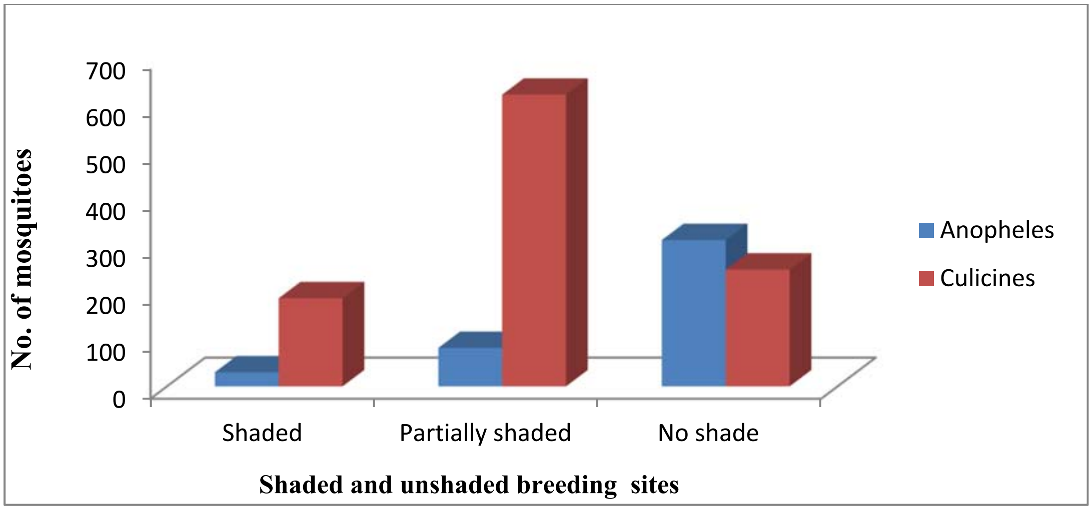
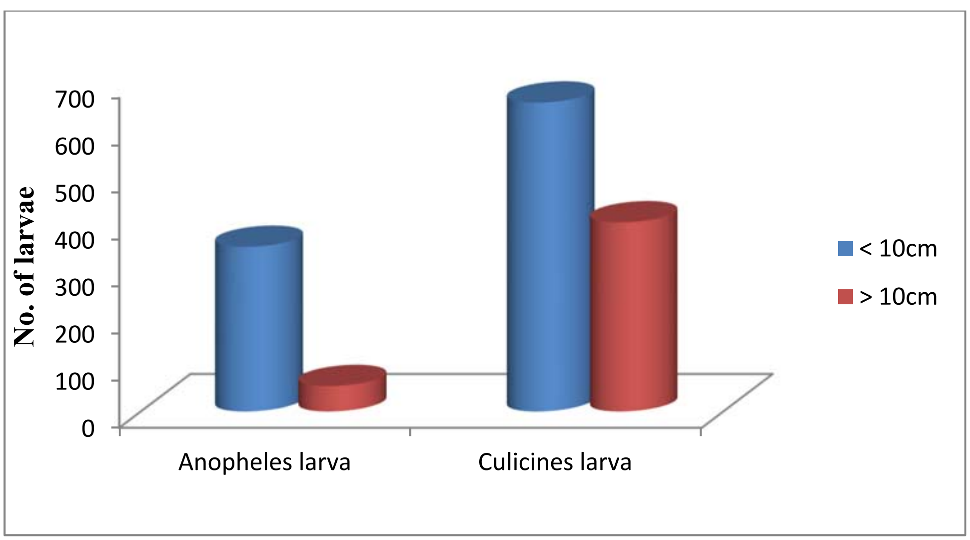


Figure 3.1: Influence of canopy cover over breeding habitats and mosquito abundance

Shaded larval habitats produced 112 Anopheles and 809 Culicines larva whiles open larval habitats produced 312 Anopheles and 249 Culicines larva.

3.4 Influence of habitat depth on larval density



Mosquito larvae

Figure 3.2: Habitat Depths and Mosquito Abundance

Shallow and clear breeding sites produced higher densities of Anopheles larva.

3.5 Breeding index of the study areas

Table 3.3: Breeding Index in the Three-Study Sites

BREEDING INDEX IN THE THREE STUDY AREAS					
Site	**No. of Breeding Sites**	**Total No. of Dips**	**No. of larva**	**Total Number of Pupa**	**Breeding Index**
Adum	23	595	542	8	21.26
Ayeduase	50	1701	649	13	19.46
Akropong	15	287	291	8	15.63

3.6 Comparative pollution levels of breeding sites

The presence/abundance of Anopheles and *Culicine* aquatic stages were not significantly correlated with pH ($p = 0.184$, $p > 0.05$), conductivity ($p = 0.368$, $p>0.05$), turbidity ($p = 0.427$, $p> 0.05$), colour ($p = 0.423$, $p > 0.05$), alkalinity ($p=0.779$, $p > 0.05$), total dissolved solids(TDS) ($p = 0.374$, $p > 0.05$), hardness ($p=0.249$, $p > 0.05$), chloride ($p = 0.406$, $p > 0.05$), sulphate ($p = 0.077$, $p > 0.05$).

4.0 DISCUSSION

In terms of population figures and levels of infrastructural development, Adum is the most urbanized followed by Ayeduase. Akropong is the least urbanized. There are more buildings and access routes still under construction in Ayeduase compared to Adum and Akropong. This probably explains the multiplicity of mosquito breeding sites in Ayeduase doubled that of Adum.

Construction sites frequently create land excavations which fill up with rain water and constitute suitable aquatic habitats for various mosquito species [7].

In the dry season most of the swamps along river banks dry up leaving stagnant pockets of water. This might probably add up to the number of breeding sites in the dry season explaining the high recorded breeding sites in the dry season.

In all the three study areas, more than 70% of the breeding sites identified were manmade in nature. Natural breeding sites produced only 18 Anopheles mosquitoes compared to 406 Anopheles mosquitoes in manmade breeding sites. This shows that malaria transmission is highly dependent on human activities and is supported by work of [11]

The occurrence of the *Culex* species in many breeding sites shows that they are very versatile. Presence of Anopheles larva in drainage channels is indicative of capability of colonizing polluted water bodies. This is supported by [4], in a research in Kumasi. Breeding index was unexpectedly high in a more urbanized Adum with few identified breeding sites (23) compared to progressively urbanizing Ayeduase with fifty (50) identified breeding sites. This is due to high temporary breeding sites in Ayeduase and regular clearing of choked concrete and earth channels linking various hostels to allow free flow of sewage.

This study also showed that the density of *Anopheles* and *culicines* in the presence of their sub-family competitor was lower compared to when each sub-family was found alone. [12], in Kenya reported that female *Anopheles gambiae*s.l. laid fewer eggs where *Culicine* eggs were present. Anopheles preference to small open pools compared to permanent large pools could probably be that larval predation is less prevalent or non –existent in the temporal small pools as opposed to large permanent habitats.

The *p*H range between 5.23 and 9.64 established at the breeding sites is an indication that mosquitoes can be found in both acid and alkaline environments. [8] reported that under laboratory conditions, *A. gambiae* carries out normal development when pH varies as much as from 4.0 to 7.8 as long as there is sufficient phytoplankton and zooplankton for it to consume.

Culicines were more present in collections of water containing sewage with high conductivity, turbidity, sulphate and total dissolved solids compared to *Anopheles,* although the influence of physicochemical parameters (pH, conductivity, turbidity, colour, hardness, alkalinity, TDS, chloride, sulphate) on mosquito larvae was not significant ($p < 0.05$) in this study.

A research in Mali by [3], reported that Nitrate, Orthophosphate, Turbidity and Temperature had no effect on niche partitioning of species and forms of *Anopheline* mosquitoes. The findings also agree with the positive association of *Culicines* which have greater range of pH values (pH 5.23 – 9.64) [1].

5.0 CONCLUSION

Urbanization increases breeding capacity of the area and man vector contact as the highly urbanized study areas (Adum and Ayeduase) recorded high breeding sites and breeding index, high percentage of mosquito larva collected compared to the least urbanized Akropong. Manmade activities (e.g. construction, etc) in the process of urbanization creates preferred breeding sites for Anopheles as only 18 Anopheles were collected in natural breeding sites compared to 406 in manmade breeding sites. The process of urbanization could therefore increase malaria transmission.

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