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Original Research

Distribution of Mosquito Larvae in Relation to Physico-chemical Characteristics of Breeding Habitats in Minna, North Central Nigeria

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Abstract

This paper reports on a study carried out in Minna, Nigeria, during the rainy season of 2008, to elucidate larval distribution, variations in water quality and relationships between both variables in conventional mosquito breeding habitats. Mosquito larvae were sampled weekly from randomly selected sites across the city, using standard techniques. Water samples obtained from breeding sites during larval collection were analyzed for physico-chemical parameters, and such were correlated with larval abundance. The results indicated that mosquito larval distribution in Minna was heterogeneous, with the Swamps been the most active mosquito production sites while, the Drains and Rivers did not support larval development. Also, the mosquito types demonstrated distinct preferences for larval habitats. While, Temperature, Phosphate, Sulphate, Carbonate and Transparency did not differ significantly ($P > 0.05$) among the habitats, other parameters namely, Total Dissolved Solids, Dissolved Oxygen, Conductivity and p^H varied significantly ($P < 0.05$) thus, explaining the heterogeneous distribution of mosquito larvae among the habitats, especially, as some of the physico-chemical parameters correlated strongly with larval abundance. The implications of these results for larviciding interventions in Minna were discussed and concluded that the findings of the study should promote targeted cost-effective mosquito larval control in the area.

Keywords: *Aedes*, *Anopheles*, *Culex*, Larval Abundance.

Introduction

Mosquito-transmitted diseases are the major causes of morbidity and mortality in sub-Saharan Africa. For example, there are up to 500 million clinical cases and about one million deaths due to malaria globally, and sub-Saharan Africa accounts for over 90% of these cases [1]. While, Bancroftian filariasis affects over 90 million people worldwide [2], yellow fever epidemics have had debilitating effects on human populations [3] [4]. In Nigeria, these diseases constitute the number one public health challenge, imparting negatively on the country's economic development, to the tune of more than 1% growth penalty per year [5].

The heavy burdens exerted by mosquito-transmitted diseases informed the implementation of aggressive control interventions, particularly, against the parasites. However, the wide-spread distribution of drug-resistant parasites has shifted attention to anti-vector interventions [6,7]. In Nigeria, this strategy is focused mainly on measures that kill or deter adult mosquitoes including, the promotion of the use of insecticide-treated bed nets and indoor residual spraying [8]. Though, when applied properly, these tools have enormous potentials to reduce morbidity and mortality due to mosquito-transmitted diseases [9,10], studies have shown that like every known mosquito-vector control measure, they have their drawbacks including insecticide resistance [11] and difficulties in attaining adequate population coverage [12,13], and hence may not be sufficient to achieve the World Health Organization's (WHO) targets regarding mosquito-transmitted diseases. Additional vector control interventions, particularly, those that will complement existing adulticiding measures, are therefore required to

Table 1. Mean Mosquito larval abundance and distribution in breeding habitats in Minna, during the rainy season of 2008

Species/Habitat	Ponds	Swamps	Drains	Rivers	Domestic container
Aedes	1	1	-*	-	2
Anopheles	1	3	-	-	2
Culex	9	4	-	-	2
Aggregate	10	9	-	-	6

*Larvae absent

build truly integrated mosquito-vector control programs. To this end, larval control measures are being re-appraised and recommended for immediate adoption in areas where these diseases are prevalent [14,15].

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. Though, some of these variables have been systematically investigated in Nigeria, very few studies, if any, have been published on the physico-chemical characteristics of mosquito larval habitats in the country. Yet, according to [16], larval habitat water-type plays significant roles in determining mosquito oviposition site selection and hence, the productivity of such sites regarding adult mosquito emergence rates, all critical factors determining the vectorial capacity of mosquitoes.

Thus, in order to elucidate the breeding ecology of mosquitoes in Minna, Nigeria, this study was carried out to assess the larval abundance in conventional mosquito breeding sites, evaluate the physico-chemical characteristics, and establish the relationships between such characteristics and larval abundance in the area.

Materials and Methods

Study Area

The study was carried out in Minna, the capital of Niger sate, north central Nigeria. Minna, is located within longitude 6^o 33′E and latitude 9^o 37′N, covering a land area of 88 km^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^{o}C, 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.

Mosquito Larval Collection, Processing, Identification and Analysis

Five kinds of conventional mosquito breeding habitats namely, Ponds, Swamps, Drains, Rivers and Domestic Containers were selected for investigation [17]. Two replicates of each larval habitat type were randomly selected across the city, and mosquito larvae were sampled weekly from such habitats during the rainy season of 2008. Sampling was done between 0900hr and 1100hr, using a standard 300 ml capacity dipper. Where this was not possible, especially with Domestic Containers, water from a number of breeding sites was pooled to make-up the required volume. Twenty dipper samples were taken randomly from each sampling site, and the mosquito larvae recovered were preserved immediately using 4% formaldehyde solution. The specimens were identified to genus level using aids provided [18,19].

Collection and Fixing of Water Samples for Physico-chemical Analysis

Water samples, for physico-chemical analysis, were collected concurrently with larvae from the five habitat types investigated, using 500ml capacity specimen bottles. The water was fixed immediately, using standard procedures [20], in preparation for laboratory analysis. However, water temperature and transparency were determined at the sites, during larval collection, using ordinary mercury thermometer and secchi disc, respectively.

Physico-chemical Analysis of Water from Larval Habitats

Water samples were analysed for the following physico-chemical parameters: Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Conductivity, p^H, and concentrations of Nitrate (NO_3), Phosphate (PO_4), Sulphate (SO_4) and Carbonate (CO_3). Analyses of these parameters were carried out in the Quality Control Laboratory of the Niger River Basin Authority, Minna, Nigeria.

Statistical Analysis

The abundance of each type of mosquito was determined as the mean frequency of occurrence per 300ml of water. The relationship between larval abundance and physico-chemical parameters was assessed using Linear Coeffi-

Table 2. Physico-chemical properties of mosquito larval breeding habitats in Minna, during the rainy season of 2008

Parameters	Ponds	Swamps	Drains	Rivers	Domestic containers	Means ± S.D
Temperature (ºC)	825.50^{a}	25.90^{a}	26.1 ^{a}	26.00 ^{a}	26.20 ^{a}	25.94±0.27^{a}
Dissolves Solids (mg/1)	5.80^{a}	93.30^{a}	108.5^{b}	90.60 ^{a}	123.60^{c}	100.36±15.52^{b}
Transparency (m)	0.14^{a}	0.06^{a}	0.09^{a}	0.13^{b}	0.02^{a}	0.12±0.11^{a}
Dissolved Oxygen (mg/1)	26.5 ^{a}	30.20^{b}	31.40^{b}	28.30^{a}	38.10^{c}	30.90±4.44^{b}
Nitrate (mg/1)	0.50^{a}	0.87^{a}	20.7^{d}	11.00^{b}	14.30^{c}	9.47±8.75^{b}
Phosphate (mg/1)	0.19^{a}	0.21^{a}	0.20^{a}	0.31^{a}	0.24^{a}	0.23±0.05^{a}
Sulphate (mg/l)	0.44^{a}	0.40^{a}	0.57^{a}	0.34^{a}	0.43^{a}	0.44±0.08^{a}
Carbonate (mg/1)	0.51^{a}	0.81^{a}	0.93^{a}	0.77^{a}	0.99^{a}	0.80±0.18^{a}
Conductivity (ps/cm)	228.60^{b}	245.90^{b}	423.30^{e}	333.30^{d}	129.70 ^{a}	272.16±111.20^{c}
p^{H}	8.26 ^{a}	8.44^{b}	6.21^{a}	8.92^{b}	8.22^{b}	8.01±1.04^{b}

Values followed by same superscript alphabets in a row are not significantly different, at P = 0.05 level of significance.

cient Correlation. Differences in physico-chemical properties among habitat types were determined using ANOVA.

Results

Table 1 shows the mean occurrence of mosquito types in the different breeding habitats in Minna. Mosquito larvae were not encountered in the Drains and Rivers. The Frequency of larval occurrence in the positive habitats occurred in the following order of decreasing abundance: Ponds> Swamps > Domestic Containers. The distribution of mosquito types in the positive habitats varied considerably. *Aedes* mosquitoes occurred more freque-ntly in Domestic Containers, with equal presence in Ponds and Swamps. Generally, the *Culex* individuals were the most frequently occurring mosquitoes. The mosquito preferred breeding in Ponds, with some presence in Swamps and least encountered in Domestic Containers.

The mean physico-chemical characteristics of water in the five larval breeding habitat types are shown in Table 2. Temperature, Phosphate, Sulphate, Carbonate and Transparency were not significantly different ($P > 0.05$) among the five larval habitat categories. However, the same can not be said for the remaining physico-chemical parameters that varied significantly ($P < 0.05$) among habitats.

Total dissolved solids in ponds, swamps and rivers were not significantly different ($P > 0.05$), but were all significantly lower than recorded in Drains and Domestic Containers, with the latter having the highest amounts of Total Dissolved Solids (Table 2). The Dissolved Oxygen content of the breeding habitats ranged from 26.50mg/l in Ponds to 38.10mg/l in Domestic Containers. Dissolved Oxygen in Ponds and Rivers were significantly ($P < 0.05$) lower than in Swamps and Drains that were, in turn, significantly ($P < 0.05$) lower than in Domestic Containers. On the other hand, Conductivity was least in Domestic Containers but highest in the Drains, and except between the Ponds and Swamps, it varied significantly ($P < 0.05$) among the breeding habitats. p^{H} was more or less uniform except that it was significantly ($P < 0.05$) higher in the rivers.

Table 3 shows the relationships between physico-chemical parameters and larval abundance. The correlation coefficients between physico-chemical prope-rties and larval abundance were mostly high though, while some were positive, quite a number were negative. The weak correlation coefficients were mostly restricted to *Aedes* and *Anopheles* mosquitoes. The abundance of *Culex* mosquitoes correlated weakly only with Dissolved Oxygen.

Discussion

Mosquito larvae were not encountered in the Drains and Rivers; and also, the frequency of larval occurrence varied considerably in the positive habitats. This pattern of larval distribution has been attributed to the specificity of mosquito species to varying degrees of physico-chemical parameters in larval habitats [21]. The results of this study, therefore, indicate that mosquito larval habitats in Minna are not equally active in terms of mosquito production thus, suggesting the need to pin-point active breeding sites for targeted larviciding interventions. This may go a long way in reducing the costs and efforts involved in mosquito larval control. The larval habitat specificity shown by the mosquito agreed with the known preferred breeding sites of certain species belonging to the three mosquito *genera*. For example, while *Aedes aegypti* breeds conventionally in containers [22,23], *An. funestus* breeds preferentially in large water bodies including swamps and rice-fields [24].

Certain physico-chemical characteristics namely, Te-mperature, Phosphate, Sulphate and Carbonate were not significantly different in the habitats. This may be due to the homogeneity of weather conditions and, perhaps, edaphic factors in the area. [25] while investigating the influence of land-use on mosquito fitness in Minna obse-

Table 3. Correlation coefficients between mosquito larval abundance and physico-chemical properties of breeding habitats in Minna, during the rainy season of 2008

Parameter	*Aedes*	*Anopheles*	*Culex*	Aggregate
Temperature (ºC)	0.6401	0.7475	0.9893	0.9588
Dissolved Solids (mg/1)	0.3842	0.5905	0.5201	0.6269
Transparency (m)	0.7321	0.1875	-0.2905	-0.1098
Dissolved Oxygen (mg/1)	0.9071	-0.0927	-0.4304	-0.2915
Phosphate (mg/1)	0.7826	-0.8626	-0.888	-0.9014
Sulphate (mg/1)	0.2777	0.4875	0.6742	0.7084
Carbonate (mg/1)	0.9276	-0.4134	-7217	-0.6192
Conductivity (ps/cm)`	-0.4831	0.773	0.9981	0.9872
p^H	0.2777	0.4875	0.6742	0.7085

rved that, with the exception of Refuse Dumps, water temperatures in different larval habitats across the city did not differ significantly. The results of this study, therefore, suggest that that these factors may play no significant roles in determining larval abundance in breeding sites, as both positive and negative habitats had more or less similar values of these physico-chemical parameters. In a Malian village, Nitrate, Orthophosphate, Turbidity and Temperature had no effect on niche partitioning of species and forms of anopheline mosquitoes [26].

The strong correlations found between certain physico-chemical parameters and larval abundance, perhaps, confirms the influence of these parameters on the breeding activities of mosquitoes, and indicates the possibility of mosquito larval control through the manipulations of such parameters.

Conclusion

Mosquito breeding activities in conventional larval habitats in Minna is heterogeneous, with the Swamps been the most active source of mosquito production while, the Drains and Rivers constituted no serious threat to human health with respect to mosquito-transmitted diseases. Strong relationships were found between mosquito larval abundance and certain physico-chemical properties, suggesting their influence on the distribution and abundance of mosquito larvae in their breeding habitats. These findings should promote the development of targeted larviciding interventions thus, reducing the costs and efforts required for effective mosquito-vector control in Minna.

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