International Journal of

Zoological Research

ISSN 1811-9778

Academic Journals Inc.

www.academicjournals.com

OPEN ACCESS International Journal of Zoological Research

ISSN 1811-9778
DOI: 10.3923/ijzr.2020.63.68

Research Article
Effect of Physicochemical Parameters on Mosquito Larva Population in the Niger Delta University Campuses, Bayelsa State, Nigeria

Ebenezer Amawulu, Thomas Commander and Amain Amaebi

Department of Biological Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

Abstract
Background and Objective: The effective control of malaria through larva source management requires the information on the breeding sites and the physico chemical parameters that affects their abundance. This study investigated the ecology of mosquito larva in relation to the physico chemical parameter in the Niger Delta University campuses. **Materials and Method:** Five breeding sites of mosquitoes were identified. Mosquito larva in each breeding sites was collected into labeled containers using standard procedures. Morphological identification of larva followed standard procedures. The physico chemical parameter: temperature, turbidity, salinity and conductivity, pH , CL and alkalinity of each of the mosquito breeding sites were determined following standard techniques. The relationship between larva productivity and physico chemical parameters were analysed using t-test and correlation matrix at 0.05 level of confidence. **Results:** Three hundred and fifty mosquito larva were collected from five microhabitats such as motor tyres, gutter, containers, water pools and block holes. A significantly high proportion of *Culex quinquefasciatus* larva were more productive in all the breeding sites than and *A. gambiae* ($t = 2.966$, $p<0.05$). Except for alkaline, *Culex quinquefasciatus* larva productivity showed significant positive correlation with temperature, Turbidity, salinity and conductivity. *Anopheles gambiae* larva productivity showed a significant positive correlation with temperature and alkalinity but were negatively correlated with Turbidity, salinity, conductivity and CL. **Conclusion:** The breeding adaptability of culex mosquitoes to wide range of microhabitats and tolerance to varied physico chemical parameter is an indication that there are increase transmission foci for filariasis in rural communities of Amassoma.

Key words: Microhabitat, ecology, *Culex quinquefasciatus, Anopheles gambiae*, transmission-foci, Bayelsa State

Citation: Ebenezer Amawulu, Thomas Commander and Amain Amaebi, 2020. Effect of physicochemical parameters on mosquito larva population in the Niger Delta University Campuses, Bayelsa State, Nigeria. Int. J. Zool. Res., 16: 63-68.

Corresponding Author: Ebenezer Amawulu, Department of Biological Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Mosquitoes borne diseases are responsible for over 630,000 deaths in sub-Saharan Africa and beyond[1] with infant and children accounting for >20-30% of the total death. Three hundred mosquito species have been identified worldwide[2-3]. Only few are known vector species of human and veterinary importance[4]. Parasites transmitted by mosquitoes include, *Wuchereria bancrofti* transmitted by *Culex quinquefasciatus;* dengue and viral encephalitis are transmitted by *Aedes aegypti*, *Mansonella perstan* is transmitted by culicoides (midges) species; *Loa loa* is transmitted by *Chrysops dimidiata* while female *Anopheles* mosquito transmit Plasmodium species[5].

Mosquito vectors spend three quarter of their life stages in aquatic environment. Consequently, anything that affect the condition and composition of the water body may invariably cause changes in the water ecosystem, which may also impact negatively on the breeding behavior, diversity and larva population of the mosquito fauna[6]. Urbanization, Human and industrial activities are various factors that cause changes in the water ecosystem. These changes affect different kinds of water related organism. Mosquito is far the most sensitive organism that respond to ecosystem changes[7] .

Physicochemical parameters are the products of the changes that take place in the water ecosystem. These parameters affect the composition of local fauna[8]. Physicochemical parameter of water bodies that influences mosquito composition include salts, dissolved inorganic and organic matter, turbidity, temperature, light and shade, hydrogen ion concentration[9]. Suitable pH, temperature and nutrient composition increases mosquito abundance[10]; reduced oxygen tension in the water body reduces the population and emergence of the adult mosquito by stranding their larvae[11]. pH ranging from 6.8-7.2 can optimally weaken the egg shells for the emergence of the first instar larvae[12]. Consequently, the chemical properties of the mosquito larval habitat can impair the development and survival of larva, which also may affect adult emergence[13].

The effective control of vector borne diseases through vector source management requires information on the breeding sites, species distribution and abundance of the vectors in a targeted area[14]. Understanding the microhabitat ecology of the mosquitoes is therefore a critical component of larva source management in vector control programme. Several studies assessing the habitat of vector species among communities have been carried out. Okiwelu and Noutcha[15], who assessed the breeding sites of *Culex quinquefasciatus* (Say) in 5 villages in Ikwerre Local Government Area (LGA) of Rivers State reported that *C. quinquefasciatus* (Say) immatures was approximately 6-fold that of *An. gambiae* s.l. in the study location and nearly 80% of *C. quinquefasciatus* breed in container-type breeding sites (metal, plastic containers, "calabashes", tyres. Onyido *et al.*[16] who also studied the ecology of malaria vectors in a suburban community of Umudioka, Dunukofia Local Government Area of Anambra State reported that ground pool accounted for 31.45% of the *Anopheles* mosquito larvae. Afia and Efiong[17] in a survey on the mosquito breeding potentials of dumpsites in selected locations in Uyo Local Government Area of Akwa Ibom State reported that *Anopheles, Aedes and Culex* spp. were more predominant. Understanding the physico chemical parameter of the breeding site of mosquito is crucial in studying the biodiversity of mosquito of parasitological and veterinary important in human habitation[18]. However, information on the relationship between physico chemical parameter and mosquito larva productivity in the rural community of Bayelsa State is scarce. In this study, the relationship between the physico-chemical parameters on the mosquito larva productivity in the Niger Delta University campuses, Bayelsa State was studied.

MATERIALS AND METHODS

Study area: Niger Delta University (6°08'N and 4°57'E) is located in Amassoma community; an ancient community in the wilberforce Island in Southern Ijaw Local Government Area of Bayelsa State. The details of the study locations have been exclusively described by Amawulu *et al.*[19].

Study design: The study combines both field and laboratory study. A field and cross sectional study design was adopted to identify mosquito breeding sites within the Niger Delta University Campuses during March-May, 2019. It is a cross sectional because the study was carried out at a single visit without necessarily going out for a follow up.

Mosquito sampling and collection: The study was carried out in the Niger Delta University, Amassoma. The study locations were New site and Main campus. In each location, waste dumpsites, water containers, gutters, block holes, motor tyres and water pools were identified and inspected for the presence of mosquito larva. Larva were either collected using giant plastic pipette where they are found in small container or the entire container contents were upturn into collection vessels. In a deeper water body, larva was collected with a ladder following the dip method described by Service[20]. The procedures for dipping and larva collection has been described in Amawulu and Amakiri[21]. Collected samples were labeled according to the macro habitat.

Morphological identification: Identification of mosquito larvae were done as per standard keys[22-23]. The position of the head and abdomen in relation to the water body was used to separate the Anopheles from Culex and Aedes.

Measurement of physico-chemical parameters: The physico chemical parameters such as water temperature, pH, Biochemical oxygen Demand (BOD), turbidity and conductivity were determined at the Quality Control Laboratory, Niger Delta University, Bayelsa State.

Statistical analyses: Two statistical tools used for statistical analysis were simple percentage and ANOVA. Simple percentage was used to show the distribution of mosquito larva in different micro habitats and locations. The relation between larva abundance and microhabitats were all determined using ANOVA at p = 0.05. Karl Pearson's correlation matrix was used to assess the relationships between larva abundance and the physicochemical parameter.

RESULTS

Three thousand and five hundred mosquito larva was collected from five micro habitats across two locations in Niger Delta University Campuses during March-May, 2019. The population of Culex *quinquefasciatus larva* (66.86%) were more than *Anopheles gambiae* sl. larva (33.14%). The differences were significant (t = 2.966, df = 1, $p<0.05$) (Table 1).

Mosquito Larva productivity across breeding sites in Niger Delta University (March-May, 2019): Five mosquitoes breeding sites were identified. These are; motor tyres, gutter, containers, water pools and block holes. Triplicate of each kind of microhabitats were inspected for mosquito larva. When the mosquito larva was pooled into breeding sites (Fig. 1), more mosquito Larvae was recovered in containers, followed by block holes. The least was recovered in motor tyres.

Culex and *Anopheles* mosquito species were sympatric in all the breeding sites. The mean and standard deviation of the *Culex quinquefasciatus* larva productivity across the microhabitat were in the order, CT>BH>MT>GT>WP. The mean and standard deviation of *Anopheles* productivity across breeding sites in their increasing order of abundance were CT>GT>MT>BH>WP, respectively. Differences in the mosquitoes' larva productivity across the breeding sites was significant (t = 4.715, $p<0.05$).

Relationships between physico-chemical parameters and mosquito larva productivity: The effect of physico chemical parameters on larva population varied across the breeding sites. The mean pH was highest in block hole and least in motor tyre; Temperature was slightly uniform in all breeding sites and ranges from 25.80-28.03°C. The mean turbidity was highest in water pool and least in gutter, although the differences was not significant ($p>0.05$). The mean salinity (ppm) ranges from 0.32-12.93, with a significant higher value in water pool. The mean conductivity and alkalinity were not significantly different across the breeding sites. The mean chlorides differ significantly between block hole, water pool and containers (Table 2).

Culex quinquefasciatus larva productive was significantly higher than *A. gambiae* larva in all the breeding sites (t = 2.966, $p<0.05$). The larva productivity was influenced by physico chemical parameters (Ph, T^O, Turbidity, Salinity, Conductivity, Alkalinity and Chlorides). A correlation matrix analysis (Table 3) shows that relationship exist between physico chemical parameters and mosquito larva productivity. *Culex quinquefasciatus* larva had a positive correlation with temperature, Turbidity, salinity and conductivity, However, a

Table 1: Population of mosquito fauna in NDU, March-May, 2019

Species	No. Counted	Counted (%)
Culex quinquefasciatus	2340	66.86
Anopheles gambiae	1160	33.14
Total	3500	100.00

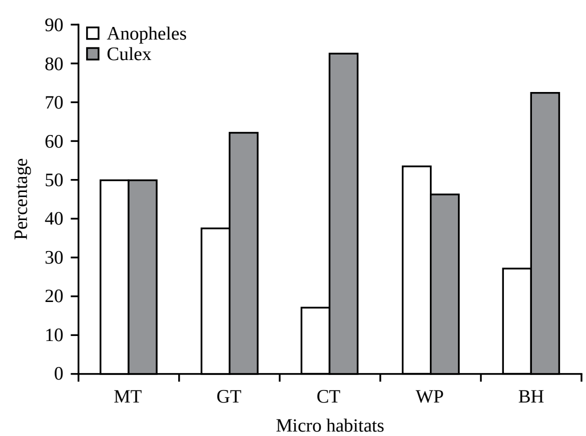

Fig. 1: Percentages of mosquito larva species across five micro-habitats

MT: Motor Tyre, GT: Gutter, CT: Container, WP: Water pool, BH: Block holes

Table 2: Mosquito Larva productivity across breeding sites in Niger Delta University, during March-May, 2019

Micro habitats	Mosquito species		Physico chemical parameter						
	Culex	*Anopheles*	T⁰	pH	TUB	SAL	COND	ALK	CL
BH	11.67±2.89[b]	3.33±1.15[a]	28.03±0.05[b]	6.60±0.17[a]	100.00±17.32[a]	0.42±0.02[a]	201.00±35.51[a]	35.33±1.53[a]	27.37±1.18[b]
WP	4.33±3.51[a]	1.67±1.53[a]	25.80±0.72[a]	6.53±0.21[a]	104.17±8.95[a]	12.93±21.71[b]	203.67±21.96[a]	34.00±3.46[a]	27.00±1.73[ab]
CN	12.00±3.60[b]	4.67±4.16[a]	27.23±0.15[b]	6.57±0.25[a]	103.83±9.56[a]	0.42±0.02[a]	203.67±21.96[a]	32.67±2.52[a]	26.33±1.15[ab]
MT	7.33±2.08[ab]	3.33±1.53[a]	27.67±0.58[b]	6.43±0.11[a]	90.37±0.90[a]	0.39±0.01[a]	183.67±6.23[a]	36.17±2.89[a]	25.00±1.00[a]
GT	6.67±1.15[ab]	4.33±1.52[a]	26.33±0.58[a]	6.57±0.06[a]	86.00±4.33[a]	0.32±0.09[a]	177.00±8.66[a]	152.00±197.45[a]	25.00±0.00[a]

***BH: Block hole, WP: Water pool, CN: Container, MT: Motor tyre, GT: Gutter, **T⁰: Temperature, pH: Hydrogen ion concentration, TUD: Turbidity, Sal: Salinity, COND: Conductivity, ALK: Alkalinity, CL: Chloride, *Different alphabets a, b and c on each column indicates a significant difference between containers at alpha level p<0.05. There was a significant difference between treatment value among containers at p<0.05, Values are presented as Mean±standard deviation

Table 3: Correlation between mosquito larva productivity and physico-chemical parameters

	Culex	*Anopheles*	T°	pH	TUD	SAL	COND	ALK	CL
Culex	1								
Anopheles	0.5780[a]	1							
T°	0.6523[a]	0.3300[a]	1						
PH	0.2604[b]	0.3299[b]	0.2119[a]	1					
TUD	0.0362[a]	-0.3178[a]	-0.1113[a]	-0.4717[a]	1				
SAL	0.1013[a]	-0.1022[b]	0.3583[a]	-0.0759[b]	0.5347[a]	1			
COND	0.0409[a]	-0.2166[a]	-0.0419[a]	-0.5307[a]	0.9614[a]	0.5156[a]	1		
ALK	-0.1215[a]	0.2588[a]	0.1332[a]	0.5013[a]	-0.8340[a]	-0.5045[a]	-0.7927[a]	1	
CL	0.2510[a]	-0.1118[a]	0.1652[a]	0.6752[a]	0.0101[a]	0.2576[a]	-0.1139[a]	0.0534[a]	1

T°: Temperature, pH: Hydrogen ion concentration, TUD: Turbidity, Sal: Salinity, COND: Conductivity, ALK: Alkalinity, CL: Chloride, *Different alphabets a, b and c on each column indicates a significant difference between containers at alpha level p<0.05. There was a significant difference between treatment value among containers at p<0.05

negative correlation exist between *Culex* mosquito and alkalinity. Nevertheless, *Culex* larva productivity was significantly influenced by pH. *Anopheles gambiae* larva productivity showed a positive correlation with temperature, pH and alkalinity but were negatively correlated with Turbidity, salinity, conductivity and Chlorides. However, the increased productivity of *Anopheles* mosquito in some breeding sites was influenced by pH While their reduced productivity in some breeding sites was influenced by salinity.

DISCUSSION

The knowledge about the ecology and factors that affects the breeding of mosquitoes is a germane to predict the likelihood of mosquito borne diseases. In this present study, *Culex quinquefasciatus* and *Anopheles* were the only mosquitoes' species encountered in the study location. Similar observation has been reported elsewhere in similar environment[24]. The presence of these mosquito species is an indication that the environment is conducive for the mosquito development. The higher numbers of *C. quinquefasciatus* larvae is an indication that the species, which was once considered an urban mosquito is also colonizing rural pockets that were once free of this mosquito[15]. However, these observations contradict the report of Emidi *et al.*[25] who reported more *Anopheles* than *Culex* mosquitoes in similar experimental environment in Tanzania. The higher density of *Culex* mosquito than *Anopheles* affirmed the hypothesis that where *Culex* mosquito increases, the population of *Anopheles* mosquito is suppressed[3]. The population abundance of *C. quinquefasciatus* in all the breeding sites in this present study is an indication that the changes in the oviposition behaviour of *C. quinquefasciatus* were necessitated by human population characteristics. The establishment of the Niger Delta University in this study area may not be unconnected with these changes.

Five breeding sites were identified in the study locations. Similar observation has been reported elsewhere[26]. In all the breeding sites, there was sympatric association between *Culex* and *Anopheles*. This observation concurs with the report of Kudom[18], who reported that *Anopheles* and *Culex* shows the tendency of co-existence despite the differences in their breeding ecology.

Information on the effect of physico chemical parameter on the mosquito larva productivity is useful in assessing the menace of mosquito borne diseases. In this present study, the physico chemical parameter analyzed were temperature, pH, turbidity, salinity, conductivity, alkalinity and chloride. The breeding sites with higher physico chemical parameters were considered polluted[25] Studies have shown that mosquito can breed suitably in a water body whose pH is above 7. However, in this present study, a mean pH of 6.5 was recorded. The pH of 6.5 was slightly lower than 7.07 in Olajiri *et al.*[27], 7.33 in

Diana *et al.*[28] and 8.47 in Kipyab *et al.*[29]. The abundance of *Anopheles* mosquito in a breeding site whose PH is slightly acidic (6.5) is an indication that Anopheles is adapting to both polluted and unpolluted water bodies. The adaptability of *Culex* mosquitoes to both polluted and unpolluted water bodies has been reported[9].

The mean temperature of mosquito breeding site in this present study ranges between 25.08-28.03°C. The temperature range was comparable with 25.09°C in Olajiri *et al.*[27]. A moderately high temperature is said to be suitable to facilitate the growth and development of mosquito larva. The temperature range in this present study was adequate to the larva productivity in all the study locations. Conductivity, turbidity, salinity and chloride in the study location was favorable to the breeding of all mosquito species. *Culex* mosquito showed positive correlation with temperature, pH, salinity and chloride. This observation is consistent with Nikookar *et al.*[30] *Anopheles* mosquito larva showed positive correlation with pH, Temperature and alkalinity. However, the population of *Anopheles* was significantly influenced by pH. This observation contradicts the report of Kipyab *et al.*[29] who reported that a negative correlation exists between Anopheles and pH, but had a positive correlation with salinity. The correlation between mosquito and physico chemical parameters are said to affect the preferences in the choice of habitats and common food web[30]. By implication, the physico chemical parameters may have originated from the domestic activities of students in the hostels or from laboratory effluents. Since most part of the school campus is water-log, the effluents are easily circulated. These, have shown enhanced impact on the breeding activities of mosquito in the school campus. Indiscriminate breeding may increase the population of active larva, which can also increase emerge adults. Understanding many of the emerging microhabitat characteristics can thus assist in promoting development of effective control measures against mosquitoes. The adaptability of Anopheles and Culex mosquitoes in the Niger Delta University is an indication that the environment is a foci zone for filariasis. It is recommended that domestic discharge from students' hostels and laboratory effluents and many other effluents that contains metallic ions that can increase the breeding activities of mosquitoes be properly regulated.

CONCLUSION

It is evident from the study that the predominant mosquito larva recovered from the study location were *Culex* and *Anopheles* mosquitoes. Although the two mosquito species showed differences in their breeding ecology, both have shown the tendency of co-existing in the same breeding sites. The breeding characteristics and population abundance of the mosquitoes were influenced by physico chemical parameters such as temperature, humidity, pH, conductivity and turbidity of the water body. The higher population of *Culex quinquefasciatus* in the study location is an indication that Niger Delta University is a foci zone for Filariasis.

SIGNIFICANCE STATEMENT

This study discovered important information that can be beneficial for the control of mosquito borne parasitic infections in the rural community. Several studies have reported the microhabitat of mosquito species in the rural communities in Bayelsa State. Limited study has shown the relationship between the mosquito breeding site and physico chemical parameter. This study has uncovered the critical role of physico chemical parameter on the breeding preferences of mosquito species. Breeding preferences is the link between mosquito abundance and their chances to make mosquito-man contact. Manipulating the physico chemical parameter of the mosquito breeding site is a milestone to reducing the menace of mosquito-related diseases.

ACKNOWLEDGMENT

We are grateful to our field workers that assisted us in the collection of the mosquito larva. We are also grateful to the staff of the Central Research Laboratory of the Faculty of Science, Niger Delta University for the analyses of the physico chemical parameters.

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