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Original article

PHYSICOCHEMICAL EFFECT OF MOSQUITO LARVAL HABITAT ON ADULT BODY SIZE AND VECTORIAL FITNESS

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ABSTRACT

The effects of physicochemical factors of mosquito larval habitats on the body size and vectorial fitness of adults mosquitoes was studied in four selected Rice fields located in Fadikpe, Bosso, Maitumbi and Chanchaga areas of Minna, north central Nigeria. Water sample was collected from larval habitats for analyses. Mosquito larvae were also collected from sampling sites and reared under laboratory condition. Adult mosquitoes were identified using Standard Morphological keys. Mosquito wings were removed carefully with forceps, mounted on a microscope glass slide and measured using calibrated dissecting microscope. The results revealed that *Aedes* mosquitoes are larger in size than *Anopheles* and *Culex* mosquitoes, with Fadikpe producing larger *Aedes* mosquitoes (MWL 3.1), (n=155). Although *Anopheles* and *Culex mosquitoes* had a better vectorial fitness than *Aedes* mosquitoes because their fluctuating asymmetry is perfect or near perfect (i.e. 0.0 or 0.1). However, the vectorial fitness of the three mosquito genera were not significantly different ($P > 0.05$) among the rice fields. All the physicochemical variables correlated positively with the wing length of *Aedes* except for Hardness that correlated negatively very strong (-1.000). *Anopheles* wing length correlated negatively weak with Temperature, P^{H}, Turbidity, Conductivity, Hardness, Sodium, Nitrate, Ammonia and Chloride, but correlated negatively strong with Phosphate. Apart from Potassium that correlated positively weak with *Culex* wing length, all other parameters had a negative correction with the wing lengths of *Culex* mosquitoes. The Mosquito vectors encountered in this study are of public health importance, hence the manipulation of physicochemical factors of larval habitats to reduce vectorial fitness is recommended.

Keywords: Physicochemical, Mosquito, Larval habitat, Body size, Vectorial fitness

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INTRODUCTION

Water quality of aquatic habitats is an important determinant of female mosquito oviposition and successful larval development [1]. Larval abundance reflects oviposition preference of female. Changes in physicochemical characteristics of Rice field water may create conditions that are either favourable or unfavourable to breeding success. The attractiveness of gravid females for oviposition largely depends on the interactions between the physicochemical parameters and also on the availability of suitable water bodies [2]. This is to say that mosquito species differs in the type of aquatic habitats they prefer for oviposition.

The terms vectorial capacity, competence, and fitness are often used interchangeably to describe the ability of a mosquito to serve as a disease vector. Vectorial capacity is defined quantitatively and is influenced by such variables as vector density and longevity as well as vector competence [3]. Estimates of vectorial capacity take into account all the environmental, behavioural, cellular, and biochemical factors that influence association between a vector, the pathogen transmitted by the vector, and the vertebrate host to which the pathogen is transmitted [4]. Similarly, vectorial fitness of mosquitoes is greatly influenced by its breeding ecology [5].

Body size is a pivotal trait for mosquitoes, because it has been related to survival, blood feeding behavior, reproductive success and vectorial Wing size reflects body size, which is related to survival and reproductive success [6]. Adult body size is often correlated with higher vectorial fitness. Larger body size confers better fitness [6]. The best measure of body size is assumed to be dry weight; therefore weight is used in many studies involving association with body size [6].

However, the weight of an adult mosquito varies considerably and depends on whether the mosquito has recently had blood or sugar meal. For example, mosquito weight can sometimes give unreliable results due to different factors such as gravidity or recent intake of blood meal [6]. To circumvent this problem, many researchers have used wing length as an indicator of body size. This approach is justified with the observation that wing length generally is correlated closely to a power function of body weight. Body size therefore confers better fitness to mosquitoes in a natural population. Various biotic and abiotic factors affects the growth, development and survival of the immature mosquitoes and consequently affects their vectorial fitness. By implication, physicochemical factors of mosquito breeding habitat certainly have an influence on larval development and adult body size.

MATERIALS AND METHODS

Study Area.

The study was carried out in Minna, North- central Nigeria. The study covers four rice fields in four widely spaced sites located in Fadikpe, Bosso, Maitumbi and Chanchaga areas of the city. The ecotype of all these four sites is that of Fadama wetland rice agro-ecosystem with temporary stagnant fresh water pools of various -sizes constituted by rains.

Collection of Water Samples and Physicochemical Analyses

Water samples were collected concurrently with larval sampling from the four Rice fields investigated. From each sampling station, 125ml of water was collected to make 500ml per sampling site using 500ml capacity specimen bottles to ensure adequate representation. The water was fixed immediately using the procedures described by [7] in preparation for laboratory analysis. Water Temperature, pH and Conductivity were determined at the sites during larval collection using ordinary mercury thermometer and conductivity meter respectively. Water samples were further analyzed for the following physicochemical parameters. Temperature, P^H, Conductivity, Turbidity, Alkalinity, Hardness, Potassium (K), sodium (N), phosphate (PO_4), Nitrate (NO_3), Ammonia (NH_4) , Carbon dioxide (CO_2) chloride (CL), Dissolved Oxygen (D.O) and Biochemical Oxygen Demand (B.O.D).

Analyses of these parameters were carried out in Water Resources and Fisheries Technology (WAFT) Laboratory, Federal University of Technology, Minna, Nigeria.

Mosquito Larval Collection, Rearing and Identification

Mosquito larvae were collected by dipping (using an improvised dipper 1.5 liters capacity) at depths of no more than 5cm at the various sampling stations. Total larvae number and larval instars were recorded within 24 hours of collection.

Larvae were reared in white plastic bowls (2 liters size) in the laboratory of the Department of Biological Sciences, Federal University of Technology Minna. Rearing was done according to the methods described by [8] and [9]. The adult were demobilized by spraying with insecticide (Raid) for identification. Adult mosquitoes were identified under microscope using standard morphological and Taxonomic keys, i.e. [10]; [11] and [12].

Determination of Wing Symmetry

Both left and right wings of individual adult mosquitoes were removed carefully with forceps and mounted on a Microscope glass slide. The wings were measured using calibrated Dissecting Microscope.

Statistical Analysis

Data obtained were analyzed using SPSS Software (Version 20). Mean Wing length (MWL) and Fluctuating Asymmetry (FA), were analyzed using one-way ANOVA, and Duncan multiple range test was employed to separate their means, and $P<0.05$ was considered significant. The relationships between Mosquito Wing length and Physicochemical Variables of breeding habitats were compared and correlated using Paired Sampled t-test to determine the degree of association between the variables.

RESULTS

The results revealed that *Aedes* mosquitoes are larger in size than *Anopheles* and *Culex* mosquitoes, with Fadikpe producing larger *Aedes* mosquitoes (MWL 3.1), (n=155). Although *Anopheles* and *Culex had* a better vectorial fitness than *Aedes* because their fluctuating asymmetry is perfect or near perfect (i,e 0.0 or 0.1). However*, Culex* breeding in Chanchaga had a better vectorial fitness (FA 0.0). Similarly, *Anopheles* mosquitoes breeding in Fadikpe and Maitumbi rice fields had a perfect vectorial fitness (FA 0.0). However, the vectorial fitness of the three mosquito types were not significantly different (P>0.05) among sampling sites'

Table 1: Mean wing length (MWL) in (mm) of mosquitoes in relation to sampling sites

	Mosquitoes		
Locations	*Aedes*	*Anopheles*	*Culex*
Fadikpe	3.1	2.8	2.95
Bosso	3.0	2.75	2.95
Maitumbi	3.0	2.8	2.8
Chanchaga	2.9	2.85	2.9

Table 2: Fluctuating Asymmetry (FA) in (mm) of wings (Means ± SE)

	Mosquitoes		
Locations	*Aedes*	*Anophele*	*Culex*
Fadikpe	0.20±0.06[a]	0.00±0.00[a]	0.10±0.06[a]
Bosso	0.20±0.06[a]	0.10±0.06[a]	0.10±0.06[a]
Maitumbi	0.20±0.06[a]	0.00±0.00[a]	0.10±0.06[a]
Chanchaga	0.00±0,00[a]	0.10±0.06[a]	0.00±0.00[a]
Aggregate	0.12±0,05	0.05±0.03	0.08±0.05

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

Relationship between wing length and physicochemical factors of larval habitats

All the physicochemical variables correlated positively with the wing length of *Aedes* except Hardness. *Anopheles* wing length correlated negatively weak with Temperature, P^H, Turbidity, Conductivity, Hardness, Sodium, Nitrate, Ammonia and Chloride, but correlated negatively strong with Phosphate. There also exist a strong positive correlation between the wings of *Anopheles* mosquitoes with Potassium and a weak positive correlation with Carbon dioxide, Dissolved Oxygen and Biochemical Oxygen Demand. Apart from Potassium that correlated positively weak with *Culex*, all other parameters had a negative correction with *Culex*.

Table 3: Correlation between Wing Length and Physicochemical factors of larval habitats

	Correlations		
Physicochemical Variables	*Aedes*	*Anopheles*	*Culex*
Temperature	1.000	-0.013	-0.474
P^H	0.999*	-0.022	-0.449
Turbidity	0.993	-0.108	-0.479
Conductivity	1.000	-0.001	-0.472
Alkalinity	1.000	-0.003	-0.469
Hardness	-1.000	-0.020	0.484
Phosphate	0.414	-0.887*	-0.622
Sodium	0.999*	-0.035	-0.458
Potassium	0.353	0.816*	0.452
Nitrate	0.988*	-0.133	-0.435
Ammonium	0.980*	-0.195	-0.487
Carbon dioxide	0.998*	0.050	-0.436
Chloride	0.998*	-0.001	-0.419
D.O	0.999*	0.040	-0.429
B.O.D	0.996*	0.350	-0.528

*indicates strong correlations.

DISCUSSION

The body size of mosquitoes is influenced by water temperature [13], larval nutrition [14] and in part photoperiod [15]. Wing length which is correlated with dry weight can be used as proxy for body mass. In this study, wing length was used as proxy for body size and the results shows that *Aedes* mosquitoes are larger in size than *Anopheles* and *Culex* mosquitoes (Table 1 and 2) respectively.

The wing length of *Aedes* ranged from 2.9mm to 3.1mm, *Anopheles* ranged from 2.75mm to 2.85mm and *Culex* ranged from 2.8mm to 2.9mm. In comparison, [16] measured the wing length of *Aedes* mosquitoes to range from 2.4 to 3.3mm with a mean of 2.83mm. Rice field in Fadikpe harbored larger *Aedes* and *Culex* while larger *Anopheles* was encountered in Chanchaga. Fitness estimation is however very difficult, largely because of its biological complexity. But the present study revealed that *Anopheles* and *Culex* mosquitoes breeding in rice fields have better vectorial fitness than *Aedes* mosquitoes because their fluctuating asymmetry (FA) is almost perfect (i.e. 0.0 or 0.1). However, there was no significant difference ($P>0.05$) in the vectorial fitness of the three mosquito type among the rice fields. This means that, all the mosquitoes can serve as good disease vectors, provided they are genetically and biochemically compatible for the complete development of a particular pathogen. Even though, variation in the wing lengths of *Culex quinquefasciatus* and *Mansonia africana* was reported to be higher in wet season than dry season, but was not statistically significant ($P>0.05$) [17].

Research also revealed that cool temperature prolong larval development and result in the emergence of large adults [18]. It was established by [19] that short photoperiod mosquitoes have greater wings than long photoperiod mosquitoes. In this study, photoperiod is not considered, but other variables including Temperature might play an important role in the body size of all the mosquito types.

Larger *Anopheles* are found in association with Potassium, Carbon dioxide, Dissolved Oxygen and Biochemical Oxygen Demand, whereas *Culex* mosquitoes associated negatively with such parameters in breeding water. (Table 3). All physicochemical variables correlated positively with the wing length of *Aedes* except for Hardness that correlated negatively very strong (-1.000). This implies that such physicochemical factors with positive correlation have greater influence on the body size of *Aedes* mosquitoes. *Anopheles* wing length correlated negatively with Temperature, P^H, Turbidity, Conductivity, Hardness, Sodium, Nitrate, Ammonia, Chloride and Phosphate. Such negative correlations indicate the negative effects of the said variables on the body size of *Anopheles* mosquitoes. However, physicochemical factors such as pH, and Dissolved Oxygen might provide a perfect environment for survival and breeding activity of *Anopheles* species [20]. Apart from Potassium that correlated positively weak with *Culex*, all other parameters had a negative correction with *Culex* mosquitoes. This explains their small size as compared to *Aedes* mosquitoes breeding in rice fields larval habitats.

CONLUSION

The study shows that *Aedes* mosquitoes are larger than *Anopheles* and *Culex,* but the two (i.e *Anopheles* and *Culex)* have better vectorial fitness than *Aedes* mosquitoes and can therefore serve as good disease vectors. Furthermore, the physicochemical factors of larval habitats have greater influence on the body size and vectorial fitness of adult mosquitoes and consequently accounts for much of the variations among the groups.

RECOMMENDATIONS

The manipulation of physicochemical characteristics of larval habitats to reduce the survival rate, fecundity, progeny development, as well as vectorial fitness of mosquitoes should be considered seriously.

REFERENCES

1. Joseph, M. (2007). Environmental Covariate of *Anopheles arabiensis* in rice agro ecosystem in Mwea Central Kenya. *Journal of the American mosquito control Association,* 23(4), 371 – 377.

2. Filinger, U. S., Sonye, G. F., Killeen, B. G. & Berker, N. (2004). The Practical importance of permanent and semi-permanent habitats for controlling aquatic stages of *Anophels gambiae.* S.L. Mosquitoes: operational observation from a rural town in Western Kenya*. Journal of Tropical Medicine and International Health*, 9, 1274 – 1289.

3. Black, I. V., and Moore, C. G. (1990). Population Biology as a tool for studying vector-borne diseases. In B. J. Beaty and W. C. Marquaat (Eds). *The Biology of Disease Vectors.* Colorado, University press.

4. Bearntsen, B.T., James, A. A., & Christensen, B. M. (2000). Genetics of Mosquito Vector competence*, Microbiologia and Molecular Biology reviews*, 64, 115-137.

5. Olayemi, I. K. (2008). Influence of land use on the fitness of *Anopheles gambiae.* The principal vector of malaria in Nigeria*. Online Journal of Health and allied Sciences,* 7(4), 3-9.

6. Carron, A. (2007). Correlation between wing measurement and dry body weight in male and female *Ochlerotatus caspius*. (Drptera: culicidae) *Journal of European mosquito control Association*, 24, 4-8.

7. American Public Health Association APHA. (1999). Standard Methods for Examination of Water and Waste water (19th edition). *American Public Health Association Inc*. United State.

8. Pecor, J. & Graffigan, T. (1977*). Laboratory and field protocols.* Washington D. C. water Read Biosystematics Unit, Smithsonian institution. http./wrbu.siedu/www/labman.html. Retrieved April 2003

9. Gerberg, J. E. (1970). Manual for mosquito rearing and experimental techniques*. Journal of American mosquitoes control Association Bulletin* 5, 17 – 28.

10. Gillet, J. D., & Smith J. G. (1972) *Common African Mosquitoes and their Medical Importance*. London, Willian Heimenn medical Books Ltd.

11. Gordon, H. R. & Lovopierre, M. M. (1978). *Entomology for students of medicine.* Oxford, London. Blackwell Scientific co.ltd.

12. Service, M. W. (2000*). Medical Entomology for Students.* London. Liverpool Cambridge University Press. Pp 213-223.

13. Day, J. F., Ramsey, A. M. & Zhag, J. T. (1990). Environmentally mediated seasonal variation in mosquito body size. *Environmental Entomology*, 19, 409 – 473.

14. Briegel, H. (1990). Metabolic relationship between female body size, reserves and fecundity of *Aedes aegypti. Journal of Insect physiology*, 36, 165 – 172.

15. Lanciani, C. A. (1992). Photoperiod and the relationship between wing and body weight in Anopheles

quadrimaculatus. *Journal of America mosquito control Association,* 8,297 – 300.

16. Jocop, C.K and Lyimo, E.O. (1996). Variability in the relationship between weight and wing length of Anopheles gambiae. (Diptera: Culicidae). Journal of Medical Entomology, 33(2), 261-264.

17. Adeleke, M. A., Mafiana, C. F., Idowu, A.B., Adekunle, M. F. & Samwobo, S. O. (2008). Mosquito Larval Habitats and Public Health implication in Abeokuta, Ogun State, Nigeria. *Tanzania Journal of Health Research,* 10 (2), 103 – 107.

18. Mullens, B. A. (1987). Seasonal Size variability in *Culicoides variipennis* (Diptera: (eratopogouidae) in sourthern California*. Journal of American mosquito control Association,* 3,512 – 513.

19. Lanciani, C. A. & Edwads, R. (1993). Effects of photoperiod on wing area in *Anophels quadrimaculatus* Diptera: Culicidae*). Journal of American mosquito control Association,* 4,301 – 314.

20. Oyewole, I. O., Momoh, O. O., Anyasor, G. N. Ogunnowo, A. A., Ibidapo, C. A., Oduola, O. A. … Awolabi T. J. (2009). Physicochemical characteristics of Anopheles breeding sites. Impact on fecundity and progeny development. *African Journal of Environmental Science and Technology, 3*, 12, 447 – 452.