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Abundance and Diversity of Mosquito Species Larvae in Shendam LGA, Plateau State, North-Central Nigeria: A Panacea for Vector Control Strategy

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ABSTRACT

The breeding of mosquitoes takes place in various habitat types. Some breed in natural habitats while others prefer artificial breeding sites where they mature to adult mosquitoes which are haematophagous in nature and are vectors of diseases in which some are either anthropomorphic or zoophilic. Thus, this study investigated the abundance and diversity of mosquito species larvae in Shendam LGA, Plateau State, North-Central Nigeria as a panacea for vector control strategy in relation to their habitat types and gradients to houses. The selected habitats were surveyed weekly between August and October, 2014 across five communities. A total of 1,700 mosquitoes larvae of variable instars were collected and reared to adults in which 1,241 successfully emerged as adults comprising of four genera namely: Anopheles (38.92%), Culex (60.11%), Aedes (0.81%) and Mansonia (0.16%), and a total of fifteen species were identified of which Anopheles spp. were 6, Culex spp. 5, Aedes spp. 3 and Mansonia species 1. Culex quinquefasciatus and Anopheles gambiae were the most abundant species. There was no significant difference ($P > 0.05$) in larval abundance between anopheline and culicine groups. The abundance of anopheline larvae in relation to habitats types showed significant difference ($P < 0.05$) while no significant difference ($P > 0.05$) was recorded in abundance of culicine larvae across habitats. There was significant variation ($P < 0.05$) in mosquitoes abundance in relation to locations. Anopheline breed far away from houses and there was a significant difference ($P < 0.05$) in their abundance in relation to gradients. Culicine breed close to houses but there was no significant difference ($P > 0.05$) in their abundance in relation to gradients. Rice paddy was the most productive habitat type. The results of this study depicts high species abundance and relatively low diversity but a high larval breeding index due to enabling environment that has been created by anthropogenic activities which may result in serious threat of mosquito-borne diseases among the inhabitants of the selected communities in Shendam LGA, Plateau State. Implementing a larviciding strategy in most especially rice paddy during the wet season is presumably the most cost-effective strategy to consider.

Keywords: *Mosquitoes larvae breeding, Abundance, Diversity, Habitat types, Gradients, Breeding Index.*

INTRODUCTION

Mosquitoes are insects belonging to the order Diptera. They differ from other flies due to the presence of long piecing and sucking mouthpart called the proboscis. Their flight ranges is about 1.5 – 2.5 km/hr and are most nocturnal in nature (Harbachs and Knight, 1981). Over 3,500 species of mosquitoes have been described from various parts of the world (Afshin, 2007; Leisnham, 2013). Mosquito species are vectors of emerging infectious diseases, capable of affecting both human and animals (Gubler, 2002). Mosquito-borne diseases emerges as full-blown outburst which needed immediate attention or drastic approach. High rate of mosquito-borne diseases in Africa currently have serious public health challenge at the global scale and served as breeding ground for most zoonotic diseases (Gould et al., 2003).

Agricultural changes of the landscape such as afforestation, deforestation, irrigation and desertification provide a conducive breeding ground for the proliferation of mosquito species. Land use and land cover changes such as agricultural expansion and increased human population contributed immensely to the increase in breeding sites and formation of habitat for mosquito species (WHO, 2004; Afrane et al., 2012). Furthermore, anthropogenic activities have seriously encouraged the breeding successes of mosquito species close to human habitation, thereby increasing the rate of disease transmission. Climate change such as temperature extremes, rainfall, relative humidity are major ecological factors which have devastating effect on the environment, thereby influencing the abundance and diversity of mosquito species (Hasnana et al., 2016; Wilke et al., 2019). Mosquito species have shown high preferences and greater affinity to different habitats. The breeding sites can be very diverse, including ponds, lakes, swamps, mashes, rice field, small rain pools, hoof prints, tyre-tracks, tree holes, plant axils, edge of streams (Castro et al., 2010; Wilke et al., 2019; Zogo et al., 2019). Natural breeding sites such as ponds, swamps, springs and streams sustain vector populations. Anopheles larvae are most likely to be found in permanent, shallow, sunlit pools of water of perimeter less than 10m (Matthys et al., 2006; Matthys et al., 2010).

Artificial breeding sites which include gutters, ditches, tyre-tracks, construction sites and swimming pools provides the most abundant sources of mosquito larvae in urban centres of Africa (Chaki et al., 2009; Castro et al., 2010; Siri et al., 2010). Tyre tracks and swimming pools were reported to contain all life stages of mosquito species, suggesting that they were particularly productive habitats (Impoinvil et al., 2008; Matthys et al., 2010) and were found mainly in poorly-drained peri-urban areas (Keating et al., 2003). Hence, the study investigated the abundance and diversity of mosquito species larvae in selected communities of Shendam Local Government Area (LGA), Plateau State, North-Central Nigeria as a panacea for vector control strategy.

Materials and Methods

Study Sites

They survey was carried out in five selected communities namely Dokan-Tofa, Total Shendam, Ntuer, Shepwan and Tumbi in Shendam LGA, Plateau State, North-Central Nigeria. The main stay of the people is agricultural activities. The LGA is situated in the lowland part of the Plateau characterized by high temperature, relative humidity and rainfall which supports breeding success of mosquitoes (Nanvyat et al., 2017; Mwansat et al., 2019).

Sampling

Mosquito larval breeding sites were surveyed in the five selected communities, and dipping sampling method was used. The larval collection was done from 25th August to 7th October 2014. The collection was done from early hours of the day around 6:30 am to3:00pm daily irrespective of the site. The dipper was lowered gently at an angle of 45° to avoid disturbance of the water, this enable larvae to flow into the dipper, the dipper is then raised gently to avoid water spillage, and different mosquito larvae were estimated per dip. The larvae collected was then transferred into a small rubber tub, this was to facilitate moving from one habitat type to another within the community. Ten dips were made in each of the habitat types examined for mosquito larvae except in some conditions where the entire water body in the breeding site is less (WHO, 1975; Williams and Pinto, 2012).

Larvae were collected from rice field, tyre tracks, potholes, ponds and animal hoof prints. The larvae collected were then transferred into a jerry-can and transported to the in sectary.

Breeding of Larvae to Adults

The cages were arranged and marked according to the five communities. The larvae collected from the field in each community were distributed into smaller rubber plates and kept into the cage, the larvae were fed with biscuit twice a day from the day of collection, also yeast was introduced on the first day of collection to enable the growth of phytoplankton and zooplankton thereby enriching the water body to enhance larval growth and development.

Morphological Identification

All mosquito species sampled from various sites were morphologically identified using a dissecting microscope and an identification keys by Gillies and Coetzee (1987) and Kent (2006).

Data Analysis

Breeding Index (BI)

The risk index as described by WHO (1997) and Webb (2008) was calculated as follows:

$$BI = \frac{\text{Number of positive habitats}}{\text{Total number of habitats inspected}} \times 100$$

An area is at a high risk of transmission of mosquito-borne diseases as expressed by Pan American Health Organization (1994) and the World Health Organization (Rozendaal, 1997) when this index is above the threshold of 5%.

Diversity Index

Shannon-Wiener diversity index according to Begon et al. (2003) and Lamead (2011) was used to determine the diversity level of mosquitoes in the area.

$$H' = -\sum_{i=1}^{S} (Pi)\ (\ln Pi)$$

Where:

H' is the diversity index

Pi is the proportion of individual species

S is the total number of species in the habitat and

i is the proportion of S species

Diversity index ranges from 0 - 5. Diversity index of 0 - 2.4 shows a low diversity, while 2.5 – 5 shows high diversity.

Data obtained was analyzed using R Console software version 3.2.2. The mean abundance between culicine and anopheline groups was compared using student t-test. One-way analysis of variance was used to compare the abundance of mosquitoes larvae in relation to habitats, locations and as well along gradients. P value < 0.05 was considered statistically significant.

Results

All apparently potential breeding sites encountered during the survey were sampled. A total of 1,700 culicidae larvae were collected out of which the abundance of culicine larvae was higher 1083 (63.71%) than the anopheline larvae 617 (36.29%). However, there was no significant variation in the mean abundance between anopheline and culicine larvae collected ($t = -1.4627$, $df = 84.88$, $P = 0.1472$, Figure 1).

Of the 1,700 larvae collected and reared, only 1,241 (73%) emerged to adults which spread across anopheline 483 (38.92%) and culicine 758 (61.08%) comprising of four genera: Anopheles (38.92%), Culex (60.11%), Aedes (0.81%) and Mansonia (0.16%), and a total of 15 species were identified, 6 of which were Anopheles spp. (An. pretoriensis, An. rufipes, An. maculipalpis, An. gambiae, An. coustani, An. squamosus), 5 Culex spp. (Cx. univittatus, Cx. quinquefasciatus, Cx. bitaeniorhynchus, Cx. tigripes, Cx. antennatus), 3 Aedes spp. (Ae. aegypti, Ae. dazielli, Ae. Hirsutus) and 1 Mansonia species (Mn. uniformis) as shown in Table 1. The numbers of unidentified individuals for Culex and Aedes genera down to species level were 12 and 2 respectively. Culex quinquefasciatus (36.10%) and Anopheles gambiae (36.10%) were the most abundant while Aedes dazieli (0.08) and Anopheles coustani (0.08%) were the least abundant.

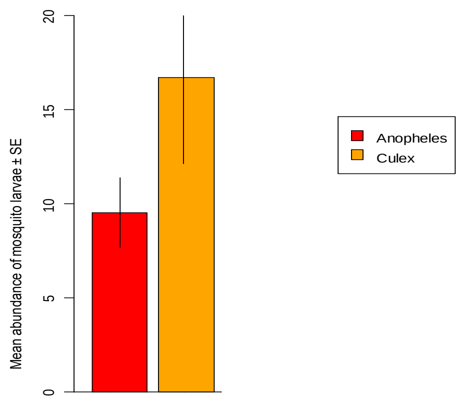

Figure 1. *The mean abundance of anopheline and culicine larvae in Shendam LGA, Plateau State*

Table 1. *Checklist of emerged adult culicidae from field collected larvae in Shendam LGA, Plateau State, Nigeria*

Subfamily	Genus	Species	Number	% Composition
Anophelinae	Anopheles	An. pretoriensis	20	1.61
		An. rufipes	10	0.81
		An. maculipalpis	2	0.16
		An. gambiae	448	36.10 most abundant
		An. coustani	1	0.08 least abundant

		An. squamosus	2	0.16
Culicinae	Culex	Cx. univittatus	6	0.48
		Cx. quinquefasciatus	448	36.10 most abundant
		Cx. bitaeniorhynchus	219	17.65
		Cx. tigripes	51	4.11
		Cx. antennatus	10	0.81
		Cx. species	12	0.97
	Aedes	Ae. aegypti	4	0.32
		Ae. dazieli	1	0.08 least abundant
		Ae. hirsutus	3	0.24
		Ae. species	2	0.16
	Mansonia	Mn. uniformis	2	0.16
Total			**1241**	**100**

Comparison of the Abundance of Larvae in Relation to Habitat Types

The abundance of Anopheles and as well as Culex larvae was significantly different (Anopheles: F_{60} = 3.124, Adjusted R-squared = 0.1172, P = 0.02117, Figure 2; Culex: F_{60} = 1.164, Adjusted R-squared = 0.01012, P = 0.3359, Figure 3) across the habitat types.

Comparison of the Abundance of Larvae in Relation to Gradients of Breeding Water Bodies to the Nearest House

The abundance of Anopheles and as well as Culex larvae in relation to gradients to the nearest house showed a significant difference (Anopheles: F_{57} = 4.365, Adjusted R-squared = 0.2691, P = 0.0006213, Figure 4; Culex: F_{57} = 11.84, Adjusted R-squared = 0.5424, P = 0.00000001, Figure 5).

Comparison of the Abundance of Larvae in Relation to the Communities Sampled

The abundance of Anopheles and as well as Culex larvae across the communities sampled varied significantly (Anopheles: F_{60} = 8.056, Adjusted R-squared = 0.306, P = 0.0000288, Figure 6; Culex: F_{60} = 7.213, Adjusted R-squared = 0.2797, P = 0.00008231, Figure 7).

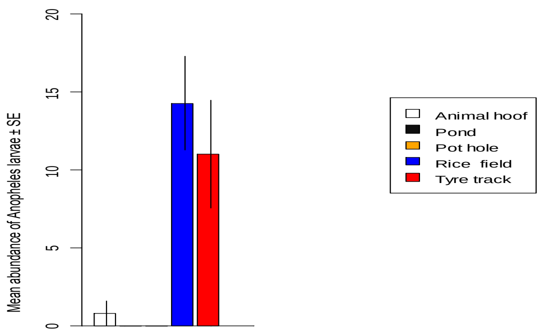

Figure 2. *Mean abundance of Anopheles larvae across habitat types*

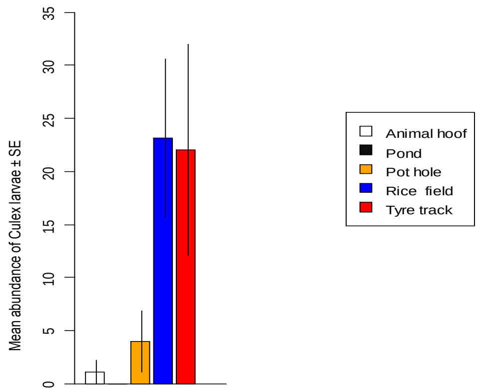

Figure 3. *The mean abundance of Culex larvae across habitat types*

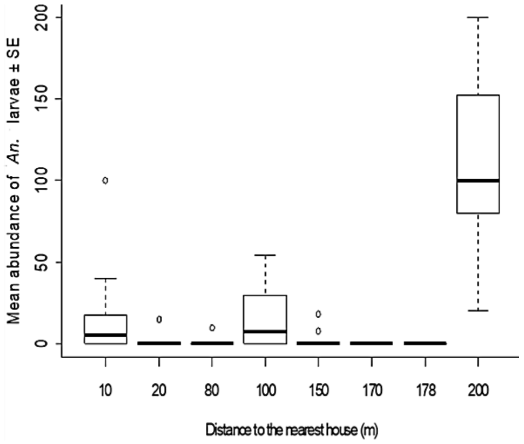

Figure 4. *Mean abundance of Anopheles larvae in relation to gradients to the nearest house*

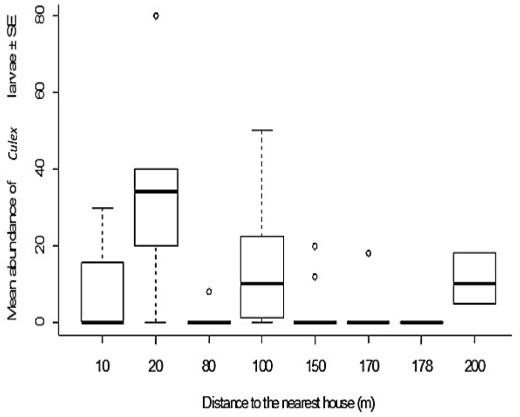

Figure 5. *Mean abundance of Culex larvae in relation to gradients to the nearest house*

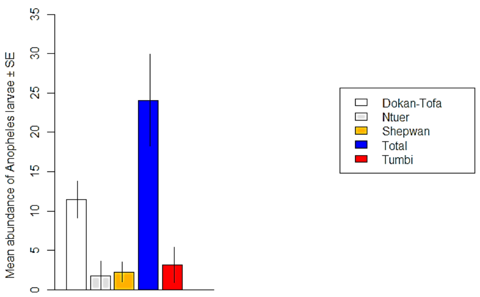

Figure 6*. The mean abundance of Anopheles larvae across locations sampled*

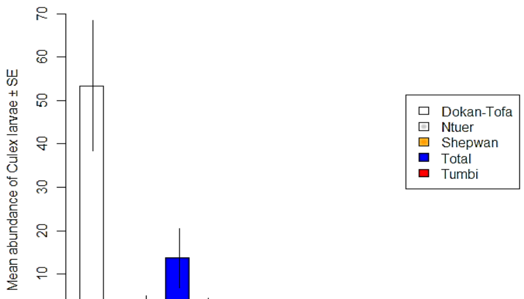

Figure 7. *The mean abundance of Culex larvae across locations sampled*

Breeding Index (BI) of Mosquitoes Larvae

Breeding Index of anopheline and culicine groups in relation to habitat types recorded in the study area is as shown in Tables 2 and 3 respectively. Rice field was the most productive habitat and had the highest breeding index of 51.81 and 85.64 for the anopheline and culicine respectively followed by tyre track, while pond was the least productive habitat type with breeding index of 0. The overall average BI recorded for anopheline and culicine larvae were 16.06 and 25.76 respectively which are above 5.00% threshold connoting high transmission risk of mosquitoes-borne diseases in the area.

Mosquitoes Diversity in Shendam LGA, Plateau State

Shannon-Wiener diversity index (H′) showed that mosquitoes diversity was relatively low (H′ ≈ 1.5) as shown in Table 4.

Table 2. *Breeding Index (BI) of Anopheles larvae in relation to habitat types and communities in Shendam LGA, Plateau State, Nigeria*

Habitat types	**Communities**					**Total BI**
	Dokan-Tofa	**Total**	**Shepwan**	**Tumbi**	**Ntuer**	
Rice field	10.40	31.9	3.47	3.47	2.57	**51.81**
Tyre track	22.67	4.2	0.00	0.00	0.00	**26.87**
Animal hoof	0.00	0.00	1.6	0.00	0.00	**1.60**
Pot hole	0.00	0.00	0.00	0.00	0.00	**0.00**
Pond	0.00	0.00	0.00	0.00	0.00	**0.00**
Average BI	**6.61**	**7.22**	**1.01**	**0.69**	**0.51**	**16.06**

Table 3. *Breeding Index of Culex larvae in relation to habitat types and communities in Shendam LGA, Plateau State, Nigeria*

Habitat types	Communities					Total BI
	Dokan-Tofa	Total	Shepwan	Tumbi	Ntuer	
Rice field	73.60	5.10	2.67	4.27	0.00	**85.64**
Tyre track	21.67	15.50	0.00	0.00	0.00	**37.17**
Animal hoof	0.00	0.00	2.00	0.00	0.00	**2.00**
Pot hole	0.00	0.00	4.00	0.00	0.00	**4.00**
Pond	0.00	0.00	0.00	0.00	0.00	**0.00**
Average BI	**19.05**	**4.12**	**1.73**	**0.85**	**0.00**	25.76

Table 4. *Level of mosquitoes diversity in Shendam LGA, Plateau State*

Species	Number	Pi	ln(Pi)	Pi[ln(Pi)]
An. pretoriensis	20	0.016116	-4.12794	-0.0665
An. rufipes	10	0.008058	-4.82109	-0.0388
An. maculipalpis	2	0.001612	-6.43053	-0.0104
An. gambiae	448	0.360999	-1.01888	-0.3678
An. coustani	1	0.000806	-7.12367	-0.0057
An. squamosus	2	0.001612	-6.43053	-0.0104
Cx. univittatus	6	0.004835	-5.33191	-0.0258
Cx. quinquefasciatus	448	0.360999	-1.01888	-0.3678
Cx. bitaeniorhynchus	219	0.176471	-1.7346	-0.3061
Cx. tigripes	51	0.041096	-3.19185	-0.1312
Cx. antennatus	10	0.008058	-4.82109	-0.0388
Cx. species	12	0.00967	-4.63877	-0.0449
Ae. aegypti	4	0.003223	-5.73738	-0.0185
Ae. dazieli	1	0.000806	-7.12367	-0.0057
Ae. hirsutus	3	0.002417	-6.02506	-0.0146
Ae. species	2	0.001612	-6.43053	-0.0104
Mn. uniformis	2	0.001612	-6.43053	-0.0104
Total	**1241**			**-1.4738**
$H' = -(-1.4738)$				
$H' = +1.4738$				
$\therefore H' \approx 1.5$				

Discussion

This study found out that mosquitoes larvae co-habit together in relation to the breeding habitats sampled across the five selected communities in Shendam LGA of Plateau State. This is in accordance with the finding of Wilke et al. (2019) who collected mosquitoes larvae and pupae in 76 different types of aquatic habitats scattered throughout 141 neighborhoods located in the urbanized areas of Miami-Dade County of Florida, USA. Similarly, Bashar et al. (2016) collected culicidae larvae from 14 different habiat types in semi-urban areas of Bangladesh. Also, another study found that both Anopheles and Culex mosquito larvae co-existed in different breeding sites in a rural setting of Muheza, Tanzania (Emidi et al., 2017).

The lack of variation in larva abundance between culicine and anopheline possibly suggests that the habitat types sampled supports breeding success of both mosquitoes groups. This is accordance with the finding of Emidi et al. (2017) who showed that there was no significant variation in mosquitoes larvae abundance between Anopheles and Culex in rural setting of Muheza, Tanzania. On the other hand, Awolola et al. (2007) and Wilke et al. (2019) reported a significant difference in the abundance of mosquito species in Lagos, Southwestern Nigeria and in the urbanized areas of Miami-Dade County of Florida, USA respectively. However, on the average, culicine had higher abundance over anopheline larvae in this study. But, Emidi et al. (2017) recorded more immature stages of Anopheles than Culex in the sites surveyed.

Of the species that emerged to adult from reared larvae, Culex quinquefasciatus and Anopheles gambiae were the most dominant species which suggests their preference for high temperature, relative humidity and an average rainfall which is synonymous to the weather condition in Shendam LGA of Plateau State. On the contrary, Ferede et al. (2018) identified Ae. aegypti adults as the most abundant mosquito species that emerged from larvae collected across breeding habitat sin residential areas of northwest Ethiopia and reared. Rice paddy accounting for the site with the highest abundance of mosquito larvae may probably be due to the fact that other breeding sites were easily prone to flooding and water run-off since the study was carried out during the wet season whereas rice seedlings served as breaks or reduced the speed of flowing water in rice field thereby providing a suitable breeding ground for mosquitoes since they are known to breed in stagnant water bodies.. This is in agreement with the work of Wim et al. (2002) who reported paddy rice field as potential breeding ground for mosquito species. This is in agreement with the work of Amarasinghe (1995), who reported that, rice field have significant influence on the production of mosquito larvae. Also, Zogo et al. (2019) showed that rice fields had the highest likelihood of anopheline throughout the wet and dry season over other breeding sites. This is not in agreement with the work by Emidi et al. (2017) who showed that the overall association between mean larval and pupa densities of Anopheles and Culex were highest inbreeding sites comprised of roadsides water collections and in road potholes.

The mosquito larval abundance in tyre track was next to rice field due to its productivity. This is in line with the work of Impoinvil et al. (2008) who reported that tyre tracks were the second most-cited artificial vector breeding site in Malindi, Kenya, and accounted for 28% of all water bodies that were positive for mosquitoes. Tyre tracks are more common in areas of high socioeconomic status, which tend to house more vehicle owners. Mwangangi et al. (2009), reported high larval abundance of Cx. quinquefasciatus and An. gambiae in tyre tracks in Kibwezi, lower eastern Kenya.

The abundance of mosquito larvae in potholes was less compared to other habitat types. This is probably due to recent refilling of potholes along the Yelwa-Shendam and Shendam-Kurgwi roads bisecting the study area by the National Environmental Maintenance Agency (NEMA). Mwangangi et al. (2009) reported that poor quality of road lead to the formation of potholes which serve as a breeding site for mosquito species.

The low population of mosquito larvae in animal hoof print recorded is probably due to high rainfall which resulted in flood thereby washing away the larvae. This is in accordance with the finding by Emidi et al. (2017) who observed that animal hoof prints had significantly lower densities of Culex larvae.

The observed variation in the abundance of mosquito's larvae in relation to selected communities may probably be due to varying microclimatic conditions across the study sites. This agrees with Wilke et al. (2019) who recorded a high difference in the number of larvae collected in relation to neighborhoods in Florida.

The variance in abundance of Anopheles larvae in relation to breeding gradients to the nearest house possibly suggests their preference to breed far away from human habitation where there is clear water bodies and low human presence. This is in line with the finding of Zogo et al. (2019) who recorded the density of Anopheles spp. larvae to be significantly higher in habitats surrounded by low-density housing and green areas than habitats surrounded by high-density housing.

The gradient at which Culex larvae were collected was very close to the nearest house to breeding site which may imply their preference to breed in habitats surrounded by high-density housing containing polluted water bodies. This agrees with the finding by Wilke et al. (2019) who collected abundant culicine larvae at point source location in urban habitats within neighborhoods.

The very high breeding index values of the mosquito populations recorded (anopheline: 16.06; culicine: 25.76) over the threshold value (5.00) signifies a likelihood of multiples of transmission of mosquito-borne diseases amongst inhabitants of Shendam LGA of Plateau State. This is in agreement with the finding by Ferede et al. (2018) who reported a container index of 32.9, a house index of 25.5, and a Breteau index of 48.4 for Ae. aegypti, the main vector of dengue and other arboviruses which suggested a high potential for arbovirus transmission in residential areas of northwest Ethiopia. Also, Dikin et al. (2011) recorded occurence of dengue fever in localities with low Aedes indices whose BI were 20 and 5.

Conclusion

It is very obvious that the inhabitants of Shendam LGA are at high risk of mosquito-borne diseases transmission based on the observed BI value. Hence, the need for good water management practices should be employed in order to circumvent the spread of various mosquito-borne diseases in the localities. Farmers should create drainages in their rice paddy farms in order to reduce breeding sites of mosquito species. Also, larval source management should be deployed in the entire Shendam Local Government Area in order to prevent breeding success of mosquitoes larvae.

References

[1] Afrane, Y.A., Beernard, L.W., Ruth, B., Thomas, K., and Guiyun, Y. (2012). The ecology of mosquitoes in an irrigated vegetable farm in Kumasi, Ghana: abundance, productivity and survivorship. Parasitology Vectors, 5: 233.

[2] Afshin, M. (2007). Africa's malaria Death Toll Still "Outrageously High'' National Geographic Centre for Disease Control and Prevention (CDC). Infectious Disease Information: Mosquito–Borne disease.

[3] Amarasinghe, F. P., Indrajith N. G. and Ariyasena, T. G. (1995). Physico-chemical characteristics of mosquito breeding habitat in an irrigation development area in Sri Lanka. Ceylon Journal of sciences, 24: 13-29.

[4] Awolola, T. S., Oduola, A. O., Obansa, J. B., Chukwura, N. J. and Unyimadu, J. P. (2007). Journal Vector-borne Disease, 44: 241-244.

[5] Bashar, K., Rahman, M. S., Nodi, I. J. and Howlader, A. J. (2016).Species composition and habitat characterization of mosquito (Diptera: Culicidae) larvae in semi-urban areas of Dhaka, Bangladesh. Pathogens and Global Health,110 (2):48-61.Doi10.1080/20477724.2016.1179862

[6] Begon, M., Harper, J. L. and Townsend, C. R. (2003). Ecology of individuals, California Press, Berkeley. 360 Pp.

[7] Castro, M. C., Kanamori, S., Kannady, K., N kude, S., Killeen, G.F. and Fillinger, U. (2010). "The importance of drains for the larval development of lymphatic filariasis and malaria vectors in dares alaam, United Republic of Tanzania," PloS Neglected Tropical Diseases, 4(5): 693.

[8] Chaki, P. P., Govella, N. J. and Shoo, B. (2009). "Achieving high coverage of larval-stage mosquito surveillance: challenges for a community-based mosquito control programme in urban Dar' es salaam, Tanzania." Malaria Journal, 8 (1):311.

[9] Dikin, S. K., Schuster-Wallace, C. J., Elliot, S. J., (2011). Developing a vulnerability mapping methodology: Applying the water Associated Disease Index to dengue in Malaysia. PloS One, 8(5): ARTN e63584.

[10] Emidi, B., Kisinza, W. N., Mmbando, B. P., Malima, R. and Mosha, F. W. (2017). Anopheles and Culex mosquito larvae abundance in different breeding sites in a rural setting of Muheza, Tanzania. Parasites & Vectors, 10(304):1-12 doi 10.1186/s13071-017-2238-x

[11] Ferede, G., Tiruneh, M., Abate, E., Kassa, W. J., Wondimeneh, Y., Damtie, D., and Tessema, B. (2018). Distribution and larval breeding habitats of Aedesmosquito species in residential areas of northwest Ethiopia. Epidemiology and Health, 40:1-7. https://doi.org/10.4178/epih.e2018015

[12] Gillies, M. T. and Coetzee, M. (1987). A supplement of the Anophelinae of Africa South of the Sahara (Afro tropical Region). Johannesburg: The South African Institute of Medical Research.

[13] Gould, E. A., delambalerie, X., de Azonotto, P. M., and Holmes, E. C. (2003). Origin, evolution and vectors/host co-adaptations with the genus Flavivirus. Adv virus Res., 59: 277-314.

[14] Gubler, D. J. (2002). The global emergence/ resurgence of arboviral diseases as public health problems. Archive Medicine Reserve, 103(2): 109-121.

[15] Harbachs, R. E. and knight, K. L. (1981). Mosquitoes Systematic. Glossary of Mosquito Anatomy, 13: 201-217.

[16] Hasnana, A., CheDoma, N., Rostya, H., and Say Tyong, C. (2016). Quantifying the distribution and abundance of Aedes mosquitoes in Dengue Risk Areas of Sha Alam Selango. Procedia-Social and behavioural Science, 234:154-163.

[17] Imponvil, D. E., Keating, J., Mbogo, C. M., Potts, M. D., Chowdhury, R. R. and Beier, J. C. (2008). "Abundance of immature Anopheles and culicine (Diptera:Culicidae) in different water body types in the urban environment of Malindi, Kenya," Journal of Vector Ecology, 33(1):107-116.

[18] Keating Macintyre, K., Mbogo, C. M., Githure, J. I. and Beier, J. C. (2004). Characterisation of potential larval habitats for Anopheles mosquitoes in relation tourban land-use in Malindi, Kenya. International Journal of Health Geography, 3:9.

[19] Kent, R. J. (2006). Johns Hopkins Malaria research institute, department of molecular microbiology and immunology Johns Hopkins Blomberg School of public health Balti more M.D USA.

[20] Lamead. G. A. (2011). Species diversity and abundance of Wild birds in Dagona Waterfall sanctuary Borno State, Nigeria. African Journal of Environmental Science and Technology, 5:855-866.

[21] Leisnham, P. (2013). Taking a bite out of mosquito research. University of Maryland. Enst.Umd.edu.

[22] Matthys, B., Koudou, B. G. and N'goran, E. K. (2010). "Spatial dispersion and characterization of mosquito breeding habitats in urban vegetable-production areas of Abidjan, Cote d'voire," Annals of Tropical Medicine and Parasitology, 104(8): 649-666.

[23] Matthys, B., N'goran, E. K. and Kone, M. (2006). "Urban Agricultural land use and characterization of mosquito larval habitats in a medium-sized town of Cote d'voire," Journal of Vector Ecology, 31(2): 319-333.

[24] Mwangangi, J. M., Muturi, E. J. and Mbogo, C. M. (2009). Seasonal Mosquito larval abundance and composition in Kibwezi, lower eastern Kenya. J Vector Borne Dis., 46 (1): 65-71.

[25] Mwansat, G. S., Nanvyat, N., Ombugadu, A., Mafuyai, M. J., Lapang, M. P., Nkup, C. D., Oduola, A. O., Inyama, P. U., Samdi, L. M., Okeke, I. and Bewa, C. (2019). Insecticide susceptibility status, resistance intensity and mechanism of pyrethroids resistance in An. gambiae s.l. mosquitoes from six Local Government Areas in Plateau State Nigeria. Abstract of the 50th Annual Conference of Entomological Society of Nigeria (ESN) Yola 2019. ESN24/MVE07. P 66.

[26] Nanvyat, N., Mulambalah, C. S., Barshep, Y., Dakul, D. A. and Tsingalia, H. M. (2017). Retrospective analysis of malaria transmission patterns and its association with meteorological variables in lowland areas of Plateau State. International Journal of Mosquito Research, 4(4): 101-106. ISSN:2348-5906

[27] Pan American Health Organization (1994). Dengue and dengue hemorrhagic fever in the Americas: guidelines for prevention and con-trol. Washington, DC: Pan American Health Organization. Pp 9-10.

[28] Rozendaal, J. A. (1997). Vector control: methods for use by individuals and communities. Available from: http:// www.who.int/ iris/handle/ 10665 /41968.

[29] Siri, J. G., Wilson, M. L. and Murray, S. (2010). "Significance of travel to rural areas as a risk factor for malaria anemia in an urban setting." Journal of Tropical Medicine and Hygiene, 82(3): 391-397.

[30] Webb, C. E. (2008). Mosquito ecology: field sampling methods. Aust Entomol, 47:382-383.

[31] Williams, J. and Pinto, J. (2012). Training Manual on Malaria Entomology: For Entomology and Vector Control Technicians (Basic Level). 78 Pp.

[32] Wilke, A. B. B., Chase, C., Vasquez, C., Carvajal, A., Medina, J., Petrie, W. D. & Beier, J. C. (2019). Urbanization creates diverse aquatic habitats for immature mosquitoes in urban areas. Scientific Reports Nature Research, 9 (15335): 1-12. https:// doi.org/ 10.1038/s41598-019-51787-5

[33] Wim, V. H., Sakthivadivel, R., Renshaw, M., Birley, H. and Konradsen, F. (2002). Alternate wet/dry irrigation in rice cultivation: a practical way to save water and Control Malaria and Japanese encephalitis. 20-35 Pp.

[34] WHO (2004). The global burden of disease: 2004 update Geneva Switzerland; Plos one: tempt. Larval diet and Density. 1-23.

[35] WHO (1997). Dengue haemorrhagic fever: diagnosis, treatment, prevention and control, 2nd ed. Available from: http://www.who.int/ iris/handle/10665/41988.

[36] WHO (1975). Manual on practical entomology in malaria. Part II. Methods and Techniques. Geneva; World Health Organization.

[37] Zogo, B., Koffi, A. A., Alou, L. P. A., Fournet, F., Dahounto, A., Dabiré, R. K., Baba-Moussa, L., Moiroux, N. and Pennetier, C. (2019). Identification and characterization of Anopheles spp. breeding habitatsin the Korhogo area in northern Côte d'Ivoire: a study prior to a Bri-based larviciding intervention. Parasites Vectors, 12(146):1-10.https://doi.org/ 1 0.1186/ s13071-019-3404-0

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