Journal of Applied Life Sciences International

Volume 27, Issue 3, Page 49-57, 2024; Article no.JALSI.114691
ISSN: 2394-1103

Diversity of *Anopheles* Larvae in Toro Local Government Area, Bauchi State, North-East Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JALSI/2024/v27i3646

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114691

Original Research Article

Received: 23/01/2024
Accepted: 26/03/2024
Published: 02/05/2024

ABSTRACT

Vector control is a critical element of malaria control programs in Africa. To reduce human exposure to infective *Anopheles* mosquitoes, most programs rely on methods that kill adult mosquitoes. Therefore, the study on the distribution and abundance of *Anopheles* larvae in Toro Local Government Area (LGA.), Bauchi State, North-East Nigeria was carried out in July 2013. Five villages were randomly selected for the collection of *Anopheles* larvae. A total of 988 *Anopheles*

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larvae were collected from five habitat types. The paddy habitat recorded the highest abundance of 494(50%) while the canal habitat had the least abundance 53(5.36 %). The mean abundance of *Anopheles* larvae in relation to gradients of larval habitat to houses showed no significant difference (F_9 = 0.434, Adjusted R^2 = -0.39, P = 0.885). However, there was a significant difference (F_{14} = 9.18, Adjusted R^2 = 0.65, P = 0.001) in the mean abundance of *Anopheles* larvae in relation to habitat types. The larval abundance in relation to water depths varied significantly (F_{13} = 29.61, Adjusted R^2 = 0.888, P = 0.001). There was no significant difference (P > 0.05) in larval abundance between still and moving waters; light versus shaded water bodies; and clear versus turbid waters, respectively. In conclusion, the inhabitants of Toro LGA should always clear stagnant water bodies so as to hinder mosquitoes breeding success. Also, larval source management should focus more on paddy habitat in peri-urban agricultural sites when designing intervention programmes in order to control mosquitoes' larvae.

Keywords: Anopheles larvae; distribution; habitat types; larval source management.

1. INTRODUCTION

Mosquitoes can be found all over the world and commonly known to pose a significant threat to public health. The biodiversity of mosquitoes is very evident, with many genera having worldwide distribution and some genera with limited or endemic distribution [1]. The common fear of mosquitoes is their role as vectors that can spread disease pathogens such as Dengue, Malaria, Filariasis, Yellow Fever and Japanese Encephalitis. The common in the study area is Malaria which is an infectious disease caused by parasitic protozoa of the genus plasmodium, transmitted by the bite of the female mosquito Anopheles. This disease kills more than 600,000 people every year [2]. It is the main tropical parasitic disease and one of the most frequent causes of death in children in Africa. According to WHO, malaria kills one African child every 30 seconds, and many children who survive severe cases have serious brain damage and learning difficulties [3].

Malaria is a major public health problem in Nigeria contributing a quarter of Malaria burden in Africa. Malaria contributes to over 30 percent of childhood mortality in Nigeria and contributes to 11 percent of maternal mortality [4].

Anopheles mosquitoes exploit varying habitats for breeding. They breed in and around vicinities of deteriorating infrastructure such as broken water pipes, open tins/cans, poorly maintained drains, culverts, lorry tyre tracks on unpaired roads, low lying areas that are liable to flooding hydrants, catch pits among others [5].

A potentially important target of malaria vector control is anopheline larvae source reduction through modification of larval habitat was key to malaria eradication efforts in United States, Israel and Italy [6]. Thus, this study focused on distribution and abundance of *Anopheles* larvae in Toro LGA, Bauchi State, North-East Nigeria with the view of generating a checklist of habitat types utilized by *Anopheles* species, comparing the abundance of larvae of species between habitat types, their breeding preference along gradient away from human habitation as well as determining the abundance of *Anopheles* larvae in relation to water depth.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in five villages randomly selected, which are Anguwan Baro, Balo, Government College Toro, Ribina and Rinjim Gani of Toro LGA of Bauchi State North-Eastern Nigeria. It has an area of about 6,932 km^2 and a population of 350,404 at the 2006 census. Toro LGA lies between Latitude 9˚15΄85‶N and Longitude 10˚30΄30‶ E. It has a mean rainfall of 1,100 mm and a minimum temperature of 33℃. It has a sudden savanna with a mixture of guinea savanna Southwards as its vegetation [7].

2.2 Field Sampling of Mosquitoes Larvae

Anopheles larvae breeding sites were surveyed in the five selected villages. Dipping sampling method was used. The materials used for the dipping were small soup ladle dipper, a labeled bottle, and a plastic ruler. The larval collection was done in the month of July, 2013 during the breeding season of mosquitoes. The collection was done in the early hours of the day around 6:30am – 2:00pm daily. The dipper was lowered gently at angle of about 45˚ to minimize disruption and the water and nearly larvae flow into the dipper and the dipper was raised gently from the water to avoid water spilling. The larvae collected were transferred to a well labeled bottle. Ten dips were made in each of the habitat types examined for *Anopheles* Larvae [8]. This was important for the calculation of larval density.

2.3 Larval Habitat Characterization

The characteristics of the breeding sites were recorded and they include: Habitat type: canal, hoof print, paddy, pool and tyre marks (impression), distance to the nearest house, water PDE: water present, dry, eliminate, PT: Permanent/Temporary, SM: Still/Moving, LS: Light/Shaded: Turbidity: high, low, clear, EFM: emergent, floating or submerged, vegetation, predators, PA Present/absent, Village name, date of collection, depth of water, larval stage (L_1 – L_4) the recording was done in larval collection form.

All the specimens collected from a particular breeding site were kept in a bottle and labeled. The label included date, location and sample number. Small incisions were made on the labeled bottles for oxygen penetration to ensure the survival of the larvae for larval count.

2.4 Samples Preservation

The larvae collected from the habitat sites were later counted and the different larval stages examined (L_1 – L_4). The larvae were then preserved in about 70% ethanol. The data were recorded in a larval collection form for data analysis.

2.5 Statistical Analysis

The data was analyzed using R-Console Software version 2.9.2. One-way analysis of variance (ANOVA) was used to compare the mean abundance of *Anopheles* species larvae across habitat types, distances of house nearest to larval habitat, and water depths, respectively. T-test was used to compare the mean abundance of *Anopheles* larvae between still and moving water bodies, light and shaded waters, as well as between clear and low turbid waters. Level of significance was set at $P < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Habitat Types Utilized by Anopheles Mosquitoes for Breeding in Toro Lga

The checklist of habitat types utilized by *Anopheles* mosquitoes for breeding as generated at the end of this study is shown in Table 1. An overall total of 988 larvae were collected with paddy having the highest abundance of 494 (50%) whereas very low abundance was recorded in canal habitat 53 (5.36%). Hence, there was a very high significant difference in mean abundance of *Anopheles* larvae across habitat types (F_{14} = 9.18, Adjusted R-squared = 0.65, P = 0.001, Fig. 1).

This study was able to establish the breeding behaviour of *Anopheles* mosquitoes which is characterized in relation to five habitat types recorded; canal, hoof print, paddy (rice field), pool and tyre marks (impression). About a thousand *Anopheles* larvae were collected just within a very short period of time of this study have proven to our high contribution in reducing the breeding success of *Anopheles* mosquitoes in that locality.

The very high abundance of *Anopheles* larvae in paddy (rice field) is presumably due to the early stage of rice growth and heavy rainfall during the survey which agrees with previous findings other researchers who reported that early stages of rice growth have been associated with high densities of mosquito larvae [9-13].Larval counts and density of *Anopheles* mosquitoes are known to be high during rainy seasons and decline at dry seasons [14]. Studies have shown similar trends where greater assemblages of anopheline species were associated with villages in rice growing which had permanent and diverse larval habitats [15].

Table 1. Checklist of habitat types utilized by *Anopheles* mosquitoes for breeding

Habitat type	Total (%)
Canal	53 (5.36%)
Hoof print	61 (6.17%)
Paddy	494(50%)
Pool	303 (30.67%)
Tyre impression	77 (7.79%)
Total	**988**

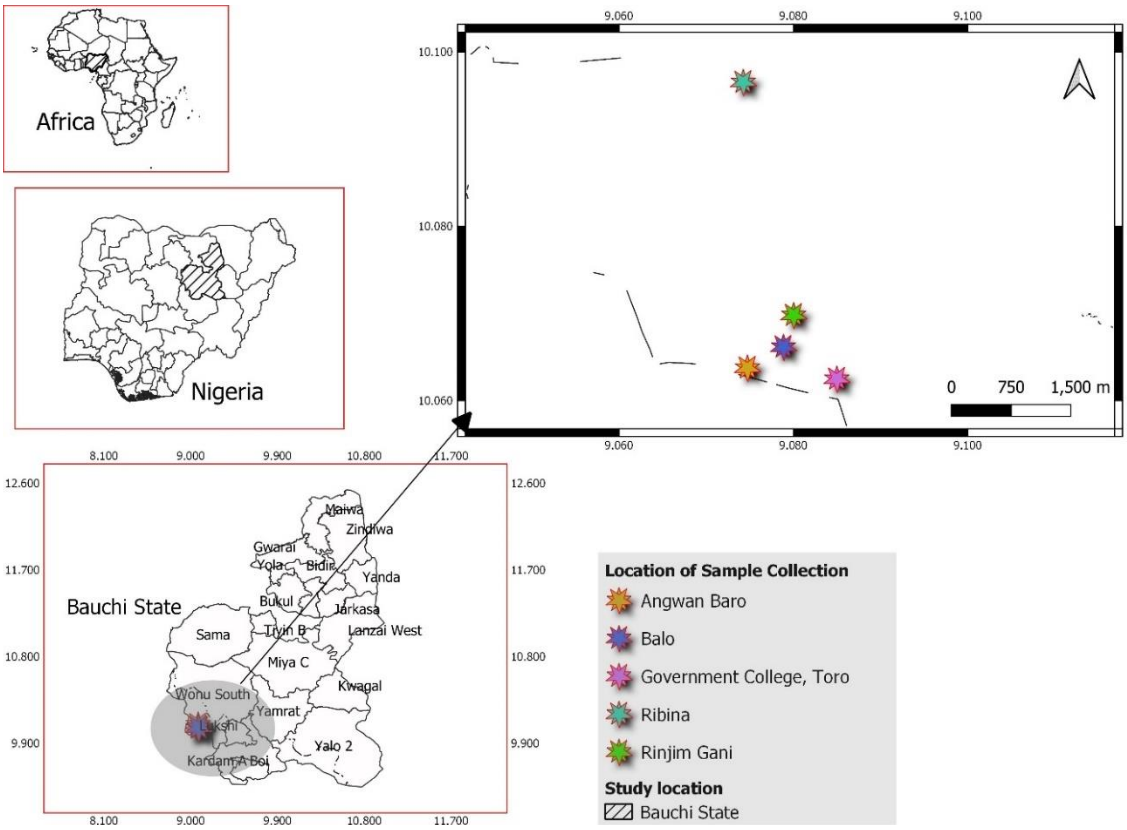

Fig. 1. Map of study area showing sample collection locations

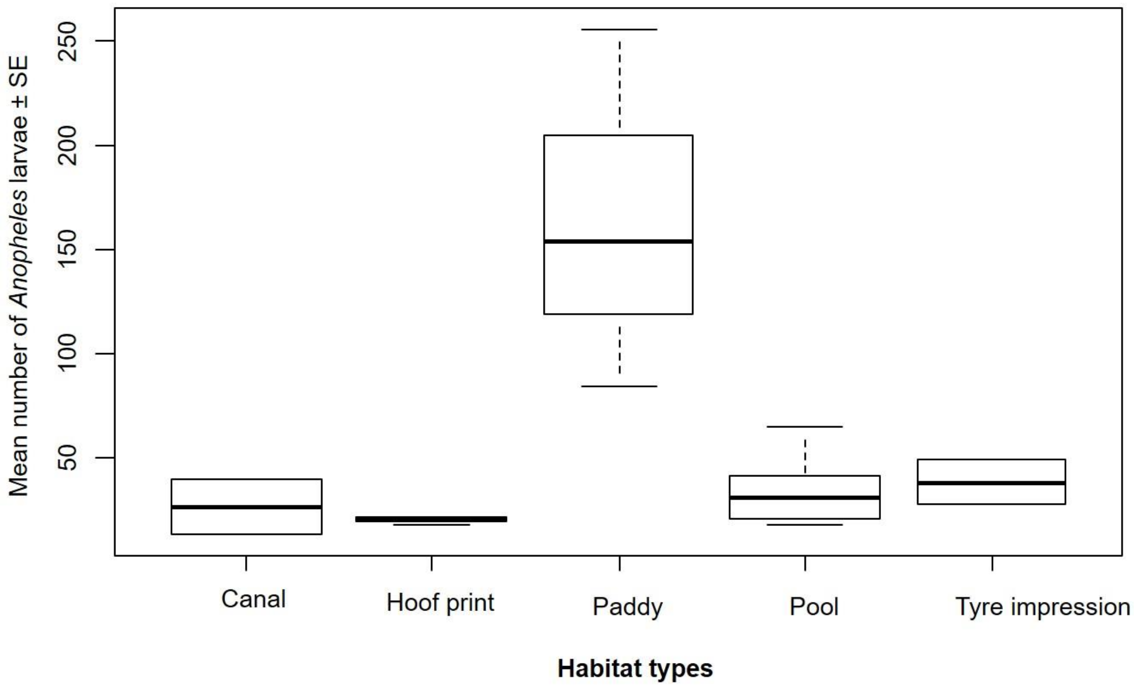

Fig. 2. Mean abundance of Anopheles larvae across habitat types

In pools which represents 30.67% of the total *Anopheles* larvae collected during the study was lower than the *Anopheles* larvae collected in paddy area which may probably be due to the heavy rain that floods the larvae away from the pools thereby making or rendering the habitat unsuitable for mosquito breeding success. It is possible that heavy rains flushed away and/or killed the larvae. This agrees with the experimental results by [16] who recorded that precipitation flushed, ejected and killed *An. gambiae* larvae, since the larval collection was done at a period of abundant rain and the pool is a natural water source the larvae might have been possibly flushed away.

The decline in larval density of *Anopheles* larvae in hoof print habitat is probably due to instability of the habitat, this agrees with the findings of other workers reported that hoof prints are faced with severe problem due to small size such as cow hoof prints [17,18]. In addition, heavy rain may flush out larvae and eggs during rainy season, hence, leading to decline in anopheline larval density on cow hoof print. Another factor that may have possibly led to low anopheline larval count in hoof print is the small unstable habitat which gives rise to cannibalism which a more severe challenge in small habitats due to limited food source as earlier reported [19,20].

The decrease in the number of anopheline larvae in tyre marks in comparison to the paddy this might be that the tyre mark habitat is a temporary breeding site for *Anopheles* mosquitoes and are constantly disturbed by vehicles that pass through the tyre marks crushing the larvae in that breeding site. This is contrary with other findings which revealed that proportions of *Anopheles* mosquitoes produced by permanent sites were less than those of temporary sites [21,22].

The least number of *Anopheles* larvae in canal habitat may be due to the presence of grasses and weeds which cover the canal hence shading potential breeding habitat. This agrees with the findings of [23] but contradicts [24] whose studies found out that habitat with grass grown in them had more anopheline mosquitoes than habitats with other vegetation types and open habitats.

3.2 Comparison of Anopheles Larvae Abundance Along Gradient of the House Nearest to Larval habitats

No significant difference (F_9 = 0.434, Adjusted R-squared = -0.39, P = 0.885, Fig. 2) was recorded in the mean abundance of *Anopheles* larvae along gradients of house nearest to larval habitats, however, most *Anopheles* mosquitoes preferred to breed 800 metres away from human habitation followed by 200 metres and 400 metres gradient.

As regard distance away from houses, it can be seen from the bar plots in Fig. 2 that the *Anopheles* larvae increased with distance away from houses, this may probably be due to the insecticides sprayed by residents which is believed to reduce the abundance of gravid mosquitoes in breeding sites close to houses. On the other hand, this contradicts [25,12] which shows that larval counts decreased with increasing distance from homesteads.

3.3 Comparison of the Abundance of Anopheles Larvae in Relation to Varying Water Depths

Anopheles predominantly utilize breeding habitats that are very deep 31-35 cm with average larval abundance of 256.00 ± 00.00 followed 11 – 15 cm depth having 119.00 ± 35.00 larvae while 16-20 cm water depth had no larvae. Thus, the mean abundance of *Anopheles* larvae in relation to water depths varied very highly (F_{13} = 29.61, Adjusted R-squared = 0.888, P = 0.001 Fig. 3).

The number of *Anopheles* mosquito larvae in relation to water depth increased at 31-35 cm and this agrees with the report by [25] who indicated that mosquitoes prefer to breed in water with depth below 91.5 cm.

3.4 Comparison on the Abundance of Larvae in Relation to other Parameters as Follows

A. Still versus moving water bodies

No significant difference (t = -0.3938, df = 17, P = 0.6986, Fig. 4) was observed in the mean abundance of *Anopheles* larvae between still and moving water bodies, nevertheless, the still water body still had more *Anopheles* larvae over moving water body.

B. Light versus shaded water bodies

Habitats that are directly open to light had more *Anopheles* larvae than those under shade or plant cover. Yet, the differences in the mean abundance of *Anopheles* larvae between light and shaded water bodies was not significant (t = 1.6189, df = 9.502, P = 0.1381, Fig. 5).

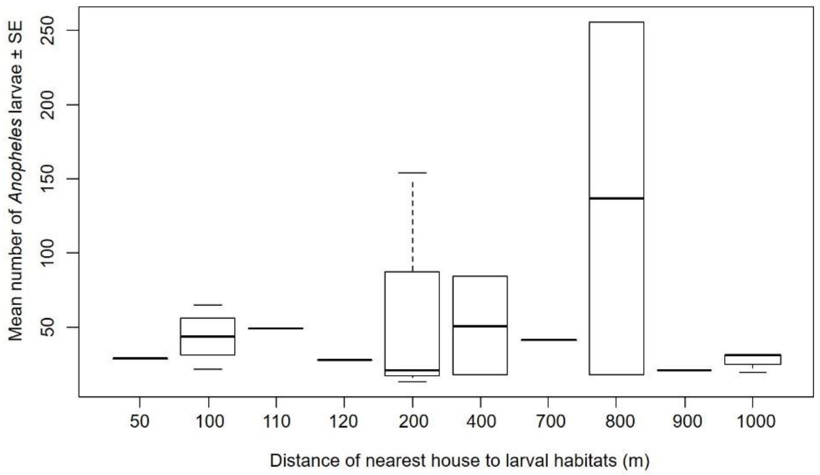

Fig. 3. Mean abundance of Anopheles larvae along gradients of house nearest to larval habitats

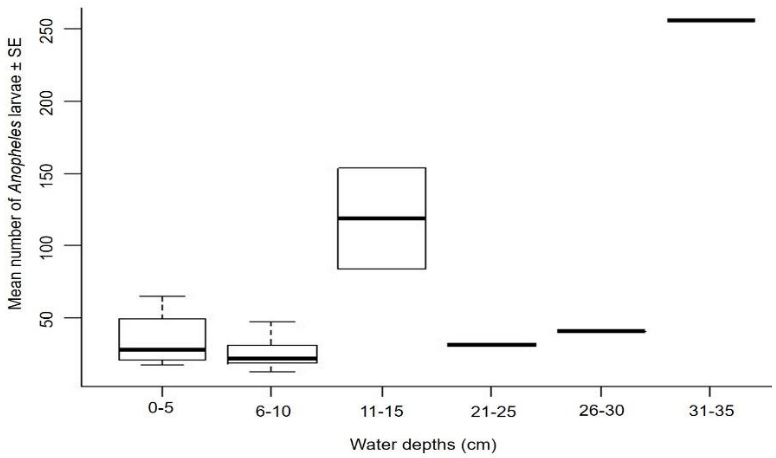

Fig. 4. Mean abundance of Anopheles species larvae in relation to water depths

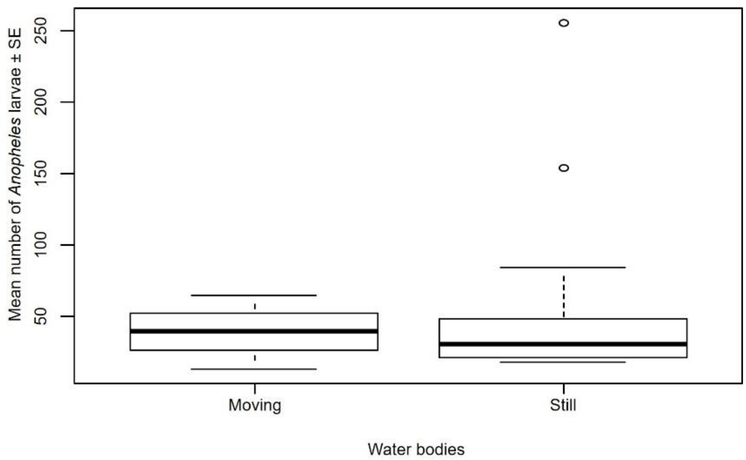

Fig. 5. Mean abundance of Anopheles larvae between moving and still water bodies

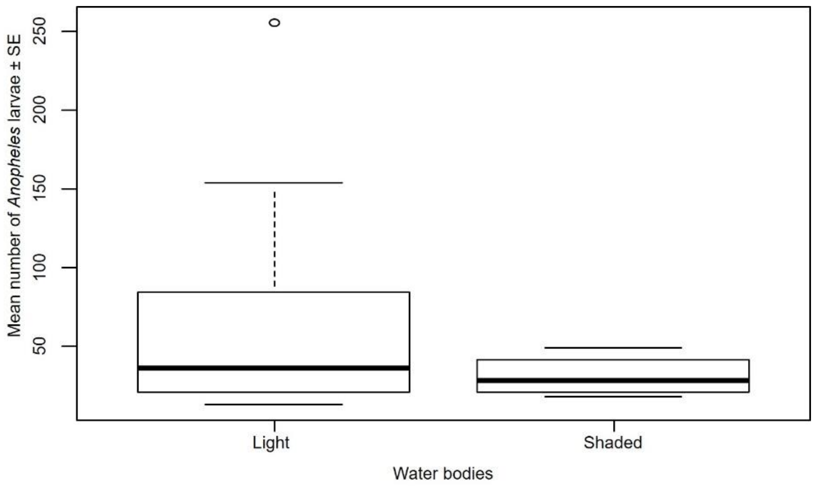

Fig. 6. Mean abundance of Anopheles larvae between light and shaded water bodies

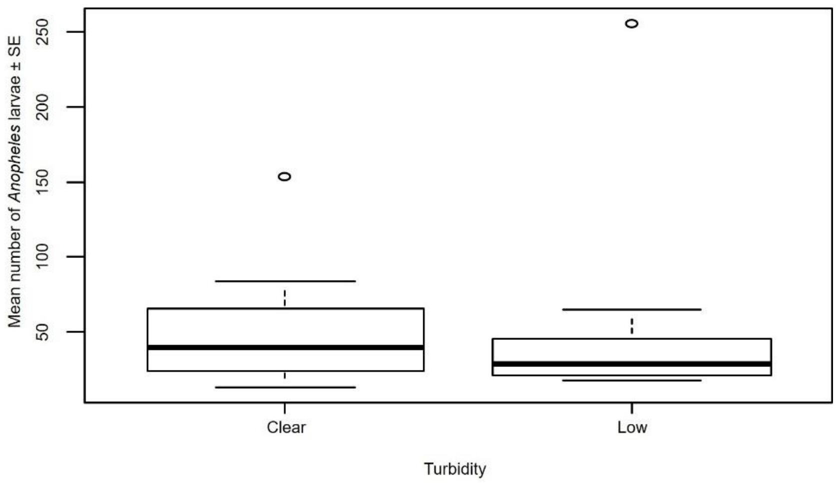

Fig. 7. Mean abundance of Anopheles larvae between clear and low turbid water bodies

C. Clear versus low turbid water bodies

Larval abundance was higher in clear water bodies than turbid habitats. Nonetheless, there was no significant difference in the mean abundance of *Anopheles* larvae between clear and turbid waters (t = 0.1873, df = 17, P = 0.8536, Fig. 6).

Anopheles larvae occur in a wide range of habitats, but most species prefer clean, unpolluted water [26,27,28]. On the contrary, Scientist have reported that mosquito larvae have been found in habitats organically polluted by rotting vegetation, human faeces or oil [29,30]. Larvae of *Anopheles* mosquitoes have been found in fresh water or salt water marshes, mangrove swamps, rice fields, grassy ditches, the edges of streams and rivers and small temporary rain pools. In paddy area, turbidity of water results from agronomic activities such as manual weeding and other factors. It has been observed that top dressing with nitrogenous fertilizers lowered turbidity of water and it corresponded with increase of *Anopheles* mosquito larvae [31,9,32].

4. CONCLUSION

In summary, this study shows that *Anopheles* mosquitoes utilize five major breeding sites which include paddy, tyre marks, canals, hoof prints and pool habitats. Paddy habitat had the highest anopheline larvae. This result suggests that there is need for the implementation of larval source management programme which should be targeted on early stage of rice growth during rainy season, this is key in controlling/reducing mosquitoes' population.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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